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Geology of National Parks Modules for the Spreadsheets Across the Curriculum Library

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Introduction

THE NATIONAL PARK SERVICE (NPS) NATURAL RESOURCE CHALLENGE PROVIDES AN OPPORTUNITY to promote the teaching of quantitative literacy (QL) in the undergraduate curriculum. At the same time, it provides an opportunity to illustrate for students that geology in the parks comprises not only captivating interpretive stories behind the parks' informative rocks and magnificent scenery, but also a body of knowledge useful to parkland stewardship. With those thoughts in mind, our Geology of National Parks Collection for the online Spreadsheets Across the Curriculum (SSAC) Library aims to add environmental geology to the traditional Geology of National Parks course and infuse it with student exercises to do foundational math in context. We make use of NPS inventory and monitoring data where we can, and we are kept on course by collaborators and advisors from the NPS network of research learning centers.

Background

Mathematics and Democracy: The Case for Quantitative Literacy (Steen 2001) is an argument for an educational focus on the kind of concepts and skills required for us to function in “a world awash in numbers” (p. 1). Also known as numeracy (Madison and Steen 2008) and characterized as a habit of mind, QL is the opposite of math avoidance. In concept, QL is one of the dimensions in which students can improve by taking general education (non-major) science courses in college. To achieve QL in these courses, students must do math in them—what mathematics educators call doing “math in context.” Geology of national parks is one such general education science course; nationally, it is a particularly popular one, because it is about our national parks. In short, Geology of National Parks, the course, provides the opportunity for students to do math in the context of *America's Best Idea* (Duncan and Burns 2009).

The SSAC Library was initiated with a National Science Foundation (NSF) Division of Undergraduate Education (DUE) grant (NSF DUE 0442629) to develop and populate an online repository of “spreadsheet modules” to support undergraduate college courses at the intersection

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of mathematics and context—i.e., for mathematics educators wishing to bring context to their math classes, and for non-mathematics educators wishing to bring mathematics to their courses. “Spreadsheet modules,” very briefly, are elaborate word problems, short PowerPoint presentations (15–20 slides) that students work through to answer one or more questions posed in context. In working through the module, students are introduced to the context, they consider what math is relevant, and then build or expand a spreadsheet to carry out the plan, which can be one or more calculations, or one or more graphs. Thus the students climb aboard three mutually-reinforcing learning curves: the context of the word problem, a little math that solves it, and some spreadsheet work that does the math. The result of the initial grant was a collection of 55 modules touching 26 different Library of Congress categories. The modules were created by 40 authors from 21 institutions in 11 states. For more information about the collection, the modules, and the project, see Table 1 and Vacher and Lardner (2010).

The Geology of National Parks Collection and course

The 55 modules of the initial SSAC project are housed in the General Collection of the SSAC Library. The SSAC Library now contains two additional collections: the Physical Volcanology collection (9 modules), developed for an advanced undergraduate course of that title at the University of South Florida (USF) and Pennsylvania State University (Penn State), and the Geology of National Parks Collection being developed in the current project, “Geology of national parks: spreadsheets, quantitative literacy, and natural resources” (NSF DUE-0836566).

The Geology of National Parks Collection consists, so far, of 22 park-oriented modules (Figure 1) and two tutorials. Figure 2 lists the titles of the 24 completed modules, 17 of which are online. The other seven completed modules are in final review and editing stages (April 2011), and three more are being written as part of the present project. Eighteen modules were prepared from learning experiences at eight research learning centers:

- Old Growth Bottomland Forest Research and Education Center (Congaree National Park)
- Great Lakes Research and Education Center (Indiana Dunes National Lakeshore)
- Appalachian Highlands Science Learning Center (Great Smoky Mountains National Park)
- Greater Yellowstone Science and Learning Center (Yellowstone National Park)
- Crown of the Continent Research Learning Center (Glacier National Park)
- Pacific Coast Science and Learning Center (Point Reyes National Seashore)
- Mammoth Cave International Center of Science and Learning (Mammoth Cave National Park)
- Urban Ecology Research and Learning Alliance (Washington DC).

The modules of the Geology of National Parks Collection are designed for the online Geology of National Parks (GNP) course taught by Judy McIlrath at USF. GNP is included in the list of approved physical science core courses that students may choose to satisfy their requirements in the Foundations of Knowledge and Learning Core Curriculum, which itself is under the purview of USF’s General Education Council. To qualify for approval, the course must engage the students in learning activities, in addition to the usual information transfer. Over the years, GNP has augmented the study of the text *Parks and Plates* (Lillie 2005) with 10 to 12 writing exercises and virtual field trips as the additional learning activities.

