SCAPE 2.0 SUMMATIVE REPORT

Arizona State University

Findings and Summary

EPA Environmental Education grant #9687101
Dan Collins, Principal Investigator

The health of our waters is the principal measure of how we live on the land — Luna Leopold

I. INTRODUCTION

SCAPE 2.0 Summative Report

September 1, 2018 – October 31, 2021
Submitted by Dan Collins, Principal Investigator, Arizona State University
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Summary

SCAPE (Sustainable Communities and Place-based Education) is a high school and community-based science education project combining online learning and field observations involving high schools across three western States. *SCAPE* 1.0 was funded by the EPA in 2016 with a $192K grant. *SCAPE 2.0* was funded for a second grant by the EPA in 2018 for 100K.

Budget (*SCAPE 2.0*)

TOTAL PROJECT PERIOD & COST
Original Project Period and Cost: 09/01/2018 - 08/31/2020 for $133,833.00
Amended Project Period and Cost: 09/01/2018 – 10/31/2021 for $133, 833.00

Notice of Award (Award made on August 21, 2018)

Based on our application dated 04/11/2018 the US Environmental Protection Agency (EPA) awarded the project $100,000 on 8/21/2021. EPA agreed to cost-share 74.72% of all approved budget period costs incurred, up to and not exceeding total federal funding of $100,000.

Project Description

SCAPE 2.0 increases public knowledge about environmental issues and provides students and teachers the skills necessary to make informed decisions and to take responsible actions. The project addresses the whole of the EE continuum from awareness to stewardship, through the following goals: connect local data to system knowledge, experience behavioral changes through non-regulatory means, use digital tools and conduct field research, increase environmental literacy, implement career development opportunities, and catalyze public participation and community collaboration.

The project utilizes recognized environmental education (EE) curriculum design guidelines and workshops and provides opportunities for science teachers to learn and practice the science of water quality and best practices for EE. *SCAPE* trained teachers introduce students to concepts of hydrology, methods for measuring in-stream flow, and techniques for testing water quality. Resources are provided in computer literacy, environmental history, policy, and ethics, with special emphasis on "water in the West." *SCAPE* incorporates state and national education standards and has been successfully used to augment existing teaching plans. It can also be used as a stand-alone curriculum. The program uses EE pedagogy to create lessons related to real-world problems—in particular, water quality and supply—and gives our partner teachers the tools and methods to move from knowledge to action.

The original *SCAPE 1.0* curriculum focused on the Colorado River Basin. *SCAPE 2.0* encompasses a much broader geographic area (some of the original "Colorado River States" plus Montana) along with new content areas in snow science, environmental ethics, community mapping, data visualization, and occupational training. (See p. 15, Fig. 1).

SCAPE 2.0 was utilized in 9 schools and non-profit institutions located across the states of Colorado, Wyoming, and Montana. The updated version includes nineteen lessons.

Three schools were added to the initial program (Gunnison HS; CO; Ronan HS, MT; Columbia Falls HS, MT); three schools continued from *SCAPE 1.0*. Columbia Falls was dropped from the program due to overcommitted school staff and faculty. Resources and ongoing support were shifted from Columbia Falls to the West End School District (Montrose County, Colorado) encompassing the towns of Naturita, Nucla, Bedrock, and Paradox in the form of training and water quality test equipment.

An extension through the end of October 2021 was approved by EPA administrator Wendy Dew on April 1, 2020.

Since the Spring of 2020, restrictions related to COVID-19 severely limited the scope of work that could be done in person and in the field. Some of the partner schools engaged complete remote teaching for a time. While some fieldwork was conducted by partner schools at the beginning of the Summer of 2020, subsequent variants again restricted travel in buses.

Work continues on integrating the *SCAPE* curriculum into the website of the non-profit, The Telluride Institute.

Approvals for a reallocation of funds were secured for the development of a "Water Quality App" for use by students in the Field. A BETA version of the app was recently completed. Initial coding of the app was undertaken by the *Luminosity Lab* at ASU. Refinement and preparation for the distribution of the app via the Apple Store and Google play have been successfully completed by the *GIS Collective* in Berlin, Germany.

We received Notification in early August 2021 that our panel presentation proposal was accepted to the prestigious North American Association of Environmental Educators. A panel presentation was organized and presented by Dan Collins and included presentations by Collins and two SCAPE teachers, Krystal Brown of Gunnison High School, Colorado and Jedd Tougas of Ronan High School, Montana. A video of the full presentation can be found on the *SCAPE* Vimeo channel here: https://vimeo.com/671312030.

EE Teaching Skills

In Year One of *SCAPE 2.0*, master teachers, curriculum designers, and media experts met to refine the SCAPE EE curriculum. *SCAPE 2.0* classroom teachers learned about the curriculum through one-on-one training sessions, conference calls, and accessing online resources. In Years 2 & 3, partner teachers introduced their students to the *SCAPE 2.0* curriculum in their regular classrooms.

Educational Advancement

Through a STEM-focused curriculum, students become stewards of the environment by linking their experience of place (personal habits and patterns of living) with conditions and evidence from specific locations (local, regional, global), as well as with a network of living classrooms across the Mountain West through the *SCAPE* website. Each classroom adopted one or more natural bodies of water as their "living classroom" for conducting fieldwork and stewardship activities. The *SCAPE* curriculum uses online tools, documentary video, field research, and discussions and readings of environmental history, policy, and ethics to raise students' awareness of the importance of healthy river ecosystems and water security. The courses culminated in a variety of student projects that catalyzed action within their schools and local communities and fostered behavioral changes. This fulfills the priority of educational advancement by connecting STEM skill development to real environmental conditions and outcomes.

Participants

Core Team

Dan Collins—Principal Investigator, Arizona State University, AZ / Telluride Institute, CO
Kaard Bombe—Videographer, Phoenix, AZ
Monica Elser—Co-Investigator, Flathead Lake Biological Station, MT
Zora Ziazi—Evaluator, UOEEE, Arizona State University, Tempe,AZ
Elena Ortiz—Co-Investigator, Professor, Phoenix College, Phoenix, AZ
Vicki Phelps—Former Co-Director, Watershed Education Program, Telluride Institute, CO
Jeff Sellen—Professor, ENVS, Western Colorado U., Gunnison, CO
Renu Singh—Director, Gifted & Talented Academy, Maryvale HS, Phoenix, AZ
Garrett Smith—Director, Watershed Education Program, Telluride Institute, CO
Toby Kidd—Networking & Database Specialist, Arizona State University
Elizabeth Stuffings—San Miguel Watershed Coalition / Telluride Institute, Telluride, CO

Contributors (reflects participants over the course of the two granting periods)

Brian Anderson (last day, April 27, 2021)—Fiscal Specialist, HIDA, Ariz State Univ., Tempe, AZ
Krystal Brown—Science Teacher, Gunnison High School Gunnison, CO
Michelina Calo—Graphic Designer and UX/UI specialist, Arizona State University
Alison Cook-Davis—UOEEE, Arizona State University, Tempe, AZ
Elena Davis (1st day, May 1, 2021)—Fiscal Specialist, HIDA, Ariz. State Univ., Tempe, AZ
Kevin Dunbar—Science Teacher, Cedaredge High School, Cedaredge, CO
Theo Eckhardt—Asst. Direct. of Research Advancement, HIDA, Ariz. State University, Tempe, AZ
John Hausdoerffer—Dean, ENVS, Western Colorado U., Gunnison, CO
Kelly Houle—Science Teacher, Columbia Falls High School, Columbia Falls, MT
Laurie Lundquist—Environmental Artist, Telluride, CO
Deb Noble—Science Teacher, Pinedale High School, Pinedale, WY
Steve Smith—Science Teacher, Animas High School, Durango, CO
Tina Trujillo, Science Teacher, Animas High School, Durango, CO
Jessica Vincent, Intern, Fort Lewis College, Durango, CO
Jedd Tougas—Science Teacher, Ronan High School, Ronan, MT
Luminosity Lab – (Alex Slaughter). ASU interdisciplinary tool development lab
GISCollective – (Bogdan Szabo & Alexandra Cipiscu). GIS mapping and app development lab.

II. SUMMARY OF MAJOR *SCAPE 2.0* ACCOMPLISHMENTS (Sept. 1, 2018 – Oct. 31, 2021)

1. Used *SCAPE 1.0* as a basis for an expanded EPA proposal for 2018 – 2020 called SCAPE *2.0*.
2. Additional materials were added and earlier materials were revised including new lessons (Snow Science and Data Visualization), an expanded inventory of online maps, an updated glossary, and an ever-growing bibliography. The full curriculum now stands at approximately 350 pages and provides a comprehensive curriculum that combines classroom, field, and online learning.
3. Identification and mapping new data collection sites by partner schools in Wyoming, Colorado, and Montana.
4. Review and updates of online data structure and mapping protocols (for data visualization) with Toby Kidd, Networking & Database Specialist, ASU including a transition from Google G-Suites to Google Workspace.
5. Overhauled Evaluation Tools used by Instructors. We moved away from "Quarterly Surveys" to "just in time" evaluation questions embedded in each Unit/Lesson.
6. Conducted extended ZOOM calls and reviews with App Development Team.
7. Researched and approved the purchase of additional water-quality test equipment for Gunnison HS (Colorado), Pinedale HS (Wyoming), Ronan HS (Montana), Paradox Valley School (Colorado), and Animas HS (Colorado).
8. Transferred "front end" of *SCAPE 2.0* project to the Telluride Institute website to ensure ongoing online presence after the end of ASU/EPA support. https://www.tellurideinstitute.org/scape/
9. Integration of *SCAPE* curriculum into international UN-sponsored effort called "UNESCO Futures of Education Initiative: Zero Water Day Partnership," by Gunnison HS Teacher, Krystal Brown.
10. Trained teachers to create and interact with *SCAPE 2.0* in regional high schools and institutions;
11. Taught students and citizens sustainability, water quality/supply, and environmental protection.
12. Fostered "stewardship" of water in the Mountain West—our shared "commons" among students, teachers, and communities, especially in under-represented groups.
13. Developed a unique set of computing resources "in the cloud" for uploading and sharing data and doing comparative analysis across our schools.
14. Implemented an equitable funding mechanism for sub-awardee grants of $5000 or less.
15. Collaborated with *SCAPE* videographer, Kaard Bombe, to produce a library of videos (https://vimeo/scapeworld) spanning both SCAPE 1.0 & 2.0 and produce a video overview of the project.
16. Presented the *SCAPE* concept and curriculum at a major national conference, the North American Association of Environmental Education (NAAEE). See video documentation here: https://vimeo.com/671312030.
17. Planning and implementation of a partnership with Western Colorado University's "Masters of Environmental Management" program (MEMs). *SCAPE affiliated Master's students* will introduce an EE program focused on water for an expanded cohort of schools across SW Colorado.
18. In conjunction with ASU's Luminosity Lab and the Berlin-based GIS Collective, a smartphone application called the *SCAPE Water Quality App was developed.* The App is now available for public download for free from both the Apple Store and Google Play and is integrated with the *SCAPE 2.0* curriculum.

III. OUTPUTS & OUTCOMES (*SCAPE 2.0*)

The following table provides a general overview of Outputs and Outcomes.

Outputs	Outcomes		
	Short-term	**Medium-term**	**Long-term**
Developed and implemented recruitment plan for teachers and students with emphasis on rural and low income/high minority school districts	Identified 9 schools and non-profits and partner teachers and ~300 students. Increased access and engagement by under-represented communities to EE resources	Participants demonstrated increased awareness and comprehension of environmental issues and how policies and practices affect their community's environment	Established sustainable EE programs on water conservation and quality in targeted regions featuring well-defined, professionally formatted curricula
Successfully ran development workshops and training for high school teachers and community educators (Sept. 2018 – Oct. 2021).	High school teachers and community educators participated in summer workshops, online training, and service learning work to increase awareness.	Teachers integrated increased knowledge of EE best practices into the classroom. Teachers and students led environmentally-focused projects in their schools and their communities.	Materials were shared online and with educators at local and national EE and science teacher conferences (e.g., Telluride Institute Watershed Education Program (WEP) and NAAEE conference, , Oct. 2021). Widely distributed video documentation via *SCAPE* Vimeo channel.
Developed high quality online-accessible curricular materials on sustainable water use and quality; assisted teachers in developing materials for wider use	Increased capacity and motivation for teachers to develop quality EE materials. Reinforce local identity. Assessment and evaluation of materials	Took specific actions on water conservation and quality at campus and community levels to reinforce local identity.	Students and teachers demonstrated behaviors and commitments to environmental protection and educated others outside of program about environmental issues— especially in under-served communities. Persistence in and knowledge of STEM skills. Wide adoption and dissemination of *SCAPE* curriculum. Comprehensive summative report completed and submitted to EPA (January 2022).
Supported teachers in implementing STEM-driven environmental education (EE) program focused on sustainable water use and quality	Increased capacity for teachers to implement EE programs tied to STEM learning objectives. Increased teacher and student understanding and awareness of water quality across the Mountain West.	Formative assessment of student and teacher actions completed. Quarterly tracking replaced by "just in time" assessment Lesson by Lesson. Persistent application of proven STEM and EE learning methods.	

IV. EVALUATION (Summary)

Please refer to Appendix 4. (attached) for the complete Evaluation from ASU's University Office of Evaluation and Educational Effectiveness (UOEEE).

To evaluate perceived impacts of the *SCAPE 2.0* program, the University Office of Evaluation and Educational Effectiveness (UOEEE), in collaboration with Dr. Collins (the PI), developed a retrospective summative survey during Fall 2021.

- Most survey participants taught up to 20 lessons, although a few individuals were involved in the project in different capacities than teaching.

- Participants reported implementing the *SCAPE 2.0* curriculum in grade levels 3rd through 12th in five high schools and 2 non-profit institutions across Region 8.

- Respondents implemented four particular lessons more frequently than they did other lessons, including lessons "***2.4 Macroinvertebrates***," "***2.2 Streamflow=Volume x Velocity***," "***2.3 Water Characteristics and Chemistry***," and "***2.1 Riparian and Habitat Diversity***."

- Survey participants highlighted the curriculum's various strengths, including simple lesson plans with straightforward directions; online access to the curriculum and other readily-available information; content that balances science and social studies in ways that integrate 21st century cognitive skills and technologies; engaging students in the science field, and helping them understand the role of water in communities.

- Participants identified the main areas of weakness for the SCAPE 2.0 curriculum as issues related to technology (data sharing, working on cloud platforms); lesson format (pdf, googlesheets); lack of supporting materials such as videos; and the COVID pandemic limiting curriculum implementation.

