# Module 2, Investigation 2: Briefing

## What is industrial agriculture?

### Background

Where did your last meal come from? It was probably produced by industrial agriculture, a high-energy and technology-using system of commercial agriculture that spans the globe. (The term "industrial" is used because it is associated with industrialized countries in Europe and North America rather than with the traditional low-energy and low-technology subsistence agriculture of Asia, Africa, and Latin America.) Industrial agriculture is the dominant type of agriculture in Europe and North America. It is also found in other countries such as Japan, Australia, South Africa, Argentina, and southern Brazil. It is especially associated with agriculture in the United States. Even some developing countries have small segments of this type of agriculture, often found alongside traditional forms of subsistence agriculture.

Found in a variety of physical environments, industrial agriculture creates a variety of landscapes. It is highly productive when measured in terms of labor—a single worker can produce food and fiber (such as cotton) for large numbers of people. Industrial agriculture is responsible for large gains in food and fiber output, but it requires a host of costly inputs that may cause environmental problems. In this activity, you will investigate industrial agriculture as a system of inputs and outputs. You will also examine the effect of this system on human and physical landscapes, and consider how changes in technology are transforming the way this system operates. Finally, you will debate the pros and cons of industrial agriculture.

### Objectives

In this activity you will

- describe and explain the productivity of industrial agriculture,
- use satellite imagery to interpret landscapes created by industrial agriculture,
- explain industrial agriculture as an input-output system,
- discuss environmental problems associated with industrial agriculture, and
- explain how remote sensing and precision agriculture are being used to increase agricultural efficiency and reduce environmental problems.

### Part 1: How productive is industrial agriculture?

Agriculture can be thought of as an input-output system. Farmers must put land, labor, and materials into the system in order to derive outputs, or farm products, from the system. The term production refers to the total amount of output from a given enterprise (e.g., Jones' farm produced 10,000 bushels of wheat last year). Productivity, on the other hand, refers to the amount of output (e.g., 40 bushels of wheat produced) per amount of input (e.g., hectare of land). Generally, farmers try to increase productivity by reducing inputs and/or increasing outputs. Industrial agriculture has been highly successful at increasing productivity, as the following passage illustrates:

> When [the 20th] century began, each American farmer produced enough food to feed seven other people in the United States and abroad. Today [1999], a U.S. farmer feeds 96 people [Table 1*]. Staggering gains in agricultural productivity in the United States and elsewhere have underpinned the emergence of the modern world as we know it. Just as the discovery of agriculture itself set the stage for the emergence of early civilization, these gains in agricultural productivity have facilitated the emergence of our modern global civilization.
>
> This has been a revolutionary century for world agriculture. Draft animals have largely been replaced by tractors; traditional varieties of corn, wheat, and rice have given way to high-yielding varieties; and the world irrigated area has multiplied sixfold since 1900. The use of chemical fertilizers—virtually unheard of in 1900—now accounts for an estimated 40 percent of world grain production.
>
> Technological advances have tripled the productivity of world cropland during this century. They have helped expand the world grain harvest from less than 400 million tons in 1900 to nearly 1.9 billion tons in 1998. Indeed, farmers have expanded grain production five times as much since 1900 as during the preceding 10,000 years since agriculture began (Brown 1999: 115).

*Of course, one farmer does not feed 96 people all by himself. He or she has a lot of help from the fertilizer producer, fuel dealer, machinery builder, seed geneticist, veterinarian, grain elevator operator, truck driver, and others who work to support industrial agriculture.

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**Table 1: Number of people for whom food was produced by each U.S. farm worker**

| Year | Number of people |
|---|---|
| 1900 | 7 |
| 1930 | 10 |
| 1940 | 11 |
| 1950 | 15 |
| 1957 | 23 |
| 1981 | 78 |
| 1999 | 96 |

Sources: Seitz 1995; Brown 1999

**Table 2: World grain production and area of grain cropland per person, 1950-2000**

| Year | Grain Production (millions of metric tons) | Area of Grain Cropland (hectares* per person) |
|---|---|---|
| 1950 | 650 | 0.23 |
| 1960 | 800 | 0.21 |
| 1970 | 1,200 | 0.18 |
| 1980 | 1,550 | 0.16 |
| 1990 | 1,800 | 0.14 |
| 2000 | 1,900 | 0.12 |

Sources: Brown 1987; 1989 (data for 1990 and 2000 are estimated) *1 hectare = 2.471 acres

**Table 3: Number and size of U.S. farms**

| Year | Number of Farms (millions) | Average Size (acres) |
|---|---|---|
| 1940 | 6.4 | 170 |
| 1950 | 5.6 | 210 |
| 1960 | 4.0 | 300 |
| 1970 | 2.9 | 370 |
| 1980 | 2.4 | 430 |
| 1990 | 2.1 | 460 |

Sources: Seitz 1995

Throughout this investigation, you will find questions that you should answer on the Log. The first asks you to <u>graph the data given in Table 1. What do these data tell you about agricultural trends?</u>

The key reason that industrial agricultural systems use genetically improved seeds, pesticides, herbicides, fertilizers, and often irrigation is that they increase output. Since World War II, U.S. farmers have more than doubled the total production of grain crops (Table 2). These major grain crops include wheat, rice, corn, oats, and barley. Two-thirds of the world's croplands are planted in cereal grains that are a critical resource for feeding human and animal populations (Brown 1987).

<u>On the Log at #2, graph the data given in Table 2. What do these data tell you about agricultural trends?</u>

Industrial agriculture has been called "agribusiness" because of the large size of farms and the large inputs of money required to run these systems. Because hundreds of thousands of dollars must be invested in today's "corporate" farms, the small, family-owned and operated farm has difficulty competing and thus is in rapid decline (Table 3).

