GEOSCIENCE
INFORMATION
SOCIETY

Discovery and Preservation of Geoscience Data and Information Resources

Proceedings ● Volume 45 ● 2017

Proceedings of the 52nd Meeting of the Geoscience Information Society

October 22-25, 2017

Seattle, Washington

Discovery and Preservation of Geoscience Data and Information Resources

Edited by

Christopher A. Badurek

Proceedings

Volume 45

2017

Geoscience Information Society

GEOSCIENCE

INFORMATION

SOCIETY

ISSN: 0072-1409

For information about copies of this proceedings volume or earlier issues, contact:

Publications Manager
Geoscience Information Society
c/o American Geoscience Institute
4220 King Street
Alexandria, VA 22302-1502 USA

Or consult the GSIS Website at: www.geoinfo.org

Cover photos:

TABLE OF CONTENTS

PREFACE:

The Geoscience Information Society (GSIS) was established in 1965 as an independent nonprofit professional society. Members include librarians, information specialists, publishers, and scientists concerned with all aspects of geosciences information. Members are based in the United States, Canada, Australia, Sweden, Taiwan and the United Kingdom.

GSIS is a member society of the American Geosciences Institute and is an associated society of the Geological Society of America. The GSIS annual meeting is held in conjunction with the annual GSA meeting, and the papers, posters, and forums presented are a part of the GSA program.

Papers and Posters provided in these proceedings were given at the 2017 Annual Meeting of the Geological Society of America held in Seattle, Washington, October 22-25, 2017. Papers are arranged in the same order as the presentations. Where the entire paper is not available, the abstract is provided with the permission of GSA. Papers were provided in session and posters were presented all day with the authors available during a two-hour session. The theme of these sessions were on geoscience data and information resources and co-sponsored with the Geoinformatics Division of the GSA.

The proceedings in this volume are divided into two parts:

1. Papers presented at the GSA Oral Session No. 313: Discovery and Preservation of Geoscience Data and Information Resources and posters presented at the GSA Poster Session No. 264: Use of Geoscience Data and Information Resources in Education and Research.
2. GSIS Meeting Supplemental Materials

Thank you to all our poster presenters, the leadership of GSIS, and to the session conveners'/proceedings editors who have preceded us for their hard work in the name of the Society and their contributions to our profession.

Christopher A. Badurek
GSIS Technical Session Convener 2017

Part 1: GSA Oral Session No. 313

Discovery and Preservation of Geoscience Data and Information Resources

Technical Session Convener

Christopher A. Badurek

October 25, 2017

FROM ZERO TO A TRILLION – REFLECTIONS ON NINE YEARS OF OPENTOPOGRAPHY, A PLATFORM TO ENABLE OPEN ACCESS TO HIGH RESOLUTION TOPOGRAPHY

Christopher J. Crosby
UNAVCO
6350 Nautilus Drive, Boulder, CO 80301

Viswanath Nandigam
San Diego Supercomputer Center, University of California, San Diego
MC 0505, 9500 Gilman Drive, La Jolla, CA 92093-0505

J. Ramón Arrowsmith
School of Earth and Space Exploration, Arizona State University
Tempe, AZ 85287-1404

Abstract—This year, OpenTopography, a National Science Foundation supported data facility oriented towards high-resolution topographic data, exceeded a trillion lidar points freely accessible via a Web-based portal (http://opentopography.org/). This milestone comes nine years after the initiation of OpenTopography in fall 2008, and is the product of considerable cyberinfrastructure development and partnerships with organizations that fund and collect lidar data. During this period, lidar point cloud data and derivative digital elevation models have become a fundamental observable for Earth and environmental science, engineering, and education. Sampling the Earth's surface, its vegetation cover, and the built environment at sub-meter length scales, these data (and their changes in time) provide a powerful geometric measure of Earth processes. As appreciation for the power of lidar data has grown, investments in the collection of these data have increased, and issues related to data sharing have emerged. OpenTopography is a community-oriented initiative that emphasizes easy and free online access to point cloud data collocated with tools for on demand processing and generation of derivatives. In addition to data access, OpenTopography has also been a leader in training the Earth science community to process and analyze lidar data through an extensive short course program. With nearly 18,000 registered users and an order magnitude more guest users, OpenTopography has a rapidly growing community using data for a myriad of applications.

This presentation will reflect upon the state of OpenTopography and lessons learned. We'll highlight new cyberinfrastructure developments to enhance management and processing of high resolution topographic data; partnerships and collaborations; and will discuss emerging opportunities and challenges associated with the proliferation of high resolution topographic data ("ubiquitous point clouds") enabled by UAS, structure from motion photogrammetry, and low cost lidar.

OREGON LIDAR CONSORTIUM: A SUCCESSFUL MODEL FOR ACQUIRING AND SHARING LIDAR

Jacob Edwards
Oregon Department of Geology and Mineral Industries
800 NE Oregon St. #28 Suite 965, Portland, OR 97232, jacob.edwards@oregon.gov

Abstract—The Oregon Department of Geology and Mineral Industries (DOGAMI) has been supervising and coordinating the collection of large swaths of high resolution, high accuracy lidar data in the Pacific Northwest since 2006. In 2007, the Oregon legislature designated DOGAMI as the lead agency for lidar acquisition in Oregon. DOGAMI established the Oregon Lidar Consortium (OLC), to develop cooperative agreements for lidar collection. The consortium model for lidar collection leverages funding from multiple project partners to cost-effectively obtain lidar data, which is ultimately made available to the public. To-date, the OLC has had more than 70 project partners and collected more than 45,000 sq. miles of lidar data, covering 95 percent of Oregon's populated areas.

High resolution lidar data has a wide range of uses in forestry, agriculture, geology, and engineering. Since 2006, DOGAMI has been utilizing lidar data to conduct geologic hazard and resource mapping for an accurate and vastly improved understanding of floods, landslides, tsunami, coastal erosion and geology within Oregon. DOGAMI is currently working with OLC partners to implement an on-demand data sharing model to provide streaming access to the data sets produced by the OLC. Improving access to OLC data is an ongoing priority, with the goal of reaching a wider audience who will incorporate lidar into their daily business needs and expand applications through further research and development of novel environmental analysis techniques. Stewardship of this massive database (60 TBs) presents challenges that DOGAMI aims to overcome through technical innovation and partner collaboration.

DATA STRUCTURE, WORKFLOW, AND DISPLAY OF SUBSURFACE DATA FROM GEOTECHNICAL REPORTS IN WASHINGTON STATE

Daniel W. Eungard
Washington Department of Natural Resources, Washington Geological Survey
1111 Washington St SE, MS 47007, Olympia, WA 98504-7007, daniel.eungard@dnr.wa.gov

Abstract—The Washington Geological Survey maintains a state-wide publicly available database of subsurface data contained within over 35,000 documents. These documents hold over 100,000 borehole logs that survey geologists, local municipality, public works, planning offices, and private consultants use to satisfy their business needs. This includes development of resource maps, subsurface interpretation of geologic maps, and production of 3D geologic models. The centralization of these data represents a significant effort that benefits the entire geologic and geophysical community in Washington. The logs are processed into ArcGIS for highly accurate horizontal and vertical spatial referencing. Layer information from the logs, including lithology, hydrology, and in-situ testing data are digitized into a standard schema. This information is displayed on our geologic information portal which allows for easy searching, viewing (both in 2D-3D), and downloading the data. A simplified version of the dataset is also available on a mobile app allowing for use in the field. Future progress includes production of small-scale 3D geologic models, tools for improved visualization of the data, and on-going data updates on a regular bi-annual cycle.

PRESERVATION AND WEB ACCESSIBILITY OF LIMESTONE AND DOLOMITE RESOURCE DATA FOR KENTUCKY

Douglas C. Curl
Gerald A. Weisenfluh
Kentucky Geological Survey, University of Kentucky
228 Mining and Mineral Resources Building, Lexington, KY 40506-0107, doug@uky.edu

Abstract—Since 1947, the Kentucky Geological Survey has conducted ongoing field investigations of Kentucky's limestone and dolomite resources to characterize their stratigraphy, lithology, geochemistry, and petrology. Early work was focused on agricultural and construction uses of stone, whereas later work characterized carbonate stone for specialty uses such as in fluidized bed combustion processes. Quarries, mines, outcrops, and cores were sampled and described on a foot-by-foot basis to determine vertical variations in rock type and major-element oxide composition. The legacy of this half-century program is a rich collection of data and materials including detailed field notes, more than 15,000 chemical analyses, 600 thin-section and petrographic analyses, and a repository of sample materials for future work.

These data continue to be of value to stakeholders for the traditional purpose of locating sources of limestone having particular qualities. They also serve novel applications for identifying potential localities for specialty products and provide the potential for new analyses to be performed on legacy samples to meet the requirements of those markets. Moreover, the data have high potential for noncommercial applications such as characterization of karst susceptibility at a detailed map scale.

KGS has developed a new website to allow users access to all these limestone data for more than 700 historical sites. This map-based website is located at http://kgs.uky.edu/kylimestone/ and provides users the ability to view and search for sites where limestone data are available. Users can search for sites either by using the map interface, entering site attributes, or filtering sites by bulk chemistry. Once a user locates a site of interest, both the site information and, if available, a variety of the preserved data are immediately viewable. These preserved data include an historic site photo, scanned field notes (PDF), a report displaying tables with sampling event history, detailed information on samples collected, and the chemical analyses of samples in both incremental and ledge results. The tables are also downloadable to users in CSV files and, where available, plots in PDF format displaying the chemistry of sampled sections can be viewed.

THE ARCHIVAL PAPERS OF FIELD GEOLOGISTS: THE CHALLENGES OF DISCOVERY AND ACCESS TO THE BREADTH OF GEOLOGIC DATA FROM UNPUBLISHED FIELD RESEARCH

Lisa G. Dunn
Christine Baker
Arthur Lakes Library, Colorado School of Mines
1400 Illinois St, Golden, CO 80401, ldunn@mines.edu

Abstract—Library special collections, including those in the geosciences, are about telling the story, about creating compelling narratives around central themes and connecting them to context that enriches those narratives. The archival papers of a field geologist tell a story of that geologist's professional life and contribution to science through his or her notes, maps, correspondence, reports, etc. Collection description, which makes it possible for users to discover archival papers, is often framed around the geologist's "story." If it's the data within the geologist's archival papers that the user wants, for example on field work done in a specific region, the path to that data is through the geologist, and requires the user to have some foreknowledge of the connection between geologist and field area(s). A lack of enhanced description of the field work associated with a collection that facilitates users seeking this data can be an active barrier to discovery. The broader the field geologist's career as reflected in their papers, the more fragmented the "story" of the field work may become to the user seeking the geologic information across different collections. How do we tie together the data within these collections to form a different sort of story that benefits the user? Collections from the Russell L. & Lyn Wood Mining History Archive, Colorado School of Mines Library, will be used to illustrate the depth and breadth of early field geologists' activities as preserved in their working papers, the potential barriers to users, and our evolving best practices for discovery and metadata. Local practices applied to archival papers can support discovery and access, open this content to a wider audience in our digital environment, and promote further serendipitous discoveries of geologic data.

INTRODUCTION

Historical documents on the field work of geologists are primary source materials that can include field observations, quantitative data, diagrams, or maps. (Today we would add GIS data and digital files.) These are unique items and contain unique data, even if the creator did publish the results. A number of archives and special collections have materials of this type, and typically treat them according to the organizations' best practices to "tell the story" of the creating scientist or organization through their works. However, discovery of the content of these materials as scientific data is not so easily achieved.

To explore opportunities for enhancing discovery of our archival geologic field materials, we began a project to improve searchability of the geographic range represented in selected collections. Examples are taken from the Russell L. & Lyn Wood Mining History Archive at the Colorado School of Mines Library. Mines is a small state university specializing in STEM education and research, and the Mining History Archive focuses on the technology and science of mining and related industries, with an emphasis on Colorado and the US West. Our collections include field notes and data of geologists and mining engineers.

ISSUES IN DISCOVERY AND OUTREACH

Telling the Story, or Context vs Content in Archival Description

Archives and special collections, in contrast to the stand-alone structure of scientific journals, data repositories, etc., are about the context as well as the content. They have a subjective component that seeks to "tell the story" of a collection and its creator(s). A collection of field data is not just about that data in the form of maps, cross sections, reports, and interpretations, but also about the information that reflects the historical setting and the creator's role in the process. The Field Book Project blog, "From Dayton to Cambridge and Back Again: The Field Notes of August F. Foerste" illustrates the interweaving of content and context (Smithsonian National Museum of Natural History, 2017).

As a result of the emphasis on telling the story, description of archival collections is often framed around the context, which tells a collection-based story of the creator as the more relevant component of description. The collection's content in comparison may be described in a more general fashion or with an inventory that emphasizes item formats. Limited availability of resources to catalog archival collections, which require original metadata, means that most archives operate under a backlog of uncataloged materials and must prioritize their use of staff. Scientific data as a resource with modern applications may be viewed as a secondary concern, or not recognized as such. In addition, an archive may not have STEM subject specialists available to evaluate the needs for discovery of this content.

An example of a catalog record from the Smithsonian Institution Archives representing USGS field notebooks from 1881-1915 lists the creators by name and describes the collection in a way that allows the user to place this collection in a biographical and historical context. When the user displays "Place" for this record, the list of geographic locations is at the level of state. This is a common practice and usually sufficient for the general archive user, but is not sufficiently granular for someone seeking specific geologic content relevant to a narrower location.

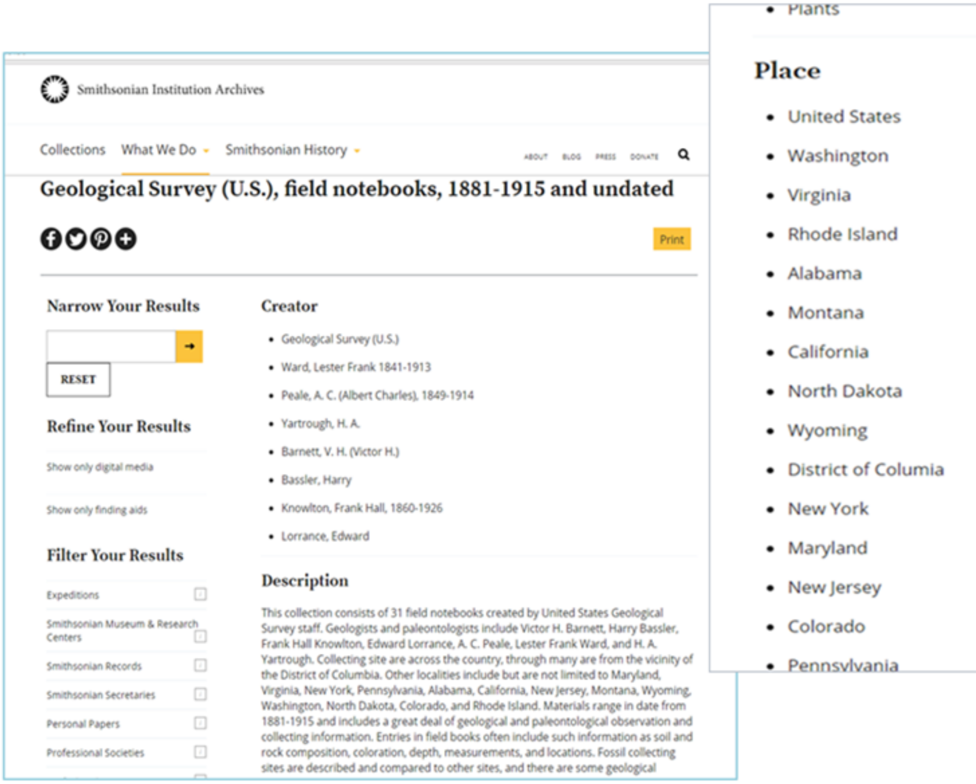


Figure 1. Catalog record, Smithsonian Institution Archives, representing a collection of USGS field notebooks (Smithsonian Institution Archives, 2017).

An example of a catalog record from the Colorado School of Mines Library representing the C. H. Wegeman collection from our Mining History Archive shows fewer historical/biographical details but a similar treatment of metadata as that of the Smithsonian's record, with an over-broad geographic description—this one at the level of country. Again, the geographic description is not sufficiently granular to promote discovery of the scientific content. (Given our limited cataloging resources, this geographic information was taken from the collection description by the metadata librarian; the collection description was a minimal write-up created by the author, who has a large backlog of un-inventoried materials in the Mining History Archive.)

Manuscript
C. H. Wegeman collection, 1911-1930
Wegeman, C. H.
1911-1930

Details

Title	C. H. Wegeman collection, 1911-1930
Author/Creator	Wegeman, C. H.
Subject	Geology Petroleum - Prospecting Core drilling Mines and mineral resources
Description	The C. H. Wegeman collection (1911-1930) consists of geologic reports, maps, and papers on regions, with a focus on South and Central America including Brazil, Columbia, Peru, Ecuador, Venezuela, Guatemala, British Guiana, and Mexico. Many materials are related to oil exploration, but some include information on the mining industry.
Creation Date	1911 - 1930
Format	2 (1 box linear ft.)

Figure 2. Catalog record, Colorado School of Mines Library, representing the C. H. Wegeman collection. Geographic descriptors for this record are highlighted (Colorado School of Mines Library, 2017).

The mission-oriented focus of archives on the context of creator and historical relevance is important, but it doesn't support access to the geologic data. Why does this matter? The historical scientific data (legacy data, heritage data) are still relevant and their discoverability by users is crucial to retaining that relevance. Field notes are primary source materials, original records that reflect the observations of the field geologist. Their work may or may not be available elsewhere—any subsequent publications are unlikely to include all of the data, and field geologists and engineers working for commercial rather than research purposes did not necessarily publish their findings at all. Some historical field studies are not feasible to recreate today due to cost, or can't be duplicated because the geological features are no longer accessible due to urban development, underground mine closures, etc.

The relevance and value of historical field data is acknowledged by organizations that manage collections of historical materials and expend significant resources to preserve these collections, for example the USGS Field Records Collection and its National Geological and Geophysical Data Preservation Program. An entire issue of GeoResJ (6 June 2015) was devoted to this topic in 2015. Although focusing on physical specimens and core, Ramdeen (2015) and Jackson (1999) see historical scientific data as necessary evidence confirming and reproducing today's science. Some collections that are not yet discoverable or accessible could contribute to geology and other disciplines in unforeseen ways (Heidom, 2008; Wallis and others, 2013). Part of the growing interest in access to historical data is the possibility of new applications. There's reason for "promoting and ensuring the preservation of legacy scientific data so that they can be available for reuse and repurposing, often for use cases never considered by the person who originally recorded the data" (Wyborn and others, 2015, p. 106).

Defining Objectives

One of the goals for our library's Special Collections is to expand awareness of our resources. For this pilot project we chose to explore our treatment of geologic field records from the Mining History Archive. We hoped to identify ways to boost users' discovery of these materials in a geologist-friendly manner; to encourage serendipitous discovery by all users; to supplement the field geologist's own story (the context); and to do so through a sustainable workflow.

External factors provided additional motivation for the project. As part of library-wide strategic planning in 2016, we identified areas of distinction to develop and promote; one of those areas is Special Collections. The Library became a participant in the Colorado Alliance's Shared Print Trust in 2017. Economic geology, in which the Library has historical roots and an ongoing focus, is one of our possible subject contributions to the Shared Print Trust. Taking action to make our historical geologic field records more accessible is relevant to both of these initiatives.

Archives and their communities have benefited greatly from digitization projects and use of OCR (Optical Character Recognition) to make text discoverable and open to additional computer-related manipulations. Digitization was an early consideration for our project, but was not a practical option for us at that time. Digitization projects carry their own demands on staff and resources, and our field documents don't lend themselves well to the process. Many materials have handwritten content or are written in pencil sometimes faded to near invisibility, making them a challenge for OCR and requiring post-digitization formatting and transcription of the contents to address accessibility needs. Some of our materials would require substantial preservation work as part of pre-production. For us, digitization of our geologic collections needs to be a well-planned large-scale project for the future.

Improving the metadata was identified as a more realistic focus for the project. The lack of enhanced geographic metadata translates directly into a lack of discovery (findability) by users. General geographic metadata places an over-reliance on data-seekers perseverance--few science-oriented users are going to piece together clues from the accompanying contextual description of an archive collection to identify specific locations where the geologist did their field work. While Google has opened up discovery to archive collections in an unprecedented way, it can only do so much without the proper keywords to index.

Of the many things that could be included in enhanced metadata for archival collections, geographic terms generally provide the biggest "bang for buck" for geologic records, giving the scientific audience a useable framework to identify this content. Geographic metadata use common terminology that is comparatively easy to apply for non-STEM metadata librarians. This strategy met our critera for improving discovery supporting outreach in a sustainable manner.

METHODOLOGY

Common ways to represent an archive collection include using a catalog record, an online finding aid, and a descriptive website. Each of these interfaces has advantages and disadvantages, alone or in combination. Our pilot project was designed to identify strategies, develop sample workflows, and test outcomes within this framework.

Many of our archival collections are already in our library catalog, with the metadata at a collection level. Our catalog is a familiar resource for users, and with the use of MARC format we share these records with our regional consortial catalog as well as OCLC's WorldCat. However, the catalog is text-heavy and not visually compelling. Standardized formats, by their nature, have constraints on how they're used, and while we're aware of the advantages of MARC as a standardized format, it is not particularly user-centric. Online finding aids typically provide a wealth of detail about the collection which can include an inventory, graphics, and narratives. Their main disadvantage is that it requires significant staff time to craft a good finding aid. A descriptive webpage (with SpringShare's LibGuides™ as our platform) can be easily customized and made visually appealing, but lacks the advantages of standardization, the chief of which is the ability to migrate the data to a new platform. Records from both library catalog and LibGuides are crawled by Google, supporting our goal of discovery.

Because LibGuides was a relatively unexplored platform for promoting our archival collections, we decided to focus on how we could use it in conjunction with our existing catalog records. LibGuides pages were used to create a short finding aid with brief descriptions, illustrations of materials, and geographic metadata. In addition to the geographic metadata, proper names for selected mines, mining districts, and companies were included. While selecting these names requires additional expertise, they are a valuable addition of metadata to improve context and searchability for users.

We selected two collections with different characteristics for our test:

Robert D. Hoffman Collection (1917-1977) – Hoffman was a mining engineer who during his career worked throughout Canada and the Western US. He was a published author but his few publications don't reflect the breadth and depth of his work in the field. The small size of the collection allows us to display a list of Areas and Companies associated with Hoffman's field work (Robert D. Hoffman Collection, 2017).

