Go Beyond: Thinking in Systems Part 2
Concentrating Phosphorus in Space and Time

**Systems and Cycles**
Systems and cycles form an important part of science. A system is the setting in which cycles occur. A cycle can be changes in state, such as the water cycle: for example, liquid to solid to gas and back again. A cycle can also be a change in life phase such as the life cycle: birth to adulthood to reproduction, then death. Cycles can also involve changes in composition, such as the carbon cycle could involve the change of CO$_2$ to CH$_3$O + O$_2$ (organic matter) to decomposition, where carbon is broken down and released as CO$_2$ or CH$_4$. Systems include both a cycle and all the factors that may influence the cycle. In order to study and better understand them, systems can be represented by simple models.

The basic idea of this activity is to develop a systems model with inputs, outputs, stocks (or “pools”), and flows (or “fluxes”).

In the series of videos on phosphorus, Dr. Crews uses a technique common to many scientists to simplify a complex system for further understanding it or better communicating it to others. In this activity you will think about how to use a simple model to illustrate a complex system found in your everyday life.

In part 1 (see How did phosphorus shape early agriculture?: Crews Video 2/3), you diagramed this system in its simplest form, assuming the system is fully functioning. In part 2, you will think about what can cause this system to not work well, adding complexity to your simple model to use it as a tool to explain the cause of proper/improper functioning.

**Part 2: Manipulating a System**
The idea of this activity is to continue development of a systems model created in Thinking in Systems Part 1 with inputs, outputs, stocks (or “pools”), and flows (or “fluxes”). In this part, you will begin to manipulate your system in ways comparable to how traditional farmers discovered techniques to augment the cycle of phosphorus.

**Rationale/Overview**
Recall the simple system you developed in Part 1.

The example system used in Part 1 was a city bike share system, where stations for specific types of bikes are installed throughout a city, bikes are shuffled around the city by users making one-way trips from place to place, and bicycles leave the system either by getting stolen or decommissioned. In this exercise, you will be asked to consider ways to augment your system in ways that allow for higher productivity or operability within that system all the while operating within limits to growth that you identify.
INSTRUCTIONS
1. Think about all the dimensions of your system from start to finish. Write down all the pressures for growth on the system as well as all the limits within that system to growth.

2. Identify strategies that respond to each of the pressures for growth you listed that are sensitive to the limits to growth you noted. Think about the strategies used in traditional agriculture that Tim Crews described as analogies to strategies that you may choose to implement in your system.
3. Augment your system map to describe how strategies affect the performance of the system. Use additional visuals as needed.

4. When you have finished, graph a potential change within your system based on one of the pressures or limits you described. In the bike system example, you might project growth of bike numbers if the population grows by 10% over the next 15 years. What other factors might play a role and keep your line from being a simple increase or decrease? For our bike share program, an increase in population might also lead to an increase in bike theft. If you were graphing the current phosphorus cycle, do you think that the pool of phosphorus in the soil would be growing, shrinking, or neither? What are the factors influencing this system?

5. How is your system similar to a natural system like the phosphorus cycle? How is it different? Share your ideas with a friend or record them in your science journal.