Your ECOLOGICAL *footprint*

The Land Requirements of Your Diet

How much land is used to grow the food you eat? At first glance this question seems simple to answer. It is relatively easy to obtain information about the yields of most crops. Indeed, this chapter contains information about yields for several important crops, such as corn and wheat (see Figure 16.10). Information about yields (bushels per acre) could be combined with information about your diet to calculate the amount of land used.

But compiling the relevant information about your diet is more difficult than it seems. You know what you eat—but try answering the following question: How much corn, wheat, or soybeans did you eat today? You might answer none, but this answer probably is wrong. Most of us don't eat much corn, wheat, or soybeans directly. Instead we eat these crops indirectly as bread, pasta, and other foods. The quantity of wheat cannot be deduced from the nutritional information on a box of spaghetti.

Similarly, most of us eat some corn on the cob in late summer and early fall. But this seasonal consumption does not come close to the total amount of corn grown in the United States. Most of the corn grown in the United States and other developed nations is fed to cows, pigs, and chickens. You cannot estimate this quantity of corn without knowing the diet fed to livestock and the physiological efficiency with which livestock convert various foods to meat.

The highly processed nature of the foods consumed in developed nations makes it difficult to calculate the land used to grow food. To estimate this quantity, information about two stages of food production is needed. In the first step, food is grown using land. The importance of land has long been recognized, and careful records are kept for agricultural yields.

In the second step, raw foods are processed into forms we eat. Corn, wheat, eggs, sugar, and many other ingredients are used to make breakfast cereals. Similar "recipes" are required for nearly all other foods. So the second set of information includes the recipes that are used to produce processed foods.

Food processing is a highly interconnected, technically sophisticated sector of the economy. While the number of people who work on farms to grow food has declined over the last century, the number of people who work to process food has increased. Hence input–output tables sometimes are used to trace the agricultural products that are used to produce the foods we consume (see Chapter 3's Your Ecological Footprint on page 49).

Using these tables, estimates have been compiled for the amount of land per year that is needed to produce a kilogram of food in five groups (Table 1). Though the land use requirements are calculated with data from the Netherlands, they should be applicable to other developed nations. For these nations, the conversion factors in Table 1 may understate land use because agricultural yields in the Netherlands are among the highest in the world. For example, wheat yields averaged 8.9 metric tons per hectare in the Netherlands during 1996; the European Union average was about 3 metric tons per hectare, while U.S. yields were about 2.5 metric tons per hectare.

Calculating Your Footprint

You can use the data in Table 1 to calculate the amount of land that is required per year to grow the food you eat. For Chapter 5's Your Ecological Footprint (pages 80–81) you compiled information about the food you eat in a day. Many of those foods are listed in Table 1. Calculate the area of agricultural land that is used to support one day's worth of food. For example, suppose you had a quarter-pound cheeseburger with fries for lunch. The land requirements associated with some of the more visible ingredients would be as follows:

Beef patty (.25 lb)	$2.29\ m^2$ year/kg = 0.11 kg × $20.9\ m^2$ year/kg
Cheese (1 oz)	$0.306\ m^2$ year/kg = 0.03 kg × $10.2\ m^2$ year/kg
Bun (flour, .25 cup)	$0.02\ m^2$ year/kg = 0.01 kg × $1.6\ m^2$ year/kg
French fries (.25 lb)	$0.02\ m^2$ year/kg = 0.11 kg × $0.2\ m^2$ year/kg

Much of the nitrogen that is applied to the fields is washed into waterways by irrigation (see *Policy in Action: Reducing Agricultural Pollution and Increasing Farmer Profit*), where it eventually reaches the Gulf of California. There the timing and size of phytoplankton blooms coincide with irrigation.

Most Green Revolution croplands are planted with a single crop, often a single cultivar. Growing a single crop over a large area is known as **monoculture.** Although this approach reduces costs by increasing the efficiency of farm machinery and material inputs, monoculture increases the crop's vulnerability to pests and disease. That is, a monoculture is the ideal feeding or breeding ground for a pest or disease that specializes in that crop. Under these conditions huge economic losses are possible. For example, the corn leaf blight of 1970 ruined 15–25 percent of the U.S. corn crop and caused about $1 billion in losses.

