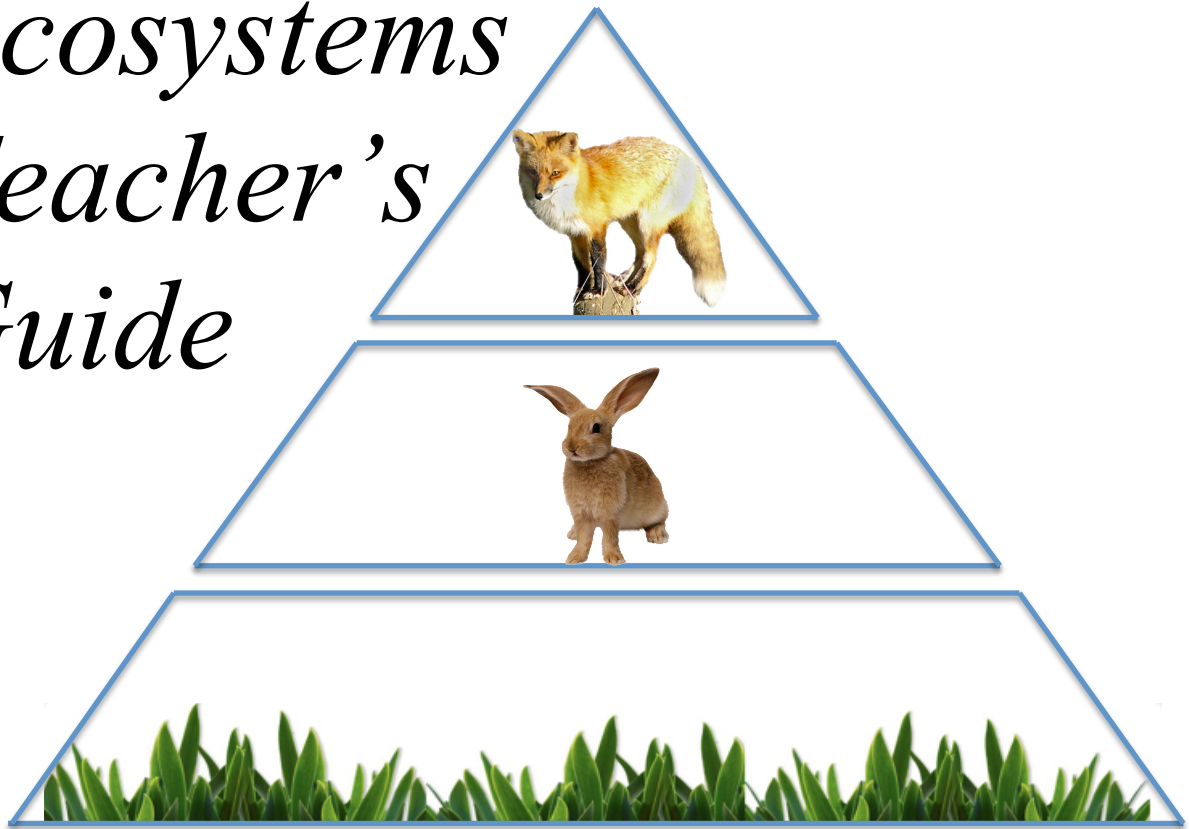


Ecosystems Teacher's Guide



How ecosystems store

and cycle *Carbon*

and chemical energy

**The Environmental Literacy Project
Carbon: Transformations in Matter and Energy
(Carbon TIME)
2012-2013
WORKSHEETS**

Ecosystems Unit At a Glance

Lesson 1: Unit Pre-test and Carbon in Our Ecosystems	Time Estimate
Activity 1: Ecosystems Unit Pre-Test	20 min
Activity 2: Where is the Carbon in Ecosystems?	20 min
Lesson 2: Sunny Meadows Investigation	
Activity 1: Sunny Meadows Investigation	30 min
Activity 2: Comparing Different Ecosystems	20 min
Lesson 3: Matter Cycles and Energy Flows in Ecosystems	
Activity 1: The Three Questions for the Large-Scale	20 min
Activity 2: Carbon Dice Game	30 min
Activity 3: Tracing Carbon: The Answer to the Carbon/Movement Question	30 min
Activity 4: Tracing Energy: The Answer to the Energy Question	30 min
Lesson 4: Carbon Pools and Fluxes	
Activity 1: What Happens When Carbon Pools Change Size?	45 min
Activity 2: Carbon Pools and Fluxes	45 min
Lesson 5: Ecosystems Applications	
Activity 1: Farm Ecosystems	40 min
Activity 2: Satellite Images of Our Community	
Activity 3: How do Our Food Choices Change the Carbon Cycle?	
Activity 4: How does Carbon Cycle Through Our School Yard?	
Activity 5: Animals Unit Post-Test	20 min

Teacher _____ Grade _____ Period _____ Date _____ Your initials _____

Ecosystems Unit Pre- and Post-test

Lesson 1, Activity 1

1. Think about what might happen to carbon atoms and to energy in a forest. Decide whether each of the following pathways is possible or not:

Carbon atoms could leave the forest after they have been used by plants or animals.	Possible	Impossible
Carbon atoms could be recycled and used again by plants or animals after they have been used by plants or animals.	Possible	Impossible
Energy could leave the forest after they have been used by plants or animals.	Possible	Impossible
Energy could be recycled and used again by plants or animals after they have been used by plants or animals.	Possible	Impossible

Explain your thinking. How are the possible pathways for carbon atoms and for energy alike and different?

