**HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.**

**Vocabulary**

* Abiotic
* Biotic
* Carrying capacity
* Competition
* Limiting factors
* Overpopulation
* Population

**Objective**

Students will:

* define a limiting factor.
* describe how limiting factors affect animal populations.

**Method**

Student become “bears” to look for one or more components of habitat during the physically involved activity

**Materials**

* Envelopes or bags for students to collect their food in
* Food cards for plants, meat, insects, berries and nuts. Refer to chart to determine how many cards to make depending on class size.
* Green paper = plants (leaves, grasses, herbs)
  + - P-10 (plants 10lbs),
    - P-20 (plants 20 lbs),
* Red paper = meat (mice, rodents, peccaries, beaver, muskrats, young deer)
  + - M-4, (meat 4 lbs),
    - M-8 (meat 8 lbs),
* Yellow paper = insects (grub worms, larvae, ants, termites);
  + - I-6 (insects 6 lbs),
    - I-12 (Insect 12lbs)
* Blue paper = berries and fruit (blackberries, elderberries, raspberries, wild cherries
  + - B-10, (berries 10 lbs),
    - B-20 (berries 20 lbs)
* Orange paper = nuts (acorns, pecans, walnuts, hickory nuts)
  + - N-10 (nuts 10 lbs)
    - N-20 (nuts 20 lbs)
* A blind fold (for the blind bear)

Use this chart to determine the number of food cards which is dependent on the number of students in the class.

Number of students in class:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10-15 | 16-20 | 21-25 | 26-30 | 31-35 | 36-40 | 41-45 |
| Nuts (N-20) | 2 | 3 | 3 | 4 | 5 | 6 | 7 |
| Nuts (N-10) | 8 | 13 | 17 | 21 | 25 | 29 | 33 |
| Berries (B-20) | 2 | 3 | 3 | 4 | 5 | 6 | 7 |
| Berries (B 10) | 8 | 13 | 17 | 21 | 25 | 29 | 33 |
| Insects (I-12) | 2 | 3 | 3 | 4 | 5 | 6 | 7 |
| Insects (I-6) | 8 | 13 | 17 | 21 | 25 | 9 | 33 |
| Meat (M-8) | 2 | 3 | 3 | 4 | 5 | 6 | 7 |
| Meat (M-4) | 8 | 13 | 17 | 21 | 25 | 29 | 33 |
| Plants (P-20) | 2 | 3 | 3 | 4 | 5 | 6 | 7 |
| Plants (P-10) | 8 | 13 | 17 | 21 | 25 | 29 | 33 |

Background

In this activity, the black bears are the focus in order to illustrate the importance of suitable habitat for wildlife. One or more components of habitat - food, water, shelter and space in a suitable arrangement - are emphasized as one way to convey the concept of "limiting factors."

Black bear habitat limits black bear populations, especially through the influences of shelter, food supply and the social tolerances or territoriality of the animal. Shelter or cover is a prime factor. Black bears need cover - for feeding, hiding, bedding, traveling, raising cubs and for denning. With limits of space, adult bears will kill young bears or run them out of the area. These young bears must keep moving around either until they die or find an area vacated by the death of an adult.

When food supplies are reduced by factors such as climatic fluctuations, competition becomes more intense. Some adult bears might temporarily move to seldom-used areas of their home range, sometimes many miles away. They must live on what food is available in the area. These individuals may become thin and in poor condition for winter hibernation or, in the case of young bears, be forced from the area by more aggressive adults.

All components of habitat are important. Food, water, shelter and space must not only be available, but must be available in an arrangement suitable to meet the animals' needs. For black bears, shelter is especially important.

All possible conditions are not covered by the design of the activity. However, by this simple illustration, it is possible for students quickly to grasp the essential nature of the concept of limiting factors.

The major purpose of this activity is for students to recognize the importance of suitable habitat. Inadequate food and/or shelter are two examples of what is called a limiting factor - something which affects the survival of an animal or a population of animals.

