Bio 20 Biogeochemical Students Worksheet – Answer Key

Part A: Biogeochemical Cycles

Go to www.albertatomorrow.ca and register for a student account. Please do not use your real name in your username. Once you have created your account and logged in, launch the simulator. You will find the videos on left side of the screen.

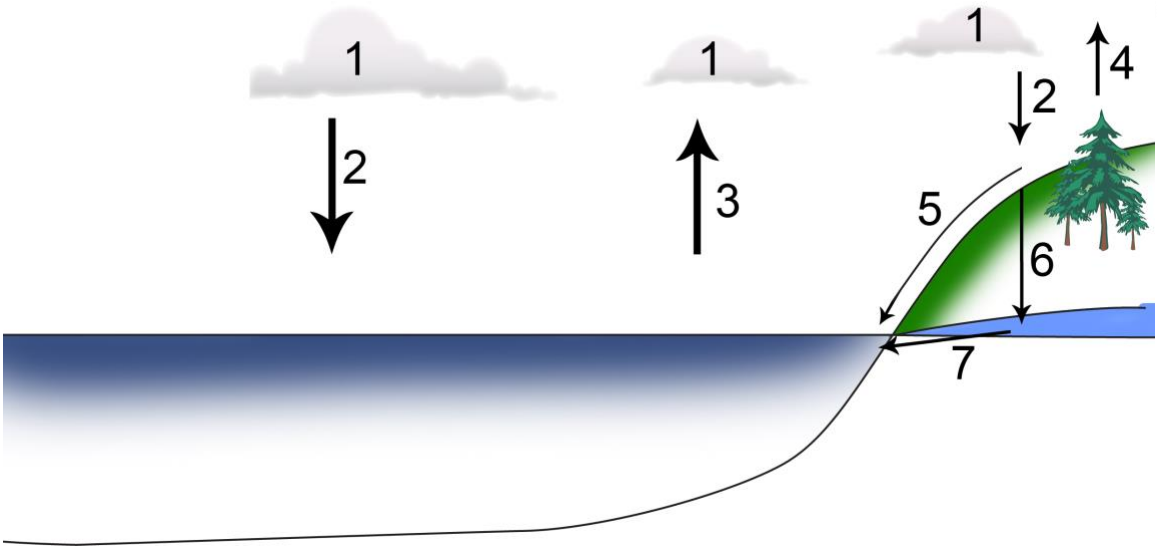
Water Cycle

1.View the Water Consumption Video.

Label the following diagram using these terms:

Condensation, Percolation, Evaporation, Ground Water, Overland Flow, Precipitation, Transpiration

1. **Condensation, 2. Precipitation, 3. Evaporation, 4. Transpiration, 5. Overland Flow, 6. Percolation, 7. Ground Water**



Fill in the blanks:

In the water cycle, condensation in the clouds causes water to fall to the earth's surface. Once on the ground, it may end up in water bodies directly, or be absorbed into the soil. Once in the soil, the water may be used by producers in the process of photosynthesis, or may eventually reach ground water. Energy from the sun causes water on earth to evaporate returning it back to the atmosphere. Water may also return to the atmosphere from plants through the process of transpiration.

Long Answer:

1. Could the water cycle proceed as a cycle if there were no living things on earth? Explain.
   Yes, as long as there is energy from the sun. Evaporation, condensation and precipitation will all take place without living things on earth.
2. List any biotic components to the water cycle.
   Photosynthesis, transpiration, cellular respiration.
3. Write out the formula for photosynthesis and cellular respiration. Circle water.
   $6H_20 + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2$
   $C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_20 + 6CO_2 + ATP$
4. List any abiotic processes in the water cycle.
   Evaporation, condensation, precipitation, etc.
5. All rivers, streams and ground water eventually end up in the ocean yet the oceans never overflow. Explain.
   Water continues to evaporate and is returned to the atmosphere.
6. What powers the water cycle?
   Energy from the sun.
7. What industries interfere with the water cycle?
   Industry such as oil and gas and agriculture use and pollute water. Forestry can affect the amount of absorption vs overland flow.

