Phosphate Mining: Borrowed Land

A middle school grade level unit
created by

Teresa Urban
Lawton Chiles Middle Academy
Polk County, FL
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Unit Summary

Dear Teachers,

I believe that middle school students know that human activities have had an impact on the global environment; erosion, deforestation, water quality, etc. They have watched television documentaries and movies that depict the destruction of large areas of tropical rain forests. Students read about water pollution and soil erosion in textbooks. Do we want to simply tell students about global environmental problems and assume they will become good stewards of the land? Let’s bring these issues down to the local level and allow students to get involved and actually participate in environmental problem solving.

This unit is designed to provide students with hands-on experience working on a local land area that has been disturbed by either phosphate mining, farming, development and other human activities. Using technology applications they learn about phosphate mining processes, natural communities where the mining takes place, and the methods and trials associated with land reclamation. Using this knowledge students create a working plan to improve a disturbed land site.

The learning lessons for Phosphate Mining: Borrowed Land include the following key activities:

- Phosphate mining in central Florida, manufacturing crop nutrients and land reclamation learning video and technology application.
- Using GPS technology to simulate core hole sampling techniques used by geologists to locate and measure phosphate deposits before mining.
- PowerPoint lesson on earth’s elemental cycles with a technology application on the phosphorus cycle.
- On-site learning activity where students recognize various natural communities and their characteristics with a follow-up technology application.
- Learning activity—game style—where students understand the role of phosphate mining companies to preserve the habitat of the endangered gopher tortoise and learn about reclamation technology.
- A culminating activity where students plan and implement a reclamation-type project to improve a small land area either on school grounds or a nearby park or wildlife preserve.

Eighth graders at LCMA have participated in these activities. The student-created video documents (Resource CD)—Gopher Tortoise and Cogongrass: Invasive Plants—show how these students enthusiastically participated in a local reclamation project. They were proud to participate in a project that allowed them to create a solution to a local environmental problem. Students seemed to appreciate the trials and challenges of the scientists and experts working on land reclamation.

For suggestions about local areas to visit and funding for supplies and field trips contact me via email: teresa.urban@polk-fl.net.
Phosphate Mining: Borrowed Land

Perspective

Phosphate is mined in Florida and is an integral part of the economy of Central Florida. Phosphate is used to make fertilizer used for agriculture, returning phosphorus to the soil so crops can grow. When the crops are consumed phosphorus returns to living things to fuel biochemical processes in cells and make deoxyribonucleic acid (DNA). Phosphate is also used in thousands of other common household items and plays a key role in our everyday life. As we mine phosphate to support our economy and our daily life, the environment is disturbed and human activities such as this impacting the global environment.

Humans have a major impact on the global environment. It is up to humans to fix the negative impacts we cause. Our impact on the global environment not only affects our species but also affects entire habitats and the plant and animal species that live within them. The word global can give the impression that the solution should be someone else’s problem. However, human impact begins on the local level. In Florida, the land has been disturbed by mining, farming, and other human activities. Florida law requires that some of the environmental problems be solved. Mining has been regulated and since 1975 reclamation is mandatory. Further information on reclamation and regulations can be found on our webpage at http://www.fipr.poly.usf.edu.

This unit should benefit teachers by making the issues we face local, so their students can become a part of the solution to the environmental problems we face in Florida. The unit begins with the mining process but also teaches about the natural communities where the mining is taking place, and finally explores reclamation of the natural communities that were mined. This demonstrates that the land mined is just as important as the phosphate that came out of it.

Teresa Urban has used the information she has learned about phosphate mining and reclamation as both an attendee and facilitator at our FIPR Institute Summer Workshops to create this unit with her eighth grade students. Students used scientific inquiry to understand the value of land during mining by using technology such as GPS to simulate the core sampling techniques used by geologists. A lesson on the role of the phosphorus cycle in a natural community allows students to understand the characteristics they will encounter during an on-site natural community learning activity. They will then go in depth and focus on a species that is endangered in Florida, the gopher tortoise in order to understand the role of phosphate companies in the preservation of habitats. Finally, the students will demonstrate all they have learned by planning and implementing a reclamation-type project in their community.

This unit will help both teachers and students understand the entire process of mining in relationship to the land that is being borrowed and will bring local awareness to this global issue.
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Concept Map

Directions: Develop the web below with your students as you progress through this unit. Show it on an overhead or draw it on chart paper. Students will want to refer to it as you build on their knowledge base. Completing a concept map is an effective way to show students how much they have learned.

Phosphate Mining: Borrowed Land

The phosphate industry utilizes modern technology, such as GPS, to increase the efficiency of extracting phosphate rock.

Phosphate mining and processing have an impact on the environment.

Florida and its habitats and wildlife have evolved and changed. The phosphate industry must know the natural ecosystems and reclaim the land to useful wildlife habitats or other purposes after mining.

Phosphate is an essential mineral that all living things need to survive and grow.
Next Generation Sunshine State Standards

Science Benchmarks

SC.6.N.1.4 Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation.

SC.7.E.6.2 Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and sub-surface events (plate tectonics and mountain building).

SC.7.E.6.6 Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water.

SC.7.L.17.1 Explain and illustrate the roles of and relationships among producers, consumers, and decomposers in the process of energy transfer in a food web.

SC.7.L.17.2 Compare and contrast the relationships among organisms such as mutualism, predation, parasitism, competition, and commensalism.

SC.7.L.17.3 Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation.

SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.

SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.

SC.8.L.18.3 Construct a scientific model of the carbon cycle to show how matter and energy are continuously transferred within and between organisms and their physical environment.
Cite evidence that living systems follow the Laws of Conservation of Mass and Energy.

Explain that science is one of the processes that can be used to inform decision making at the community, state, national, and international levels.

**Language Arts Benchmarks**

LA.6.3.5.2 The student will use elements of spacing and design for graphics (e.g., tables, drawings, charts, graphs) when applicable to enhance the appearance of the document.

LA.6.4.2.2 The student will record information (e.g., observations, notes, lists, charts, legends) related to a topic, including visual aids to organize and record information and include a list of sources used.

LA.6.4.3.1 The student will write persuasive text (e.g., advertisement, speech, essay, public service announcement) that establishes and develops a controlling idea, using appropriate supporting arguments and detailed evidence.

LA.6.4.3.2 The student will include persuasive techniques (e.g., word choice, repetition, emotional appeal, hyperbole, appeal to authority, celebrity endorsement).

LA.6.5.2.1 The student will listen and gain information for a variety of purposes, (e.g., clarifying, elaborating, summarizing main ideas and supporting details).

LA.6.5.2.2 The student will deliver narrative and informative presentations, including oral responses to literature, and adjust oral language, body language, eye contact, gestures, technology and supporting graphics appropriate to the situation.

LA.6.6.4.2 The student will determine and apply digital tools (e.g., word processing, multimedia authoring, web tools, graphic organizers) to publications and presentations.

LA.7.3.5.2 The student will use elements of spacing and design for graphics (e.g., tables, drawings, charts, graphs) when applicable to enhance the appearance of the document.

LA.7.4.2.2 The student will record information (e.g., observations, notes, lists, charts, legends) related to a topic, including visual aids to organize and record information, as appropriate, and attribute sources of information.

LA.7.4.3.1 The student will write persuasive text (e.g., advertisement, speech, essay, public service announcement) that establish and develop a controlling idea and supporting arguments for the validity of the proposed idea with detailed evidence.
LA.7.4.3.2 The student will include persuasive techniques (e.g., word choice, repetition, emotional appeal, hyperbole, appeal to authority, celebrity endorsement, rhetorical question, irony).

LA.7.5.2.1 The student will use effective listening strategies for informal and formal discussions, connecting to and building on the ideas of a previous speaker and respecting the viewpoints of others when identifying bias or faulty logic.

LA.7.6.4.1 The student will select and use appropriate available technologies (e.g., computer, digital camera) to enhance communication and achieve a purpose (e.g., video, presentations).

LA.7.6.4.2 The student will evaluate and apply digital tools (e.g., word processing, multimedia authoring, web tools, graphic organizers) to publications and presentations.

LA.8.3.5.2 The student will use elements of spacing and design for graphics (e.g., tables, drawings, charts, graphs) when applicable to enhance the appearance of the document.

LA.8.4.2.2 The student will record information (e.g., observations, notes, lists, charts, legends) related to a topic, including visual aids to organize and record information, as appropriate, and attribute sources of information.

LA.8.4.3.1 The student will write persuasive text (e.g., advertisement, speech, essay, public service announcement) that establishes and develops a controlling idea, and supports arguments for the validity of the proposed idea with detailed evidence.

LA.8.4.3.2 The student will include persuasive techniques (e.g., word choice, repetition, emotional appeal, hyperbole, appeal to authority, celebrity endorsement, rhetorical question, irony, symbols, glittering generalities, card stacking).

LA.8.5.2.1 The student will demonstrate effective listening skills and behaviors for a variety of purposes, and demonstrate understanding by paraphrasing and/or summarizing.

LA.8.5.2.2 The student will use effective listening and speaking strategies for informal and formal discussions, connecting to and building on the ideas of a previous speaker and respecting the viewpoints of others when identifying bias or faulty logic.

LA.8.6.4.1 The student will use appropriate available technologies to enhance communication and achieve a purpose (e.g., video, digital technology).

LA.8.6.4.2 The student will evaluate and apply digital tools (e.g., word, processing, multimedia authoring, web tools, graphic organizers) to publications and presentations.
Math Benchmarks
MA.7.A.1.1 Distinguish between situations that are proportional or not proportional, and use proportions to solve problems.

MA.8.S.3.1 Select, organize and construct appropriate data displays, including box and whisker plots, scatter plots, and lines of best fit to convey information and make conjectures about possible relationships.

Social Studies Benchmarks
SS.6.G.1.1 Use latitude and longitude coordinates to understand the relationship between people and places on the Earth.

SS.6.G.1.2 Analyze the purposes of map projections (political, physical, special purpose) and explain the applications of various types of maps.

SS.6.G.1.4 Utilize tools geographers use to study the world.
Specific Objectives

The students will...

Lesson 1
1. Learn the basic steps of phosphate mining, beneficiation processes, and the manufacturing of granular crop nutrients.
2. Demonstrate the basic steps of phosphate mining, beneficiation processes, and the manufacturing of granular crop nutrients.

Lesson 2
1. Use a GPS receiver to locate given waypoints on school grounds—the locations of core samples.
2. Draw a sectional phosphate ore location map using data from the core samples.
3. Analyze their drawings to determine the approximate depth of the phosphate ore.

Lesson 3
1. Gain knowledge about the phosphorus cycle and development of phosphate deposits in Florida.
2. Apply their knowledge of the phosphorus cycle by generating an electronic drawing of the cycle.

Lesson 4
1. Recognize biotic and abiotic factors in a natural plant community.
2. Observe and note the unique characteristics of natural plant communities.
3. Compare and contrast two different natural plant communities.
4. Describe the impact that human action has had on nearby natural plant communities.

Lesson 5
1. Describe the problems of the gopher tortoise’s survival and cause of its habitat loss.
2. Draw inferences about the effects of limiting factors on gopher tortoises.
3. Describe efforts to protect gopher tortoises made by mining companies, commercial and housing developers, and private or government agencies.
4. Communicate ways in which the public can protect and preserve gopher tortoises, their burrows and habitats.

Lesson 6
1. Analyze abiotic and biotic factors existing in a given land area.
2. Identify the impact of human activities on this land area.
3. Describe the tested methods used to eradicate invasive/exotic plants.
4. Explain the competition between native and invasive/exotic plants in Florida’s natural communities.
5. Identify the independent and dependent variables in an investigation to eradicate invasive/exotic plants from a given land area.
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### Unit Vocabulary

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<th>Habitat</th>
<th>Phosphate rock</th>
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<tr>
<td>Acidic</td>
<td>Hatchling</td>
<td>Phosphogypsum stack</td>
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<tr>
<td>Ammonia</td>
<td>Herbaceous plants</td>
<td>Phosphoric acid</td>
</tr>
<tr>
<td>Atom</td>
<td>Herbivore</td>
<td>Phosphorus</td>
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<tr>
<td>Basicity</td>
<td>Herpetologist</td>
<td>Photosynthesis</td>
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<td>Beneficiation</td>
<td>Hydric hammock</td>
<td>Plant density</td>
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<tr>
<td>Biotic</td>
<td>Hypothesis</td>
<td>Plastron</td>
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<tr>
<td>Burrow apron</td>
<td>Independent variable</td>
<td>Recipient site</td>
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<td>Carapace</td>
<td>Invasive</td>
<td>Reclamation</td>
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<tr>
<td>Carbon dioxide</td>
<td>Invertebrates</td>
<td>Refuge</td>
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<td>Commensal</td>
<td>Keystone species</td>
<td>Scute</td>
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<tr>
<td>Community</td>
<td>Land reclamation</td>
<td>Shrub</td>
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<tr>
<td>Controlled burn</td>
<td>Latitude</td>
<td>Slurry</td>
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<tr>
<td>Controlled variables</td>
<td>Limiting factor</td>
<td>Sulfur</td>
</tr>
<tr>
<td>Core sample</td>
<td>Longitude</td>
<td>Sulfuric acid</td>
</tr>
<tr>
<td>Dependent variable</td>
<td>Marsh</td>
<td>Swamp</td>
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<tr>
<td>Dichotomous key</td>
<td>Matrix</td>
<td>Symbiosis</td>
</tr>
<tr>
<td>End chamber</td>
<td>Matter</td>
<td>Take</td>
</tr>
<tr>
<td>Environmental consultant</td>
<td>Mesic hammock</td>
<td>Transects</td>
</tr>
<tr>
<td>Eradicate</td>
<td>Microorganism</td>
<td>Tree canopy</td>
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<tr>
<td>Exotic plants</td>
<td>Mitigation</td>
<td>Uplands</td>
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<tr>
<td>Fertilizer</td>
<td>Molecule</td>
<td>Upper respiratory tract disease (URTD)</td>
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<tr>
<td>Forage</td>
<td>Native plants</td>
<td>Upwelling</td>
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<tr>
<td>Fossil fuels</td>
<td>Natural community</td>
<td>Vegetation assessment</td>
</tr>
<tr>
<td>Geologist</td>
<td>Nitrogen</td>
<td>Vertebrates</td>
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<tr>
<td>GPS (global positioning system)</td>
<td>Nutrients</td>
<td>Wetlands</td>
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<tr>
<td>Granulation</td>
<td>Overburden</td>
<td>Xeric hammock</td>
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<tr>
<td>Gular</td>
<td>pH scale</td>
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<tr>
<td>Gypsum</td>
<td>Phosphate</td>
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Vocabulary Definitions

**Abiotic:** An environmental factor not associated with or derived from living organisms.

**Acidic:** Of low pH value below 7.

**Ammonia:** A compound of nitrogen and hydrogen, NH₃.

**Atom:** The smallest unit of a chemical element that can still retain the properties of that element.

**Basicity:** Having a high pH value above 7.

**Beneficiation:** Separating a wanted material from other material contained in a mixture. In the case of phosphate, where the mixture is called “matrix,” this means separating clay and sand from the phosphate rock.