With the development of the spreadsheet modules for the course, GNP has been trading out as many as six of the old activities for new modules. The six that are being used in the course for the spring 2011 semester are the following:

Spreadsheets Across the Curriculum

http://serc.carleton.edu/sp/ssac_home/index.html	Home page for the project
http://serc.carleton.edu/sp/ssac/index.html	The pedagogy
http://serc.carleton.edu/sp/ssac_home/design.html	Module design
http://serc.carleton.edu/sp/ssac_home/general/examples.html	Access to General Collection

Geology of National Parks Collection

http://serc.carleton.edu/sp/ssac/national_parks/index.html	Home page for collection
http://serc.carleton.edu/sp/ssac/national_parks/GNP_modules.html	Access to collection

Table 1. Links to more information.

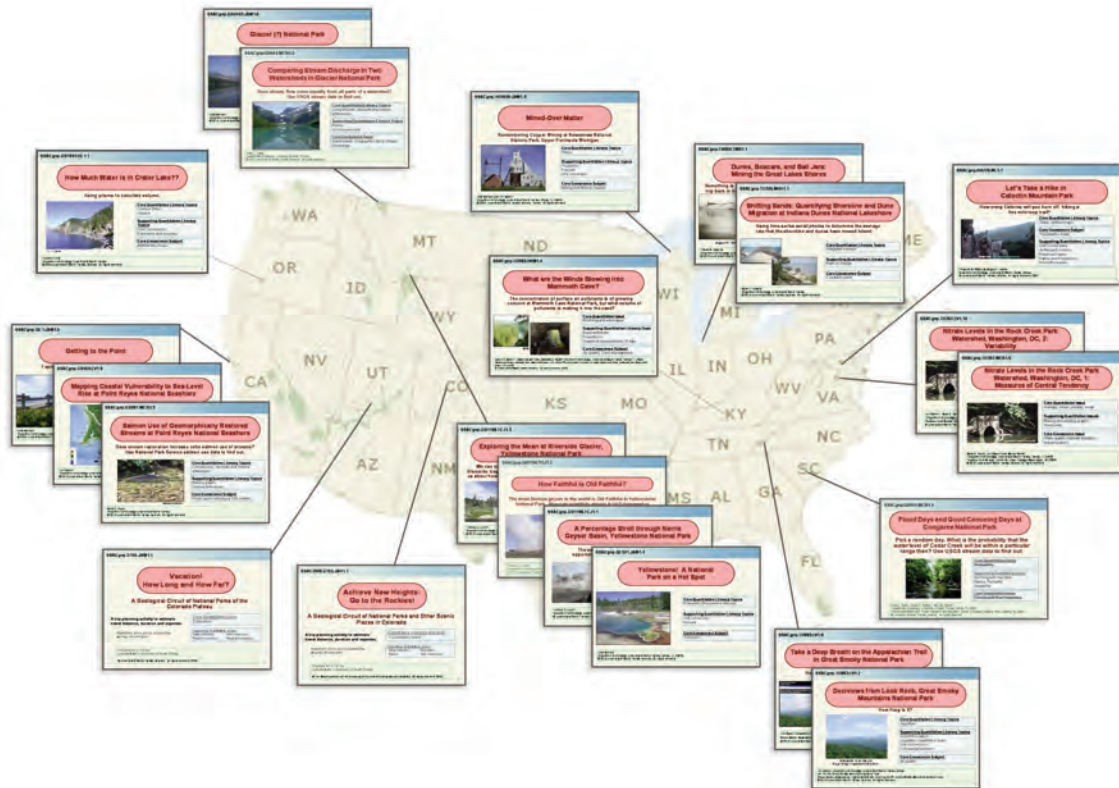


Figure 1. Title pages of modules completed as of the George Wright Society Conference, March 2011.

✓ Live Online!

• In final editing stages

Beginner

- ✓ Spreadsheet Warm Up for Geology of National Parks Modules
- ✓ Spreadsheet Warm Up for SSAC Geology of National Parks Modules, 2: Elementary Spreadsheet Manipulation and Graphing Tasks
- ✓ Achieve New Heights: Go to the Rockies!
- ✓ Mined-Over Matter: Remembering Copper Mining at Keweenaw National Historic Park, Upper Peninsula Michigan
- ✓ Yellowstone! A National Park on a Hot Spot
- ✓ A Percentage Stroll through Norris Geyser Basin, Yellowstone National Park
- ✓ Vacation! How Long and How Far? A Geological Circuit of National Parks in the Colorado Plateau