- The majority of respondents felt that the *SCAPE 2.0* lessons were "Effective" or "Very effective," and further highlighted positive aspects of the curriculum. These included the curriculum's flexibility to accommodate diverse classroom settings, simplicity and straightforwardness, and accessibility to students' data by other schools.

- Most respondents felt that the blend of the "online" and "hands-on" experiences were "Effective" or "Very effective," further explaining that the blended format was both easy for teachers and beneficial to students.

- Some participants faced challenges related to finding an interesting location to study; time and resources for fieldwork or to implement the lessons; preparing for teaching the lessons; and a lack of staff to implement the curriculum.

- All respondents reported being "Satisfied" or "Strongly satisfied" with the curriculum. They further explained that the curriculum served students and teachers in great ways, providing them with knowledge and resources that were easily accessible and easy to implement.

V. BUDGET & FISCAL MANAGEMENT for SCAPE 2.0

Accounting and Procurement Management

The Principal Investigator was responsible for managing and reporting on the budget on a quarterly basis, including budgetary planning, tracking, reporting, and management of costs. All expenditures were routed through Arizona State University's Herberger Institute for Design and the Arts (fiscal team: Elena Davis, Brian Anderson, and Theo Eckhardt) and approved by the PI, and verified by Knowledge Enterprise and ASU Accounts Payable.

Budget Summary

09/01/2018 - 10/31/2021

	SCAPE BUDGET	EXPENDITURES INCEPTION TO DATE
7110 SALARIES	$5,436.00	$5,479.97
7120 WAGES	$928.00	$2,500.00
7200 EMPLOYEE RELATED EXP	$3,380.00	$2,213.16
7310 SERVICES	$23,115.00	$22,615.00
7314 SUBAGRMNTS LT $25,000(SP ONLY)	$0.00	$0.00
7320 MATERIALS AND SUPPLIES	$2,239.67	$2,295.26
7520 TRAVEL/OUT-OF-STATE	$3,469.00	$3,349.33
SUB-AWARDS	$29,000.00	$28,677.74
DC SUBTOTAL	$67,568.00	$67,130.46
8201 INDIRECT COSTS RECOVERED	$32,432.00	$32,222.62
IC SUBTOTAL	$32,432.00	$32,222.62
TOTAL	$100,000.00	$99,353.08

Teacher Compensation

$1500 of the $4000 sub-award was used for teacher stipends.

Sub-award Equipment Purchase

The remainder of the $4000 sub-award (~~$50K~~ total) was used for water testing kits and field trips. These expenses advanced the water quality environmental priority and educational priorities of the EPA. See sample inventory of recommended equipment in Appendix X3.

VII. TECHNOLOGY & COMPUTING

Digital Technology & *SCAPE*

There is real value in the application of Digital technology to Environmental Science Education. *SCAPE*, a high school environmental education curriculum, is a case in point. The curriculum involves students sampling environmental data with digital probes, performing rapid analysis using software, and sharing these observations regionally across the Mountain West using cloud-based technologies. In addition to classic environmental science pedagogy (which complemented our digital toolset), *SCAPE* provides a framework for teaching key STEM objectives, introduces important 21st century computer skills, and challenges students to make meaning from data using digital analytic tools.

Content Management Systems: Google Workspace

A Content Management System (CMS) is an incredibly powerful tool. Not only does it provide an array of tools needed to complete tasks, it has a full range of enterprise critical features that provide for data management, data analysis, sharing, and security.

The *SCAPE* project was developed around the CMS by Google called *Google Workspace* and other Google cloud technologies. The following box highlights the Google Workspace tool set:

<u>Google Workspace (formerly Google G-Suite)</u>

The entire curriculum development process as well as project documentation and analysis is supported by the new *Google Workspace* line of tools and cloud-based technologies. The various applications that we now utilize in the curriculum include the following Google products: My Maps (interactive mapping tool…different from Google Maps or Google Earth), Docs (a word processing app), Sheets (a spreadsheet app similar to Microsoft Excel), Forms (an easy way to create online tests and surveys), Google Analytics (a set of measurement and analysis tools that provide insight into website performance), and Google Sites (to build a protected portal for project participants). Besides the distinct operations supported by each application, the integration of all of these apps in one Suite is extremely useful and efficient. When creating a set of building blocks and a "pipeline" for processing data, the products of one application can seamlessly "feed" into another. For example, data uploaded using Google Forms can be instantly viewed and manipulated in Google Sheets which in turn can be viewed and visualized as a graph or as a map in Google My Maps (see Unit III, Lesson 3). Further, the fact that each and every page has a unique URL allows for improved organization, navigation, and sharing. Finally, Google Analytics provides features such as automated data collection, real-time visitor tracking, and customizable reports. Analytics has also been built into popular video posting sites such as YouTube (which is now owned by Google) providing a window into student utilization and comparison of *SCAPE* video products.

Because of our relationship with the Telluride Institute, we were able to secure access under their non-profit account for no fee. This account, accessible to our Core Team, allowed for coordination of the project. In addition, all of our researchers and teachers have dedicated user accounts (with the shared domain of @coloradoriverscape.org) that allow us to work together as an organization.

Lessons that specifically introduce the technology to the students are as follows:

Unit III / Lesson 1: Post Your data to the Cloud
Unit III / Lesson 2: Using Pivot Tables
Unit III / Lesson 3: Data Visualization with Google Sheets & My Maps
Unit IV / Lesson 4: Story Maps (using online GIS to visualize data and "stories of place.")
Unit IV / Lesson 5: Collaborative "Smart Map" of All Partner Schools

Security and management are critical. Careful consideration went into finding the right balance of freedom and control. The CMS had to allow viewing and engagement for a select group of researchers and teachers, but also provide a window into the project for the general public. The CMS enables secure active development and the hosting of finished forms, pages, and documents. Implementation requires a lot of work and is loaded with many tasks such as helping people get access, applying access to users, architecting data aggregation and file organization, providing a structure where people can effectively share and produce viable content, and trouble-shooting the inevitable problems that arise.

The content creators are the environmental science classes at our partner schools. They have opportunities to publish different analysis spreadsheets, maps, or other documents to the *SCAPE* website and folders. Each school was set up with a web page—a "dashboard" —that hosted their data analysis and interpretive maps. (See for example Pinedale High School in Wyoming: https://sites.google.com/a/coloradoriverscape.org/units/partner-schools/pinedale_hs) As more data was added to the system there were opportunities for comparative analysis between the school and class site to the schools up and down river.

System Implementation

What are some of the key aspects of design and implementation of *Google Workspace* as a Content Management System? We needed to plan on a diverse group of over 20 people, and these teachers, researchers, and education administrators would be actively participating in the development of the written curriculum and the Water Quality survey form. The researchers would have 'write access' to the content and the instructors would have 'read' access. In this implementation we had many researchers writing content, with too little consistent training and documentation. Because of this, people struggled with access and maintaining content. Most of the researchers and instructors would be better served with tailored web views and more limited access to the writing of web content. For example, instead of browsing a Google Drive looking for content, an instructor reading the curriculum would be better served with clean web pages; where they wouldn't know that the Google Drive is behind the scenes 'hosting content'. For the size of this project, the participating researchers and instructors need more stream-lined views to the content without risk of making administrative mistakes. Many of these issues were resolved in the most recent iteration of Google Workspace (implemented in September of 2021) which provides a much cleaner interface for teacher engagement, while still providing details for "advanced users" should an instructor have a desire and technical capability to dig deeper.

Much time and energy was spent creating and refining the *SCAPE* Field assessment Form, which supports the submission of water quality data. Not only is there a need to ensure that the process of entering values into the form is easy and understandable, the data being submitted needs to be secure of personally identifiable information as well as protected against erroneous data submissions. The data also is required to be consistent across all partner schools in order to properly combine and analyze the results from the region. This implementation relied on people having access to the Google Form with a Google account, in the coloradoriver*SCAPE*.org domain. People struggled with a new Google account, mainly because it is difficult to know when the person is signed in under the right account to edit the form. In the next iteration, the security design should remove the constraint of adding data with a Google Account, but instead have project researchers reviewing submitted data and validating it for accuracy. The next iteration could also explore the inclusion of stronger data and map visualizations through integrated third-party tools for public presentation and analysis. (We worked up some sample maps in ArcGIS for example—which were very attractive--but it was difficult to integrate the products with the overall "Google-based" design).

Thus, this project was solely reliant on Google products. The services were very inexpensive, or free, but the quality of the tools only met and rarely exceeded the basic needs of the project. This also means that all technology used is easily portable to any environment due to the ubiquity of Google products and services, as opposed to a licensed solution. Much more development investment would increase the user experience and more fully leverage the Google Workspace service as well as add the option to connect with other tools and services outside Google as an enhancement to the core project. With the diversity of students, teachers, and researchers, there are many personal preferences about how to use a computer. There are services other than Google, and some people prefer them—such as when comparing Google Sheets to Microsoft Excel. There is also the comparison of Learning Management Systems like Canvas versus the publicly accessible content via Google deployed as a CMS. Or, many teachers are using other established websites for participating in water quality monitoring. Teachers even have preferences with the units in the *SCAPE* curriculum, versus units taken from other books and lectures; so, there are a lot of preferences to account for, which requires a lot of development and design time. The project would benefit if it included more developers and lead designers or a narrowing of its scope.

Beyond any one digital tool or service, the sharing of water quality data between disparate communities across the Mountain West is a reality. Development is needed in integrating numerous online datasets (e.g., USGS, Forest Service, globe.gov; etc). This cloud-sourced data has potential for providing insights into the broader information "ecology." It is clear that Content Management Systems can be applied to more than blogs or businesses—they can host environmental data for sharing and collaborative research.

The *SCAPE* framework is developed, tested, and solid. Despite certain difficulties with technical implementation and meeting the needs of a diverse user-base at the beginning, the digital tools and cloud-based technologies were enthusiastically embraced and effectively utilized by project researchers, teachers, and (especially) the students.

VIII. MEDIA (summary)

Kaard Bombe, our project videographer and photographer, contributed wonderfully engaging video footage and still images to the project.

A dedicated Vimeo Channel has been established to support all of the video products produced over the last five years. It can be accessed here: https://vimeo.com/scapeworld

As an example of Kaard's work, please take a few minutes to review the following videos to see compelling portraits of two of the project schools:

- PPEP Tec High School, San Luis, Arizona: https://vimeo.com/272983792
- Cedaredge High School, Cedaredge, Colorado: https://vimeo.com/282112861

An extensive photo archive has been established using Google Drive. A sample of some nearly 60 photos can be found in Appendix 1.

Three *SCAPE* Websites

We continue to expand on the public website for the project: The site features interactive maps, a document repository, a bibliography, links to team members and project partner schools, and all of our quarterly and reports. A direct link is here: http://coloradoriverscape.org A second website was developed using the Google Site application as a portal to the cloud-based services and the databases utilized by project participants. A link is here: https://sites.google.com/a/coloradoriverscape.org/units/home Finally, a third site has been established on the Telluride Institute webpages here: https://tellurideinstitute.org/scape

New *SCAPE* Water Quality Smart Phone App

The *SCAPE Water Quality App* has been developed for educators, students, citizen scientists, and researchers engaged in water-monitoring and data-collection efforts. The App automatically determines user location, date, and time of day. It aids in the calculation of in-stream flow, provides a framework for water chemistry sampling, and equips the researcher with an easy-to-follow and richly illustrated guide for keying out and recording benthic macroinvertebrates. Once users log data in the field, they can export it directly from their personal devices to shared online databases for further study and comparative analysis with other users. The *SCAPE Water Quality App* provides the user with a tool for recording the majority of the physical (e.g., streamflow and turbidity), chemical (e.g., conductivity, dissolved oxygen, pH, nitrates) and biological indicators (including some 22 benthic macroinvertebrates) needed to determine water quality. The *SCAPE Water Quality App* is available for Apple (iPhone, iPad, iPod Touch) and Android (phones and tablets) mobile devices via the Apple Store and Google Play.

SPECIAL FEATURES of the SCAPE App:

- FREE and Open-source. Easy to download from both the Apple and Google Play Stores.
- Works on both Apple (iPhone, iPad, and iPod Touch) and Android (phones and tablets)
- User location is shown on a live map and lat/long are automatically entered.
- Water quality is assessed using three parameters—physical, chemical, and biological.
- Nearly 100 photos and line drawings of macroinvertebrates in both their juvenile and adult forms are provided to aid in the identification of these biological indicators.
- Videos illustrate the characteristic behaviors of macroinvertebrates in their natural settings.
- The App supports export functions to standard databases in Google Sheets or Excel.

The *SCAPE Water Quality App* was developed by educators, scientists, designers, and programmers

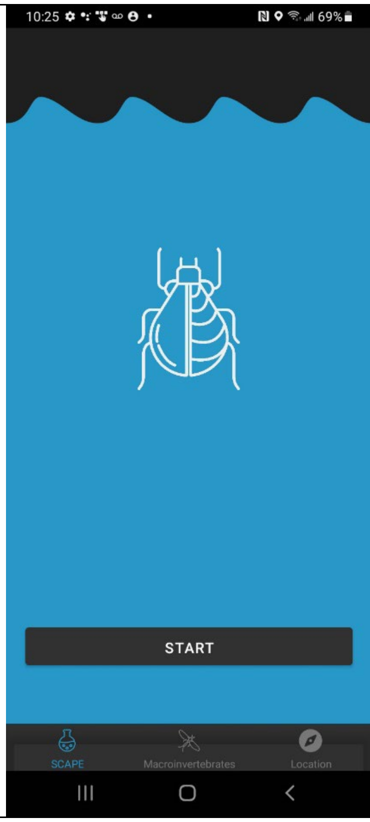


Fig. a. *SCAPE* Water Quality App Home Page

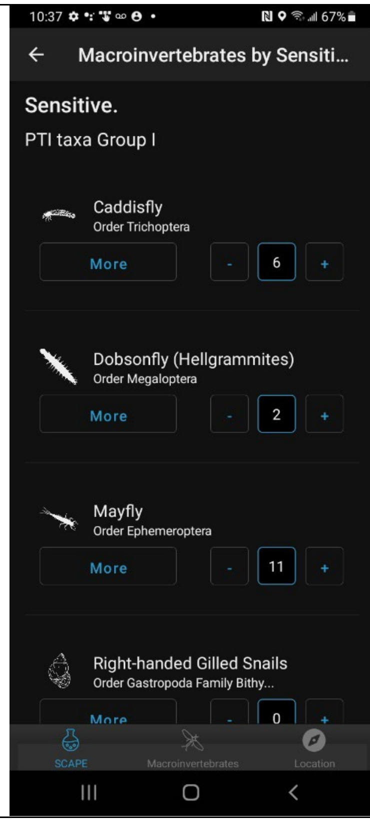


Fig. b. Detail of Macroinvertebrate selection.