**Biotic:** Factors in an environment relating to, caused by, or produced by living organisms.

**Burrow apron:** The mound of sand shaped like a half circle that spreads outward from the mouth of an animal’s burrow. For example, the gopher tortoise.

**Carapace:** Top shell or dorsal side of a tortoise or turtle, also applies to crustaceans and arthropods.

**Carbon dioxide:** A gas, the molecules of which are formed from the combination of one carbon and two oxygen atoms CO₂; necessary for photosynthesis.

**Commensal:** Organisms that live together; participation in a symbiotic relationship in which one species derives some benefit while the other is unaffected.

**Community:** A population of different species occupying a particular area at the same time, interacting with each other and their environment.

**Controlled burn:** A technique used in forest management, farming, or prairie restoration. An intentionally-ignited fire contained within a designated area to remove highly-flammable undergrowth and to stimulate the germination of some desirable forest trees, thus renewing the forest.

**Controlled variables:** Serves as a standard of comparison with another variable to which the control is identical except for one factor.

**Core sample:** A cylindrical sample of soil, rock or minerals obtained from beneath the surface of the Earth by driving a hollow tube-like sampling device down
into the ground to a specified depth, followed by careful extraction.

**Dependent variable:** Factor being measured or observed in an experiment.

**Dichotomous key:** A written or pictorial tool comprised of "couplets" describing mutually exclusive qualities that allows the user to identify a specimen (usually of natural origin) by choosing the best-fitting description.

**End chamber:** The final compartment to an animal’s burrow which is usually enlarged by the animal to allow room to move around and rest comfortably; for example the gopher tortoise.

**Environmental Consultant:** A biologist, geologist, chemist, or engineer with knowledge of local biota, environmental systems, conditions and regulations that is hired to give their professional judgment or opinion on possible environmental impacts, oversee permitted work, or monitor conditions of the land, water, air or living resources.

**Eradicate:** To completely remove an unwanted plant or animal.

**Exotic:** A species that is not indigenous (not native) to a region.

**Fertilizer:** Any natural or synthetic material that is chemically or naturally produced, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its capacity to support plant growth, quality and yield.

**Forage:** The act of collecting or searching for food and provisions.

**Fossil fuels:** Fuels that originate from ancient deposits of decomposing organisms. Over millions of years, coal, oil, and natural gas have formed from these deposits.

**Geologist:** A scientist who studies Earth’s origin, history, and structure, including the rocks and minerals found in Earth’s crust.

**GPS (global positioning system):** A system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver. The accuracy is usually within 4 meters.

**Granulation:** The process of making granules, or small grains or crystals of a product.

**Gular:** Referring to the area under the chin of some animals; the gular scale of the male gopher tortoise is usually elongated and used in male-to-male interactions to ram and flip the other male tortoise.
Gypsum: A finely-grained solid consisting primarily of calcium sulfate, either naturally or chemically produced, in which case is referred to as phosphogypsum.

Habitat: A place in an ecosystem where an organism normally lives.

Hatchling: An organism that has just left the egg.

Herbaceous plants: Non-woody plants.

Herbivore: An organism that consumes producers.

Herpetologist: A scientist that studies reptiles.

Hydric hammock: Poorly drained forested areas on sand/clay/organic soil, often over limestone. Characteristic species include water oak, cabbage palm, red cedar, red maple, bays, hackberry, hornbeam, black gum, needle palm, and mixed hardwoods.

Hypothesis: A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

Independent variable: The factor that is changed in an experiment in order to study changes in the dependent variable.

Invasive: Any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem; and whose introduction does, or is likely to, cause economic or environmental harm or harm to human health.

Invertebrate: An animal that has no backbone or spinal column and therefore does not belong to the subphylum Vertebrata of the phylum Chordata. Invertebrates are the most numerous animals. Corals, insects, worms, jellyfish, starfish, and snails are examples of invertebrates.

Keystone species: A species that is critical to the functioning of the ecosystem in which it lives because it affects the survival and abundance of many other species in its community.

Land reclamation: The process of restoring a site that has sustained environmental disturbance. This is done to minimize environmental impact and/or to allow for some form of human use. Usually involves soil moving, filling and recontouring, ensuring appropriate hydrology, and, in the case of reclamation to a wildlife habitat, the planting of appropriate native plant species.
Latitude: A measure of relative position north or south on the Earth’s surface, measured in degrees from the equator, which has a latitude of 0°, with the poles having a latitude of 90° north and south.

Limiting factor: An environmental variable that limits or slows the growth, activities, or distribution of an organism or population.

Longitude: A measure of relative position east to west on the Earth’s surface, measured in degrees from the Prime Meridian (which is the longitude that runs through Greenwich, England).

Marsh: A wetland area covered mostly by grasses.

Matrix: The phosphate-bearing layer or strata, consisting of phosphate rock, clay and sand, usually found 15-50 feet below the ground surface in the Bone Valley region of west central Florida.

Matter: Substance that possesses inertia and occupies space, of which all objects are constituted.

Mesic hammock: Ecosystem where soils are moist but do not become water-logged; they hold oxygen and drain well, providing habitat for a mixture of evergreen and deciduous trees. This ecosystem supports an abundant population of bird species and the insects that they eat.

Microorganism: A living organism that is visible only by use of a microscope. Includes bacteria, fungi, protists, green algae, plankton, and others. They can live in the air, on land, and in fresh- or salt-water environments.

Mitigation: An environmental crediting system established by governing bodies which involves allocation of debits and credits. Debits occur in situations where a natural resource has been destroyed or severely impaired and credits are given in situations where a natural resource is deemed to have been improved or preserved.

Molecule: The smallest unit of matter of a substance that retains all the physical and chemical properties of that substance; consists of a single atom or a group of atoms bonded together.

Native: That which occurs naturally in a particular region, state, ecosystem, and habitat without direct or indirect human actions.

Natural community: An interactive assemblage of organisms, their physical environment, and the natural processes that affect them and that have not been overly affected by human influence.

Nitrogen: The chemical element with the atomic number of 7, represented by the
symbol, N. Nitrogen is a colorless, odorless gas composing about 78% of the volume of the Earth's atmosphere. Nitrogen is a required nutrient for healthy plant growth.

**Nutrients:** A substance or compound that provides nourishment (food) or raw materials needed for life processes.

**Overburden:** The soil or rock that covers a mineral source; dirt miners dig through in order to reach the matrix below. In Florida this layer is used for reclamation.

**pH scale:** A range of values that are used to express the acidity or alkalinity (basicity) of a system; each whole number on the scale indicates a tenfold change in acidity; a pH of 7 is neutral, a pH of less than 7 is acidic, and pH greater than 7 is basic (or alkaline).

**Phosphate:** A class of mineral that is the only known source of the element phosphorus. Phosphate is a nutrient that all living things need to survive and grow. Phosphate rock, which cannot be dissolved in water, is mined to be used as a raw material in fertilizers and animal feeds. The resulting final product is a form of phosphate that is water-soluble and usable by plants and animals.

**Phosphate rock:** A commercial term for rock containing phosphate materials that have a high enough grade and composition to permit their use, before or after beneficiation, in manufacturing commercial phosphate products.

**Phosphogypsum stack:** Large above-ground piles (up to 200 feet high) of co-product phosphogypsum located near phosphoric acid plants. The gypsum slurry is pumped to the top of the stack where it settles out and the slurry water returns to the plant as part of the system to cool process water. As the stack fills with deposited gypsum, the solids are scooped out to build up the sides, and the stack grows in height as the process is repeated. Since there is a required slope to the sides, a point is reached where no further material can economically be placed on the top, and the stack is then closed.

**Phosphoric acid:** \( \text{(H}_3\text{PO}_4 \) The basic ingredient used in making phosphate fertilizers and phosphate-based animal feed ingredients. It is produced by reacting ground phosphate rock with sulfuric acid.

**Phosphorus:** The chemical element with the atomic number of 15, represented by the symbol, P. Phosphorus is never found in its elemental form in nature, but rather as an oxidized form, phosphate. Phosphorus is an essential nutrient for all life, and is an important component in fertilizers.
**Photosynthesis:** A chemical process by which plants use light energy to convert carbon dioxide and water into carbohydrates (sugars).

**Plant density:** A quantitative measure of the plant cover on an area, i.e., the amount of plant material per unit area or space.

**Plastron:** The bottom shell of an organism; for example, a turtle or tortoise.

**Recipient site:** A habitat or location to which organisms are moved from their original or donor site; for example, the gopher tortoise.

**Reclamation:** The process of rehabilitating lands disturbed by mining so that they serve a desirable and useful purpose, the result of which may or may not be returning the land to its original uses and functions.

**Refuge:** A place where a living organism can survive extreme stressors such as drought, flood, freezing weather or fire. The refuge offers localized protection from adverse conditions.

**Scute:** The horny skin plates or scales over an organism's bony shell; for example, a gopher tortoise.

**Shrub:** A woody plant of relatively low height, having several stems rising from the base and lacking a single trunk; a bush.

**Slurry:** A semi-fluid mixture of a liquid (usually water) and insoluble solid particles such as clays, phosphogypsum or sand.

**Sulfur:** The chemical element with the atomic number of 16, represented by the symbol, S. Sulfur is a bright yellow, crystalline solid at room temperature. In phosphate fertilizer production, elemental sulfur is used to produce sulfuric acid, used to digest the phosphate rock in the formation of phosphoric acid.

**Sulfuric acid:** A strong mineral acid, notated as H\(_2\)SO\(_4\), made by burning molten sulfur in the presence of air, followed by hydration. Sulfuric acid is highly corrosive, especially on reactive metals. In phosphate fertilizer production, the generation of sulfuric acid is the first industrial step, as it subsequently used to digest (or dissolve) the phosphate rock to form phosphoric acid and phosphogypsum in a replacement reaction.

**Swamp:** A piece of wet, spongy land that is permanently or periodically covered with water, characterized by growths of shrubs and trees.

**Symbiosis:** A relationship in which two different organisms live in close association with each other.
**Take:** A regulatory agency term for the illegal act of killing a protected species or interfering with the animal’s nest or burrow.

**Transects:** In the context of sampling natural populations, a line drawn across the region of interest. Sampling may consist of examining the occurrence of organisms along the line, or visible from the line or within a sequence of quadrants centered on the line.

**Tree canopy:** The upper reaches of a tree; the leaf crown. Responsible for the shade footprint of the tree.

**Uplands:** The wide category of Florida habitat types that are not considered wetlands. Includes pine flatwoods, dry prairies, scrub, coastal strands, beach dunes, hardwood and palm hammocks, sandhills, and pine rocklands.

**Upper respiratory tract disease (URTD):** The illness affecting gopher tortoises caused by a bacterium, Mycoplasma agassizii. It is transmissible between tortoises, resulting in sickness or death. There is no known cure.

**Upwelling:** A process in which cold, often nutrient-rich waters from the ocean depths rise to the surface. In the Miocene Epoch, upwelling contributed to the formation of phosphate.

**Vegetation assessment:** A method or methods of quantifying or qualifying the plants growing in a given area.

**Vertebrate:** Any of a large group of chordates of the subphylum Vertebrata (or Craniata), characterized by having a backbone. Vertebrates include fish, amphibians, reptiles, birds, and mammals.

**Wetlands:** An area that is saturated by surface or ground water with vegetation adapted for life under those soil conditions, such as swamps, bogs, fens, marshes, and estuaries.