Fairchild Collection (1926-1980?) -- The collection contains field and working documents of Gerald D. Fairchild and, to a lesser extent, his brother Harry V. Fairchild. Gerald Fairchild was a geologist by training who worked in mining districts throughout Colorado and the US West. In contrast to Hoffman, Fairchild has no appreciable publication record. His field-based collection includes both his work and over a hundred site reports by other authors that he gathered together over his career. This collection is larger than the Hoffman Collection and represents a wider variety of geologic records. The descriptions of the boxed contents focus on geographic names, mines and mining districts, and companies (Fairchild Collection, 2017).

The resulting LibGuides are shown below. The displays are user-friendly and eye-catching, allowing us to incorporate images from the field records collections. These guides appeared in Google searches within ~4-5 days of publication through SpringShare.

Figure 3a. Screen shot showing the title LibGuides page for the Robert D. Hoffman Collection.

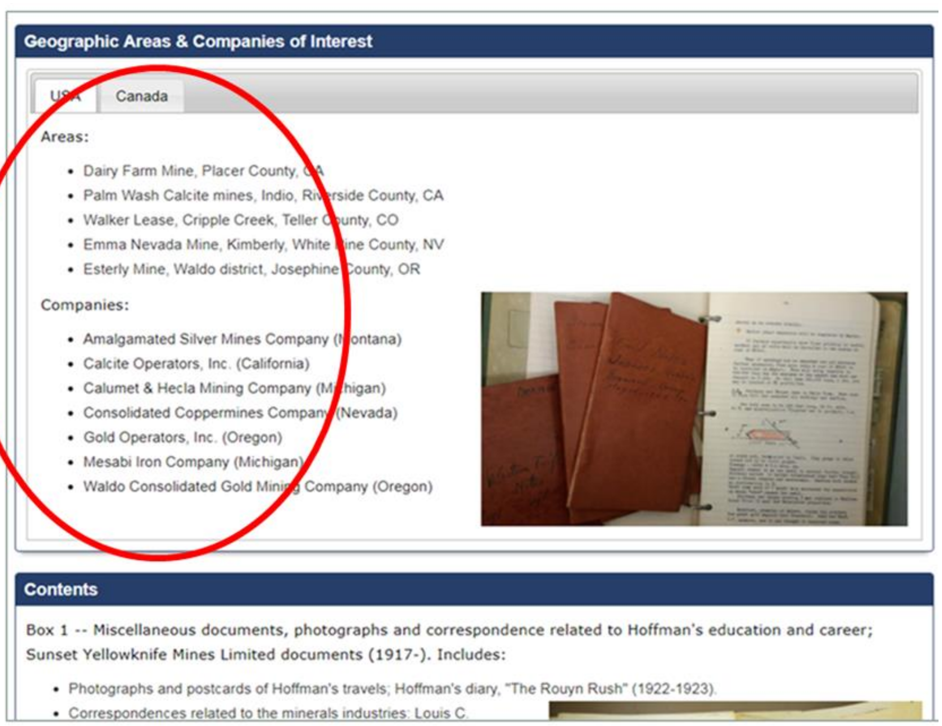


Figure 3b. Screen shot of the LibGuides page showing Areas and Companies, Robert D. Hoffman Collection.

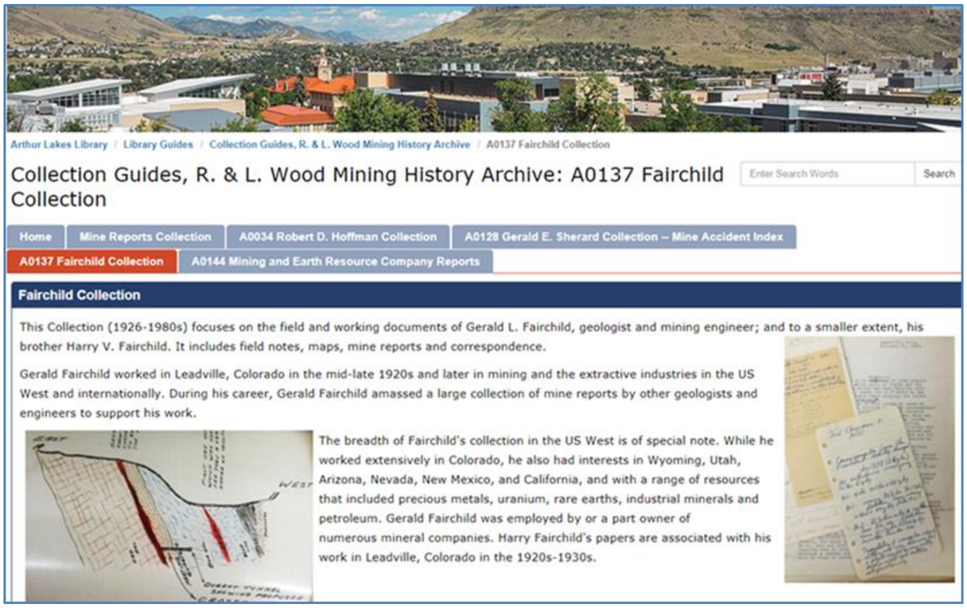


Figure 4a. Screen shot showing the title LibGuides page for the Fairchild Collection.

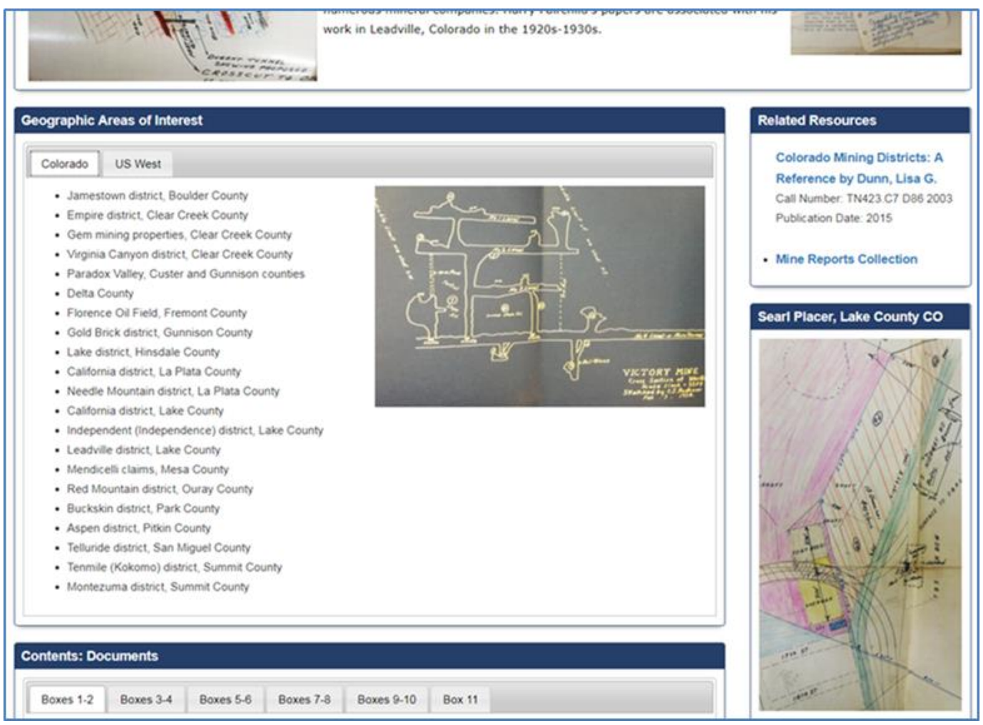


Figure 4b. Screen shot of the LibGuides Page showing Geographic Areas of Interest, Fairchild Collection.

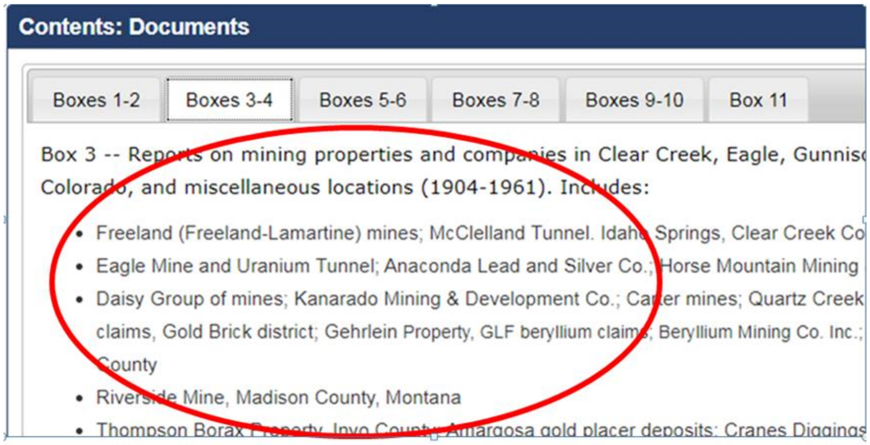


Figure 4c. Screen shot of the LibGuides page showing a summary of box contents with geographic and proper names (mines and mining companies).

RESULTS

The two test cases provided a reasonable idea of the workflow that will be needed to expand our descriptions to other geologic collections. The availability of the LibGuides pages provided an added benefit by acting as an easy resource for the metadata librarian to use to enhance the collection's MARC catalog records as her workflow permited. In re-examining the collections as part of the project and enhancing their descriptions, we gained a deeper understanding of the rich resources potentially available to our user communities.

Both collections became more readily discoverable by Google. In a search by creator and profession (example: robert hoffman mining engineer):

- Robert Hoffman has a moderate profile in Google. In addition to his publications, he was an active industry leader in his day and a wealthy businessman; he donated the funds for a building of experimental geology at Harvard University. A Google search shows the Robert D. Hoffman Collection LibGuide in the top results page.
- Gerald Fairchild has very little presence in comparison to Hoffman. However, a Google search shows the Fairchild Collection LibGuide in the top results as well.

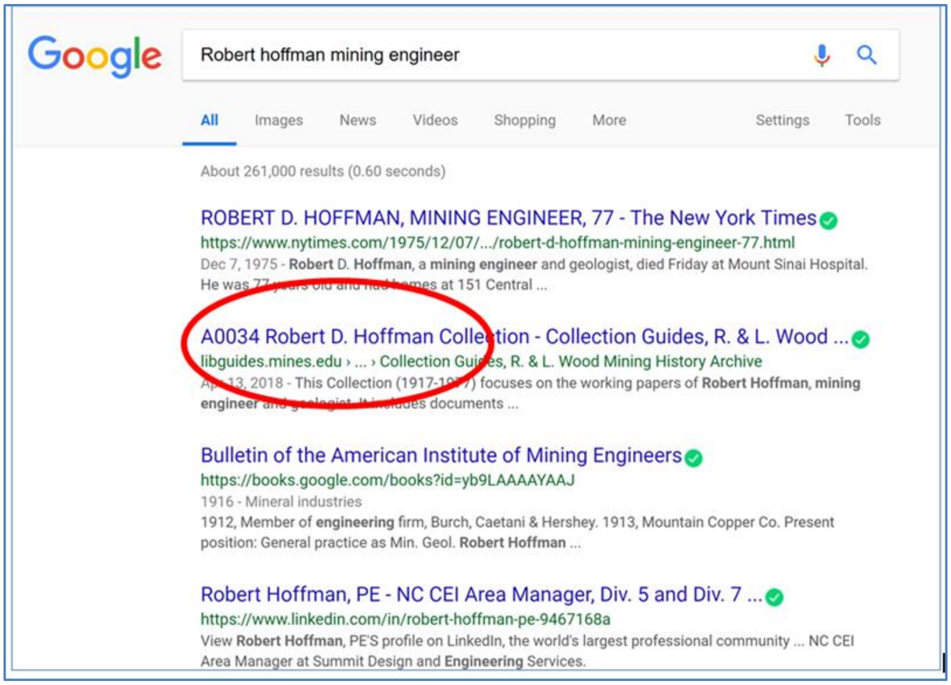


Figure 5. Results page, Google search for “robert hoffman mining engineer”. Accessed 21 July 2018.

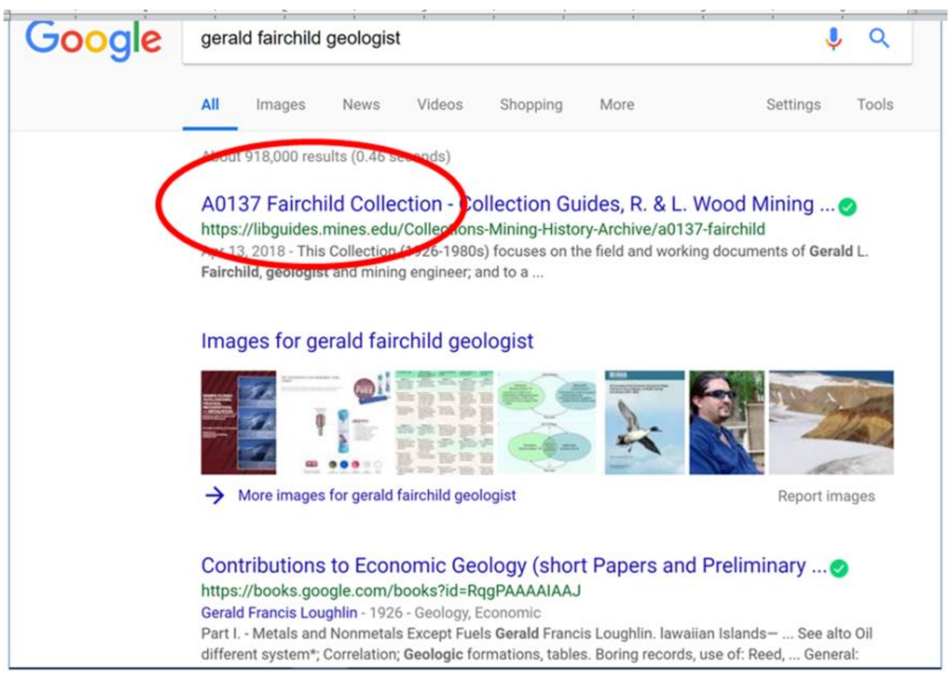


Figure 6. Results page, Google search for “gerald fairchild geologist”. Accessed 21 July 2018.

The original project goal and the real test of discoverabilty for the two examples, however, is whether a user can discover these resources by their geographic-related metadata. We were successful in having both collections appear in Google search results using geographic locations, mines and mining districts, and companies, although their positions on the results page are dependent on the subject—the more uncommon the keyword the higher up the results these collections appear. For example, a search for "riverside mine madison county montana" retrieves the Fairchild Collection on results page 3 of a Google search. (Users could skew the results upward by adding the word "archive" to the search, although this is unrealistic since most users don't deliberately plan to search archives for geologic data.)

Because of the limited scope of our pilot project, we don't have much data on user discovery to date. Workflow demands elsewhere resulted in little further development or outreach for the Mining History Collections LibGuides since November 2017—not an unusual circumstance for our Special Collections staff. LibGuides statistics show that from Nov 2017 to July 2018 our Mining History Collections guide that includes the Hoffman and Fairchild collections received a total of 813 visits. While this is not a large number, it does show an increase in visits over time.

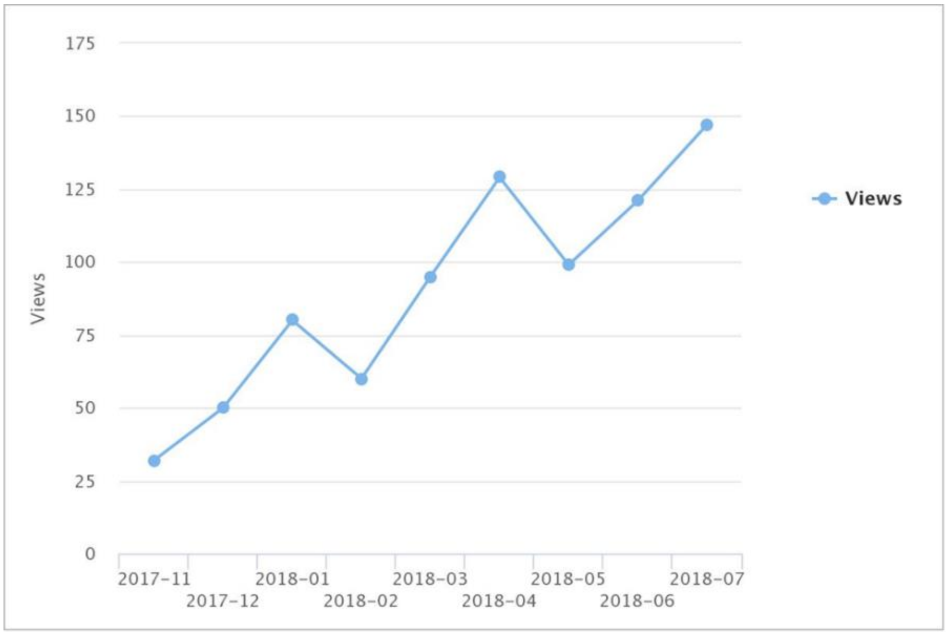


Figure 7. LibGuides statistics for Total Views on "Collections, Mining History Archive" Nov 1 2017-July 31 2018, Colorado School of Mines Library. Note: Coverage dates exclude spikes that are attributed to the author's own visits to these webpages.

CONCLUSIONS

LibGuides can be a good tool to improve the profile of collections of geologic field records and engage users. However, creating customized LibGuides pages for each collection of geologic field records is not a sustainable workflow for all or even the majority of our archival resources. Using LibGuides to showcase a select number of collections to strengthen outreach and promote the Archive is an attractive option. This method is also scalable, allowing us to choose all of a collection or a subset. Creating a standardized template would facilitate development of additional guides, and we can take advantage of the platform's "slideshow" feature to display snapshots of collections as a very abbreviated introduction to them. SpringShare's ability to provide metrics that reflect usage is a helpful tool. This benefits our user communities and is relevant to our mission. We now have a model for promoting our archival collections--another tool in the toolbox.

Experimenting with the Springshare LibGuides platform allowed us to knowingly approach discovery in a different and more free-form way. To do this we had to let go of the perfect metadata description and its long-term viability, and work with the notions of findability and engagement that our users value. Using the two platforms (library catalog and LibGuides) for our archival geologic records is a viable strategy—if we balance them with one another. There are good reasons to use standardized metadata in a platform that supports data sharing and migration. The library catalog will remain as the stable discovery tool for Archive materials at this time.

Is allocating resources to enhance discovery of geology materials the correct decision for every library? No, but it serves both our mission and outreach efforts for our archives.

In all of this, we're not ignoring context—we're finding ways to make it mean more. Strategies that increase discovery of historical geologic content by the scientific community promote a richer body of context and educate users on the history of their discipline. The relationship of context and content is reflected in a description of the geologic field records collection of the Missouri Department of Natural Resources,

> "These fascinating notebooks are indispensible tools for geologists and they serve as guidebooks to the future as well as the past. They contain drawings, maps, and information and observations about Missouri's geologic and hydrologic wonders, including important mineral and energy resources. Some contain carefully pressed leaves from trees, very old paper clips, advertisements, business cards and newspaper clips that shed light on aspects of Missouri geology and everyday life at the time. Geologists continue to use field notebooks to record information about geologic and hydrologic features while doing research in the great outdoors (Missouri Department of Natural Resources, 2018).

Future Directions

Our eventual goal is to improve the user experience by the addition of web-based finding aids for all of our significant archival geologic collections. Selective digitization will be explored to take advantage of its benefits for both access and outreach. Technological developments and additional resources for our new Digital Lab may make the digitization of challenging items more feasible. Digital content gives us options to partner with others, for example with Digital Public Library of America (DPLA). DPLA supports and encourages third-party apps that may someday allow users to manipulate metadata, including geographic metadata, from its records (Digital Public Library of America, 2018). We want to see users bring together our content in new ways. OCR can't fix many of our discovery and accessibility issues, but some day crowdsourcing may. The possibilities of crowdsourcing, from text transcription to metadata tagging to adding contextual data outside of our own collections, make for an exciting future.

REFERENCES

Colorado School of Mines Library. 2017. Catalog record, C. H. Wegeman collection, 1911-1930: Golden CO, Colorado School of Mines Library, https://mines.primo.exlibrisgroup.com/, accessed October 1 2017.

Digital Public Library of America, 2018. Developers: Boston MA, Digital Public Library, https://pro.dp.la/developers, accessed 25 July 2017.

Fairchild Collection (1926-1980?), A0137, Russell L. & Lyn Wood Mining History Archive. 2017: Golden CO, Colorado School of Mines Library, http://libguides.mines.edu/Collections-Mining-History-Archive/a0137-fairchild, accessed 18 Oct 2017.

Heidorn, P. B. 2008. Shedding light on the dark data in the long tail of science, Library Trends, 57(2), p. 280-299.

Missouri Department of Natural Resources. 2018. Field Notebooks: Rolla MO, Missouri Department of Natural Resources, https://dnr.mo.gov/geology/fieldnotebooks.html, accessed 27 July 2018.

Robert D. Hoffman Collection (1917-1977), A0034, Russell L. & Lyn Wood Mining History Archive. 2017: Golden CO, Colorado School of Mines Library, http://libguides.mines.edu/Collections-Mining-History-Archive/a0034-hoffman-r, accessed 18 Oct 2017.

Smithsonian Institution Archives. 2017. Catalog record, Geological Survey (U.S.), field notebooks, 1881-1915 and undated: Washington DC, Smithsonian Institution, https://siarchives.si.edu/collections/fbr_coll_ncdc436, accessed October 1 2017.

Smithsonian National Museum of Natural History. 2017. Field Book Project blog: Washington DC, Smithsonian Institution, http://nmnh.typepad.com/fieldbooks/2017/12/from-dayton-to-cambridge-and-back-again-the-field-notes-of-august-f-foerste.html, accessed 25 July 2018.

Wallis, J. C.; Rolando, E.; Borgman, C. L. 2013. If we share data, will anyone use them? Data sharing and reuse in the long tail of science and technology, PLoS ONE, 8(7), e67332, 20 p., https://doi.org/10.1371/journal.pone.0067332.

Wyborn, Lesley; Hsu, Leslie; Lehnert, Kerstin; Parsons, Mark A. 2015. Guest editorial: Special issue Rescuing Legacy data for Future Science, GeoResJ, 6, p. 106-107.