1. Your muscles are made of proteins, fats, and other materials that contain many carbon atoms. Think about where those carbon atoms came from.

Which of the following statements is true? Circle the letter of the correct answer.

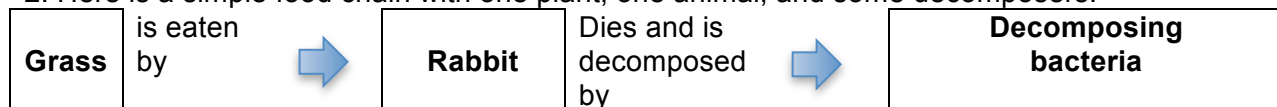
- a. ALL of the carbon atoms came into your body in food, OR
b. SOME of the carbon atoms were made by your muscles when your muscle cells grew and divided.

Circle the best choice to complete each of the statements about possible places where the carbon atoms in your muscles might have come from.

How many of the carbon atoms were once in the AIR?	Al l	Most	Some	Non e
How many of the carbon atoms were once in the PLANTS?	Al l	Most	Some	Non e
How many of the carbon atoms were once in the ANIMALS?	Al l	Most	Some	Non e
How many of the carbon atoms were once in the DECOMPOSERS?	Al l	Most	Some	Non e

Explain your choices. How might the carbon atoms have gotten to your muscles?

2. Here is a simple food chain with one plant, one animal, and some decomposers:



Describe what happens to matter and energy in this food chain by filling in the following table:

	<i>Matter</i>	<i>Energy</i>
Similar matter and energy	How are the materials in the grass, the rabbit, and the bacteria all alike?	How are the types of energy in the grass, the rabbit, and the bacteria all alike?
Different matter and energy	How are the materials in the grass, the rabbit, and the bacteria different from one another?	How are the types of energy in the grass, the rabbit, and the bacteria different from one another?
Connections	How are the materials in the grass, the rabbit, and the bacteria connected?	How is the energy in the grass, the rabbit, and the bacteria connected?

Name: _____ Period: ____ Date: _____

Sunny Meadows Investigation Worksheet

Lesson 2, Activity 1

Organisms eat one another to obtain organic matter and chemical energy. In order for large numbers of organisms to survive there must be enough food (organic matter) for the organisms to eat. So all the fox in an ecosystem depend on having enough food—like rabbits—to eat.