<u>On the Log at #3, graph the data in Table 3. What do these data tell you about agricultural trends?</u>

It is the nature of commercial, as opposed to subsistence, agriculture to produce surpluses for sale. In some countries, industrial agriculture produces huge surpluses, which are exported to other countries. These surpluses have great economic importance. For example, grain surpluses are vital in world trade, and wheat is the most important grain traded. In fact, wheat is second only to petroleum in terms of world trade value. Five surplus-producing entities account for 90 percent of the world's grain exports: the United States, Canada, Argentina, Australia, and the European Union (mainly France). The United States exports one-third of all the wheat in world trade, half of all coarse grains (those used mainly for livestock feed—barley, oats, corn, millet, sorghum), and is the world's greatest exporter of rice. Distribution is even more concentrated. Just five privately-owned corporations control 85 percent of U.S. grain exports, 80 percent of Argentina's wheat exports, 90 percent of Australia's sorghum, and 90 percent of all wheat and corn from the European Union. Of the five multinational corporations—Cargill, Continental, Bunge and Born, Louis Dreyfus, and Andre Carnac—only Cargill began in the United States. The others started in Europe in the 19th century. These international giants have interests in banks, railroads, shipping, and insurance as well as in agriculture (Marshall 1991).

Cargill and Archer Daniels Midland (ADM), another U.S.-based agribusiness, have far-flung operations. For example, Cargill markets, processes, and distributes products at locations in 60 countries (http://www.cargill.com). ADM's worldwide transportation network, which includes 13,000 railcars, 2,250 barges, and 1,200 trucks, links over 205 domestic and internationally based plants to process cereal grains and oilseeds into many products used for food, beverages, and animal feed markets worldwide <http://www.admworld.com>.

Answer questions 4, 5, and 6 in the Log.

## Part 2. What do the landscapes of industrial agriculture look like?

Industrial agriculture creates many different landscapes, including dry land cereal farming, beef feed lots, apple orchards, and irrigated rice fields, to name only a few. Consider, for example, a landscape of corn and wheat near Dodge City, Kansas (Figure 1).

**Figure 1: Arkansas River and Dodge City, Kansas, October 1995**

Thousands of farm fields along the Arkansas River in western Kansas are featured in this photograph. The Arkansas River is observable as the dark line in the center of the picture. Dodge City (left center), a distribution center in this wheat and livestock area, also produces agricultural implements and supplies. How do you think all those circles were made?

Source: http://earth.jsc.nasa.gov/photoinfo.cgi?PHOTO=STS073-704-092

**Figure 2: Center-pivot irrigation in south-central Nebraska (1986)**

Source: http://www-geoimages. berkeley.edu/GeoImages/Starrs/CENPIVOT.html

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As with many human traces on the landscape, industrial agriculture typically produces regular-looking patterns, which are readily observed and interpreted from above with satellite imagery. In the landscapes in Figures 1 and 2, the patterns are rectangles and circles. Rectangular crop fields derive from the land survey system in this part of the United States—the system of townships and ranges based on longitude and latitude. The rectangles in this image are wheat fields, which are probably not irrigated. However, superimposed on this essentially rectangular system are very large circles. What are they?

**Figure 3: Center-pivot irrigation**

Source: http://clay.agr.okstate.edu/alfalfa/images/water/irrig-02.htm

The large, field-sized circles are formed by a special technology called *center-pivot* or *circle method* irrigation. The center-pivot machine has a large arm, supported by wheels, that sprays water as it rotates around a center pivot. Water is pumped up to the surface from a large underground **aquifer** (called the Ogallala Aquifer, which underlies much of the Great Plains of the United States) and distributed onto the crops in a large circle. Corn and alfalfa, crops that require more water than wheat, are growing in these circular fields. Figure 3 shows a center-pivot rig watering alfalfa.

**Figure 4: Lake Texoma, Oklahoma, and Texas**

Source: http://earth.jsc.nasa.gov/photoinfo.cgi?PHOTO=STS068-247-079

Irrigated farming produces more per acre than nonirrigated farming, but it also costs more. Center-pivot irrigation uses water more efficiently than does flood irrigation, but it requires more energy inputs. Energy, in the form of gasoline or diesel fuel, is required to run the pumps and engines that drive these machines. Currently, heavy pumping is lowering the water table of the Ogallala aquifer. The lower it gets, the more energy is needed to pump the water to the surface.

Industrial agriculture includes both irrigated and nonirrigated, or dry land, farms. In dry regions such as the Great Plains of the United States, the availability of water for irrigation is vital to high levels of production of crops and livestock. To

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**Figure 5: Land leveling for California rice production**

Source: http://agronomy.ucdavis.edu/uccerice/PRODUCT/rpic03.htm

ensure supplies of water, large dam projects are often associated with agricultural landscapes (Figure 4).

Lake Texoma (Figure 4) was created when the Denison Dam was built on the Red River between Oklahoma and Texas. The dam serves the region as a source of hydroelectricity, irrigation water, and recreation. A number of cities can be seen in this photograph, including the city of Durant, Oklahoma, a commercial and processing center for agricultural products including peanuts, winter wheat, cotton, and cattle. As with the previous satellite images, you can see here how industrial agriculture has left its imprint on the physical landscape.

Industrial agriculture is not just recognizable as corn and wheat fields utilizing center-pivot irrigation. Rice production in the United States, for example, leaves a distinct geographic landscape. Figure 5 is a photograph of land leveled into terraces for rice production in California.

Rice production in California is highly mechanized, requiring only about four hours of labor per acre. In contrast, nonmechanized rice production in much of Asia and Africa requires more than 300 hours of labor per acre. Mechanization includes laser technology to precision-level rice land and establish field grades, large tractors, and heavy-duty implements to prepare seedbeds, and combines with half or full tracks for harvesting in muddy soils. Aircraft are used for seeding, pest control, and some fertilization.