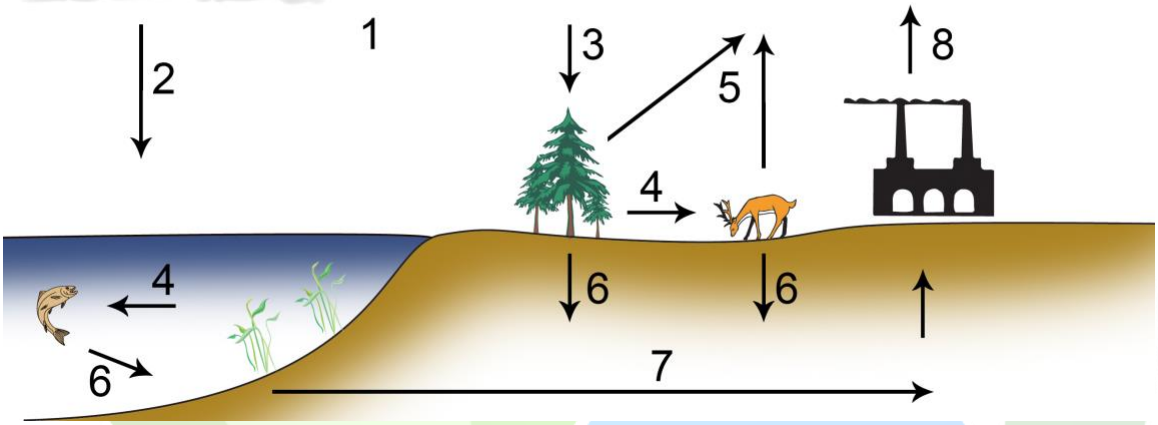
Carbon Cycle

2. View the Greenhouse Gases Video.

Label the following diagram using these terms:

CO_2 in the atmosphere, Cellular Respiration, Death and Decomposition, CO_2 dissolved in water, photosynthesis, Combustion, Consumption, Fossil Fuels

1. **CO_2 in the atmosphere, 2. CO_2 dissolved in water, 3. Photosynthesis, 4. Consumption, 5.Cellular Respiration, 6. Death and Decomposition, 7. Fossil Fuels, 8. Combustion**



Fill in the blanks:

Carbon dioxide can be found in the form of gas in the atmosphere, or can be dissolved in water. CO_2 is used by producers in the process of photosynthesis. In this process, the carbon in CO_2 is incorporated into a molecule of glucose. Animals acquire carbon when they consume producers. CO_2 is released back to the atmosphere by plants and animals through the process of Cellular Respiration. Decomposition of waste and the remains of plants and animals releases CO_2 back to the atmosphere. The same biotic processes can take place in water bodies.

If decomposition is delayed, under certain conditions, the remains of plants and animals may be converted into fossil fuels including oil, gas and coal. The burning of fossil fuels, as well as natural processes such as forest fire and decomposition releases CO_2 back to the atmosphere.

Long Answer:

1. Which complementary biotic processes form an integral part of the carbon cycle?
   Photosynthesis and Cellular Respiration
2. Write out the formula for photosynthesis and cellular respiration. Circle carbon dioxide.
   $6H_20 + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2$

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_20 + 6CO_2 + ATP$

3. Explain how the earth's atmosphere produces the greenhouse effect.
   Incoming solar radiation is transmitted through the atmosphere, hits the earth's surface, and is reflected back to space. Gases in the atmosphere, including carbon dioxide, absorb this energy, warming the atmosphere, thus creating the greenhouse effect. If this energy was not absorbed, the earth's climate would be drastically cooler.
4. What processes in the carbon cycle increase carbon dioxide?
   Combustion, Decomposition
5. What processes in the carbon cycle decrease carbon dioxide?
   photosynthesis
6. The carbon cycle is in effect in aquatic systems too. Refer to you textbook and write a short description of that cycling.
   Plants use the carbon dioxide dissolved in the water for photosynthesis. The glucose produced is used for cellular respiration and released back into the water, or the plants are consumed by aquatic animals and the glucose is incorporated into their tissues. The carbon dioxide may be released back to the water through cellular respiration. If the plant or animal dies, the carbon may be released through decomposition, or over millions of years the carbon may be turned into fossil fuels.
7. Explain why it is important to maintain the health of the carbon cycle?
   If there is too much carbon dioxide in the atmosphere, more energy is absorbed, leading to an increase in global temperature.
8. How does a balance between photosynthesis and cellular respiration affect the atmospheric composition?
   If there is less photosynthesis, more carbon dioxide will remain in the atmosphere.
9. What is the importance of biotic carbon storage in the carbon cycle?
   Plants store large amounts of carbon in their tissues, therefore keeping it out of the atmosphere.
10. What can we do in Alberta to help reduce climate change?
    By planting more trees, preventing deforestation and the loss of native prairie, and decreasing the amount of fossil fuels burned by conserving energy or moving towards renewable energy, we can help reduce climate change.