MANAGING THE DIGITAL GEOLOGIC PUBLICATION LIFECYCLE WITH DIGITAL COMMONS: A PARTNERSHIP BETWEEN THE MAINE GEOLOGICAL SURVEY AND THE MAINE STATE LIBRARY

Christian Halsted
Maine Geological Survey
93 State House Station, Augusta, ME 04333-0093

Adam Fisher
Maine State Library
Augusta, ME

Robert G. Marvinney
Maine Geological Survey
93 State House Station, Augusta, ME 04333-0093, robert.g.marvinney@maine.gov

Abstract—State geological surveys and other public institutions often struggle with long-term access to digital information, both in terms of discovery and persistent web addresses. Many have developed custom web interfaces to their digital collections, often with limited search capabilities, but are challenged to maintain them in the ever-changing digital environment within scarce human and financial resources. To address these problems, the Maine Geological Survey (MGS) has partnered with the Maine State Library (MSL) on a unique project. The MSL is using a relatively new, cloud-based tool called Digital Commons to host and manage state agency digital documents (http://digitalmaine.com/). MGS has loaded all of our digitally available maps and reports (~2600 items) into this system. The tool offers perma-links for MGS maps and reports, management and maintenance of the PDF files themselves, simple and advanced search capabilities, elimination of storage costs, integration with ArcGIS Online and Server, and it removes the need for MGS to build and maintain custom front-ends on our web site for document management. Through Digital Commons, discovery of MGS documents has been greatly enhanced by their inclusion in the Digital Public Library of America (DPLA). Prior to the launch of DPLA in 2013, a person interested in searching the collections of the Library of Congress, Smithsonian Institution, and National Archives had to search three different portals to find historical content. DPLA has created the umbrella that makes all kinds of digital collections searchable in one place. DPLA does not host digital content, it only indexes the descriptive metadata associated with those items and points users to the repository where the content is stored. Other uses for the Digital Commons include archiving and geotagging digital photos and scanned photo slide collections, and to archive historical spatial datasets. Digital Commons is available to any teaching, research, library or government

OPEN EDUCATIONAL RESOURCES IN THE EARTH SCIENCES: EXAMPLES FROM THE UC BERKELEY LIBRARY'S AFFORDABLE COURSE CONTENT PILOT PROGRAM

Samantha Teplitzky
UC Berkeley Library, Earth Sciences & Map Library
50 McCone Hall, Berkeley, CA 94720, steplitz@berkeley.edu

Abstract—Access to geoscience publications can take many forms. In the digital era, textbooks continue to provide a foundation for many students in a highly visual subject like the earth and geological sciences. Rising textbook costs can impact a student's ability to engage with the material and may influence their decision to continue in the discipline. To address this issue locally, an affordable course content pilot program was launched by the Scholarly Communications Office of the UC Berkeley Library in the summer of 2017. The pilot offers two services to assist faculty in the adoption and creation of open educational resources. In the first service, the Library will process faculty syllabi to locate free or Library-licensed resources to defray the cost of print course packs. For the second service, the Library will offer grants and assistance to encourage faculty to adopt open or library-licensed ebooks, or to create their own open textbooks.

This talk will examine textbook trends and the adoption of open educational resources in the earth sciences broadly, and offer details of the Berkeley pilot. Examples of past efforts by librarians in the Earth Sciences and Map Library to support and license course materials will be described as well as the Library's current outreach to and coordination with the Earth and Planetary Sciences (EPS) Department. Libraries have been long involved in making course content available for students and this pilot provides a renewed opportunity for libraries and campus departments to partner in reducing fees and increasing access for students.

Open Educational Resources in the Earth Sciences:

Examples from the UC Berkeley Library's Affordable Course Content Pilot Program

Samantha Teplitzky
Earth & Physical Sciences Librarian
UC Berkeley
steplitz@berkeley.edu

Berkeley
UNIVERSITY OF CALIFORNIA

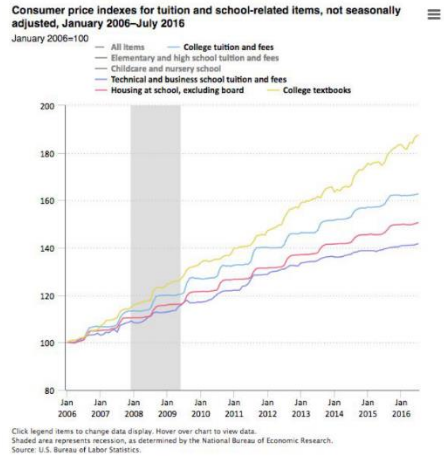
Outline

- Background: Open Educational Resources
- Textbook Choice in the Earth Sciences
- Past practice in Earth Sciences & Map Library at Berkeley
- Berkeley's Affordable Course Content Pilot Program
  - Early results
- Next steps

Berkeley
UNIVERSITY OF CALIFORNIA

Background: Open Educational Resources

Textbook prices have risen
88 percent in the past decade



Source:
https://www.bls.gov/opub/ted/2016/college-tuition-and-fees-increase-63-percent-since-january-2006.htm

Berkeley
UNIVERSITY OF CALIFORNIA

Background: Open Educational Resources

UC Berkeley annual
Textbook cost estimate: $900

Undergraduate Student Budgets 2017-18

Updated April 21, 2017

Academic Year 2017-18	Living in a Campus Residence Hall	Living in an On-Campus Apartment	Living in an Off-Campus Apartment	Living with Relatives
Direct Costs Charged by UC Berkeley				
Tuition and Fees	$14,068	$14,068	$14,068	$14,068
Room and Board	$15,716*	$12,874*		
Total Direct Costs	**$29,784**	**$26,942**	**$14,068**	**$14,068**
Other Estimated Costs				
Housing and Utilities			$8,992	$2,630
Food	$1,558	$3,480	$4,264	$3,174
Books and Supplies	$894	$894	$894	$894
Personal	$1,782	$1,782	$1,780	$1,892
Transportation	$382	$382	$542	$1,432
Total Cost of Attendance	**$34,400***	**$33,480**	**$30,540**	**$24,090**

Source:
http://financialaid.berkeley.edu/cost-attendance

Berkeley
UNIVERSITY OF CALIFORNIA

Top Ten Most Frequently Assigned Earth Science Textbooks

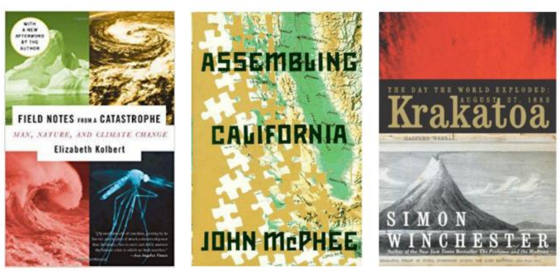
Rank	Text	Author	Publisher	Cost ebook/print		Year	Edition	library license?	open access?
1	**Earth Science**	Tarbuck	Pearson		$191.00	2015	14th	no	no
2	**Physical Geology**	Plummer	McGraw Hill	$58.00	$227.00	2016	15th	no	no
3	**Earth Science and the Environment**	Thompson, G	Cengage		$228.95	2007	4th	no	no
4	**The Earth Through Time**	Levin	Wiley	$64.00	$122.95	2017	11th	no	no
5	**Earth : Portrait of a Planet**	Marshak	Norton	$65.00	$146.25	2015	5th	no	no
6	**The Earth: An Introduction to Physical Geology**	Tarbuck	Pearson		$183.20	2017	12th	no	no
7	**Understanding Earth**	Press	Freeman		Out of print	2004	3rd	no	no
8	**Applied Hydrogeology**	Fetter	Prentice Hall/Pearson		$226.54	2001	4th	no	no
9	**Understanding Earth**	Grotzinger	Freeman	$65.00	$146.00	2014	7th	no	no
10	**Earth System History**	Stanley	Macmillan	$18.00	$140.43	2015	4th	no	no

Source: http://explorer.opensyllabusproject.org/

Berkeley
UNIVERSITY OF CALIFORNIA

Alternative texts

Some instructors choose to assign less expensive, popular geology books.



Source: http://blogs.agu.org/geoedtrek/2015/04/01/textbook/

Berkeley
UNIVERSITY OF CALIFORNIA

Past Practice

Encouraged the adoption and use of library-licensed ebooks within the Earth and Planetary Science department through

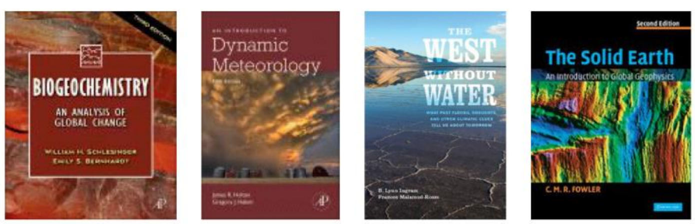
- Individual outreach
- Course reserve lists
- Student requests

Berkeley
UNIVERSITY OF CALIFORNIA

Past Practice

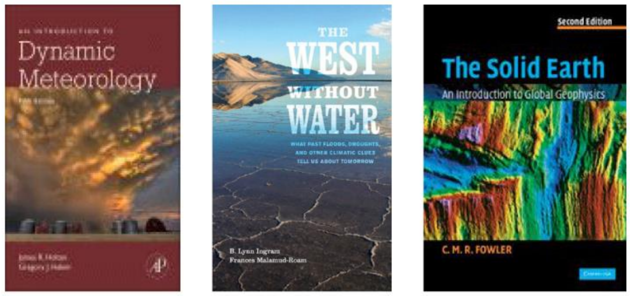
Turn requests into library licensed books.

Examples:



Berkeley
UNIVERSITY OF CALIFORNIA

The math



$950 $45 ~$140

Approx savings = cost * # students * semesters used

Berkeley
UNIVERSITY OF CALIFORNIA

Berkeley's Affordable Course content pilot program

http://news.lib.berkeley.edu/2017/08/28/free-textbooks/

Free textbooks? Effort aims to take some financial burden off students' shoulders

Tags: library communications, scholarly communication

By Tor Haugan in Scholarly Communication, What's New on August 28, 2017

From left: ASUC Senator Hung Huynh talks with Rachael Samberg, Scholarly Communication Officer at the University Library, and Richard Freishtat, Director of the Center for Teaching and Learning, about how new course content affordability programs will help Berkeley students. (Photo by Cade Johnson for the University Library)

Berkeley
UNIVERSITY OF CALIFORNIA

Berkeley's Affordable Course content pilot program

Pilot #1: Course Packs

The Library will process participating instructors' syllabi and locate Library-licensed, open or free versions of readings that students would have had to purchase as print course packs.

Berkeley
UNIVERSITY OF CALIFORNIA

Berkeley's Affordable Course content pilot program

Pilot #1: Course Packs

The Library will process participating instructors' syllabi and locate Library-licensed, open or free versions of readings that students would have had to purchase as print course packs.

We will provide links or accessible PDFs to post to bCourses at no cost to students, reducing any remaining readings that a student would have purchased as part of a print course pack.

Berkeley
UNIVERSITY OF CALIFORNIA

Berkeley's Affordable Course content pilot program

Pilot #1: Course Packs

The Library will process participating instructors' syllabi and locate Library-licensed, open or free versions of readings that students would have had to purchase as print course packs.

We will provide links or accessible PDFs to post to bCourses at no cost to students, reducing any remaining readings that a student would have purchased as part of a print course pack.

We will also provide guidance to instructors for making **fair use decisions**–further reducing the cost of course packs. We can help tailor instances in which a third party copy center would need to secure copyright clearance for assigned readings.

Berkeley
UNIVERSITY OF CALIFORNIA

Berkeley's Affordable Course content pilot program

Pilot #2: eTextbooks

Grants and programmatic support to instructors to enable them to **switch** to Library-licensed eBooks, or to **adopt** or **create** open textbooks and related materials ("OERs").

Grants:

$500

Switch one required print book to a library-licensed electronic book

Berkeley
UNIVERSITY OF CALIFORNIA

Berkeley's Affordable Course content pilot program

Pilot #2: eTextbooks

Grants and programmatic support to instructors to enable them to **switch** to Library-licensed eBooks, or to **adopt** or **create** open textbooks and related materials ("OERs").

Grants:

$500 → **$5,000**

Switch one required print book to a library-licensed electronic book

Receive programmatic support to design your own open & electronic course materials

Berkeley
UNIVERSITY OF CALIFORNIA

Pilot program: early results

Pilot announced Spring 2017 in preparation for Fall 2017.

Most work done by Scholarly Communications Officer, one instructional librarian and members of Berkeley's Scholarly Communications Expertise Group.

To date, **20 instructors** and **16 departments** are participating.

Berkeley
UNIVERSITY OF CALIFORNIA

Pilot program: early results

Pilot #2: eTextbooks

Grants:

$500 → **$5,000**

Switch one required print book to a library-licensed electronic book

↓

37 ebooks ordered
Cost: $2105

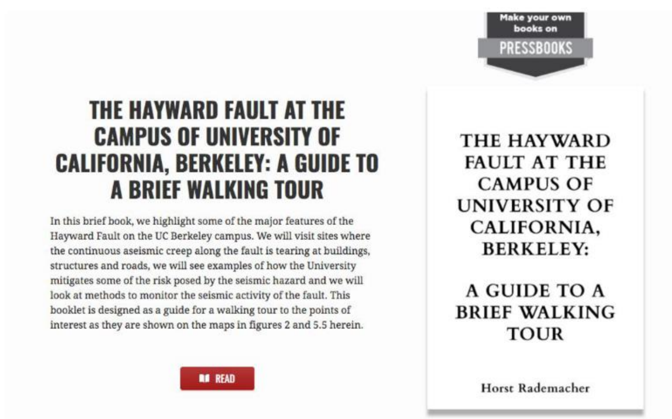
Receive programmatic support to design your own open & electronic course materials

↓

5 OERs funded, 1 completed
Grants: $20,500

Berkeley
UNIVERSITY OF CALIFORNIA

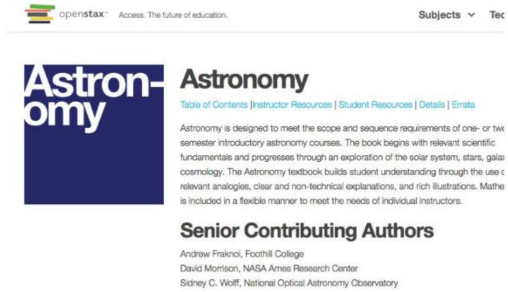
Example from Earth and Planetary Science Department



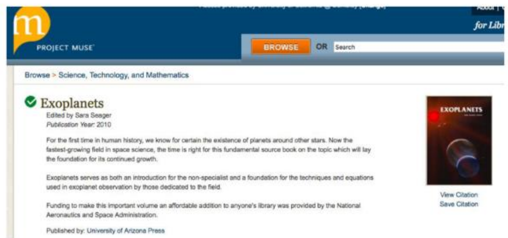
Berkeley
UNIVERSITY OF CALIFORNIA

Other examples

OER:
Open Stax (Astronomy)



Library Licensed:
Exoplanets



Berkeley
UNIVERSITY OF CALIFORNIA

Next steps

Evaluate results of the **pilot**, considering both sustainability and scalability.

Continue department level **outreach** and encouragement of participation in OER use from the Earth Sciences & Map library.

Affordable Course Content Workshop Series
Workshops will be held during open access week and later this fall to promote open textbook use.

Berkeley
UNIVERSITY OF CALIFORNIA

References

Bureau of Labor Statistics, U.S. Department of Labor, The Economics Daily, College tuition and fees increase 63 percent since January 2006, https://www.bls.gov/opub/ted/2016/college-tuition-and-fees-increase-63-percent-since-january-2006.htm (visited September 21, 2017)

http://financialaid.berkeley.edu/cost-attendance

http://www.lib.berkeley.edu/scholarly-communication/publishing/affordable/campus-initiatives

http://explorer.opensyllabusproject.org/

https://openstax.org/details/books/astronomy

Berkeley
UNIVERSITY OF CALIFORNIA

DOCUMENTATION IN THE MIDDLE: ACTIVE PHASE PROJECT DOCUMENTATION FOR INCLUSIVE AND EFFECTIVE TEAM-BASED RESEARCH

Lori Tschirhart
University Library, University of Michigan
3164 Shapiro Library, 913 S. University Ave., Ann Arbor, MI 48104, ltz@umich.edu

Abstract—With increasing team-based research across disciplines, how can librarians support and ensure inclusive and effective participation of all team members?

Documentation is an essential component of good data management and yet data service providers often struggle to provide effective support to researchers. There are materials available for creating or assisting researchers with documentation at the beginning and end of a project; from data management plans to documenting data for archival purposes. However, we don't yet have a solid understanding of how research teams incorporate (or not) documentation into their everyday work.

I will describe a collaboration among academic librarians to investigate, analyze, and synthesize real and ideal documentation practices within research teams in order to develop a universal project manual documentation template. It is our contention that "lab manuals" or "project organization protocols" will enhance the effectiveness and efficiency of research teams, while creating an inclusive environment by making local practices and expectations clear to all team members regardless of previous research experience and disciplinary background.

Through presentation of a beta lab manual template, I will describe the basic considerations that any researcher from any discipline should consider for their local documentation in support of team-based research projects, and I will explain how such documentation may benefit research teams seeking to actively support diversity, equity, and inclusion efforts.

VIRTUAL FRONTIERS: MANAGING 3D AND VIRTUAL REALITY CONTENT AND SYSTEMS IN GEOSCIENCE LIBRARIES

Elise D. Gowen
University Libraries, Pennsylvania State University
105 Deike Building, University Park, PA 16801, edg16@psu.edu

Abstract—The advent of affordable and accessible virtual reality systems presents many opportunities for the geoscience librarian to support new ways of teaching, researching, and producing content in the geosciences. While geoscience libraries can use virtual reality to help students and researchers visualize data, develop spatial literacy and supplement field work with virtual experiences, many libraries are still in the conceptual stages of exploring these possibilities. In practice, implementing virtual reality in the library comes with many challenges and choices that librarians must consider before implementation, including staffing, space, services, and collection management, as geoscience faculty and students produce 3D content that must be preserved and made findable for other users. This presentation will explore the possibilities and issues represented by this new information resource, and how librarians can integrate it into the geoscience library. We will share examples of the kinds of 3D and virtual reality content that geoscience faculty and students are producing, and how research libraries can incorporating virtual reality into their services and collections.

USE OF WEB GIS AND SATELLITE IMAGERY FOR COMMUNICATING CONCEPTS OF UNCERTAINTY IN EARTH SCIENCE DATA

Christopher A. Badurek
Department of Geography, SUNY Cortland
Cortland, NY 13045, christopher.badurek@cortland.edu

Abstract—The concepts of uncertainty are a critical component of the quality of geospatial data in the earth sciences, including GIS, satellite imagery, and field collection data points. Increasing interest in policy implications of climate change underscore the importance of understanding the uncertainty inherent to greenhouse gas (GHG) emissions data, particularly in terms of explanations for undergraduate students and communicating science to the general public. Despite its importance, students and beginning GIS users often neglect to examine measures of uncertainty found in metadata or consider impacts on analysis. A sample of NASA GHG data sets used for mapping atmospheric concentrations of greenhouse gases are presented as case examples for teaching concepts of uncertainty in courses including fully focused on geospatial analysis or including some aspects. Teaching modules are presented for the concepts of spatial uncertainty, attribute uncertainty, and vagueness found in determining borders of greenhouse gas emissions. Use of web GIS tools and open source GIS software is highlighted for teaching each of the modules and summary recommendations for teaching concepts for upper and lower division students as well as public science communication are provided.

A CITIZEN SCIENCE APPROACH TO GROUNDWATER MONITORING: THE IMPACTS OF PARTICIPATION ON KNOWLEDGE AND ATTITUDES, AND IMPLICATIONS FOR MANAGEMENT

Cynthia Grace-McCaskey
Anthropology, East Carolina University
211 Flanagan Building, Greenville, NC 27858

Alex K. Manda
Department of Geological Sciences and Institute for Coastal Science and Policy,
East Carolina University
387 Flanagan Building, East 5th Street, Greenville, NC 27858, mandaa@ecu.edu

James Randall Etheridge
Engineering, East Carolina University
RW-214, Greenville, NC 27858

Jennifer O'Neill
Anthropology, East Carolina University
211 Flanagan Building, Greenville, NC 27858

Abstract—Citizen science is the participation of non-scientists in the collection of scientific data and other aspects of the scientific process. While public participation in science is not new, this approach to research has become increasingly common in the past two decades. Despite the increasing popularity of this approach, due to the technologically complex and expensive techniques typically required to take hydrological measurements, its use in water related sciences has been primarily limited to monitoring of surface water quality or measurement of precipitation amounts. In this paper, we present the results of a study that involved citizen scientists in the monitoring of groundwater levels and subsequent characterization of the water table on Bogue Banks, North Carolina. The data and results presented here aim to fill the gap in the literature regarding relationships between citizen science, scientific knowledge, and environmental attitudes in a hydrogeological context. Specifically, we use a pretest-posttest survey design to assess the effects of participation in a citizen science groundwater monitoring project on participants' knowledge of hydrologic concepts, and attitudes toward science and the environment. Further, by examining participants' perceptions regarding causes of and impacts from localized stormwater flooding as well as climate change more generally, we explore the potential ways that citizen science can contribute to improved management of water resources. We found that participation in the citizen science project increased knowledge of hydrological concepts, but did not change attitudes toward science and the environment.

1. INTRODUCTION

Citizen science is the participation of non-scientists in the collection of scientific data and other aspects of the scientific process, such as developing research questions and analyzing data. While the participation of members of the public in science projects is not new, this approach to research has become increasingly common in the past two decades (Crain et al., 2014; Dickinson et al., 2012; McKinley et al., 2017). This increase reflects growing concern for environmental issues and awareness of human impacts on ecosystems (Bonney et al., 2014; Johnson et al., 2014), and falling public spending on the environment (Conrad and Hilchey, 2011). Although questions remain regarding the reliability of data collected by citizen scientists and the extent to which citizen science facilitates greater scientific knowledge and understanding, researchers highlight the important role citizen science plays in linking members of the public to environmental management (Jordan et al., 2011; McKinley et al., 2017). Participation in citizen science projects can expose volunteers to local environmental conditions, increasing awareness of associated problems and the related potential management or policy options. This, in turn, can lead to increased engagement in management, either directly by providing input to policymakers, or indirectly by sharing information and encouraging others to get involved (Dunlap, 1992; Marcinkowski, 1993; McKinley, 2017). Dickinson et al. (2012) emphasize how participation in citizen science projects creates authentic learning experiences, providing opportunities for scientists to engage directly with community members, often regarding critical issues of scientific concern. This can lead to increased public support for science and policies that promote environmental sustainability.