**Xeric hammock:** Areas where soils are dry and contain ample oxygen to meet plant needs. Rain water drains rapidly from xeric soils. Oaks and hickory are abundant in this habitat, which has a wide diversity of animal species such as squirrels, wild turkey and hogs, deer, toads, snakes, owls, opossums, and armadillos.
Lesson 1: Phosphate Mining in Central Florida
Author: Teresa Urban

Introduction:
Florida’s phosphate was formed about fifteen million years ago and this “hidden treasure” can be found 15 to 30 feet under a sandy overburden. As early as 1842, an Englishman, John Bennett Lawes, treated coprolites—phosphorus bearing ore—with sulfuric acid which yielded phosphoric acid. Science and technology is utilized in the manufacturing plants of today, producing a fertilizer product used worldwide. Since 1975, Florida law requires that mined lands become beneficial habitats for plants and animals. The reclamation process involves restoring mined land to nearly the same condition including the water flow and natural communities that were in place before mining began.

Today, phosphate mining in central Florida is a temporary use of the land. In this lesson, students learn how modern machinery mines phosphate and the steps in processing the phosphate ore, preparing it for manufacturing into fertilizer and animal feed. Students learn that before mining begins there must be a reclamation plan in place.

Learning Essential Questions: How does the phosphate industry utilize modern technology? What is the impact of phosphate mining on the land?

Students should understand the concepts of the geological changes that have led to the deposition of phosphate in Florida.

Activity:
Students watch a video titled The Phosphate Story: Florida’s Hidden Treasure. They work in groups or individually to answer the accompanying video worksheet. Reinforcing the mining process steps, students use graphic software to create a flow chart illustrating the steps involved in the removal of phosphate from the ground to the final product.

Estimated Time:
Two to three 45-minute class periods

Grade Level:
6-8

Standards:
LA.6.5.2.1 LA.6.5.2.2 LA.6.6.4.2
LA.7.5.2.1 LA.7.6.4.1 LA.7.6.4.2 SC.7.E.6.6
LA.8.5.2.1 LA.8.5.2.2 LA.8.6.4.1 LA.8.6.4.2

Objectives:
The student will…
1. Learn the basic steps of mining, beneficiation, and manufacturing of granular crop nutrients.
2. Demonstrate their knowledge of the basic steps of mining, beneficiation, and manufacturing of granular crop nutrients.
Phosphate Mining: Borrowed Land

Vocabulary:

phosphate          overburden
matrix             slurry
beneficiation      reclamation
sulfur             sulfuric acid
granulation        phosphoric acid
ammonia            gypsum
phosphate rock     fertilizer
phosphogypsum stack

Materials:

Computer lab with LCD projector for demonstrating the assignment
DVD—The Phosphate Story: Florida’s Hidden Treasure (can borrow from FIPR Institute 863-534-7160)
DVD player or computer that plays DVDs with LCD projector
The Phosphate Story: Florida’s Hidden Treasure DVD worksheet
Copies of the diagram checklists

Procedure:

Day 1
1. Before viewing the video The Phosphate Story: Florida’s Hidden Treasure, point out to the students that large amounts of phosphate rock must first be processed in order to be made into the final product, fertilizer.
2. Distribute the worksheet with questions from the video. Instruct the students that all of the answers will be found throughout the video. The video can be paused after each of the three sections to allow students to finish the worksheet in increments. Guide the completion of worksheet as desired.
3. While watching the video point out key steps in the mining process that they will illustrate later. (Key steps - Day 2.) After the video, mention that all phosphate mined in Florida is now processed in Florida only, not also in Louisiana.

Day 2
1. Schedule a computer lab for the day after viewing the video. Computers should have graphical software such as Inspiration (recommended) or Microsoft Office Word where students can design flow charts, timelines, or other similar illustrations.
2. In the computer lab, demonstrate how to make a flow chart. Use the software’s graphical clip art and symbols for the arrows and illustrations. Students may use their worksheets and checklist sheets while they create their flow charts.
3. Print diagrams for display or save to be included in students’ electronic portfolios or project folios. Have students use the checklist to evaluate their own diagrams.

List of key steps in phosphate mining process:

- Planning for reclamation
- Dragline mining
- Transportation of ore (slurry pumped through pipeline)
- Beneficiation plant for removing clay and sand from slurry
- Transportation of phosphate rock to manufacturing plant
- Production of sulfuric acid
- Production of phosphoric acid
- Production of granular crop nutrients

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Analysis/Conclusion:
Use checklist for assessing the computer assignment.

Use these discussion questions to assess student learning.
1. Name all the examples of modern technology that you see in the video.
2. Name and describe the jobs of the people in the video.
3. How do you think the land is put back to usefulness after mining is completed?
4. List the raw products needed in order to produce fertilizer.
5. What must be done to the phosphate rock before it is sent to the manufacturing plant?

Extension:
Kids Dig It! Part 1 and Kids Dig It! Part 2 kits, available at FIPR Institute, are great for building on the geology background knowledge.

Students may research online to find out how much fertilizer product is made each year. They may research to find other economic factors that affect Florida’s economy.

Students may research earlier techniques used to mine phosphate in central Florida. Compare them to today’s mining and processing techniques.

Teacher Notes:
Borrow the DVD—The Phosphate Story: Florida’s Hidden Treasure from FIPR Institute—863-534-7160
Make copies of the video questions worksheet (1 per student)
Make copies of the checklist for the students’ diagrams
The Phosphate Story: Florida’s Hidden Treasure

Part 1: Mining for Phosphate Rock

1. In the video, phosphate is referred to as ___________ ____________.

2. The soil on top of the phosphate deposit is called _____________________.

3. While digging, a dragline operator can tell where the phosphate is located by the _____________________.

4. A dragline operates on what source of power? ____________________

5. The mechanical feet of a dragline move it a little faster than the speed of the ____________ ____________ when it is being rolled to the launch site.

6. One dragline bucket can hold up to ________ tons.

7. The mixture of sand, clay, and phosphate rock is called _____________________.

8. Describe how phosphate rock, sand and clay are moved from the mine site to the beneficiation plant where the mixture is separated.

9. What happens to the clay after it is separated from the mixture?

10. When the sand is removed from the mixture, how does the industry use it?

11. How much of the water used in the beneficiation process is recycled? _________

12. What happens to the phosphate rock (pebbles) after the clay and sand are separated?
Part 2: Manufacturing Crop Nutrients

13. The raw material, ______________, is mixed with air to produce sulfuric acid.

14. Steam from the sulfuric acid plant is used to generate ____________________.

15. The raw material, ______________ __________ is transported by rail from the beneficiation plant to the crop nutrient manufacturing plant.

16. Phosphate rock must be ____________ into a fine ___________ before it can be reacted with the sulfuric acid to make phosphoric acid.

17. Why must the co-product phosphogypsum be continually stacked rather than used for road beds or other products?

18. What do the manufacturing companies do to protect the ground water underneath the gypsum stacks?

Part 3: Reclaiming the Land

19. Before the land is mined for the phosphate, what must the experts do?

20. Land that has been mined must be reclaimed for useful purposes. List some of these uses.
The Phosphate Story: Florida’s Hidden Treasure

Answer Key

1. In the video, phosphate is referred to as **gray gold**.
2. The soil on top of the phosphate deposit is called **overburden**.
3. While digging, a dragline operator can tell where the phosphate is located by the **color**.
4. A dragline operates on what source of power? **electricity**
5. The mechanical feet of a dragline move it a little faster than the speed of the **space shuttle** when it is being rolled to the launch site.
6. A dragline bucket can hold up to **65** tons of earth.
7. The mixture of sand, clay, and phosphate rock is called **matrix**.
8. Describe how phosphate rock, sand and clay are moved from the mine site to the beneficiation plant where the mixture is separated. **The buckets of matrix are dumped into a pit (or well) where high powered water guns are used to break up the large clumps of matrix to make a slurry. The slurry is then pumped through pipes to a beneficiation plant.**
9. What happens to the clay after it is separated from the mixture? **The clay water is pumped to clay-settling ponds.**
10. When the sand is removed from the mixture, how does the industry use it? **The sand is shipped back to the mine site to be used during reclamation.**
11. How much of the water used in the beneficiation process is recycled? **98%**
12. What happens to the phosphate rock (pebbles) after the clay and sand are separated? **The phosphate is transported by railcar to the manufacturing plants.**
13. The raw material, **sulfur**, is mixed with air to produce sulfuric acid.
14. Steam from the sulfuric acid plant is used to generate **electricity**.
15. The raw material, **phosphate rock** is transported by rail from the beneficiation plant to the crop nutrient manufacturing plant.
16. Phosphate rock must be **crushed** into a fine **powder** before it can be reacted with the sulfuric acid to make phosphoric acid.
17. Why must the co-product phosphogypsum be continually stacked rather than used for road beds or other products? **The phosphogypsum contains minute traces of radiation.**
18. What do the manufacturing companies do to protect the ground water underneath the gypsum stacks? **The companies place a liner on the ground before stacking the phosphogypsum and constantly monitor the pH of the water.**
19. Before the land is mined for the phosphate, what must the experts do? **Before mining begins a mining permit and reclamation plan must be submitted.**
20. Land that has been mined must be reclaimed for useful purposes. List some of these uses.
   - Habitats such as: wetlands, lakes, scrub lands, forests, grasslands, etc.
   - Housing developments
   - Cattle grazing land or other agricultural uses
   - Shopping Centers

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Phosphate Mining - Sample Flow Chart

Planning for Reclamation

Dragline mining

Slurry pumped to Beneficiation plant

Sand and clay removed

Sand stored for Reclamation

Phosphate rock

Clay retention pond

Manufacturing plant
(Sulfuric acid is combined with crushed phosphate rock to form phosphoric acid)

Granular Crop Nutrients
Lesson 2: GPS Technology and Phosphate Mining
Author: Teresa Urban

Introduction:
“Florida's typical phosphate ore (matrix) is found about 15-50 feet below the earth's surface and is about 10-20 feet thick. Draglines strip off the top layer of earth (known as overburden) to get at the matrix, which is then processed to separate the phosphate from the sand and clay that make up this layer of Florida.”

http://www.fipr.poly.usf.edu

Planning for a phosphate mine begins with prospecting, where overburden depth, matrix depth, and matrix quality are determined using core samples. Typically this kind of core sample is drilled on a 330’ grid—one core sample per 2.5 acres. Each core sample is logged, tagged and sent to a pilot plant for further analysis. There the quality of the phosphate matrix is determined. The data is recorded and section maps are created to serve as guides for dragline operators.

Core samples are analyzed and mapped providing a guide for dragline operators to precisely dig phosphate deposits. GPS technology increases mining efficiency by tracking equipment and shovel and drilling positioning. This lesson allows students to become familiar with GPS technology and practice using GPS receivers. The activity is a simulation of a technique used by the mining companies to efficiently find and remove phosphate ore.

Learning Essential Questions: How does a dragline operator analyze data from a sectional core map to know where to dig for phosphate? How does the mining industry use GPS technology to make maps of phosphate deposits?

Play Ore Body Battleship (Lesson Plan on Resource CD) to acquaint students with the techniques used to find phosphate deposits—core drilling. Another activity from Women in Mining, Cupcake Core Sampling, may be played before or after this lesson. (http://www.coaleducation.org/lessons/wim/4.htm)

Students must be familiar with directional coordinates—latitude and longitude. They must be familiar with the Garmin eTrex GPS receiver functions. Use Locating Waypoints for assistance. Basic linear measuring skills in metrics required.

Activity:
Student teams use a GPS receiver to navigate to the core sample target. At the target site, students remove the core sample. They measure and record the layers of earth; limestone, matrix (phosphate deposit), and overburden. After completing the chart by measuring all six bottles—they return to the classroom where they will draw a sectional core sample map of the layers of earth.

Estimated Time:
One 45-minute class period

Grade Level:
6-8
Standards:
SS.6.G.1.1    SS.6.G.1.3    SS.6.G.1.4
MA.7.A.1.1    SC.7.N.1.1

Objectives:
The students will …
1. Use a GPS receiver to locate given waypoints on school grounds—the locations of core samples.
2. Record data measurements from each core sample.
3. Using the data collected they will draw a sectional phosphate ore location map.
4. Analyze their drawings to determine the approximate depth of the simulated phosphate deposit.

Vocabulary:
latitude   longitude
core sample   matrix
Geologist   overburden
GPS (Global Positioning System)

Materials:
Set of GPS receivers available for check-out at FIPR Institute (1 per group of 2-6)
Have extra AA batteries on hand
Guide for Location Waypoints Using Garmin eTrex Receivers
Centimeter grid paper (1 per student, used in classroom)
Pencils
Clipboards
Core Sample Data Chart worksheet (per group/team’s field work)
Meter stick to measure distance between waypoints (approximately 5-8 meters between waypoints)
5 clear plastic 16 oz. water bottles for core samples
Centimeter ruler for each team
Play sand
Aquarium gravel
Topsoil or potting soil
Funnel
Newspapers
Small hand spade

Procedure:
1. Explain to students that before phosphate is mined the land must be prospected. Explain how geologists and technicians drill core samples in order to analyze the layers of earth.
2. Next, explain the directions that they as teams will follow to locate the core samples. If necessary, review GPS receiver Locating Waypoints.
3. After team assignments, tell students to head to the first waypoint core sample target. Pull the sample (water bottle) from the ground at the waypoint. Measure, in centimeters, each layer starting from the bottom of the bottle. Record the depth of each layer on the Core Sample Data Chart. (Have the students rebury the core sample for the next group, if using the same for all groups.)
4. When teams have completed the chart, they return to the classroom to make the section map on centimeter graph paper. Provide enough grid paper for each student to complete a map. Number cm. on the left of graph paper. Mark waypoints across the top (use A, B, C, etc.). Place a dot for each measurement. After marking dots draw lines showing the layers of earth. Label the layers.