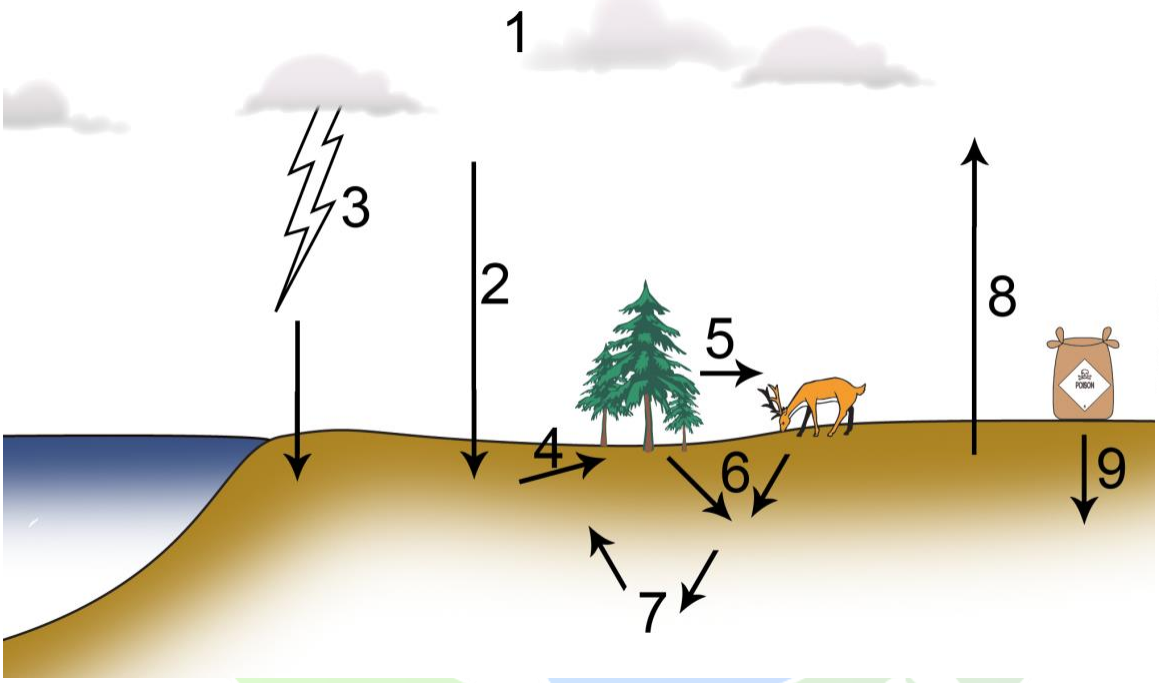
Nitrogen Cycle

3. View the Water Quality Video.

Label the following diagram with these terms:

Fertilizer, Death and Decomposition, Nitrogen Uptake by Plants, Denitrifying Bacteria, Nitrogen Fixing Bacteria in Soil, Nitrogen in Atmosphere, Nitrogen Fixing Bacteria, Nitrogen Fixation by lightning, Consumption

1. **Nitrogen in the atmosphere, 2. Nitrogen Fixing Bacteria, 3. Nitrogen fixation by lightning, 4. Nitrogen uptake by plants, 5. Consumption, 6. Death and Decompotision, 7. Nitrogen Fixing Bacteria in the soil, 8. Denitrifying Bacteria, 9. Fertilizer**



Fill in the blanks.

