Critical Zone Science: Creating an Interdisciplinary Approach to Teaching Science in Secondary Schools using *NGSS

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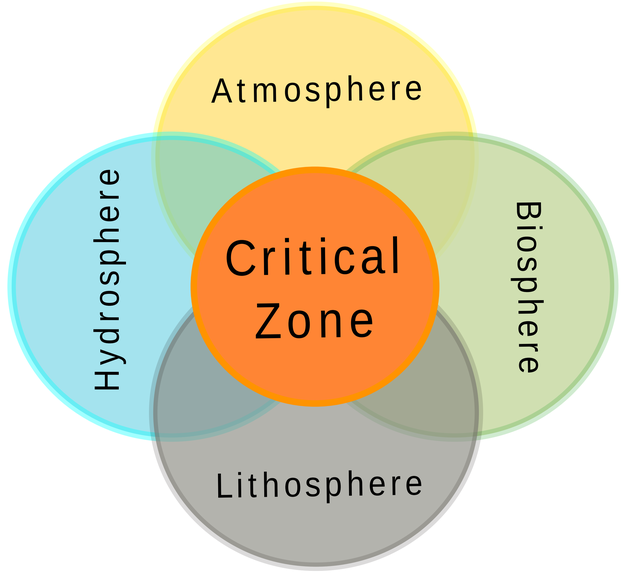
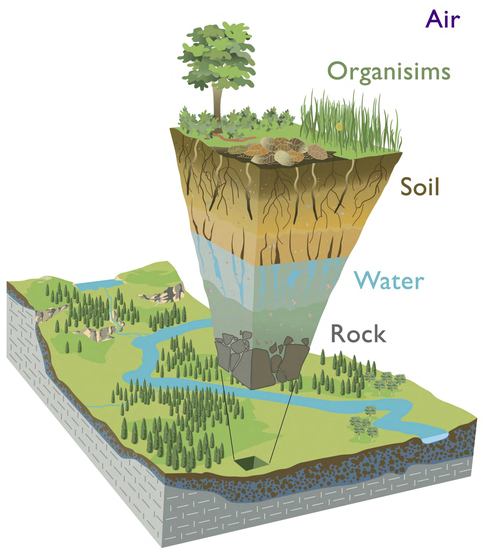
Abstract

The Critical Zone (CZ) is defined as the permeable layer from the top of the vegetation canopy to the bottom of freely circulating groundwater where rock, soil, water, air and life overlap. Critical Zone Observatories (CZO) are research field sites spanning a range of climatic, ecologic, geologic, and physiographic environments where scientists look to understand coupled physical, chemical, and biological processes. Interdisciplinary expertise and collaboration are required to understand and visualize these complex processes, which can be challenging for the general public. One approach uses Virtual Field Experiences (VFE) to expose people to different landscapes to answer: "Why does this place look like it does?" To develop a VFE on the Susquehanna-Shale Hills CZO (Shale Hills), information on the data, instrumentation and research questions at the site were compiled to explain the interconnectedness of the CZ in PA. This Shale Hills VFE was developed for seconday classrooms, however, VFEs can be modified to a broad range of educational settings. Teachers and students both benefit by the affordability, flexibility, and relevance to the *Next Generation Science Standards (NGSS). The Shale Hills VFE allows students to gain a better understanding of asking and answering questions through CZ research.



Critical Zone Science



The purpose of studying Critical Zone Science is to understand the short-term and long-term responses to changes in, for example, rainfall, human activities, land-use, climatic, and tectonics over time.
The complex interactions control the natural habitat and determine the availability of life-sustaining resources, such as food production and water quailty.

Figure 1: Generalized CZ cross-sectional schematic modified from Chorover, J., et al,. 2007. Soil biogeochemical processes in the critical zone. Elements 3, 321-326. (artwork by R. Kindlimann)

NGSS Standards

Next Generation Science Standards are implemented to remove from classrooms the notion in the school system of "teaching to the test." The idea is to stop memorizing facts and instead do research in which students spend more time discovering for themselves. Students spend more time questioning and discovering facts for themselves. These standards combine knowledge with practice, teaching students to develop ideas and evalute them according to scientific principles. Some examples of NGSS addressed by CZ Science:

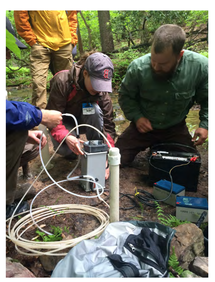
MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.
* "NGSS is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and do not endorse it."

Importance of an Interdisciplinary Approach

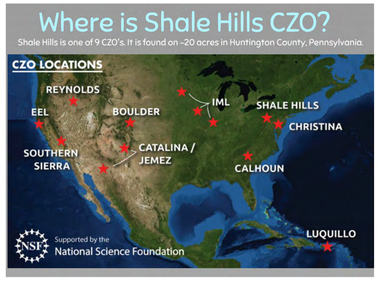
CZ Science includes multiple disciplines like hydrology, ecology, pedology, and geology to name a few. The goal is to understand the various spheres that overlap within the CZ.

Some examples of indiscinplinary reserach are:
- Does bedrock chemistry determine the type of vegetation?
- How does soil depth affect root density?
- How does soil type affect ground water chemisty?

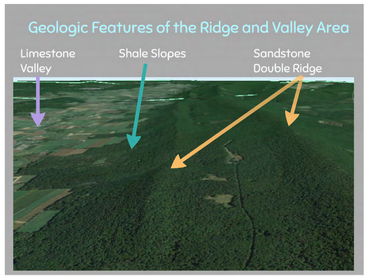


What is a VFE?

A Virtual Field Experience (VFE) is designed to introduce secondary students to different areas to understand breadth of natural processes. This VFE is designed to introduce Critical Zone (CZ) Science to students using reserach at Shale Hills including the study of natural and human-influenced changes to the landscape and ecosytem over time.

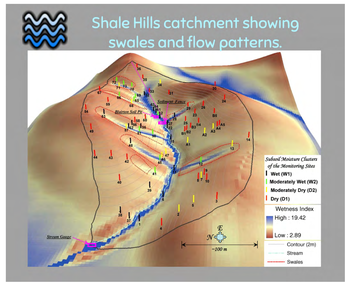


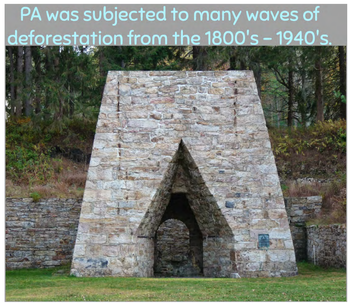
Why does Shale Hills look the way it does?



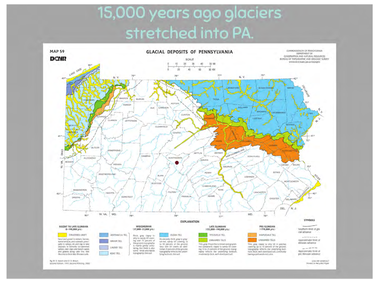
Explain why the ridges are capped in sandstone while the valley is limestone.

How does water sculpt the landscape?





Explain the effects of deforestation.



What affect has climate had on life and the landscape?

Acknowledgements

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