Perspectives of Conservation

NATURE Sunday Academy 2017-2018

Project Description:

In this workshop, students will learn about the relationship between the view of the ecosystem from native perspectives and the human dependence on this ecosystem and modern techniques used to indulge in this dependence. The native perspective will be compared with the approaches of scientists who have spearheaded conservation efforts, and with quantitative measures for assessing conservation such as the Ecological Footprint. The concept of overshoot, which underlies the Ecological Footprint, has many parallels in conservation biology. Students will get to experiment with the mathematical modeling of predator-prey dynamics by modifying computer code. Students will, furthermore, create and analyze fractal structures that are relevant to the study of the environment. The coastline of Lake Sakakawea, will be used as an example.

Project Objectives:

The workshop focuses on the idea that the ecosystem works in a cyclical manner. The idea is that everything works together in a healthy, well-functioning ecosystem and if one item is out of place, the whole ecosystem can show the consequences. In current times, the demands we, as people, put on the environment sometimes skews the cylindrical effect in one direction or the other.

Environmental footprints are one approach for assessing whether our impact on the biosphere exceeds acceptable thresholds, which corresponds to the concept of. Students will get to explore the concept of overshoot for the example of predator-prey modeling. They will simulate the abundance of predator and prey by modifying a computer program, and will get direct experience with dynamical systems.

As a related topic, students learn about fractals and the idea that some structures are best described by dimensions that are not integers. E.g., if one were to ask the question how long the shoreline of Sakakawea is, one would have to specify the resolution of the map, because the resulting length would be different for different resolutions. Such concepts are important for understanding environmental structures in general. Students will get hands-on experience creating and examining fractal structures (see Appendix).

The workshop also allows students to experience the general concept of computer programming in a context that is fun, and is directly relevant to tasks for understanding the environment. Students will use actual computer code that was designed such that they can change the behavior of the code without need for programming experience.

Session Organization:

11:00-11:30 *Cultural connection/brief introduction*
11:30-12:00 *Circle of Life*
12:00-12:45 *Lunch*

1:00-1:45 *The Dynamics of Conservation Science*
1:45-2:30 *Fractal Dimension of Landscapes*
2:30-3:00 *Wrap up*

ND State Science Standards:
9-10.1.1. Explain how models can be used to illustrate scientific principles
9-10.1.2. Describe the interaction of components within a system (e.g., interactions between living and nonliving components of an ecosystem, interaction between organelles of a cell)
9-10.2.3. Identify questions and concepts that guide scientific investigations
9-10.4.11. Explain how matter and energy flow through living and nonliving components in an ecosystem (e.g., carbon cycle, water cycle, nitrogen cycle)