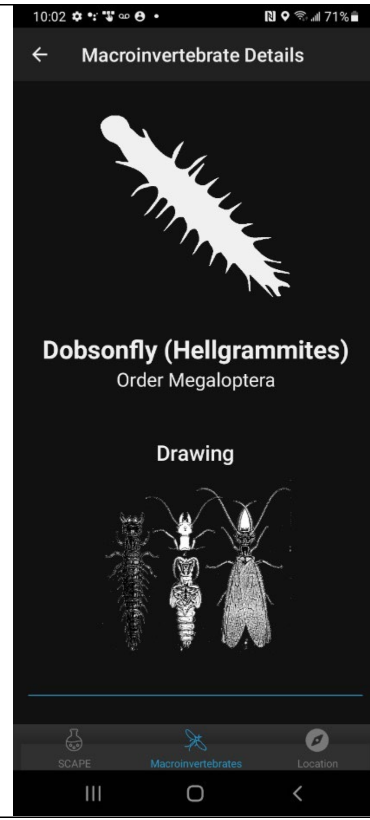


Fig. c. Detail of additional info on one Macroinvertebrate (Dobsonfly).

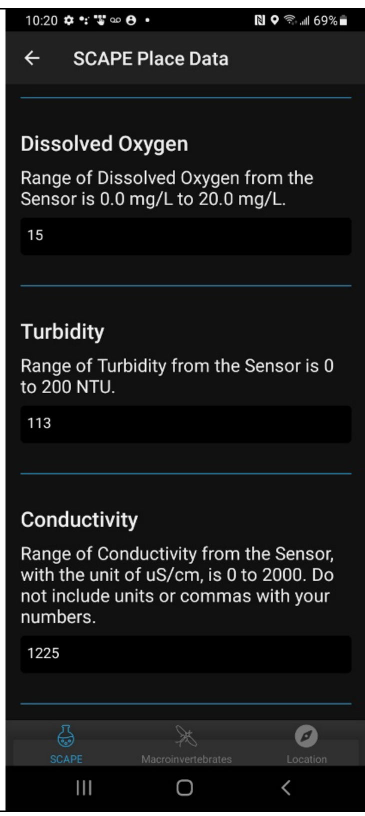


Fig. d. Detail of selected chemical parameters in "dark mode."

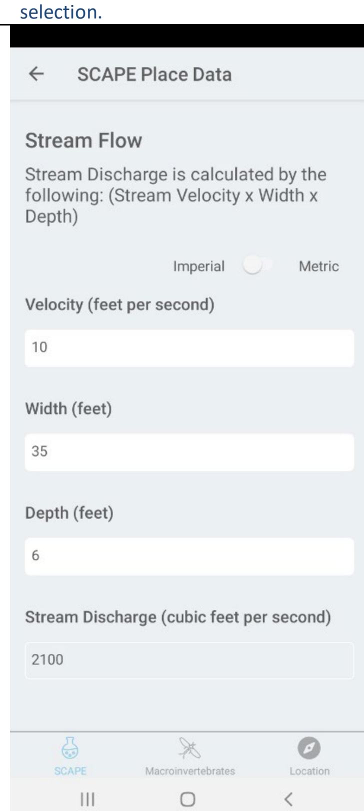


Fig. d. Detail of physical characteristics (Stream Flow) in "light mode."

APPENDICES

X1. PHOTO and IMAGE ARCHIVE

This gallery is a compilation of images by *SCAPE* staff and instructors that reflects work done during *SCAPE* workshops, classroom work at the Orme School with Casey Jones, and field work with students and teachers from Cedaredge, CO; Gunnison, CO; Pinedale, WY, and Ronan, MT.

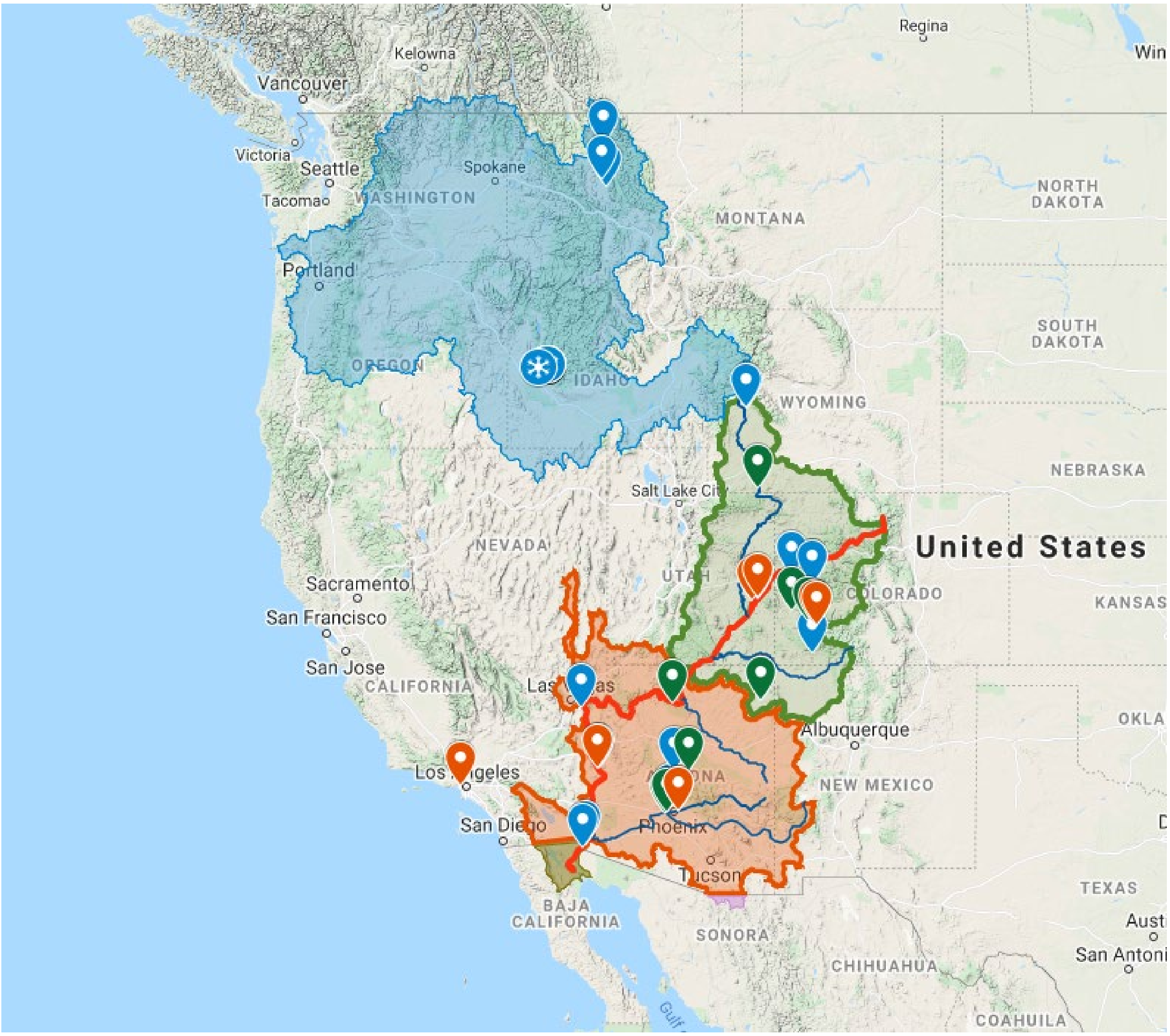


Fig. 1. Map showing combined study areas of SCAPE 1.0 & 2.0. The Blue boundary demarcates the Columbia River watershed; the Green and Orange boundaries demarcate the Upper and Lower sections of the Colorado River watershed. Blue pins designate partner schools.

Fig. 2. SCAPE title page. All project teachers were given both a 3-ring binder and a flashdrive with the entire curriculum. (image: Kaard Bombe)

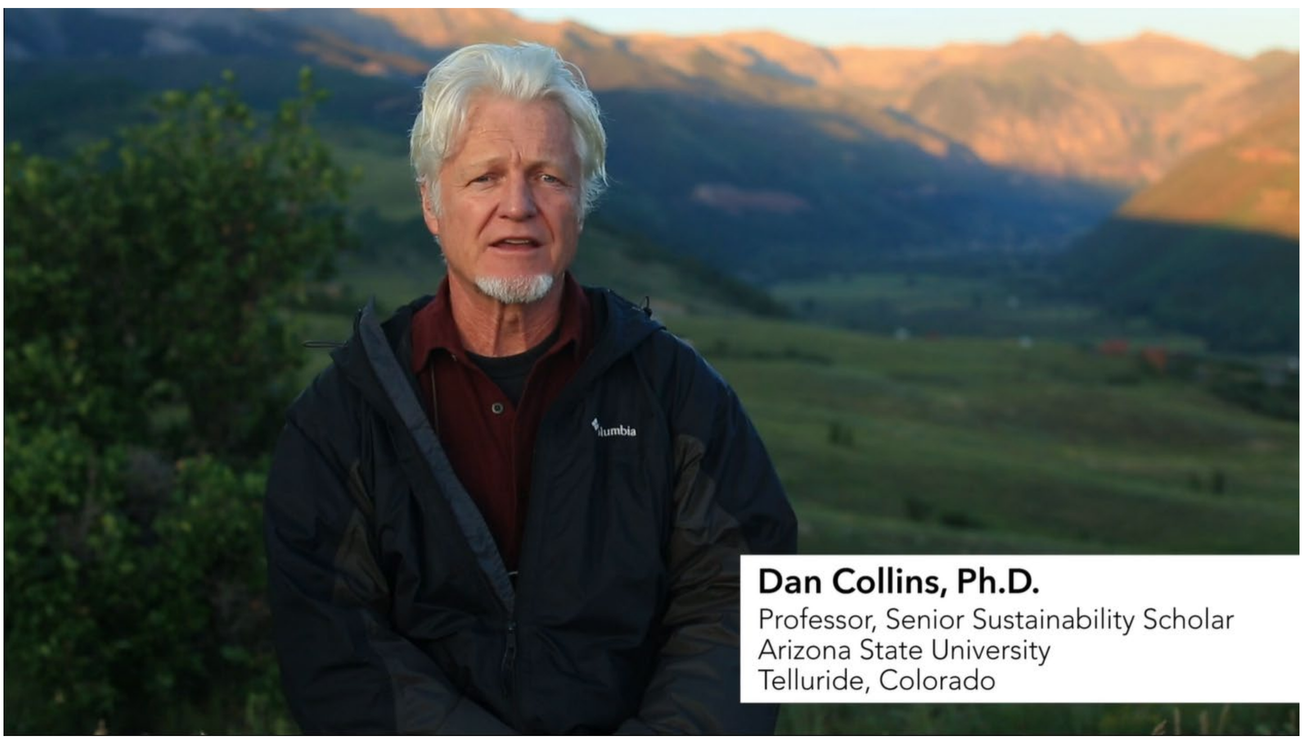


Fig. 3. Dan Collins, *SCAPE* Principal Investigator (image: Kaard Bombe)

Fig. 4. Elena Ortiz (left) and Monica Elser (right), *SCAPE* Core Team members (image: Kaard Bombe)

Fig. 5. Vicki Phelps, Telluride Institute Environmental Education Consultant and *SCAPE* Core Team member. (image: Kaard Bombe)

Fig. 6. Deb Noble, SCAPE project teacher from Pinedale High School, Wyoming. (image: Kaard Bombe)

Fig.7. Vernier pH sensor soaking in buffer solution. (image: Kaard Bombe)

Fig. 8. The confluence of Deep Creek with the San Miguel River via drone photography. (image: Kaard Bombe)

Fig. 9. Looking east above the San Miguel River adjacent to Deep Creek Canyon. (image: Kaard Bombe)

Fig. 10. Field work—recording macroinvertebrates at the confluence of Deep Creek and the San Miguel River (image: Kaard Bombe).

Fig. 11. Collins attempting to get accurate "rate of flow" of Deep Creek with Vernier sensor (image: Kaard Bombe).

Fig. 12. Vicki and Kristen use a D-net to collect macroinvertebrates in Deep Creek (image: Kaard Bombe).

Fig. 13. Renu uses a Vernier sensor to test for dissolved oxygen in Deep Creek (image: Kaard Bombe).

Fig. 14. Recording water chemistry values in student data worksheet at Deep Creek (image: Kaard Bombe).

Fig. 15. Macroinvertebrates! The big bug is a Stonefly nymph (image: Kaard Bombe).

Fig. 16. Vicki and Dan confer about macroinvertebrates at Deep Creek (image: Kaard Bombe).

Fig. 26. High level discussion about methods for calculating streamflow (discharge) (image: Kaard Bombe, 2017).

Fig. 17. Kick-net detail (image: Kaard Bombe).

Fig. 18. Renu uses a “tree height gauge” as part of the Riparian Habitat lesson (image: Kaard Bombe).

Fig. 19. Elena sets up a 100 foot transect for the Riparian Habitat lesson (image: Kaard Bombe, 2017).