There should be less than 80 pounds of food per student so that there is not actually enough food in the area for all the "bears" to survive. The following estimates of total pounds of food for one bear in ten days are used for this activity:

|  |  |
| --- | --- |
| nuts | 20 pounds = 25% |
| berries and fruit | 20 pounds = 25% |
| insects | 12 pounds = 15% |
| meat | 8 pounds = 10% |
| plants | 20 pounds = 25% |
| TOTAL | 80 pounds = 100% |

NOTE: These figures represent a typical bear's food. The components of an actual bear's diet will vary between areas, seasons and years. For example, a bear in the state of Alaska would likely eat more meat (fish) and fewer nuts than a bear in Arizona. One similarity among black bears everywhere is that the majority of their diet is normally made up of vegetative material

Procedure:

1. Make up a set of food cards from colored construction paper to represent the different food types depending on the size of the class (refer to the above chart).

2. In a fairly large open area (e.g., 50' x 50'), scatter the colored pieces of paper.

3. Have each student write his or her name on an envelope. This will represent the student's "den site" and should be left on the ground (perhaps anchored with a rock) at the starting line on the perimeter of the field area.

4. Have the students line up on the starting line, leaving their envelopes between their feet on the ground. Give them the following instructions: "You are now all black bears. All bears are not alike, just as you and I are not exactly alike. Among you is a young male bear who has not yet found his own territory. Last week he met up with a larger male bear in the big bear's territory, and before he could get away, he was hurt. He has a broken leg. (Assign one student as the crippled bear. He must hunt by hopping on one leg.) Another bear is a young female who investigated a porcupine too closely and was blinded by the quills. (Assign one student as the blind bear. She must hunt blindfolded.) The third special bear is a mother bear with two fairly small cubs. She must gather twice as much food as the other bears. (Assign one student as the mother bear.)"

5. Do not tell the students what the colors, initials, and numbers on the pieces of paper represent. Tell them only that the pieces of paper represent various kinds of bear food. Since bears are omnivores, they like a wide assortment of food, so they should gather different colored squares to represent a variety of food.

6. Students must walk into the "forest." Bears do not run down their food; they gather it. When students find a colored square, they should pick it up (one at a time) and return it to their "den" before picking up another colored square. (Bears would not actually return to their den to eat; they would eat food as they find it.)

7. When all the colored squares have been picked up, the food gathering is over. Have students pick up their den envelopes containing the food they gathered and return to class.

8. Explain what the colors and numbers represent. Each color is a kind of food and the numbers represent pounds of food eaten. Ask each student to add up the total number of pounds of food he or she gathered - whether it is nuts, meat, insects, berries or plant materials. Each should write the total weight on the outside of his or her envelope.

9. Using the whiteboard, list "blind," "crippled," and "mother." Ask the blind bear how much food she got. Write the amount after the word "blind." Ask the crippled bear and the mother bear how much they got and record the information.

Tell the students each bear needs 80 pounds to survive. Which bears survived? Is there enough to feed all the bears? How many pounds did the blind bear collect? Will she survive? What about the mother bear? Did she get twice the amount needed to survive? What will happen to her cubs? Will she feed her cubs first or herself? Why? What would happen to her if she fed the cubs? What if she ate first? If the cubs die, can she have more cubs in the future, and perhaps richer, years? (The mother bear will eat first and the cubs will get whatever, if any, is left. The mother must survive; she is the hope for a continued bear population. She can have more cubs in her life; only one needs to survive in order for the population to remain static.)

11. Ask each student to record how many pounds of each of the five categories of food he or she gathered. Ask each student next to convert these numbers into percentages of the total poundage of food each gathered. Provide the students with the background information about black bears so that they can compare their percentages with what are typical percentages eaten by black bears in Arizona. Ask each student to attempt to guess how healthy their bear would be. How do the bears' requirements for a diet seem to compare with the needs of humans for a balanced and nutritious diet?