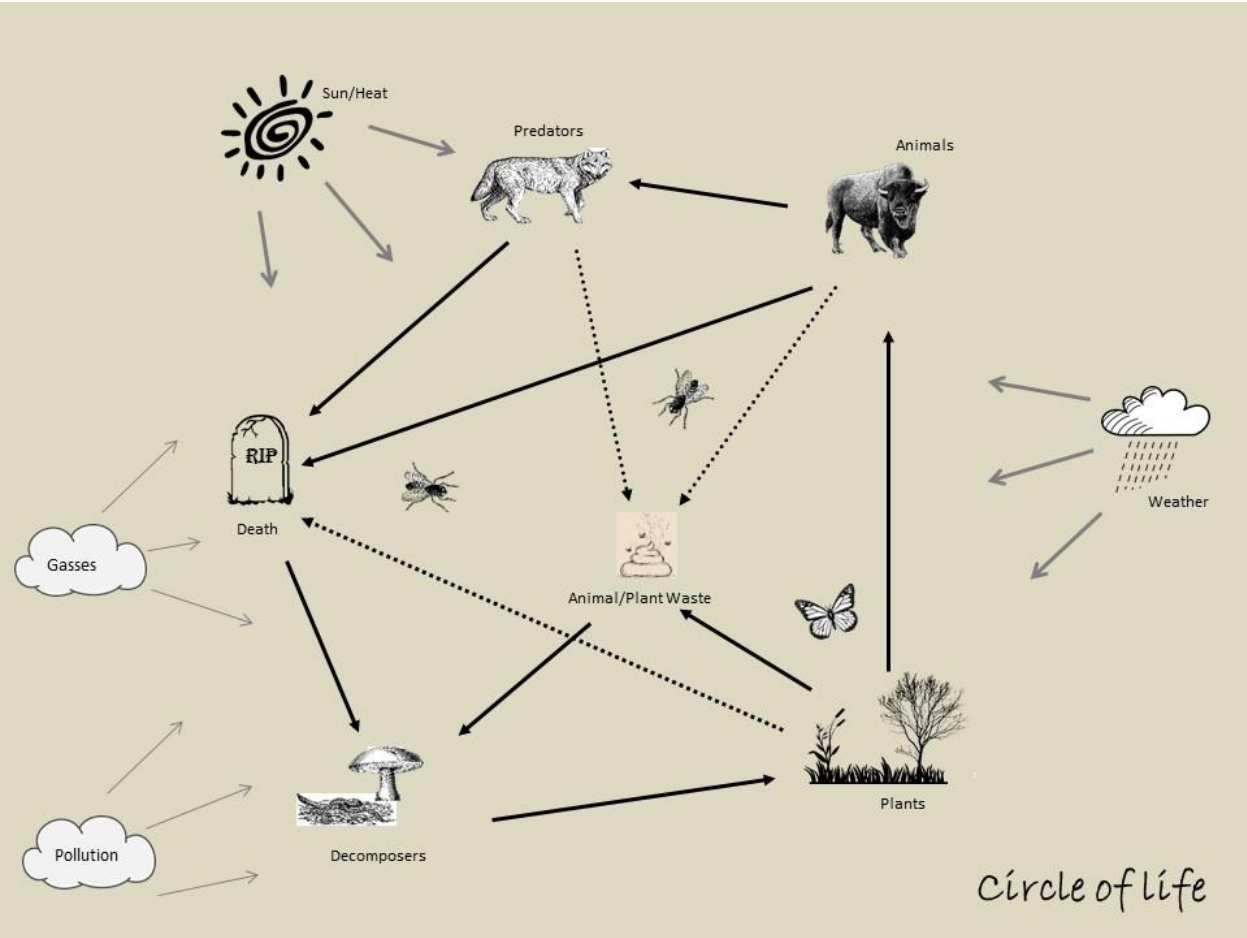
Materials and Equipment:
Computer access
- Python with packages Numpy and Image would be helpful but web-based environment Repl-IT would work
- Need for ArcGIS or Google Earth TBD

Activity I:

The Circle of Life

The circle of life is a concept that teaches everything thing on earth works together to create balance. Every part of the ecosystem, good and bad, have a part in the circle. Native peoples from all over the world have similar teachings on how the ecosystem work, the yin-yang circle and the medicine wheel are two examples. When parts of this circle are disrupted or taken away, it affects how everything on the circle works together. Some of the disruptions are able to be healed over time, but other disruptions change how the circle functions and the balance will falter.

The circle can be viewed more as an orb or ball with lots of connecting fibers that connect everything together. All parts of the ecosystem are involved, including sunlight, gasses, weather, animals, plants, etc. Pollution and other man-made factors also factor into how the circle is balanced. Each component effects multiple other components in the circle, nothing effects just one thing.



C.Duafala 2016

Questions:

1. What are some examples of a food web or food chain failing?
2. Can you think of some traditional stories that try to explain the circle of life? Give one example.
3. What is the difference between a traditional story about the circle of life and an ecological circle of life?
4. In what ways do we, as humans, alter the circle?
5. Are all alterations bad? Why or why not.

Activity:

This activity needs to be done either in a room free of desks or move desks to the outer walls of the room.