**Assessment:**
The student’s grid paper drawings should be similar to the example below.

Questions for further assessment:
1. Ask students where the bottom of the phosphate deposit lies at waypoints A, B, C, D, and E.
2. Ask students to determine how deep that is from the top of the overburden.
3. Ask students where the “thickest” deposit lies—between what two waypoint locations.
4. Have students use the Core Sample Data Chart to average the depth of the top of the deposit (see example below).
5. If each centimeter represents one meter of actual depth, ask what the average depth to the top of this phosphate deposit would be.
6. If each centimeter grid mark between the waypoints represents 10 meters, ask what the length of this cross-section of core sampling would be.

**Average depth of the top of phosphate matrix is 5.9 cm or 3 m x 5.9 cm (300 cm x 5.9 = 1770 cm or 17.7 m)**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>(overburden)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>(phosphate matrix)</td>
<td>5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>(limestone)</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**Teacher Notes:**
Follow directions on *Core Sample Preparation* worksheet a day or two ahead of class
Check GPS receivers for battery charge; have extra AA batteries available
Review the *Guide for Location Waypoints Using Garmin eTrex Receivers*
Using a straight path on school grounds enter up to 5 waypoints in GPS Receiver Station each sample at least 5-6 meters apart
Partially bury the core samples at the waypoint locations. (Be sure to inform school grounds custodians before they mow or pick up trash.)
Prepare grid paper for each student and have centimeter rulers on hand

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Core Sample Preparation (Teacher Instructions)

For each team, fill up to 5 clear plastic 16 oz. water bottles with three different materials that indicate limestone bedrock, phosphate matrix and overburden /soil.

1. Label each bottle A, B, C, D, or E.
2. Use sand for the limestone layer measuring around 2-3 centimeters from the bottom of bottle.
3. Use aquarium gravel for the phosphate matrix layer measuring around 4-6 centimeters from the top of the sand—colored gravel would work well.
4. Use topsoil or potting soil to represent the overburden. This layer could measure all the way to the same level on each bottle, about 15 centimeters from the bottom of bottle.
5. Measure and record the levels for answer key.
6. Partially bury core samples in the ground at each waypoint—going in a straight line about 5-8 meters apart.
Guide for Locating Waypoints Using Garmin eTrex Receivers
(adapted from eTrex Manual)

Selecting a Page
There are five main pages or display screens: SkyView, Map, Pointer, Trip Computer, and Menu. Press the PAGE button to switch between these pages.

Marking Waypoints
The first step in the exercise is to mark your location as a waypoint.
(NOTE: The unit must be “READY TO NAVIGATE” before you mark a waypoint.)

To mark a waypoint:
• Press and hold the ENTER button to activate the MARK WAYPOINT page.
• The waypoint is assigned a numeric name at the time it is created. You could press ENTER and save the waypoint now, but for this exercise, you will make some changes to the waypoint first.
• The eTrex comes equipped with 31 different waypoint symbols that can be displayed on the map to help quickly identify the waypoints.

To change the waypoint symbol:
• On the MARK WAYPOINT page, press the UP or DOWN button to highlight the waypoint symbol (above the waypoint name), then press ENTER.
• Press the UP or DOWN button to scroll through the symbols and highlight the house symbol. Press ENTER.
Renaming Your Waypoint
The name can be up to six characters in length. For this exercise, you will name the waypoint ‘HOME.’

To change the waypoint name:
- On the MARK WAYPOINT Page, press the UP or DOWN button to highlight the Waypoint.
- Name ‘001.’ Press ENTER. The EDIT WAYPOINT NAME Page appears.
- Press ENTER. Press the UP or DOWN button to scroll through the letter selections.
- Select ‘H’ and press ENTER. Repeat this process and finish the word ‘HOME.’
- Press the UP or DOWN button to highlight the ‘OK’ field, then press ENTER. The MARK WAYPOINT Page appears.
- Press the UP or DOWN button to highlight the ‘OK’ field, then press ENTER. Your location, named HOME, is now marked and stored in memory.

Now that you’ve marked your location, it’s time to go for a walk. Press the PAGE button and switch to the Map Page. Walk in a straight line for 2-3 minutes at a moderate pace and watch the Map Page. Your location is shown by the figure in the middle of the screen. As you move, the animated figure walks and a line—called a “track”—appears along the path you have just covered. If you do not see the animated figure walk, you may need to zoom in closer by pressing the DOWN button. Now take a sharp right or left turn and walk for another 2-3 minutes.

GOTO function.
The GOTO function provides you with a straight line navigation path to your selected destination.

To start a GOTO:
- Press the PAGE button to switch to the MENU Page.
- Press the UP or DOWN button to highlight ‘WAYPOINTS’, then press ENTER. The WAYPOINTS Page appears.
- Press the UP or DOWN button to select the tab containing ‘HOME’, then press ENTER.
- Press the UP or DOWN button to select ‘HOME’, then press ENTER. The REVIEW WAYPOINT Page appears.
- Press the UP or DOWN button to highlight ‘GOTO’, then press ENTER.
- The Compass Page appears and you’re ready to begin navigating!
Core Sample Data Chart

<table>
<thead>
<tr>
<th>Waypoint A</th>
<th>Waypoint B</th>
<th>Waypoint C</th>
<th>Waypoint D</th>
<th>Waypoint E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lat._______</td>
<td>Lat._______</td>
<td>Lat._______</td>
<td>Lat._______</td>
<td>Lat._______</td>
</tr>
<tr>
<td>Long.______</td>
<td>Long.______</td>
<td>Long.______</td>
<td>Long.______</td>
<td>Long.______</td>
</tr>
</tbody>
</table>

Measure the height of the "overburden" layer in cm. (soil)

Measure the height of the "phosphate matrix" layer in cm. (gravel)

Measure the height of the "limestone" layer in cm. (sand)

Core sample instructions:
1. Record the latitude and longitude where the core sample was found.
2. Measure, in centimeters, from the bottom of the bottle to the top of the “limestone” layer (sand) and record the depth in the corresponding box.
3. Measure from the top of the “limestone” layer (sand) up to the top of the "phosphate matrix" layer (gravel) and record the depth in the corresponding box.
4. Measure from the “phosphate matrix” layer (gravel) up to the top of the “overburden” layer (soil) and record the depth in the corresponding box.
5. Make sure to measure and record the depths for each core sample in order.
Lesson 3: Phosphorus Cycle
Author: Teresa Urban

Introduction:
“Phosphorus is in nature, always combined with other elements, most commonly with calcium, hydrogen, oxygen, and fluorine. Other elements found in smaller amounts include iron, aluminum, and even uranium.” (Ray Driver: FIPR Workshop, 9-11-99) Atoms like carbon, nitrogen, phosphorus, and other elements contained in living organisms today are the same atoms that have been on Earth since its beginning. They are constantly being recycled. The phosphorus cycle is the slowest of all the matter cycles. Unlike the other matter cycles, phosphorus cycles through water, soil and sediment, not air. Phosphorus is primarily found in rock formations and ocean sediment as phosphate salt. These phosphate salts dissolve in soil water allowing plants to absorb them. However, the quantity of phosphorus in soil is low so farmers apply phosphate in the form of fertilizer to their crops. Phosphorus is an essential nutrient for plants and animals. It is part of DNA molecules that store energy (ATP and ADP), the fats in cell membranes, and are present in both animal and human bones and teeth. Phosphorus cycles faster through plants and animals than through soil and rock. Phosphates return to the soil and ocean sediments when plants and animals die and decay. Eventually these sediments become part of the rock cycle where phosphorus may be stored for millions of years. http://www.lenntech.com/phosphorus-cycle.htm

Phosphate is an essential mineral that all living things need to survive and grow. This lesson makes a connection between the natural recycling of nutrient matter—including phosphorus—on the earth to the formation of phosphate deposits in Florida.

Essential Question: How does matter, like phosphorus, cycle in nature?

How is phosphate formed?
Matter, in the form of nutrients, moves through ecosystems, but cannot be replaced like energy from the sun. Nutrients enter the water through a variety of sources and are part of the larger food chain. Vertebrates, invertebrates and microorganisms all contribute to the formation of phosphate by simply living and dying. The remains and activities of vertebrates and invertebrates contribute to “phosphate deposition.” Marine vertebrates shed teeth and produce coprolites (pieces of fossilized excrement/animal waste) during their lifetime. When they die and decompose the skeletal remains enter the nutrient cycle. Invertebrates contribute to this cycle.

Crabs and shrimp carcasses contain high levels of phosphate though their remains are rarely fossilized in Florida. Mollusks may have excreted phosphate particles. Worm-like animals may have excreted phosphate particles in response to an irritant in the digestive process. Microorganisms process the waste on the ocean floor and release phosphate and other nutrients. Changing sea levels and upwelling of ocean waters, caused by cold and warm water currents, churned up this nutrient-rich water over the hills, trapping it in the basins of the limestone foundation of Florida. The continued food chain in the oceans, upwelling and sea level changes brought about an accumulation of phosphate-enriched sediments over the limestone bedrock, thus forming the phosphate deposits in central Florida.
A source on the formation of phosphate is an article by Stanley R. Riggs, *Petrology of the Tertiary Phosphate System of Florida*, found in *Economic Geology, Volume 74*.

Students should be familiar with the geological history of Florida. Students need to have a basic knowledge of the structure of matter—atoms, molecules, compounds, etc. They should also be familiar with the basic functions of word processing and drawing applications.

**Activity:**
The water, carbon, nitrogen and phosphorus cycles are presented through a teacher guided PowerPoint. Students learn about the phosphorus cycle and its relation to the central Florida phosphate deposition and then generate an electronic illustration depicting the cycling of phosphorus on earth and showing the connection to the mining of Florida phosphate deposits.

**Estimated Time:**
Two to three 45-minute class periods

**Grade Level:**
6-8

**Standards:**
LA.6.5.2.1  LA.6.5.2.2  LA.6.6.4.2  
LA.7.5.2.1  LA.7.6.4.2  SC.7.E.6.2  SC.7.L.17.1  
LA.8.5.2.2  LA.8.6.4.1  LA.8.6.4.2  SC.8.L.18.3  SC.8.L.18.4

**Objectives:**
The students will…
1. Gain knowledge about the phosphorus cycle and development of phosphate deposits in central Florida.
2. Apply their knowledge of the phosphorus cycle to generate an electronic graphical drawing.

**Vocabulary:**
atom  carbon dioxide  
fossil fuels  invertebrates  
matter  molecule  
microorganism  nitrogen  
nutrients  phosphate  
phosphorus  upwelling  
vertebrates  symbiosis

**Materials:**
Computer with internet connection and LCD projector  
PowerPoint *Cycles of Matter on Earth* located on the Resource CD from FIPR Institute  
Computer lab  
Paper and pencil for computer-based research  
Handout of checklist for phosphorus cycle drawing

**Procedure:**
1. Use the *Cycles of Matter on Earth* PowerPoint notes pages to aid in explaining each slide.
2. Click on the star on slide #4 to play the Carbon Cycle Game for an optional learning activity.
3. There is a link to an online phosphorus cycle animation with audio that is suitable for middle school students.
   (http://www.wadsworthmedia.com/biology/starr_udl11_tour/phos_anim.html)
4. After the presentation explain to students that they will generate a phosphorus cycle using the computer (Microsoft Office Word, Inspiration or other suitable drawing software).
5. Hand out the phosphorus cycle checklists for the next day’s assignment in the computer lab. Students may use the internet at home to review the phosphorus cycle. Most software contains a variety of clipart to make a flowchart-type drawing of the cycle. Include these labels in your phosphorus cycle drawing:
   • the ocean sediment and deposition of phosphate on the Florida platform
   • phosphate mining
   • fertilizer applied to crops
   • absorption by plants
   • animals eating plants
   • excrement from animals
   • decomposers
   • phosphate stored in soil
   • run-off going to lakes, rivers or oceans

**Analysis/Conclusion:**
Use the phosphorus cycle checklist to assess the drawing of the phosphorus cycle. An example, created in Inspiration software, is on the next page.

Additional questions for assessing student learning are:
1. Why is phosphorus an essential element for plants and animals? **It is part of their DNA and the building blocks of bones and teeth.**
2. Where would you find phosphorus on earth? **It is found in rock, soil, sediment and water.**
3. How does phosphorus move between soil and plants? **Plant roots absorb phosphorus in the form of phosphates.**
4. How does phosphorus enter bodies of water? **It is washed away from the soil and animal waste and from the food chains in water.**

**Teacher Notes:**
Print a copy of the *Cycles of Matter on Earth* PowerPoint notes
Set up class time in the computer lab
Make copies of the *Phosphate Cycle Drawing Checklist* for each student
Phosphate in plants → phosphate in animals

decomposers

fertilizer containing phosphate

phosphate stored in soil

animal wastes and remains

run-off to oceans

Ocean sediment from marine organisms deposited over the Florida platform forming phosphate deposits

phosphate mining
Name __________________________________________________________

**Phosphorus Cycle Drawing Checklist**

Are the following key steps included in the diagram?

Phosphates in…

____ the ocean sediment and deposition of phosphate on the Florida platform

____ phosphate mining

____ fertilizer applied to crops

____ absorption by plants

____ animals eating plants

____ excrement from animals

____ decomposers

____ phosphate stored in soil

____ run-off going to lakes, rivers or oceans

Are each of these steps illustrated or emphasized in some way?

Are there arrows making connections to each level of the phosphorus cycle?
Lesson 4: Natural Communities of Central Florida
Author: Teresa Urban

Introduction:
Ecosystems are made up of the living and the non-living things in a particular place. Each part of an ecosystem is important, because all of the parts must work together if the system is to survive. Since the mining process is conducted in many types of ecosystems, reclamation plans are custom-made for each mine site.