Figure 5 shows terraces precisely leveled by laser technology, which allows for the maintenance of a uniform water depth within the basin to improve rice production. Precision leveling also improves water-use efficiency. Following the adoption of laser-leveling technology in the late 1970s, more than 90 percent of California rice land was precision-leveled (Hill et al. 2000). As with the previous images of industrial agriculture, rice production in the United States combines a variety of energy-intensive techniques and leaves a specific type of landscape observable from above.

Answer questions 7 and 8 in the Log.

### Part 3: What inputs does industrial agriculture require?

The tremendous gains in the productivity of industrial grain agriculture in the 20th century were built on five technologies, four of which were available before 1900 (Brown 1999):

- irrigation, which goes back several thousand years;
- chemical fertilizer, based upon the work of a German chemist in 1847;
- plant breeding, from Gregor Mendel's discovery of the principles of genetics in the 1860s;
- short-strawed wheats and rices, from Japanese success dwarfing cereals in the 1880s; and

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- hybrid corn, from development in 1917 at the University of Connecticut.

One should add to this list the application of huge amounts of energy, especially petroleum, which is needed to
- manufacture, transport, and operate farm machinery;
- build and operate irrigation systems;
- manufacture, transport, and apply pesticides and herbicides;
- mine, manufacture, and transport fertilizers; and
- process, package, transport, and display food.

How have farmers increased their yield in grain crops while utilizing less agricultural area (Table 2)? Agricultural systems use a variety of inputs to improve their yield. One of the most important inputs to industrial agriculture is fertilizer produced from petroleum. Table 4 documents the amount of fertilizer use throughout the world.

Changes in the use of fossil fuels and other energy inputs in agriculture over time are shown in Table 5.

**Table 4: World fertilizer use, 1950-1995**

| Year | Millions of Metric Tons |
|---|---|
| 1950 | 14 |
| 1960 | 27 |
| 1970 | 63 |
| 1980 | 112 |
| 1990 | 140 |
| 1995 | 120 |

Sources: Brown 1987; 1997; 1999

**Table 5: Energy use in world agriculture (millions of barrels of oil)**

| Year | Fuel* | Fertilizer Manufacture | Other ** |
|---|---|---|---|
| 1950 | 160 | 70 | 46 |
| 1960 | 321 | 133 | 91 |
| 1970 | 498 | 310 | 162 |
| 1980 | 789 | 552 | 268 |
| 1985 | 940 | 646 | 317 |

Notes: *Fuel = fuel for tractors and other farm machines, including irrigation equipment. **Other = energy used to (1) synthesize pesticides and herbicides, (2) manufacture farm machinery, (3) apply fertilizer, and (4) dry grain. Figures are estimates because no reliable data exist.

Source: Brown 1987

**Table 6: Calories* of energy used to produce 1 calorie of food in various food production systems**

| Calories | Traditional Agriculture | Industrial Agriculture |
|---|---|---|
| 10-20 | | Ocean fishing |
| 5-10 | | Feedlot beef |
| 2-5 | | Intensive eggs |
| 1-2 | Coastal fishing | Modern milk from grass-fed cows |
| 0.5-1 | Low-intensity eggs | Intensive soybeans and peanuts |
| 0.2-0.5 | Range-fed beef | Intensive corn |
| 0.1-0.2 | Low-intensity corn, peanuts | Intensive wheat, potatoes |
| 0.05-0.1 | Wet rice | Intensive rice |
| 0.02-0.05 | Wet rice | |

* A measure of heat energy, 1 calorie will raise 1 gram of water 1 degree Celsius.

Source: Adapted from Paul R. Ehrlich et al. 1977. *Ecoscience: Population, Resources, Environment*, p. 349. W. H. Freeman and Company

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The high productivity of labor in industrial agriculture (Table 1) is made possible by the application of huge amounts of energy. In traditional, or subsistence, agriculture, the amount of energy used is small compared to the yield, but in industrial agriculture, more energy is expended than produced (Table 6). For example, to produce and deliver to a U.S. consumer one can of corn that has 270 **calories** in it, a total of about 2,800 calories of energy must be used. And to produce about 4 ounces of beefsteak, which also provides about 270 calories, takes 22,000 calories of energy (Seitz 1995).

Thus, we can say that in terms of labor inputs, industrial agriculture is highly productive, but in terms of energy inputs, it is not. Because of this, Barbara Ward was led to remark:

> The high-energy U.S. food system is one reason why the United States, for 5 percent of the world's people, is now consuming nearly 40 percent of its nonrenewable resources (Ward 1979: 92).

The use of various inputs in industrial farming assures that fluctuations in prices affect the amount of money spent on these inputs. Figure 6 is a listing of costs for three farm inputs from 1992-1997.

<u>Answer Questions 9-12 in the Log.</u>

### Part 4. What problems does industrial agriculture create?

In the following passage from a prominent magazine, one critic suggests some of the problems with industrial agriculture as it was practiced in the United States during the 20th century.

> A third of [U.S.] farmland topsoil, accumulated over millennia, [has been lost in the last century]. For every bushel of corn that Iowa grows, it sheds at least two bushels of soil. Farm runoff is . . . poisoning our drinking water . . . In 1948, at the dawn of the chemical age, American farmers used 15 million pounds of insecticides and lost 7 percent of their crops to insects; today they use 125 million