Not all citizen science projects employ the same format. For example, Bonney et al. (2009) describe three types of citizen science projects: contributory projects, collaborative projects, and co-created projects. Contributory projects, which can be either active or passive in nature, are those in which volunteers' primary role is to collect data. These are the most common (Price and Lee, 2013) and have been used in a variety of fields, including ornithology (Brossard et al., 2005), environmental education (Mannion et al., 2013), astronomy (Percy, 1999), and risk communication (Kar, 2016). In collaborative projects, volunteers collect data but may also contribute to additional aspects of the scientific process, such as helping to develop the project goals or scientific objectives, analyzing data, or disseminating findings. One of the better-known projects of this type is the Galaxy Zoo astronomy project, which resulted in one citizen scientist discovering a new astronomical structure in the course of the study (Cardamore et al., 2009; Price and Lee, 2013). Collaborative projects are also common in water quality (Cunha et al., 2017) and ornithology (Brossard et al., 2005) studies. In co-created projects, all aspects of the research design and process are co-designed by scientists and volunteers. This type of citizen science project is the least utilized at present (Price and Lee, 2013). The three formats of projects therefore provide a myriad of opportunities for the public to participate in citizen science, allowing for different deliverables, commitments and benefits.

A broad range of benefits have been attributed to a citizen science approach. Involving citizen scientists in data collection can allow for large increases in sample sizes and the total number of observations that can be recorded. Importantly, these data may be collected from locations that are not accessible to the scientists themselves due to geographical and/or funding limitations (Brudney, 1999; Cooper et al., 2007; Danielsen et al., 2014; Johnson et al., 2014). Such efforts contribute to the establishment of ecological or environmental baselines, assist in long-term monitoring of organisms or environmental conditions, facilitate documenting shifts associated with global phenomena such as climate change, and assist responses to crises such as oil spills (Dickinson et al., 2012; Fuccillo et al., 2015; McCormick, 2012; Sullivan et al., 2009; Thomas et al., 2016). While questions remain regarding the validity of data collected by citizen scientists, several studies have shown that with proper training, these data can be reliable and useful (e.g., Little et al., 2015; Lowry et al., 2013).

Researchers have also focused on how citizen science contributes to increased scientific knowledge and understanding of the scientific process (Crall et al., 2012; Evans et al., 2005; Jordan et al., 2011). While this is often put forth as a potential benefit of citizen science in general and as a goal of specific studies, the relationship between participation in citizen science projects and increases in scientific knowledge is not well-documented. Experts suggest that it is challenging to demonstrate increases in knowledge due to the lack of established metrics and techniques to do so, and the expense involved in proper evaluation (Bonney et al., 2016; Phillips et al., 2012). However, a small number of studies have demonstrated increases in scientific knowledge related to the specific topic being examined, such as bird biology (Brossard et al., 2005) or invasive species (Crall et al., 2012; Jordan et al., 2011).

Although research projects involving a citizen science approach have increased dramatically over the past two decades, the use of the approach in water related sciences has been limited (Buytaert et al., 2014). Further, those projects involving citizen scientists in hydrologic research primarily involve water quality monitoring (e.g., Macknick and Enders, 2012; EarthEcho Water Challenge, 2017) or precipitation measurement (e.g., Cifelli et al., 2005; Community Collaborative Rain, Hail and Snow [CoCoRaHS] Network, 2017), likely due to the relative ease with which those parameters can be measured. Many hydrological measurements, however, rely on technologically complex and expensive techniques, and meaningful analysis of data associated with the water cycle often requires data collected over long temporal and large spatial scales, which contributes to the limited adoption of citizen science approaches in hydrologic research (Buytaert et al., 2016). While technological advances have led to the development of low-cost, high quality hydrological equipment, as well as new ways for volunteers to record and submit data via cell phones and other personal devices, only a small number of projects have attempted to involve citizen scientists in studies addressing more complex hydrological questions. For example, Mazzoleni et al. (2017) demonstrated that citizen scientists' streamflow observations can be integrated into hydrological models to improve flood predictions, and Turner and Richter (2011) showed how citizen scientists' wet/dry mapping observations contributed to improved understanding of hydrologic systems at the watershed scale. To our knowledge, however, these and similar studies focused primarily on determining the reliability and utility of citizen scientist collected data, and did not examine the impacts of participation in hydrological projects on participants' scientific knowledge and attitudes toward the environment, as we do here.

This research study aims to fill a gap in the literature regarding relationships between citizen science, scientific knowledge, and environmental attitudes in a hydrological context. Specifically, we assess whether participation in a citizen science groundwater monitoring project affects participants' knowledge of hydrologic concepts, and attitudes toward science and the environment. Second, we examine whether and how participants' perceptions of threats and impacts from flooding and climate change are altered by their participation. Lastly, we evaluate whether participation in a hydrologic citizen science project increases the understanding of relationships among coastal flooding, sea-level rise (SLR), and climate change. To the authors' knowledge, this study is one of the first to evaluate how citizen scientists' perceptions about climate change may evolve due to participation in a hydrologic study. By examining participants' perceptions regarding causes of and impacts from localized stormwater flooding as well as climate change more generally, we explore the potential ways that citizen science can contribute to improved management of water resources. Further, by using standardized survey instruments to measure attitudes, we contribute to Brossard et al.'s (2005) call for citizen science studies to use such scales to improve the capacity for valid comparisons of results across studies.

2. METHODS

2.1 Study site description

The citizen science project was conducted on Bogue Banks, a ~28 km^2 barrier island comprised of the communities of Emerald Isle, Pine Knoll Shores, Atlantic Beach, Salter Path, and Indian Beach (Figure 1). Situated off the coast of North Carolina, the island is located in Carteret County, and is a popular destination for vacationers and retirees. In 2015, Bogue Banks had a permanent population of 7,413, reflecting a 7.5% increase from 2010 (US Census Bureau, 2017). The seasonal influx of visitors to Carteret County generates over $350 million in tourism revenues each year and supports nearly 3,500 jobs (EDPNC, 2017).

The topography on the island is characterized by a series of shoreline parallel dunes and swales, with elevation ranging from approximately 1m below sea-level to 17m above sea-level. The southeastern portion of the island is home to the largest dunes, while the ground surface in the northern portion of the island generally slopes gently into Bogue Sound. Lautier (2001) characterizes the hydrogeologic framework of the North Carolina Coastal Plain aquifer system as a wedge of formations that dip and thicken to the east. The surficial or water table aquifer (relevant to this study) is an unconfined, Quaternary aquifer composed mainly of sandy material with some beds of mud and clay that is present throughout the North Carolina Coastal Plain (Lautier, 2001). The predominant source of recharge for the surficial aquifer is precipitation. The water table is typically close to the ground surface in the surficial aquifer. On Bogue Banks, the water table may vary from being above the ground surface in depressional areas, to several meters below the surface on top of large dunes.

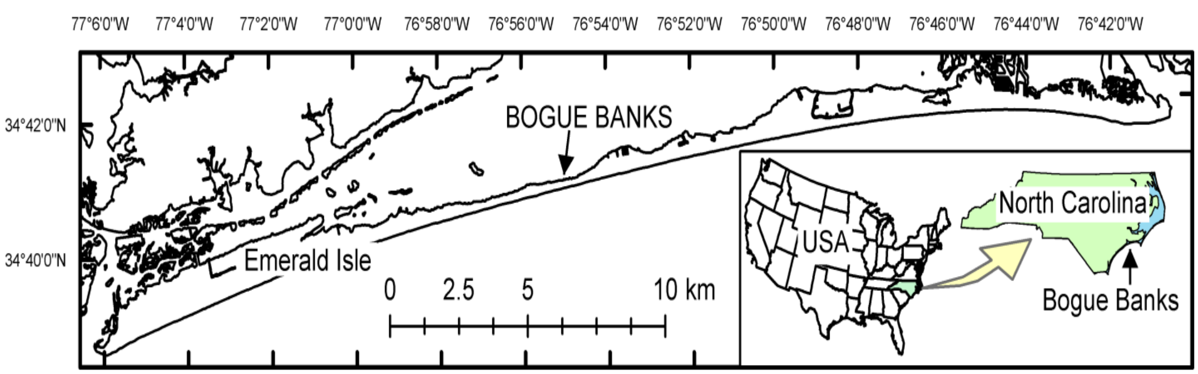


Figure 1. Location of Bogue Banks off the coast of North Carolina.

Bogue Banks was selected as the study site because it represents a coastal community that is at risk from climate change and SLR, similar to many other regions across the globe (e.g., Nicholls and Cazenave, 2010; Green et al., 2011; Taylor et al., 2013). Global projections of SLRs of 0.2 m to >1 m by the end of this century (Jevrejeva et al., 2012; NRC, 2012; Rahmstorf et al., 2012; Horton et al., 2014) will cause major water resources problems of marine inundation (where previously dry land is occupied by sea water) and saline water intrusion (where saltwater replaces freshwater in aquifers) in coastal regions (Cooper et al., 2013). Additionally, future SLR may cause groundwater inundation (where groundwater tables reach the land surface leading to localized flooding) in low-lying coastal areas (e.g., Mastersen et al., 2013; Rotzoll and Fletcher, 2012; Manda et al., 2014).

Stormwater flooding events are of great concern to residents on Bogue Banks. Town managers on the island are therefore intent on employing engineering solutions to alleviate the frequency and intensity of stormwater flooding events. However, engineering solutions may be inadequate if the drivers of the flooding are not entirely understood. Since the island is dominated by dunes and swales, the low-lying areas may be prone to flooding where the water table rises above the ground surface, thereby contributing to stormwater flooding. To characterize the island's water table and assess the proportion of land on Bogue Banks impacted by groundwater inundation, and to assess the reliability of water level measurements taken by citizen scientists, 29 shallow groundwater monitoring wells were installed on Bogue Banks, and a pilot study with seven volunteer citizen scientists was conducted on Bogue Banks in 2015. Based on the researchers' experiences during the pilot study and feedback from those participants, the research design was expanded to attract more citizen scientists, to collect data from a greater number of wells over a longer time period, and to assess the impacts of participation in hydrological citizen science projects on participants' scientific knowledge and attitudes toward the environment.

2.2 Data collection

Participants were recruited by putting up flyers in frequently visited locations on Bogue Banks, publishing announcements in local newsletters, and soliciting volunteers from local organizations (e.g., aquariums and environmental non-governmental organizations). Two informational sessions were held in February 2017, attracting a total of 31 participants. During these sessions, the researchers introduced the project and described the responsibilities of citizen scientists in the project, which included: participating in a workshop and training session to learn about groundwater systems and how to properly take water level measurements in shallow groundwater monitoring wells; measuring and recording groundwater levels at assigned wells at least once a week over a three-month period; submitting those data to researchers via a dedicated website (https://coastalwater.org/cgsw/); completing pretest and posttest surveys; and participating in occasional meetings or email discussions with researchers and other citizen scientists during the research period. At the end of the informational sessions, all 31 participants agreed to volunteer as citizen scientists, completed the informed consent process and pretest survey (approved by East Carolina University's Institutional Review Board), and participated in the workshop and training session. During the workshop, citizen scientists manipulated and interacted with physical groundwater models in small groups. The authors also led them through a hypothesis-testing process in which they tested hypotheses about groundwater flow directions and water level variations in monitoring wells. The citizen scientists then received hands-on, one-on-one instruction at one of the installed groundwater wells to ensure proper water level measurement. Before leaving the workshop and training session, each participant was given a water level meter, keys to the wells, data recording sheets, and laminated copies of instructions for accessing wells, taking measurements, and submitting groundwater level data.

Throughout the three-month monitoring period, researchers were in continued communication with the citizen scientists, primarily via email, to assist with any issues or concerns that arose. A meeting was held half-way through the data collection period (March 2017) during which researchers presented the data collected up until that point and facilitated a discussion with the participants ($n = 9$) who attended. At the end of the three-month data collection period, final meetings were held on two different occasions (in May 2017) to debrief the participants. The citizen scientists were encouraged to attend the event to return their equipment, complete the posttest survey, provide feedback to the researchers regarding their experiences with the project, and participate in discussions regarding how the data will be analyzed and results disseminated. A total of twelve citizen scientists participated in the final meetings. The discussions at these meetings included examining time-series graphs of data collected by the citizen scientists, comparing groundwater levels to rainfall data, and evaluating groundwater contour maps developed from the citizen scientists' data.

2.3 Survey instruments

As with many citizen science projects, the participants in this study were volunteers; as such, the number of potential participants was limited. For this reason, it was not possible to create a directly comparable control group, and so we used a pretest-posttest design (Bernard, 2011). Two surveys were administered to participants. The pretest was administered at the start of the project during the first group meeting (February 2017), after the citizen scientists had agreed to participate but prior to receiving in-depth instruction on groundwater concepts. The posttest was administered at the conclusion of the project, once all data had been collected and turned in to the project scientists (May 2017). All the participants completed the pretest during the initial meeting, but because several participants were not able or willing to attend the final meeting, some of the posttests were administered and returned by email or the regular postal service.

Other researchers have emphasized the importance of using standardized and widely used survey instruments that will allow for comparison of data collected in various citizen science studies as well as national survey efforts (Brossard et al., 2005; Dickinson and Bonney, 2012). While the authors agree with Brossard et al. (2005: p.1103) that survey instruments designed for national random samples may not be completely suitable for a project such as this in which participants are volunteers and, therefore, self-selected, the authors wanted to contribute to efforts to produce comparable data. For this reason, two widely-used instruments to measure participants' attitudes toward science and attitudes toward the environment were employed in the pretest and posttest surveys (MATOSS and NEP scales, see below). Other sections of the surveys were developed specifically for this study.

Knowledge of hydrologic concepts was assessed with 21 multiple choice questions (Supplementary materials, Table SM1) that were developed collectively by the study's lead scientists and pilot tested with a small sample of students ($n = 10$) at East Carolina University.

This section of the survey was designed to measure participants' knowledge of hydrology in general, stormwater management practices, the potential effects of SLR, and their knowledge of groundwater systems specific to Bogue Banks. The knowledge test questions were the same on the pretest and posttest, and they all addressed concepts or facts that were presented to participants during the project's initial training workshop and reinforced via in-person meetings or other communications throughout the project's duration.

Attitude toward science was assessed with a modified version of the National Science Foundation's attitude toward organized science scale (ATOSS) (National Science Board, 1996). Previous citizen science studies have used a modified version of this scale (MATOSS) (Brossard et al., 2005; Crall et al., 2012), and the authors calculated participants' overall MATOSS scores in a similar manner. However, because the survey developed for this study included six items from the ATOSS (Supplementary materials, Table SM2), MATOSS scores for the participants in this study range from -12 (strong negative attitude toward science) to 12 (strong positive attitude toward science). Identical items were used on the pretest and the posttest.

Attitude toward the environment were assessed using a subset of the new environmental paradigm scale (Supplementary materials, Table SM3), originally developed in 1978 (Dunlap and Van Liere, 1978) and revised as the new ecological paradigm (NEP) scale (Dunlap et al., 2000). It is one of the most commonly used scales to measure environmental attitudes, and has previously been used in other citizen science studies (e.g., Brossard et al., 2005; Crall et al., 2012). The survey developed for this study included 8 items from this scale and, following common practice of the use of this scale, participants' overall scores range from 1 to 5, reflecting the mean of their responses to each item (Hawcroft and Milfont, 2010). Higher NEP scores indicate an ecocentric orientation reflecting commitment to the preservation of natural resources, and lower NEP scores indicate an anthropocentric orientation reflecting commitment to exploitation of natural resources. Identical items were used on the pretest and the posttest.

Additional questions on the survey asked participants about their perceptions of and beliefs about flooding on Bogue Banks and climate change more generally. These questions varied in format, including both closed- and open-ended questions. Again, the same questions were included on the pretest and posttest (Tables 2 – 4). The pretest also contained items that were not part of the posttest, including questions about demographics and other participant characteristics, such as place of residence, previous participation in a citizen science project, and motivations for volunteering. The posttest also included items that were not on the pretest, including questions for evaluating the project and soliciting feedback from participants regarding their experiences as citizen scientists.

2.4 Data analysis

Survey responses were statistically analyzed using either a paired t-test or the Wilcoxon signed-rank test (depending on data characteristics, such as distribution normality) in the commercially available SPSS software package. Because this study is focused on evaluating the extent to which participation in the citizen science project impacted knowledge and attitudes, those analyses are limited to the number of participants who completed both the pretest and posttest (n = 20).[1] Since small sample sizes and participant drop-out is common in pretest-posttest designs, including those involving citizen scientists (Druschke and Seltzer, 2012; Johnson et al., 2014), data was also collected via focus groups during the final project meeting. Focus groups were recorded, then analyzed for themes. These results are used to augment the results from the survey data.

3. RESULTS

3.1 Response rates and participant characteristics

A total of 31 citizen scientists participated at least partially in the study by attending one of the groundwater monitoring training workshops, taking water level measurements, and completing the pretest survey. However, as mentioned previously, because only 20 participants completed the posttest survey (64.5% response rate), the results reported here are limited to that sample.

Participants represented a wide range of ages; 35% of participants were under the age of 30, 20% were between the ages of 31 and 50, and 40% were aged 51 and older (5% did not answer this question). About two thirds of the citizen scientists who completed the project were female. An overwhelming majority of the participants reported their ethnicity as white (95 percent), while the remaining five percent identified as Black/African American. The participants were also highly educated, with 80 percent reporting a credential beyond a high school diploma or General Education Diploma. When asked if they had been involved with environmental groups in any capacity, 40% of the citizen scientists reported that they had.

Given the seasonal shifts in population on Bogue Banks, the residency pattern of the citizen scientists was evaluated. The majority (65%) of participants were full-time residents of Bogue Banks; however, given the seasonality of Bogue Banks' population, 15% were part-time residents and 20% traveled from surrounding areas to participate in the project. Participants were also asked about their employment status, and a significant number of the citizen scientists were retirees (40%), while the second largest group reported being employed full-time (30%).

3.2 Knowledge of hydrologic concepts

On the pretest knowledge questions, participants answered an average of 14.55 questions correctly out of 21 (about 69.3%). On the posttest, the mean score increased to 16.50 (about 78.6%) (Table 1). A paired t-test indicated this difference in mean scores was statistically significant (Table 1). These results suggest that participants did increase their knowledge of hydrologic concepts by participating in the project.

---

[1] Although it is not described in detail in this manuscript, we did look for potential differences between those participants who completed both the pretest and posttest (n=20) and those who only completed the pretest (n=11). Non-parametric tests did not find statistically significant differences in terms of gender (p=.449), age (p=1.000), residency (p=.405), MATOSS score (p=.341), or NEP score (p=.845).

3.3 Attitudes toward science

MATOSS scores for the participants in this study could range from -12 (strong negative attitude toward science) to 12 (strong positive attitude toward science). On the pretest, the mean score was 5.85, indicating a fairly positive attitude toward science. On the posttest, the mean score was 5.70, and a paired t-test indicated this difference was not statistically significant (Table 1). This suggests that participants' attitudes toward science did not change by participating in the project.

3.4 Attitudes toward the environment

Participants' mean NEP score on the pretest was 3.52 and 3.43 on the posttest, indicating a slightly ecocentric orientation. Although there was a slight decrease in the mean score, a paired t-test indicated this difference was not significant (Table 1). This suggests that participants' attitudes toward the environment did not change by participating in the project.

3.5 Perceptions of threats of and impacts from flooding on Bogue Banks

The results of Wilcoxon signed-ranks tests comparing participant responses on the pretest and posttest for each item indicate that there was little change in participants' perceptions of threats from flooding on Bogue Banks from the pretest to the posttest, and none of the changes were statistically significant (Table 2).[2] Nearly 90% of participants believed that the flood intensity and frequency on Bogue Banks would increase in the next 50-100 years. Although a large proportion of participants (85%) responded that they were concerned about flooding on Bogue Banks, smaller percentages reported that flooding impacts their physical and/or mental health (20%) or that it impacts them financially (30%). Much larger percentages of respondents felt that flooding has negative economic impacts on Bogue Banks (75%), and negative environmental impacts (70%).

3.6 Perceptions of climate change

The results of Wilcoxon signed-ranks tests comparing participant responses on the pretest and posttest for each item also indicate that there was little change in participants' perceptions of climate change from the pretest to the posttest, and none of the changes were statistically significant (Table 3).[3] Two-thirds of participants responded that the issue of climate change is important to them personally, and 75% reported they were at least "somewhat worried" about climate change. While all participants indicated that they knew at least "a little" about climate change, only 10% reported that they knew "a lot." Regarding the extent of consensus among scientists regarding climate change, 70% reported they felt that "most scientists think climate change is happening," while 20% believe that there is "a lot of disagreement among scientists."

---

[2] Because none of the changes were found to be statistically significant, for clarity, the results described here reflect pretest responses. For the posttest results, see Table 2.

[3] Because none of the changes were found to be statistically significant, for clarity, the results described here reflect pretest responses. For the posttest results, see Table 3.

The majority of participants (70%) reported that they think climate change is “caused mostly by human activities” (as opposed to natural changes in the environment), and most (70%) believe that while humans could reduce climate change, it is unclear at this point if we will do so. Participants were also asked a series of questions regarding the extent to which they believed climate change will be a problem in the future at various scales (i.e., the world, Bogue Banks, you and your family) if nothing is done to reduce it. While 90% reported they felt it is a serious problem (i.e., “somewhat serious” or “very serious”) for the world, smaller percentages reported they felt it is a serious problem for Bogue Banks, or for them and their families (85% and 70%, respectively).

3.7 Perceptions of relationship among flooding, sea-level rise, and climate change

Participants were asked to indicate whether they agreed or disagreed with a series of statements about relationships among flooding on Bogue Banks, SLR, and climate change (Table 4). Comparison of pretest and posttest responses to these items reveals that for each statement, a slightly larger percentage of participants agreed after participating in the project than before. These differences, however, were not found to be statistically significant using Wilcoxon signed-ranks tests.