The reservoir of nitrogen is found in the atmosphere in the form of nitrogen gas. There are two ways in which this nitrogen can be converted into forms useable to living organisms. Lightning causes nitrogen to combine with oxygen to form nitrates. This newly formed molecule dissolves in rain water and can enter the soil. Nitrogen Fixing bacteria, usually found in soil, or in the root nodules of legumes such as clover and peas, can also form nitrates. If excess nitrates are made in the root nodules, it moves into the soil.

Plants use the nitrates to make DNA, and amino acids, which are joined together to make proteins. Animals eat the plants and break the proteins back down into amino acids to make their own proteins.

When plants and animals die, or produce waste, the nitrogen containing compounds are returned to the soil by decomposers. Bacteria convert the amino acids back into nitrates, which are once again taken up by the plant.

Other bacteria called denitrifying bacteria take the nitrates and convert it back into nitrogen gas which is released back into the atmosphere. These bacteria are anaerobic, meaning they do not require oxygen and grow best where there is none. They complete the nitrogen cycle.

Long Answer:

1. Nitrogen gas makes up almost 79% of the atmosphere. Why then is it so difficult for living organisms to acquire nitrogen?
   Nitrogen gas is not the useable form for most living organism. It needs to be converted into nitrates for most plants to use it.
2. Explain how lightening plays a role in the nitrogen cycle.
   The energy from lightning causes nitrogen gas to combine with oxygen, forming nitrates. The nitrates dissolve in the rain and fall to the ground where they are absorbed into the soil.
3. What role do decomposers play in the nitrogen cycle?
   Decomposers are able to convert nitrogen-containing compounds like nitrites or ammonia back into nitrates so plants can once again use them.
4. What are nitrates?
   Nitrate is a molecule containing both nitrogen and oxygen atoms.
5. How do denitrifying bacteria affect your lawn?
   Denitrifying bacteria take the nitrates and convert them back into nitrogen gas, releasing the nitrogen back to the atmosphere. They prefer anaerobic conditions; therefore if you aerate your lawn and make sure there is plenty of oxygen, you'll be decreasing the chances of losing the nitrogen.
6. Why do farmers often practice crop rotation?
   Farmers will plant legumes such as field peas or lentils in one field. Legumes have nodules attached to their roots that contain nitrogen-fixing bacteria. The nitrogen fixing bacteria take the nitrogen gas and convert it into nitrates. The legumes use some nitrates and excess nitrates are left in the soil. The following year, the famer may plant a non-legume plant, which can use the nitrates already in the soil. This will decrease the amount of additional fertilizer the farmer needs to apply to the field.
7. How do humans affect the nitrogen cycle?
   We add excess nitrogen to the system through excess human or animal waste seeping into water, or runoff from excess fertilizer. This causes eutrophication.
8. Define and describe Eutrophication.
   Eutrophication is the gradual filling in of a lake or pond due to excess nutrients such as nitrogen. When excel nitrogen gets into bodies of water, the additional nutrients stimulate plant growth.

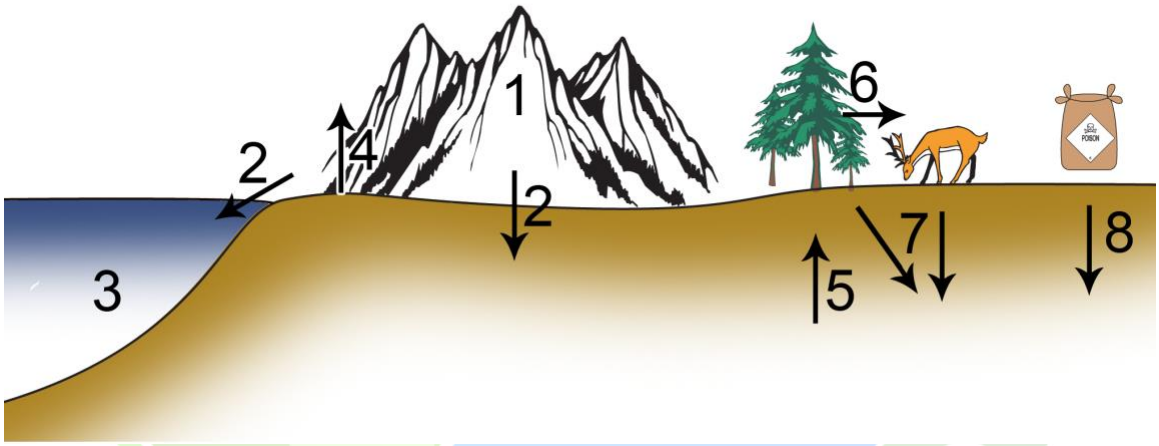
The result is an algal bloom and increased plant growth. The algae and plants grow, die, fall to the bottom of the body of water, and decompose. The process of decomposition uses up oxygen dissolved in the water, and causes the body of water to gradually become shallower. With less oxygen in the water, the type of animals able to live in the water changes.