Prediction: In this investigation you will try to create a **large number of foxes** by adjusting the number of plants, rabbits, and foxes in the ecosystem. Keep in mind that rabbits eat the plants, and the fox eat the rabbits, so all three organisms are connected.



Plants: _____

Rabbits: _____

Fox: 100

About how many plants and rabbits do you think you would need to support a large number of foxes (around 100 foxes)? Try predicting and explaining the number of rabbits and plants you need. Write your numbers above, and explain your reasoning in the space below.

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Data Collection Table:

Trial	Start			After 50 Years		
	Grass	Rabbits	Foxes	Grass	Rabbits	Foxes
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Name: _____ Period: ____ Date: _____

1. On your data collection table, circle your BEST attempt at creating an ecosystem with a large number of foxes.

2. Was the **grass, rabbit and fox** biomass always the same size throughout the game? Why or why not? What processes are causing them to change size?

3. For your BEST attempt (circled on your table above), what was the pattern of biomass size at the end of the game (after 50 years) between grasses, rabbits and foxes? Rank them from largest to smallest.

4. **Results for the whole class.** Look at the average biomass size across the whole class. What was the pattern of average biomass size between grasses, rabbits and foxes? Rank them from largest to smallest.

5. Why do you think you see these patterns?

Name: _____ Period: ____ Date: _____

Tracing Carbon Paths Worksheet

Lesson 3, Activity 3

Part I

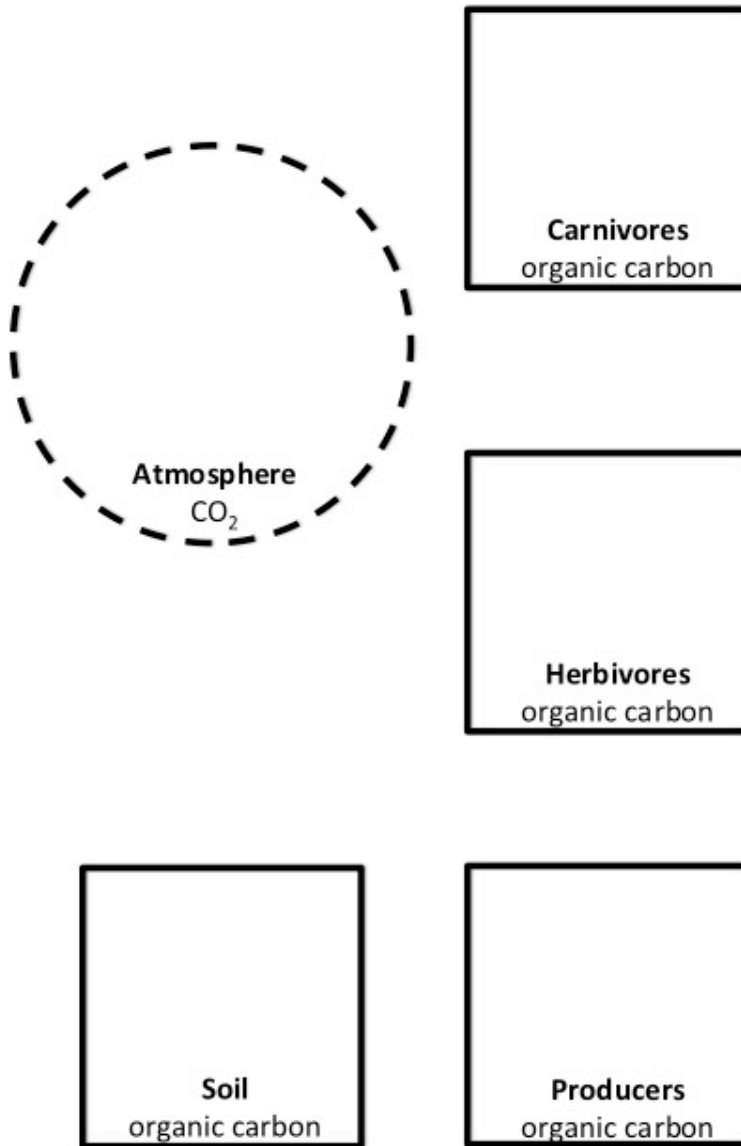
You just spent some time as a carbon atom moving around a simple ecosystem. You probably moved from the atmosphere pool to the producer pool. Some of you may have become part of an herbivore, carnivore, or decomposer. Each of you took unique paths through the ecosystem. What does that path look like in a real ecosystem?

