The Potato and the Prius

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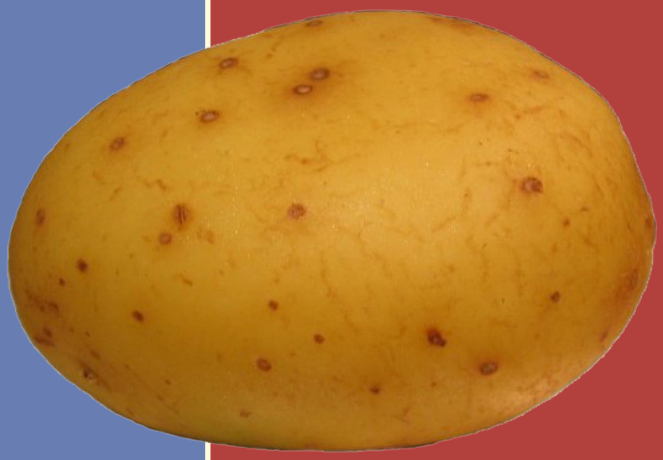

Keynote address to the 2018 Potato Business Summit
of the United Potato Growers of America

Acknowledgments

This essay is based on the keynote address to the 2018 Potato Business Summit of the United Potato Growers of America. Thanks to President Mark Klompien, Buzz Shahan, and George Martin of the United Potato Growers of American for inviting me to participate in the 2018 Potato Business Summit. Thanks to my colleagues, Alan Curry, Perrin Meyer, Paul Waggoner, and especially Iddo Wernick, who helped me with the research and analysis I share. Thanks to H. Dale Langford for editorial assistance.

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Suggested citation:

Ausubel, Jesse H. 2018. "The Potato and the Prius" Keynote address to the 2018 Potato Business Summit of the United Potato Growers of America, Orlando, 10 January 2018. http://phe.rockefeller.edu/docs/Potato_and_Prius.pdf.

Abstract

Potatoes are a green vegetable. They spare other natural resources, especially land, through their high and rising yields achieved mainly with increases in information and capital. Since 1950 growers have reliably tripled yields and doubled production, while reducing area harvested by 30 percent. Farming resembles other modern industries: more bits and fewer kilograms. Drones, sensors, and autonomy are the central subjects of discussion in Silicon Valley, the Pentagon, and the Potato Summit. In this essay I show how potatoes resemble an efficient car, and consider strategies for a healthy potato industry in light of trends in both supply and demand.

The 2014 Potato Summit in San Antonio taught me that potato growers are good-humored people searching for smart ways to prosper and ready for heavy lifting. Your attendance at this seminar in Orlando instead of the Magic Kingdom or Typhoon Lagoon testifies to your commitment to the potato industry. During the next few days I will learn from you about blackleg and powdery scab, high-performance F1 hybrids, certification, and how Amazon's entry into the food business could affect potatoes.

My message is about efficiency sparing natural resources. I believe in the 21st century we have a new reality of resource use, and that potato growers can match well with it. I call this matchup "The Potato and the Prius," acknowledging both the vegetable and the vehicle as efficient, green products. The Toyota Prius was the first mass-produced hybrid electric vehicle and for twenty years has ranked profitably among the cleanest and most efficient reliable cars sold in the US. Comparisons with the potato will become clear.

A new reality of resource use

The term *resource* embraces four great categories. The first is the traditional one of natural resources: water, energy, land, and minerals. The second is labor, the human resource. The third resource is information, now often measured in bits and bytes and bandwidth. The fourth is capital, which we can think of as both money and machines.

Slowing population growth, moderate economic growth, changes in consumer taste and behavior, and technical progress from seeds to systems are combining to create a new reality of resource use. The new reality includes lightening use of natural resources in the US and globally, as efficiency "decouples" outputs from inputs. My view surprises many people who worry about adequacy of arable land, water, and fertilizer.

The new reality also involves labor sparing, less need for lots of people and hours of their work. In contrast, the new reality of resources requires heavier use of information. Think how much information a self-driving car will need. Think of the global market news that participants in the potato industry already use to make their decisions.

The new resource reality also implies a large, continuing role for capital and machines. A combine replaced stoop labor in the potato fields. Now farmers invest in drones, and so does Amazon.

The new reality is characterized by sensors, precision, autonomy, coordination of logistics at huge scales, and sharing to boost asset utilization. The Expo associated with the 2018 Potato Summit displays these and other technologies and systems.

