APES MINI-LAB: CARRYING CAPACITY

INTRODUCTION

An ecosystem can be as small as a drop of water or as large as the entire Earth. The productivity of an ecosystem limits its carrying capacity, that is, the mass of living organisms that the ecosystem can support. The carrying capacity of the Earth usually refers to its ability to support human life, because it is the human population that is currently undergoing explosive exponential growth. But the carrying capacity can be applied to any life form and to any part of the biosphere, such as the number of deer that can be supported by an oak forest. As any population increases in size, the same resources must be shared by a greater and greater number of individuals. The decreasing supply of resources may lower the population's birth rate, increase its death rate, or both - until birth and deaths are in balance. At that point of balance, and as long as the resource supply remains constant, the population should stabilize at some equilibrium size. Ecologists call this balance point of a population's equilibrium the carrying capacity of the environmental system inhabited by that particular species.

Ecologists use the term *carrying capacity* to define the maximum population of a particular species that a given area of habitat can support over a given period of time. The ecological principles that govern a habitat's carrying capacity are the same for all species. A sustainable supply of resources-including nutrients, energy, and living space-defines the carrying capacity for a particular population in a particular environmental system.

Acorns, produced by oak trees, are a favorite food for deer, as well as for squirrels, jays, quail, crows, woodpeckers, raccoons, rabbits, and foxes. In areas with mild winters, acorns may be available for 8 months of the year and constitute about 75% of the diet of deer. Acorns are higher in fat and easily-digested carbohydrates than other food sources, such as leaves, twigs, small green plants, and fungi. In areas with hard winters, reproductive success of deer decreases with greater snow cover, when acorns may be harder to find. Deer have reduced birth weights and lower survival of fawns when acorns are less available. In areas with mild winters, such as the southeastern United States, deer appear to be better able to survive years of low acorn production by shifting to other foods.

In this activity, you will create a model of an oak forest and estimate the number of deer that can be supported by the forest. This is modeled after a forest in Virginia which covers 19,535 acres (metric equivalent = 7906 hectares).

PROCEDURE

1) Use the data in the table, "Acorn Yield Per Year" to make a graph of acorn yield in kilograms (vertical axis) versus diameter at breast height (centimeters) for the five species of oak.

2) Using the information in Table 1: "Oak Species in Virginia" and Table 2: "Acorn Yield Per Year," answer the following questions, showing all work.

QUESTIONS

1) A forest of what type (species and diameter) of oak tree will yield a maximum supply of acorns?

2) Assume a density of 25 oaks per hectare and, using the species and diameter of tree you selected for #1, calculate the acorn potential for *each hectare* of the forest for one year.

3) Assuming that the average deer requires 3 kilograms of food a day and that 75% of the diet is acorns…

a) calculate how many deer *each hectare* of this forest could support for a year. This is the carrying capacity. NOTE: If the carrying capacity is less than one, this means a hectare is not sufficient to support one deer!

b) calculate how many deer the *entire forest* could support for one year. The forest covers 7906 hectares.

4) Scientists estimate that about 15% of the acorn yield is eaten by birds and others that feed in the trees; only 85% reaches the ground. Adjust your calculations to take this factor into account:

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b) calculate how many deer the *entire forest* could support for one year. The forest covers 7906 hectares.

5) What is the relationship between diameter of oaks at breast height and acorn production? If information were available for trees greater than 65 centimeters in diameter, what would you predict for their acorn production? (Blackjack and post oaks rarely grow over 70 centimeters in diameters, and the others rarely over 90 centimeters.)

6) Based on the information about the species, can you offer a hypothesis about why some species produce greater acorn yields than others?

7) Is it realistic to assume that the forest will be made up of only one species of oak? Why or why not? If the forest was made up of a variety of the oak species in Table 1, how would this affect the carrying capacity?

8) How would the presence of other animals that eat acorns from the ground affect the number of deer the forest can support?

9) Squirrels are more dependent upon acorns as a food source than are deer; that is, they have fewer alternative food supplies. How might a high density of deer in an area affect the population of squirrels?

10) Although squirrels can usually find the acorns they have buried, some escape. Deer eat acorns directly from the ground or trees, without burying them. How might succession in a forest that had deer, but no squirrels, differ from one that had squirrels, but no deer?

TABLE 1: OAK SPECIES IN VIRGINIA

Common Name	Scientific Name	Habitat
white oak	*Quercus alba*	dry or moist woods
post oak	*Quercus stellata*	dry soil
blackjack	*Quercus marilandica*	dry, barren soils
spanish oak	*Quercus falcata*	woods
water oak	*Quercus nigra*	coastal plain

TABLE 2: ACORN YIELD PER YEAR (kilograms)

Diameter (cm)	Oak Species				
	white oak	post oak	blackjack	Spanish oak	water oak
10	-----	0.3	-----	-----	-----
15	-----	0.6	-----	-----	-----
20	0.2	1.0	-----	0.5	0.7
25	1.2	1.3	0.8	1.4	1.8
30	2.2	1.6	1.5	2.3	3.1
35	3.2	1.9	2.2	3.2	4.2
40	4.2	2.3	3.0	4.1	5.4
45	5.2	2.6	3.7	5.0	6.6
50	6.2	3.0	4.6	5.9	7.8
55	7.2	3.3	5.2	6.7	9.0
60	8.2	3.6	5.9	7.6	10.1
65	9.2	4.0	6.7	8.5	11.3

Adapted from Rosenthal, Dorothy B. Environmental Science Activities. pp. 63-65. John Wiley & Sons. 1995