Ecologists have not always agreed on the best ways to classify Florida’s ecosystems. The most widely used approach is to classify the natural vegetation. There are over 80 documented natural communities in the state of Florida. The focus here is on the general plant communities of central Florida (Peace River, Alafia River, and Hillsborough River Basins).

Generally Florida is flat. There is an imperceptible change in elevation. However, as little as a few inches can result in changes in plant composition or natural communities. The Lakeland Ridge and Lake Wales Ridge offer rich upland and scrub-type habitats. Nestled between the ridges and rivers are the flatwoods, dry and wet prairies, basin swamps, basin marshes, ponds and lakes. The lowlands provide freshwater marshes, bay heads, and floodplain hardwood forests.

Students realize that Florida and its habitats and wildlife have evolved and changed. They understand that in order for phosphate mining companies to reclaim land, they must first understand the soils, natural communities, and hydrology of the land before it is mined.

Essential Questions: What are the characteristics of two natural plant communities in central Florida?

Students must understand that an ecosystem may include both living and nonliving things. Students should know the difference between grasses, shrubs, and trees. Students should understand why we take pH readings to determine acidity and alkalinity of soil.

<table>
<thead>
<tr>
<th>Upland</th>
<th>Wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry prairies</td>
<td>Marsh and wet prairie</td>
</tr>
<tr>
<td>Pine flatwoods</td>
<td>Cypress swamp</td>
</tr>
<tr>
<td>Sand pine scrub</td>
<td>Hardwood swamp</td>
</tr>
<tr>
<td>Sandhill</td>
<td>Bay swamp</td>
</tr>
<tr>
<td>Xeric oak hammock</td>
<td>Shrub swamp</td>
</tr>
<tr>
<td>Mixed hardwood pine forests</td>
<td></td>
</tr>
<tr>
<td>Hardwood hammocks</td>
<td></td>
</tr>
</tbody>
</table>

Activity:
Students take a field trip to two nearby natural vegetation sites. Teams of students collect information about the site and record their results. Students participate in a field trip follow-up discussion and compilation of information gathered at the sites.

Estimated time:
Four to five 45-minute class periods
One field trip day
Grade Level:
6-8

Standards:
LA.6.3.5.2  LA.6.4.2.2  LA.6.5.2.2  LA.6.6.4.2  LA.7.3.5.2  LA.7.4.2.2  LA.7.5.2.1  LA.7.6.4.1  LA.7.6.4.2  SC.7.E.6.6  SC.7.L.17.1  SC.7.L.17.2  SC.7.L.17.3  LA.8.3.5.2  LA.8.4.2.2  LA.8.5.2.2  LA.8.6.4.1  LA.8.6.4.2

Objectives:
The students will…
1. Recognize biotic and abiotic factors in a natural plant community.
2. Observe and note the unique characteristics of natural plant communities.
3. Compare and contrast two different natural plant communities.
4. Describe the impact that human action has had on nearby natural plant communities.

Vocabulary:
plant density  tree canopy  swamp  natural community
marsh  wetlands  shrub  biotic
abiotic  dichotomous key  pH scale  acidic
basicity  hydric hammock  mesic hammock  vegetation assessment
xeric hammock  controlled burn  photosynthesis

Materials:
Copies of Central Florida Oak—Dichotomous Key and Key to Common Florida Pine Trees
Copies of Natural Communities Comparison Chart
National Audubon Society: Field Guide to Florida (available for check-out at FIPR Institute)
Science probes for temperature and pH (if available)
Coffee can (both ends cut out)
Hammer
Bottles of water (same size)
Clipboards
Pencils
Weather thermometer
Glass lab thermometer (soil temp)
Soil pH meter (available at FIPR Institute)
Computers with internet connection
Microsoft Office PowerPoint or other presentation software
LCD Projector
Digital cameras

Procedure:
Day 1
Demonstrate in the schoolyard how to collect site information such as soil pH (follow directions on box), temperature, description, soil porosity, and plant identifications using the dichotomous keys.
Day 2 (Field Trip)
1. On the field trip divide students into teams with one recorder. Distribute charts with clipboard and pencil, guides, keys, and other equipment.
2. Have groups spread out and gather the information for charts. The groups need to work in similar plant community areas.

Day 3
1. Compile information from all the groups on large chart paper or computer with LCD projector.
2. Distribute the Natural Communities of Central Florida Chart. Lead the discussion or have groups determine which natural community is most like the two locations that they visited.
Class discussion questions:
   a. Did you notice any differences in the types of soils at the different sites?
   b. What were the primary differences in plants at each site?
   c. Was there a connection to the soil and type of plants growing there?
   d. What types of plants were most abundant in each site?
   e. Was there any evidence of fire in the sites?
   f. What would be the effect of fire on the sites?
   g. How would the sites change if the trees were removed? What evidence of wildlife did you see at the sites?
   h. What kinds of wildlife would typically live there?

Day 4:
1. In the computer lab have students create a brief PowerPoint presentation showing the major differences in the two locations visited.
2. Have the students use the digital photos taken at the site or find them online.

Analysis/Conclusion:
1. Participation on field trip—completion of Natural Community Comparison Charts by each student or group.
2. Use the ready-made rubric to assist in evaluating the presentations.

Extension:
Have each group draw a poster illustrating the unique plants and animals of one natural community of central Florida.

Teacher Notes:
Arrange two different field trips to nearby natural sites, school yards or parks. Arrange for two or three chaperones per group. Most places that provide suitable field trip locations have only one community type. See list of Polk County parks and reserve sites.
Gather and prepare field work supplies (measuring for soil porosity). Cut out both ends of a coffee can. Make a mark about 1 inch up from the bottom. Have students clear the leaf litter and push the can 1 inch into the ground before pouring in the water. Copy enough sheets of the Central Florida Oak—Dichotomous Key and Key to Common Central Florida Pine Trees for the groups assigned to gather this site information.
Copy two or three Natural Community Comparison Charts for the teams responsible for recording the team reports.
Other tools and supplies: water, lab thermometer, weather thermometer, soil pH meter, clipboards, and pencils.

**Resources:**

- Rubrics can be created at: [http://rubistar.4teachers.org/](http://rubistar.4teachers.org/)
- Information for possible natural community field trip locations:
  - [http://www.floridastateparks.org/coltcreek/default.cfm](http://www.floridastateparks.org/coltcreek/default.cfm)
  - [http://www.floridastateparks.org/lakekissimmee/default.cfm](http://www.floridastateparks.org/lakekissimmee/default.cfm)
Key to Common Central Florida Pine Trees

Gather pine needle clusters and pine cones from the ground. Notice that the needles are clustered together where they attached to the limbs. These are referred to as bundles in the dichotomous key below.

1. Needles in bundles of 3 only. Yes…go to 3
2. Needles in bundles of 2 and 3. Yes…go to 4
3. Needles are 9 to 18 inches long and cones 6 to 10 inches long. Yes…Longleaf Pine No…go to 6
4. Needles in bundles of 2 and 3 on the same tree. Yes…Slash Pine Needles are 5 to 10 inches long. Bark is rough. No…go to 5
5. Needles are 2 to 4 inches long. Bark is scaly. Yes…Sand Pine
6. Needles are up to 3 inches long and sometimes twisted. Cones are 3 to 5 inches long and grayish in color. Yes…Loblolly Pine

Example:
Bark is rough and pine needles—from the same tree—are 5 to 10 inches long in bundles of 2 and 3. The tree is a Slash Pine.

(Adapted from “Key to Common Florida Pine Trees,” The Schoolyard Wildlife Activity Guide, Linda Cronin-Jones, Florida Game and Fresh Water Fish Commission, 1992.)
Central Florida Oak—Dichotomous Key
Assembled by Jeff Keene—
Hillsborough County Teacher

Central Florida Oak - Dichotomous Key Activity
Jeff Keene—Hillsborough County Teacher

1. Is the leaf shaped like a hand with fingers spread out?
   Yes – Go to #2
   No – Go to #4

2. Does the leaf have rounded ends?
   Yes – sand post oak
   No – Go to #3

3. Does the leaf have many veins?
   No - turkey oak
   Yes – Southern red oak

4. Is the leaf wider at the tip with wrinkled edges?
   Yes – Chapman oak
   No – Go to #5

5. Is the leaf wide at the tip with smooth edges?
   Yes – Go to #6
   No – Go to #7

6. Does the wide end stay wide?
   Yes – myrtle oak
   No – water oak

7. Is the leaf narrow with very curly edges?
   Yes – sand live oak
   No – Go to #8

8. Is the leaf narrow and pointed?
   Yes – Go to #9
   No – live oak

9. Is the bottom of the leaf copper brown (tree no more than 4 ft tall)?
   Yes – running oak
   No – Go to #10

10. Is the bottom of the leaf a purple/blue-like color?
    Yes – bluejack oak
    No – Go to #11

11. Is the leaf pointed but NOT curled?
    Yes - Laurel oak
    No – scrub oak
<table>
<thead>
<tr>
<th>Community</th>
<th>Location</th>
<th>Soil type</th>
<th>Plants and Trees</th>
<th>Wildlife</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Pine Scrub</td>
<td>Desert-like hilltop islands located along the shore and slightly inland</td>
<td>Fine-textured sandy soil</td>
<td>Sand Pine, Chapmans oak, Myrtle oak, Sand live oak, Broomsedge, Gopher apple, Ground blueberry, Lichens, Rosemary, Saw palmetto</td>
<td>Flycatchers, woodpeckers, wrens, screech owls, flying squirrels, black bear, deer, raccoon, wild hog, grey fox, bobcat, spotted skunk, Gopher tortoises, mice, indigo snake, sand skink, mole skink, scrub jay, scrub lizard, blue-tailed mole skink, sand skink</td>
</tr>
<tr>
<td>Sandhill</td>
<td>Savanna-like habitats with sloping terrains</td>
<td>Sandy, and well-drained</td>
<td>Longleaf pine, Turkey oak, Black cherry, Bluejack oak, Persimmon, Sand post oak, Sassafras, Southern red oak, Blackberry, Blazingstar, Black birch, Deer tongue, Golden aster, Gopher apple, Ground blueberry, Lopsided Indiangrass, Pawpaw, Prickly pear, Sparkleberry, Wiregrass</td>
<td>Gopher tortoises, Sherman's fox squirrel, red-cockaded woodpecker, bob-white quail, pine warblers, ground dove, kingbird, bluebird, nuthatch, and red-billed woodpecker, indigo snake, Gopher frog, sand skink, Florida mouse, scarab beetle</td>
</tr>
<tr>
<td>Xeric Hammock</td>
<td>Remnant dune; high areas</td>
<td>Dry soil</td>
<td>Shortleaf, spruce, longleaf and loblolly pine, cabbage palms, scrub and sand hickory, flowering dogwood, American holly, sweetgum, water oak</td>
<td>Barking treefrog, spade-foot toad, gopher tortoise, worm lizard, fence lizard, black racer, red rat snake, hognose snake, crowned snake, screech-owl, turkey, blue jay, eastern mole, gray squirrel, and eastern flying squirrel</td>
</tr>
<tr>
<td>Xeric Hardwood Hammock</td>
<td>High areas surrounded by marshes</td>
<td>Moderately moist, sandy soil</td>
<td>Spruce pine, cabbage palm, red maple, sugarberry, sour orange, southern magnolia, wax myrtle, black cherry</td>
<td>Squirrels, mice, opossums, foxes, armadillos, raccoons, deer, bobcats, black bear, wolves, snakes, lizards, turtles, tmitice, hawks</td>
</tr>
<tr>
<td>Mesic Hammock</td>
<td>Forested wetlands</td>
<td>Wet soil</td>
<td>Sugarberry, common persimmon, water ash, loblolly bay, American sycamore, swamp laurel oak, water oak, live oak</td>
<td>Mole, bats, common kingsnake, box turtle, indigo snake, swallowed-tailed kite, otter, black bear</td>
</tr>
<tr>
<td>Wetland Hardwood Hammock</td>
<td>Low flat areas</td>
<td>Poorly drained, acidic sandy soils</td>
<td>Longleaf, slash, or pond pine dominates; shrub understory contains species such as saw palmetto, wax myrtle, gallberry, and wiregrass</td>
<td>Eastern diamondback rattlesnake, threatened red-cockaded woodpecker, white-tailed deer, threatened Florida black bear, endangered Florida panther</td>
</tr>
<tr>
<td>Hydric Hammock</td>
<td>Low flat areas, poorly drained</td>
<td>Inland marshes have allaline soils; sand is found in marshes near waves or flowing water; protected areas have clay</td>
<td>Water lily, cattail, maidencane, pickerel weed, sawgrass</td>
<td>Midges, mosquitoes, and crane flies, muskrats, shrews and mice, ducks, geese, swans, songbirds, swallow, pike and carp, American alligator, white-tailed deer, endangered Florida panther</td>
</tr>
<tr>
<td>Freshwater Marsh and Prairie</td>
<td>Low lying areas around rivers and sloughs</td>
<td>Very rich soil covered by water</td>
<td>Oaks, black gum, willow, cypress, red maple, sawgrass</td>
<td>Eastern screech owl, swallow-tail kite, wading birds, yellow-crowned night heron, bobcat, mink, raccoon, river otter, American alligator, frogs, snakes</td>
</tr>
<tr>
<td>Hardwood Swamp</td>
<td>Low-lying areas around rivers and sloughs</td>
<td>Saturated with water for varying periods each year</td>
<td>Bald cypress, willow, wax myrtle, red maple</td>
<td>Otter, alligator, salamander</td>
</tr>
<tr>
<td>Cypress Swamp</td>
<td>Low-lying areas</td>
<td>Sand, silt, clay, and shell fragments</td>
<td>Sea grass beds, large algae, turtle grass</td>
<td>Shrimp, blue crabs, spotted sea trout, oysters</td>
</tr>
<tr>
<td>Marine Grass Flats</td>
<td>Low-lying, coastal areas covered by shallow water</td>
<td>Waterlogged, brackish sediment</td>
<td>Red mangrove, black mangrove, white mangrove, buttonwood</td>
<td>Endangered American crocodile, osprey, pelican, roseate spoonbill, crab</td>
</tr>
<tr>
<td>Mangrove Swamp</td>
<td>Low-lying, intertidal zone</td>
<td>Waterlogged, brackish sediment</td>
<td>Cordgrass, black needlerush, multicellular seaweeds</td>
<td>Clapper rails, long-billed marsh wrens, seaside sparrows, endangered Atlantic salt marsh snake</td>
</tr>
<tr>
<td>Salt Marsh</td>
<td>Relatively flat, intertidal areas</td>
<td>Often waterlogged, sandy sediment</td>
<td>Beach morning glory, railroad vine, sea oats, saw palmetto, Spanish bayonet, yaupon holly, wax myrtle, sea grape, cocoplum, nickerbean</td>
<td>Mice, black bear, raccoon, hermit crab, eastern diamondback rattlesnake, loggerhead turtles, Florida scrub jay, hognose snakes</td>
</tr>
<tr>
<td>Coastal Strand</td>
<td>High-energy shorelines, parallel to the Atlantic Ocean, Gulf of Mexico</td>
<td>Well-drained, sandy soils</td>
<td>Longleaf pine, Turkey oak, Black cherry, Bluejack oak, Persimmon, Sand post oak, Sassafras, Southern red oak, Blackberry, Blazingstar, Black birch, Deer tongue, Golden aster, Gopher apple, Ground blueberry, Lopsided Indiangrass, Pawpaw, Prickly pear, Sparkleberry, Wiregrass</td>
<td>Gopher tortoises, Sherman's fox squirrel, red-cockaded woodpecker, bob-white quail, pine warblers, ground dove, kingbird, bluebird, nuthatch, and red-billed woodpecker, indigo snake, Gopher frog, sand skink, Florida mouse, scarab beetle</td>
</tr>
</tbody>
</table>
PowerPoint Rubric