1. Draw some arrows that show how carbon atoms can move from carbon dioxide in the atmosphere to organic matter in the ecosystem. Label these arrows with the letter "P."
2. Draw some arrows that show how carbon atoms in organic matter move through the ecosystem during two processes: 1) Eating, label these arrows with an "E" and 2) Death or defecation label these arrows with a "D." Make sure your arrows include:
 - a. Plants
 - b. Rabbits
 - c. The fox
 - d. The soil
3. Draw some arrows that show how carbon atoms in soil organic matter can get back to carbon dioxide in the atmosphere. Label these arrows with the letters "CR."
4. How are the arrows labeled "P" (from the atmosphere to the ecosystem) and "R" (from the ecosystem to the atmosphere) different?



Part II.

1. Use the tally marks for each pool (visitation data) to fill in a number for each pool on the diagram below.
2. Draw arrows between pools.
3. Label each arrow with the process that moves carbon atoms from one pool to another.



4. The answer to the Carbon/Movement Question:
How are carbon atoms moving from one pool to another?
- How are pools growing or getting smaller through carbon-transforming processes?
 - What processes are involved?

[illegible]

Part III.

1. *Why* do plants do photosynthesis? (What is the purpose of photosynthesis for a plant?)

2. *Why* do animals do digestion?

3. *Why* do plants and animals do biosynthesis?

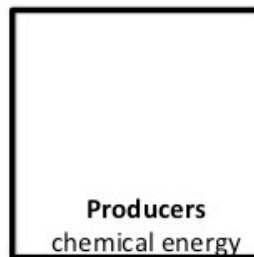
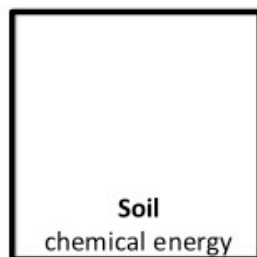
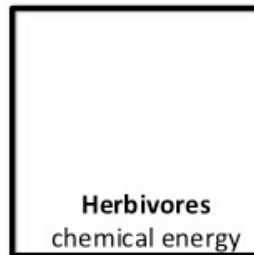
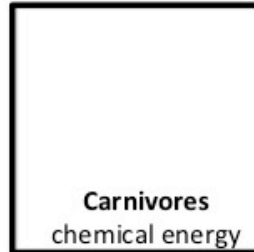
4. *Why* do plants and animals do cellular respiration?

Name: _____ Period: ____ Date: _____

Tracing Energy Worksheet

Lesson 3, Activity 5

- 1) Draw dashed arrows (- - ->) to represent how energy flows through ecosystems.
- 2) Label each arrow with a form of energy.
- 3) Label the process that occur (photosynthesis, cellular respiration, eating, death and defecation), when energy changes form or location.



- 2) When energy is in the form of chemical energy, it is associated with matter in the form of a food (or fuel). Put a star on your diagram where matter and energy part ways. What is the name of the process that happens when matter and energy part ways?

The Answers to the Energy Question: Where does the chemical energy in ecosystems come from? How is it transformed? Where does it go?