Fig. 20. Chris, Elena, and Kevin use dichotomous keys to identify macroinvertebrates at Deep Creek. (image: Kaard Bombe)

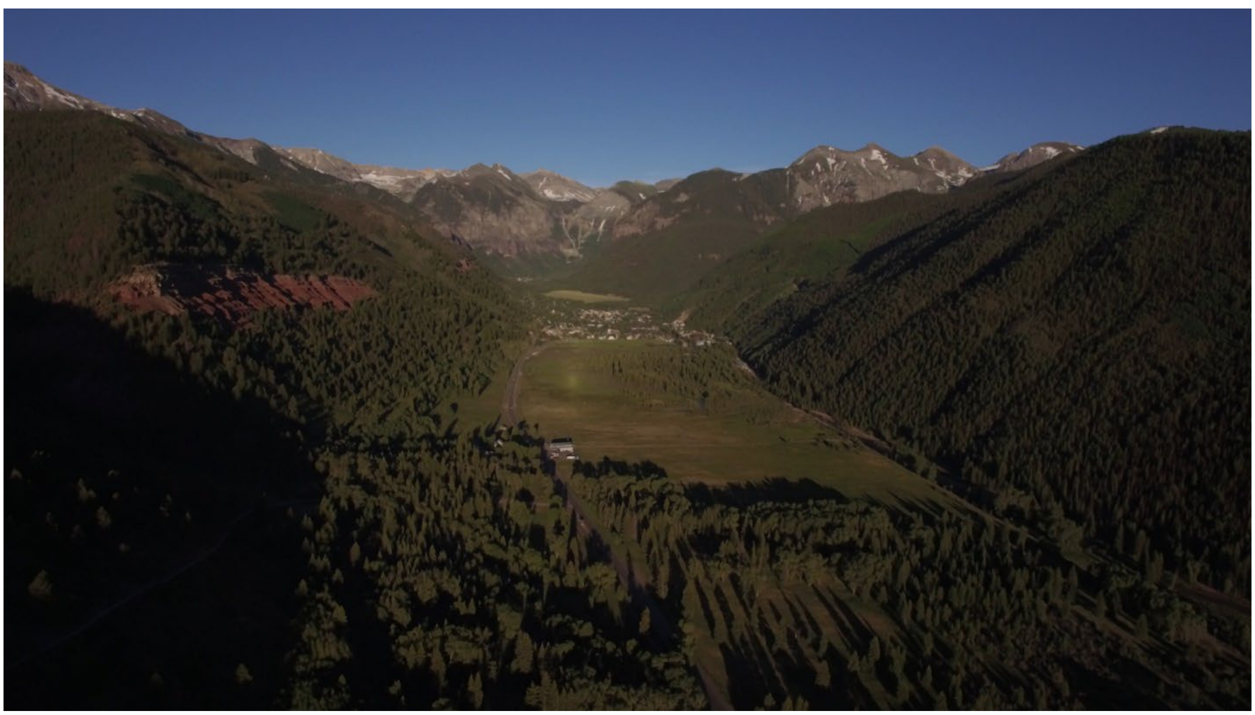


Fig. 21. Looking east towards Telluride from Mill Creek via drone camera (image: Kaard Bombe).

Fig. 22. Looking east above San Miguel River towards Telluride via drone photography (image: Kaard Bombe)

Fig. 23. Deep Creek (image: Gerhard Bombe).

Fig. 24. Rafters on the San Miguel River (image: Gerhard Bombe).

Fig. 25. Large homes on Deep Creek mesa (image: Gerhard Bombe).

Fig. 26. Telluride from Deep Creek mesa (image: Gerhard Bombe).

Fig. 27. Large private estates at entrance to Mountain Village above Telluride. Note golf course in lower foreground. The ski area recently expanded into "Prospect Basin," the area above treeline (image: Gerhard Bombe).

Fig. 28. Sunshine and Mt. Wilson (14,250 feet) (image: Gerhard Bombe).

Fig. 29. Kaard Bombe at work (image: Gerhard Bombe).

Fig. 30. Elk on Telluride Valley Floor (image: Gerhard Bombe).

Fig. 31. SUP (Stand Up Paddleboard) on the San Miguel River where it flows through the Town of Telluride (image: Gerhard Bombe).

Fig. 32. Casey Jones introduces his students to water quality testing processes using an artificial stream in his lab at the Orme School. (Image: Kaard Bombe)

Fig. 33. Detail shows LabQuest handheld computer developed by Vernier. The unit provides real-time data from various digital probes used to capture water quality parameters. This system is being used by students in the field to test water quality at various collection sites across the Mountain West for the *SCAPE* project. (Image: Kaard Bombe)

Fig. 34. Detail shows the digital probes used for measuring temperature, dissolved oxygen, and pH in an artificial stream at the Orme School. (Image: Kaard Bombe).

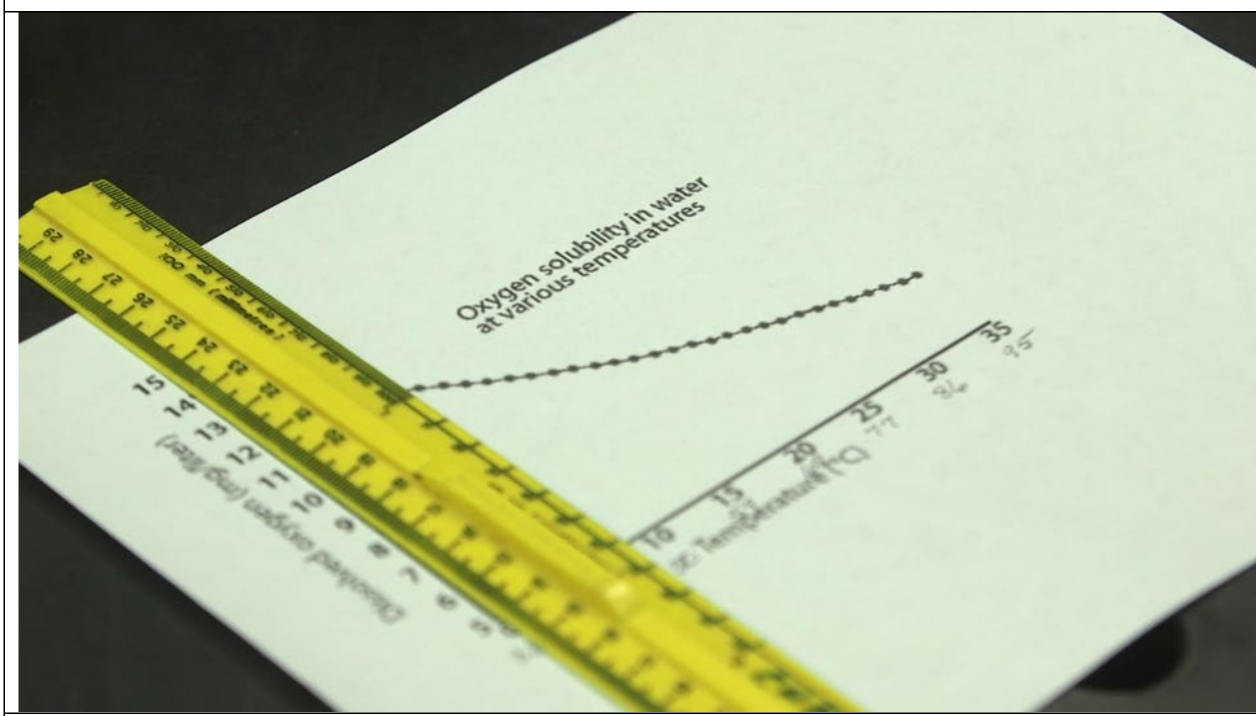


Fig. 35. Graph of Oxygen solubility used by Casey Jones at the Orme School. (Image: Kaard Bombe).

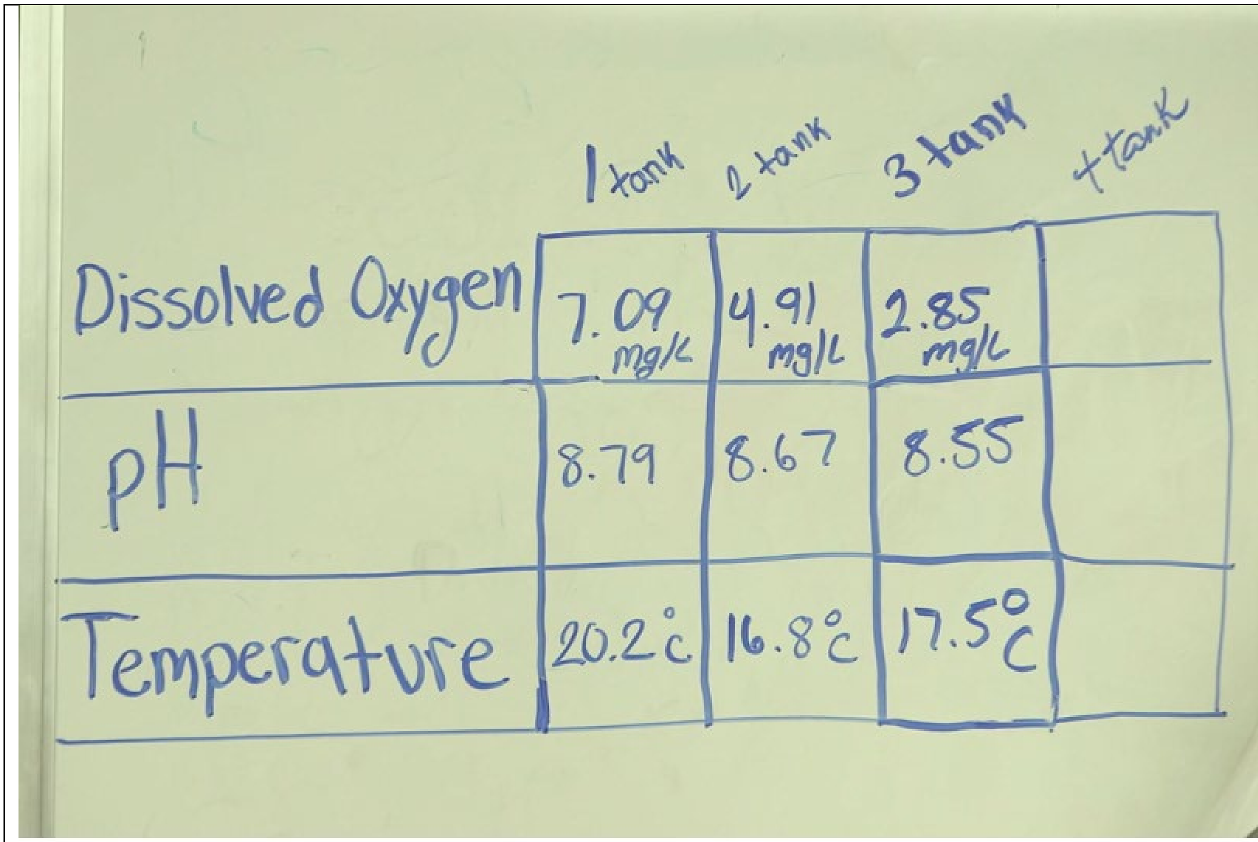


Fig. 36. Tabulation of data derived from Vernier digital probes at the Orme School.

Fig. 37. “So, one of the reasons when you see fish belly up (could be due to lack of dissolved oxygen in the water)?”

Fig. 38. One Orme School student's responses to the prompts "What is a Sustainable Community" and "What are the benefits of a Place-based Education?" (photo: Kaard Bombe).

Fig. 39. Gunnison High School students in search of Macroinvertebrates. Sept. 2019. (photo: Krystal Brown).

Fig. 40. Gunnison High School student and macroinvertebrate collection equipment. Sept. 2019. (photo: Krystal Brown).

Fig. 41. Ice cube trays used for macroinvertebrate collection and sorting. Sept. 2019. (photo: Krystal Brown).

Fig. 42. Left: Gunnison high school students determine streamflow in Tomichi Creek, September 2019.
Fig. 43. Right: Krystal Brown, Gunnison high school science teacher. (Photo credits: Krystal Brown).

Fig. 44. Snow science with Vicki Phelps, students, and avalanche experts at Lizard Head Pass south of Telluride, Colorado.

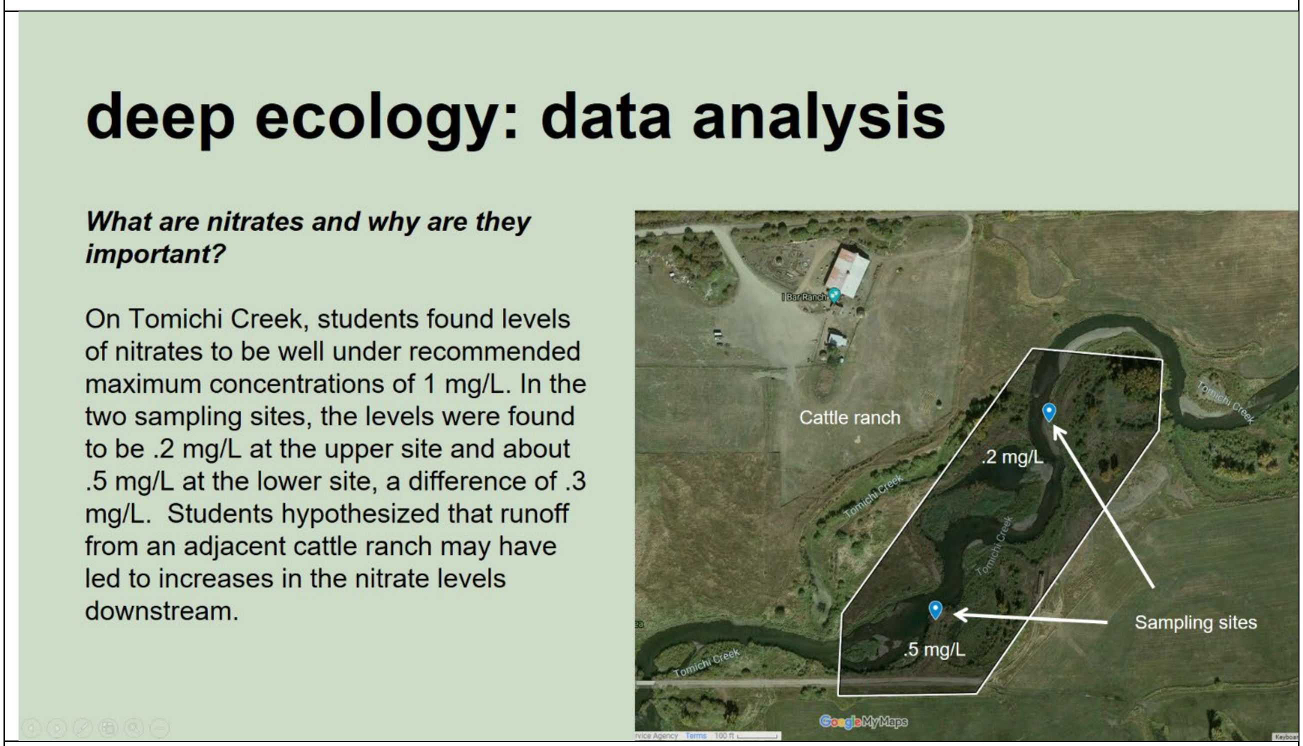


Fig. 45. Slide from Krystal Brown's NAAEE presentation showing mapping of results of student fieldwork near Gunnison Colorado.