In my scenario, advantage will accrue to those who develop and adopt the new technologies and especially those who integrate and regularly refresh them. A way to summarize the new reality is more bits and capital, and fewer acres and hands. Cheap labor matters little. A risk is fragility of finely tuned systems.

Two examples about use of natural resources, such as metals and minerals, illustrate my scenario. First, through use of metals salted with rare-earth elements such as neodymium, we have miniaturized magnets. These new magnets offer the same power at perhaps one-twentieth the volume of magnets made with plain old iron. The miniaturization also means they can assume new roles and pervade devices from cordless tools and disk drives to dentures and doorstops.

Second, consider telephones. Readers my age and older will remember the old black Bell telephone, which weighed more than a five-pound bag of potatoes. Your smartphone has about one-twentieth the mass and handles hundreds of times more data. It uses less copper and plastic, and its reduced energy demand and superior batteries provide autonomy for a day or so.

Now consider all the things your smartphone can do. It replaces everything from a compass to a road atlas and from a newspaper to a television. It accomplishes a big "dematerialization" or decoupling of services from stuff.

Both producers and consumers play important parts in decoupling the economy and natural resources. While the world economy grows at about 3 percent per year, food supply grows a lot slower. Meanwhile, world hunger has halved over the past generation, and persists mainly through lack of income, not calories and protein, which abound globally. More affluent people download a lot more videos, but they buy only a little more food.

Growers have been especially smart about getting more product without using a lot more inputs. Consider the decoupling of bushels of American corn from American land. Farmland acreage tracked with the size of the American corn harvest until 1940. Since then yields have grown crazy high. In 2017 Virginia corn grower David Hula set the world record with 542 bushels per acre, approaching the yield in tons per hectare of an experienced potato grower. Mr. Hula planted densely, monitored closely, and optimized tightly, operating from a cab or office as rich in information as a Wall Street trader.

Top US corn yields like Mr. Hula's are about twice the yield of Iowa master growers, who double the US average, who in turn double the world average (**Figure 1**). Headroom abounds for growers worldwide to lift yields still further and thus spare a lot of land.

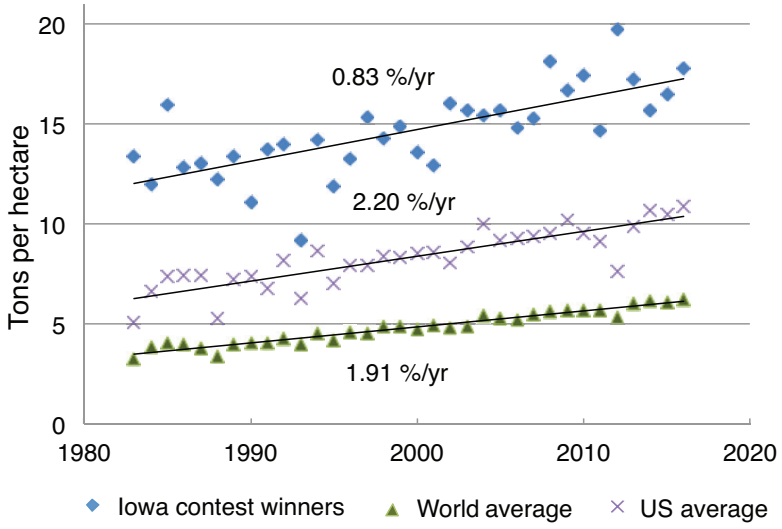

Figure 1. Corn yields for Iowa contest winners, and average US and world farmers, 1983–2016.

Data sources: National Corn Growers Association, personal communication 2012, and National Yield Contest Guide archives; US Department of Agriculture National Agricultural Statistics Service; UN Food and Agriculture Organization Statistics Division.