4) Explain how energy is transformed into chemical energy when it enters an ecosystem:

5) Explain how chemical energy moves between ecosystem pools:

6) Explain how chemical energy is transformed when plants or animals use it:

7) Explain how chemical energy eventually leaves an ecosystem:

The Three Questions: Large Scale Version

Question	Rules to Follow	Evidence to Look For
The Location Question: Where are the available carbon atoms in our environment? What pools of materials are they in?	Atoms endure. Carbon atoms stay in pools unless a process moves them in or out.	The air has carbon atoms in CO ₂ Organic materials are made of molecules with carbon atoms <ul style="list-style-type: none"> • Fuels • Living and dead plants and animals (including foods)_
The Carbon/Movement Question: How/why do carbon pools change over time? How are carbon atoms moving?	Carbon-transforming processes move carbon atoms among pools Carbon atoms cycle within environmental systems	Evidence of carbon-transforming processes: <ul style="list-style-type: none"> • organisms eating, growing, breathing, dying • decay • combustion If a carbon pool size changes, that means carbon atoms moved
The Energy Question: What is happening to chemical energy? How does energy flow through environmental systems?	Carbon-transforming processes change energy from: <ul style="list-style-type: none"> • sunlight to • chemical energy to • heat radiated into space Energy flows through environmental systems	We can observe indicators of different forms of energy <ul style="list-style-type: none"> • Organic materials with chemical energy • Light • Heat energy • Work or motion energy