Elementary

- ✓ Getting to the Point at Point Reyes National Seashore
- ✓ Dunes, Boxcars, and Ball Jars: Mining the Great Lakes Shores
- ✓ Salmon Use of Geomorphically Restored Streams at Point Reyes National Seashore
- ✓ Comparing Stream Discharge in Two Watersheds in Glacier National Park
- ✓ Shifting Sands: Quantifying Shoreline and Dune Migration at Indiana Dunes National Lakeshore
- ✓ Mapping Coastal Vulnerability to Sea-Level Rise at Point Reyes National Seashore
- ✓ Glacier (?) National Park
- ✓ Let's Take a Hike in Catoctin Mountain Park
 - Just How 'Faithful' is Old Faithful? Finding Order in Random Behavior
 - What are the Winds Blowing into Mammoth Cave?
 - Exploring the Mean at Riverside Geyser, Yellowstone National Park

Moderate

- ✓ How Much Water Is In Crater Lake?
- ✓ Flood Days and Good Canoeing Days at Congaree National Park
 - Deciviews from Look Rock, Great Smoky Mountains National Park: How Hazy is it?
 - Take a Deep Breath on the Appalachian Trail in Great Smoky Mountain National Park: How Many Ozone Molecules Do You Inhale?
 - Nitrate Levels in the Rock Creek Park Watershed, Washington DC, 1: Measures of Central Tendency
 - Nitrate Levels in the Rock Creek Park Watershed, Washington DC, 2: Variability

Figure 2. Status and Excel level of the modules at the time of the George Wright Society Conference, March 2011.

- Achieve new heights: Go to the Rockies!
- Yellowstone: A national park on a hot spot
- Mined-over matter: Remembering copper mining at Keweenaw National Historical Park
- Getting to the point: Exploring the tectonic motion of Point Reyes National Seashore, California
- Shifting sands: Quantifying shoreline and dune migration at Indiana Dunes National Lakeshore
- Glacier (?) National Park

Pre- and post-implementation assessment data are being gathered as part of the project to examine whether this change in the course has the desired effect of improving these general edu-

cation students' QL skills, attitudes, or both. The skills exercised in these modules are standard fare for QL (e.g., Vacher and Lardner 2011): ratios, unit conversions, percentage increase, probability, graph interpretation. The attitudes are familiar too: "I don't do math," or not. Enrollment fluctuates between about 70 and 200 students.

Other courses

One of the features of SSAC modules is that each module is easily adapted to serve courses other than the one that the module author had in mind. Changes are easily made to modules by, for example, adding or trading out slides in the PowerPoint presentations, making alterations within the slides, combining parts of different modules, and changing the Excel spreadsheets embedded within the slides. Although the modules are copyrighted, instructors are encouraged to adapt the modules to their use, and simply note on the new version the source of the original. Our own experience illustrates the adaptability of the modules, as does the fact that they can be used in a variety of courses. We have used modules from the Geology of National Parks Collection in the three courses described in the next three paragraphs.

Hazards of the Earth's Surface (Juster), like the Geology of National Parks course, is an approved introductory-level physical science course in the Foundations of Knowledge and Learning Core Curriculum. The course is designed to introduce students to both catastrophic hazards, such as earthquakes and volcanoes, and slow-moving hazards, such as ground subsidence. Students must complete five spreadsheet activities that they select from a menu of eleven—three from the Geology of National Parks Collection, and the others from a set made specifically for the course and a potential new geohazards collection for the SSAC Library. The modules in the Geology of National Parks Collection used in the course are these:

- Yellowstone! A national park on a hot spot
- A percentage stroll through Norris Basin, Yellowstone National Park
- Flood days and good canoeing days at Congaree National Park

The three modules were adapted by the addition or alteration of a few slides (including end-of-module assignments) to give more focus to the hazard concepts and phenomena. Typical enrollment is 40 students, and it is expected to grow with the addition of an online section.

Fluid Earth 2: Hydrogeology (Rains) is an upper-division, lecture and lab course required for the geology major. The purpose of the course is to introduce principles affecting groundwater occurrence and flow, fundamental tools used by hydrogeologists, and concepts pertaining to groundwater management and water law. As part of the lab, the students do a total of six to eight modules, including three to four modules from the Geology of National Parks Collection and others made by the instructor, colleagues, and teaching assistants specifically for the course. The modules from the Geology of National Parks Collection follow:

- Flood days and good canoeing days at Congaree National Park.
- Comparing stream discharge in two watersheds in Glacier National Park.
- Nitrate levels in the Rock Creek watershed, Washington DC, 1: Measures of central tendency.
- Nitrate levels in the Rock Creek watershed, Washington DC, 2: Variability.

Typical enrollment is around 20 students, about half from geology, and half from environmental science and interdisciplinary science.