Phosphorus Cycle

4. Label the following diagram using these terms:

Fertilizer, Consumption, Geologic Uplift, Phosphorus in Soil, Erosion, Phosphorus in rocks, Death and Decay, Phosphorus in ocean sediments,

1. Phosphorus in rock, 2. Erosion, 3. Phosphorus in the ocean, 4. Geologic Uplift, 5. Phosphorus in soil, 6. Consumption, 7. Death and Decay, 8. Fertilizer



Fill in the blanks:

The phosphorus cycle has two different parts: a long-term cycle and a short term cycle. The long-term cycle involves the formation and erosion of rocks. The short-term cycle involves plants and animals.

Through erosion, phosphates, a combination of phosphorus and oxygen, end up in the soil and water bodies. Here they can be used by plants to make DNA. Animals eat the plants and obtain calcium phosphate for bones. In the marine environment, when plants and animals die, they form rock on the ocean floor. Over millions of years, this rock may come to the surface through geologic uplift. This is the long-term cycle.

The short-term cycle involves decomposers. The waste and remains of plants and animals are converted back into phosphates, which can again be taken up by plants.

Long Answer:

1. What are phosphates?

   Phosphates are molecules containing both phosphorus and oxygen.

2. How do land plants obtain phosphates?

   Plants get phosphorus from the soil.

3. What makes this cycle different from the other 3 cycles?

   The reservoir of phosphorus is found in rock. In the other 3 cycles, the reservoir of the element is found in the atmosphere.

4. How do humans affect the phosphorus cycle?
   Human and animal waste, as well as runoff from fertilizer, seeps into water bodies causing eutrophication.
5. An ecological indicator is a variable that is measured to determine the health of a component of the ecosystem. Explain why phosphorus runoff is a good indicator of the status of the phosphorus cycle.
   The amount of phosphorus in an ecosystem determines the primary production, and excess levels can cause eutrophication. It is relatively easy to measure and if high, may be an indication that other nutrient levels are high also.

Biogeochemical Cycle Review:

1. What is a biogeochemical cycle?

   A biogeochemical cycle is the movement of a nutrient between the abiotic and biotic components of an ecosystem.

2. For each of the following, identify the cycle affected, and describe how it is affected.
   a. Feedlot operations

      Nitrogen and Phosphorus. Excess runoff into water bodies can cause eutrophication.

   b. Fertilizer applications

      Nitrogen and Phosphorus. Excess can reach water bodies and lead to eutrophication.

   c. Sewage disposal

      Nitrogen and Phosphorus. Excess can reach water bodies leading to eutrophication.

   d. Vehicle and refinery emissions

      Carbon and Water. Emissions release excess carbon dioxide to the atmosphere, leading to Global Warming. Nitrous oxides and sulphur dioxide from emissions can also cause acid rain.

3. How is water quantity and quality affected by the following?
   a. Oil and gas industry

      Oil and Gas extraction uses large quantities of water. Oil sand development also results in large tailing ponds.

   b. Agricultural systems

      Agriculture is the single larges user of water in Alberta. Excess fertilizers, as well as manure ends up in water bodies, polluting the water and leading to eutrophication. The filling in of sloughs and wetlands, the land's natural water purifiers also affects quality.

   c. Domestic water consumption

Domestic water consumption uses large quantities of water. What we put down the drain, or in storm sewers can affect water quality.

4. Explain five ways you could reduce your impact on biogeochemical cycles.

Answers will vary. Some examples are: conserve energy at home, walk more and drive less, purchase food produced closer to your city/town, don't over-fertilize your lawns. Etc.