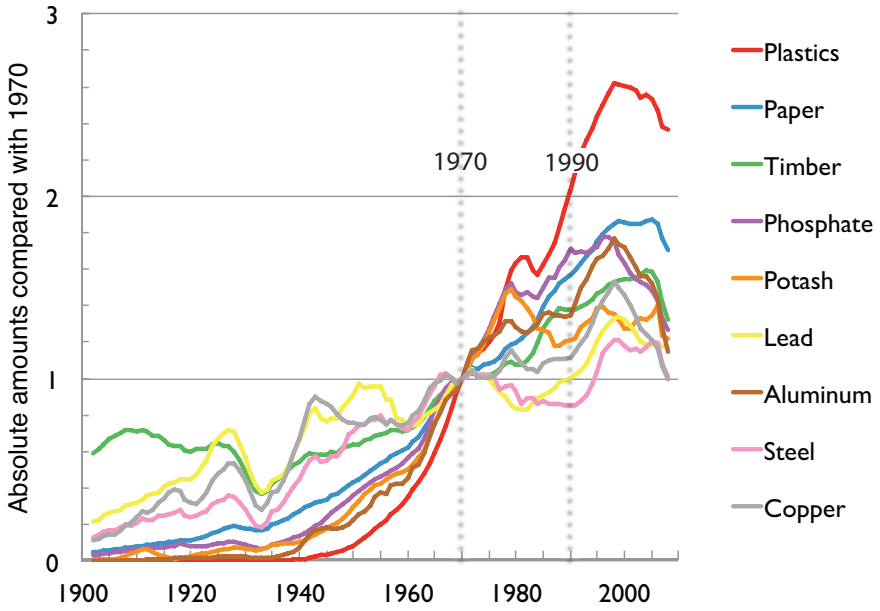

Figure 2. US use of nine basic commodities, 1900–2010. Absolute amounts compared with 1970.

Notes: Uses five-year moving average. Legend is ordered top down by value in 2010.

Data source: US Geological Survey National Minerals Information Center. https://minerals.usgs.gov/minerals/pubs/historical-statistics/#data

Until about 1970 Americans grew our economy by using more inputs. Consider use of nine basic commodities in the US from 1900 through 2010, with 1970 as the reference year when, for comparison, we used one unit of that commodity (**Figure 2**). Up to 1970 we kept using lots more raw materials to grow our economy. No wonder lots of folks worried about resource shortages and projected collisions with hard limits to growth. But between 1970 and 1990, use of inputs like steel and copper slowed, and since 1990 the use of all nine has plateaued or fallen, even plastics and aluminum. An easily appreciated example from your sister industry of forestry is that emails and tablet computers softened demand for paper. Newstands sell many fewer newspapers.

The declines in phosphate and potash stimulate a closer look at agriculture from 1900 to 2015, again compared against the year 1970. **Figure 3** traces the output of eight agricultural products: five plants (corn, soybeans, wheat, potatoes, and cotton) and three meats (chicken, pork, and beef). In dark green, we see King Cotton, America's largest export from 1800 until the year 1937, fluctuating a lot within a market of unchanging size. All four food plants and the three meats grew steeply to 1970. Beef saturated around that time and wheat about 1980. Pork and potatoes seem to have

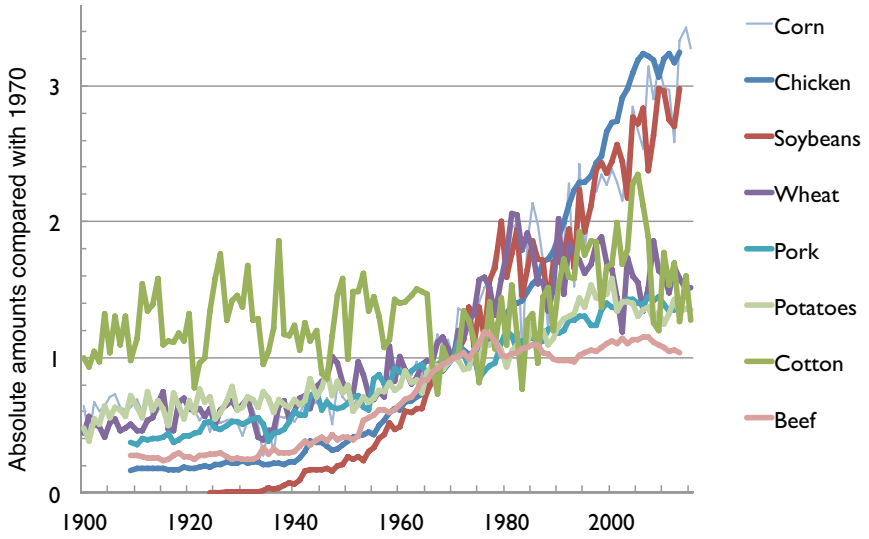

Figure 3. US agricultural outputs, 1900–2015. Absolute amounts compared with 1970.
Data source: US Department of Agriculture National Agricultural Statistics Service.

