Sustainable Island

Introduction

The idea of **sustainability** has become a core idea of environmental science. The idea is most often applied to humans and is generally defined as a goal of using available resources in such a way that the needs of today's generation are met without reducing the quality of life for future generations. The goal of sustainability is not met when natural resources are exploited at the expense of environmental quality.

In this exercise you will attempt to create an island environment that is sustainable for a minimum of 8 generations.

Your island will start with a fixed number of people and **resources** (water, land, energy). The water supply will be drawn from a lake on the island. The available land is considered the farmed and cultivated land on the island. The people of your island will meet their electric utility needs through coal-fired, hydroelectric, and nuclear plants and through alternative energy sources (the collective reference for solar, geothermal and wind energy).

The people of your island will have several employment options available to them. You must employ 75% of your island's inhabitants. People will work in either the industrial sector (assembly line, construction, day laborers, etc.), the service sector (computing, banking, law, etc.,), or the agricultural sector (farmers).

We will, once again, be using beans to represent the components of the ecosystem. Since every generation of people uses water, land and energy resources, your island will lose some of these resources (represented by beans) each generation while the number of people increases (usually).

If you exceed the quantity of any resources allotted (any type of bean), you have NOT created an environment that was sustainable and your island colony will die out.

Materials

- Navy beans, represent water
- Kidney beans, represent land
- Black beans, represent energy
- Black-eyed peas, represent people
- Cups
- Die

Procedure

1. **Setup**: You should start with the following types and

numbers of beans, each in their labeled cup. The starting numbers have been recorded in Table 1 for you. You will also have 4 empty cups labeled "'spent' water", "'spent' land", "'spent' energy", and "gone forever". At the beginning of each generation you will add to your island's population by taking black-eyed peas from a cup labeled "people reservoir".

- 70 navy beans (water)
- 40 kidney beans (land)
- 40 black beans (energy)
- 4 black-eyed peas (people)

2. **<u>BEFORE</u> you start EACH generation:** Your group must <u>decide</u> what type of 1) <u>energy</u> and 2) <u>employment</u> your people will be using. Record your choices in Table 1. Each type of energy and employment has associated with it different "costs" in terms of the impact on the water, land and energy resources of the island. Choosing wisely in the beginning will enhance your colony's likelihood of surviving for 8 generations. The costs associated with the energy and employment types are as follows:

a. energy types

i. coal-fired electric plant

1) each plant supports a <u>maximum of 10</u> people for their household needs and uses <u>per generation</u>
   i) 1 black bean (energy)
   ii) 2 kidney beans (land)
   iii) 1 navy bean (water)
2) for multiples of 10 people, an additional plant must be started with costs as indicated above

ii. **hydroelectric plant**

1) each plant supports a <u>maximum of 5</u> people for their household needs and uses <u>per generation</u>
   i) 1 black bean (energy)
   ii) 1 kidney bean (land)
2) for multiples of 5 people, an additional plant must be started with costs as indicated above

3) for every 2 hydroelectric plants installed, there is an additional cost per generation of
   i) 1 navy bean (water)

iii. nuclear power plant

1) each plant supports a maximum of 10 people for their household needs and uses per generation
   i) 1 black bean (energy)
   ii) 1 kidney bean (land)
   iii) 1 navy bean (water)
2) for multiples of 10 people, an additional plant must be started with costs as indicated above
3) due to the need to store radioactive waste, additional costs will incur every 3 generations of
   i) 1 kidney bean (land)
   ii) 1 navy bean (water)

iv. alternative energy

1) each alternative energy source supports a maximum of 4 people for their household needs and uses per generation
   i) minimal energy, charged as 0 black beans (energy)
2) for multiples of 4 people, an additional alternative energy source must be added with costs as indicated above
3) for every 3 alternative energy sources being used there is a cost per generation of
   i) 1 black bean (energy)

b. employment types

i) industrial plant

1) each plant provides a maximum of 10 jobs and uses per generation
   i) 1 black bean (energy)
   ii) 2 kidney beans (land)

