RC2: Effects of Inputs and Outputs on a Region

Purpose

To identify what enters and leaves the regional system, and how changes in the input or output of one component can affect other components

Overview

Using the region they identified for study in *Activity RC1,* or a region identified by the teacher for this activity, students draw an imaginary box around the region. The box includes what is above the Earth's surface (the atmosphere), and what is below (the soil, or pedosphere). Using their existing knowledge, they discuss and list inputs and outputs of the region, prompted by guidance questions from the teacher if necessary. Next, students generate and explore "what if" scenarios. (e.g. What if the water flowing into the region were reduced by half? What if it were doubled? What if the land cover upstream were removed, or changed from forest to cropland? What if no birds moved across the region's boundaries?) Students learn to ask such provocative questions and to make thoughtful predictions of ways in which changing one component might affect the properties of others in the regional system. Prompted by guidance questions, they write about what they have learned.

Student Outcomes

Students will be able to:

- Identify some scientifically appropriate inputs and outputs of a system at the regional scale;
- Predict how changes in the input or output of one component of a system might affect other components, reflecting the concept that parts of a system shape each other through their interactions.

Science Concepts

Physical Sciences

Heat is transferred by conduction, convection and radiation.

Heat moves from warmer to colder objects.

Sun is a major source of energy for changes on the Earth's surface.

Energy is conserved.

Chemical reactions take place in every part of the environment.

Earth and Space Sciences

Weather changes from day to day and over the seasons.

The sun is the major source of energy at Earth's surface.

Solar insolation drives atmospheric and ocean circulation

Each element moves among different reservoirs (biosphere, lithosphere, atmosphere, hydrosphere).

Life Sciences

Organisms can only survive in environments where their needs are met.

Earth has many different environments that support different combinations of organisms.

Organisms' functions relate to their environment.

Organisms change the environment in which they live.

Humans can change natural environments.

Plants and animals have life cycles.

Ecosystems demonstrate the complementary nature of structure and function.

All organisms must be able to obtain and use resources while living in a constantly changing environment.

All populations living together and the physical factors with which they interact constitute an ecosystem.

Populations of organisms can be categorized by the function they serve in the ecosystem.

Sunlight is the major source of energy for ecosystems.

The number of animals, plants and microorganisms an ecosystem can support depends on the available resources.

Atoms and molecules cycle among the living and non-living components of the ecosystem.

Scientific Inquiry Abilities

Identify answerable questions.

Recognize and analyze alternative explanations.

Communicate results and explanations.

Time

One or two class periods

Level

Middle, Secondary

Materials and Tools

Landsat image of your school (provided by GLOBE)

Topographic maps and/or other such as vegetation, physical, soil maps of the region covered by the Landsat image, (as available)

Preparation

This activity will be most meaningful if your students have completed *RC1*. If you did not conduct *RC1*, read Steps 1 and 2 of What To Do and How To Do It in this activity.

Gather Landsat images and maps.

Make student copies (See Step 1. Preparation.)

Prerequisites

None

What to Do and How to Do It

Step 1. Preparation

If you did not conduct *Activity RC1*, identify a region for study as an Earth system, and draw its boundaries on the Landsat image provided by GLOBE, or on a map.

The region you identify may be large or small. It should be larger than a study site, (defined by what one might see while standing in one place), and small enough for students to learn about it in a short period of time. If you need a specific size guideline, select an area that is about 5 km on a side.

Natural boundaries are best, but if by using only natural boundaries you have a region that is too large, use a man-made feature, such as a road. Do not worry if regional boundaries cannot be sharply defined.

Because one of the great values of this set of activities is the opportunity it provides for integration with the rest of your students' work on GLOBE, you may want your students to identify a region that includes one or more GLOBE study sites.

Make Student Copies

Work Sheets:

– *Inputs and Outputs of a Regional System*

– *Predicting Changes to the Regional System*

– *Student Self-reflection Log: Regions as Systems*

Landsat image or map on which you draw the boundaries of the region for study

Assessment rubrics provided for this activity (You may want to share with students.)

Step 2. Introduce the activity.

If you conducted *Activity RC1*, have students refer to their copies of the Landsat image or map on

which they drew the boundaries of the class region.

If you did not conduct *Activity RC1,* distribute student copies of the Landsat image or of a map showing the region you have identified for this activity.

Explain to students that in this activity, they will look at a region for study as a system: they will consider what enters and leaves the system — its inputs and outputs.

Step 3. Ask students to put an imaginary box around the region and, using their current knowledge, consider what enters and leaves the box.

Instruct students to imagine a box that includes not only the surface of the Earth, but also what is above (atmosphere) and what is below the surface (the pedosphere or soil).

Write the names of these four major components of Earth systems on the board:

Atmosphere — air, clouds, and precipitation (rain, snow, hail)
Hydrosphere —bodies of water, such as streams, canals, rivers, ponds, lakes, and oceans; also ground water
Pedosphere — soil
Biosphere — living things

Conduct a class discussion about a region's inputs and outputs – what enters and leaves the system.

