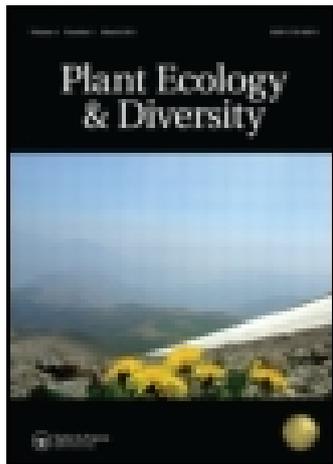


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### Children's book series and associated curricula support elementary education and outreach in water resources

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## Children's book series and associated curricula support elementary education and outreach in water resources

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**Background:** Water resources are of fundamental importance to society, and are better managed by stakeholders who understand resource issues. Gaining such knowledge is a lifelong process best begun at an early age and best supported by educational approaches integrating across science, technology, engineering and mathematics (STEM). Research scientists can bring resource education to young audiences through children's books and curricula that emphasise and integrate across STEM principals.

**Aims:** To encourage empathy for the environment in younger students, researchers at the Niwot Ridge Long Term Ecological Research site have developed a children's book series and methods for training teachers in water science education.

**Methods:** Children's books in the *My Water* series are paired with curricula, hands-on learning kits, teacher development training and dissemination of materials through school districts to further water science education.

**Results:** Thousands of children and educators have received training through the *My Water* book series, and a more broadly focused, federally funded Schoolyard Children's Book Series has grown out of these efforts towards water resource education.

**Conclusions:** Children's books and curricula that integrate STEM principals can play a key role in the development of environmental empathy and lifelong learning to support resource management.

**Keywords:** environmental empathy; Long Term Ecological Research; My Water; Schoolyard Children's Book Series; teacher development

### Introduction

As attention has been placed on improving the quality of curricula and instruction in science, technology, engineering and mathematics (STEM), the value of making explicit connections between and among subjects has been emphasised (Kozma 2003; Nathan et al. 2013). Proponents of more integrated STEM educational approaches argue that teaching STEM in a manner that connects with other subjects and real-world issues can enhance motivation for learning and improve achievement (NRC 2014). Research on cognition and learning in children suggests that making connections between concepts promotes retention of knowledge (Lehrer and Schauble 2006). Children's books provide a format for presenting STEM concepts in an explicitly integrated and engaging manner, while also providing a vehicle into classrooms, as well as homes and other informal education settings.

Other foundational aspects of STEM education for future learning by children are interest and identity (NRC 2014). In the specific context of environmental education, these can correspond to development of "environmental empathy", which includes developing an appreciation and understanding of the local environment (Sobel 1999). Environmental empathy can be stimulated by translating results from

environmental research into narratives that speak to children (McKnight 2010). Thus, in addition to presenting STEM concepts in an integrated manner, books that present an engaging narrative can help develop environmental empathy in young audiences (Cress and Holm 2000).

In the Rocky Mountain region, important real-world issues that affect many communities are current and future changes in water quantity and water quality. Thus, leaders in water resource management recognise the value of greater public understanding of the ongoing changes in the hydrologic cycle. To contribute to the education of children and their families about their local watershed, a decade ago researchers at the Niwot Ridge Long Term Ecological Research (LTERR) site produced a book and associated curriculum that employed approaches based on STEM integration and development of environmental empathy (McKnight 2010). Focused on the watershed serving Front Range communities in Colorado, *My Water Comes from the Mountains* was the first book in what over time became the LTERR Schoolyard Children's Book Series (SCBS), supported by the National Science Foundation (NSF).

The LTERR SCBS is designed to engage children and their families in learning about the earth's ecosystems

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**Box 1. Schoolyard Children's Book Series Mission Statement.**

The mission of the Schoolyard Series is to engage children and their families in learning about the earth's ecosystems, both locally and internationally, through narratives that reflect the dynamic research being conducted at the National Science Foundation's Long-Term Ecological Research Sites.

Books support the Schoolyard mission of LTER sites by emphasising four themes:

- (1) Connection to the local community;
- (2) Interdisciplinary ecological concepts;
- (3) Long-term perspectives and
- (4) A connection with scientists and scientific questions that are being studied within the LTER network.

(Box 1). In addition to presenting information about ecosystems in an integrated manner, a common aspect of the SCBS is that each book presents a narrative, i.e., a story with a beginning and an end. Themes emphasised by the series resonate with the mission of the LTER programme: gaining long-term and interdisciplinary perspectives on ecology, and making connections between local communities and the scientists and scientific questions associated with each LTER site. The place-based perspectives offered by these books combine to illustrate the diversity of research conducted across the spectrum of LTER sites. Collectively, these books represent the most accessible educational product of the LTER community. Furthermore, by reaching out to a young audience, the SCBS conveys the message that LTER researchers value young students and their interest in joining the scientific community as observers and explorers of their own environments.