2) for multiples of 10 jobs, an additional plant must be added with costs as indicated above

ii) service industry

1) each service industry provides a maximum of 10 jobs and uses per generation
   i) 1 black bean (energy)
   ii) 1 kidney bean (land)
2) for multiples of 10 people in a service industry, an additional service industry must be added with costs as indicated above

iii) farming

1) each farm provides a maximum of 4 jobs and uses per generation
   i) 1 black bean (energy)
   ii) 1 kidney bean (land)
   iii) 1 navy bean (water)
2) for multiples of 4 jobs, an additional farm must be added with costs as indicated above
3) due to soil erosion, there is an additional cost after 4 generations of
   i) 1 kidney bean (land)

3. **Working through the generation**. You will now work through a generation making adjustments to your resources according to the following guidelines:

a. general needs

1) to support their basic water needs, each person uses per generation
   i) 1 navy bean (water)

b. food supply

1) to support their food needs, every 10 people uses per generation
   i) 1 kidney bean (land)
   ii) 1 navy bean (water)
2) for multiples of 10 people, additional costs incur as indicated above

c. energy

1) apply the costs indicated in step 2 above depending on the type of energy you chose at the beginning of the generation

d. employment

1) apply the costs indicated in step 2 above depending on the type of

employment you chose at the beginning of the generation

e. waste disposal

1) one sanitary landfill (or incinerator) will support the needs of a maximum of 20 people and uses
   i) 1 kidney bean (land) for every 5 generations
   ii) 1 black bean (energy) every generation
2) for multiples of 20 people, an additional landfill or incinerator must be added with costs as indicated above

f. drinking and waste water treatment

1) each facility supports a maximum of 20 people for their water treatment needs and uses
   i) 1 kidney bean (land) for every 5 generations
   ii) 1 black bean (energy) every generation
2) for multiples of 20 people, an additional landfill or incinerator must be added with costs as indicated above

4. **Completing a generation**. At the end of the generation you will "balance the books" so to speak in terms of the long term impact the generation has had on natural resources. You will also adjust your population based on births, immigration, deaths and emigration. Apply the following steps.

a. water resource

1) since water is a renewable resources, you may retrieve all but 2 of the navy beans (water)
   i) the 2 that remain are lost due to evaporation and some contamination
   ii) you may regain 1 of these 2 water beans by implementing water conservation methods at the expense of
      a) 1 black bean (energy)

b. land resource

1) since land is ever present, you may retrieve all but 2 of the kidney beans (land)
   i) the 2 that remain are lost due to poor farming and construction

practices that lead to soil erosion and sedimentation

ii) you may regain 1 of these 2 land beans by implementing soil conservation methods at the expense of
   a) 1 black bean (energy)
   b) you may use this option of land conservation only 3 times during the 8 generations

c. energy resource

1) you may retrieve all black beans (energy) that were "spent" for alternative energy sources, since those are renewable sources of energy
2) you may regain 3 of the remaining black beans (energy) by implementing energy conservation measures (such as energy efficient lighting and appliances, regulated thermostats, recycling, etc.) at a cost of
   i) 1 black bean (energy)
   ii) you may use this option of energy conservation only 3 times during the 8 generations

d. population adjustment

1) multiply the number of people present at the start of the generation by 1.75 and add the resulting number (rounded to the nearest whole number) of black-eyed peas (people from the people reservoir) to your current population
   i) this represents the increase to your population as a result of births and immigration
2) multiply the new number of individuals in your population by 0.2 (20%) and remove the resulting number (rounded to the nearest whole number) of individuals from your population (they can be returned to the people reservoir)
   i) this represents the decrease in your population as a result of deaths and emigration
3) the resulting number of people will be the number of people that will start the next generation

5. You have now completed the generation. *Any beans (water, land, or energy) that remain in the "spent" cups are now to be discarded forever in the "gone forever" cup.*

6. Before starting the 2nd generation. You may change your selection of energy and employment types. Record any changes. Proceed through generation 2 following the same procedures outlined in steps 3 through 5 above.