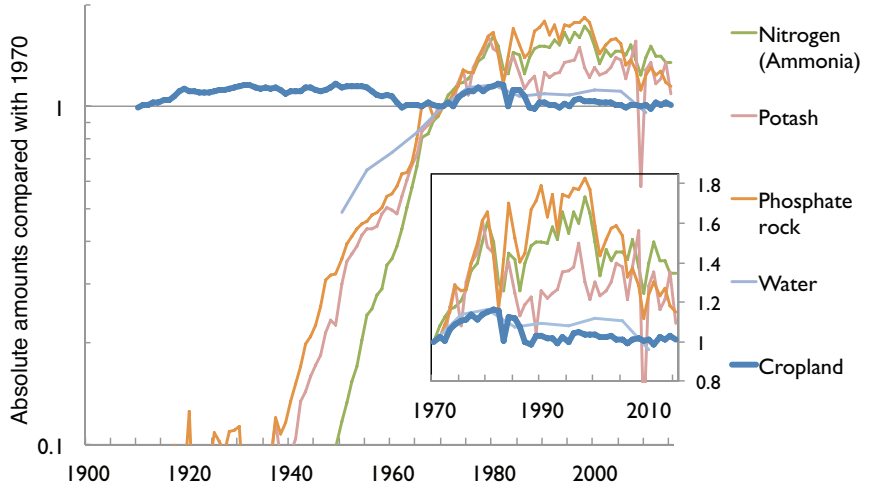

Figure 4. US agricultural inputs through 2015. Saturation of use of bulk materials. Absolute amounts compared with 1970.

Data sources: Data on cropland from USDA Economic Research Service (ERS). https://www.ers.usda.gov/webdocs/DataFiles/52096/summary_Table_3_cropland_used_for_crops_19102016.xls?v=42766

Data on minerals from the USGS National Minerals Information Center. https://minerals.usgs.gov/minerals/pubs/historical-statistics/#data

saturated around 2000. Corn, soybeans, and chicken continued to soar. Corn or chicken now wears cotton's crown.

In the same period, agricultural inputs to produce farm products followed a different path, as **Figure 4** shows for cropland, water, and three forms of fertilizer: nitrogen, potash, and phosphate. Cropland (in blue)

has been flat for more than a century. Americans moved farming from low-yielding states like Connecticut to high-yielding ones like Iowa and California but we did not use more land net. Into the 1970s we did use a lot more fertilizer and water. But then something happened in agriculture as in other economic sectors. The most accurate label is precision agriculture. American farmers favored deploying more information, like more reliable weather forecasts, while lessening use of the natural resources, even water.

The water story for America surprises everyone but farmers. Between 1975 and 2010 water withdrawals in the US actually fell while farmers grew 300 percent more corn and soy, 60 percent more wheat, and 25 more potatoes, and 105 million more Americans demanded goods and services.

Besides the astonishing growth of corn yields, corn has succeeded brilliantly on the demand side as well. After being creamed and popped, corn multiplied its use by becoming meat for several decades and then fuel around 2000, before fracking transformed our view of the domestic abundance of gas and oil. Yet ethanol production still accounts for more than one-third of US corn production, or roughly the present bushels from an area the size of Iowa.

Similarly, soybeans became chicken. Americans eat little tofu. Poultry has overtaken swine and cattle as the machine of choice to convert grain to meat (**Figure 5**). Some commentators attribute the success of poultry to concerns about health and red meat. Farmers understand that chickens are much more efficient machines than hogs or cattle, and more easily matched to

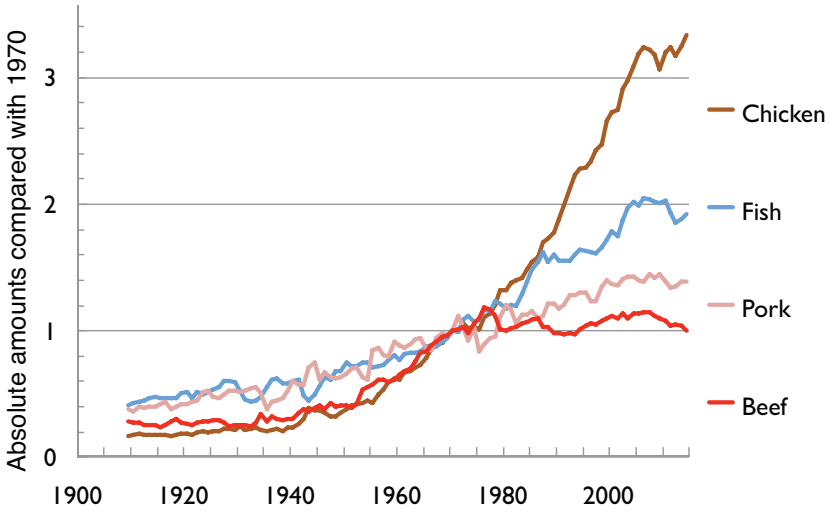

Figure 5. US meat consumption: Efficient poultry wins market share. Absolute amounts compared with 1970.