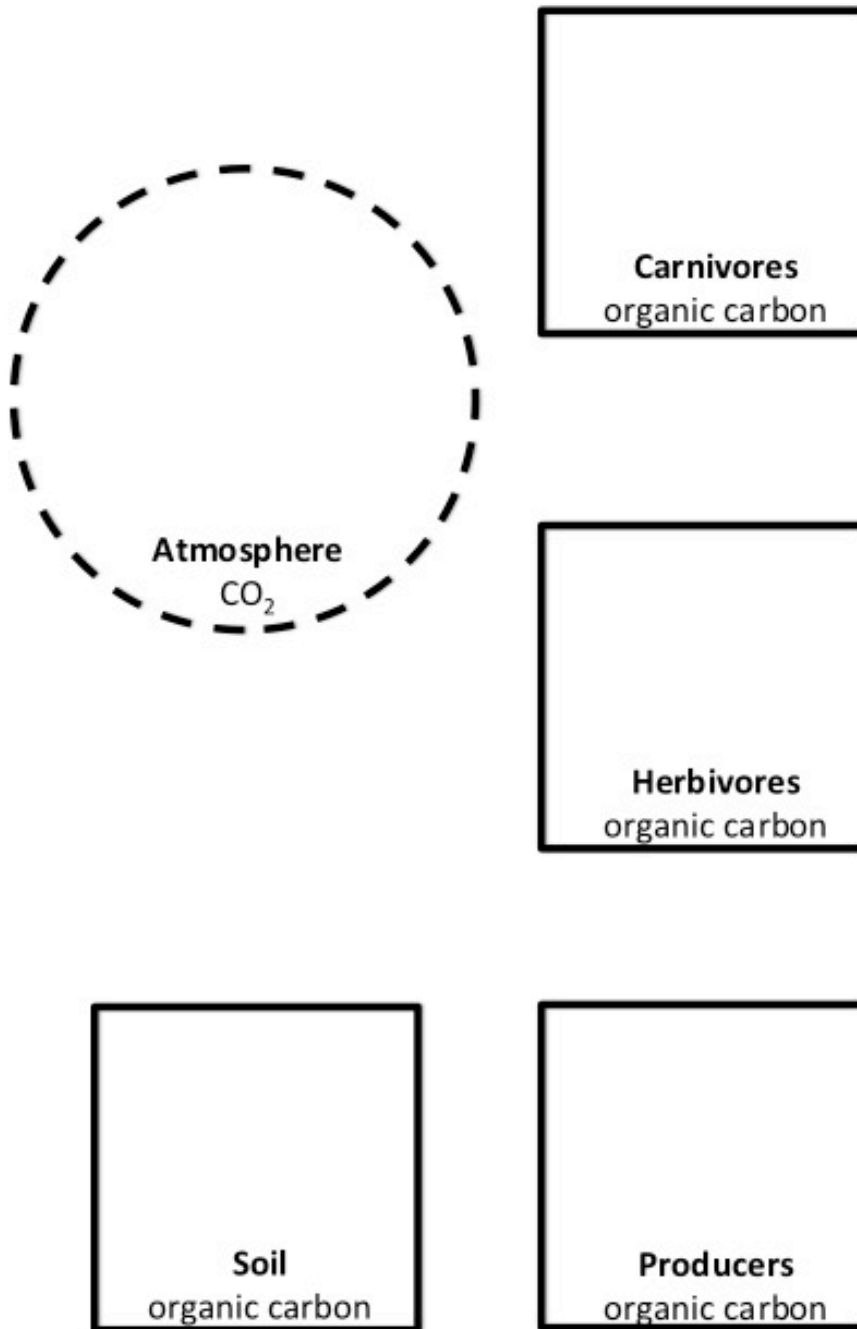
Name: _____ Period: ____ Date: _____

Why are Carbon Pools Different Sizes? Worksheet

Lesson 4, Activity 1

During the power-point presentation,

- 1) Draw an arrow in the direction that the carbon atoms moved.
- 2) Write the name of the process that occurred when the carbon atoms moved.
- 2) Record the number of carbon atoms that moved.
- 3) Record the number of carbon atoms that stayed.



After the power point presentation:

- 1) **Do the math!** What is the total amount of carbon atoms in each pool?
- 2) Write the pools below in order from *smallest* to *largest*:

	Pool:	Number of Carbon Atoms:
<i>smallest</i>	_____	_____
	_____	_____
	_____	_____
	_____	_____
<i>largest</i>	_____	_____

- 2) For all the carbon atoms in the producers that become organic matter through photosynthesis, where do **most** of the carbon atoms go? **Why?**

- 3) For all the carbon atoms in the organic matter (grass) that are digested by rabbits in the herbivore pool, where do **most** of the carbon atoms go? **Why?**

- 4) Why does this pattern of relative pools sizes exist in ecosystems? Does it have anything to do with energy?

Name: _____ Period: ____ Date: _____

Carbon Pools and Fluxes Worksheet

Lesson 4, Activity 2

Place squares of 100 carbon atoms in the inorganic and organic carbon pool. Move the squares of carbon atoms to represent the flux that occurs. Count the carbon atoms in each pool at the end of the game.

Round 1: Fluxes are balanced

Pools at the start:

Inorganic = 800 carbon atoms

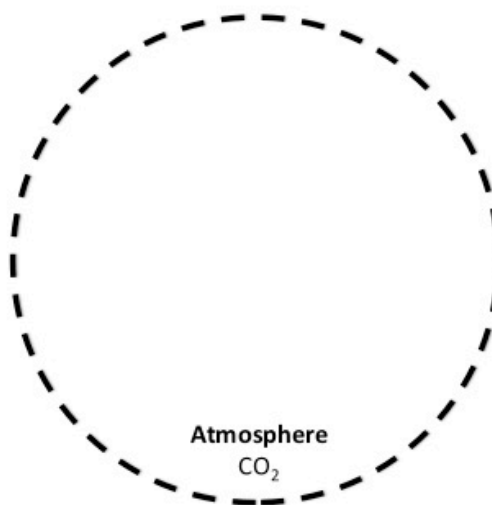
Organic = 400 carbon atoms

Fluxes:

Photosynthesis = 200 per year

Respiration = 200 per year

Circle the larger flux. Predict: how will the fluxes affect the size of the pools after a few years?



Round 2: Trees were planted in an abandoned cornfield

Pools at the start:

Inorganic = 800 carbon atoms

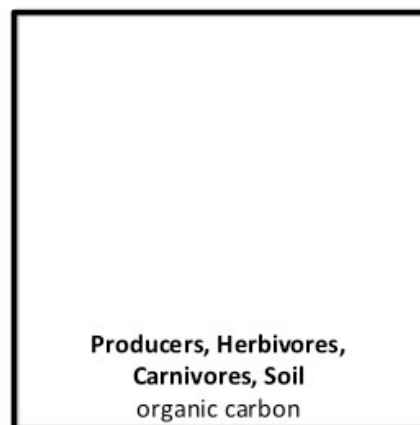
Organic = 400 carbon atoms

Fluxes:

Photosynthesis = 300 per year

Respiration = 200 per year

Circle the larger flux. Predict: how will the fluxes affect the size of the pools after a few years?