VIDEO QUESTIONS:

1. *Watch the "Introduction" video*
2. Define Sustainable Development: This means our actions today should not harm the health of ecosystems for future generations.
3. *Watch the "Natural Landscapes" video.*
4. What region of Alberta do you live in? Answers will vary.
5. What type of land-use is present in your area? Answers will vary.
6. Why is native prairie important? 5/11 species at risk in Alberta live in native prairie.
7. *Watch the "Mammal Habitat" video.*
8. How much woodland caribou habitat is left in Alberta? Half of what existed historically.
9. How does human disturbance affect caribou? Roads, pipelines, seismic lines, well sites and cutblocks increase the chances of caribou encountering humans and wolf. Caribou prefer large tracts of undisturbed older forest.
10. What are the factors that make Grizzly Bears populations so susceptible to decline? They have a low reproductive rate and don't reach breeding maturity until they are 5-7 years old. They breed only once every 3 or 4 years.
11. What can be done to help Grizzly Bear populations? Limit the possibilities of human/bear encounters by limiting development in Grizzly Bear habitat.
12. *Watch the "Fish Habitat" Video.*
13. What do fish populations need to thrive? Fish require adequate food, cover from predators, and the ability to reproduce.
14. How does human activity affect fish populations? The road network, as well as fishing pressure adversely affect fish populations.
15. *Watch the "Water Quality" Video.*
16. What is the unintended consequence of fertilizer application on lakes, rivers and ponds? Excess fertilizer runoff into lakes, rivers and ponds result in increased algae and plant growth. Once these plants die, they decompose, a process that uses up oxygen in the water. This can lead to fish kills and the gradual filling in of the water body, called eutrophication.
17. *Watch the "Water Consumption" Video.*
18. Why is water important to us? We need water to live, but our economy also relies on water.
19. *Watch the 'Greenhouse Gas and Biotic Carbon Storage" Video.*
20. Describe the flow of carbon through an ecosystem. Carbon cycles between the living and non-living things in an ecosystem. Atmospheric carbon is taken in by plants in the process of photosynthesis. The animals eat the plants, and give off carbon through cellular respiration, and when they die and decompose. This carbon returns once again to the atmosphere.
21. *Watch the "GD"P and "Human Population" Videos*.
22. How does Alberta compare to the rest of Canada? Alberta has a higher GDP and population growth than any other province in Canada.
23. *Watch the following three videos: "Oil and Gas Production", "Forestry", and "Agriculture Production" Videos*
24. For each type of natural resource production describe the benefit to Albertans.
    a. oil and gas
       The industry provides us with gasoline, natural gas, nylon plastic, As well, the provincial government collects royalties from companies. That collected money goes to pay for things like education and healthcare. 7/100 jobs in Alberta are related to the oil and gas industry.

    b. Forestry
       The forestry industry produce timber, pulp and paper. 2/100 jobs in Alberta is related to the forestry industry, and the industry provides money to the provincial government.
    c. Agriculture

3/100 jobs in Alberta are related to Agriculture. Agriculture contributes to Alberta's GDP and provides you and I with food!

25. For each type of natural resource production describe the environmental liabilities.
    a. oil and gas
       Ecosystems are disturbed to locate and extract oil and gas. Roads and seismic lines fragment wildlife habitat, making it less suitable for certain species. The industry uses large amounts of water.
    b. Forestry
       Forestry reduces the area of old growth forests which are reservoirs of biotic carbon. Forestry roads further fragment wildlife habitat.
    c. Agriculture
       Agriculture uses large amounts of water. Runoff from Agricultural practices impact surface water quality. Cows release large amounts of methane gas, a greenhouse gas. Tillage of fields also adds carbon to the atmosphere.
26. *Watch the "Best Practices' video.*
27. What do best practices do?
    Best practices lower our impact on ecosystems.
28. List some of the best practices currently being used in Alberta.
    Integrated resource management reduces the number of roads needed. Low tillage farming, and careful fertilizer application reduces the amount of nutrient runoff from farmlands. Some basic best practices are driving less, using renewable energy, and conserving energy and water at work, school, and home.

29. Watch the "Ecological Goods and Services" Video. Ecological Goods and Services are also referred to as Ecosystem Goods and Services. What are they? Ecosystem or Ecological Goods and Services are simply just what it sounds like: the services or products the ecosystem provides for us (at no charge!)

