Water, soils, and erosion in the high school science classroom

Ryan Boylan (rboylan@uidaho.edu) UI, Chelsea Walsh UI, Hilary Davis UI, and Troy White UI

Educational research suggests that students are leaving high school ill prepared for science, technology, engineering, and mathematics (STEM) careers. International math and science literacy rankings from 2006 and 2012 placed students in the United States 21st of the 30 developed nations included in the rankings. These rankings, along with a growing gap in career readiness, prompted scientists, educators, and policy makers to call for a greater emphasis on STEM content and concepts in all science-related classrooms. Motivated to produce a better-trained workforce and maintain the United States' standing as a competitive and innovative leader in the global economy, educational leaders from across the nation collaborated to produce the Next Generation Science Standards (NGSS). These standards require students to develop a deep understanding of core disciplinary ideas, provide evidence of their knowledge through scientific and engineering-related activities, and connect concepts across disciplines.

IMPACT

Increasing math and science literacy for high school students entering the workforce has become an important priority in the United States. Lessons integrating multiple disciplines, illustrating links between climate change and agriculture, utilizing current relevant research, and aligning with the Next Generation Science Standards provide teachers and students with the resources they need to address these integrated standards.

To address the need for integrated hands-on lessons that fit within the NGSS framework, an interdisciplinary team of REACCH graduate students from the University of Idaho developed a Water and Erosion of the Soil unit for high school science and agricultural technology classrooms. The team, comprising graduate students in the disciplines of soil science, water resources management, economics, and education, developed the unit to be cost-effective for teachers to implement, include relevant scientific literature, align with NGSS, and incorporate aspects of each of the team members' research. The specific topics of soil infiltration, runoff, and erosion were selected because of their regional significance, importance to agriculture, and role in strategies for adapting to climate change in the Pacific Northwest (PNW). The dryland cropping areas of the inland Pacific Northwest and many other regions have a long history of soil erosion negatively affecting the environment and local economies, making the topic relevant to growers and local students alike (Figure 1). In addition, future climate scenarios could lead to erosion rates equal to or greater than those measured prior to the 1970s.

Addressing interdisciplinary aspects of water and soil erosion and integrating the impacts of climate change required collaboration within the interdisciplinary team. A set of three PowerPoint presentations were developed to provide teachers with background information and visual aids. Each presentation focused on one of three major themes: hydrology, soil science, and modeling. The team integrated economic aspects with the hydrology and soil science lessons to provide real-life applications and relevance. An inquiry-based lab activity titled Soil Infiltration and Runoff (Figure 2) was developed to demonstrate principles covered in the PowerPoint presentations. In the lab, students are given the opportunity to physically model and measure runoff, soil erosion and infiltration under various rainfall intensities, slope steepness, and residue cover.

In addition, the team developed two lab extensions to address (1) the economics of soil water and erosion and (2) computer

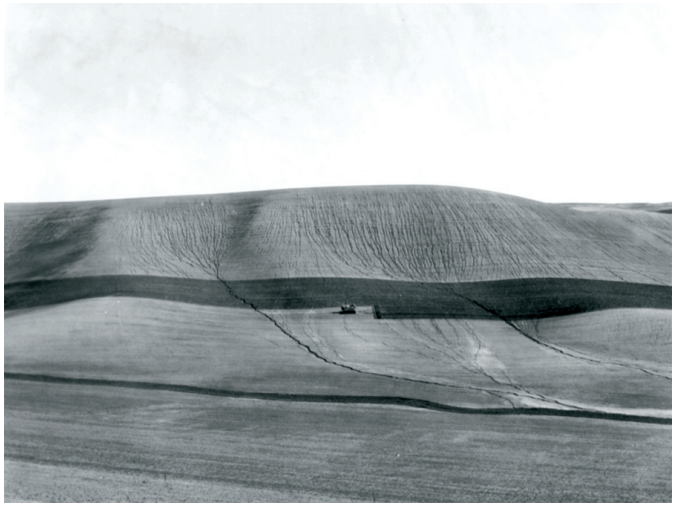

Figure 1. *Erosion on the Palouse, 1959. Photo by Verle Kaiser.*

Erosion on the Palouse hills south of Colfax in early February, 2011. Photo by Kathleen Painter.