The purposes of this discussion are to make sure students understand what inputs and outputs are, and to stimulate their thinking about systems. In the next step, they will be asked to make their own lists of inputs and outputs of the region.

Ask students to be as specific as possible in their responses. For example, they might mention storms coming to the region from the direction of another city (naming the city); garbage being trucked to a particular landfill in another region; pine seeds from a specific forest (naming the forest and even the species of pine if possible) outside the region blowing into a particular meadow; fish swimming upstream (naming the stream) across the regional boundary to spawn.

Assure students that whatever they know about the water cycle, the energy cycle, and the chemical cycle can be applied to this question, as water, energy and chemicals move among the different parts of the Earth system. Remind students that people are also part of the Earth system.

This activity can make wonderful use of students' existing knowledge in a range of subject areas: meteorology, chemistry, biology, ecology, geology, and others. Students may need some prompting from you in order to draw upon that knowledge.

Step 4. Distribute the Student Work Sheet *Inputs and Outputs of a Regional System,* and ask students to complete it.

Have students work in small groups for about 10 minutes as they complete the work sheet.

If they wish, students can include general quantities — a little, some, or a lot — for any given input or output.

Step 5. Compile a class list of inputs and outputs of the region.

Ask students to share inputs and outputs from their lists, and have selected students compile a class list on the board. If the class needs prompting, refer to the list of possibilities in the following section, *Teacher Guidance*.

Suggest that students make notes about what they are thinking and learning. They can use their notes later in a summary about what they have learned.

Teacher Guidance

If necessary, prompt students with *concepts* from this list.

You may add to this list if you wish!

Students should be as explicit as possible in their responses, specifying geographic names and identifying any plant and animal groups.

Inputs

Atmosphere

Air currents from the southwest (or other appropriate direction)

Heat or cold, rain or snow from other regions, carried by winds

Dust carried by the wind

Nitrogen from the air, taken into plants

Heat and light from the sun

Hydrosphere

Water from upstream

Sediment eroded from stream banks upstream

Biosphere

Seeds carried by birds and other animals

Sediment eroded from stream banks upstream

Nitrogen from the air, taken into plants

Outputs

Atmosphere

Air currents to the northeast (or other appropriate direction)

Water in the air that may have been evaporated from the surface, moving from inside the region to outside it

Heat or cold carried by winds, movement of air masses

Water evaporating into the atmosphere

Heat radiating back into space

Light reflected back into space

Hydrosphere

Water flowing downstream

Sediment and other substances carried by the water

Leaves falling into stream and carried away

Biosphere

Animals crossing regional boundaries

(Students should think about specific animal groups one at a time, both vertebrates and invertebrates)

Animals eating within the region and leaving the region

Seeds carried away by birds and other animals

Leaves falling into stream and carried away

Step 6. Ask students to generate "what-if" questions about changes in the amounts of specific inputs and outputs, and to predict answers to those questions.

Distribute the *Predicting Changes to the Regional System Work Sheet* .

Have students generate a list of questions, and then ask for predictions. Make sure that the students' questions and predictions deal with only one change to the system at a time.

Following are some questions with categories of change that students might consider:

- What if the region got half as much rain as it does now? (Change in atmosphere)
- What if the region got twice as much rain as it does now? (Change in atmosphere)
- What if a dam were built upstream? What if one were built downstream? (Change in hydrosphere)
- What if there were no water at all entering the region? (Change in hydrosphere)
- What if the prevailing wind changed direction? (Change in atmosphere)
- What if the number of people living in the region were halved? What if it were doubled?

(Change in biosphere)

- What if all people left the region? (Change in biosphere)
- What if no birds flew into the region? (Change in biosphere)
- What if different species (kinds) of birds flew into the region? (Change in biosphere)
- What if the meadow became a forest? (Change in biosphere)
- What if the meadow became a shopping center? (Change in biosphere and pedosphere)
- What if there were no soil? (Change in pedosphere)

What if the imaginary box around the region were impermeable and nothing could enter or leave it? (Change in all components)

Instruct students to state their predictions by describing changes to the four major components of the system: atmosphere, hydrosphere, pedosphere, and biosphere. In other words, for each "what if" question, how would that change influence the properties of the soil? How would it influence the properties of the hydrosphere? How would it affect the properties of the living component of the region? How would it affect the properties of the atmosphere?

The critical concept here is that changing the properties of one component of the system alters the properties of other components.

As in the last activity, there are no "right" questions or predictions. There are only reasonable, thoughtful, well-informed ones. The importance lies in students enhancing their awareness and perception of the region as a system.

Step 7. Have the class decide: Is the region an open system or a closed system? Why?

This question is significant not only when one considers the region as an Earth system, but also when one considers systems in general. An *open system* is one that exchanges matter and/or energy across its boundary. A *closed system* is one that does not exchange any matter across its boundary. Given their work with inputs and outputs of their region, students should be able to say that their region is an open system. A great deal enters and leaves it.