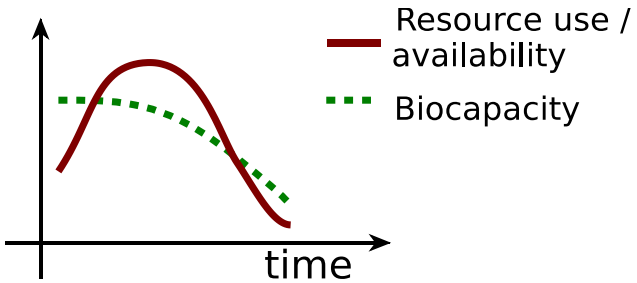
- Ask for 4 volunteers from the students and have these students stand facing each other with shoulders touching. Ask them to stand on one leg while holding the other leg up.
- Have the rest of the students form 'rings' around the first group with their shoulders touching. Ask them to stand on one leg while holding the other leg up. They should put their remaining hand on the shoulder of the person in-front of them. Do this with the remaining students in rings.
- The students that are not able to form a complete ring will be acting as an additive component to the circle (i.e. smog, garbage, greenhouse gasses, etc.).
- Select a biological component to be removed from the circle. Examples of this component could be aphids, mosquitoes, predators, deer, trees, flowers, etc.). Randomly select one student from the circle to be this component and have them be removed from the circle. This student wouldn't have to move, but rather crouch down.
- Continue to select more biological components (they may be the same) to be removed and select students to be those components. Have them crouch down. The question they are looking at is "*how many components or how much of one component can be removed before the balance of the circle falters*?"
- Have some of the students stand back up and be part of the circle again (with only one leg).
- Add in a student who is an additive component. Have this student slowly push their way into the circle. *Will the circle remain balanced on one leg or will the circle start to falter? How far does the student have to push in before the circle falters?*
- If one student makes his/her way in and the circle is still balanced, add more of the additive components into the circle to see how much makes the balance falter.

Activity II:

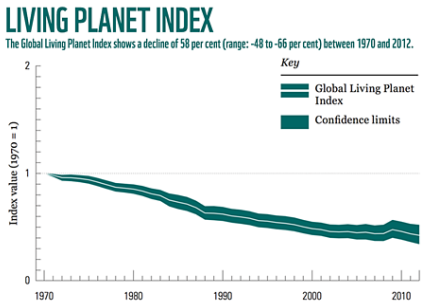
The Dynamics of Conservation

Needs of our Planet

- Needs of future life
  - Prevent overshoot
  - Globally, we currently use about 70% more resources than sustainable
  - In the US we use about 7 times as much

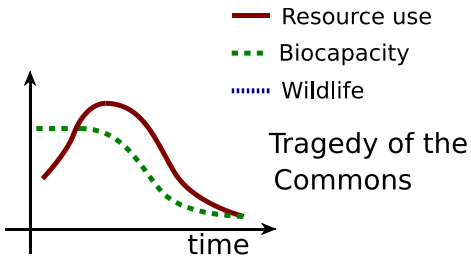


- Needs of nonhuman life
  - Work on preventing decline of wildlife indices



The Tragedy of the Commons

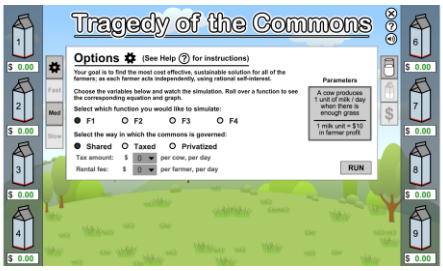
- When resources are shared every individual may benefit from adding more than is good collectively
- Imagine a meadow that can feed 30 cows, but 5 families each have 10 cows
  - How many cows should each family sell?



  - If you were one of those families, would you sell those cows?
  - What if only you sell and not the other families?
  - What happens when the number of cows is not reduced?
  - How about the soil?

- Consider climate change
  - We know we produce too much CO2
  - Yet, to do our jobs, we all benefit from travelling …

Play the game at: https://blossoms.mit.edu/legacy/tragedy/index.htm



- Play game once without making changes
  - Stop when doing so is suggested
  - At that point no more profit is made
  - You can pick any of the functions

- Try different values for taxes, e.g. 10, 9, 1
  - Again stop when asked
  - What is the result for 10?

  - What is the result for 9?

  -
  - What is the result for 1?

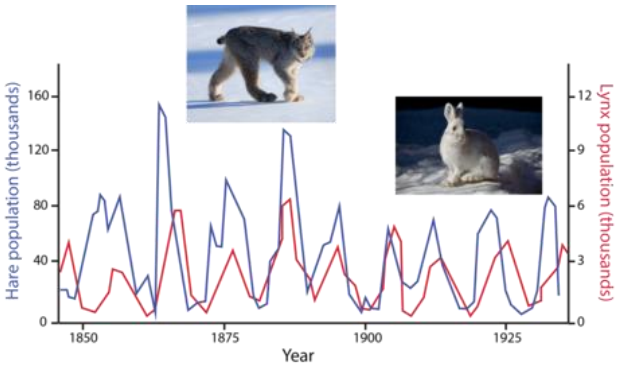
- Try privatization with different values for rent and taxes, including none
  - What happens with privatization?