12. Ask the students to arrive at a class total for all the pounds of food they gathered as bears. Divide the total by the 80 pounds needed by an individual bear (approximately) in order to survive in a ten-day period. How many bears could the habitat support? Why then did only \_\_\_\_ bears survive when your class did this activity? Is that realistic? What percentage of the bears survived? What percentage would have survived had the food been evenly divided? In each case, what percentage would not survive? What limiting factors, cultural and natural, would be likely to actually influence the survival of individual bears and populations of bears in this area?

**Activity adapted from:**

* Illinois Natural History Survey <http://www.inhs.illinois.edu/resources/virtualbird/how_many_bears.html>
* Project Wild “How Many Bears Can Live in this Forest?” from Council for Environmental Education 2000 <http://www.fs.fed.us/outdoors/naturewatch/implementation/Curricula/Meeting%20Standards%20Naturally/science/S4.pdf>
* http://local.brookings.k12.sd.us/biology/ch3biosphere/bears.htm

**Food cards for “How Many Bears can live in this forest”**

P-10 P-10 P-10 P-10

P-10 P-10 P-10 P-10

P-10 P-10 P-10 P-10

P-10 P-10 P-10 P-10

**Food cards for “How Many Bears can live in this forest”**

P-20 P-20 P-20 P-20

P-20 P-20 P-20 P-20

P-20 P-20 P-20 P-20

P-20 P-20 P-20 P-20

**Food cards for “How Many Bears can live in this forest”**

N-20 N-20 N-20 N-20

N-20 N-20 N-20 N-20

N-20 N-20 N-20 N-20

N-20 N-20 N-20 N-20

**Food cards for “How Many Bears can live in this forest”**

N-10 N-10 N-10 N-10

N-10 N-10 N-10 N-10

N-10 N-10 N-10 N-10

N-10 N-10 N-10 N-10

**Food cards for “How Many Bears can live in this forest”**

B-10 B-10 B-10 B-10

B-10 B-10 B-10 B-10

B-10 B-10 B-10 B-10

B-10 B-10 B-10 B-10

**Food cards for “How Many Bears can live in this forest”**

B-20 B-20 B-20 B-20

B-20 B-20 B-20 B-20

B-20 B-20 B-20 B-20

B-20 B-20 B-20 B-20

**Food cards for “How Many Bears can live in this forest”**

M-4 M-4 M-4 M-4

M-4 M-4 M-4 M-4

M-4 M-4 M-4 M-4

M-4 M-4 M-4 M-4

**Food cards for “How Many Bears can live in this forest”**

M-8 M-8 M-8 M-8

M-8 M-8 M-8 M-8

M-8 M-8 M-8 M-8

M-8 M-8 M-8 M-8

**Food cards for “How Many Bears can live in this forest”**

I-6 I-6 I-6 I-6

I-6 I-6 I-6 I-6

I-6 I-6 I-6 I-6

I-6 I-6 I-6 I-6

**Food cards for “How Many Bears can live in this forest”**

I-12 I-12 I-12 I-12

I-12 I-12 I-12 I-12

I-12 I-12 I-12 I-12

I-12 I-12 I-12 I-12

**Student Handout: How Many Bears can live in this forest**

NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period \_\_\_\_\_\_\_

**HOW MANY BEARS CAN LIVE IN THIS WOODS?**

1. Bears are described as: Carnivores Herbivores Omnivores Detritivores Decomposers

because they eat \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| **Table 1. Tally the cards you collected in your foraging** |
| P-10 \_\_\_\_ X 10 = \_\_\_\_\_\_\_ N-10 \_\_\_\_ X 10 = \_\_\_\_\_\_ M-4 \_\_\_\_\_ X 4 = \_\_\_\_\_  P-20 \_\_\_\_ X 20 = \_\_\_\_\_\_\_ N-20 \_\_\_\_ X 20 = \_\_\_\_\_\_ M-8 \_\_\_\_ X 8 = \_\_\_\_\_  TOTAL PLANTS = \_\_\_\_\_\_\_\_ TOTAL NUTS = \_\_\_\_\_\_\_\_ TOTAL MEAT = \_\_\_\_\_\_  I-6 \_\_\_\_ X 6 = \_\_\_\_\_\_\_ B-10 \_\_\_\_ X 10 = \_\_\_\_\_\_  I-12 \_\_\_\_ X 12 = \_\_\_\_\_\_\_ B-20 \_\_\_\_ X 20 = \_\_\_\_\_\_ TOTAL POUNDS OF FOOD = \_\_\_\_\_\_\_\_\_  your bear collected  TOTAL INSECTS = \_\_\_\_\_\_\_\_ TOTAL BERRIES = \_\_\_\_\_\_\_\_\_ |