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphics Sources</td>
<td>Graphics are hand-drawn. The illustrator(s) are given credit somewhere in the presentation.</td>
<td>A combination of hand-drawn and stock graphics are used. Sources are documented in the presentation for all images.</td>
<td>Some graphics are from sources that clearly state that non-commercial use is allowed without written permission. Sources are documented in the presentation for all &quot;borrowed&quot; images.</td>
<td>Some graphics are borrowed from sites that do not have copyright statements or do not state that non-commercial use is allowed, OR sources are not documented for all images.</td>
</tr>
<tr>
<td>Use of Graphics</td>
<td>All graphics are attractive (size and colors) and support the theme/content of the presentation.</td>
<td>A few graphics are not attractive but all support the theme/content of the presentation.</td>
<td>All graphics are attractive but a few do not seem to support the theme/content of the presentation.</td>
<td>Several graphics are unattractive AND detract from the content of the presentation.</td>
</tr>
<tr>
<td>Content - Accuracy</td>
<td>All content throughout the presentation is accurate. There are no factual errors.</td>
<td>Most of the content is accurate but there is one piece of information that might be inaccurate.</td>
<td>The content is generally accurate, but one piece of information is clearly flawed or inaccurate.</td>
<td>Content is typically confusing or contains more than one factual error.</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Project includes all material needed to gain a comfortable understanding of the topic. It is a highly effective study guide.</td>
<td>Project includes most material needed to gain a comfortable understanding of the material but is lacking one or two key elements. It is an adequate study guide.</td>
<td>Project is missing more than two key elements. It would make an incomplete study guide.</td>
<td>Project is lacking several key elements and has inaccuracies that make it a poor study guide.</td>
</tr>
</tbody>
</table>
### Natural Community Comparison Chart

<table>
<thead>
<tr>
<th>Abiotic Characteristics</th>
<th>Location 1</th>
<th>Location 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil Description</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(color, are there organic materials present?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soil Moisture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Does the soil hold its shape in your hand or fall apart?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soil pH</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(use probe if available)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soil Porosity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Does the water in the can disappear quickly, slowly, or not move at all?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soil Temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(use lab type thermometer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Air Temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(use weather thermometer)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vegetation Observations</th>
<th>Location 1</th>
<th>Location 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree Canopy Density</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(estimate coverage in percentage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Understory Density</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(describe how thickly the shrubs, young trees, and grasses are growing)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant Identification</th>
<th>Location 1</th>
<th>Location 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(identify prominent trees—pines and oaks)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shrubs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wildflowers</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evidence of Wildlife (Scat, feathers, snake skins, owl pellets, tracks, tunnels or burrows, nests, tree cavities, birds singing, frogs croaking, etc.)</th>
<th>Location 1</th>
<th>Location 2</th>
</tr>
</thead>
</table>
Lesson 5: Gopher Tortoise
Author: Teresa Urban

Introduction:
Gopher tortoises, *Gopherus polyphemus*, in Florida are a species of special concern. The gopher tortoise inhabits well-drained sandy soil areas, such as longleaf pine-xeric oak sandhills, scrub, pine flatwoods, xeric hammock, dry prairie, coastal grasslands and dunes, mixed hardwood-pine communities and a variety of disturbed habitats. Gopher tortoises excavate burrows in these sandy soils that average 14 feet in length and six feet deep. The burrows serve as protection from extreme temperatures, predators, and serve as refuges for approximately 360 other species. The tolerant gopher allows many species to share the burrow either full-time or part-time. Some of these tenants are so dependent on burrows that when the gopher tortoise disappears, they disappear as well.* For that reason the gopher tortoise is named a “keystone species.” Examples of animals that share the burrow are the eastern indigo snake, Florida pine snake, wolf spider, mole skink, gopher frog, Florida mouse, southern toad, quail, burrowing owl, and black racer. Paleontologists have discovered fossils from the Miocene Epoch that are closely related to the modern gopher tortoise. The modern animal survived many hardships; it has endured climate changes and other challenges. Fifty years ago mankind became the species’ worst enemy. Men have collected the tortoises and sold them as pets; snake hunters have poured gasoline in the burrows to flush out rattlesnakes; drivers have crushed animals on the highways. Yet the most extreme threat man poses is destruction of the gopher tortoise’s habitat. Timber companies clear away pine forests in which gopher tortoises made their homes. Bulldozers raze other “high and dry” habitats, replacing burrows with houses, tourist resorts, and other commercial projects. In 1978, the Gopher Tortoise Council was established to promote research studies and determine best practice methods of protecting the gopher tortoise and its habitats. The Florida Fish and Wildlife Conservation Commission enforce the rules and regulations regarding the gopher tortoise. When phosphate mining companies must clear land and tortoises are onsite, regulators allow companies two options: mitigating for the take, by providing habitat protection elsewhere, or relocation, whereby the company captures tortoises and releases them at another site.

Students learn that human actions—such as farming, phosphate mining and processing, building roads, commercial and housing developments—have an impact on the environment. *Essential Question:* How have mining and other human activities impacted the survival of gopher tortoises in central Florida?

Students should understand that all animals need food, water, shelter and space to survive. Recognize basic habitats and communities of central Florida (scrub, forested uplands, wetlands, and sandhills). Know that tortoises are reptiles. Understand that tortoises are turtles adapted for living on land. Understand that gopher tortoises in Florida have survived for many years—from as early as the Miocene Epoch.

Activity:
Students watch and listen to a PowerPoint presentation giving background information about the gopher tortoise. In small groups they play *Survival: The Gopher Tortoise Game*, reinforcing

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the information taught in the PowerPoint presentation. Students follow up with a group activity such as creating a public service poster, pamphlet or video.

**Estimated Time:**
Two 45-minute class periods
Extension— One field trip day

**Grade Level:**
6-8

**Standards:**
LA.6.4.3.1  LA.6.4.3.2  LA.6.5.2.1  LA.6.5.2.2  LA.6.6.4.2  SS.6.G.1.1
LA.7.4.3.1  LA.7.4.3.2  LA.7.5.2.1  LA.7.6.4.1  LA.8.6.4.1  LA.7.6.4.2
LA.8.4.3.1  LA.8.4.3.2  LA.8.5.2.2  LA.8.6.4.2  SC.8.N.4.1
LA.7.4.3.1  LA.7.4.3.2  LA.7.5.2.1  LA.7.6.4.1  LA.8.6.4.2

**Objectives:**
The students will...
1. Describe the problems of the gopher tortoise’s survival and cause of its habitat loss.
2. Draw inferences about the effects of limiting factors on gopher tortoises.
3. Describe efforts to protect gopher tortoises made by mining companies, commercial and housing developers, and private or government agencies.
4. Communicate ways in which the public can protect and preserve gopher tortoises, their burrows and habitats.

**Vocabulary:**
burrow apron  carapace
commensal  community
controlled burn  end chamber
forage  gular
habitat  hatchling
herbivore  herpetologist
keystone species  limiting factor
plastron  recipient site
land reclamation  refuge
scute  take
transects  uplands
xeric  mitigation
environmental consultant  upper respiratory tract disease (URTD)

**Materials:**
Computer lab with internet, publishing software, or simple movie making software (Windows Movie Maker)
Computer with LCD projector
Legal size manila folder per group
Copies of game board
Copies of game directions
Copies of Cool Gopher Tortoise Facts
Enough game board markers/tokens for each student in class
One die for each group
Cut-out copies of the Limiting Factor Cards - 12 per game board (card stock)
Cut-out copies of the Data Sheets- 4 per game board (card stock)
Extension — GPS receivers (class set available for loan at FIPR Institute)
Gopher Tortoise Burrow Survey worksheet
Rubric for project evaluation

Procedure:
Day 1
Present the background information to students using the Gopher Tortoise Council’s PowerPoint presentation, Gopher Tortoise: A Species in Decline. (Be sure to print the note pages to assist with the presentation.)

Day 2
1. Explain the rules of the Gopher Tortoise Game.
2. Divide students into appropriate groups of 3 or 4 and distribute the game folders and materials.
3. Monitor students during the playing of game. If students finish too quickly, suggest that they begin again and read aloud the draw cards. 20 minutes would be an appropriate amount of time for playing.
4. Continue playing game, if needed. Ask students to list the factors that limit the gopher tortoises’ survival.
5. Ask students for specific recommendations to increase the successful reproduction and survival of the gopher tortoises.

Analysis/Conclusion:
Project
In small groups create a brochure, PowerPoint presentation, poster, or video report to share with other students and community. This project communicates ways in which the general public can help preserve and protect the gopher tortoises, their burrows and their habitats. Use rubric to evaluate final product. What other animals or plants are endangered in this area? Allow research and presentation of other endangered species unique to central Florida (gopher frog, Eastern indigo snake, bluetail mole skink, burrowing owl, Florida scrub jay, Florida mouse, etc.).
http://www.floridaendangeredspeciesnetwork.org/specieslist.htm

Extension:
Arrange a field trip to a park or preserve of known gopher tortoise burrows. Have students complete the Gopher Tortoise Burrow Survey of the area, marking GPS coordinates, and share this information with the local government or agency. The surveyed site might be a suitable donor area where gopher tortoises need to be relocated.
(GPS units may be borrowed from FIPR Institute—863-534-7160.)
Teacher Notes:
Download the PowerPoint presentation, *Gopher Tortoise: A Species in Decline*. This can be found at [http://www.gophertortoisecouncil.org/](http://www.gophertortoisecouncil.org/) under Featured Projects. Print the notes pages to use during the presentation. Reserve or set up computer and LCD projector.

Prepare enough games for groups of three or four students. Make copies of the game instructions and use cardstock to print out the *Limiting Factor Cards* and *Data Sheets*. Cut out the *Limiting Factor Cards* and *Data Sheets*. These sheets could be placed in a plastic insert sheet. Print out the game board templates on legal-size copier paper. Glue or staple the game board templates on the inside of a legal-size manila folder. Fill a baggie with 3-4 game markers and one die for each game board.

Resources:


Survival: The Gopher Tortoise Game
Author: Teresa Urban

Number of players:
2-4

Materials:
3-4 game markers, one die, limiting factor cards, data sheet cards, game board sheets

Goal:
Move a tortoise playing piece ahead through the burrow to the space marked “Adult,” when the tortoise is capable of successful reproduction. (Females reach sexual maturity around 9-21 years of age.)

Rules:
• All playing pieces begin in the nest. The nest is located either in the burrow apron or near the apron. To leave the nest a player must roll a one or two on the die (one roll per turn).
• Once a player has rolled the appropriate number to move out of the nest, the playing piece is placed on the end chamber (space at the end of the tunnel). At the next turn, the player rolls the die again and proceeds counting the correct number of spaces.
• Player rolls the die, moves to corresponding space. They read aloud the directions or information on the space that they have landed on. The player follows the instructions on the space occupied. (See list below.)
• If a player lands on a space shared by another player, they continue to play as normal.
• To reach adulthood, a player must roll the exact number of spaces to land on the adult gopher tortoise at the burrow opening.