4. DISCUSSION

Results of the study suggest that participation in the Bogue Banks Coastal Groundwater and Stormwater Watch citizen science project increased knowledge of hydrological concepts. Because the scientific content involved in this study was quite complex (e.g., hydrogeology and the water cycle), this significant increase in knowledge is promising, particularly for water-related fields. Whereas previous studies documenting knowledge increases have examined knowledge changes regarding the biology and behavior of specific species (Brossard et al., 2005; Evans et al., 2005) and species identification (Jordan et al., 2011; Lentijo and Hostetler, 2013), results of this study indicate that participation in citizen science can also increase knowledge of complex physical processes such as groundwater-surface water interactions.

This is also encouraging in that the time the citizen scientists spent on learning hydrologic concepts and how to take water level measurements in wells was relatively short, occurring during a two-hour period. As described above, during the workshop and training session, however, citizen scientists manipulated and interacted with physical groundwater models in small groups, and were led through a related hypothesis-testing process by the authors. Additionally, the citizen scientists received hands-on, one-on-one instruction at one of the installed groundwater wells to ensure proper water level measurement. This experiential approach to learning, followed by the three-month data collection period during which they used and refined their newly acquired measurement skills and reinforced the underlying knowledge, likely contributed to increased scores on the knowledge test.

Similar to Brossard et al. (2005), results of this study do not indicate a significant change in participants’ MATOSS or NEP scores as a result of participating in the citizen science project. The citizen scientists’ mean MATOSS scores (5.85 on pretest, 5.70 on posttest) indicate a positive attitude toward science, and their average NEP scores (3.52 on the pretest and 3.43 on the posttest) indicate an ecocentric orientation. These scores are not surprising, as previous research has demonstrated that science volunteers tend to already hold pro-science and pro-environment beliefs (Price and Lee, 2013). Nevertheless, these results may have important implications for water management in that individuals with an ecocentric orientation may be more likely to support practices that mimic nature, such as the use of rain gardens or wetland restoration, whereas those with an anthropocentric orientation may be more supportive of practices that utilize manmade technological solution, such as installing pumps to lower the water table.

The results of this study also do not indicate significant changes in participants' perceptions of climate change between the pretest and the posttest. When compared with national surveys of the general American public (NSB, 2016; RFF, 2015), however, the study participants reported greater concern for climate change and the associated impacts. For example, while 60% of this study's participants responded that climate change was either "extremely important" or "very important" when asked its importance to them personally, results from a nationally representative survey conducted by the Yale Program on Climate Change Communication found that only 26% of respondents reported the same level of importance (Leiserowitz et al., 2016). Another representative sample study, Stanford University's 2015 National Global Warming Study, found that 45% of respondents indicated that they felt the issue was extremely or very important (RFF, 2015).[4] The participants of the current study also reported being more worried about climate change than a nationally representative sample. While 75% of the current study's participants responded that they were "very worried" or "somewhat worried" about climate change, only 58% of respondents to the Yale study reported the same level of concern (Leiserowitz et al., 2016). It is also interesting to note that a much greater percentage of respondents from this study perceived that most scientists think climate change is happening (70% in this study and 48% in Leiserowitz et al., 2016), and a greater percentage also believe climate change is caused mostly by human activities as opposed to natural environmental changes (70% and 20% in this study, respectively; 53% and 34% in Leiserowitz et al., 2016). Although these data are not directly comparable, they do suggest that those individuals who volunteered for this citizen science project were already highly concerned about climate change and the associated impacts prior to their participation in the study.

The results from this study do not indicate significant changes in participants' perceptions about relationships among flooding on Bogue Banks, SLR, and climate change; however, it should be noted that the authors purposefully did not emphasize the project's applicability to climate change related issues. Because of the political and controversial nature of the topic in North Carolina, and the desire to recruit as many citizen scientist volunteers as possible, the project's foci on characterizing the island's water table, assessing the proportion of land on Bogue Banks impacted by groundwater and marine inundation, and assessing the reliability of water level measurements taken by citizen scientists were emphasized. Additional studies that include specific instruction on the relationships among these phenomena could result in participants' increased understanding.

Importantly, the study results support claims that citizen science plays an important role in linking members of the public to environmental management by exposing them to local

[4] Question wording was slightly different in that the current study asked about perceptions of "climate change," whereas the 2015 National Global Warming Study asked about "global warming."

environmental conditions and increasing awareness of associated problems and the related potential management or policy options (Jordan et al., 2011; McKinley et al., 2017). Discussion among the authors and this study's citizen scientists frequently focused on how the data collected could be transmitted to local policymakers and used to inform management decisions. Additionally, the results highlight the relationship between participation in citizen science projects and the dissemination of information related to the topic of study. During focus group interviews, the majority of study participants described how they used a variety of methods to share their experiences as citizen scientists with friends and family, acquaintances, and fellow community members, including the use of social media as well as more traditional means of communication, such as face-to-face conversation. Many described they discussed not only *what* they were doing (i.e., taking water level measurements), but also *why* they had volunteered to participate.

Results also suggest that the public is interested in participating in hydrologic studies in their communities, but the project must be relevant to the citizen scientists to generate significant interest. The citizen scientists who were the most engaged and active in the project (e.g., took additional measurements beyond what they were asked) indicated during focus groups that they participated because they were personally concerned with the issues of flooding, SLR, and climate change, on both a local and global scale. They felt that by participating in the project, they were able to actively contribute to the scientific and management efforts geared toward increasing understanding of these issues and how to adapt to these environmental changes. Water managers and professional scientists could therefore leverage this resource to meet the challenges of providing long term groundwater data over large spatial scales. However, participants also emphasized the need for scientists to continually engage with citizen scientists and active community members after studies end, and/or between research efforts. They indicated that such continued engagement is critical for citizen scientists and volunteers to feel connected to the researchers, the topic of study, and the long-term implications of their involvement.

5. SUMMARY AND CONCLUSIONS

This paper presents the results of a study that involved citizen scientists in the monitoring of groundwater levels and subsequent characterization of the water table on Bogue Banks, North Carolina. The data and results aim to fill the gap in the literature regarding relationships between citizen science, scientific knowledge, and environmental attitudes in a hydrological context. The results suggest that participation in the citizen science project increased knowledge of hydrological concepts, which is particularly promising since this is the first study to examine this connection in regards to physical processes such as groundwater-surface water interactions. Further these results emphasize the importance of the hands-on, experiential learning opportunities that citizen science projects often provide.

Although significant changes in participants' attitudes toward science or the environment were not found, the results support those from previous studies (e.g., Price and Lee, 2013) which demonstrate that science volunteers tend to already hold pro-science and pro-environment beliefs. These results may have important implications for the types of water management strategies citizen scientists are likely to support. Similarly, while this study's results do not indicate significant changes in participants' perceptions of climate change as a result of participation in the citizen science groundwater study, when the data are compared with those from nationally representative samples, they indicate that those individuals who volunteered for this citizen science project were already highly concerned about climate change and the associated impacts prior to their participation.

The results suggest that citizen science projects can play an important role in increasing participants' knowledge of hydrological concepts, but that long-term participation by volunteers is a significant challenge. The most committed, active, and engaged citizen scientists in this study were those individuals who were concerned about flooding, SLR, and climate change prior to their involvement, and who viewed their participation as a way to make an important contribution to the related scientific and management concerns. Moreover, these individuals expressed strong interest in continuing their engagement with scientists, and helping to translate results into locally-relevant policy recommendations. Water resources scientists and managers interested in developing management solutions supported by local level observations and supported by community members should, therefore, consider using a citizen science approach as a first step toward increasing knowledge of hydrological concepts, increasing awareness of water management issues and solutions, and identifying highly-committed community members interested in cultivating long-term working relationships with researchers.

ACKNOWLEDGEMENTS

The authors thank the citizen scientists who participated in the study, along with the Towns of Emerald Isle, Pine Knoll Shores, and Atlantic Beach. We also thank the Trinity Center in Pine Knoll Shores and the NC Aquarium at Pine Knoll Shores. This work was supported by the National Science Foundation [Grant number 1644650].

REFERENCES

Bernard, R. H., 2011. Research Methods in Anthropology. Qualitative and Quantitative Approaches. 5th edition. Walnut Creek: Alta Mira Press.

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., Wilderman, C.C., 2009. Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. Center for Advancement of Informal Science Education. (CAISE), Washington, DC.

Bonney, R., Phillips, T.B., Ballard, H.L., Enck, J.W., 2016. Can citizen science enhance public understanding of science? Public Understanding of Science 25, 2-16.

Bonney, R., Shirk, J.L., Phillips, T.B., Wiggins, A., Ballard, H.L., Miller-Rushing, A.J., Parrish, J.K., 2014. Next steps for citizen science. Science 343, 1436–1437.

Brossard, D,, Lewenstein, B., Bonney, R., 2005. Scientific knowledge and attitude change: The impact of a citizen science project. International Journal of Science Education 27(9): 1099–1121.

Brudney, J.L., 1999. The effective use of volunteers: best practices for the public sector. Law and Contemporary Problems 62, 219–255.

Buytaert, W., Zulkafli, Z., Grainger, S., Acosta, L., Alemie, T.C., Bastiaensen, J., De Bièvre, B., Bhusal, J., Clark, J., Dewulf, A., Foggin, M., Hannah, D.M., Hergarten, C., Isaeva, A., Karpouzoglou, T., Pandeya, B., Paudel, D., Sharma, K., Steenhuis, T., Tilahun, S., Van Hecken, G., Zhumanova, M., 2014. Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. Frontiers in Earth Science 2, 1-21.

Buytaert, W., Dewulf, A., De Bièvre, B., Clark, J., & Hannah, D. M., 2016. Citizen science for water resources management: toward polycentric monitoring and governance? Journal of Water Resources Planning and Management, 2016, 142(4): 01816002

Cardamone, C., Schawinski, K., Sarzi, M., Bamford, S.P., Bennert, N., Urry, C.M., Lintott, C., Keel, W.C., Parejko, J., Nichol, R.C., Thomas, D., Andreescu, D., Murray, P., Raddick, M.J., Slosar, A., Szalay, A., and VandenBerg, J., 2009. Galaxy Zoo Green Peas: discovery of a class of compact extremely star-forming galaxies. Monthly Notices of the Royal Astronomical Society, 399(3), 1191-1205.

Cifelli, R., N. Doesken, P. Kennedy, L.D. Carey, S.A. Rutledge, C. Gimmestad, and T. Depue., 2005. The community collaborative rain, hail and snow network: Informal education for scientist and citizens. Bulletin of the American Meteorological Society 86, no. 8: 1069–1077.

Crain, C., Cooper, C., Dickinson, J.L., 2014. Citizen science: a tool for integrating studies of human and natural systems. Annual Review of Environment and Resources 39, 641-665.

Community Collaborative Rain, Hail and Snow Network, 2017. Community Collaborative Rain, Hail and Snow Network. http://www.cocorahs.org/, accessed June 30, 2017.

Conrad, C.C., Hilchey, K.G., 2011. A review of citizen science and community-based environmental monitoring: issues and opportunities. Environmental Monitoring and Assessment 176, 273–291.

Cooper, C.B., Dickinson, J., Phillips, T., Bonney, R., 2007. Citizen science as a tool for conservation in residential ecosystems. Ecology and Society, 12, 11.

Cooper, H.M., Fletcher, C.H., Chen, Q., Barbee, M.M., 2013. Sea-level rise vulnerability mapping for adaptation decisions using LiDAR DEMs. Progress in Physical Geography 37: 745-766.

Crall, A., Jordan, R., Holfelder, K., Newman, G., Graham, J., Waller, D., 2012. The impacts of an invasive species citizen science training program on participant attitudes, behavior, and science literacy. Public Understanding of Science 22(6), 745–764.

Cunha, D.G.F., Casali, S.P., de Falco, P.B., Thornhill, I., and Loiselle, S.A., 2017. The contribution of volunteer-based monitoring data to the assessment of harmful phytoplankton blooms in Brazilian urban streams. Science of the Total Environment, 584, 586-594.

Danielsen, F., Jensen, P.M., Burgess, N.D., Altamirano, R., Alviola, P.A., Andrianandrasana, H., Brashares, J.S., Burton, A.C., Coronado, I., Corpuz, N., Enghoff, M., Fjeldsa, J., Funder, M., Holt, S., Hubertz, H., Jensen, A.E., Lewis, R., Massao, J., Mendoza, M.M., Ngaga, Y., Pipper, C.B., Poulsen, M.K., Rueda, R.M., Sam, M.K., Skielboe, T., Sørensen, M., Young, R., 2014. A multicountry assessment of tropical resource monitoring by local communities. Bioscience 64, 236–251.

Dickinson, J.L., Bonney, R., 2012. Citizen science: public collaboration in environmental research. Ithaca, NY: Cornell University Press.

Dickinson, J.L., Shirk, J., Bonter, D., Bonney, R., Crain, R.L., Martin, J., Phillips, T., Purcell, K., 2012. The current state of citizen science as a tool for ecological research and public engagement. Frontiers in Ecology and Environment, 10, 291–297.

Druschke, C. G., and Seltzer, C. E., 2012. Failures of engagement: Lessons learned from a citizen science pilot study. Applied Environmental Education & Communication, 11(3-4), 178-188.

Dunlap, R.E., Van Liere, K.D., 1978. The new environmental paradigm: A proposed measuring instrument and preliminary results. Journal of Environmental Education, 9, 10–19.

Dunlap, R., Van Liere, K., Mertig, A., Jones, R.E., 2000. Measuring endorsement of the new ecological paradigm: A revised NEP scale. Journal of Social Issues 56:425–442.

Dunlap, R.,1992. Trends in public opinion toward environmental issues: 1965–1990. In R. Dunlap and A. Mertig, eds., American environmentalism: the US environmental movement, 1970–1990, pp 89-116. Taylor and Francis, Philadelphia.

EarthEcho Water Challenge, 2017. EarthEcho Water Challenge. http://www.monitorwater.org/, accessed June 30, 2017.

Economic Development Partnership of North Carolina (EDPNC), 2017. Economic impact studies. https://partners.visitnc.com/economic-impact-studies, accessed September 22, 2017.

Evans, C., Abrams, E., Reitsma, R., Roux, K., Salmonsen, L., Marra, P., 2005. The Neighborhood Nestwatch program: participant outcomes of a citizen-science ecological research project. Conservation Biology 19(3), 589–594.

Fuccillo, K.K., Crimmins, T.M., de Rivera, C.E., Elder, T.S., 2015. Assessing accuracy in citizen science-based plant phenology monitoring. International Journal of Biometeorology 59, 917-926.

Green, T.R., Taniguchi, M., Kooi, H., Gurdak, J.J., Allen, D.M., Hiscock, K.M, Treidel, H., Aureli, A., 2011. Beneath the surface of global change: Impacts of climate change on groundwater. Journal of Hydrology 405: 532-560.

Hawcroft, L.J., Milfont, T.L., 2010. The use (and abuse) of the new environmental paradigm scale over the last 30 years: A meta-analysis. Journal of Environmental Psychology 30, 143-158.

Horton, B.P., Rahmstorf, S., Engelhart, S.E., Kemp, A.C., 2014. Expert assessment of sea-level rise by AD 2100 and AD 2300. Quaternary Science Reviews 84: 1-6.

Jevrejeva, S., Moore, J.C, Grinsted, A. 2012. Sea-level projections to AD2500 with a new generation of climate change scenarios. Global and Planetary change 80-81:14-20.

Johnson, M.F., Hannah, C., Acton, L., Popovici, R., Karanth, K.K., Weinthal, E., 2014. Network environmentalism: citizen scientists as agents for environmental advocacy. Global Environmental Change. 29 2014, 235-245.

Jordan, R., Gray, S., Howe, D., Brooks, W., Ehrenfeld, J., 2011. Knowledge gain and behavioral change in citizen-science programs. Conservation Biology 25(6), 1148–1154.

Kar, B., 2016. Citizen science in risk communication in the era of ICT. Concurrency and Computation: Practice and Experience, 28(7), 2005-2013.

Lautier, J.C., 2001. Hydrogeologic framework and ground water conditions in the North Carolina Central Coastal Plain. North Carolina DENR: Division of Water Resources.

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Rosenthal, S. (2016). Climate change in the American mind: March, 2016. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication.

Lentijo, G. M., and Hostetler, M. E., 2013. Effects of a participatory bird census project on knowledge, attitudes and behaviors of coffee farmers in Colombia. Environment, development and sustainability, 15(1), 199-223.

Little, K. E., Hayashi, M., and Liang, S., 2016. Community-Based Groundwater Monitoring Network Using a Citizen-Science Approach. Groundwater, 54(3), 317-324.

Lowry, C. S., and Fienen, M. N., 2013. CrowdHydrology: crowdsourcing hydrologic data and engaging citizen scientists. GroundWater, 51(1), 151-156.

Macknick, J.E., Enders, S.K., 2012. Transboundary forestry and water management in Nicaragua and Honduras: from conflicts to opportunities for cooperation. Journal of Sustainable Forestry 31, 376–395.

Manda, A.K., Sisco, S., Mallinson, D., Griffin, M. 2014 Relative role and extent of marine and groundwater inundation on a dune-dominated barrier island under sea-level rise scenarios, Journal of Hydrologic Processes DOI: 10.1002/hyp.10303.

Mannion, G., Fenwick, A., and Lynch, J., 2013. Place-responsive pedagogy: learning from teachers' experiences of excursions in nature. Environmental Education Research, 19(6), 792-809, DOI: 10.1080/13504622.2012.749980.

Marcinkowski, T, 1993. Assessment in environmental education. In R. J. Wilke, ed., Environmental education teacher resource handbook, pp. 143-197. Corwin Press, Thousand Oaks, California.

Masterson, J.P., Fienen, M.N., Thieler, E.R., Gesch, D.B., Gutierrez, B.T., Plant, N.G., 2013. Effects of sea-level rise on barrier island groundwater system dynamics – ecohydrological implications, Ecohydrology DOI: 10.1002/eco.1442.

Mazzoleni, M., Verlaan, M., Alfonso, L., Monego, M., Norbiato, D., Ferri, M., Solomatine, D.P., 2017. Can assimilation of crowdsourced streamflow observations in hydrological modelling improve flood prediction? Hydrology and Earth System Sciences 21, 839-861.

McCormick, S., 2012. After the cap: risk assessment, citizen science and disaster recovery. Ecology and Society, 17.

McKinley, D.C., Miller-Rushing, A.J., Ballard, H.L., Bonney, R., Brown, H., Cook-Patton, S.C., Evans, D.M., French, R.A., Parrish, J.K., Phillips, T.B., 2017. Citizen science can improve conservation science, natural resource management, and environmental protection. Biological Conservation 208, 15–28.

National Research Council (NRC), 2012. Sea-level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (Board on Earth Sciences and Resources, Ocean Studies Board, 2012).

National Science Board, 1996. Science and technology: Public attitudes and public understanding. In Science and engineering indicators: 1996, Chapter 7. U.S. Government Printing Office, Washington, D.C.

Nicholls, R.J., Cazenave, A., 2010. Sea-level rise and its impact on coastal zones. Science 328:1517-1520.

Percy, J., 1999. Amateur-professional partnership in astronomical research and education. Publications of the Astronomical Society of the Pacific, 111, 1595-1596.

Phillips, T., Bonney, R., Shirk, J.L., 2012. What is our impact? Toward a unified framework for evaluating outcomes of citizen science participation. In J. Dickinson and R. Bonney, eds., Citizen science: Public participation in environmental research. Cornell University Press, Ithaca, NY.

Price, C., Lee, H., 2013. Changes in participants' scientific attitudes and epistemological beliefs during an astronomical citizen science project. Journal of Research in Science Teaching 50(7): 773–801.

Rahmstorf, S., Foster, G., Cazenave, A., 2012. Comparing climate projections to observations up to 2011. Environmental Research Letters 7: 1-5. DOI:10.1088/1748-9326/7/4/044035.

Resources for the Future (RFF), 2015. Global Warming National Poll. http://www.rff.org/files/sharepoint/Documents/RFF-NYTimes-Stanford-global-warming-poll-Jan-2015-topline-part-3.pdf, accessed July 15, 2017.

Rotzoll K., Fletcher C.H., 2012. Assessment of groundwater inundation as a consequence of sea-level rise. Nature Climate Change DOI: 10.1038/NCLIMATE1725.

Sullivan, B.L., Wood, C.L., Iliff, M.J., Bonney, R.E., Fink, D., Kelling, S., 2009. eBird: a citizen-based bird observation network in the biological sciences. Biological Conservation 142, 2282–2292.

Taylor, R.G., Scanlon, B., Doll, P., Rodell. M., va Beek, R., Wada, Y., Longuevergne, L., Leblanc, M., Famigelietti, J.S., Edmunds, M., Konikow, L., Green, T.R., Chen, J., Taniguchi, M., Bierkins, M.F.P., MacDonald, A., Fan, Y., Maxwell, R.M., Yechieli, Y., Gurdak, J.J., Allen, D. M., Shamsudduha, M., Hiscock, K., Yeh, P., J-F Holman, I., Treidel, H., 2013. Ground water and climate change. Nature Climate Change 3: 322-329.

Thomas, M., Richardson, C., Durbridge, R., Fitzpatrick, R., Seaman, R., 2016. Mobilising citizen scientists to monitor rapidly changing acid sulfate soils. Transactions of the Royal Society of South Australia 140, 186-202.

Turner, D., Richter, H., 2011. Wet/dry mapping: using citizen scientists to monitor the extent of perennial surface flow in dry land regions. Environmental Management 47, 497–505.

US Census Bureau, 2017. American Factfinder. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml#, accessed September 22, 2017.

TABLES

	Pretest mean	**Posttest mean**	***t***	***p***
Knowledge test	14.55	16.5	4.33	0.000
MATOSS	5.85	5.7	0.269	0.791
NEP	3.52	3.43	1.2	0.245

Table 1. Comparison (via paired t-tests) of mean scores for knowledge test, MATOSS, and NEP on pretest and posttest (n = 20).

Question	Response	Pretest (%)	Posttest (%)	*p*
In the next 50-100 years, how do you think flood intensity and frequency on Bogue Banks will change?	It will become worse; Bogue Banks will flood more frequently and the flooding will become more significant	89.5	85.0	0.317
	It will stay the same	0.0	5.0	
	It will improve; Bogue Banks will flood less frequently and the flooding will be less significant	10.5	10.0	
I am concerned about flooding on Bogue Banks.	Disagree	5.0	5.0	0.527
	Neither agree nor disagree	10.0	20.0	
	Agree	85.0	75.0	
Flooding impacts my physical and/or mental health.	Disagree	55.0	55.0	0.792
	Neither agree nor disagree	25.0	20.0	
	Agree	20.0	25.0	
Flooding impacts me financially.	Disagree	50.0	40.0	0.450
	Neither agree nor disagree	20.0	25.0	
	Agree	30.0	35.0	
Flooding has negative economic impacts on the Bogue Banks community.	Disagree	5.0	0.0	0.705
	Neither agree nor disagree	20.0	25.0	
	Agree	75.0	75.0	
	Disagree	5.0	5.0	0.705

Flooding has negative environmental impacts on Bogue Banks.	Neither agree nor disagree	25.0	30.0
	Agree	70.0	65.0

Table 2. Comparison (via Wilcoxon signed-ranks tests) of mean ranks on pretest and posttest questions regarding perceptions of threats from flooding on Bogue Banks (n = 20).