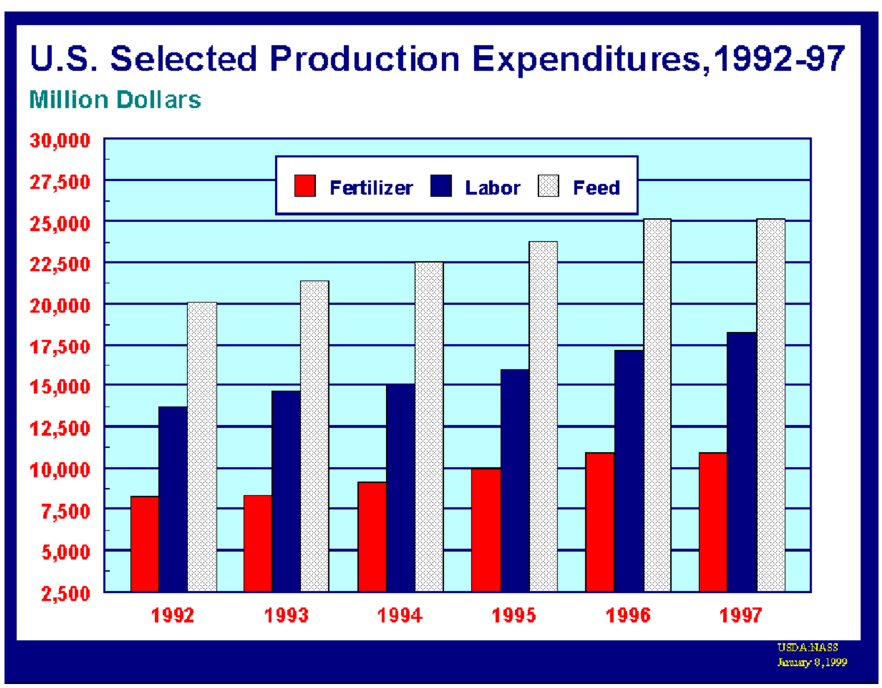


**Figure 6: U.S. production expenditures for commercial agriculture, 1992-97**

Source: USDA http://www.usda.gov/

> pounds and lose 13 percent. Because most agricultural chemicals are made from fossil fuels, we [use] three calories of energy to produce each calorie of food we eat . . . In contrast, Tsembaga farmers in New Guinea, using Neolithic slash-and-burn methods, [use] less than a 10th of a calorie for each calorie they eat. For each American man, woman, and child, our agriculture [uses] 160 pounds of nitrogen, phosphate, and potash fertilizer each year, and 325 gallons of water each *day*. The Ogallala aquifer of the Great Plains held enough water 40 years ago to fill Lake Huron; in another 20 years it may be too low to pump. The great dams of the West are silting up. Sloppy irrigation and poor drainage . . . have caused [salty] conditions on 10 percent of our crop and pasture land. Should we escape the fate of the ancient empires that were done in by erosion, we may instead face that of the Sumerians, whose civilization crumbled as their soil turned salty (Eisenberg 1989: 59).

<u>Answer Question 13 in the Log.</u>

## Part 5: How are improvements in technology reshaping industrial agriculture?

The use of remote sensing and **precision agriculture** is a promising attempt to reduce the reliance upon certain inputs, while improving both crop productivity and the environment. At the present time, diminishing crop prices coupled with increased costs have led to numerous attempts by farmers to increase yields per acre. Increasing irrigation, fertilizer, insecticide, and herbicide have been attempted, and excessive applications of these inputs means more costs and increased environmental pollution. As a result, industrial agriculture is moving toward the use of remote-sensing technologies and *precision agriculture*, a farming technology that attempts to specify the exact quantities of water, fertilizer, herbicide, and pesticide needed. Precision agriculture is being used to identify when and where these inputs should be applied to each specific field.

At the Global Hydrology and Climate Center in Huntsville, Alabama, managed by the Marshall Space Flight Center, NASA scientists are collaborating with university scientists in Alabama and Georgia to apply remote-sensing technology to support precision farming (NASA Marshall News 1999). In precision farming, growers break fields down into regions, or cells, analyzing growth characteristics of each cell and improving crop health and yield by applying precise amounts of seed, fertilizer, herbicides, and pesticides as needed. Traditionally, farmers have lacked the ability to make close analyses of specific cells. When they fertilized their crops, they simply spread the fertilizer uniformly across the entire field. Improvements in technology, including the use of remote sensing, allow farmers to tailor the amount of this agricultural input more precisely.

Remote sensing uses instruments on airplanes or orbiting satellites to gather information about Earth's surface. These instruments, which measure electromagnetic radiation, including thermal energy reflected or emitted by all natural and synthetic objects, can be an excellent tool for increasing agricultural production. As Doug Rickman, lead scientist for the Global Hydrology and Climate Center, stated:

> We can fly over an area and precisely map its plant quality and soil makeup—including mineral variation and organic carbon content—in approximately 6-foot increments. Farmers have sought this ability for 30 years (NASA Marshall News 1999).

Figure 7 is a remote-sensing image of land types of the Midwest. The various colors indicate different types of land systems that scientists can then identify to assist agricultural production.

Using remote sensing, scientists can identify areas that will naturally have a low yield and reduce the amount of fertilizer applied. As Paul Mask, professor of agronomy at Auburn University, stated:

> If the maximum capability of an area is 50 bushels an acre, there is no need to fertilize for 120 bushels. It does no good (NASA Marshall News 1999).

Such precise crop maintenance benefits society in another way, according to Mask:

> Excess nitrogen can leak into groundwater. Other fertilizers can increase pollution problems,