Data source: USDA Economic Research Service (ERS). https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-per-capita-data-system/

markets. Only a small fraction of a broiler is bone or cartilage, and it matures in six weeks. Like an efficient car, like a Prius, a chicken gets 60 miles to the gallon, while a pig gets 30 and a steer about 12, if we think of chicken feed as fuel. No wonder world farmers now grow about 20 billion chickens.

American meat consumption grew from 15 million tons in 1969 to about 24 million in 2014. However, because of rising yields of soybeans and corn, more efficient meat machines, and better animal breeding and nutrition, Iddo Wernick and I estimate the amount of cropland used for raising meat fell by nearly a third, around 9 million acres, about the size of Maryland. This occurred over four American decades famous for burgers, sausages, and fried chicken.

New biotechnology merits mention here. To me genetic modification is a form of information, a super-precise and microscopic one. Biotechnologies that confer pest resistance and drought tolerance, among other output traits, are chief examples of genetic modification in agriculture. Although journalists report that many people worry about GMOs, adoption has been steady, now reaching about 185 million acres around the world.

While a lot of attention to GMOs has related to corn, soybeans are the crop most often modified. When asked for an example of a GMO, I point not to a plant but to a chicken. About 80 percent of soybeans globally are GMO, and few chickens grow without soybean feed, so most all the chickens we eat result from GMOs. In fact, the soaring of poultry demanded GMOs, or more accurately abundant low-cost soy.

What global picture emerges from the trends in land use and land cover? I believe we are at peak farmland. Even with growing population and affluence, I believe yields will rise faster than demand, efficiency will continue to win, and farmers will spare a lot of land now used for crops for other uses.

The central reason continues to be precision agriculture. Already a drone can scan sensors embedded in a field to determine how much water, fertilizer, and pesticide to apply, and the answer is usually much less than might be applied without the information. Of course, we need to take care not to build brittle farms that fail if the internet is down.

A heartening result of the changes in forestry as well as farming is that the biosphere is growing globally. Rather than browner, Earth is getting greener. Satellites observing Earth from space show large areas have more woodlands and more foliage, for example, comparing 2011 and 1982. Growers are still clearing land in some areas, like the southern Amazon and parts of Indonesia, and these deservedly win attention because of suffering wildlife, but in larger areas, farmers are sparing land and allowing it to become wilder again.

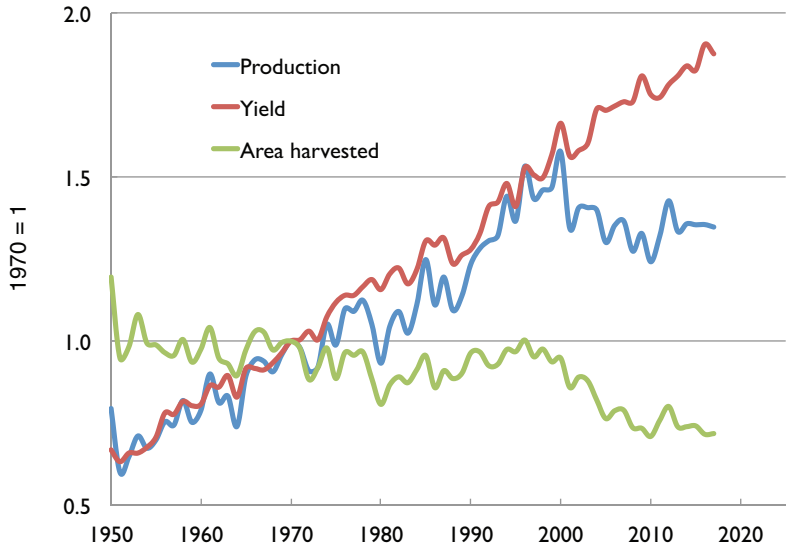

Figure 6. US potato production, harvested area, and yield, 1950–2017.

Source: Ausubel and Wernick (2017).