Question		**Pretest (%)**	**Posttest (%)**	***p***
How important is the issue of climate change to you personally?	Extremely important	40.0	40.0	0.414
	Very important	20.0	10.0	
	Somewhat important	30.0	40.0	
	Not too important	10.0	10.0	
	Not at all important	0.0	0.0	
How worried are you about climate change?	Very worried	45.0	50.0	0.083
	Somewhat worried	30.0	35.0	
	Not very worried	25.0	15.0	
	Not all all worried	0.0	0.0	
How much do you feel you know about climate change?	A lot	10.0	10.0	0.705
	A moderate amount	60.0	55.0	
	A little	30.0	35.0	
	Nothing	0.0	0.0	
Which is closest to your view?	Most scientists think climate change is happening	70.0	68.4	0.705
	There is a lot of disagreement among scientists	20.0	15.8	
	Most scientists think climate change is not happening	0.0	0.0	

	Don't know enough to say	10.0	15.8	
Assuming climate change is happening, do you think it is:	Caused mostly by human activities	70.0	63.2	0.655
	Caused mostly by natural changes in the environment	20.0	31.6	
	Neither, because climate change isn't happening	0.0	0.0	
	Other	10.0	5.3	
Which is closest to your view?	Humans can reduce climate change, and we are going to do so successfully	10.0	5.6	0.317
	Humans could reduce climate change, but its unclear at this point whether we will do what's needed	70.0	83.3	
	Humans could reduce climate change, but people aren't willing to change their behavior, so we're not going to	10.0	5.6	
	Humans can't reduce climate change, even if it is happening	10.0	5.6	
	Climate change isn't happening	0.0	0.0	
If nothing is done to reduce climate change in the future, how serious of a problem do you think it will be for the world?	Very serious	65.0	52.6	0.564
	Somewhat serious	25.0	42.1	
	Not so serious	10.0	5.3	
	Not serious at all	0.0	0.0	

If nothing is done to reduce climate change in the future, how serious of a problem do you think it will be for Bogue Banks?	Very serious	55.0	57.9	0.180
	Somewhat serious	30.0	36.8	
	Not so serious	15.0	5.3	
	Not serious at all	0.0	0.0	
If nothing is done to reduce climate change in the future, how serious of a problem do you think it will be for you and your family?	Very serious	45.0	36.8	0.257
	Somewhat serious	25.0	47.4	
	Not so serious	25.0	15.8	
	Not serious at all	5.0	0.0	

Table 3. Comparison (via Wilcoxon signed-ranks tests) of mean ranks on pretest and posttest questions regarding perceptions of climate change (n = 20).

Question		**Pretest (%)**	**Posttest (%)**	***p***
Climate change contributes to flooding experienced on Bogue Banks	Disagree	0.0	5.0	0.564
	Not sure	63.2	55.0	
	Agree	36.8	40.0	
	Climate change is not happening	0.0	0.0	
Climate change is related to sea level rise.	Disagree	0.0	0.0	0.157
	Not sure	36.8	25.0	
	Agree	63.2	75.0	
	Climate change is not happening	0.0	0.0	
Sea level rise is related to coastal flooding.	Disagree	0.0	0.0	1.000
	Not sure	16.7	15.8	
	Agree	83.3	84.2	
	Climate change is not happening	0.0	0.0	
Climate change is a threat to Bogue Banks.	Disagree	0.0	0.0	1.000
	Not sure	31.6	30.0	
	Agree	68.4	70.0	
	Climate change is not happening	0.0	0.0	

Table 4. Comparison (via Wilcoxon signed-ranks tests) of mean ranks on pretest and posttest questions regarding perceptions of relationships among flooding, sea level rise, and climate change (n = 20).

SUPPLEMENTARY MATERIAL

Knowledge Question	**% Correct (Pretest)**	**% Correct (Posttest)**
Layers of rock or sediment that transmit groundwater in sufficient quantities to meet demand are called __________.	70.0	95.0
Which of the following reservoirs contains the most water?	55.0	65.0
Which of the following combinations make for the best groundwater reservoir?	40.0	30.0
The boundary between the saturated zone and the unsaturated zone is called the _____________.	80.0	80.0
What percentage of Earth's liquid freshwater is in the form of groundwater?	10.0	30.0
Which of the following is not a factor that will influence infiltration of groundwater?	55.0	95.0
How will the water table of an aquifer close to the earth's surface respond during a wet spring season?	85.0	95.0
When there is a drought, how will the depth to the water table respond over time?	60.0	70.0
What is porosity?	75.0	85.0
What is permeability?	75.0	90.0
Which environmental issue will most commonly affect aquifers in coastal or island areas?	50.0	65.0
What is infiltration?	85.0	85.0
The ___________ describes the path water takes as it moves between the land, the ocean, and the atmosphere.	95.0	90.0
How would sea level rise impact the elevation of the water table in an aquifer near the earth's surface?	75.0	85.0
What is the major source of drinkable water on Bogue Banks?	40.0	65.0
Which of the following removes water from roads and the nearby ground surface?	80.0	80.0

How would paving over a natural area where grass once grew impact stormwater runoff?	85.0	90.0
It is reasonable to expect that stormwater flooding during extreme events, such as hurricanes, ________________.	90.0	95.0
It is reasonable to expect that stormwater flooding during events that occur many times per year, such as summer afternoon thunderstorms, ________________.	70.0	70.0
Which of the following practices can be used to reduce the potential of stormwater flooding?	80.0	95.0
What impact would sea level rise have on stormwater flooding due to seawater beginning to fill stormwater pipes?	100.0	95.0

Table SM1. Correct responses to hydrogeologic concepts knowledge test multiple choice questions (*n* = 20).

Because of science and technology, there will be more opportunities for the next generation.
Science makes our way of life change too fast.
Science and technology are making our lives healthier, easier, and more comfortable.
Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government.
Science is too concerned with theory and speculation to be of much use in making concrete government policy decisions that will affect the way we live.
The benefits of scientific research are greater than any harmful effects.

Table SM2. Items included in the MATOSS scale. Response options were: strongly disagree, disagree, neither agree or disagree, agree, strongly agree.

When humans interfere with nature it often produces disastrous consequences.
Humans have the right to modify the natural environment to suit their needs.
Human ingenuity will insure that we do not make the Earth unlivable.
The Earth has plenty of natural resources if we just learn how to develop them.
Despite our special abilities, humans are still subject to the laws of nature.
The so-called "ecological crisis" facing humankind has been greatly exaggerated.
The Earth is like a spaceship with very limited room and resources.
If things continue on their present course, we will soon experience a major ecological catastrophe.

Table SM3. Items included in the NEP scale. Response options were: strongly disagree, disagree, neither agree or disagree, agree, strongly agree.

Part 1: GSA Poster Session No. 264

Use of Geoscience Data and Information Resources in Education and Research

Technical Session Convener

Christopher A. Badurek

October 24, 2017

TOOLS FOR EDUCATIONAL ACCESS TO SEISMIC DATA AND DATA PRODUCTS

Russ Welti
Michael Hubenthal
John Taber
IRIS Consortium
1200 New York Ave. NW, Suite 400, Washington, DC 20005, russ@iris.washington.edu

Abstract—Student engagement can be increased both by connecting data-rich activities to a student's sense of place, and by addressing newsworthy events such as recent large earthquakes. IRIS has a suite of access and visualization tools that can be used for such engagement, including a set of three tools that allow students to explore global seismicity, visualize seismic wave propagation through the Earth, and use seismic data to determine Earth structure. These tools are linked to a set of online lessons that are designed for use in middle school through intro undergraduate classes.

The **IRIS Earthquake Browser** allows discovery of key aspects of plate tectonics, earthquake locations (in pseudo 3D) and seismicity rates and patterns. IEB quickly displays up to 20,000 seismic events over up to 30 years, making it one of the most responsive, practical ways to visualize historical seismicity in a browser. Maps are bookmark-able and preserve state, meaning IEB map links can be shared or worked into a lesson plan.

The **Global Seismogram Plotter** creates seismic record sections (seismograms of a single earthquake recorded at various distances). A guided exercise is provided where students "discover" the diameter of Earth's outer core. Only visually-clear seismograms are used, and the plots resize to their window, are tablet-friendly and can be printed. Users can include a recording station near a chosen location. Hovering over seismograms provides the exact time of a feature, making it easy for students to pick and compare phase arrival times, key to performing the exercise. A companion, color-coded station map shows station locations and further information. Interacting with stations on this map highlights the corresponding time series on the plot, and vice-a-versa.

Seismic Waves is a web app that links the plotting of a record section with the animated propagation of waves through the Earth and across the Earth's surface. When combined with the Earth structure activity, students gain a much better understanding of how deep Earth structure has been determined.

For each of these tools, the societal impact of earthquakes can provide an additional motivation for students to engage in their exploration.

INTRODUCING THE LARGEST SINGLE OIL FIELD (GREATER ANETH, SOUTHEASTERN UTAH) COLLECTION OF CARBONATE CORES IN THE ROCKY MOUNTAINS— TOOLS FOR EDUCATION AND RESEARCH

Thomas C. Chidsey Jr.
Michael D. Vanden Berg
Peter Nielsen
Utah Geological Survey
1594 W. North Temple Suite 3110, Salt Lake City, UT 84114, michaelvandenberg@utah.gov

Jason Burris
Resolute Energy
Denver, CO 80203

Abstract—The Utah Core Research Center (UCRC) has added to its inventory a significant collection of carbonate cores (as well as thin sections and other formerly proprietary data) taken from wells in Utah's largest oil field, Greater Aneth, in the Paradox Basin. Greater Aneth has produced over 483 million barrels of oil and 441 billion cubic feet of gas from the shallow marine Pennsylvanian (Desmoinesian) Paradox Formation. Limestone and finely crystalline dolomite reservoir rocks are sealed by organic-rich, overlying and underlying shale beds, that are also the source of hydrocarbons in this enormous stratigraphic trap.

The new collection consists of cores from 127 wells totaling about 7.4 km. These cores display a wide variety of characteristics that are critical for understanding carbonate rocks—lithofacies, diagenetic events, petrophysical properties, and sequence stratigraphy (flooding surfaces, stacking patterns, cyclicity, systems tracts). The Aneth cores reveal complex packages of carbonate rocks consisting of (1) oolitic, peloidal, and skeletal grainstone and packstone, (2) phylloid-algal bafflestone, (3) microbial boundstone, and (4) deeper water, crinoid-bearing wackestone and mudstone. These lithotypes are the products of diverse depositional environments including shallow-marine beach and shoal, algal mound, low-energy restricted shelf, open-marine shelf, etc., that produce significant heterogeneity within the Aneth cores. Fractures are relatively common and there is evidence (i.e., hydrothermal dolomite, stylolite swarms, and local brecciation) of minor but important faults that may affect fluid flow. Porosity includes interparticle, shelter, intraparticle, vuggy, moldic, and intercrystalline pore networks, often enhanced by fractures. The original carbonate fabrics are commonly overprinted by dolomitization, early marine cementation, dissolution, and late, post-burial compaction and calcitic or anhydritic filling.

The Aneth core collection is now permanently preserved and publicly available at the UCRC for detailed studies by students, professors, and research organizations, as well as oil companies. The carbonate characteristics of the Paradox Formation observed in the Aneth cores provide outstanding teaching tools for geology students.

STUDENT PERCEPTIONS OF USING THE PALEOBIOLOGY DATABASE (PBDB) TO CONDUCT UNDERGRADUATE RESEARCH

Laura A. Lukes
Stearns Center, Department of Atmospheric, Oceanic, and Earth Sciences
George Mason University, Fairfax, VA 22030

Katherine Ryker
Geography and Geology, Eastern Michigan University
301W Mark Jefferson, Ypsilanti, MI 48197

Camerian Millsaps
Department of Atmospheric, Oceanic, and Earth Sciences
George Mason University, Fairfax, VA 22030

Rowan Lockwood
Department of Geology, The College of William and Mary
PO Box 8795, Williamsburg, VA 23187

Mark Uhen
Department of Atmospheric, Oceanic and Earth Sciences,
George Mason University, Fairfax, VA 22030

Callan Bentley
Geology program, Northern Virginia Community College,
Annandale, VA 22652

Peter J. Berquist
Geology Department, Thomas Nelson Community College,
Hampton, VA 23670

Christian O. George
Department of Biology, High Point University,
One University Parkway, High Point, NC 27268

Abstract—Undergraduate research experiences have been linked to positive student success measures in STEM. With dwindling budgets and growing online programs across 2YC/4YC institutions, large datasets like the Paleobiology Database (PBDB) offer students an opportunity to engage in meaningful research experiences without the high cost associated with lab-based research experiences. As part of an NSF IUSE Grant (DUE-1504588), inquiry-based activities in which students use the PBDB to investigate a variety of phenomena were developed, evaluated, and implemented in introductory level undergraduate geoscience courses across five institutions (three 4YC; two 2YC). Students completed a survey (comprised of OSCAR and SALG instrument elements), as well as a three open-ended question future research project interest reflection.

A preliminary examination of the survey data (n = 224; 46% plan on majoring in science) suggests students are divided between whether they've done or plan to do research (34.9% yes, 30.7% no, 34.4% not sure). The most motivating factors for doing research are working on a specific project (18.3%), gaining experience for career/graduate school (16.0%), and being excited by/loving the work (14.2%). Students described working with the PBDB as being of moderate or much help in increasing their comfort level working with complex ideas and large datasets. A preliminary analysis of student reflections (n=189), yielded four emergent categories for student perceptions of research: research as making observations of distribution patterns; research as making observations of distribution patterns in relation to another variable; research as making observations and formulating hypotheses or making predictions; and other. Reported future interest in conducting research using PBDB varied (yes, no, maybe/non-committal) with emergent themes around interest level in geoscience and/or research in general; the perception of the value of the PBDB dataset; user experience with dataset (e.g., ease of use, likability); and appropriateness of dataset for their research topic/questions. These results suggest that students do have interest in using large datasets to engage in research, but more explicit instruction around conducting research is needed to ensure quality experience.

GENUINE OR REPRODUCTION: A COMPARISON OF PHOTOGRAMMETRY AND 3D SCANNING TECHNIQUES

Erica Anne Loughner
Jordan C. Oldham
Geology, Cedarville University,
251 N. Main St. #3318, Cedarville, OH 45314, eloughner@cedarville.edu

Abstract—Advancements in technology associated with 3D imaging for both print and digital applications are transforming many aspects of geology. Museums, researchers, and educators are now using 3D models to depict and reproduce fossils, minerals, and crystals for study, thereby reducing the risk of damage to valuable original specimens. This project evaluates readily-available digital imaging methods to determine the process for obtaining the best quality 3D models for printing. The criteria included cost effectiveness, quality of digital images and prints, length of time of each method, and availability of software and hardware. Several methods utilize smartphone cameras or standalone digital cameras to take overlapping photos of an entire specimen (fossil or mineral). Then, a variety of digital 3D models were created using multiple image-manipulation software programs (AgiSoft, and Autodesk ReMake). The digital models were then sent to a 3D printer for printing. Another method made use of a 3D-scanner (NextEngine 3D Scanner) rather than static images from cameras -- a specimen was placed on a rotating pedestal and laser scanners swept across the specimen as cameras within the scanning unit determined how much distortion was created. The scanner data was imported into software (ScanStudio 3D) that then created a point cloud of the specimen. From the point cloud a 3D model was created for viewing on the computer, or, ultimately, for 3D printing. For this study the quality of the digital images and printed reproductions that were derived from the multiple methods were compared. In the final analysis of the various 3D models (printed and digital) the determination was made that the 3D scanning process produced the better quality facsimiles. However, under the pre-defined criteria, the 3D scanning method was not cost effective, and the process was very time consuming. While the methods that involve making point clouds from the overlapping static images did not produce the best quality 3D models (printed and digital), these methods were cost effective, the processes were easy to learn and were not as time consuming, and the software and hardware were more readily available.

CONNECTING THE DOTS WITH DATA: LEARNING WITH GEOSCIENCE DATA

Cynthia L. Prosser
Science Collections - Science Library, University of Georgia,
Athens, GA 30602, cprosser@uga.edu

Monica Pereira
Collections, California State University Channel Islands,
P.O. 212, Camarillo, CA 93011-0212

Abstract—Visualizing and reading data have become key information literacy skills. The finding and use of appropriate data underpins a variety of learning and research opportunities for a range of participants through formal and informal ventures. Learning how data is collected, stored, and manipulated allows learners to gain intimate and nuanced perspectives of research objectives, and uncovers fresh connections. Directed projects illustrate the potential for creating data, or using publicly available data to teach, learn, and share the interconnectivity among ostensibly disparate elements. These opportunities can occur formally or informally, in youth or adulthood, personally or professionally, and cross a spectrum of subjects and topics. They can include citizen science projects, school projects whether in elementary school and high school or through research associated with an advanced degree, community projects or throughout a professional career. The type of geoscience data used can be as basic as the use of elevation and bathymetric data to enhance mathematics skills. More complex projects may use: data collection through NASA's GLOBE Program for the 2017 eclipse, census data to chart historical or socioeconomic change in an area, or address larger scale issues such as climate change. These kinds of projects demonstrate how crucial data is to understand the complexity of our environment, and change attitudes.

INTRODUCTION

The world is made up of data and people interact with data on a daily basis as they go about their lives. Being able to understand and make sense of that data, i.e. the world around them, is crucial for successfully navigating life. Understanding what is and isn't possible in the real world is a part of spatial literacy. Spatial literacy is the kind of reasoning that sees: all space as interconnected, interactions occur between and among spaces, implications of the connections and interactions (Edelson, 2014).

With the rise of smaller and more powerful electronics such as laptop computers, tablets, and smartphones, people have become increasing able to use these resources on a nearly daily basis. GPS units or mobile apps allow real world application of data at the basic level. Simply being able to access information remotely, whether for professional reasons or leisure, anywhere, at any time, has changed how people interact with information. These resources have led to a rise in citizen science projects (Pereira and Prosser, 2017).

DATA IN CITIZEN SCIENCE

Direct interactions with data, through citizen science projects, range from single-day activities to longer term projects that can continue for years. Capitalizing on the public's interest about natural phenomena can lead to significant learning in the subject as well as a solid and grounded knowledge in that area. One outstanding example is the Indonesian tsunami in 2004 (McDougall, 2005). Other examples include data collection through NASA's GLOBE Program for the 2017 eclipse, census data to chart historical or socioeconomic change in an area, and wide-spread weather observations to address larger scale issues such as climate change. It is important to remember that for the citizen scientist, the primary goal is learning and participating in the project and that the data collection, itself, is of secondary importance. Conversely for the scientist, the data collection is of primary importance (Jollymore, et al., 2017). By participating in data collection, citizen scientists gain familiarity with, and appreciation of, the scientific process. As one is involved with the observations, measurements, and collection of information in the form of separate data points and observations, one becomes aware of the variations and impacts of those individual pieces of information that make up the greater whole (Steel et al., 2005; Jollymore, et al., 2017; Pereira and Prosser, 2017). Never the less, it is important to plainly communicate to participants how their data collection has added to and impacted the goals of the scientific project (Jollymore, et al., 2017).

Scientists are increasingly using citizen scientist projects to expand the reach and scope of their investigations as well as accomplishing engagement and educational goals; the increasing popularity of citizen science activities has been demonstrated by its increasing prevalence in the scientific literature (Jollymore, et al., 2017; Pereira and Prosser, 2017).

DATA IN PROBLEM SOLVING

The connection between data and problem-solving is a natural progression. Without knowing what the individual parts of a question are, a satisfactory solution cannot be found. Studies have examined the effect on citizen science participants and whether their involvement increases their basic understanding of science and/or the scientific process (Jollymore, et al., 2017). Results can be mixed on whether this effect always leads to an increased understanding; but an increased understanding shows the importance of the educational goals inherent in many citizen science projects (Jollymore, et al., 2017).

Once data is collected for a project it can be used not only for the original project but also subsequent projects. Educational uses of data need the data to be accessible. Accessibility includes: the data and data products need to be easily located, the data should be presented in a way that is understandable by a nonscientist, data sources should be integrated in useful data products, the data should be accompanied by an explanation with examples of the types of questions scientists ask, and the metadata should be provided (McDougall, 2005). Data can be used to visualize impacts and outcomes of natural forces. Public environmental literacy can be increased through allowing the public *"to observe environmental processes and long-term trends happening in their backyard and subsequently demonstrating the link between these processes and global processes"* (McDougall et al., 2005, p.7). Participants in local citizen science projects can have a unique advantage over formal scientists in that they are very familiar with and have insider knowledge of the location. Local participants know the context and concerns of the area and as such may be able to capture information regarding short timescale events (Jollymore, et al., 2017). However, the absence of a two-way dialogue between scientists and citizen participants can hinder the meaningful delivery of goals embedded in citizen science projects (Jollymore, et al., 2017).

DATA IN DAILY LIFE

Other aspects of interacting with data occur throughout daily life. These can include school projects, whether in elementary school and high school or through research associated with an advanced degree, community projects, or throughout a professional career. Problem solving, whether in formal schooling as a specific exercise or the type that arises in everyday life, reinforce connections between data, measurement, and graphic representations illustrating complex scientific ideas (Kastens, 2015; Kochevar, 2015). Training students, whether formally or informally, to readily use data for solving complex problems is not easy. It can be a long and complicated process (Kastens, 2015). However, teaching students to build on experience with smaller, less complex, student collected data will give them the skills necessary to tackle larger, more complex, and professionally collected data (Kastens, 2015; Kochevar, 2015). First-hand experience in the scientific process promotes engagement. Classroom activities that use real and/or near real-time data help to build a student's understanding and knowledge of the environment and Earth processes around them as well as to develop their overall scientific literacy (McDougall, 2005; Kochevar, 2015). Current students may not yet have attained the necessary suite of skills surrounding data (re: quality, safety, and ethics) that professional researchers value (Kastens, 2015).