Here, we illustrate the impact and educational value of an integrated approach to STEM education in the context of real-world issues, using examples from the development of *My Water* books over the past decade. We exemplify both the process and the outcome of developing these educational products, reporting on the confluence of factors that supported each product's development as well as the transference of scientific information to meet current educational standards. We show that development of STEM integration and environmental empathy were factors enhancing the effectiveness of the *My Water* books as this series expanded to serve new communities, and present recent data on the use of curricula associated with these books.

### **An integrated approach to education through place-based children's literature**

The Niwot Ridge LTER (NWT), located in Boulder County, Colorado, supports research on alpine ecosystems and the services that these ecosystems provide to downstream communities. The NWT mission includes improving understanding of connections between local communities and alpine environments. This local focus is inherently well-matched with the educational approach of

leveraging environmental empathy to raise awareness about the ways in which water is produced and used in local communities. Mountain views and alpine inputs dominate the landscapes of Boulder. Local children can see the mountains from their homes and schools, and these views can inspire both an aesthetic appreciation of the snowcapped peaks and a curiosity about alpine processes.

Such appreciation and curiosity give way to serious interest in watershed issues among mature audiences. Rapidly increasing demands on the region's water supply over the last decade have accentuated issues of water quality and quantity. In a State of the State address, Colorado's governor affirmed that "the natural resource that may, in the end, have the greatest impact on Colorado's economic growth, is water" and that "a 'status quo' approach to water will inevitably lead to pressures that harm our environment and dry up precious agricultural land" (Colorado State of the State Address, 13 January 2011). The Geological Society of America (GSA) has adopted a position urging actions to "increase stakeholder involvement in all aspects of water resource education, assessment, and decision making" while working to "broaden education and outreach to foster collaboration among government agencies, educational institutions, industrial and agricultural users, and the public" (GSA 2012).

*My Water Comes from the Mountains* was written to increase understanding of local water resources and related issues by integrating reading and art with several STEM fields (earth science, biology and environmental engineering). Published in 2004, this first book in the LTER SCBS was authored by a former student at the University of Colorado, Boulder (Tiffany Fourment), who was inspired to write a children's book about the water cycle while taking a NWT summer field course for in-service and pre-service teachers (Alpine Ecology and Experiential Learning was taught from 1998 to 2005 using funds for outreach provided through supplemental funding of the NWT LTER programme by the NSF). The field course was taught by experts in science education, general ecology and limnology encompassing the range of scientific disciplines relevant to an integrated presentation of watershed issues (including ecologists Hector Galbraith and Joyce Gelhorn, and NWT limnologist Diane McKnight). As part of their

classwork, the NWT students prepared for and led field trips for children in grades 4–8 (ages 10–14, including students in upper elementary and middle school). Each field trip included a hike high into the watershed above Boulder, Colorado, to visit the NWT LTER Tundra Lab. Highlights of the trip were experiential activities such as drawing pictures of wildflowers and writing in a journal during rest breaks on the hike up to the Tundra Lab, as well as sliding down a steep snowfield on the way back down the mountain. In this experiential setting, children learned about the hydrology of the mountains concurrently with learning about the life history of alpine wildflowers and small mammals such as pikas and marmots. They drew and wrote about their observations and experiences.

Artwork and comments from schoolchildren eventually helped shape the development of *My Water Comes from the Mountains*, which was inspired by the author's experiences integrating lessons about the water cycle with lessons about alpine flora and fauna for third-grade students (ages 8–9). In this 6-week programme on the water cycle, students learned about the source of their water and then created their own book as a culminating art and writing project. Artwork created by the students was used to illustrate their book, which also contained their comments about interesting aspects of the water cycle. *My Water Comes from the Mountains* was written to capture the integration of STEM fields, using student feedback to identify the most interesting aspects of the Boulder watershed from a third-grade perspective.

Because some students were particularly interested in the different animals that live in the different elevational zones in the mountains, this book included descriptions of these animals within the narrative about water melting from the snowpack in the alpine and flowing down onto the plains. This aspect of the narrative aligns with a recent recommendation that STEM connections to earth science and ecology be explicitly presented (NRC 2014). To inspire young readers to draw their own pictures of the watershed, the author worked with the book's illustrator (Dorothy Emerling) to incorporate the children's artwork and comments as sidebars on each illustrated page.

Local dissemination of this place-based book was a high priority of NWT researchers, and attracted funding by the NSF. Upon publication in 2004, 2000 books were distributed to schools and educational programmes, including classroom sets of 30 books for every elementary school in the Boulder Valley School District (BVSD). To familiarise teachers with the books, graduate students from the University of Colorado, Boulder, visited BVSD schools as part of an interdisciplinary, NSF-funded outreach programme focused on "Carbon, Climate and Society". Books were also provided to the resource distribution centre for the Saint Vrain Valley School District (SVVSD) and other private schools and educational programmes in Boulder County and the surrounding area (e.g., Thorne Nature Center and Wild Bear Mountain Ecology Center). The deployment of these books in the schools provided an early foundation for development of a

water resources curriculum based on STEM integration and environmental empathy.