Data source: USDA National Agricultural Statistics Service.
https://quickstats.nass.usda.gov/results/D55A61E0-413B-3C53-AA0A-3655FCF61CC5

Potato trend lines

American potatoes exemplify the set of trends I have described. **Figure 6** highlights the achievement of American potato growers from 1950 to 2017. Growers have reliably tripled yields and doubled production, while reducing area harvested by 30 percent. If we consider the past 40 years, American potato farmers grow about 40 percent more tons, while planting about 20 percent fewer acres.

Success of potato growers at lifting yields can affect many landscapes. Idaho grows about a third of American potatoes, while other important grower states include Colorado (12%), Washington, Wisconsin, Maine, Michigan, and Florida. UPGA members probably have land to spare in all these states.

Moreover, because many potatoes are irrigated, cropping fewer acres means more water in rivers and wells. UPGA members probably have many gallons to spare. Like a Prius.

How to prosper? **Figure 7** suggests that, like corn and soybean farmers, potato growers need to think about new markets. I doubt we will feed potatoes to chickens or catfish. That means we need to focus on humans, and Asia, home of many humans enjoying more calories.

Let's examine the story of per capita corn consumption in Japan, South Korea, China, and India. Corn saturated in Japan and Korea, and not

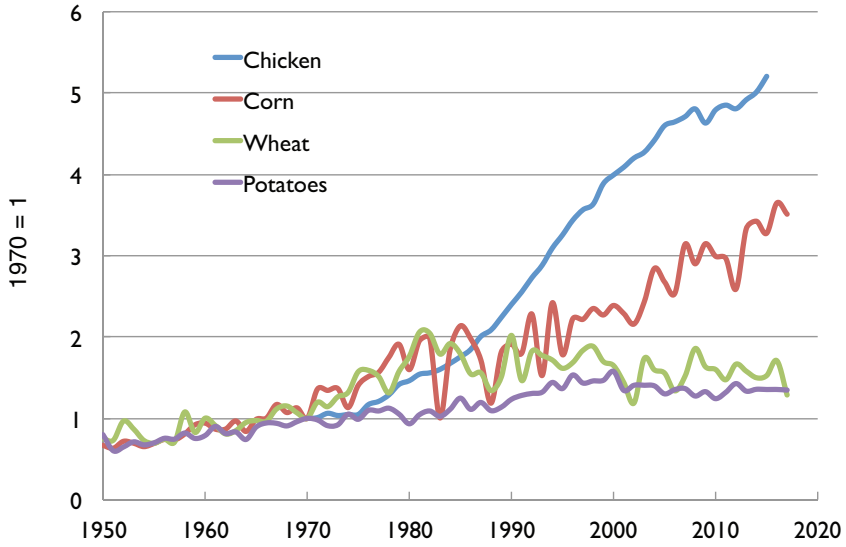

Figure 7. US production of wheat, corn, chicken, and potatoes, 1950–2017 (except through 2015 for chicken).

Source: Ausubel and Wernick (2017).

Data sources: Data for corn and wheat from the USDA National Agricultural Statistics Service.

Data for beef and chicken from the USDA Economic Research Service (ERS). https://www.ers.usda.gov/webdocs/DataFiles/51875/MeatStatsFull.xls?v=43158

yet in China. In India, corn has never caught on. Think of corn as a proxy for beef, and the reason becomes obvious, as Hindus have no appetite for beef. Flat or declining per capita beef consumption among Koreans and Japanese since 2000 indicates they have had as much beef as they want for a full generation. Chinese beef eating continues to rise, but the low beef consumption of India is sliding even lower.

For soy, the Japanese and Koreans, even before the efficient chicken, seem saturated. But Chinese soy consumption has soared and India's is rising. KFC now has more stores in China (4,563) than in the United States (4,491 units), but only 372 in India. As in other industries, Asian markets offer great growth prospects. UPGA members may find increasing use for the Hindi and Chinese words for potato—respectively, *aloo* and *tǔdòu*. If US potato production resumes rising, the likely reason is success in meeting a larger fraction of growing global demand (**Figure 8**).

While researching new products and products with different attributes is good, in the short run new products will attract small revenue. In 2014 fingerlings were less than 1 percent and purple/blue potatoes about 0.1 percent of production, though a much larger fraction at small farmer's markets, where farmers smartly earn $5 a pound for novel-looking potatoes. Potatoes called organic get about 2 percent of the market.