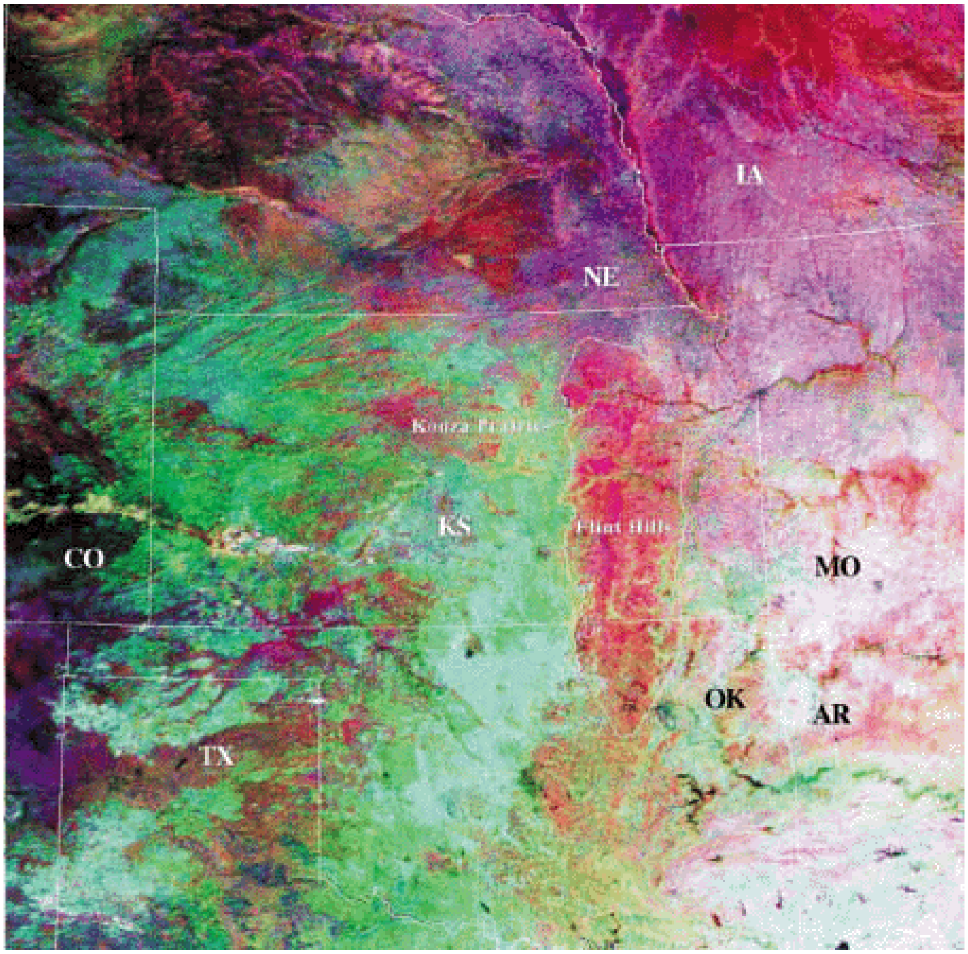


**Figure 7: AVHRR composite image of the central United States showing land cover classification**

Source: http://www.earth.nasa.gov/visions/app_factbk99/

> threatening public health. By adding only the amount of fertilizer the land and the crop can effectively use, we can reduce such problems.

When NASA began studying precision agriculture techniques in the 1970s, the practice was hampered by scientists' inability to accomplish such precise mapping. Measuring yield was also inconvenient, time consuming, and often imprecise. According to Doug Rickman:

> To measure a single field of 80 to 100 acres, you might take six soil samples from different parts of the field, send them to a lab, and wait days or weeks for the results. And six samples don't give you a very accurate measure anyway — soil quality can vary dramatically all across that area (NASA Marshall News 1999).

Remote sensing, therefore, offers an improvement to sampling techniques that can assist precision agriculture techniques.

The Kansas Applied Remote Sensing Program is using remote sensing to determine corn and wheat yields in the Midwest region of the United States. Figure 8 shows the 1998 corn yield estimates in Iowa. This type of information assists farmers in predicting their yields and in improving agricultural output.

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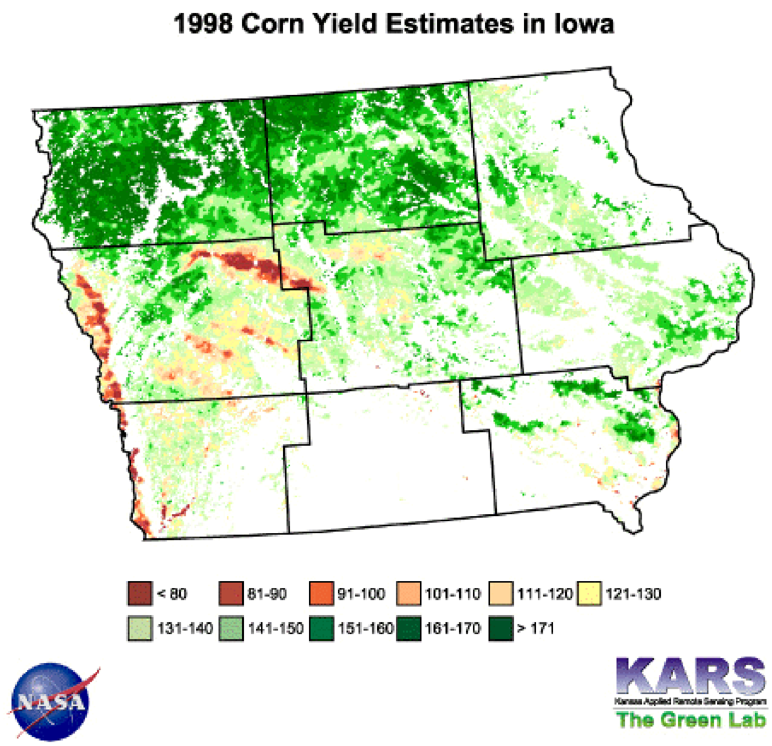


**Figure 8: 1998 Iowa corn yields measured as NVDI (greenness) of crops so yield predictions can be made**

In the first half of the corn growing season, strong winds and several isolated hailstorms did large amounts of damage to the corn crops in Iowa. This image is used to demonstrate that the areas damaged by the storms had reduced yields.

Source: http://www.kars.ukans.edu/products/iowa.htm

The Upper Midwest Aerospace Consortium (UMAC) is another group investigating the use of remote sensing for increasing agricultural output. UMAC is providing remote-sensing data to sugar beet growers in the Red River Valley in North Dakota, an important sugar beet producing region. UMAC scientists use aerial crop scouting to examine an area of 6 miles by 10 miles covering St. Thomas Township in North Dakota. Let's imagine how this type of information is helpful to farmers.