  - Do rent and taxes matter?

  - Is privatization realistic for the atmosphere, i.e. greenhouse gases?

Predator-Prey Dynamic

- Overshoot also happens in nature
  - Time delay before effects are felt
- Imagine people who depend on fishing and the number of fish drop
  - This is why we have hunting and fishing quota for some regions and species
  - We would not like human populations to drop like those of Canadian lynx!



Try it out!

- http://www.phschool.com/atschool/phbio/active_art/predator_prey_simulation/
- Click on the "Next" button a few times. What happens?

About Mathematical Models

- Tragedy of the Commons model
  - Effects felt immediately
  - All damage was permanent
- In the Predator-Prey Model
  - Effects were delayed
  - Prey species bounced back
- What happens really, for example for over-fishing or climate change??

Let's use Programming

- Open Windows Explorer
- Locate Lexar drive
- Go into WinPython folder
- Double-click IDLEX
- Select File -> Open

In SA_PerspectivesOfConservation

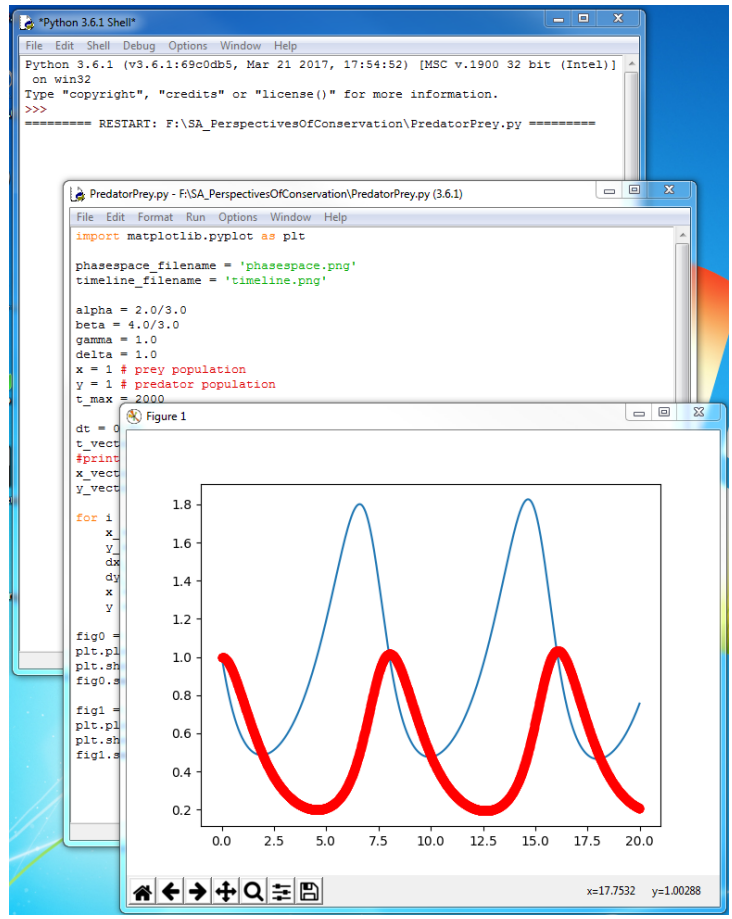
Open PredatorPrey

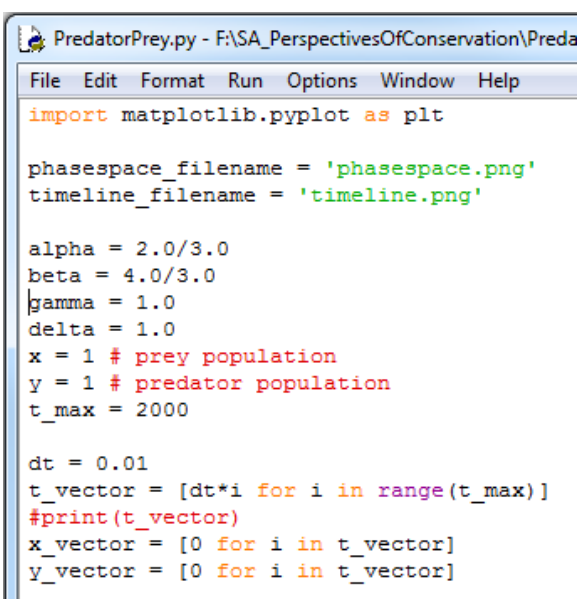
- A new window PredatorPrey.py should open
- For the new window