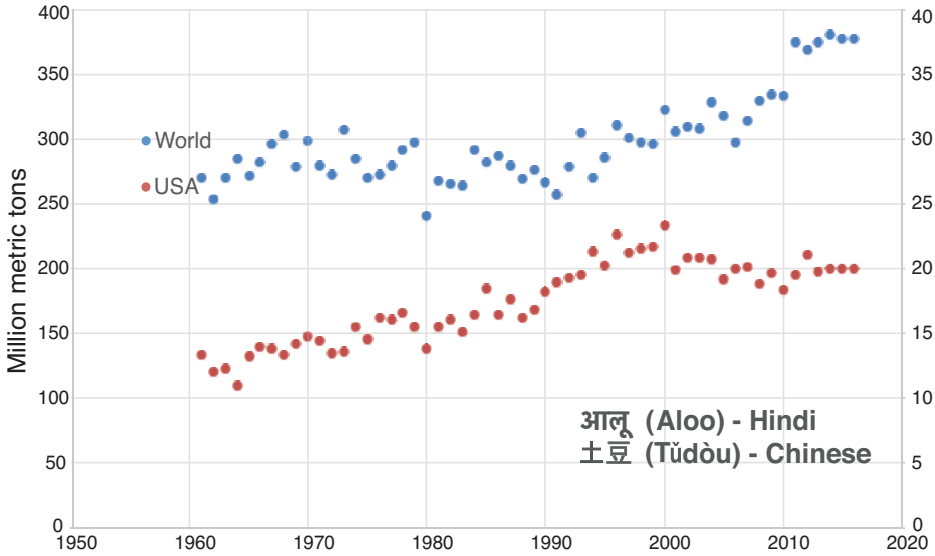

Figure 8. Potato production, 1961–2016: World (in blue, left scale) and US (in red, right scale). US production has fluctuated between 5% and 7% of world.

Data sources: International data from UN Food and Agriculture Organization Statistics Division (FAOSTAT). http://www.fao.org/faostat/en/#data/QC

US data from USDA National Agricultural Statistics Service.

The $4 billion potato sector needs big product ideas comparable to french fries and potato chips, which surged in popularity during the 1970s, 80s, and 90s. As you know deeply, even chips, while great for processors and retailers, tease growers, who sell by weight, and a big bag of chips is only a few ounces.

In his 1992 autobiography *Grinding It Out*, Ray Kroc, the founder of McDonald's, admitted that he was not in the hamburger business; he was in the french fry business. His real genius was finding a way to charge a lot of money for a potato. Kroc rode a wave of social change.

The wave affected not only what but how and where we eat. In 1900, 50 percent of an American's income went to food, while in 2012 less than 10 percent did so, but an American adult now goes to a restaurant about 200 times per year. Restaurants get about half of the US food dollar. Of the $620 billion Americans spent in 2012 on food, only $175 billion, less than 25 percent, went to producers. Of each dollar spent at a grocery store such as Kroger and Whole Foods or at McDonald's, 23 cents on average goes to the farmer or fisher.

Also affecting the strategy of growers is that about 8 billion pounds of potatoes go to restaurants (80% to chains) and only one billion pounds to retail. And contrary to wishful thinking, all vegetable consumption in North

America has been falling, including potatoes. I learned in San Antonio that total Canadian vegetable consumption declined from 418 pounds per person in 1987 to 380 pounds per person in 2011, a drop of more than 1.5 pounds per year. All produce is only 12 percent of grocery sales, and bags of potatoes account for just a small fraction of that share.

A reason is that consumers now suffer, or feel they suffer, time poverty. Total average adult American food preparation now occupies only 20 minutes a day and shopping 15 minutes a day. Preparing fresh potatoes and the rest of a meal within 20 minutes is not easy. Convenience is winning, and for the potato this means encouraging apps for smartphones like those now spreading fast for delivery of pizza, which Amazon will bring to you on the beach.

No wonder people want to be chefs or restaurant managers. About one million food establishments now service the US. In contrast, according to the 2012 Census of Agriculture, the US now has about 660,000 farms defined by sales of $25,000 or more (and about the same number with 180 acres or more). Moreover, in 2012 the average age of an American farmer was 58 years old, and about two-thirds were older than 55.

But let's not be glum about age or labor, because the new reality of resources spares labor as well as natural resources. During Christmas, many people in this Summit probably added an intelligent personal assistant like the Amazon Echo to their homes. Robots and mechanization will replace or diminish many occupations, a familiar scenario in agriculture. American farm employment declined steeply from 12 million to 4 million between 1910 and 1970, and halved since then. Those declines were mainly associated with tractors and other devices multiplying horsepower.