7. Before starting the 3rd generation. You may change your selection of energy and employment types. Record any changes. Proceed through generation 3 following the same procedures outlined in steps 3 through 5 above.

8. Before starting the 4th generation. You may change your selection of energy and employment types. Record any changes. Proceed through generation 4 following the same procedures outlined in steps 3 through 5 above. **ADDITIONALLY**, roll the die one time. Record the number in Table 1 in the row immediately under the generation number. The results of this roll of the die will determine the manner in which your population increases in size at the end of this and subsequent generations.

a. roll of 1, 2, 4, or 5
   1) at the end of this and all subsequent generations, your population will increase by a factor of 1.75 as in all previous generations
   2) record this result in the appropriate columns (generations) in the row for population increase

b. roll of 3
   1) at the end of this and all subsequent generations, your population will increase by a factor of 1.35 (instead of 1.75)
   2) record this result in the appropriate columns (generations) in the row for population increase

c. roll of 6
   1) your population will not increase in size at the end of this or any subsequent generation
      i) only the death rate of 20% will be taken into account at the end of this and each subsequent generation
   2) record this result in the appropriate columns

(generations) in the row for population increase

9. **Before starting the 5th, 6th, 7th and 8th generations. You** may change your selection of energy and employment types. Record any changes. Proceed through these generations following the same procedures outlined in steps 3 through 5 above (making the population adjustments indicated in step 8 above). If at any time you run out of **ANY** beans, your colony will die out due to a lack of a critical resource. If that happens, DO NOT continue on to the next generation. Indicate on Table 1 then generation in which resource ran out.

Sustainable Island LAB WRITE-UP: Submit pages 9-12

Student Name: _____ **Lab Date:** _____

Lab Instructor: _____ **Section #:** _____

Table 1. Results of 8 generations for population and resource impacts.

Generation #:	1	2	3	4	5	6	7	8
Roll of die:								
# people-start of generation	4							
Employment- type selected								
Energy- type selected								
Available water	70							
Available land	40							
Available energy	40							
Water used: General								
Food								
Energy								
Employment								
Land used: Food								
Housing								
Energy								
Employment								
Waste disposal								
Water Treatment								
Energy used: Energy								
Employment								
Waste disposal								
Water treatment								
Population increase	X1.75	X1.75	X1.75					
Deaths (-20%)								
# people at end of generation								
Colony survives? (yes or no)								

Figure 1 Population size versus generation.

