How did phosphorus shape early agriculture?

Active Listening Questions:

- What are some differences between pre-industrial and current industrial agriculture?
- What is the purpose of fertilizer in modern day farming and why is it considered to be an essential part of modern civilization?

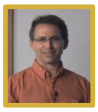
WHAT: In this clip from the 2009 public presentation "Agriculture After Norman Borlaug," Dr. Crews presents a depiction of what agriculture looked like in pre-industrial times— the period of agriculture before fossil fuel-powered equipment was used to manipulate and manage croplands. Dr. Crews describes significant shifts that happened once humans transitioned from hunter-gatherers to becoming farmers of increasing sizes of land, intentionally planting, tending, and harvesting crops for the purposes of food production.

HOW: In this clip, Dr. Crews builds upon a simple model of the phosphorus cycle in native ecosystems to illustrate the changes to the phosphorus cycle in soils changed as a result of pre-industrial agriculture. Ecologists often refer to a model like this as a budget because, like a financial budget, it tracks the influx and outflow of resources into a system. Such budgets help us to understand which ecosystems may be receiving different amounts of a nutrient than were previously available or alter ecosystems to grow larger or more productive crops than would have otherwise been possible.

"[EARLY] AGRICULTURE HAD TO PLAY BY THE SAME ECOLOGICAL RULES AS NATIVE ECOSYSTEMS."

WHY: Although Dr. Crews and other agricultural ecologists were not alive to study agriculture practices or impacts during pre-industrial periods, they are able to combine their knowledge of physical processes, such as the forces of erosion and leaching, with artifacts and traces left by civilizations practicing pre-industrial agriculture to come to conclusions illustrated in the simple model. Additionally, some societies around the world still practice agriculture in ways very similar to practices carried out centuries ago, providing more support to these conclusions.

SO WHAT: Despite agriculture's essential purpose to provide a stable food supply, it is often taken for granted. Yet scientific study of agriculture enabled advances that allowed agriculture to keep up with soaring population rates in recent decades. Agricultural ecologists like Dr. Crews study agricultural in an ecological context in order to make additional advances in the productivity of crops while considering the impacts such farming might have on surrounding natural ecosystems.



BIO: Tim Crews is the Director of Research and Research Ecologist at The Land Institute. Dr. Crews is interested in the ecology of agriculture. Specifically, his research focuses on how prairie ecosystems maintain soil fertility and how these insights can be applied to the need for fertilizer inputs.

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TAKING THE REINS

Discussion Questions:

Discuss with a friend or record your thoughts in a journal.

- How has the availability of mined and chemically produced fertilizer changed how people farm?
- What are some of the benefits of chemically produced fertilizers, and what are some of the downsides?

Quiz Questions:

Quiz 1. The use of fertilizer to provide additional phosphorus and other nutrients for plant growth has been a dominant feature of human agriculture for most of its 10,000 year history.

a) True
b) False

Quiz 1. Pre-industrial agriculture altered the native ecosystems it replaced in many ways. Which of the following was NOT a common alteration?

a) Perennial plants were replaced with annual plants.
b) Nutrients were removed from the soil at an accelerated rate.
c) Lands cleared of vegetation absorbed more phosphorus.
d) A variety of plant species might be replaced with a single or just a few plant species.

Glossary Term: System

A set of components that interact in a pattern or cycle that has certain known behaviors and responds to changes in any of the components or driving forces.

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GO BEYOND: Thinking in Systems: Part I

Complete this activity and record answers and thoughts your science journal or discuss with a friend.

Thinking in Systems

In the series of videos on phosphorus, Dr. Crews uses the scientific technique of simplifying a complex system to better understanding or communicate 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.

INSTRUCTIONS:

1. Think of a system in your everyday life that sometimes works well and sometimes doesn't work well or at all.
2. Take a picture of or draw something that represents that system. Put that image in a power point slide, like Dr. Crews did. *Alternatively, images and can be added to a science journal.*
3. Identify the basic function of the system and basic flows in and out of system. Flows might be money, energy, parts of a product, or something else. Add flows to your image as arrows. If you have numbers for each aspect, be sure to include these numbers clearly.
4. Identify places in the process where your moving component (energy, money, ect.) might be lost or changed into something new.
5. What processes that happen within the system might affect its functioning? What would slow down or speed up the process? Is there anything that would shut the system down altogether?
6. Think about ways that people, even you, could alter or improve this system to get a desirable outcome. Share your ideas with a friend or in a journal.

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Go Beyond: Thinking in Systems: Part I -continued

Example: Some cities offer a bike-share system to help residents and visitors get around without using cars or buses. In such systems, bikes are the item moving throughout the system (like phosphorus through the air and soil). Although, unlike phosphorus, the bikes (hopefully) do not change form: they move from one area to another within the bike system, and under special circumstances (purchase or theft) bikes may join or leave the system altogether.

Further Reading

Complete PowerPoint "Agriculture After Norman Borlaug" is available on the AGCI website.

Crews, Timothy E., Kanehiro Kitayama, James H. Fownes, Ralph H. Riley, Darell A. Herbert, Dieter Muller--Dombois, and Peter Vitousek. 1995. "Changes in Soil Phosphorus Fractions and Ecosystem Dynamics across a Long Chronosequence in Hawaii," *Ecology,* Vol.76, No. 5 (July, 1995). Ecological Society of America, pp 1407--1424. http://www.jstor.org/stable/1938144