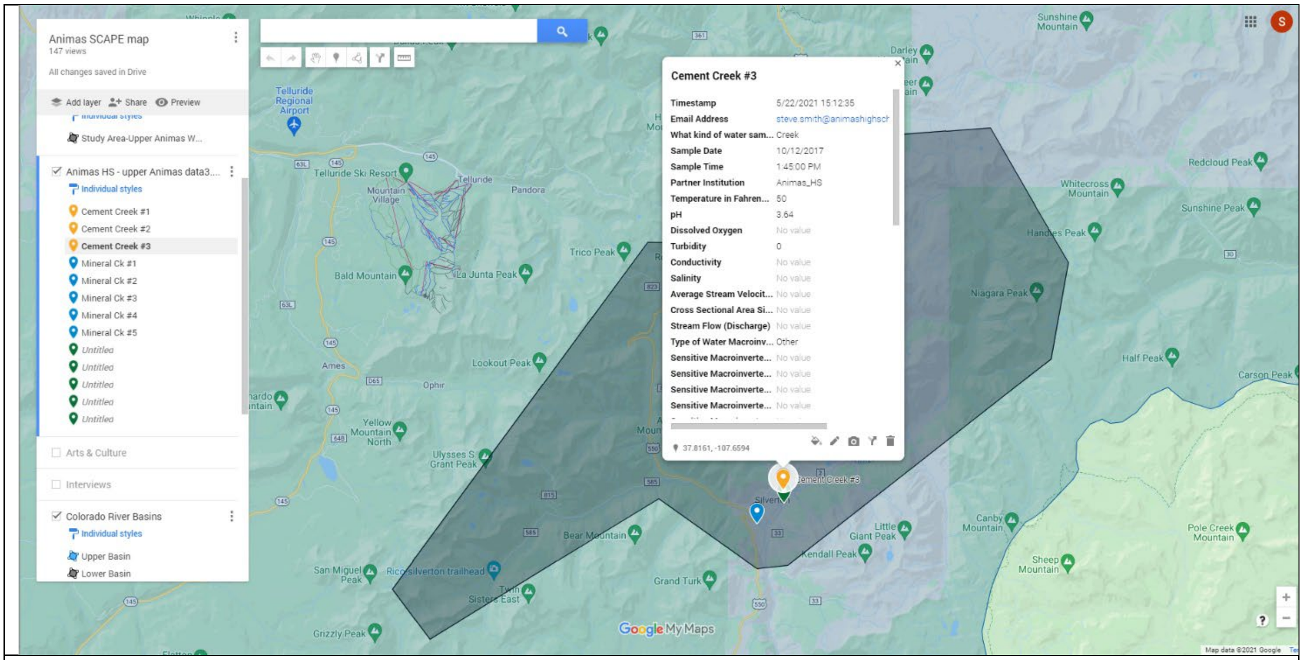


Fig. 46. Slide from NAAEE presentation showing mapping by Animas High School students of pH and heavy metal concentrations in the upper Animas River basin near Durango, CO.

Fig. 47: Gunnison high school student with Mayfly nymph. Sept. 2019. (Photo credit: Krystal Brown).

Fig. 48: Gunnison high school students with keying out macroinvertebrates on Tomichi Creek. Sept. 2019. (Photo credit: Krystal Brown).

Fig. 49: Collecting macroinvertebrates on Tomichi Creek. Sept. 2019. Note variation in crayfish size. (Photo credit: Krystal Brown).

Fig. 50. Dragonfly nymph on Tomichi Creek near Gunnison, CO (Photo credit: Krystal Brown).

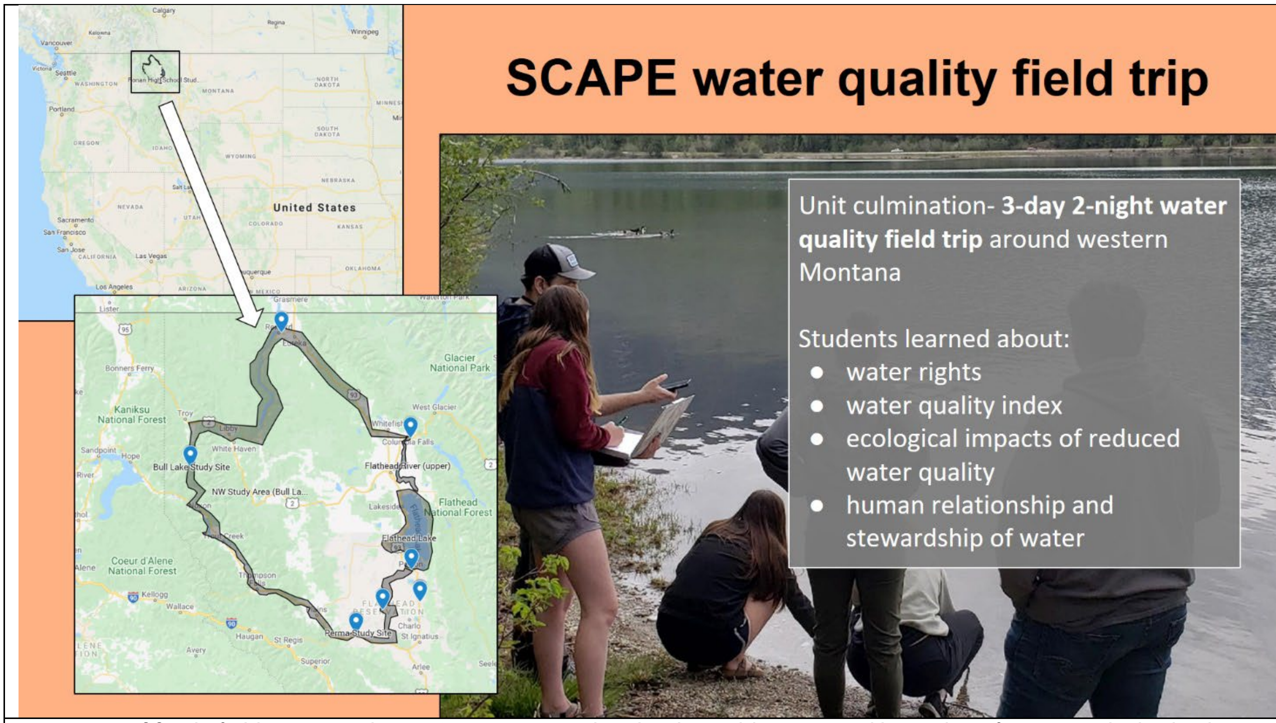


Fig. 51. A 700 mile field trip around NW Montana was undertaken by Jedd Tougas and his students from Ronan high school, Montana (Photo and map credits: Jedd Tougas).

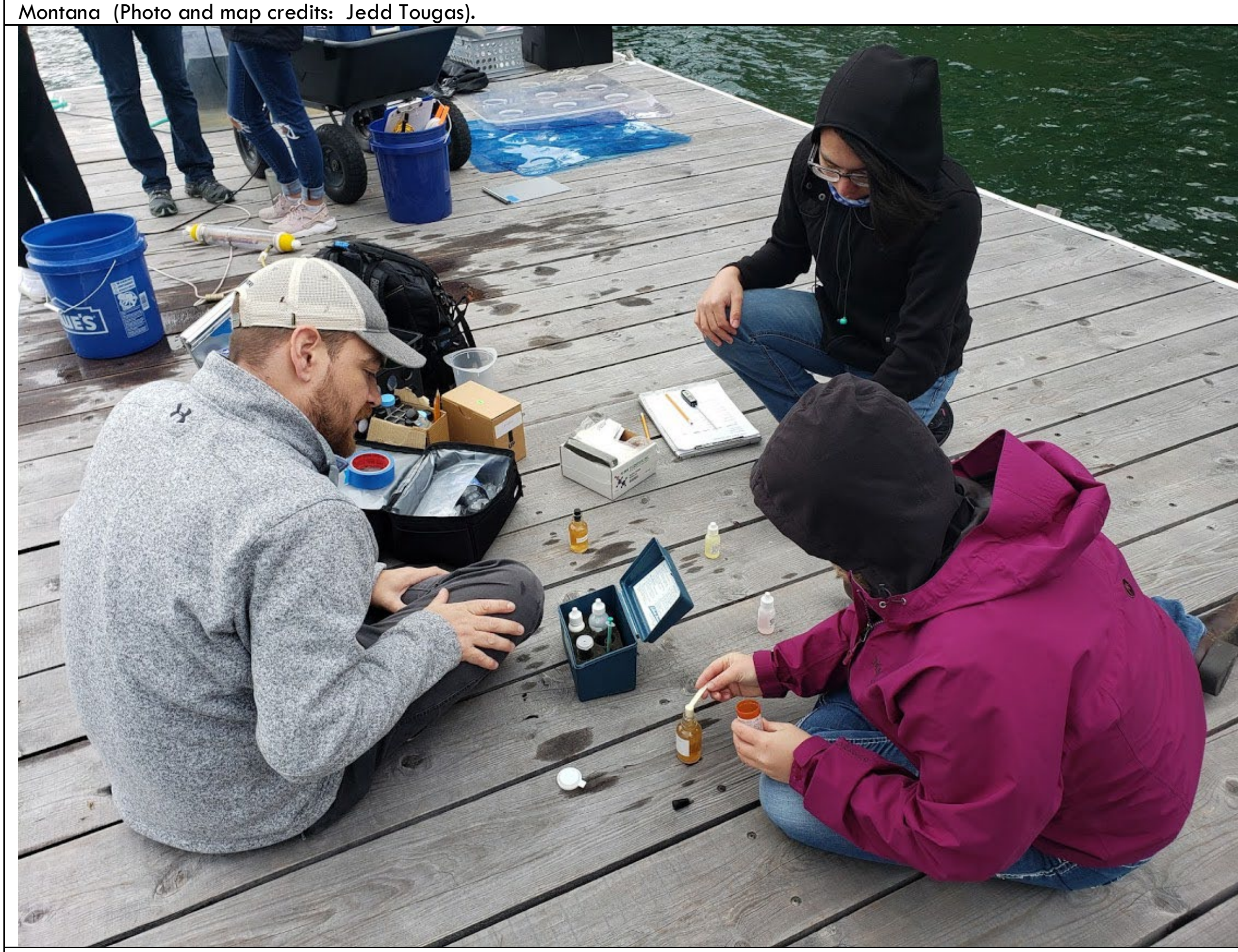


Fig. 52. Ronan High School science teacher Jedd Tougas with his students at Flathead Lake Bio Station. (Photo credit: Monica Elser).

Fig. 53. Lake Honoring Ceremony by Confederation of Salish and Kootenai Tribes at Flathead Lake, MT. The circle of indigenous folks are engaged in a drumming and singing ceremony. (Photo credit: Dan Collins).

Fig. 54. Snow science near Flathead Lake in Montana with Ronan High School students. (Photo credit: Jedd Tougas).

Fig. 55. Kevin Dunbar, SCAPE project teacher from Cedaredge High School, Colorado, indicates the location of his high school and water quality study area for the SCAPE project using Google "My Maps." (image: Kaard Bombe).

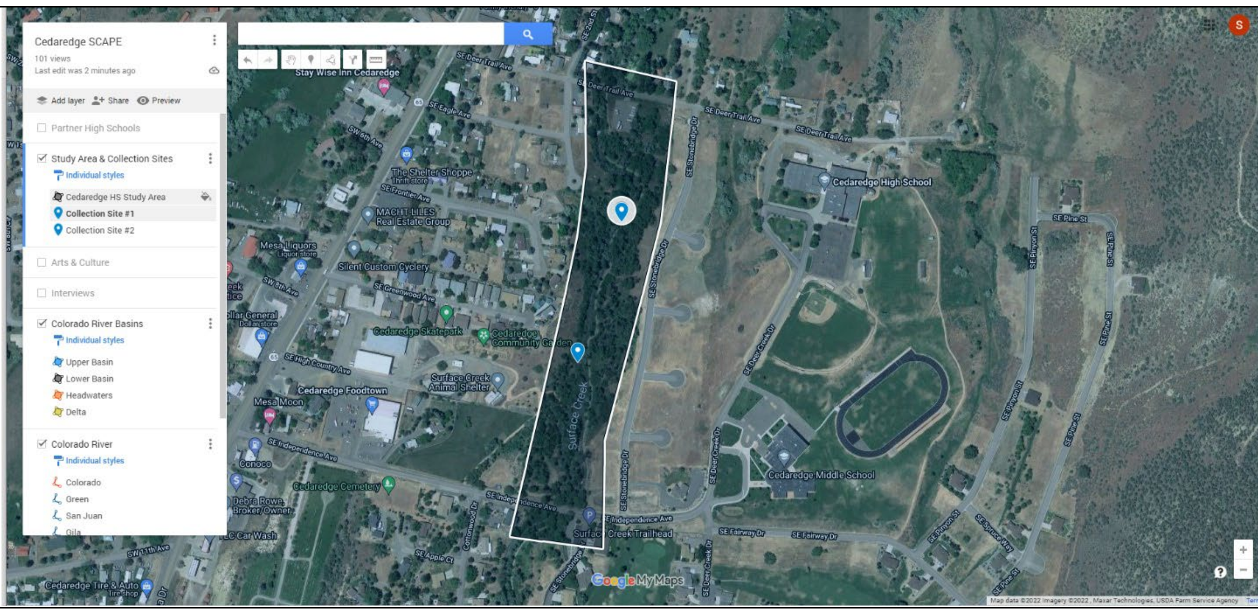


Fig. 56. Google map showing initial *SCAPE* study area on Surface Creek for Cedaredge High School, Colorado with pins for collection sites. Note proximity to the high school in the upper right of the photo. The creek was just a short walk from the school.

Fig. 57. Science teacher Kevin Dunbar from Cedaredge high school in SW Colorado and Vicki Phelps from the Telluride institute introduce students to a water chemistry exercise on Surface Creek. (Photo credit: Dan Collins).

Fig. 58. Cedaredge high school students using a Vernier sensor to sample Dissolved Oxygen. (Newer instruments are wireless allowing for untethered readings from 30 feet away). (Photo credit: Dan Collins).

Fig. 59. Cedaredge high school students using a Vernier sensor to sample temperature. (Photo credit: Dan Collins).