Scenario: Imagine that you own the farmland mapped in Figure 9. Notice that you have three crops (wheat, sugar beets, and potatoes) distributed together on the land. You have decided to buy a satellite image of your plot so you can look at a precision agriculture image of the plot to determine any needed changes. You buy Figure 10.

Answer Question 14 in the Log.

For industrial agriculture to increase output while reducing the need for inputs that put strains on the environment, techniques like precision agriculture will need to be utilized in the future. Remote sensing and other satellite technologies will be extremely useful in reducing the need for fertilizers and pesticides, while also improving crop yields.

Answer Question 15 in the Log.

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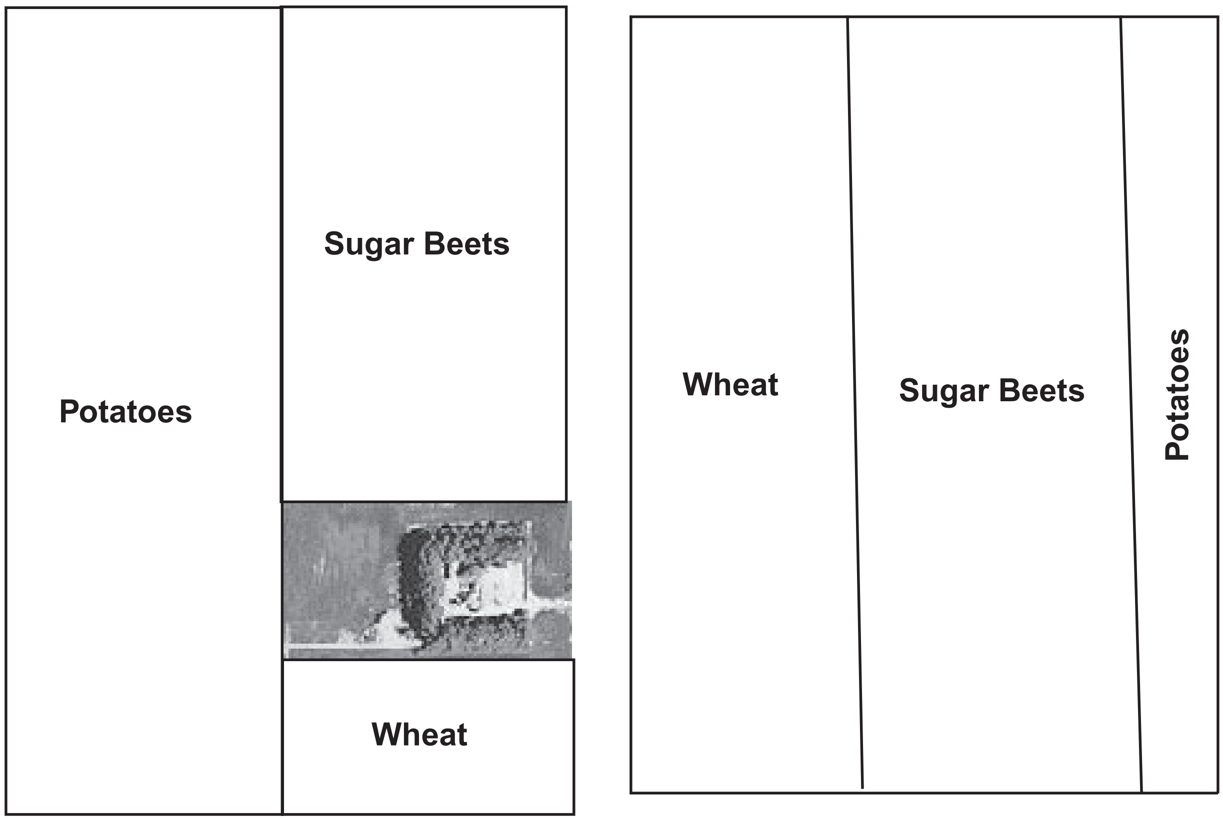


**Figure 9: Map of images shown in Figure 10**


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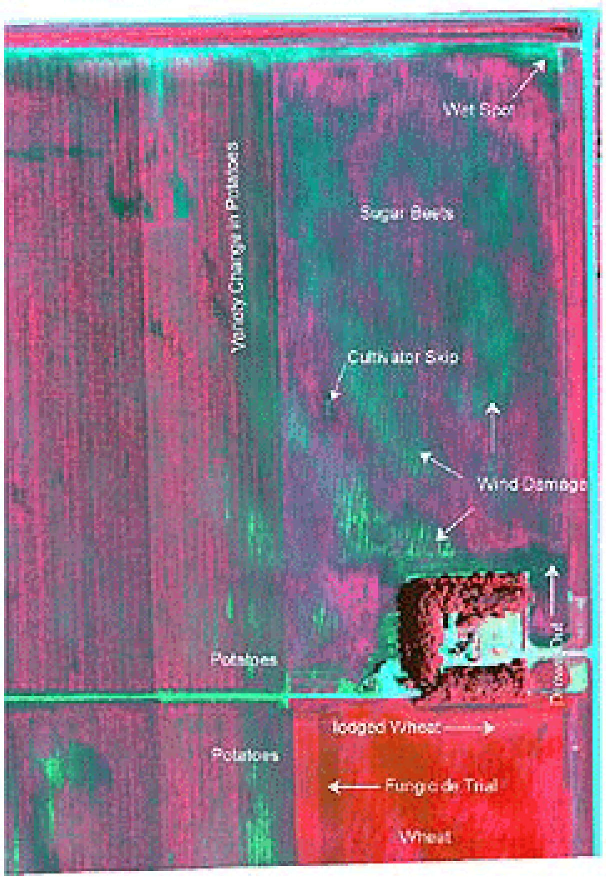