30. List at least 5 examples of Ecological Goods and Services. Water purification, oxygen production, carbon sequestration, pulp and paper, flood control, etc.

Part B: Land-Use Assessment

1. *Click on "Set Your Location". Zoom in and find your school, or house. Move the map around until the blue marker is on your study area. "Save" your location.*
2. *Click "Land-Use Assessment". Press play. Beginning with the time period 1884-1984, observe what happens to the indicators, as well as the areas of different landscape types after pressing the play button. At any time, you may click on "create report" to give you a different view of the changes you see.*
3. For all 3 time periods, look at the changes in environmental indicators. Which abiotic factors decreased?
   1884-1984: water quality
   1984-2014: water quality
   2010-2044: water quality
4. Which biotic factors decreased?
   1884-1984: natural landscapes, grizzly habitat, fish community health, biotic carbon
   1984-2014: natural landscapes, fish community health, biotic carbon, agricultural production
   2010-2044: natural landscapes, fish community health, biotic carbon, timber production, agricultural production
5. Identify the environmental indicators that increased. Are they abiotic or biotic? What was the change?
   Greenhouse gases – abiotic 0-51
6. Historically the human population in Alberta has increased exponentially. What impact does population growth have on water consumption?
   As population grows, water consumption goes up 0-55 and will go to 66 by 2044
7. 6. What impact does population growth have on agriculture? (Use specific values from the simulator dials).
   Agriculture 1884-1984 gained 22%/yr. (exponential growth) 1984-2014 declined by 0.15%/yr, 2010-2044 declined by 0.14%/yr
8. Explain the relationship between population growth and water consumption and population growth and agriculture. (Use specific values from the simulator dials).
   As human population increases, water consumption increases and agriculture decreases due to urbanization encroaching on agricultural land.
9. How does population growth impact the GDP in this area? (Use specific numbers from the dials of each time period.)
   As growth increased, 1884-1984 GDP grew from 0-38%, 1984-2010 it grew to 63%, and in 2044 GDP is expected to be 73%.
10. What can be done to keep water consumption at bay without affecting GDP? (Hint: Re-watch the Best Practices Video.)
    By implementing best practices such as low flow faucets in residential areas, watering restrictions, no tillage farming practices can be reduce water consumption by 30%.
11. Water consumption went up even though agriculture, the single largest user of water, went down. Explain.
    Industry and urban settlement use large amounts of water also.
12. What unintended consequence resulted from and increase in GDP and what is the impact on air and water quality?
    As GDP went up because resource development (mainly hydrocarbon production) went up, greenhouse gas emission also went up. As settlement area goes up, GDP goes up, however there is an increase in phosphorus runoff resulting in lower water quality.
13. Is there another measuring tool that can be used to replace GDP that measures social, environmental and economic well being? Explain. (Hint: Research Genuine Wealth Index)
    Measurements like Mark Aneilski's Genuine Wealth Index and David Suzuki's Sustainability Within a Generation Plan measure more than just GDP in measuring our well being.
14. What are Ecological Goods and Services? Give 2 specific examples.

Ecological Goods and Services include services we benefit from as a result of a healthy environment, such as water purification or carbon sequestration(removing or storing greenhouse gas emissions)

15. What conclusions about environmental and socio-economic indicators can be drawn from the changes in your study area?
    In general, socio-economic indicators go up at the expense of environmental indicators.
16. If historical rates continue, predict what will happen in your area in another 30 years.
    GDP and human population will continue to grow as a result of increased resource development and environmental indicators will continue to decline. Wastes will build up and ecological goods and services will continue to decline.

Part C: Optional Field Trip

Part D: Future Land Use Planning

1. Click on "Create New Scenario" Choose "Landuse"

2. Choose your study area, and then click "Next" (Remember, the smaller the study area the harder it is to see change.)

3. You are seeing the current land use.

4. What you see on the indicator dials are the levels as of 2020. Your first job is to set goals for 30 years from now. Move the goal slider to where you want the indicator to be in the year 2050. (if you are unsure of what the indicator is measuring, click on it and watch the video) Remember to set realistic goals.