Spaces:
• Limiting Factor - draw card and follow directions (take no other action as written on the new space).
• Capture and Release - draw Data Sheet Card and keep the card. Use it to trade for a Limiting Factor card if needed. If a player lands on a Limiting Factor space, return the Data Sheet Card to the pile and remain on that space until the next turn.
• Free space - remain until next turn, take no other action.
• Disasters - (forest fire, hurricane, brush fire and freezing weather) follow the directions on that space.
• Commensal - move two spaces forward, take no other action.
## Limiting Factor Cards

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>A new housing development has been built near your habitat. Dogs have</td>
<td>Move back 3 spaces. Take no further action.</td>
</tr>
<tr>
<td>dug up your nest and eggs and have torn up the opening of your burrow.</td>
<td></td>
</tr>
<tr>
<td>You are a hatchling. The raccoon population has increased around a</td>
<td>Return to the nest.</td>
</tr>
<tr>
<td>nearby campground. Raccoons have feasted on hatchlings this evening.</td>
<td></td>
</tr>
<tr>
<td>You wandered to the beach in search of food. A tourist mistook you for</td>
<td>Move back 2 spaces. Take no further action.</td>
</tr>
<tr>
<td>a sea turtle and took you back to the surf. The stress has made you</td>
<td></td>
</tr>
<tr>
<td>sick.</td>
<td></td>
</tr>
<tr>
<td>You are a young gopher tortoise. A cat from a nearby housing development</td>
<td>Move back 4 spaces. Take no further action.</td>
</tr>
<tr>
<td>has caught you for a tasty snack.</td>
<td></td>
</tr>
<tr>
<td>You have contracted an upper respiratory tract disease (URTD).</td>
<td>Return to the nest.</td>
</tr>
<tr>
<td>Because new housing developments have been built, landowners no longer</td>
<td>Move back 3 spaces. Take no further action.</td>
</tr>
<tr>
<td>conduct controlled burns in your habitat. Shrub and thickets have</td>
<td></td>
</tr>
<tr>
<td>crowded out your primary food sources. You have to forage far from your</td>
<td></td>
</tr>
<tr>
<td>burrow.</td>
<td></td>
</tr>
<tr>
<td>For many years, a landowner has prevented prescribed burning. The forest</td>
<td>Move back 3 spaces. Take no further action.</td>
</tr>
<tr>
<td>undergrowth, shrubs and thickets have crowded out the grasses. You are</td>
<td></td>
</tr>
<tr>
<td>forced to move to another burrow to be nearer food.</td>
<td></td>
</tr>
<tr>
<td>It is April and you are looking for a female. During your search, a</td>
<td>Return to the nest.</td>
</tr>
<tr>
<td>truck ran over and killed you.</td>
<td></td>
</tr>
<tr>
<td>A shopping mall developer applied for a relocation permit to relocate</td>
<td>Move back 4 spaces. Take no further action.</td>
</tr>
<tr>
<td>you to another donor site.</td>
<td></td>
</tr>
<tr>
<td>A phosphate mining company will dig up a site that contains your colony's</td>
<td>Move back 5 spaces. Take no further action.</td>
</tr>
<tr>
<td>burrows. The company applied for a permit to relocate you to another</td>
<td></td>
</tr>
<tr>
<td>reclaimed site nearby.</td>
<td></td>
</tr>
<tr>
<td>A farmer is expanding an orange grove near your burrow and has</td>
<td></td>
</tr>
<tr>
<td>destroyed the burrow.</td>
<td></td>
</tr>
<tr>
<td>The new highway has fragmented your habitat. You have to abandon your</td>
<td></td>
</tr>
<tr>
<td>home to find suitable forage.</td>
<td></td>
</tr>
</tbody>
</table>
Captured Tortoise Data Sheet

Date: 6-14-07  Recorder: TAU
Location: Peace River Pk

New Capture: ✓  Recapture: □

Circle: Male  Female
Juv (<60mm)  Sub (<180mm)

Weight: 204 (grams)

Length: (Straight line, longest)
Carapace 213 (mm)
Plastron 217 (mm)

Tortoise Number:  [Use Cage method] see above and circle

Health Evaluation: (circle)

General Appearance: Healthy  Perhaps a little light for size  May be sick
Tortoise is: Active and strong  Active but weak  Lethargic

Eyes: Damaged  Right: clear and no mucus or swelling  Left: clogged dry or clogged with wet mucus

Nares: Both open and clear  Right: clogged dry or clogged with wet mucus

Mouth: open mouth appears normal pinkish, Miss colored (reddish sores, brownish sores), yellowish spongy material present

Cloaca: appears normal, bleeding, sphincter area appears infected

Skin: appears normal (healed scars), scabby white areas, wounds

Shell: firm, entire, old breaks, wounds new damage

Parasites: none seen  adult ticks (large)  very small ticks  mites

Adapted from The Gopher Tortoise A Life History

Released near burrow.

KEEP THIS CARD. TRADE FOR A LIMITING FACTOR CARD.
Captured Tortoise Data Sheet

Date: 6-14-07, Recorder: *TAU*
Location: Peace River Pk

New Capture: *X*, Recapture: *

Circle: Male, Female
Juv (<80mm) Sub (<180mm)

Weight: 2.04 (grams)

Length (Straight line, longest)
Carapace: 194 (mm)
Plastron: 207 (mm)

Tortoise Number: 142
(Use Cagle method) see above and circle

Health Evaluation: (circle)

General Appearance: Healthy
Perhaps a little light for size
May be sick
Active and strong
Lethargic

Eyes: Damaged
Right clear and no mucus or swelling
Left: clear and no mucus or swelling

Nares: Both open and clear
Right: clogged dry or clogged with wet mucus
Left: clogged dry or clogged with wet mucus

Mouth: open; mouth appears normal
Miss colored (reddish sores, brownish sores), yellowish spongy material present

Cloaca: appears normal, bleeding, sphincter area appears infected

Skin: appears normal (tanned scars), scabby white areas, wounds

Shell: firm, entire
Old breaks, wounds, new damage

Shell disease: none, active, inactive, minor, serious

Parasites: none seen, adult ticks (large), very small ticks, mites

Adapted from *The Gopher Tortoise: A Life History*

Released at burrow.

KEEP THIS CARD. TRADE FOR A LIMITING FACTOR CARD.
Survival: The Gopher Tortoise Game

- Phosphate Mining: Borrowed Land
- Florida Industrial and Phosphate Research Institute

Spaces:
1. Southern cattail
2. Maidencane
3. Maidencane
4. Longleaf pine
5. Turkey oak
6. Yellow water lily
7. Prickly pear cactus
8. Paspalum grass
9. Weather
10. Freezing weather
11. Florida mouse (Podomys floridanus)
12. Brush fire
13. Commensal - move 2 spaces
14. Limiting factor
15. Capture and Release
16. Draw a data card
17. Commensal - move 2 spaces
18. Black racer

Special Spaces:
- The Nest: Landmark
- Limiting factor
- Miss one turn
- Commensal - move 2 spaces
- Move 2 spaces
## Multimedia Presentation Rubric

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation</td>
<td>Well-rehearsed with smooth delivery that holds audience attention.</td>
<td>Rehearsed with fairly smooth delivery that holds audience attention most of the time.</td>
<td>Delivery not smooth, but able to maintain interest of the audience most of the time.</td>
<td>Delivery not smooth and audience attention often lost.</td>
</tr>
<tr>
<td>Sources</td>
<td>Source information collected for all graphics, facts and quotes. All documented in desired format.</td>
<td>Source information collected for all graphics, facts and quotes. Most documented in desired format.</td>
<td>Source information collected for graphics, facts and quotes, but not documented in desired format.</td>
<td>Very little or no source information was collected.</td>
</tr>
<tr>
<td>Content</td>
<td>Covers topic in-depth with details and examples. Subject knowledge is excellent.</td>
<td>Includes essential knowledge about the topic. Subject knowledge appears to be good.</td>
<td>Includes essential information about the topic but there are 1-2 factual errors.</td>
<td>Content is minimal OR there are several factual errors.</td>
</tr>
<tr>
<td>Attractiveness</td>
<td>Makes excellent use of font, color, graphics, effects, etc. to enhance the presentation.</td>
<td>Makes good use of font, color, graphics, effects, etc. to enhance to presentation.</td>
<td>Makes use of font, color, graphics, effects, etc. but occasionally these detract from the presentation content.</td>
<td>Use of font, color, graphics, effects etc. but these often distract from the presentation content.</td>
</tr>
<tr>
<td>Organization</td>
<td>Content is well organized using headings or bulleted lists to group related material.</td>
<td>Uses headings or bulleted lists to organize, but the overall organization of topics appears flawed.</td>
<td>Content is logically organized for the most part.</td>
<td>There was no clear or logical organizational structure, just lots of facts.</td>
</tr>
</tbody>
</table>

Date Created: **Dec 13, 2010 05:19 pm (UTC)**
http://rubistar.4teachers.org/
Gopher Tortoise Burrow Survey

**Site:** ________________________________

**Surveyors:** ________________________________

<table>
<thead>
<tr>
<th>Burrow 1</th>
<th>Burrow 2</th>
<th>Burrow 3</th>
<th>Burrow 4</th>
<th>Burrow 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GPS coordinates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Elevation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plant community</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Active or inactive</strong> (apron shows tracks of GT; opening in good condition)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height/width of opening indicating juvenile or adult</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Direction of opening</strong> (N,E,S,W)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Location of burrow on land</strong> (slope, flat ground, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nearby vegetation types</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other notes</strong> (vandalism, etc.)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Lesson 6: Schoolyard Reclamation
Author: Teresa Urban

Introduction:
Before July 1, 1975, most phosphate-mined areas in central Florida were simply left alone. The leftover moonscapes, spoil piles, pits, clay settling areas were “healed” by nature or “naturally reclaimed.” Even so, the landscape, soil, and water flow was changed forever. After the Reclamation Act of 1975, mining companies were required to restore the mined land back to its former condition or make it usable for some other purpose. Mining engineers, environmental specialists and scientists work together to plan for mining and reclamation before the land is altered. “Naturally reclaimed” sites have also been used for parks, citrus groves, and cattle grazing. However, it is a bit more difficult to reclaim one of these “naturally reclaimed” areas to its original natural community or habitat. It takes time for trees to grow into a flatwoods, sandhills, scrub, or swamp community. In the meantime exotic, invasive plants, such as cogongrass, take over the area, interfering with the growth of natural plants that are native to the original community. Those specialists involved in land reclamation have conducted many trial-and-error tests to find the most effective means of removing invasive/exotic plants. There are extensive research reports online that provide tested methodology information for the removal of invasive/exotic plants.

This lesson is for those students and teachers who are interested in a hands-on reclamation project; to work on the restoration of a disturbed site either on school grounds or at a nearby park or reserve. The site may have been altered by phosphate mining or other human activities. Students will appreciate the labor, trial and error, and challenges of the biologists and other scientists who reclaim the phosphate mined lands. 

Essential question: How have human activities impacted local land areas?

Students should be familiar with central Florida natural communities and techniques used to identify them.

Activity:
This is a long-term lesson that incorporates real-world, scientific reclamation activities. Students determine the natural community type of a given site (on schoolyard or nearby disturbed property). They develop a plan to improve or enhance the natural area including adding new trees, shrubs, grasses and herbaceous plants. If invasive exotic plants exist, students research and develop a plan to eradicate the plants.

Estimated Time:
Two field trip days
Three to four 45-minute class periods
Extended time for actual work on land site improvement.

Grade Level:
6-8
Standards:
LA.6.4.2.2 SC.6.N.1.4
LA.7.4.2.2 LA.7.6.4.1 SC.7.E.6.6 SC.7.L.17.2 SC.7.L.17.3 SC.7.N.1.1
SC.7.N.1.3 SC.7.N.1.4 SC.7.N.1.5
LA.8.4.2.2

Objectives:
The students will…
1. Analyze abiotic and biotic factors existing in a given land area.
2. Identify the impact of human activities on this land area.
3. Describe the tested methods used to eradicate invasive and exotic plants.
4. Explain the competition between native and invasive/exotic plants in Florida’s natural communities.
5. Identify the independent and dependent variables in an investigation to eradicate invasive/exotic plants from a given land area.

Vocabulary:
native plants independent variables dependent variables
controlled variables herbaceous plants eradicate
exotic plants invasive hypothesis

Materials:
Computer lab with internet connection
Tree keys and field guides from previous lesson
Invasive plant recognition cards (downloaded and printed from internet)
Grid paper for drawing a map of the site area and for the improvement plan
Handout: Common Native Plants of Central Florida
Digital cameras
Large tape measure with metrics, approximately 30 meters or more
Garden stakes for marking corners of site
Bright colored marking tape available at hardware stores
Shovels
Watering pails or buckets
Garden gloves

Procedure:
1. Have students take digital photos of the site, mark it with stakes making a workable quadrangle, and measure the perimeter. Identify and record the common trees, shrubs, grasses and herbaceous plants growing there.
2. Back in the classroom have students—working in groups—draw a map of the site area, indicating the existing trees, shrubs and plants. Maps should be grid marked using 1 meter of land per 1 centimeter or another appropriate ratio. Have students color the areas where exotic plants are present. They should record the natural plant community type.
3. Ask students how they might like to improve the land area—making it more like a natural community that could support wildlife, etc. List these ideas including the new plants they would like to add and the removal of invasive plants. (Provide students with the handout: Common Native Plants of Central Florida.)
4. Have students draw a “new” map with existing native plants and showing where new plants
could be added.