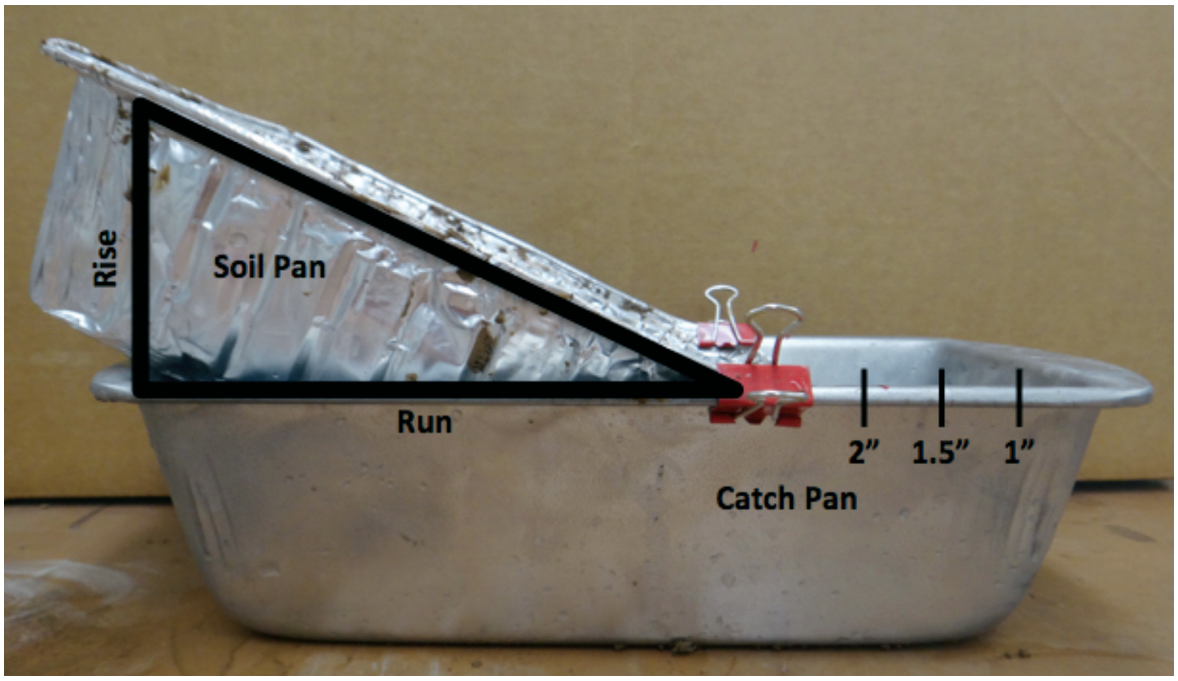

Figure 2. *Soil Infiltration and Runoff lab activity showing the setup of a baking pan full of soil students use in the classroom to measure runoff, erosion, and infiltration. Photo by Brad Stokes.*

modeling of runoff and erosion with the web-based Hydrologic Characterization Tool (HCT, wepp.ag.uidaho.edu/cgi-bin/HCT.pl). In the economics extension activity, students read selected pieces of scientific literature and complete a worksheet to calculate the effects of infiltration and erosion on crop yields. In the computer modeling activity, students simulate soil erosion and runoff, with the HCT mimicking what they physically modeled in the Soil Infiltration and Runoff lab. The students then simulate and explore different conservation measures in the model and examine the ability of these measures to mitigate runoff, sediment, and pollutant loads.

The Water and Erosion of the Soil unit was presented to 19 high school science and agricultural education teachers during the summer of 2013 at a REACCH-sponsored teacher workshop (Figure 3). Additionally, the unit was incorporated into a semester-long curriculum developed by the REACCH education team. The curriculum focuses on climate change issues in agriculture and integrates REACCH-related research. The participants in the 2013 teacher workshop agreed to teach the curriculum during the 2013-14 school year, and to give their students pre- and post-knowledge surveys to evaluate the effectiveness of the curriculum.

Bringing current, relevant research into the classroom can be a complicated task, particularly when integrating multiple disciplines. However, a lesson focused on a single disciplinary perspective would not reflect the complexity of real-life applications and would be less relevant to students. Interdisciplinary work has enabled this team to view the world from different perspectives and to communicate research in a way that is relevant to each respective discipline as well as to larger audiences. Not only is integrating real-world science and management tools into the science classroom beneficial for the students and teachers that use the unit, but its development is also beneficial for early-career researchers.

The push for STEM education and the implementation of NGSS at the state and national levels requires new practices and activities in science curricula. The unit attempts to ease this transition by incorporating relevant interdisciplinary science together with physical and computer-based models in a simple format that teachers can implement in their classrooms. Addressing challenges related to implementing the NGSS is a pivotal first step toward changing science education in the United States and better preparing the workforce of tomorrow.

Figure 3. *Two members of the interdisciplinary team, Chelsea Walsh and Hillary Davis, demonstrating the Soil Infiltration and Runoff lab activity. Photo by Brad Stokes.*