Step 8. Either in the course of class work or as a homework assignment, have students complete the *Student Self-reflection Log: Regions as Systems Work Sheet.*

Student Assessment

Three *Work Sheets* can be used for student learning assessment:

- *Inputs and Outputs of the Regional System*
- *Predicting Changes to the Regional System*
- *Student Self-reflection Log: Regions as Systems*

Assessment rubrics are provided for the first two work sheets.

Inputs and Outputs of a Regional System

Work Sheet–1

Name:_____ Class: _____Date:_____

Make a list of the inputs and outputs of a region defined by your class during the previous activity, or of another region identified for this activity by your teacher. What enters and leaves the region?

Think about these parts, or *components,* of the Earth system and the processes that connect them:

1. Air, clouds, and precipitation (rain, snow, hail): Atmosphere
2. Water in streams, canals, rivers, ponds, lakes, and oceans; also ground water: Hydrosphere
3. Soil: Pedosphere
4. Living Things: Biosphere
5. Cycling of water, chemicals and energy

What is carried by water? What is carried by air? What moves through the ground? What do animals carry? What do people carry?

Inputs - *attach additional sheet if necessary*

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Outputs - *attach additional sheet if necessary*

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Predicting Changes to the Regional System

Work Sheet–2

Name:_____ Class: _____Date:_____

Instructions

1. Think of some "what-if" questions about changes to specific inputs and outputs of the region; write them down in the space below and on the next page. Use extra paper if needed.
2. For *each* of those what-if questions, make a prediction. How will that change affect the other components (atmosphere, hydrosphere, pedosphere, and biosphere) of the region?

Tips

- Make sure your questions and predictions deal with only one change to the system at a time.
- As you did on the Student Work Sheet, *Inputs and Outputs of a Regional System,* write your predictions in terms of four major components of the Earth system (atmosphere, hydrosphere, pedosphere (soil), and biosphere). How might the change affect the atmosphere? How might it affect the biosphere (living things)?
- Be prepared to defend any predictions you make on the basis of scientific knowledge.

Example: What if *the stream coming through the region was dammed up before the water entered the region?*

Then I predict

1. The plants in the region would die and the animals would leave due to lack of water. (biosphere)
2. The region would be dryer because there would be less water both in the soil and atmosphere. (pedosphere and atmosphere)
3. The stream bed would dry up and the fish would die. (hydrosphere, biosphere)

Write your questions and predictions below. Use separate paper if you run out of space to write.

What if…this change took place:

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Then I predict that this might happen to the other components of the system:

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What if…this change took place:

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Then I predict that this might happen to the other components of the system:

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What if…this change took place:

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Then I predict that this might happen to the other components of the system:

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What if…this change took place:

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Then I predict that this might happen to the other components of the system:

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Regions as Systems

Work Sheet-3: Student Self-reflection Log

Name:_____ Class: _____Date:_____

Your responses to the questions below are intended to help your teacher become aware of what you're thinking and what you need help in understanding. You will not be graded on these responses.

Instructions

1. Summarize what you have learned about the region as a system during this activity (and the previous one, if your class completed it). Use these questions to prompt your thinking:

a. How has your study of the region helped you understand it better?

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b. What did you discover about this region that you did not know before?

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c. What questions do you have now about the region?

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2. *For students who have completed Activity RC1, Defining Regional Boundaries.* In that activity, you identified a region to study as a system, and delineated its boundaries according to certain features and characteristics. Now that you've worked with that region as a system, what do you think of your choice? Did the area you chose work well as a regional system? Why or why not? Please explain here.

Assessment Rubric: RC2: *Effects of Inputs and Outputs on a Region*

Inputs and Outputs of a Regional System

	4	3	2	1
List of Inputs and Outputs	Lists 15 or more scientifically appropriate inputs and/or outputs. Includes energy, chemicals, and water; mentions carbon, nitrogen, and heat.	Lists 10 or more scientifically appropriate inputs and/or outputs Includes energy, chemicals, or water.	Lists 5 or more scientifically appropriate inputs and/or outputs.	Lists 2 or fewer scientifically appropriate inputs and/or outputs.

Assessment Rubric: RC2: *Effects of Inputs and Outputs on a Region*

Predicting Changes to the Regional System

	4	3	2	1
Questions	Poses 4 or more scientifically interesting and reasonable questions about changes to the inputs and outputs of the region; some questions are particularly interesting	Poses 3 or more scientifically interesting and reasonable questions about changes to the inputs and outputs of the region	Poses 2 or more reasonable questions about changes to the region, but does not seem to understand concept of inputs and outputs	Poses one or no reasonable or scientifically interesting questions
Predictions	Makes predictions for all questions posed, reflecting considerable thought about ways that parts of a system shape each other through their interactions. Predictions are based on sound scientific principles	Makes predictions for most questions posed, reflecting some thought about ways that parts of a system shape each other through their interactions. Most predictions are based on sound scientific principles	Makes some reasonable predictions, reflecting a little thought about ways that parts of a system shape each other through their interactions	Bases predictions only partially on sound scientific principles. Does not make any predictions based on sound ecological and physical principles.