X2. EQUIPMENT LIST

DIGITAL WATER QUALITY TEST EQUIPMENT (typical kit for each partner school)

Notes	Description	Unit Price "wired"	Unit price "wireless"
	WATER QUALITY WITH VERNIER	48.00	48.00
	VERNIER LabQuest2	329.00	329.00
	STAINLESS TEMP SENSOR	28.13	
	STAINLESS TEMP SENSOR (Go Direct wireless)*		59.00
	PH SENSOR (wired)	79.00	
	PH SENSOR (Go Direct wireless)*		79.00
	OPTICAL DISSOLVED OXYGEN SENSOR**	299.00	299.00
	CONDUCTIVITY SENSOR (wired)	95.00	
	CONDUCTIVITY SENSOR (Go Direct wireless)*		89.00
	TURBIDITY SENSOR**	108.64	108.64
	FLOW RATE SENSOR**	129.00	129.00
Wireless link converts standard wired sensors.	Go Wireless Link (includes charging cable)	89.00	89.00
School choice?	One Sensor chosen by school.		
	LABQUEST VIEWER SOFTWARE	79.00	79.00
	Shipping (pro rata)	12.90	12.90
Total "wired"		**$1296.67**	
Total "wireless"			**$1321.54**

*Choose either the "wireless" version (which uses Bluetooth) or the "wired" version. Currently, the "Go Direct" wireless does not communicate with the LabQuest2 Interface (PDA)…but it should in coming months. It does connect directly with Labquest Viewer software enabled tablet or laptop.
**Wireless option not yet available

TRADITIONAL WATER QUALITY TEST EQUIPMENT

Hach Scientific Supply				
Notes	**Description**	**# of units**	**Unit Price**	**Total Price**
	Test Kit, Stream Survey	1	395.00	395.00
	pH paper (pk/5)	1	12.19	12.19
Seems high.	Shipping		41.67	41.67
HachTotal			**$448.86**	**$448.86**

MACROINVERTEBRATE COLLECTION KIT

Ben Meadows Scientific Supply				
Measurement	**Instrument or Material**	**# of units**	**Unit Price**	**Total Price**
Water sample collection	1 cases (24 count) 250 ml plastic bottles.	1	6.37	6.37
Aquatic or terrestrial vegetation / Algae collection	Amber Narrow-Mouth Safety- Coated Glass Bottles 24 per case = 140.10	1	14.01	14.01
Aquatic or terrestrial vegetation / Algae collection	Foam-Backed PTFE-Lined Phenolic Caps (12 count)	1	1.96	1.90
Safety Equipment	Latex Gloves. 100 per box.	1	8.79	8.79
Safety Equipment	Safety Glasses, Uncoated, Clear, 12/Box	1	20.89	20.89
Macroinvertebrate collection	Complete Bottom Kick Net - 40in handle, Nitex, 500µm.	1	187.50	187.50
Macroinvertebrate collection	Aquatic Invertebrate Lab Kit	1	333.50	333.50
	Sampling Kit contains:			
	•Twelve (12) Small white "critter pickin (TM)" pans (182-F20)			
	•Twelve (12) Forceps (7905-T10)			
	•Sink sieves (184-A15), pack of 6			
	•Plastic vials (7912-P50), 48 count			
	•Twelve (12) Clear plastic rulers (039030) for measuring specimens			
	•Twelve (12) Hand Lenses (78-520)			
	•Teasing needles (7905-T24), pack of 12			
	•Set of comprehensive teacher instructions			
	•Twelve (12) Insect ID sheet (039020) with instructions			
Ben Meadows Total				**$572.96**

TOTAL Expenses per Vendor

Vendor Totals	**Description**			**Total Price**
Vernier	Digital Water Quality Test Equipment Equipment (suggested)			1400.00
Hach	Traditional Water Quality Test Equipment			448.86
Ben Meadows	Macroinvertebrate Collection Kit			572.96

Grand TOTAL	Estimated total may vary depending on your choice of Vernier Sensors. Also, Hach equipment NOT necessary for implementation of SCAPE curriculum. For the purposes of budget tracking, reserve at least $2500 in your budget for equipment.			**$2421.82**

$344.28 is budgeted for each school to conduct one field trip; Mileage = ~100 miles @ $0.445/mi., meals @ $12 ea. for 25 students. (Note: actual mileage & meal costs may vary from school to school, but no sub-grant shall exceed the $5,000 limit).

Overhead for each school is budgeted at 10% per the RFP.

For further information, contact Dan Collins (PI), dan.collins@asu.edu / 480-206-2037

X4. Curriculum (Summary from Google Workspace).

For full curriculum (requires login): https://sites.google.com/a/coloradoriverscape.org/units/home

Overview of the Curriculum

SCAPE (Sustainable Communities and Place-based Education) is an environmental education project that combines online learning with field observations linked to "living classrooms" across the Mountain West. It encompasses the two largest watersheds in the American West—The Colorado River Basin and the Columbia River Basin. The program builds on EPA recognized environmental education (EE) curriculum design guidelines (e.g., Simmons et al, 2004) and workshops (Vital Signs, 2012), and provides opportunities for science teachers to learn both the science of water quality and best practices for EE. *SCAPE*-trained teachers introduce high school students to stream and river hydrology, methods for measuring in-stream flow, and techniques for testing water quality. The program provides specific training in EE pedagogy as related to real-world problems—in particular, water quality and supply—and will give our partner teachers the tools and methods to move from knowledge to action.

Unit 1: *Preparation.* In class, students engage readings in environmental history, policy, and ethics, with special emphasis on water across the Mountain West. They use pre-defined *SCAPE* maps to investigate a stretch of river near their school and use the *SCAPE* custom interface (text mark-ups, points, and polygons) for their living classroom. Students develop hypotheses regarding water quality above and below their chosen site, and use local sources (photographs, oral histories, data from local water boards or USGS databases) to understand historical flows, key water quality parameters, and uses of the river. Household water use logs help students quantify personal use and identify the pollutants they discharge. Students create a model of how individual water use contributes to community and regional water use, and utilize the model to demonstrate how individual actions may affect the regional water supply.

Unit 2: *Field Work.* On their river site, students make observations, measure water flow, measure chemical and physical water quality, and survey biological indicators (microorganisms and macro-invertebrates) of water quality at sites above and below their hypothesized source of pollution, as developed with online maps. With the help of trained teachers, students conduct standard water quality measurements using both traditional and digital instruments to evaluate basic water quality parameters (e.g., temperature, salinity, water clarity, and pH, as well as chemical species such as dissolved oxygen and nitrates).

Unit 3: *Analysis.* All water quality data, photos of identified insects and water samples, hand-drawn illustrations, and field notes are uploaded to the *SCAPE* website via custom forms. This data is automatically translated into Google Spreadsheets and posted to a secure website. Measurements and observations are verified by water quality and bio-indicator specialists. In collaboration with their teachers and *SCAPE* personnel, students use geo-coordinates, water quality, flow, and observed organisms to create their own hyperlinked Google map to visualize the data. They then compare and evaluate the data and identify pollution sources from their sites and those from other living classrooms across the region.

Unit 4: *System-wide Understandings.* By looking at all of the living classrooms across the Mountain West, students develop an understanding of system-wide river water quality, security, and supply issues—our shared commons. Each school decides on an action to take, such as planning a water-related stewardship project with a local farmer, agriculture specialist, natural resource professional or member of the community, and posts their solutions and reports their progress on the customized "cloud" website developed specifically for *SCAPE*.

These materials have been developed to connect with students and teachers both broadly and deeply. Information and skillsets important to understanding water across the Mountain West—as an integrated system—are paired with objectives that address the particulars of different local conditions. While all students engage foundational issues such as history, hydrology, water chemistry, riparian ecology, etc., partner schools will also receive custom-tailored curricular materials that address the issues most pertinent to their "backyard."

Grade Level

These materials target students in grades 9 – 12. Many activities require no prior experience. A select number of lessons focus on water chemistry and other skill-sets that require prior knowledge in specific STEM skills (e.g., chemistry, math).

State and National Standards

Given the evolving situation with state and federally approved standards for STEM, Math, and Literacy education, the project team has provided a document for each Unit indicating the relevant, Next Generation Science Standards, Common Core Math, and Common Core Literacy standards. The lessons in each Unit build upon each other, so completing the entire Unit will meet many requirements. Additionally, some of these lessons can be used in fulfillment of social studies requirements in individual states. Environmental Literacy standards are also interwoven into these lessons following these core key principles:

Systems

Systems help make sense of a large and complex world. A system is made up of parts. Each part can be understood separately. The whole, however, is understood only by understanding the relationships and interactions among the parts. Earth is a complex system of interacting physical, chemical, and biological interlinking processes. Organizations, individual cells, communities of animals and plants, and families can all be understood as systems. And systems can be nested within other systems.

Human Well-being

Human well-being is inextricably bound with environmental quality. Humans are a part of the natural order. We and the systems we create—our societies, political systems, economies, religions, cultures, technologies—impact the total environment and are impacted by the environment. Since we are a part of nature rather than outside it, we are
challenged to recognize the ramifications of our interdependence with Earth systems.

Diversity, Equity, and Inclusion

Environmental education instruction is inclusive, respectful, and equitable, and designed to employ the talents of people with different backgrounds, experiences, and perspectives.

The importance of where one lives

Beginning close to home, learners forge connections with, explore, and understand their immediate surroundings. The sensitivity, knowledge, and skills needed for this local connection provides a base for moving out into larger systems, broader issues, and an expanding understanding of causes, connections, and consequences.

Roots in the real world

Learners develop knowledge and skills through direct experience with the environment, current environmental issues, and society. Investigation, analysis, and problem solving are essential activities and are most effective when relevant to the real world.

Integration and infusion

Disciplines from the natural sciences to the social sciences to the humanities are connected through the medium of the environment and environmental issues. Environmental education offers opportunities for integration and works best when distributed across the curriculum, rather than being treated as a separate discipline or subject area.

Lifelong learning

Critical and creative thinking, decision making, and communication, as well as collaborative learning, are emphasized. These skills are essential for active and meaningful learning, both in school and over a lifetime.

Sustainability

Learning is future-oriented, focused on environmental, social, and economic responsibility as drivers of individual and institutional choices.1

Integration with Existing Curricula

Question for each SCAPE teacher: How do these materials complement, integrate, substitute for existing environmental studies coursework? There is no expectation that these materials will be used in their totality. Rather, we see individual teachers selecting those lessons and activities they deem most appropriate for their existing situation.

Document Navigation

Guidance on navigating this .pdf document are found in Technology and Document Navigation Notes p.277

Activity Format

(viz., Howe & Howe, 2005. This format borrows in large part from *Discover a Watershed*: The Colorado, pp. XII - XIII)

Summary

A brief introduction to the lesson and a description of the concepts and skills learned during the activity.

Learning Outcomes

The qualities or skills students should possess after participating in the activity. NOTE: Both learning and behavioral objectives should be addressed.

Materials

Supplies needed to conduct the activity. NOTE: Each SCAPE partner school is provided with the necessary equipment and supplies to successfully present a given activity to the students.

Background

Preparatory information about context, activity concepts, or teaching strategies.

Procedure - Warm Up

Prepares everyone for the activity and introduces concepts to be addressed. Provides the instructor with pre-assessment strategies.

The Activity

Provides step-by-step directions to address concepts. NOTE: Some activities are organized into “parts.” This divides extensive activities into logical segments. All or some of the parts may be used, depending on the objectives of instruction. In addition, a few activities provide “options.” These consist of alternative methods for conducting the activity.

Wrap Up

Brings closure to the lesson and includes questions and activities to assess student learning.

Assessment

Presents diverse assessment strategies that relate to the objectives of the activity, noting the part of the activity during which each assessment occurs. These often suggest ideas for assessment opportunities that follow the activity. Traditional rubrics are provided for certain lessons.

Extensions

Provide additional activities for continued investigation into concepts addressed in the activity. Extensions can also be used for further assessment.

Resources & e-Links

Lists references providing additional background information including links to Websites with relevant information for further study. An extensive Glossary is included.

Academic Standards

Correlation with NGSS (Next Generation Science Standards).
For example:
HS-LS2.C Ecosystem Dynamics, Functioning and Resilience
HS-ESS2.C The Role of Water in Earth's Surface Processes HS-ESS2.D Weather and Climate
HS-ESS3.A Natural Resources
HS-ESS3.C Human Impacts on Earth Systems HS-ESS3.D Global Climate Change

EPA SCAPE2 Program Evaluation Report

Arizona State University

Summative Survey Findings
November 2021

University Office of Evaluation and Educational Effectiveness

Contents

EXECUTIVE SUMMARY

- To evaluate perceived impacts of the SCAPE2 program, the University Office of Evaluation and Educational Effectiveness (UOEEE), in collaboration with Dr. Collins (the PI), developed a retrospective summative survey during Fall 2021.

- Most survey participants taught up to 20 lessons, although a few individuals were involved in the project in different capacities than teaching.

- Participants reported implementing the SCAPE2 curriculum in grade levels 3rd through 12 in nine high schools and in colleges/institutions across Colorado, Wyoming, and Montana.

- Respondents implemented four particular lessons more frequently than they did other lessons. Those included: lessons *"**2.4 Macroinvertebrates**," "**2.2 Streamflow=Volume x Velocity**,"* "***2.3 Water Characteristics and Chemistry***," and *"**2.1 Riparian and Habitat Diversity**."*

- Survey participants highlighted the curriculum's various strengths, including simple lesson plans with straightforward directions; online access to the curriculum and other readily-available information; content that balances science and social studies in ways that integrate 21st Century cognitive skills and technologies; engaging students in the science field and helping them understand the role of water in communities.

- Participants identified the main areas of weakness for the SCAPE2 curriculum as issues related to technology (data sharing, working on cloud platforms); lesson format (pdf, google sheets); lack of supporting materials such as videos; and the COVID pandemic limiting curriculum implementation.

- The majority of respondents felt that the SCAPE2 lessons were "Effective" or "Very effective," and further highlighted positive aspects of the curriculum. These included the curriculum's flexibility to accommodate diverse classroom settings, simplicity and straightforwardness, and accessibility to students' data by other schools in the Colorado drainage basin.

- Most respondents felt that the blend of the "online" and "hands-on" experiences were "Effective" or "Very effective," further explaining that the blended format was both easy for teachers and beneficial to students.

- Some participants faced challenges related to finding an interesting location to study; time and resources for fieldwork or to implement the lessons; preparing for teaching the lessons; and a lack of staff to implement the curriculum.

- All respondents reported being "Satisfied" or "Strongly satisfied" with the curriculum. They further explained that the curriculum served students and teachers in great ways, providing them with knowledge and resources that were easily accessible and easy to implement.

- Several participants provided suggestions for improvement, such as incorporating samples of student work in the lessons and tutorials for some topics; using the 5e model of instruction for lessons and integrating Next Generation Science Standards (NGSS) in the curriculum; and creating workable google docs to allow easy access to materials.

PROJECT OVERVIEW

SCAPE *(Sustainable Communities and Place-based Education)* is a pilot community-based science education project combining online learning and field observations. The project is linked to high schools across seven western states. Initially funded by the EPA in 2016 with a $192K grant, the project utilizes recognized environmental education (EE) curriculum design guidelines and workshops and provides opportunities for science teachers to learn both the science of water quality and best practices for EE. SCAPE-trained teachers introduce students to the hydrology of the CR System, methods for measuring in-stream flow, and techniques for testing water quality. Resources are provided to promote computer literacy, environmental history, policy, and ethics, with special emphasis on “water in the West.” SCAPE incorporates state and national education standards and can be used to augment existing teaching plans. The program uses EE pedagogy to create lessons related to real-world problems, namely pertaining to water quality and supply, and provides the partner teachers with tools and methods to help them move from knowledge to action.