As laypeople learn of the results of scientific research they are better informed to interact with their public officials. Data collected by scientists impact everyone (Jollymore, et al., 2017). There are various ways people can learn about local scientific issues, e.g. newspapers, the radio, TV, and the internet. While the impact of these media on a person's knowledge can be significant, the results of this knowledge can be mixed. There is an enormous range of sites on the web and a wide variety of newspapers as well as TV and radio stations available to the public. Whether any individual site presents good, solid scientific information may be questionable (Larsen, 2004; Steel et al., 2005) and sites must be carefully evaluated (Larsen, 2004). While there are sites that provide more misinformation than information, there are excellent resources of information provided by colleges and universities, the Federal Government, other government agencies, and independent research institutes (Steel, et al., 2005). Although increased coverage in the media would seem to imply a better understanding of scientific issues by the public, it has been determined that people are not likely to change their opinion until they have experienced the impact of the problem first hand (Steel, et al., 2005). Resources must be critically considered before acceptance and use, especially with respect to the bias of the authors or creators (Larsen, 2004; Steel, et al., 2005).

In addition to media outlets, there are further aspects to consider when using information. Is the item a part of the scholarly record or the popular press? Data and information can be found within a variety of formats including: books, book chapters, journal articles, conference proceedings, maps, and government documents (which can be comprised of any of the above) (Larsen, 2004).

Ultimately, lifelong learning begins with curiosity about nature. McDougall et al., (2005, p.2) comment that "*The general public has an inherent curiosity about rare and spectacular environmental phenomena. Also, if the phenomena is (sic) impacting their lives, they are highly motivated to seek information."* This type of curiosity can be encouraged through innovative teaching methods and strategies as well as practical assignments (Lo, et al., 2002; Larsen, 2004; Lee and Guertin, 2012).

SPATIAL LITERACY

Spatial literacy depends on the connections, interactions, and implications represented by data. Developing spatial literacy can be accomplished through a variety of methods. These methods can be as simple as playing appropriate games, participating in various research projects, or more formal learning using various types of scientific data. Lee and Guertin (2012) of Penn State developed a game, *The Amazing Race*, to assess student's knowledge of important locations around the world. Through this game, students were to identify, on a global map, the locations of various sites around the world that are well known and/or geologically important. While the authors acknowledge this is a type of surface learning as opposed to deep learning, the students were able to learn the placement of these localities by playing the game. One outcome of particular note was that a lack of basic prior knowledge would impede the acquiring of new knowledge (Lee and Guertin, 2012). Geoscience as well as other types of environmental data can be used to enhance basic learning e.g. using elevation and bathymetric data to enhance mathematics skills. Another way data can be incorporated into more formal learning is through upper level writing classes at the college level. Students in this type of class, work with and become familiar with the type of resources available to researchers (Larsen, 2004). These types of resources can be learned about, both in the academic classroom and the library (Larsen, 2004; DeBose et al., 2017). Yet another possibility invoking using data in formal learning is through the implementation of a computer-based interactive Learning Support System (LSS). In one case, an online environment was created to emphasize experiential learning. The students go into the field, collect data, and upon their return to lab, enter the data into the system. In the lab they learn about the various aspects of the scientific method, formulate a hypothesis, and test the hypothesis by working with the collected data within the LSS (Lo, et al., 2002). The collected data subsequently became a part of long-term ecological database for the area (Lo, et al., 2002).

At the professional level learning still continues. Researchers value: data quality, data safety, and data ethics. Quality data can be found in research institutions (Steel, et al., 2005; Kastens, 2015). Workshops on data management have been created to teach researchers how to manage the data collected during their investigations (Helbig, 2016; DeBose et al., 2017). The most successful workshops occur when the participants have a general understanding of research data management (Helbig, 2016). Thus, it is apparent the learning continues at all levels.

DATA IN THE COMMUNITY

Professional use of geoscience data includes the analysis of community needs as well as helping to create policy. Scientists can be the most informed individuals on scientific ideas as well as being able to effectively communicate those ideas to people, both inside and outside the scientific field (Wolters, et al., 2016). It is imperative that the science, through its researchers, inform all interested parties that any goals (environmental, regulatory, community, etc.) are carefully considered and are ultimately attainable (Frid, et al., 2006). Advocacy becomes a difficult point for researchers. Scientists do not want to lose any credibility through appearing to advocate for one position over another. Advocacy must be clearly identified. Research scientists can participate in data interpretation and contextualization. Their recommendations can aid in comprehensive resource policy decisions. However, in order to maintain their credibility, the recommendations must be carefully managed to maintain enough distance to avoid being perceived as an advocate for one position or another (Wolters, et al., 2016). The data can lead to diverse conclusions regarding a given issue. It is important to remember that cutting edge science, and even science in general, is fundamentally dynamic so there may not be one, clear, obvious answer to any given policy decision (Frid, et al., 2006).

CONCLUSION

Revisiting old data and reanalyzing it is another way to gain new information. New methods of analysis can shed new insights on old questions (Helbig, 2016). These kinds of projects demonstrate how crucial data is to understand the complexity of our environment, and to change attitudes.

REFERENCES

DeBose, K. G., Haugen, I., and Miller, R. K. (2017). Information literacy instruction programs: supporting the College of Agriculture and Life Sciences Community at Virginia Tech, *Library Trends*, 65(3), 316 – 338.

Edelson, D. C. (2014) Geo-literacy: Preparation for far-reaching decisions. Retrieved from: https://www.nationalgeographic.org/news/geo-literacy-preparation-far-reaching-decisions/

Frid, C. L., Paramor, O. A., and Scott, C. L. (2006). Ecosystem-based management of fisheries: is science limiting? *ICES Journal of Marine Science*, (9), 1567.

Helbig, K. (2016). Research data management training for geographers: first impressions, *International Journal of Geo-Information,* 5, 40, doi: 10.3390/ijgi5040040

Kastens, K. (2015) Teaching and learning with geoscience data, Presentation at Summit on Undergraduate Geoscience Education, January 8, 2015, Austin TX.

Jollymore, A., Haines, M. J., Satterfield, T., and Johnson, M. S. (2017). Citizen science for water quality monitoring: Data implications of citizen perspectives. *Journal of Environmental Management*, *200* 456-467.

Kochevar, R. E., Krumhansl, R., Krumhansl, K., Peach, C. L., Bardar, E., Louie, J., DeLisi, J. (2015). Inspiring Future Marine and Data Scientists Through the Lure of Ocean Tracks. *Marine Technology Society Journal, 49*(4), 64-75.

Larsen, S. (2004). Preparing geology undergraduates for the present and future: bibliographic instruction and information literacy as core elements in a technical writing class, *GEOINFORMATICS: Proceedings of the Geoscience Information Society,* 39, 17-19.

Lee, T., and Guertin, L. (2012). Building an education game with the Google Earth application programming interface to enhance geographic literacy. *Special Paper - Geological Society of America*, *492*, 395-401. doi:10.1130/2012.2492(29).

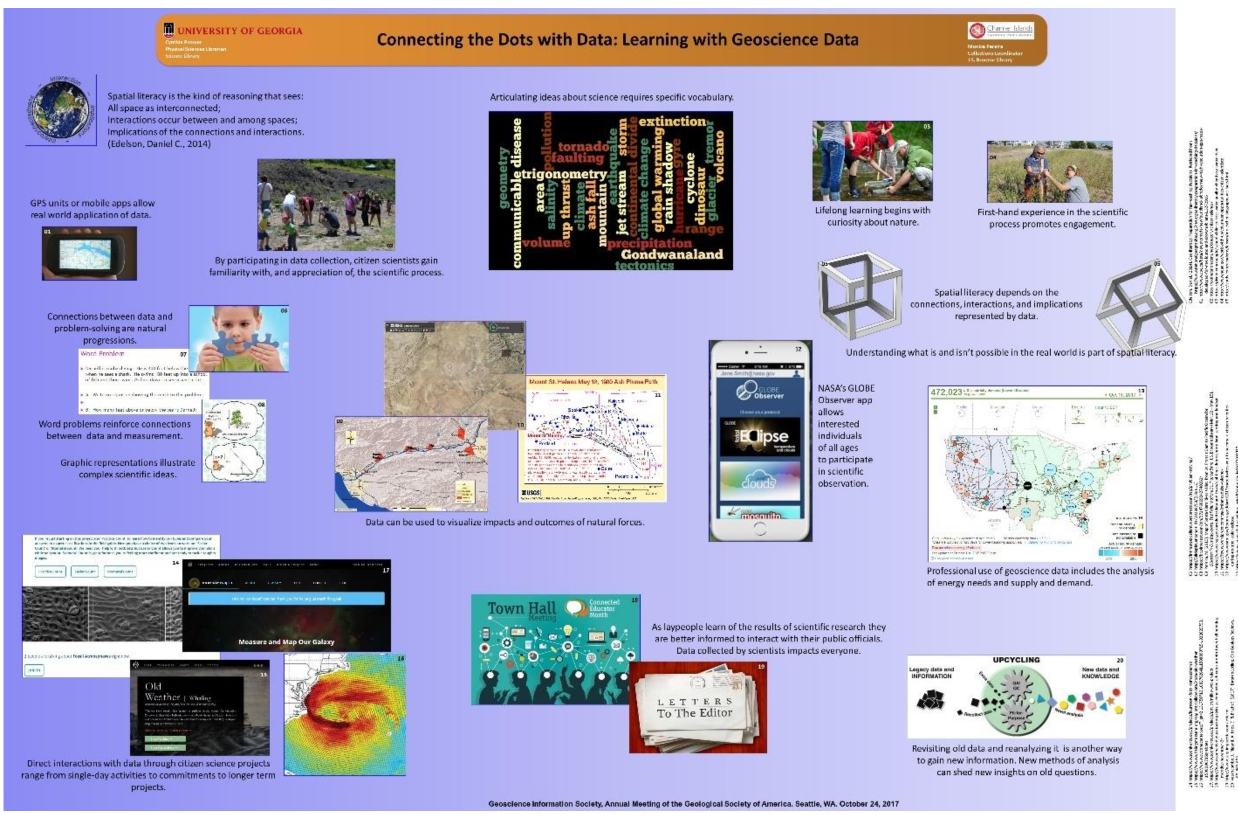
Lo, C. P., Affolter, J. M. and Reeves, T.R. (2002) Building environmental literacy through participation in GIS and multimedia assisted field research, *Journal of Geography,* 101, 10 – 19.

McDougall, C., Ibanez, A., and White, S. (2005) Utilizing Data from NOAA's Observing Systems to achieve environmental literacy, *Proceedings of OCEANS 2005 MTS/IEEE, OCEANS, 2005. Proceedings of MTS/IEEE, OCEANS 2005*, 1. doi:10.1109/OCEANS.2005.1640116

Pereira, M. and Prosser, C. (2017) Harnessing data with the citizen scientist *2013, 2014, 2015, & 2016: Four Years of Earth Science Information: Exploring Data, Access, and More*, Proceedings of the Geoscience Information Society, 44, 78 - 84.

Steel, B. S., Smith, C., Opsommer, L., Curiel, S., and Warner-Steel, R. (2005). Public ocean literacy in the United States. *OCEAN AND COASTAL MANAGEMENT*, (2). 97.

Wolters, E. A., Steel, B. S., Lach, D., and Kloepfer, D. (2016). What is the best available science? A comparison of marine scientists, managers, and interest groups in the United States. *Ocean and Coastal Management*, *122*95-102. doi:10.1016/j.ocecoaman.2016.01.011



TRENDS IN OPEN EDUCATIONAL RESOURCES IN THE EARTH SCIENCES: EMERGING ROLES FOR THE ACADEMIC LIBRARY

Samantha Teplitzky
UC Berkeley Library, Earth Sciences & Map Library,
50 McCone Hall, Berkeley, CA 94720

Mea Warren
University of Houston Library,
4333 University Drive, Room 108, Houston, TX 77204-2000, mewarren@uh.edu

Abstract—Students have cited the cost of textbooks and other class materials as a barrier to majoring in certain subjects, often in the sciences where costs are most prohibitive. In an effort to curb the high cost of textbooks on students, many universities are investigating the promotion and adoption of Open Educational Resources (OERs). These are free or low-cost materials such as textbooks or other resources that can be used as class material. This poster will examine the state of OERs in the Earth Sciences and give suggestions for adoption of OERs. Many institutions have concerns about the quality of materials for educational purposes and also encounter a lack of support for widespread adoption of many open resource materials. However, we will highlight a number of sources for high quality materials, many of which have already been adopted for use. There are also ways to use less expensive resources in your class without sacrificing quality, such as using popular geology books that cover core concepts instead of the typical textbook. This poster will examine current trends in OERs and present case studies demonstrating the use of OERs in the Earth Sciences at institutions who have supported the practice, as well as the possibilities for future use at other institutions with currently available resources. Survey data of librarians involved in OER efforts will be presented, as well as ideas of how your library can help you in adopting OERs in your classroom through licensing, support, and promotion.

WE HAVE A LESSON PLAN FOR THAT! TRAINING THE NEXT GENERATION OF SCIENTISTS TO BE BETTER EDUCATORS THROUGH PUBLIC INTERACTION AND LESSON PLAN DEVELOPMENT

Kari A. Prassack
National Park Service, Hagerman Fossil Beds National Monument,
221 North State Street, PO Box 570, Hagerman, ID 83332, kari_prassack@nps.gov

Abstract—Effective communication is a crucial skill for scientists, especially when it comes to relaying the importance of their work to an increasingly skeptical public. Unfortunately, scientists often struggle in their ability to engage non-scientists about the importance of their work. Recognizing this growing disconnect between scientist and the public, Hagerman Fossil Beds National Monument is training the next generation of scientists in the fields of interpretation, science communication, and education outreach. Recent college graduates with science degrees are hired through the Geoscientists in the Parks (GIP) internship program and work to develop high school lesson plans that utilize data from the fields of geology, paleontology, ecology, and climate science. Studies have shown that students are more engaged and can better relate to and understand new concepts and information when presented with lessons that are based on "real-world" data sets and scenarios. These lesson plans follow Common Core and Next Generation Science Standards and are made available online through the National Park Service Education Portal for teachers across the country to use in their classrooms. The goal is to equip young scientists with the communicative skills needed to succeed while helping to inspire the next generation to be actively knowledgeable citizen scientists.

GEOCORPS GIS INTERNSHIPS WITH THE NATIONAL FOREST SERVICE IN ALABAMA

Claudia Kristina Rossavik
Geology, Western Washington University,
516 High St, Bellingham, WA 98225, rossavikk@gmail.com

Stanley Glover
USDA- Forest Service, National Forests in Alabama,
2946 Chestnut Street, Montgomery, AL 36107

Abstract—I will be presenting my experience as a Geospatial Support Assistant during my GeoCorps internship with the USDA Forest Service's National Forests in Alabama from May to August 2017. The USDA Forest Service uses ArcGIS as a tool to enhance the data it collects as part of its mission to manage and restore our Nation's National Grasslands and Forests. As a Geospatial intern, I mapped the extent of and the remaining restoration opportunities across the National Forests in Alabama. I created map products which were used in decision making within the Forest Service and for public use. Additionally, I prepared geospatial data which was incorporated into the National Resource Manager's dataset by my supervisor, Stanley Glover. The National Resource Manager is a Forest Service organization responsible for coordinating FS data. A focus of the National Forests in Alabama is the restoration of the Long Leaf Pine and its ecosystem. The goals and science of active management which the National Forests of Alabama adhere to will be presented along with the ways in which data stewardship of geospatial data is used to reach those goals. Mentioned in this presentation will be some of the opportunities I had to learn more about the National Forests in Alabama which included visits and experiences in examining invasive plant species, participating in an event for the release of 27 Indigo Snakes, coring trees, and collecting soil measurements using soil penetrometers.

USING ESRI ONLINE APPLICATIONS AND GEOSCIENCE DATA IN CAPSTONE PROJECTS FOR HONORS GEOLOGY: 2Y COLLEGE

C. Dianne Phillips
Science and Math, NorthWest Arkansas Community College,
One College Drive, Bentonville, AR 72712, dphillips@nwacc.edu

Nathan Sorey
Geosciences, University of Arkansas,
340 N. Campus Drive, 216 Gearhart Hall, Fayetteville, AR 72703

Abstract—Adult learners in an honors geology class engaged in a capstone collaborative project, which integrated the use of ESRI online applications and field data collection, to produce thematic maps of their field trip experiences. These experiences included virtual data collection and visualization as well as in field data observations. The projects included: 1) the use of online, live data streams to monitor active volcanoes for a semester long volcano project, and 2) mapping the observed correlation of Mississippian karst units (Boone Formation) exposed in both NW Arkansas and extreme NE Oklahoma. The Boone Formation serves as a subsurface aquifer in the Picher, OK, Tar Creek Superfund Site of NE Oklahoma and is exposed as karst features in the surface in extreme NW Arkansas. Students collected data online and in the field to generate final presentations, report s and maps, as products of their learning experience. View story map here: http://arcg.is/uiqPy

ESRI apps which were integrated into the learning experience were: 1) ArcGIS online, 2) Collector, and 3) Story Maps. None of the learners in the Introduction to Geology Honors course were required to have GIST (geospatial information science and technology) courses or training to use these online resources for their projects.

STRATEGIES FOR CREATING STANDARDIZED GIS-BASED DIGITAL GEOLOGIC MAPS FOR GEOSCIENCE FIELD EXERCISES

Erin N. Dimaggio
Department of Geosciences, Pennsylvania State University,
University Park, PA 16802, dimaggio@psu.edu

Roman A. Dibiase
Earth and Environmental Systems Institute, Pennsylvania State University,
University Park, PA 16802

Abstract—Modern geologic maps are often created and published using Geographic Information Systems (GIS). In many geology departments an advanced field course serves as a capstone course for upper-level students, therefore it is important to keep data collection and production methods current and aligned with changing technology. However, integrating GIS into geoscience field schools presents challenges, as the need to teach geologic concepts leaves little time for subsequent data integration and map production, and students typically have limited backgrounds in GIS. Here we present an approach to teaching field exercises that combines traditional and digital data collection methods with a simplified and standardized GIS-based data integration, production, and presentation workflow. The primary goal of this effort is to efficiently teach upper-level undergraduate students how to produce professional geologic maps and cross-sections to aid in geologic interpretation, and in turn gain a valuable technical skill set.

We used the USGS National Cooperative Geologic Mapping Program (NCGMP) standard format for geologic map publications as our database structure within the ESRI ArcGIS software program and a custom cross-section toolbar designed for ArcGIS. Cartographic representations and symbology for all point and line data types follow Federal Geographic Data Committee (FGDC) national standards to ensure that the appearance and database content are consistent. We simplified the NCGMP09 database, cartographic representations, and the cross-section toolbar and customized ArcMap data and layout views. We tested this workflow during the 2017 Pennsylvania State University Geosciences Field School in the western US. Despite the steep learning curve inherent to working with ArcGIS, even students with little or no GIS background produced high-quality maps. The database and ArcGIS projects can be easily adapted to other field schools or research projects with only minor modifications.

A GIS-BASED METHOD FOR PREDICTING SOIL EROSION ON MOUNTAIN BIKING TRAILS

Todd Rayne
Samuel Bernstein
David A. Tewksbury
Geosciences Department, Hamilton College
198 College Hill Road, Clinton, NY 13323, trayne@hamilton.edu

Abstract—As the popularity of mountain biking increases, concerns about trail degradation from soil erosion has increased, particularly on informal trails constructed with little or no erosion controls. We mapped a network of informal mountain biking trails in central New York State and used a GIS-based method that uses the Revised Universal Soil Loss Equation (RUSLE) with high-resolution elevation data to quantify potential soil erosion. We found that although RUSLE was created for large-scale agricultural fields, our method was useful for predicting potential soil erosion on the narrow biking trails. We tested our results by selecting random locations in three different erodibility categories and determining the actual soil loss by measuring the cross-sectional area of the eroded trail. We found good agreement between potential erosion rates that we identified using the GIS-based method and actual erosion from measurements of the cross-sectional areas of eroded soil. Furthermore, visual inspection of trail segments that our model showed to be highly erodible were clearly more degraded than trail segments with low calculated erodibility. Our method overestimated erodibility on trails that were ridden only in a downhill direction and failed to identify topographic lows where standing water accumulates and the resulting disturbance of the soil is severe. The method is relatively easy to use and can be used to manage and protect existing trails or as a planning tool to route trails away from susceptible areas before construction.

GEOSTATISTICAL ANALYSIS: COMBINING CATEGORICAL GEOLOGIC AND CULTURAL DATA TO CREATE A PREDICTABILITY MODEL FOR ARCHAEOLOGICAL SENSITIVITY

Taylor Grysen
Dawn Lawrence
Bureau of Land Management, Pinedale Field Office,
Pinedale, WY 82941, tgrysen@blm.gov

Abstract—Being able to create areas on which to focus a cultural resources inventory is essential in the Bureau of Land Management (BLM) to better expedite the archaeological process. Cultural inventories must be conducted before any BLM project can start or be renewed whether it is related to a new oil and gas project, range grazing permits, or any other surface disturbing event. The BLM office in Pinedale, WY is in a rich cultural area due to its location at the heart of historic westward expansion on the Oregon-California Trail System and within a landscape heavily used by prehistoric Native Americans.

In creating the probability model categorical data was categorized by, low likelihood features were determined by the archaeologist to be slopes greater than 15 degrees, clay flat areas, extremely rocky or shallow soils, and any pre-existing disturbance. Moderate likelihood features were areas within 100 feet of any intermittent/dry drainage or within 100 feet of a basin or playa environment. High likelihood features were sandy soil environments, areas within a quarter mile of perennial water, 100 feet around ridges/outcrops, and 100 feet around a previously-identified cultural site. Taking this process one-step further by quantifying the likelihoods and running geostatistical models within ArcMap, what was once a probability model is now a predictive model; an advanced practice not commonly used.

The benefit of having a predictive model versus a probability model is the increased spatial refinement and quantified likelihood of a site. Probability models are a generalized likelihood of an event, but do not take into account the statistical hierarchy of how likely a site will be.