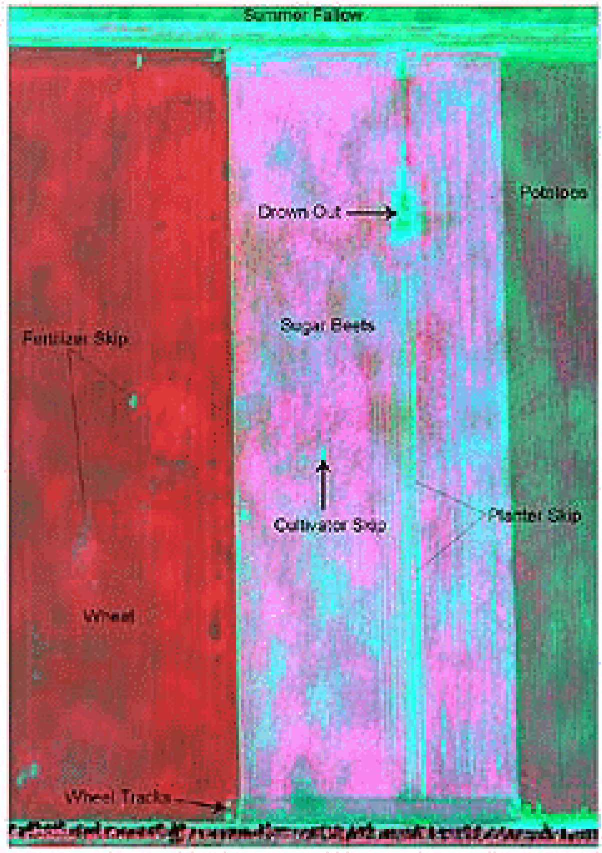


**Figure 10: Remote sensing of North Dakota**

Figure 10 is a picture taken on July 11, 1999. The area was flown over twice using the Positive Systems' ADAR 5500 camera, which collects half-meter resolution digital data in four multispectral bands. The spectral channels used to generate these color composites are green, red, and infrared. In this case, crops with fully developed canopy appear red. Sugar beets, still in their early stages, are pink, and the recently planted crops where the background soil reflectance dominates, appear green.

Source: http://www.umac.org/new/stthomas.html

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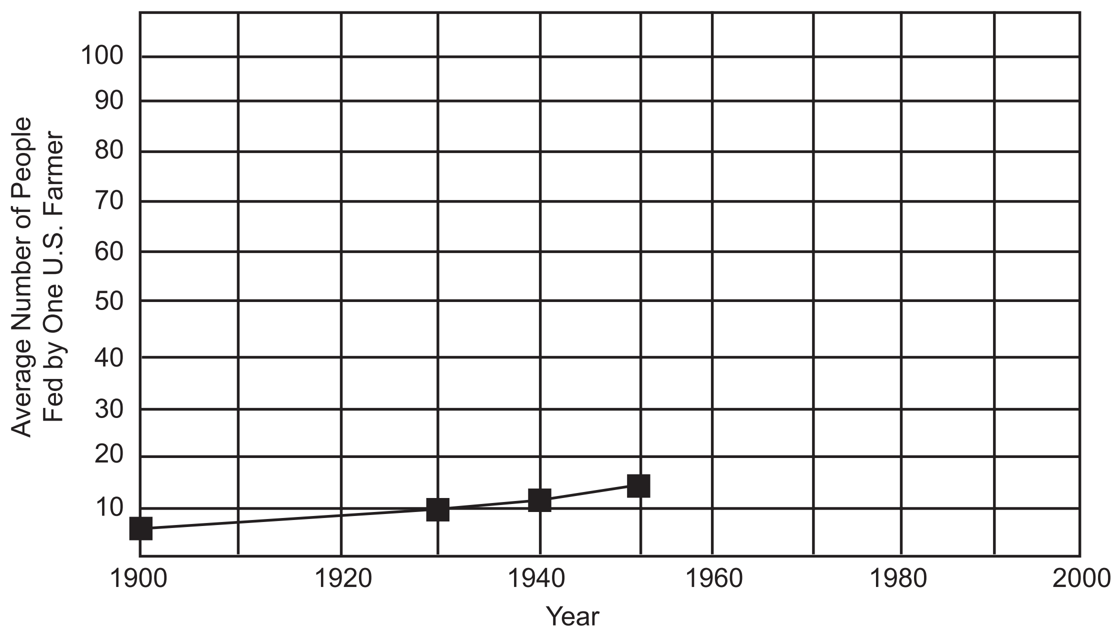
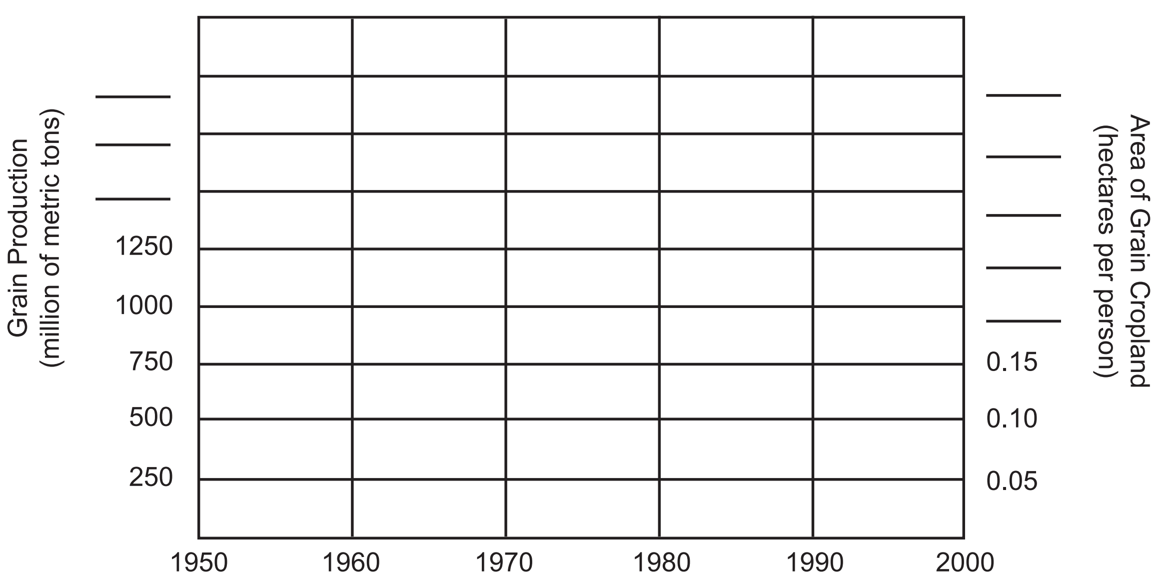
1. Complete the graph of the data given in Table 1. What do these data tell you about agricultural trends?