Round 3: Drought!

Pools at the start:

Inorganic = 800 carbon atoms

Organic = 400 carbon atoms

Fluxes:

Photosynthesis = 100 per year

Respiration = 200 per year

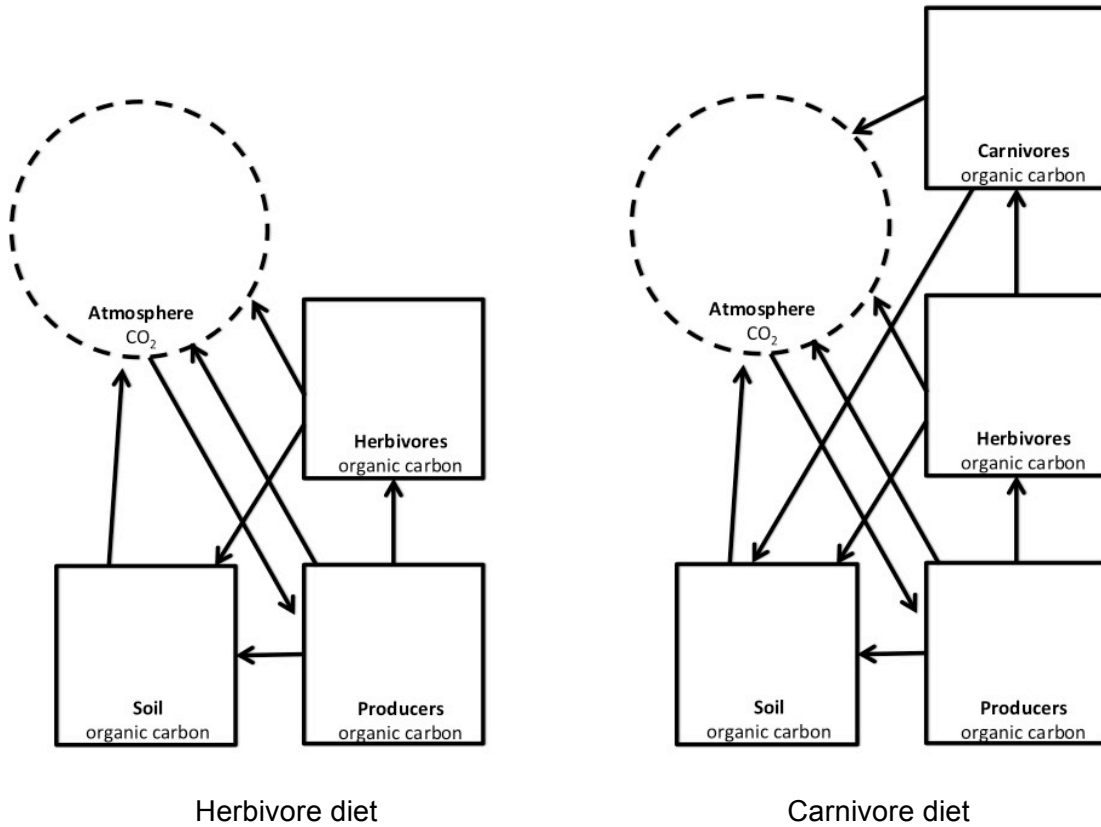
Circle the larger flux. Predict: how will the fluxes affect the size of the pools after a few years?

Name: _____ Period: ____ Date: _____

Farm Ecosystem Worksheet

During the power-point presentation,

- 1) Record the number of carbon atoms that moved.
- 2) Record the number of carbon atoms that stayed.
- 3) Record the number of carbon atoms in each pool at the end of the power point.



1) Which diet can support more people? Why?