Environmental Geology in the National Parks (Vacher) was an upper-division geology elective offered once as part of the Geology of National Parks project. The purpose of the course

was two-fold: (1) to experiment with a lecture course to introduce students to applied environmental earth science using the NPS and its Natural Resource Challenge as an example, and (2) to test-drive the modules. Specifically, the students were assigned the task of reviewing all the modules that were in draft form (spring semester 2010) and give written feedback to the module authors. Most of the modules were coordinated with the book that was used as the main textbook in the course, *Geological Monitoring* (Young and Norby 2009), which was produced by the Geologic Resources Division of the NPS. To increase breadth of coverage in the course, students were also assigned sections from *Management Policies 2006* (NPS 2006). Table 2 shows how modules were coordinated to these text resources. Twelve students from seven different majors took the course.

Concluding remarks

The guiding purpose of the Spreadsheets Across the Curriculum Library is to provide a resource to promote the teaching of QL, and a guiding purpose of the Geology of National Parks Collection is to help get out the message about resource management in the national parks. Introducing national park information into math classes would broaden the exposure of NPS stewardship to the public. It is thus appropriate to step back and look at how these modules might be assembled into a sequenced set of activities to support a QL-specific course. Selecting subject headings from prior lists of topics (e.g., Sons 1996, Steen 2001, Vacher and Lardner 2011), we see the following as one possibility:

Number sense: Estimation, ratio and proportion, unit conversions, magnitude:

- Vacation! How long and how far? A geologic circuit of national parks in the Colorado Plateau
- Getting to the point: Exploring the tectonic motion of Point Reyes National Seashore, California
- Mined-over matter: Remembering copper mining at Keweenaw National Historic Park.
- Dunes, boxcars, and bells jars: Mining the Great Lakes shores
- Take a deep breath on the Appalachian Trail in Great Smoky Mountains National Park

Making quantitative comparisons:

- Mapping coastal vulnerability to sea-level rise at Point Reyes National Seashore
- Comparing stream discharge in two watersheds in Glacier National Park
- Salmon use of geomorphically restored streams at Point Reyes National Park
- Percentage stroll through Norris Geyser Basin, Yellowstone National Park
- Deciviews from Look Rock, Great Smoky Mountains National Park: How hazy is it?

Reading graphs and maps:

- Let's take a hike in Catoclin Mountain Park
- Glacier(?) National Park
- Shifting sands: Quantifying shoreline and dune migration at Indiana Dunes National Lakeshore
- How much water is in Crater Lake?

Probability and elementary descriptive statistics:

- Flood days and good canoeing days at Congaree National Park
- Yellowstone! A national park on a hot spot
- Just how faithful is Old Faithful?
- Exploring the mean at Riverside Geyser, Yellowstone National Park

Coordinated with *Geological Monitoring* (Young and Norby 2009)

Chapter 12. Volcano monitoring

Yellowstone! A national park on a hot spot.

How much water is in Crater Lake?

Chapter 5. Geothermal systems and monitoring hydrothermal features

A percentage stroll through Norris Geyser Basin, Yellowstone National Park.

Just how faithful is Old Faithful?

Exploring the mean at Riverside Glacier, Yellowstone National Park.

Chapter 4. Fluvial geomorphology: Monitoring stream systems in response to a changing environment

Comparing stream discharge in two watersheds in Glacier National Park.

Salmon use of geomorphically restored streams at Point Reyes National Seashore.

Chapter 2. Geological monitoring of caves and associated landscapes

What are the winds blowing into Mammoth Cave?

Chapter 3. Coastal features and processes

Shifting sands: Quantifying shoreline and dune migration at Indiana Dunes National Lakeshore.

Mapping coastal vulnerability to sea-level rise at Point Reyes National Seashore.

Chapter 1. Aeolian features and processes

Dunes, boxcars, and Bell jars: Mining the Great Lakes shores.

Chapter 6. Glacier monitoring techniques

Glacier(?) National Park.

Chapter 10. Seismic monitoring

Getting to the point: Exploring the tectonic motion of Point Reyes National Seashore, California.

Table 2. Modules used in the course “Environmental Geology in the National Parks.”

Coordinated with *Management Policies 2006* (NPS 2006)

Chapter 4, Natural Resource Management. Section 4.6.3 Water Quality

Nitrate levels in the Rock Creek Park watershed, 1: Measures of central tendency.

Nitrate levels in the Rock Creek Park watershed, 2: Variability.

Chapter 4, Natural Resource Management. Section 4.7.1, Air Quality

Deciviews from Look Rock, Great Smoky Mountains National Park.

Take a deep breath on the Appalachian Trail in Great Smoky Mountains National Park.

Table 2 (continued).

- Nitrate levels at Rock Creek Park watershed, Washington DC, 1: Variability
- Nitrate levels at Rock Creek Park watershed, Washington DC, 2: Measures of central tendency

The list of subject headings also helps define what we mean by QL. Obviously our project has only scratched the surface of possible connections between the national park context and QL content.

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