In tab Run

Select Run Module

- You should see one figure and when you close it, another
- Describe what you see





- Try changing parameters!
- If you get strange results, you can always go back to the original ones
- Hint: Place a # in front of anything you want to hide from Python
- E.g. to change alpha to 1. and remember that it was 2./3. do the following
- alpha = 1.0 #2.0/3.0
- Try beta = 10.

The Ecological Footprint

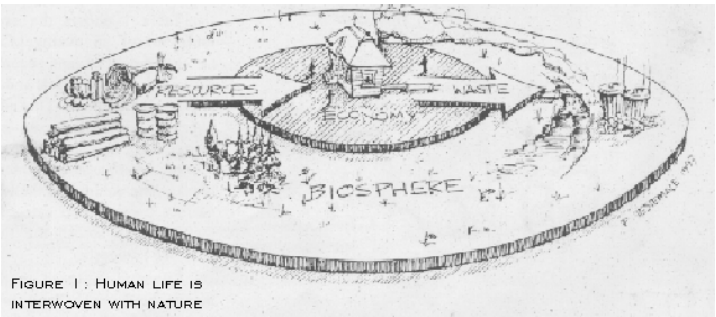


FIGURE 1: HUMAN LIFE IS INTERWOVEN WITH NATURE

- How much area is necessary to feed a city and absorb its waste?
  - Divide that area by the available area
  - Globally result is 1.7
  - In the US it is > 7
- How possible?
  - Time delays
  - Tragedy of the Commons
- Other environmental footprints address specific water, CO_2, etc.

Go to http://www.footprintnetwork.org/resources/footprint-calculator/ and determine your ecological footprint

Activity III:

Fractal Dimensions of Landscapes

- How would you measure the shoreline of Lake Sakakawea?

Koch Snowflake

- Go to the following three links
  - https://en.wikipedia.org/wiki/Koch_snowflake#/media/File:KochFlake.svg
  - https://en.wikipedia.org/wiki/Koch_snowflake#/media/File:Von_Koch_curve.gif
  - https://en.wikipedia.org/wiki/Koch_snowflake#/media/File:Kochsim.gif
- Mathematically has fractal dimension log(4)/log(3) ~ 1.26

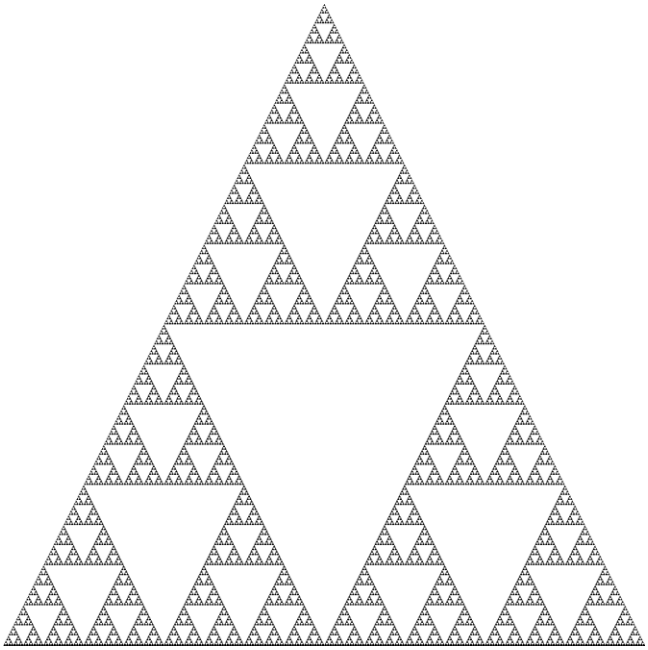
- Draw a Koch Snowflake yourself
    - Draw a triangle
    - Draw a triangle on top of the middle third of each side
    - Repeat for each of the three pieces of each side
    - Try one more iterations
    - How many iterations can you do?