The first iteration of the SCAPE curriculum (August 2016 through June 2018) focused on the Colorado River and several of its tributaries, enlisting participation from 10 high schools across Arizona, Utah, Nevada, Colorado, and Wyoming. The program received a second grant (for about 50% of the original $192K) to extend the program across the Intermountain West. The current program (SCAPE2) serves five high schools across Colorado, Wyoming, and Montana.

During the 2018-2019 academic year, the original SCAPE curriculum was refined (as SCAPE2) to incorporate evaluative feedback from the 2016-2018 period. Comprised of seventeen lessons, the curriculum initially introduced students to the history and health of the Colorado River system, procedures for sampling and testing the river’s water quality, methods for measuring in-stream flow, techniques for gathering and identifying species living in the river, and strategies for identifying potential sources of pollution across the Colorado River (CR) Basin. Later lessons introduced computer-based methods of storing, analyzing, and visualizing data gathered in the course of doing fieldwork. With the help of SCAPE faculty and the Core team, the curriculum has been expanded to encompass a much broader geographic area, and thus provide more widespread high school education in the areas of environmental ethics, community mapping, and occupational training.

Due to the restrictions imposed upon the program by COVID-19 in the spring 2020 semester, PI Collins requested - and was granted - a No-Cost-Extension year. The program picked up again in April 2021. However, because many schools were still operating on a virtual basis, many teachers were not able to implement the SCAPE2 curriculum in their classes as they had originally planned, if at all.

EVALUATION OVERVIEW

The University Office of Evaluation and Educational Effectiveness (UOEEE) at Arizona State University provided monitoring and independent evaluation services during the three-year project period beginning in the fall semester of 2019. This report summarizes evaluation activities and findings for the final (No-Cost Extension) year of the project (2020-2021).

METHODOLOGY

To evaluate perceived impacts of the SCAPE2 program, the University Office of Evaluation and Educational Effectiveness (UOEEE), in collaboration with Dr. Collins (the PI), developed a retrospective summative survey during Fall 2021.

The summative survey contained demographic questions and a set of Likert-scale questions asking participants to indicate the effectiveness of the SCAPE2 curriculum. Respondents were prompted to rate the effectiveness of the blend of online and hands-on experiences as well as respondents' satisfaction with the SCAPE2 curriculum. Participants were further prompted to answer follow-up open-ended questions about their ratings, as well as other open-ended questions, to identify curriculum strengths and weaknesses, and any barriers or challenges they faced while implementing the curriculum. Finally, participants were asked to share any additional comments or suggestions for improvement.

SUMMATIVE SURVEY RESULTS

Demographic Information

Ten of 14 participants in the SCAPE2 program responded to a summative survey administered by the UOEEE during October 2021, for a response rate of 71%. The findings are summarized below.

Lessons Implemented

Survey participants were asked to indicate the number of lessons in which they implemented the SCAPE2 curriculum over the course of the project. As illustrated in **TABLE 1**, six individuals reported having taught between 1 and 20 lessons over the course of the project. However, several respondents indicated being involved in the project in different capacities than teaching. Those included assisting with developing the curriculum or writing lessons, and assisting, advising, or mentoring other teachers. One participant mentioned planning to use the SCAPE2 curriculum in the future.

TABLE 1. Number of SCAPE2 Lessons Implemented

Overall, how many SCAPE2 lessons did you implement over the course of this project? (*n* = 10)
One.
Two or three.
Five.
I did several of the units so perhaps 7-8 lessons. However, they were heavily modified to fit my class.
I implemented 15 of the SCAPE2 lessons in 5 different sections.
Approximately 18 - 20 lessons since the induction of the program.
I assisted with developing curriculum, introduced and assisted teachers with SCAPE2, through field work, and providing resources.
I just advise the high school teachers in my area.

None as we were just added to the project in mid-October of 2021. We plan on using the curriculum in the future.
None, I helped write lessons and mentor other teachers.

Participants were then asked to indicate which lessons they had implemented over the course of the project. Respondents reported implementing four particular lessons more frequently than other lessons. Those included, lesson *"**2.4 Macroinvertebrates**,"* implemented by eight individuals; lessons *"**2.2 Streamflow=Volume x Velocity**,"* and "***2.3 Water Characteristics and Chemistry***," each taught by six participants; and lesson *"**2.1 Riparian and Habitat Diversity**,"* which was implemented by four teachers. The remaining lessons were taught by up to three individuals. Note that some participants reported implementing more than one lesson. Therefore, the frequency of responses exceeds the number of survey participants (**TABLE 2**).

TABLE 2. Participants' Responses to the Survey Question Regarding the Lesson(s) They Implemented

Which lesson(s) did you implement over the course of the project (Select All that apply)	
Lesson Name	***Frequency of Responses***
1.1 Environmental History and the Colorado River Basin	2
1.2 My Map=My Place	3
1.3 Doing Our Part	3
1.4 First Come, First Served	2
1.5 Environmental Ethics and Policy (a)	2
1.5 Environmental Ethics and Policy (b)	2
2.1 Riparian and Habitat Diversity	**4**
2.2 Streamflow=Volume x Velocity	**6**
2.3 Water Characteristics and Chemistry	**6**
2.4 Macroinvertebrates	**8**
2.5 Snow Science	2
3.1 Post Your Data to the Cloud - EZ Form	2
3.2 Using Pivot Tables	1
3.3 Data Visualization	1
3.4 Lab Report	3
4.1 System-wide River Water Quality, Security, and Supply Issues	2
4.2 Awareness to Action	2
4.3 Story Maps	2

Schools & Grade Levels

In addition, participants reported implementing the SCAPE2 curriculum in various grade levels in nine high schools and colleges/institutions across Colorado, Wyoming, and Montana, as shown in **TABLES 3 and 4**, below.

TABLE 3. Participants' School Name

School Name
Animas High School
Cedaredge High School
Flathead Lake Biological Station
Gunnison High School
Paradox Valley School
Phoenix College
Pinedale High School
Ronan High School
The Telluride Institute

While seven participants indicated implementing the SCAPE2 curriculum in grade levels ranging from 3rd through college, two individuals indicated that they did not implement the curriculum at any grade level (note: Most likely these participants worked in different capacities and their duties did not include teaching the curriculum). Another individual also commented having "used the curriculum in high school field science and provided mentoring for teachers" (**TABLE 4**).

TABLE 4. Grade Levels SCAPE2 Curriculum Were Taught

Grade Levels Taught the SCAPE2 Curriculum (*n* = 7)	
Grade Levels	***Frequency of Responses***
3-8	1 (14%)
9-12	1 (14%)
10-12	2 (29%)
11 & 12	2 (29%)
College Level	1 (14%)

Areas of Strength

Moreover, participants were asked to identify the main areas of strength for SCAPE2 curriculum. Seven individuals responded, identifying the curriculum's strength including lesson plans with simple and easy directions to follow and implement; online access to the curriculum and readily available information on phone or computer; content that balances science and social studies and integrates 21st Century cognitive skills and technologies; engaging students in science field and helping them understand the role of water in communities. The full list of participants' verbatim responses follows:

- "I loved that it was a great foundational starting place! Directions were simple and easy to follow for someone with a field data collection background."
- "Information [were] readily available on your phone or computer."
- "It would serve as a great stand-alone inter-disciplinary curriculum. It balances science and social studies well. It also does a good job of integrating relevant 21st Century thinking skills and technologies."

- “Lesson plans were well written and easy to follow and implement with students. There was a broad range of choices where you could incorporate a lot of cross curriculum options such as art, multimedia and writing portions.”

- “Students were engaged in the actual science in the field, as well as developing a greater understanding of the crucial role water plays in our lives.”

- “The place-based activities and fieldwork.”

- “Use of technology (Vernier computer interfaces and probes) to collect data, history and context of water-use in the Colorado River basin through use of maps and documentaries as well as online access to the curriculum (esp[ecially], the maps, articles and documentaries of the environmental history of CO River.”

Areas of Weakness

Participants were also asked to identify the main areas of weakness for SCAPE2 curriculum. Again, seven individuals responded, pointing out to areas mainly related to technology (data sharing, working on cloud platforms); lesson format (pdf, google sheets); lack of supporting materials; and the COVID pandemic limiting curriculum implementation. Participants’ verbatim responses are listed below:

- “I did not love that it was a pdf. Teachers strive to develop, redevelop, and update their curriculum regularly, and a pdf format to start from makes this difficult.”

- “Lessons analyzing and sharing data are more geared for upper level students and take some time to front load on how to work with pivot tables (esp[ecially] for those who have never worked with spreadsheets) and how to work with cloud platforms.”

- “Many of the technology platforms are ever-changing and it is difficult to get students to do meaningful work on them without a significant effort in training.”

- “The COVID pandemic was out of the control of classrooms, but was the most limiting factor in being able to fully apply the SCAPE2 curriculum in some schools.”

- “The Google sheets were sometimes poorly formatted or hard to read.”

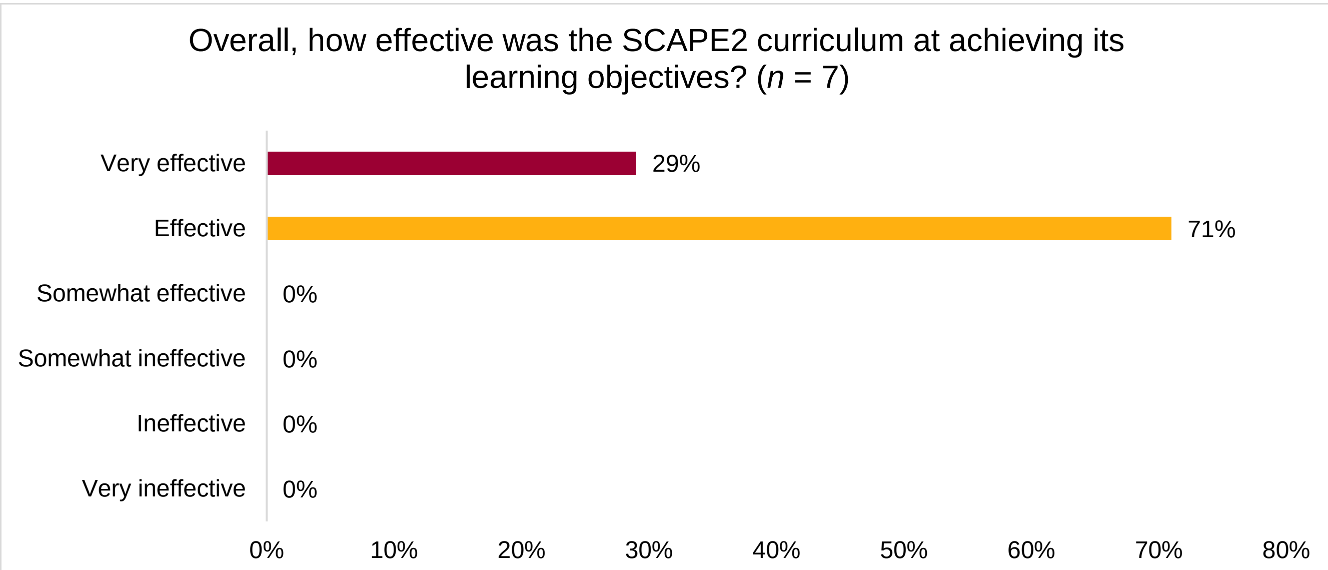
- “The materials could have a few more supports, such as videos or other materials that can be utilized, but overall it wasn't bad in this regard either. Some of the timing of the lessons is a bit tight.”

- “The upload of data to the main website is slightly challenging and not real[ly] easy for students to navigate.”

Effectiveness of SCAPE2 Curriculum

Participants were asked to rate the effectiveness of the SCAPE2 curriculum in achieving its learning objectives, on a scale of 1 “Very ineffective” to 6 “Very effective.” As **FIGURE 1** illustrates, seven individuals responded, indicating that the lessons were “Effective” (71%; *n* = 5) or “Very effective” (29%; *n* = 2).

FIGURE 1. SCAPE2 Curriculum Effectiveness



In an open-ended question, participants were asked to further explain their ratings. Seven individuals responded, with a majority highlighting positive aspects of the curriculum. Specifically, respondents acknowledged its flexibility to be adapted to diverse classroom settings; easy steps to follow macro lessons; accessibility of students’ data by other schools in the Colorado drainage basin, allowing comparisons of water quality; and providing students with a solid foundation and teaching them the importance of environmental stewardship. One individual referred to students’ challenges (e.g., struggle with data analysis and creation of pivot tables), and another respondent stated still learning how to navigate and teach the materials. Participants’ verbatim responses are listed below:

- “Feedback from teachers, who used SCAPE2 with their students was very positive. SCAPE2 curriculum has enough flexibility to be accommodated in diverse classroom configurations.”

- “I found the steps required to follow the macro lesson easy to follow. I particularly appreciated the additional follow up lesson options listed.”

- “I think this style of place-based education is an absolutely essential direction for education to take. Especially environmental education. The real-world data brings to light the significance of the parameters in the environment and gives students the sense necessary to take actions to protect our planet now. It truly captivates moving from knowledge to action.”

- “It was great to be able to show students that their data was accessible to other schools in the Colorado drainage basin and it was great to be able to compare the same water quality indicators.”

- “Students are engaged and learn the importance of environmental stewardship through historical concepts surrounding the use of water in the CO River basin, as well as through field sampling of water quality parameters through the use of technology. Students struggle with data analysis and the creation of pivot tables using spreadsheets and navigating the process to upload that data to cloud platforms.”