To prevent such losses Green Revolution agriculture depends on the development and use of pesticides, herbicides, and **fungicides,** which are chemicals designed to kill fungal diseases. Over time the application of these chemicals has increased. Without these chemicals, insects and fungi would reduce the world food crop by about 70

TABLE 1	Land Requirements for Selected Food Types		
Food Item	Land (m^2 year kg^{-1})	Food Item	Land (m^2 year kg^{-1})
Beverages		**Milk products and eggs**	
Beer	0.5	Whole milk	1.2
Wine	1.5	Semiskim milk	0.9
Coffee	15.8	Cheese	10.2
Tea	35.2	Eggs	3.5
Fats		**Cereals, sugar, potatoes, vegetables, and fruits**	
Fats for frying	21.5	Flour	1.6
Margarine	21.5	Sugar	1.2
Lowfat spread	10.3	Potatoes	0.2
Meat		Vegetables	0.3
Beef	20.9	Fruits	0.5
Pork	8.9		
Minced meat	16		
Sausage	12.1		

Source: Data from P.W. Gerbens-Leenes et al., "A Methods to Determine Land Requirements Relating to Food Consumption Patterns," *Agriculture, Ecosystems, and Enviroments* 90: 47–58.

Fats (frying, 4 tbsp) 1.20 m^2 year/kg = 0.0.056 × 56 kg × 21.5 m^2 year/kg

Total = 3.84 m^2 year

Now try similar calculations for all the foods you eat in a single day. Add their total land requirements to get the amount of land that must be used for a year to grow a day's worth of food. Multiply this total by 365: This is about the amount of land that is used per year to grow your food.

Interpreting Your Footprint

As described in Chapter 5, a vegetarian diet can increase food supplies if the land used to support livestock can also be used to grow crops. To evaluate this claim, suppose you replace the burger and fries lunch with ramen noodles. Suppose the noodles are made with .22 kg of wheat flour: Your lunch would require about 0.35 m^2 year (0.22 kg × 1.6 m^2 year/kg), which is about a tenth of the value of the quarter-pound cheeseburger. (Notice that this is consistent with the trophic efficiencies discussed in Chapter 5.)

The average U.S. citizen eats about 43 kg of beef per year. This is much greater than the world average of 9.7 kg. How much more land does U.S. beef consumption represent relative to the world average? The United States is not, however, the largest consumer of beef. That honor goes to Argentina, where the average person eats 62.3 kg per year. How much more land does the average Argentinean use for beef consumption relative to the United States?

ADDITIONAL READING

Gebhardt, S.E., and R.G. Thomas. *Nutritive Value of Foods.* U.S. Department of Agriculture, Agricultural Research Service, Home and Garden Bulletin Number 72, http://www.primeindia.com/manav/food9.html.@Data on energy content of foods.

Gerbens-Leenes, P.W., S. Nonhebel, and W.P.M.F. Ivens. "A Method to Determine Land Requirements Relating to Food Consumption Patterns." *Agriculture, Ecosystems, and Environment* 90 (2002): 47–58.

STUDENT LEARNING OUTCOME

- Students will be able to explain how their dietary choices affect the amount of land required to grow their food.

percent. Agricultural chemicals reduce that loss to about 42 percent.

Chemicals may reduce losses in the short term, but they initiate an evolutionary positive feedback loop that causes farmers to increase their use of pesticides and pressures firms to develop new pesticides. The positive feedback loop works as follows. The application of a pesticide kills most individuals in a pest population. But individuals that are less susceptible to the pesticide are more likely to survive and reproduce. If resistance is based on an individual's genetic makeup, repeated application will increase the frequency of genes that confer resistance in subsequent generations. The increasing number of resistant individuals forces the farmer to apply more pesticide, which accelerates the selection process. Eventually the genetic basis for resistance is present in most of the pest population. At this point the pesticide is ineffective, and firms must develop a new pesticide. Because of this feedback loop, the number of insects and mites, weeds, and plant diseases that are resistant has increased since the 1950s (Figure 16.17).

Furthermore, most pesticides and herbicides are not specific. Pesticides kill many species, including predators