- Now try to draw Koch triangle directly without the extra lines in the middle

Sierpinski Triangle

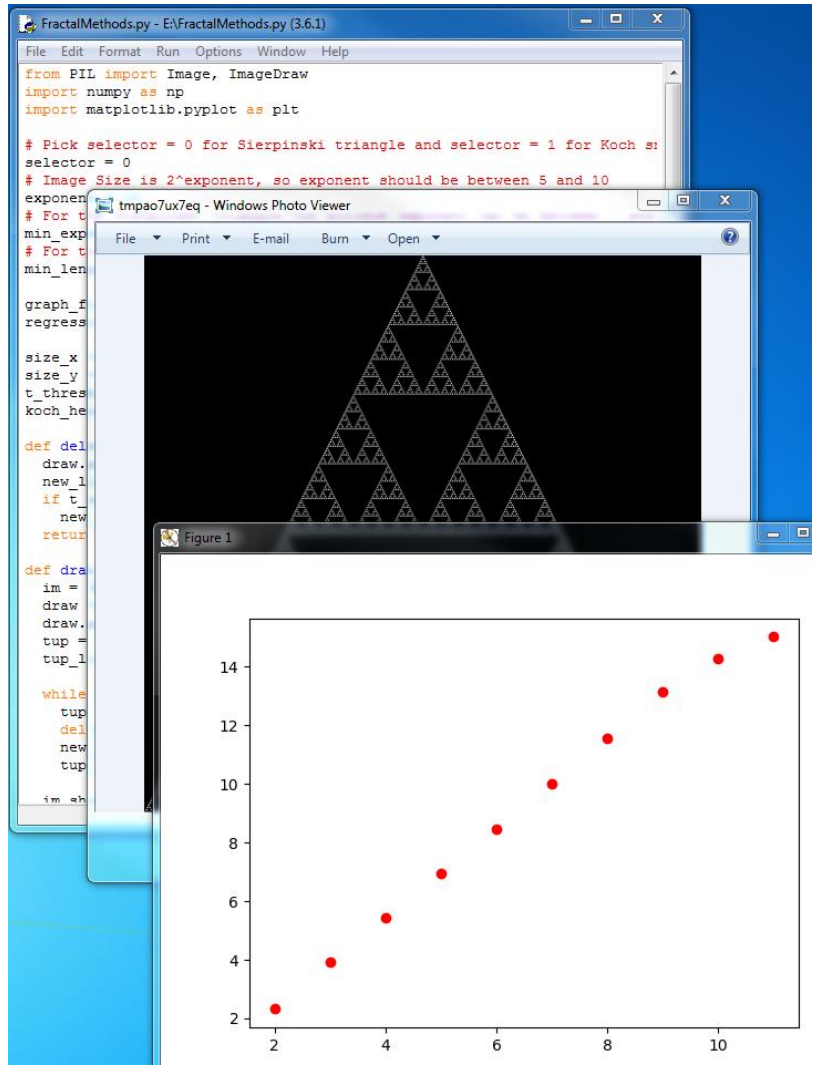
- Fractal structures can also be constructed by starting from the 2-dimensional plane
- Start with triangle in large area below
- Draw upside-down triangle inside
- Repeat as often as you can
- How many iterations did you do?

- Fractal dimension log(3)/log(2) ~ 1.59



Doing the same thing using programming

- Make sure IDLE is open
- In IDLE, open FractalMethods.py
- Run Module
- Try picking a larger min_exponent_sierpinski, e.g. 3
- What happens



What is the fractal dimension?

- Let's look at the graph with the red dots
- Fractal dimension is the slope of that line
- Can you estimate that slope?

- Close the graph and look at the IDLE window
- Can you find the fractal dimension in the output?

Doing the same for Koch Curve

- Now change selector = 0 to selector = 1
- Run again
- You should now see a Koch Snowflake
- What is the fractal dimension now based on the graph?
- Does the output in the IDLE window give the same result?
- Try changing min_length_koch to 100

Wrap-Up & Discussion:

1. How were the concepts of STEM used in today's activity?

2. What was the most successful idea you used in the activity?

3. What did you try in the activity that did not work?

4. Why do think it did not work?