|  |  |
| --- | --- |
| **Table 2. Food Collection and nutritional requirements** | |
| Food Collected by your bear  Plants \_\_\_\_\_\_\_ pounds  Berries \_\_\_\_\_\_\_ pounds  Nuts \_\_\_\_\_\_\_ pounds  Insects \_\_\_\_\_\_\_ pounds  Meat \_\_\_\_\_\_\_ pounds | The average food required for a bear for 10 days is:  Plants 20 pounds = 25% of diet  Berries 20 pounds = 25% of diet  Nuts 20 pounds = 25% of diet  Insects 12 pounds = 15% of diet  Meat 8 pounds = 10% of diet  80 pounds = 100% |

|  |
| --- |
| **Table 3. Calculated percentages for your bear’s diet** |
| Plants are \_\_\_\_\_\_\_ % of my bear’s diet. This is \_\_\_\_\_\_\_\_% higher / lower that an average bears diet.  Berries are \_\_\_\_\_\_\_ % of my bear’s diet. This is \_\_\_\_\_\_\_\_% higher / lower that an average bears diet.  Nuts are \_\_\_\_\_\_\_ % of my bear’s diet. This is \_\_\_\_\_\_\_\_% higher / lower that an average bears diet.  Insects are \_\_\_\_\_\_\_ % of my bear’s diet. This is \_\_\_\_\_\_\_\_% higher / lower that an average bears diet.  Meat is \_\_\_\_\_\_\_ % of my bear’s diet. This is \_\_\_\_\_\_\_\_% higher / lower that an average bears diet. |

2. Calculate the % of food in your bear collected, based on weight, compared to the amount required: \_\_\_\_\_\_\_\_\_\_\_\_%

3. If this amount of food collecting continues for 1 year, will your bear survive or die? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Thinking ecologically explain why only 10% of a bear’s calories come from meat.

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**Class Data Analysis**

5. Total pounds of food in the environment = \_\_\_\_\_\_\_\_\_

6. Approximately how many bears should be able to survive if all the resources were divided evenly among all the bears? \_\_\_\_\_\_\_\_\_\_

7. How many survived in this forest? \_\_\_\_\_\_\_\_\_

8. How many starved? \_\_\_\_\_\_\_\_\_

Did the mother of the cubs survive? YES NO

Did the baby bears survive? YES NO

Did the injured bear survive? YES NO

9. What type of interaction is at work in this simulation? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. Why do you think more bears died than expected? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

11. Which bear(s) were most likely to die? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Give 2 reason WHY they were likely to die: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Conclusion Questions**

12. If your bear is not eating a balanced diet, what do you think might happen to him/her?

(Don’t say it will die… most teenagers don’t eat the way they should and they aren’t dead.)

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13. What kind of limiting factor was at work in this bear simulation? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14. Name at least 3 other things organisms have to compete for in an ecosystem in addition to food.

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15. How do limiting factors affect an ecosystem’s carrying capacity for a given species?

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16. In real life, if there is not enough food, the mother bear will choose to eat the food herself and let her babies starve. Why is this a good strategy for bear populations in general?

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17. What would happen to the bear population if there was a new bacteria that infected the amount of berries grown in a summer season?

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18. What abiotic factors could affect the population of the bears?

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19. If the above diet continues, how healthy would your bear be over a period of 3 months?

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20. What human activities could be limiting factors in this activity?

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