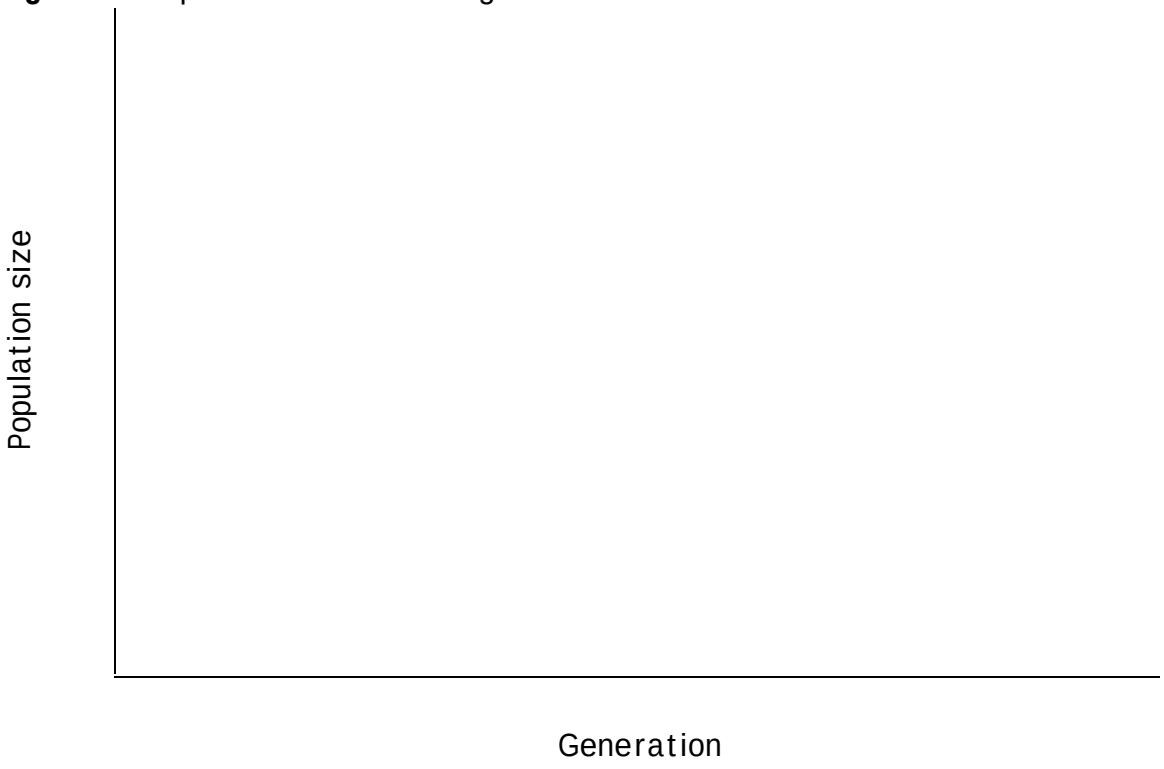


Figure 2. Water use versus generation.

