How Much Land Does It Take To Produce Your Food?

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Objectives:

The student will be able to:

- calculate the amount of land required to produce the food eaten by an individual for one year.
- compare the amount of land required to produce animal versus plant products.
- visualize the areas of land calculated in objectives 1 and 2.

Background:

Humans require energy and their energy is obtained from food. Energy moves from its source in the sun through the photosynthetic organisms that make that energy available to living things (producers) and then through organisms that eat other organisms (consumers). Land therefore yields fewer kilocalories per square meter per year in animal products than in plant products. Energy is lost in the transition from producers to consumers. (respiration, heat loss, animal waste) Plants can be divided into two groups, C-3 and C-4, based on the photosynthetic and respiratory pathways they utilize. Under the right conditions C-4 plants such as sugarcane and corn photosynthesize two to three times as fast as C-3 plants. C-4 plants are also more efficient because they don't lose energy due to photorespiration which frequently occurs in C-3 plants. C-3 and C-4 plants are separated on the Analysis Sheet because the C-3 plants are less energy efficient. A final point to remember in dealing with food energy, a food Calorie used by nutritionists is equivalent to a kilocalorie (kcal) used by chemists and physicists.

Materials:

- calorie counters
- meter stick (OTHER IDEA 1.a)
- maps of community and state (OPTION 6.a.)

Procedure:

1. Student records the types and amount of food eaten during a 24-hour period. Be sure to count everything, not just what is eaten at meals - snacks, candy, etc. too.
2. Using calorie counter references, determine the total number of calories taken in during those 24 hours. Multiply this amount by 365 to determine the total number of calories taken in during a year.
3. LOW-LEVEL BIOLOGY: Divide the total number of calories (kcal/year) by 500 kcal/square meter/year to determine the square meters of land required to

support the individual. [500 kcal/square meter/year is a compromise value. A typical teenager's diet was analyzed and 500 was found to be a suitable value that would give the same end result had all the foods been examined individually.]

MIDDLE-LEVEL BIOLOGY: Determine the percent of total calories for the year that come from plant products and the percent from animal products (including dairy products and eggs). Divide the calories from animal products by 200 kcal/square meter/year [200 kcal/square meter/year is a compromise value for all animal products.] Divide the calories from plant products by 2000 kcal/square meter/year (another compromise value). The plant and animal products combined represent the total square meters of land required to support the individual.

ADVANCED BIOLOGY: Use the attached Analysis Sheet for Trophic Ecology of Humans and the students' calorie data to determine the square meters of land required to support the individual. Do this by determining the number of calories that fall into each food category and divide each of these values by the "yield". Add all the values in the "square meters of land" column to arrive at the total land required to support the individual. Add the values in each subgroup, C-3 plants, C-4 plants, and animal products, to compare plant and animal land requirements.

4. Calculate a class average for the square meters of land required to support an individual.

OPTIONAL:

5. Calculate the amount of land required to support the following groups for one year: your class, your school, your community, your state, the USA.
6. a. Assuming a football field/soccer field is 5000 square meters, how many fields does a student need to support him/herself for one year?

   b. On maps of your community and/or state, shade in the land area needed to support your school, community, and state. [To make this easier mark grids on the maps showing square kilometers. Students need to convert the square METERS of land needed to square KILOMETERS of land by dividing the value by 1 million. 1 mile = 1.6 kilometers.]

Other Ideas:

1. Comparing land required to produce an equal amount of plant versus animal calories:

   a. Choose one plant product (e.g., rice) and one animal product (e.g., beef) from the Analysis Sheet for Trophic Ecology of Humans. Assume that an individual takes in 200 calories of each product in one meal. Divide the 200 calories by the yield from the Analysis Sheet. [e.g., Rice: 200 kcal Ö 1250 kcal/sq m = 0.16 sq m; Beef: 200 kcal Ö 130 kcal/sq m = 1.5 sq m]. Give each student a meter stick and have them measure these areas in the field or classroom in order to visualize the difference. Any foods from the Analysis Sheet could be used. A

discussion on vegetarian versus non-vegetarian diets would be appropriate.

b. Assuming a student takes in 2000 kcal per day, he/she would take in 730,000 kcal per year. Choose one plant product (e.g., rice) and one animal product (e.g., beef) from the Analysis Sheet for Trophic Ecology of Humans. Divide the 730,000 kcal by the yield from the Analysis Sheet [e.g., Rice: 730,000 kcal Ö 1250 kcal/sq m = 584 sq m; Beef: 730,000 kcal Ö 130 kcal/sq m = 5615 sq m]. Calculate how many football fields/ soccer fields each of these values would represent. [e.g., Rice: 584 sq m Ö 5000 sq m/field = .11 football/soccer fields; Beef: 5615 sq m Ö 5000 sq m/field = 1.1 football fields/soccer fields]. A discussion on vegetarian versus non-vegetarian diets would be appropriate.

Resources:

Brewer, Richard and M.T. McCann, **Laboratory and Field Manual of Ecology**, Saunders College Publishing, Philadelphia, 1982.

CALORIE COUNTERS:

Count Calories - Calories Count! David McKay Company, Inc., New York, 1980.
Editors of Consumer Guide, **Calorie, Carbohydrate and Fat Counter**, Publications International, Skokie, Illinois, 1982.
Fat and Cholesterol Counter, American Heart Association, Random House, 1991.
Food Values: Calories, Harper and Row, New York,1990.
Netzer, Corinne, **The Complete Book of Food Counts**, Dell Publishing, New York, 1988.
Williams, Walden, **Vest Pocket Calorie Counter**, Doubleday, New York, 1990.

Analysis Sheet for Trophic Ecology of Humans

Food	Your Daily	Your Annual	Yield		Square Meters
C-3 Plants					
Bread			650		
Wheat.			810		
Oranges.			1000		
Frozen			410		
Peanut			920		
Rice. rice			1250		
Potatoes			1600		
Carrots			810		
Other			200		
Apples			1500		
Pears.			900		
Vegetable			300		
Margarine			300		
Beet sugar			1990		
				Sub-	
C-4 Plants					

C-4 Plants					
Cane sugar			3500		
Soft drinks			3500		
Corn cereal			1600		
Corn			250		
				Sub-total	
Animal Products					
Milk			420		
Cheeses			40		
Eggs			200		
Chicken			190		
Pork			190		
Beef			130		
Fish (frozen)			2		
				Sub-total	
				TOTAL	

Source: Brewer, Richard and M. T. McCann, **Laboratory and Field Manual of Ecology**, Saunders College Publishing, Philadelphia, 1982.