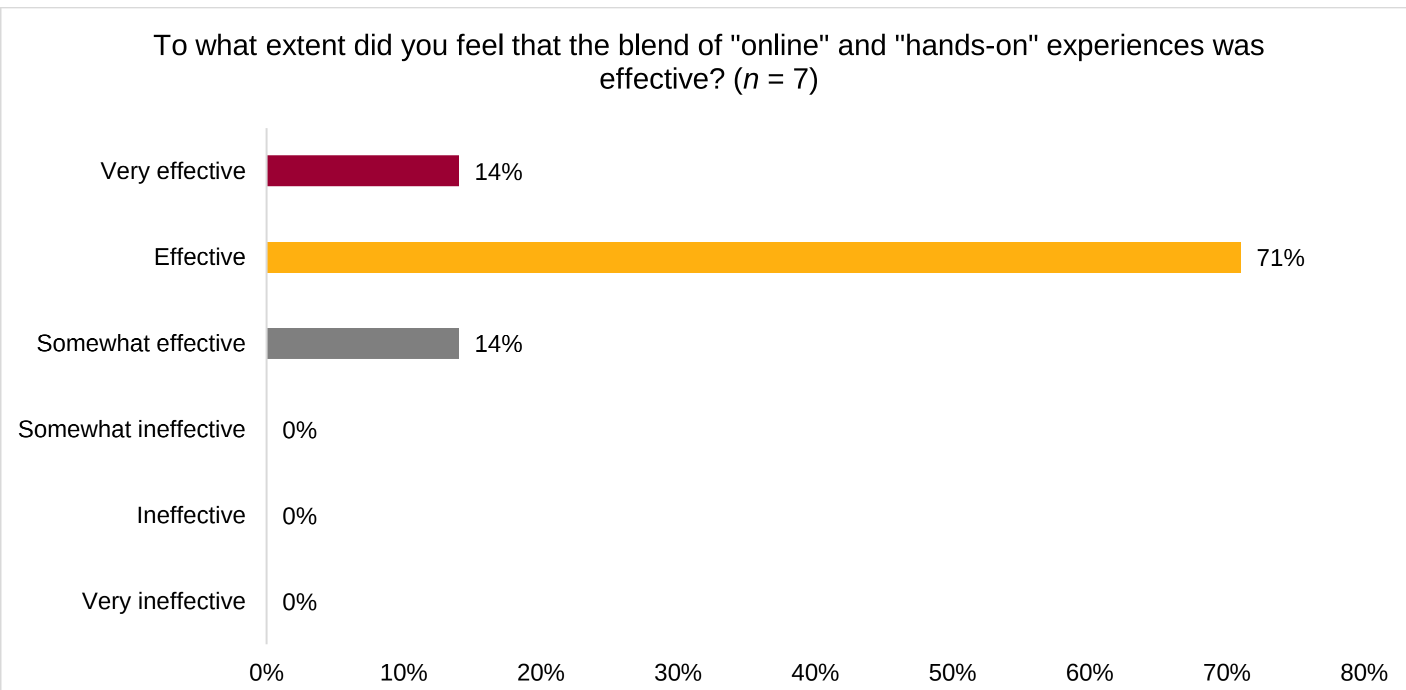
- “It is a good curriculum that would provide a solid foundation for a class if the instructor was motivated and had some background knowledge.”

- “I am still learning how to best navigate and teach the materials, I expect that as I get more comfortable with the material myself that the effectiveness of the program will increase.”

Effectiveness of the Blend of “Online” & “Hands-on” Experiences

Survey respondents were further asked to rate the effectiveness of the blend of the “online” and “hands-on” experiences on a scale of 1 “Very ineffective” to 6 “Very effective.” Of seven participants who responded, most indicated “Effective” (71%; *n* = 5) or “Very effective” (14%; *n* = 1). One individual, however, rated the blend of online and hands-on experiences as “Somewhat effective” (**FIGURE 2**).

FIGURE 2. Effectiveness of the Blend of “Online” and “Hands-on” Experiences



Note: Percentages do not add up to 100% due to rounding.

Seven respondents provided explanations for their ratings. Most comments were positive, indicating that the blend of the online and hands-on experiences was easy for teachers and beneficial to students. One person felt that the structure of the online experience could be more robust.

Participants' verbatim responses are included below:

- "Being able to front load the lessons beforehand is a great benefit as is having access to the content on a phone to double check procedures and steps."
- "I feel like the curriculum was laid out well and made it easy for teachers to share their data."
- "Many of my students that take [State's name] Natural history may have lower digital skills; however, this is a nice way to introduce them to real-world applications of technology that they may one day see in a career."
- "Students are able to experience real world skills using technology in the field to collect data and use that technology to apply to historical context of the use of water in the CO River basin. Again, the data analysis is a little clunky."
- "The field experience with data collection was further enhanced by sharing that data online. Students could gain further insight in comparing their results with students in totally different climatic regions with different biodiversity and water quality."
- "I feel like the structure for the online experiences could be a little bit more robust."
- "I have limited experience with the online portion and did not do these lessons with my students."

Barriers/Challenges

Participants were also asked to describe any barriers or challenges they faced when implementing the SCAPE2 curriculum in their school. Six individuals responded, with four indicating challenges related to finding an interesting location to study; time and resources for fieldwork or to implement the lessons; preparing for teaching the lessons; and a lack of staff to implement the curriculum. Participants' verbatim responses are listed below:

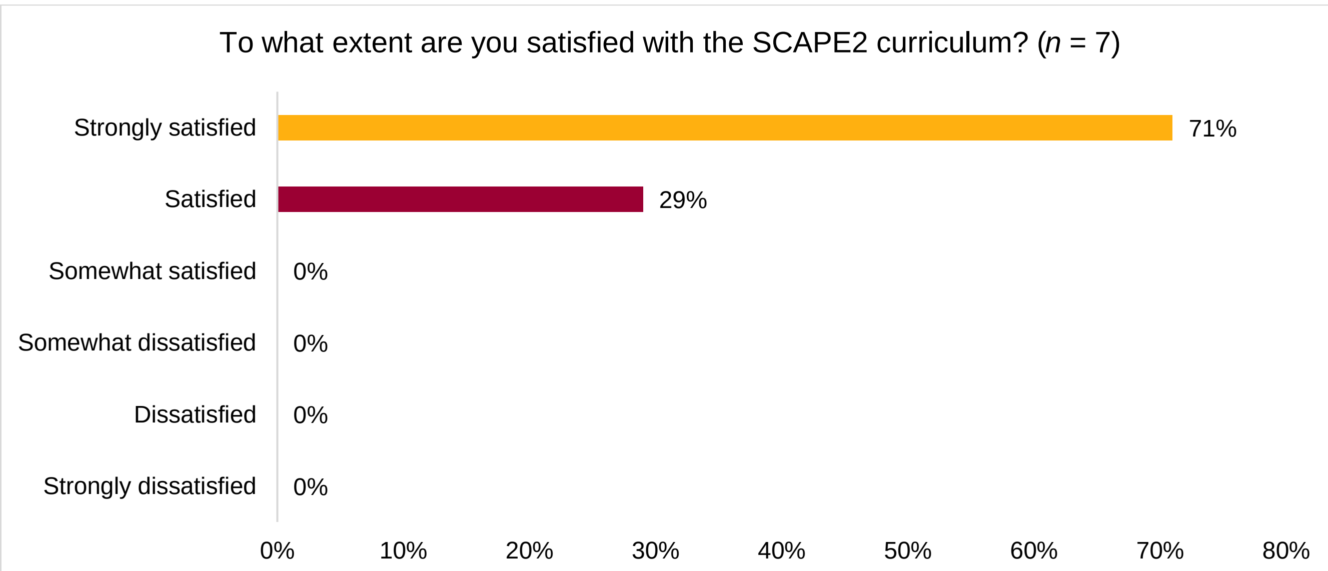
- "Finding a location that was interesting to study as an upper and lower site was difficult. Public access is limited and we had to work in the confines of our lab period."
- "Finding the time and resources for fieldwork is always an issue, as are doing the work prior to students so that I have a sample to use as a model."
- "Lack of staff previously to implement the curriculum but we are excited to use it moving forward."
- "Time to implement lessons in already set curriculum was a challenge, but the curriculum serves as a great supplement to curriculum already in place."
- "As a mentor, I assisted teachers with introducing SCAPE2 to students, providing some gear and guidance in the field, and giving feedback to their questions."

- “This isn't applicable to my school as we have a very supportive administration and it was taught as a science elective in a Field Science class, therefore I could blend any of the curriculum from SCAPE2 into my existing curriculum.”

Satisfaction with SCAPE2 Curriculum

Seven participants responded to a survey question that inquired about their satisfaction with the SCAPE2 curriculum. As **FIGURE 3** illustrates, all respondents indicated being “Satisfied” (29%; *n* = 2) or “Strongly satisfied” (71%; *n* = 5).

FIGURE 3. Participants’ Satisfaction Ratings with the SCAPE2 Curriculum



Survey participants were further prompted to explain their satisfaction ratings of the SCAPE2 curriculum. Seven respondents provided comments as shown below. All comments were very positive, indicating that the curriculum had greatly served the students and the teachers by providing them with knowledge and resources which were readily accessible and easy to implement. One respondent stated that they would recommend this curriculum to any school in the Colorado drainage basin area.

- “I appreciate the blend [of] online information, pre and post options and the accessibility of the information.”

- “It has given me structure and resources that have helped me and my students engage in hands-on activities that are relevant to our current curriculum.”

- “It was well planned and coordinated, easily accessible, and easily implemented. Overall, I would recommend this curriculum to any school in the Colorado drainage basin. The students learned a lot about the system and the stresses upon this river and it was a great way to involve them in the ecology of their community, yet showed how drastically water quality can change as it moves downstream.”

- “SCAPE2 provides a comprehensive curriculum that can be integrated in several subject areas. Teachers can collaborate to build more effective learning objectives in science, math, technology, language arts, history, etc. Depending on the school's learning scope and sequence, SCAPE2 fits in nicely with its flexibility.”

- “SCAPE2 was a great starting point for me as an environmental educator! I will continue to use aspects of this curriculum and the foundation it has provided me for my classroom for years to come. It represents an absolutely necessary educational approach.”

- “The SCAPE2 curriculum has supplemented my classes very well and introduced the use of technology for data collection to students.”

- “We have yet to examine it.”

Suggestions for Improvement

Participants were asked to provide any suggestions for improving the overall SCAPE2 curriculum or program, seven of which responded. Several respondents focused primarily on the positive aspects, expressing praise and appreciation of the curriculum, with one individual describing the potential impact of the SCAPE2 curriculum on schools and communities by offering engaging tools for learning. Suggestions for improvement included incorporating samples of student work in the lessons; using the 5e model of instruction for lessons; integrating Next Generation Science Standards (NGSS) in the curriculum; incorporating tutorials and lessons for some topics (e.g., using spreadsheets, creating pivot tables); creating time for students across different schools to share their experiments and findings; creating workable google docs to allow easy access to maps for the history portion and for teachers to make copies or modify the lessons as needed. The full set of verbatim responses is listed below.

- “A few samples of student work in the lessons would help, also I feel that the lessons could be structured using the 5e model of instruction. Deeper integration with the NGSS could also be completed to help with course alignments.”

- “Overall curriculum is excellent and has served as a great supplement to curriculum already implemented in my classroom. Students have benefit from the enrichment of field data collection using technology and by learning context of past, present and future water use in the CO River basin. Some improvements may be to incorporate beginning level tutorials and lessons on how to use spreadsheets that will build up to creating pivot tables, and uploading data to cloud platforms.”

- “I would suggest creating time for students from different schools to share with one another about their findings and watershed if possible.”

- “Several of the maps for the history portion are difficult to find/access. Workable google docs would be a great direction for this curriculum to head. Educators can make copies of the read only google docs and use the copies to digitally update and modify the material for their particular classroom needs—i.e., translation to Spanish, modifications for [Special Education]

(SPED) changes/updates for their particular field study. etc. Thanks for providing such a powerful framework for environmental education!!!!!"

- "I think that this was a great program overall and I was thrilled to be a part of this experience!"

- "I have had a very rewarding experience working with SCAPE2 teachers and their students and with fellow curriculum developers. I see the potential for SCAPE2 having a huge impact on schools and communities. Water sustainability is a universal need that all people depend on. This level of hands-on and comprehensive curriculum offers teachers and students excellent and engaging tools for learning."

- "We recently implemented a program at [Pre-Vocational School] (PVS) called Outdoor Monday on which all learning takes place outdoors. We will be using the SCAPE2 curriculum, River Watch curriculum and training, and place based educational methods in the future to monitor and report water quality in three locations."

Summary of Findings

Overall, for the most part, the SCAPE2 project led by PI Collins reached its goals in developing a curriculum and lessons that teachers in five high schools across Colorado, Wyoming, and Montana were able to implement in their classes, despite the challenges of the COVID-19 pandemic. The project provided ways to engage students in learning the importance of environmental stewardship and use of water in the CO River basin, as well as through field sampling of water quality parameters and the use of technology. A summary of findings from a summative survey of participants follows:

- Most survey participants taught up to 20 lessons, although a few individuals were involved in the project in different capacities than teaching.

- Participants reported implementing the SCAPE2 curriculum in grade levels 3rd through 12 in nine high schools and in colleges/institutions across Colorado, Wyoming, and Montana.

- Respondents implemented four particular lessons more frequently than they did other lessons. Those included: lessons *"**2.4 Macroinvertebrates**,"* *"**2.2 Streamflow=Volume x Velocity**,"* "***2.3 Water Characteristics and Chemistry***," and *"**2.1 Riparian and Habitat Diversity**."*

- Survey participants highlighted the curriculum's various strengths, including simple lesson plans with straightforward directions; online access to the curriculum and other readily-available information; content that balances science and social studies in ways that integrate 21st Century cognitive skills and technologies; engaging students in the science field and helping them understand the role of water in communities.

- Participants identified the main areas of weakness for the SCAPE2 curriculum as issues related to technology (data sharing, working on cloud platforms); lesson format (pdf, google sheets); lack of supporting materials such as videos; and the COVID-19 pandemic limiting curriculum implementation.

- The majority of respondents felt that the SCAPE2 lessons were “Effective” or “Very effective,” and further highlighted positive aspects of the curriculum. These included the curriculum’s flexibility to accommodate diverse classroom settings, simplicity and straightforwardness, and accessibility to students’ data by other schools in the Colorado drainage basin.

- Most respondents felt that the blend of the “online” and “hands-on” experiences were “Effective” or “Very effective,” further explaining that the blended format was both easy for teachers and beneficial to students.

- Some participants faced challenges related to finding an interesting location to study; time and resources for fieldwork or to implement the lessons; preparing for teaching the lessons; and a lack of staff to implement the curriculum.

- All respondents reported being “Satisfied” or “Strongly satisfied” with the curriculum. They further explained that the curriculum served students and teachers in great ways, providing them with knowledge and resources that were easily accessible and easy to implement.

- Several participants provided suggestions for improvement, such as incorporating samples of student work in the lessons and tutorials for some topics; using the 5e model of instruction for lessons and integrating Next Generation Science Standards (NGSS) in the curriculum; and creating workable google docs to allow easy access to materials.