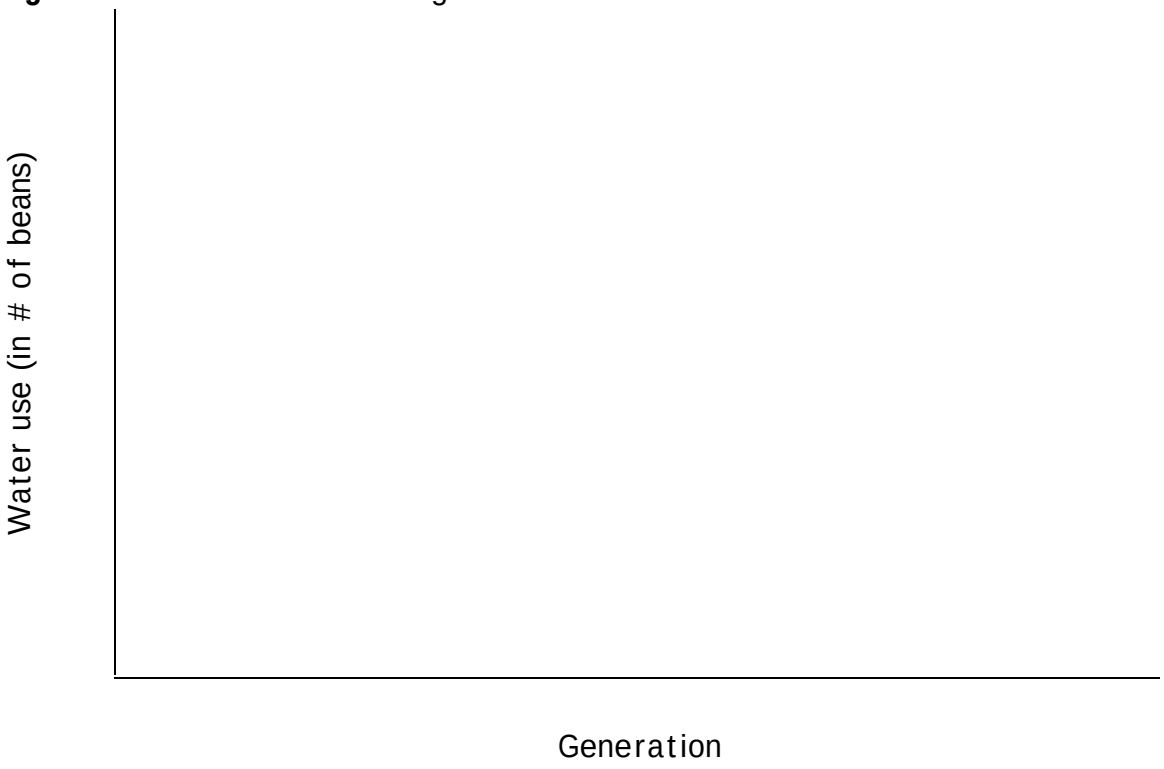
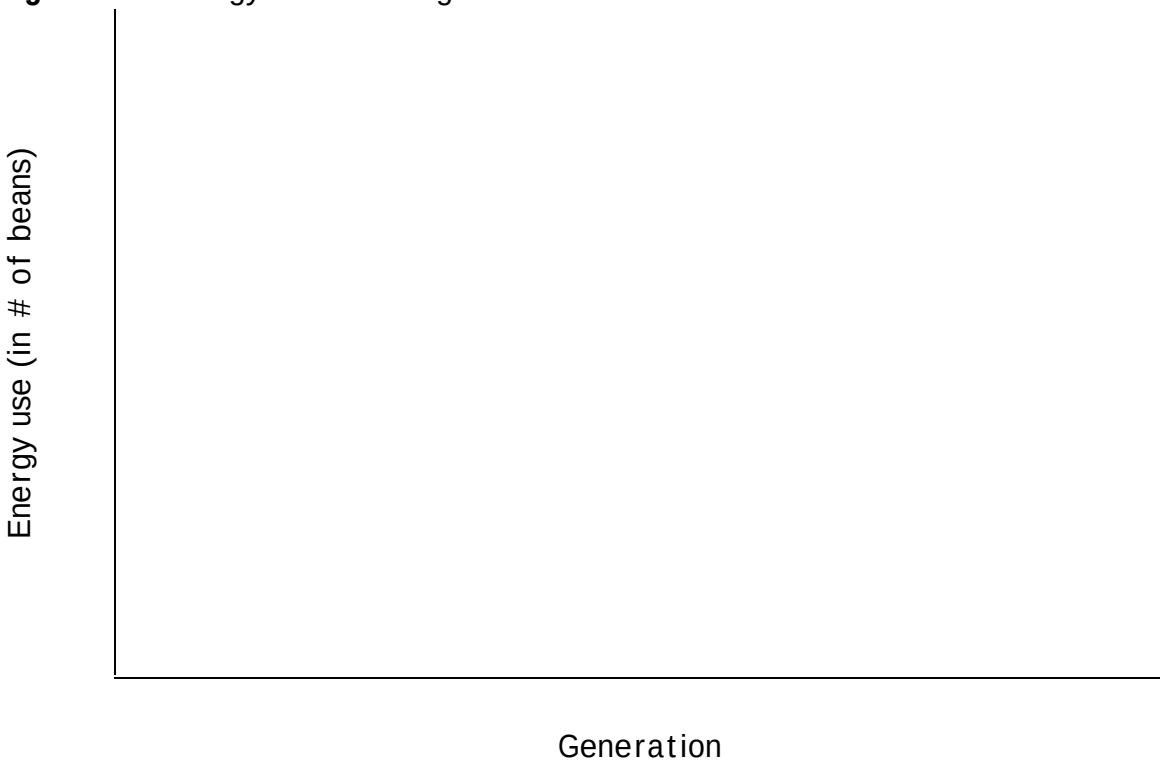


Figure 3. Land use versus generation.

Figure 4. Energy use versus generation.



Conclusions (Questions)

1. Write a summary that explains your choices of energy type, employment type, and conservation measures over the course of the generations and the consequences of those choices. Discuss whether or not your colony died out, and, if so, when and why. Include alterations you would make in your choices if you were to do this activity again and why.