5. Point out that scientists conduct many trials to determine the most effective methods of invasive plant eradication. They must also be careful not to disturb the native plants already growing there.

6. If an invasive plant has been identified at the land site, have students use the internet to find several different methods of removal or eradication. Some methods may be less expensive or less harmful to the environment. Some methods must be repeated.

7. Explain dependent and independent variables. The independent variable is the one that is purposely changed by the scientist. The dependent variable is how it responds to the change made to the independent variable. There must also be controlled variables. Controlled variables serve as a standard of comparison with another variable to which the control is identical except for one factor. Have students discuss and develop an investigation plan to eradicate an invasive plant. (See example to the right.) They may use the Invasive Plant Eradication Investigation worksheet as a guide.

http://www.sciencebuddies.org/science-fair-projects/project_variables.shtml

Analysis/Conclusion:
Collect maps of the areas for participation grades.
Assess the investigation plan to eradicate invasive plants.

Teacher Notes:
Select a small site (30 m. x 30 m.) on school grounds or nearby park that needs vegetation improvement.
Obtain permission to make improvements to the site if desired.
Prepare keys and field guides used in previous lesson.
Download and print recognition cards of the most common plant exotics in central Florida—
http://plants.ifas.ufl.edu/node/683

Suggestions for those teachers that plan to actually improve a land area:
Funding—Lowe’s Outdoor Classroom grants: http://www.lowes.com/
Native plants information—“Waterwise Florida School Landscape”—contact Nancy Bissett,—an expert on Florida native plants—The Natives in Davenport, Florida.
New vegetation planting—Demonstrate proper planting methods before assigning specific jobs to students. Take before and after photos, log planting days, log watering days, etc. Water new plants frequently at first and then less as the year progresses. Consider weeding and mulching. Mowing might be needed to rejuvenate grasses or other herbaceous species. Flag new plants to prevent them from being mowed over. Trees and shrubs may require fertilizing when planted. Plants should be measured and logged at the time of planting and periodically throughout the school year.
Vegetation assessment—use an appropriate method to measure plants before and after improvements. See information on Reclamation: Vegetation Assessment Methods CD (FIPR Institute).
Problem: Cogongrass covers a large area on the site.
Hypothesis: Spraying X herbicide before rain will kill the cogongrass blades.
Controlled variables: Entire area receives same amount of sunlight, rain water
Dependent variable: Vegetation assessment results after spraying
Independent variable: One half of area sprayed with X herbicide.
### Invasive Plant Eradication Investigation

<table>
<thead>
<tr>
<th><strong>Problem</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Name and describe how the invasive exotic plant is competing for space in the land site.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Hypothesis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(State the expected outcome as a result of the eradication method used.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Independent Variable</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Describe the one thing that is purposely changed in the investigation, such as; applying herbicide to the cogongrass on half the plot; tilling the invasive plant on half the plot; harvesting the aerial tubers of the air potato, etc)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Dependent Variable</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(What will be measured after the eradication method has been applied?)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Controlled Variables</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(List the variables that you will make sure will stay the same in all testing areas; plants receive same amount of sunshine, water, etc.)</td>
</tr>
</tbody>
</table>
Common Native Plants of Central Florida

**Pine Flatwoods or Scrubby Flatwoods**
Flatwoods occur on nearly level land. Water movement is very gradual with swamps, ponds, marshes, and cypress domes interspersed. There are numerous soil types, primarily acidic, poorly drained and coarse textured. The flatwoods of central and south Florida are best described as savannas with sparse trees and shrubs, and they require low-intensity ground fire. It is recommended to begin the restoration of the flatwoods by seeding or planting for ground cover. After the ground cover is established trees and shrubs are planted. Depending on weather conditions and site preparation such as removing unwanted plants, the restoration process may take 3+ years for establishment.

**GRASSES**
- Andropogon sp.
- Aristida strict var. beyrichiana
- Eragrostis elliottii
- Eragrostis spectabilis
- Panicum hemitomon
- Sorghastrum secundum
- Tripsacum dactyloides

**GRASSES**
- Bluestem (both M and X varieties)
- Wiregrass (M)
- Elliott lovegrass (X)
- Purple lovegrass (M)
- Maidencane (M)
- Lopsided indiangrass (X)
- Eastern gamagrass (M)

**WILDFLOWERS and Groundcover**
- Axclepias tuberosa
- Yellow buttons (X)
- Prickly pear (X)
- Elephanthopus elatus
- Panicum anceps
- Pink beardtongue (X)
- Polygonella polygama
- Black-eyed susan (M)
- Salvia coccinea
- Goldenrod (M)

**WILDFLOWERS and Groundcover**
- Butterfly weed, Fl. (X)
- Coreopsis leavenworthii
- Leavenworth’s goldenrod (M)
- Elephant’s foot (M-X)
- Beaked panicum (M-X)
- Pityopsis graminifolia var. tracyi
- October flower (X)
- Salvia azerea
- Scarlet sage (X)
- Yankee roughleaf (X)
- Yucca filamentosa

**SHRUBS**
- Licania michauxii
- Shiny lyonia (M)
- Quercus chapmanii
- Dwarf live oak (M)
- Quercus pumila
- Saw palmetto (M)

**SHRUBS**
- Gopher apple (X)
- Myrica cerifera var. pumilla
- Chapman oak (X)
- Quercus myrtilifolia
- Runner oak (X)
- Vaccinium spp.

**TREES**
- Cratageus flava
- Diospyros virginiana
- Pinus clausa
- Pinus elliottii

**TREES**
- Summer hawthorne (X)
- Persimmon (M)
- Sand pine (X)
- Slash pine (M)
Pinus palustris  Long leaf pine (X)
Quercus geminate  Sand live oak (X)
Quercus incana  Bluejack oak (X)
Quercus laevis  Turkey oak (X)
Quercus virginiana  Live oak (M)
Sabal palmetto  Cabbage (Sabal) palm (M)

Sandhills
These xeric plant communities are scattered throughout central Florida and occur in areas of rolling terrain. They are often called Longleaf Pine – Turkey Oak Hills. The sands are yellow to white, well-drained, dry, and low in nutrients. The plants of the sandhill need fire to keep them healthy and to prevent encroachment of hardwood species. Trees are widely spaced and groundcover, such as wiregrass and pine needles, provides most of the fuel to carry fire through the sandhills. Following fire, bare sand becomes a good seedbed for many plants.

The well-drained soils of sandhills allow rapid downward movement of rainwater into ground water supplies. Because of this rainwater handling characteristic, many of these communities have been converted to school campuses, residential and commercial development, agriculture and forestry land uses. Many wildlife species such as the southeastern American kestrel, red-cockaded woodpecker, blue-tailed mole skink, and eastern indigo snake are in jeopardy of extinction due to habitat loss.

The xeric plants of the scrubby flatwoods listed above are typical of the sandhills. Additional plants are listed here.

GRASSES
Muhlenbergia capillaries  Pink muhly grass (X)
Sporobolus junceus  Pineland dropseed (X)

WILDFLOWERS and ground cover
Carphephorus corymbosus  Florida paintbrush (X)
Monarda punctata  Spotted beebalm (X)
Pteridum aquilinum  Bracken fern (X)

SHRUBS
Asimina obovata  Pawpaw (X)
Erythrina herbacea  Coral bean (X)
Ilex vomitoria  Yaupon holly (X)

Hardwood Hammock
Hammocks occur on rolling terrain. The soils are somewhat poorly to well drained and high in nutrients containing more organic material and litter than drier sites. The hammock is dominated by thick stands of shade tolerant hardwoods and few pines. Understory is sparse in late successional stages. By preventing naturally occurring fires in and near developed areas, people actually have caused many natural sandhills and flatwoods to grow into hammock communities.
There are variations of hammocks.

- Mesic hammocks of the peninsula are less diverse due to the absence of hardwood species that are suited to northern climates. Common trees of the mesic hardwood are laurel oak, hop hornbeam, blue beech, sweetgum, cabbage palm, American holly and southern magnolia.

- Xeric hammocks occur on deep, well-drained, sandy soils where fire has been absent for long periods of time. These open and dry hammocks contain live oak, sand-live oak, bluejack oak, southern red oak, sand-post oak, and pignut hickory.

- Coastal and hydric hammocks are relatively wet hardwood forests that are found between uplands and true wetlands, rivers and lakes. These communities contain water oak, red maple, Florida elm, cabbage palm, red cedar, blue-beech, and sweetgum.

The mesic trees and shrubs of the pine flatwoods may be found in hardwood hammocks.

**GRASSES and grasslike**

<table>
<thead>
<tr>
<th>Carex spp.</th>
<th>Caric sedges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juncus spp.</td>
<td>Rush</td>
</tr>
<tr>
<td>Panicum spp.</td>
<td>Maidencane</td>
</tr>
</tbody>
</table>

**WILDFLOWERS, ground cover and vines**

<table>
<thead>
<tr>
<th>Athyrium filix-femina</th>
<th>Lady fern</th>
<th>Dryopteris ludoviciana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern shield fern</td>
<td>Erigeron spp.</td>
<td>Fleabanes</td>
</tr>
<tr>
<td>Hypericum spp.</td>
<td>St. John’s wort</td>
<td>Osmunda cinnamomea</td>
</tr>
<tr>
<td>Cinnamon fern</td>
<td>Osmunda regalis</td>
<td>Royal fern</td>
</tr>
<tr>
<td>Rubus argutus</td>
<td>Blackberry</td>
<td>Verbena spp.</td>
</tr>
<tr>
<td>Verbena</td>
<td>Woodwardia spp.</td>
<td>Chain fern</td>
</tr>
</tbody>
</table>

**SHRUBS**

<table>
<thead>
<tr>
<th>Callicarpa americana</th>
<th>Beautyberry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lantana spp.</td>
<td>Lantana</td>
</tr>
<tr>
<td>Myrica cerifera</td>
<td>Wax myrtle</td>
</tr>
<tr>
<td>Rhamnus caroliniana</td>
<td>Carolina buckthorn</td>
</tr>
<tr>
<td>Vaccinium arboreum</td>
<td>Sparkleberry</td>
</tr>
<tr>
<td>Verburnum dentatum</td>
<td>Arrowwood</td>
</tr>
<tr>
<td>Viburnum rufidulum</td>
<td>Rusty viburnum</td>
</tr>
<tr>
<td>Zambia pumila</td>
<td>Coontie</td>
</tr>
</tbody>
</table>

**TREES**

<table>
<thead>
<tr>
<th>Acer rubrum</th>
<th>Red maple</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpinus caroliniana</td>
<td>American hornbeam (Blue beech)</td>
</tr>
<tr>
<td>Carya glabra</td>
<td>Pignut hickory</td>
</tr>
<tr>
<td>Cornus florida</td>
<td>Flowering dogwood</td>
</tr>
<tr>
<td>Fagus grandifolia</td>
<td>American beech</td>
</tr>
<tr>
<td>Ilex cassine</td>
<td>Dahoon holly</td>
</tr>
</tbody>
</table>
Ilex opaca        American holly
Juniperus silicicola  Southern red cedar
Liquidambar styraciflua  Sweetgum
Magnolia grandiflora  Southern magnolia
Magnolia virginiana  Sweetbay magnolia
Pinus taeda         Loblolly pine
Prunus serotina    Black cherry
Quercus laurifolia  Laurel oak
Quercus nigra      Water oak

References:


Materials

Computer lab with LCD projector for demonstrating the assignment
Software such as Microsoft Office Word or Inspiration
DVD player or computer that plays DVDs with LCD projector
AA batteries
Centimeter grid paper
Pencils
Clipboards
Meter stick
5-6 plastic 16 oz. water bottles
Centimeter ruler
Play sand
Aquarium gravel
Topsoil or potting soil
Small bags
Funnel
Newspapers
Small hand spade
Science probes for temperature and pH (if available)
2 coffee cans
Hammer
Bottles of water (same size)
Weather thermometer
Glass lab thermometer (soil temp)
Digital cameras

Borrow from FIPR Institute (863-534-7160)
Resource CD
   Ore Body Battleship Game
   Cycles of Matter on Earth PowerPoint
The Phosphate Story: Florida’s Hidden Treasure DVD
GPS receivers
Soil pH meter
Resources

**Websites**
Florida Industrial and Phosphate Research Institute (FIPR Institute)
http://www.fipr.poly.usf.edu

“Cupcake Core Sampling”—Women in Mining

http://www.scientificamerican.com/article.cfm?id=phosphorus-a-loomling-crisis

Phosphorus Cycle
http://www.lenntech.com/phosphorus-cycle.htm

Phosphorus Cycle Animation

Rubric templates
http://rubistar.4teachers.org/

Guide to the Natural Communities of Florida. Florida Department of Natural Resources, 1990,
www.fnai.org/naturalcommguide.cfm.

Information for possible natural community field trip locations:
http://www.polk-county.net/parks.aspx?menu_id=52
http://www.floridastateparks.org/coltcreek/default.cfm
http://www.floridastateparks.org/lakekissimme/default.cfm
http://www.fl-dof.com/state_forests/lake_wales_ridge.html

PowerPoint—Gopher Tortoise: A Species in Decline
http://www.gophertortoisecouncil.org/

Endangered Species
http://www.floridaendangeredspeciesnetwork.org/specieslist.htm

Invasive plant recognition cards
http://plants.ifas.ufl.edu/node/683

Introduction to variables
http://www.sciencebuddies.org/science-fair-projects/project_variables.shtml

**Books**