Now we have a prospect of farming without farmers through the diffusion of artificial intelligence, sensors, and drones. Someday well-capitalized new systems with reliable software may permit farming without farmers, but for the next few decades growers will be farmers, not robots, and ones who wisely and effectively manage information and capital.

With regard to human age, 60 is the new 50. America's population has never been older if we count the years since birth for the average American. Symmetrically, if we count the distance in years from death for the average American, we have never been younger. With new knees and hips, we can keep skiing as well as farming.

As I have suggested, the new reality of resources contains good news for the outdoors. For 10,000 years growing more food used more land. With rising yields and related developments in recent decades, the amount of farmland in food production worldwide has probably peaked. The land area now needed to produce the calories to feed a person for a year is about

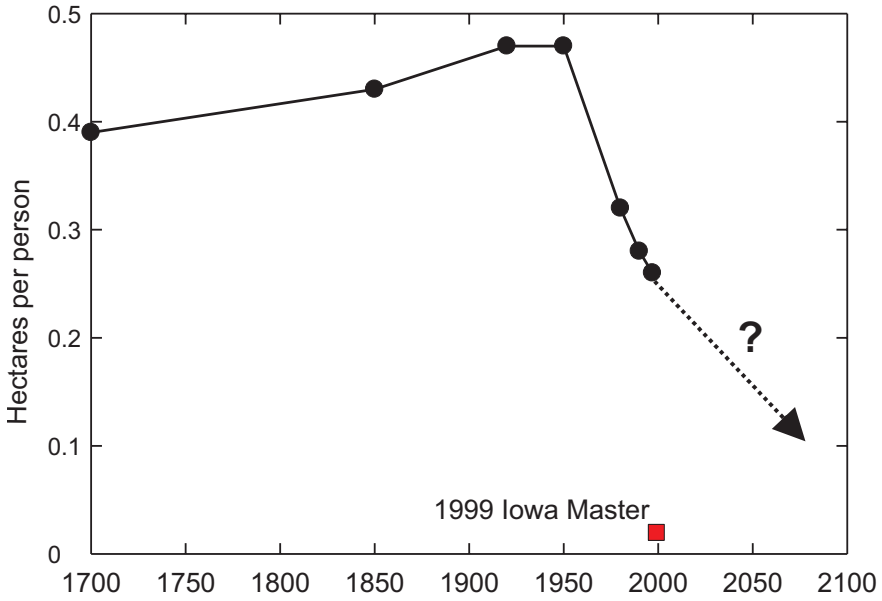

Figure 9. Average land area used to feed a person. The square refers to the acreage needed by a 1999 Iowa Master corn grower, who grew about 15 tons per hectare (about 240 bushels per acre), about half of present peak corn yield.

Source: Ausubel (2002).

a fifth of a hectare, or half an acre, and shrinking (**Figure 9**). In fact, the continents now produce a global surplus of calories and protein that permit or cause obesity and ethanol.

While I have emphasized yields, a few words about food waste carry power too. Until recently in developed nations and even today in poor nations, "gleaners" filtered fields for the last few potatoes and other crops. While rats and poor storage still cause food losses in poor countries, rich countries discard a scandalous fraction of what we grow. Recent studies suggest that restaurants and households discard one-third of food purchased. Reducing such food waste is another way to spare land for nature, and perhaps the internet will provide means.

Lots of land now used for farming and forestry can become wilder. Precision agriculture and wiser diets for people and cars create wide prospects for rebounding nature. Potato growers can meet more market demand and do more for the environment. The extensive land and water that farmers own and manage are increasingly flexible assets.

While understanding how potatoes differ from other major crops matters, my overall argument is that farming resembles other modern industries: more bits and fewer kilograms. Drones, sensors, and autonomy are the central subjects of discussion in Silicon Valley, the Pentagon, and the Potato Summit.

While the oil and salt associated with large orders of fries might not be healthy, potatoes are a deeply green vegetable in the sense of resource sparing. Potato farmers typically grow three to four times as many tons per acre as corn growers grow corn. For calories, the ratio is smaller, but still from the perspective of acres saved, potatoes are a deeply green crop. Land sparing makes the potato an ecological champion. Let's help consumers understand that the potato and the reliable, efficient, green Prius and the high-tech world have a lot in common. And the potato tastes better.

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