5. Record Current values and goals on Chart 3 and Chart 4
6. Click "Next" You will now decide how you will reach your goals by changing the landscape. Click on "changes"
7.Choose the landscape type or landuse you wish to add in the future and click the location where you want it to grow.
ie, if you want to have more grassland in the future, click on the yellow grassland icon and then click on the map where you want to increase grasslands in the future.
Remember, the simulator will only allow that change to be made if it is possible to change the current landscape type/landuse to what you want.

8. Record the change you requested on Table 4. You may choose to adjust the level of Industrial Activity, which beneficial management practices you want to use, and which Climate Change scenario you wish to see, or save this step for later and click "Next".

9. Click "Run Scenario" and then click "Play"

10. Record whether you reached your goals or not (the goal dot will be green if you reached your goal, yellow if you got close, and red if you didn't reach your goal.)

Management Practices

Now click on Management Practices. Watch the management practice video. You must make a decision on how much industrial activity you want in the study area and what management practices you wish to use from this year on.

11. Move the Industrial Activity slider to the level you wish to see moving into the future. Record your level. _____

12. Choose which Management Practices you wish to use. Record this on Chart 4

If you still have not reached your goals, you can go back and change your goals by clicking on individual goals, or go back and make more changes to the landscape by clicking on landscape changes.

Analysis

1. How would you summarize your landuse plan? What were you trying to achieve?

2. Which goals were you not able to reach? Why or why not? What is the impact of not reaching these goals?

Summary Questions:

1. Give 4 examples of how our land-use affects the Biogeochemical Cycles.
   Cutting down trees decreases the amount of carbon dioxide that is taken out of the atmosphere, affecting the carbon cycle
   Fertilizers add too much nitrogen to the nitrogen cycle, leading to eutrophication of lakes and water bodies
   Combustion adds more carbon dioxide to the atmosphere, disrupting the carbon cycle.
   Mining of phosphorus from rocks and adding it as fertilizer adds more phosphorus to the phosphorus cycle, also leading to eutrophication.

2. Explain how technology can have both intended and unintended consequences for the environment and therefore humans.
   Technology often results in increased GDP, however may lead to a decline in environmental indicators. For example, a power generation plant will increase GDP and quality of life. The unintended consequence may be loss or fragmentation of wildlife and fish habitat, decrease in water and air quality, and disruption of biogeochemical cycles.

3. A land use trade-off occurs when decreasing one land use goal makes it easier to achieve another land use goal. Describe a land use trade-off that you encountered while building your sustainable land use plan.
   Answers will vary. For example, increased hydrocarbon production results in decreased natural landscapes and increase in greenhouse gas emissions. A trade-off may be to increase hydrocarbon production moderately, to lessen the impact on natural landscapes and GHG emissions. GDP will still increase, but in a more sustainable way.

4. Why do land-use tradeoffs make sustainable development challenging?
   Balancing the social economics with environmental indicators is difficult. There will be winners and losers.

CHART 1: Indicator Dials	1910	2020	2050
Natural Landscape			
Grizzly Habitat			
Fish Habitat			
Water Quality			
Biotic Carbon Storage			
Greenhouse Gases			
Population			
GDP			
Oil and Gas Production			
Forestry			
Agriculture			
Water Consumption			

CHART 2: Area	1910	2020	2050
Agriculture			
Grassland			
Water			
Wetlands			
Forests			
Urban Area			
Industry			
Alpine			

CHART 3: Dials	2020	My Goal	Result
Natural Landscape			
Grizzly Habitat			
Fish Habitat			
Water Quality			
Biotic Carbon Storage			
Greenhouse Gases			
Population			
GDP			
Oil and Gas Production			
Forestry			
Agriculture			
Water Consumption			

CHART 4: Area	2020	Change Requests	Result 2050
Agriculture			
Grassland			
Water			
Wetlands			
Forests			
Urban Area			
Industry			
Alpine			

Chart 5	Management Practices Used	Results	Comments
First attempt			
Second attempt			

Third attempt			

Presentation Marking Rubric:

	5 Excellent	4 Proficient	3 Satisfactory	2 Limited	1 Unacceptable
Presentation	Truly convincing	Somewhat convincing	Effort made to convince,	Limited to reading notes	No effort made to convince
Land use plan	Thorough understanding	Adequate understanding	Partial understanding	Limited understanding	Little or no effort made