A FORMATIVE EVALUATION OF DIGITAL TECHNOLOGY GEOSCIENCE EDUCATION TOOLS

John Paul Asija
Helen Crompton
Yi-Ching Lin
Old Dominion University,
Norfolk, VA 23529, jasij001@odu.edu

Kristen St. John
Geology and Environmental Science, James Madison University,
Harrisonburg, VA 22807

Abstract—Technology is driving a shift from the traditional lecture approach to a learner-centric model of teaching in higher education (Wright, 2011). In a survey of 783 students in an introductory geology class, only 7% were considering majoring in geosciences (Hoisch and Bowie, 2010). Digital technologies may be a way of interesting students in geoscience learning. The purpose of this research is to evaluate the effectiveness of a Google Earth-based teaching tool developed earlier by the researchers in the same NSF-funded grant. The tool is focused on marine sediment and uses Google Earth. It can be found at GEODE.net.

We have conducted a formative evaluation of the digital tool as three parts: 1) an expert review, 2) one-to-one student evaluations, and 3) a field test. The expert reviews were conducted by both geoscience and education experts. The one-to-one student evaluations were performed at a university in the south eastern United States. Data collection for the one-to-one evaluation used the think aloud protocol. The field test was be performed at the same university in a large class of 200 students.

The formative evaluation has been used to evaluate how well the tools meet the stated learning goals. The evaluation additionally measures ease of use, student engagement, and student performance when using the new lessons compared to traditional lessons.

DEVELOPING A FRAMEWORK FOR FLYOVER COUNTY TO SUPPLEMENT DATA IN QUERIED REPOSITORIES

Marissa M. Mahoney
Department of Earth Sciences, University of Minnesota,
Minneapolis, MN 55455, mahon297@umn.edu

Shane Loeffler
LacCore/CSDCO, Department of Earth Sciences, University of Minnesota,
500 Pillsbury Dr. SE, Minneapolis, MN 55455

David M. Birlenbach
Department of Earth Sciences, University of Minnesota,
Minneapolis, MN 55455

Amy Myrbo
LacCore/CSDCO, Department of Earth Sciences, University of Minnesota,
500 Pillsbury Dr. SE, Minneapolis, MN 55455

Abstract—Flyover Country is an NSF-funded geoscience mobile app that serves as a tool for travelers to understand the landscape that they fly over, drive across, and hike through. The app loads geological points of interest along a user's travel path from databases such as Macrostrat, Paleobiology Database (PBDB), Wikipedia, and more. Device GPS allows the app to show the user's position relative to the displayed features. Large geologic features are often identified only with single point coordinates, resulting in users' paths missing information for major regions that they are traveling through. For example, the Wikipedia article on the Rocky Mountains is geolocated near Aspen, CO, so even though the Rockies occupy nearly 1 million km^2, the user would only see the article if their flight path passed within 300 km of Aspen. A GeoJSON repository modified from Natural Earth (NaturalEarthData.com) has been added to the app's queried databases so that mountain ranges, physiographic provinces, lakes, coasts, deltas, deserts, islands, and other features now display as polygons instead of single points. Using a polygon ensures that users passing through or over a region have access to the corresponding Wikipedia article. To further engage and educate the user, a script was written to query Wikipedia articles about the regions in the Natural Earth set. This method can also be modified to identify items from other databases that lack articles. For example, linking search terms with Wikipedia articles could be used to identify which fossil taxa stored in the PBDB or Neotoma do not have Wikipedia articles. These missing articles provide an opportunity for educators and researchers to address these gaps and actively contribute to information resources. By engaging the larger community and highlighting missing information, geoscientists will be able to better contextualize smaller or lesser known geologic points of interest, regions, and fossil taxa.

DISCOVER US GEOLOGICAL SURVEY GLOBAL FIDUCIALS DATA – HIGH RESOLUTION IMAGERY FOR GEOSPATIAL RESEARCH, OBSERVING EARTH PROCESSES, OUTREACH, AND EDUCATION

Bruce F. Molnia
U.S. Geological Survey, National Civil Applications Center
562 National Center, 12201 Sunrise Valley Drive, Reston, VA 20192, bmolnia@usgs.gov

Abstract—The existence of US Geological Survey (USGS) Global Fiducials data is an unintended, well-kept secret. The purpose of this presentation is to attempt to overcome this secrecy by providing a thorough introduction to Global Fiducials data, its characteristics, its history, and its availability. Since the mid-1990s, more than 500 locations, each termed a 'Fiducial Site', have been systematically and repeatedly imaged with U.S. National Imagery Systems (USNIS) space-based electro-optical (EO) sensors. Each location was selected for long-term monitoring based on its history, susceptibilities, and environmental values. Monitoring dynamic Earth surface change and developing a comprehensive understanding of sensitive areas of our planet are fundamental goals of the Fiducial Site investigation strategy.

Since 2008, imagery from more than a quarter of the Fiducial Sites has been made publicly available. More than 5,000 images, each with 1.0-1.3 m resolution, have been released for unrestricted use. The ~150 time-series, some spanning more than 20 years, focus on wildland fire recovery, Arctic sea ice change, Antarctic habitats, temperate glacier behavior, mid-continent wetland dynamics, eroding barrier islands, coastline evolution, Long-Term Ecological Research (LTER) sites, resource management, natural disaster response, global change studies, ecosystem monitoring, and other topics.

Orthorectified Fiducials images are provided in a GeoTIFF format with supporting metadata. They can be freely downloaded from the USGS EarthExplorer website: https://earthexplorer.usgs.gov and from the USGS Global Fiducials Library website: https://gfl.usgs.gov. The data may be used without restrictions. Currently, access to imagery and related investigations are facilitated by the USGS-led Civil Applications Committee (CAC). The Global Fiducials Program was developed during the early days of the Clinton Administration and initially overseen by the Central Intelligence Agency.

THE APPLICATION OF HYPERSPECTRAL IMAGING TO GEOLOGICAL STUDIES

Logan Q. Moore
Katayoun Mobasher
Zac Miller
Lewis F. Rogers Institute for Environmental and Spatial Analysis (IESA)
University of North Georgia
3820 Mundy Mill Road, Oakwood, GA 30566, lqmoor8372@ung.edu

Abstract—Hyperspectral data of the earth's surfaces with a high degree of accuracy is often very difficult to obtain. Therefore, hyperspectral imagery is largely underutilized in geological studies. Through this research project, the application of hyperspectral imaging for the identification of igneous rocks were explored. In order to acquire hyperspectral data, geological samples collected in the field were studied. Three different types of materials were used to generate hyperspectral images, including: hand samples, thin sections, and rock powders. The goal was to establish which material would provide the highest degree of accuracy when depicting the spectral reflectance patterns present in the samples. Various imaging techniques were applied when generating the hyperspectral images. These techniques were used to overcome certain obstacles, such as oversaturation and orthorectification. In order to gauge accuracy, the spectral reflectance patterns generated in the lab were compared to a pre-existing United States Geological Survey (USGS) spectral library. This was done by using an original python script to compare similarities in spectral reflectance curves in both data sets. The results show, that due to the imagers inability to magnify the materials present in the image, thin sections are not good candidates for hyperspectral imaging. The results also found that materials that formed intrusively generate the best results in a hyperspectral image. Also, because of the coarse grained nature of intrusive igneous rocks, each individual mineral would present a clear and established spectral reflectance p

Part 2: GSIS Meeting Supplemental Materials

2017 Annual Meeting

Seattle, Washington

October 22-25, 2017

2017 Geoscience Information Society Annual Meeting Schedule
October 21 - October 25, Seattle, Washington
Facilitator: Bob Tolliver

Saturday, Oct 21

9:00-4:00	Geosciences Librarianship 101 The University of Washington
5:00-7:00	Early Bird No-Host Dinner The Pike Pub & Brewery, 1415 1st Avenue, Seattle, WA 98101

Sunday, Oct 22

8:00-9:00	GSIS Executive Board Meeting Sheraton Seattle Hotel, Greenwood
9:00-12:00	GSIS Business Meeting Sheraton Seattle Hotel, Greenwood

Monday, Oct 23

12:00-1:30	GSIS Luncheon & Awards Sheraton Seattle Hotel, Ravenna A-B
2:00-2:30	Field Trip: Washington Talking Book & Braille Library 2021 9th Ave, Seattle, WA 98121
3:00-5:00	GSIS Vendor Update/Information Resources Session Sheraton Seattle Hotel, Seneca

Tuesday, Oct 24

9:00-6:30	GSIS Poster Session (T141) Use of Geoscience Data and Information Resources in Education and Research Washington State Convention Center, Halls 4EF
11:30-1:00	GSIS Common Read and Lunch Full Rip 9.0: The Next Big Earthquake in the Pacific Northwest (Sandi Doughton) Meet at the GSIS posters in the Washington State Convention Center, Halls 4EF
1:00-3:30	GSIS Professional Issues Roundtable Sheraton Seattle Hotel, Greenwood
3:30-5:00	Geology/Building Stone Walking Tour of Seattle Starting at the Washington State Convention Center
7:00-9:00	GeoInformatics Division and Geoscience Information Society Joint Reception And Presentation of the Mary B. Ansari Distinguished Service Award Sheraton Seattle Hotel, Issaquah

Wednesday, Oct. 25

8:00-12:00	GSIS Oral Session (T136) Discovery and Preservation of Geoscience Data and Information Resources Washington State Convention Center, Room 3B

Geoscience Information Society 2017
Annual Business Meeting
Sunday, 22 October, 9:00 am-12:00 pm
Sheraton Seattle Hotel, Greenwood Room

Attendance: Matt Hudson, Sam Teplitzky, Chris Badurek, Lori Tschirhart, Louise Deis, Mea Warren, Bob Tolliver, Rusty Kimball, Stephanie Earls, Amanda Bielskas, Clara McLeod, Bridget Thrasher, Afifa Kechrid, Lura Joseph, Judie Triplehorn, Michael Noga, Shaun Hardy, Linda Zellmer, Monica Pereira, Cynthia Prosser, Lisa Dunn

Introductory Remarks

1. **Call to order**
2. **Welcome and general introductions**
3. **Attendee List [22 attendees]**
4. Announcements and Acknowledgments
    a. Thanks to Clara for organizing GL 101
    b. Thanks to Bob for organizing food
    c. Hannah on leave of absence, this year covered by Matt and Bob
5. Approval of agenda
    a. Amendments
        i. Matt proposed amendment to include break at 10:30
        ii. Lori amendment to add topic about adding signers to GSIS bank account
    b. Minutes approved by Linda Z, seconded by Monica P, approved by all
6. Approval of 2016 minutes
    a. Amendment
        i. Clara thanks last years' GL101 hosts Gail Bradbeer
    b. Linda Z approved minutes, seconded by Lisa D

Executive Board and Appointed Position Reports

1. **Past President report (Matt)**
    a. Matt organized nominations.
    b. Thanks to Chris as incoming vice president starting today, Bridget as Treasurer to begin November 1.
    c. Proceedings volume, Matt finished compiling proceedings and has shared with Rusty to add to archive.
    d. GSIS owns 100 ISBNs. Matt will add ISBNs to metadata of proceedings.
    e. Webinars planned for future, didn't happen this year
    f. DC incorporation. Status renewed this year quickly and promptly. Renewal settled for next two years.

g. Website domain renewed for the next two years.

2. **Vice president report (Bob)**
   a. Thanks to Amanda and Michael for taking over newsletter.
   b. $6250 in sponsorship for meeting
   c. AGU, GSA, GSL, GSW, Society for Exploration Geophysicists will be presenting at vendor update.
   d. Mentor lunch - informal to take place after business meeting
3. **Treasurer's Report** (Lori) We are in good shape! But we still have too much money.
   a. **10/22/17 Balances**

Checking	$21,138.08
Savings	$9,709.56
General Fund	$25,880.29
Ansari Distinguised Service	$6,553.19
Ansari Best Resource	$7,353.65
Pooled Sponsorship	$4,315.54
Professional Development	$1,669.67
TOTAL	**$76,610.96**

      i. Total at 2016 Business Meeting: 69,902.12
      ii. Checks received, to be deposited:
         1. $1,715 GSA 2016 awards dinner registration collected
         2. $50 Institutional dues LM Information Delivery
         3. $750 SEG sponsorship
         4. **Total: $2,515**
   b. Treasurer Books Audit Progress
      i. 10/9/17 Angelique Jenks-Brown confirmed that she was still in possession of the 2015 books, agreed to complete the audit and have the books back to me before December 2017.
      ii. 7/13/17 Patricia Yocum agreed to audit books for 2016, 2017. She is local to Ann Arbor, so it will be less onerous to provide and collect the books.

c. **2017 Sponsorships**

AAPG Datapages	$ received
American Geosciences Institute (AGI)	750 (not received yet)
American Geophysical Union (AGU)	**$ 1000 received**
Elsevier	$500 (not received yet)
Gemological Institute of America (GIA)	**$750 received**
Geological Society of America (GSA)	**$750 received**
Geological Society of London (GSL)	$ received
GeoScienceWorld (GSW)	**$750 received**
SEPM (Society for Sedimentary Geology)	
Society of Economic Geologists (SEG)	**$250 received**
Society of Exploration Geophysicists (SEG)	**$250 (not deposited)**
Springer	**$500 (not received yet)**
Total Sponsorship Rec'd for 2017 conference:	$- thank you sponsors!

d. Concerns:

i. 2016 Annual Meeting Awards Dinner - costs exceeded estimate by significant amount due to Broker Restaurant allowing attendees to order off-menu items and alcoholic beverages beyond drink tickets. Future special events should be done differently to avoid this.

e. Recommendations:

i. **Eliminate Institutional Membership category**. Currently have $400 Ebsco check representing institutional dues for four organizations that overpaid. Human error has meant that the check has twice been written for the wrong amount. Institutions may still support the society via unrestricted gifts. I'd like the society to consider contacting these institutional dues members and tell them that institutional dues are being eliminated and checks will be returned.

1. Comments: Shaun - "we appreciate the institutional support of our members". Communication plan necessary. Organizations have historically wanted access to our membership directory. We have sold the list to corporate buyers in previous years.

ii. **Eliminate Pooled Sponsorship designation.** Let's spend down and eliminate this separate fund. The intent is noble. In practice, it just adds a layer of administration and the money never gets spent down. We only received $10 in contributions last year. We can still sponsor people's membership and travel intentionally via the general fund.

iii. **Eliminate Professional Development fund.** Let's spend down and eliminate this separate fund. The intent is noble. In practice, it just adds a layer of administration and the money never gets spent down. We received little in contributions last year. We can still sponsor people's membership and travel intentionally via the general fund.

1. Comments to both proposals:
    a. Offer to GL101 participants
    b. Offer conference registration
        i. Proposal offering lottery for members
        ii. Consider Requirements -- presenting, contributing
    c. Reimburse members for abstract fees or GL 101 instructors for lunch
    d. Fees for webinar?
    e. Fund a member who has never attended, member who is presenting
    f. Avoid international focus, too complicated
    g. Target members who are active on committees but haven't traveled to meeting

Comments and Suggestions: Travel scholarships, support/reimbursement for geoscience 101 instructors, presenter abstract fees.

iv. Propose giving **lifetime membership to retirees**.

v. Move to **online only pay** for personal dues - and corresponding proposal to offer lifetime membership to longtime dues paying members with current retiree status, and new retirees as that happens.

vi. Modify annual dues renewal process to designate membership year.

f. **Outstanding concerns:**

i. Still awaiting 1 outstanding invoice for 2015 conference sponsorship - GeoFacets - Invoice 15-07 dated 9/9/15.

ii. Reimbursement still owed to Clara McLeod for 2016 Geoscience Librarianship 101 expenses (documentation never arrived).

iii. Approval required to be reflected in business meeting minutes:

1. Chase Bank Check Signing rights to Bridget Thrasher (2018-19 Treasurer) and Sam Teplitzky (2017-18 Secretary)
    a. Debit cards for Bridget Thrasher and Sam Teplitzky

b. It is important for 2 members of the Executive Board to have access to bank accounts. Except in extraordinary circumstances, only the Treasurer will use the debit card or cut checks.
c. Both need signing rights since 2 signatures are required on checks currently.
d. In future years, checks should be changed to only require one signature - 2nd signer does not really create safety since 2nd signer could withdraw bank accounts.

iv. Sustainability of Society - It is my opinion as Treasurer that the Society would benefit immensely from becoming a divison of GSA. The administrative burden of the Executive Board is very high, and though in my opinion everyone is very dedicated and organized, we collectively are challenged to conduct administrative tasks on time and it is a threat to our future.

v. Membership checks will now be sent directly to Treasurer, Treasurer will share membership forms and checks received with Secretary monthly along with monthly PayPal statements.

vi. In progress: Concise Treasurer's guidebook for future treasurers. ETA December 2017.

vii. Suggestion: move membership to a more prominent place on website

4. Secretary's report (Sam Teplitzky)

a. Membership: 89 personal members + 11 institutional members
- **i.** 7 members dropped
- **ii.** About 10 new members (some are lapsed members rejoining)
- **iii.** 4 institutional members dropped, but all switched to personal

b. 384 geonet subscribers, 1 out of 4 subscribers are GSIS members

c. Affiliation breakdown:
- **i.** 47% academic
- **ii.** 16% retired
- **iii.** 14% government
- **iv.** 10% publishers/AGI
- **v.** 8% other - students, etc.
- **vi.** 4% oil/mining/energy corporations

d. Our membership committee tried targeting Pacific Northwest based librarians ahead of the 2017 Seattle conference. We turned to a combination of library websites and libguides to target these geoscience librarians. I think this would be good practice going forward to solicit interest in GL101 as well as the conference.

e. Concluding thoughts: Are we missing potential members? Perhaps a small handful, but overall no. The pool of potential members is small at this point.

5. Topical Session Convener (Chris Badurek)

a. Session on Wednesday, first part state government; second part GSIS
b. Tuesday - poster session 9:30-11:30
c. Joining with Geoinformatics group for reception

d. Encouraging people to present; have theme prepped at current meeting to get feedback for next
e. Proceedings - diversity of products welcome in the proceedings
    i. Standard means of citation

6. **Webmaster report (Matt on behalf of Courtney Hoffner)**
    a. Domain renewed
    b. Google analytics on site; US dominant source of site traffic
    c. Time to reinvest in website/design
7. **Geoscience Librarianship 101 (Clara McLeod)**
    a. Held at University of Washington 10/22/17, hosted by Matt Parsons. Many thanks to Matt for arranging breakfast
    b. 19 registrants; 15 attended; 5 inquiries about webinar/online content access
    c. Thanks to Shaun who served as PR
    d. Thanks to Matt and Bob for their help
    e. Thank you to instructors: Emily Wild, Stephanie Earls, Linda Zellmer, Amanda Bielskas, Samantha Teplitzky
8. Newsletter report (Amanda Bielskas and Michael Noga)
    a. Send your submissions!

9. **BREAK**

10. **Committee Reports**
    a. Membership
        i. Sam's iniated search for potential members and attendees in the Pacific Northwest
        ii. Committee talked about how to make new members welcome
            1. Developed new member's welcome letter and solicitation letter for new members
        iii. Initiated common read to create camaraderie.
        iv. Brochure updated with Bob's information.
    b. Guidebooks - Winners of the 2017 Award:
        i. Roadside geology of Southern California
        ii. Guidebook to the Geology of Barringer Meteorite Crater, Arizona
        iii. Series - GSA field guides
    c. Exhibits
        i. Linda Zellmer requests attendees use sticky notes to write brief description of how you identify fake science.
    d. Distinguished Service Award
        i. Clara thanked Louise Deis and Edward Lener for their service on the committee. Requested that people start to think about nominees earlier in the year.
    e. Best Research Resource Award
        i. Encyclopedia of Marine Geosciences
        Editors: Harff, J., Meschede, M., Petersen, S., Thiede, J.
        ISBN: 978-94-007-6237-4 (Print) 978-94-007-6238-1 (Electronic)

Published: 2016
http://www.springer.com/us/book/9789400762374

f. Best Paper Award
    i. Birgit Schmidt, Birgit Gemeinholzer and Andrew Treloar have been awarded GSIS Best Paper for their paper entitled 'Open Data in Global Environmental Research: The Belmont Forum's Open Data Survey, published in PLOS ONE, vol. 11, issue 1, pages 1-29.

11. Discussion #1: Vendor Update format

a. Policy to charge vendors $750-$1,000 to present at meeting
    i. How to give GeoRef, or other non-profits an opportunity to present without sponsoring? Most in favor of opening up the forum to more presenters, but must be balanced against paying vendors
        1. Proposal to allow non-paying vendors at vendor session
        2. An additional information resource session could be created to include these other presenters.

12. Discussion #2: Future of GSIS

a. Concern about long term stability of group
b. Membership numbers have stabilized, but activities are limited to small group of volunteers
c. Board occupied with administrative details. Would it help to become a GSA Division? Board has realized this isn't a viable option. Dues would increase.
d. How can we solicit more members, get more participation?
    i. Proposal for web conference, potentially with australian counterparts
    ii. In the past there was sponsorship of attendees to international conference on geoscience information. Is this still viable?
    iii. Sponsored field trip idea

13. Other business: possibility of scholarly communications committee to help people workshop their proceedings papers.
14. Discussion of open committee liaison spots. Clarification of roles was discussed and additional volunteers enlisted.
15. Additional topic: informal meeting at AGU when it's in DC.

Passing of gavel
Call to adjourn

Geoscience Librarianship 101

Saturday, October 21, 2017
Suzzalo Library, University of Washington Libraries
Seattle, Washington

AGENDA

9:00 - 9:30 AM	Continental Breakfast / Check-in / Welcome and Introductions: (Moderator: Clara McLeod, Washington University in St. Louis)
9:30 - 10:15 AM	Geoscience Overview / Instruction: (Instructor: Emily Wild, United States Geological Survey)
10:15 – 11:00 AM	State Geological Survey Libraries: Impact on Geoscience (Instructor: Stephanie Earls, Washington Geological Survey)
11:00 – 11:15 AM	Break
11:15 – 12:00 PM	Geospatial Information (Instructor: Linda Zellmer, Western Illinois University)
12:00 – 12:45 PM	Lunch
12:45 – 1:30 PM	Collection Development (Instructor: Amanda Bielskas, Columbia University)
1:30 - 2:15 PM	Scholarly Communications: Trends in the Earth Sciences and Opportunities for Librarians (Instructor: Samantha Teplitzky, University of California, Berkeley)
2:15– 2:30 PM	Break
2:30 – 3:15 PM	Geoscience Librarian: Challenges and Benefits (Instructor: Mary Ellen Vedas, Hess Technical Library)
3:15 – 3:45 PM	Q & A
3:45 – 4:00 PM	Feedback and wrap-up

AUTHOR INDEX