2. Graph the data given in Table 2. What do these data tell you about agricultural trends?



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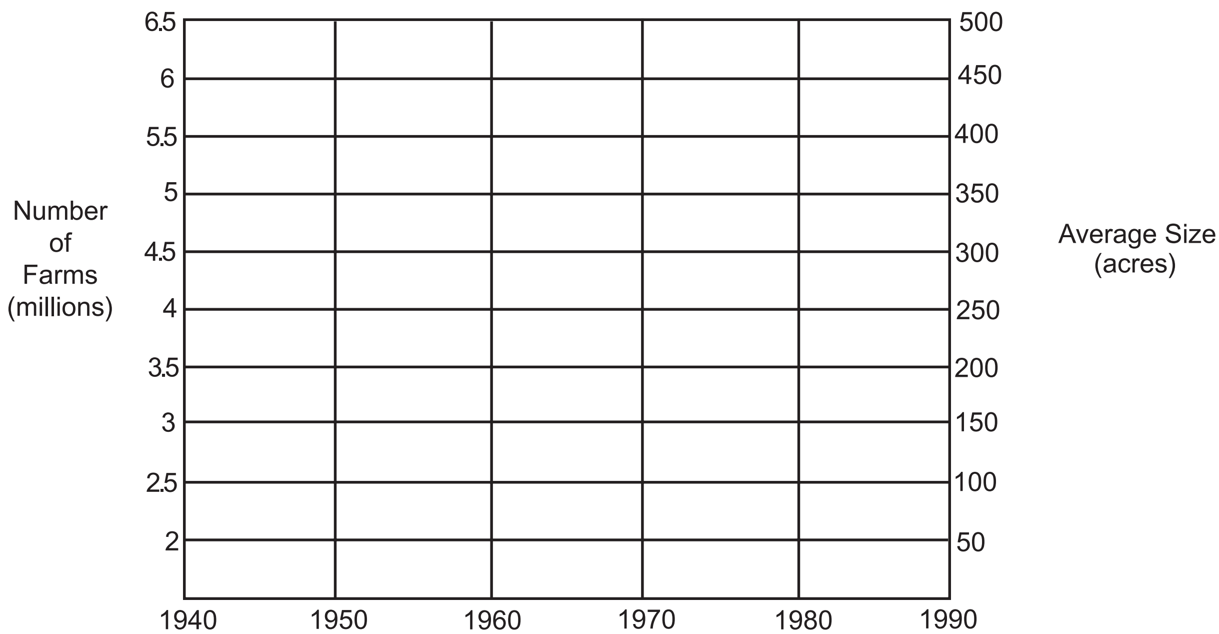
3. Graph the data given in Table 3. What do these data tell you about agricultural trends?




4. Agriculture was described as an input-output system. Write down three more examples of an input-output system and explain your examples.

   1) ______________________________

   ______________________________

   2) ______________________________

   ______________________________

   3) ______________________________

   ______________________________

5. Explain the difference between “production” and “productivity” using examples that are *not* found in these materials.

   ______________________________

   ______________________________

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6. Describe the trends in industrial agricultural production and productivity in the 20th century.

7. In **Part 2: What do the landscapes of industrial agriculture look like?** you were shown satellite images of only a few examples of these landscapes. Write down *two* more examples of different landscapes of industrial agriculture that you have personally seen.
   1)
   2)

8. What are the characteristics of industrial agriculture? In other words, what do all the examples of this type of agriculture have in common? List as many characteristics as you can.

9. What natural resource is used to make fertilizers, pesticides, and farm machinery? List three other agricultural inputs that come from this natural resource.
   1)
   2)
   3)

# Module 2, Investigation 2: Log
## What is industrial agriculture?

10. Do you think the increasing use of fertilizer in industrial agriculture is a practice that can be sustained in the future? Why or why not?

11. By what measure is "traditional" agriculture more productive than industrial agriculture? By what measure is industrial agriculture more productive than traditional agriculture?

12. What trends do you see in the amount of money spent (expenditures) on agricultural production in the United States? What is your evidence? Do these data enable us to conclude anything about changes in productivity? Why?

# Module 2, Investigation 2: Log
## What is industrial agriculture?

13. From the quote from Eisenberg and other information you have gathered, list what, in your opinion, may be the three biggest problems of industrial agriculture, and support your choices.
    1) ______________________________
    ______________________________
    2) ______________________________
    ______________________________
    3) ______________________________

14. What information can you get from remote sensing, and how would this information help you if you were a farmer? Examine the satellite image in Figure 10. What changes would you make on your plot of land and why?
    ______________________________
    ______________________________
    ______________________________
    ______________________________
    ______________________________
    ______________________________
    ______________________________

15. How might the new technologies of remote sensing and precision agriculture help solve three of the problems of industrial agriculture mentioned in **Part 4**. **What problems does industrial agriculture create?**
    1) ______________________________
    ______________________________
    ______________________________
    2) ______________________________
    ______________________________
    ______________________________
    3) ______________________________
    ______________________________
    ______________________________

# Module 2, Investigation 2: Log
## What is industrial agriculture?

16. Create a graphic organizer to illustrate the inputs and outputs of industrial agriculture.

**Inputs**

**Outputs**

**Industrial Agriculture**