### Development and use of a curriculum to enhance knowledge of the water cycle

The active construction of ideas by children through their own inquiries, investigations and analyses constitutes the best way for students to appreciate science, learn important scientific concepts and develop the ability to think critically (National Academy of Sciences 2000). This approach includes encouraging students to construct an understanding of scientific concepts through their own exploration and analyses, using laboratory equipment, student readings and interactive methods. Dubbed "inquiry-based" and "experiential" learning, this approach has been adopted by many science curriculum developers and is commonly considered more effective than learning from books alone (Kraft and Sakofs 1988; Jakubowski 2003).

Building on these considerations and the previous distribution of *My Water* books, NWT researchers sought to develop an activity-based curriculum to reinforce the messages delivered by the books. What became known as the *My H<sub>2</sub>O Curriculum Guide* integrated several experiential learning products from educational programmes local to the Boulder watershed, including NWT's ongoing summer field class as well as Project WET (Project Wet Foundation 2011), Project WILD Aquatic (Council for Environmental Education 2005) and the City of Boulder's Watershed Approach to Steam Health (WASH) programme (Laniga and Writer 2005). *My H<sub>2</sub>O Curriculum Guide*, developed with funding from a 2005 Environmental Education grant from the US Environmental Protection Agency (EPA Region 8), was researched and compiled by a NWT graduate student (Colleen Flanagan) with help from a local elementary school teacher (Kenneth Nova) who had taken the NWT summer field course and also participated in NWT limnological research through NSF's Research Experience for Teachers programme.

This first *My H<sub>2</sub>O* curriculum was organised around four themes: (1) The Water Cycle; (2) Our Watersheds; (3) Boulder County's Flora, Fauna and Life Zones and (4) Human Impact on Water. The curriculum blends Colorado state educational standards in science, language arts, geography and mathematics into activities, games, story plots and community action tasks (Flanagan 2007). The relevant educational standards (ca. 2004) were explicitly described in the curriculum. During development, the *My H<sub>2</sub>O* curriculum benefitted from the experience of in-service teachers who consulted on transference of scientific knowledge to the classroom and guided efforts to link the curriculum with State educational standards. For example, teachers in the NWT summer field course evaluated curricula as part of the process of producing a final project for the course, a clearly documented educational activity for use during or after the children's field trip. The curriculum was also evaluated during use in area classrooms by a number of these in-service teachers. Thus, participation



Figure 1. Images representing the *My H<sub>2</sub>O* kit materials and supplies, which include (a) the *My H<sub>2</sub>O Curriculum Guide* and *My Water Comes from the Mountains* book as well as other age-appropriate literature, music and video resources; (b) benthic macroinvertebrate identification keys, pipettes, hand lenses, specimen tray and dip net for animal-based water quality assessments and (c) supplies for pH studies including lemon juice, antacids, baking soda, litmus paper and pH scales. Also included (not shown) is a 3-D relief map of the local watershed.

in the NWT programme prepared dozens of teachers in the local area to evaluate the organised curriculum and to use it once it was introduced to the school districts. The experience of the in-service teachers in the class leading field trips for upper elementary and middle school students to the Tundra Lab gave them insight into how the curriculum could integrate important concepts while being based on experiences children may have had.

To directly engage each child in the learning experience, a materials kit was developed to support hands-on activities associated with each theme in the curriculum (Figure 1). Activities allow students to use simple materials to explore complex topics. In one part of the *Map Your Shed* activity, for example, students are encouraged to imagine a partially crumpled piece of paper as a watershed, predicting how water would flow and pool in this model landscape, and where houses and communities might be vulnerable to flood. Thus, “students learn the core ideas and crosscutting concepts of science through engagement in the practices of science and engineering”, the primary goal of next-generation standards (NRC 2015), through accessible activities based on simple materials. The *My H<sub>2</sub>O* curriculum includes an organised list of all materials and supplies to help distribution centres maintain kits as needed for each local school district.

The curriculum and kits were first tested during a pilot programme and then reviewed in three iterations by teachers and educators. Additional funding for this extensive development phase was provided through a regional outreach programme of the EPA, as well as other local

programmes. Funds from these sources provided support for teacher involvement, such as honoraria for teachers conducting the reviews. Key metrics of *My H<sub>2</sub>O* evaluation were provided through the EPA and the teacher feedback ratings based on North American Association for Environmental Education (NAAEE) standards. An on-site review by the EPA dubbed the curriculum “excellent” and teachers reporting back after six-month trials gave the curriculum an average rating of 4.65 of 5.0 possible points, translating into an overall NAAEE merit rating of 93% (Flanagan 2007). Teacher comments were quite positive (Box 2), and a break-down of the ratings received made it clear that students showed especially dramatic improvements in understanding the place-based themes of “Our Watersheds” and “Human Impact on Water” (Flanagan 2007).

#### Current use of the first book and curriculum in the *My Water* series

Beyond the initial evaluation of the curriculum by teachers, extended use is another metric for the effectiveness of the integrated approach adopted for the *My Water Comes from the Mountains* book and *My H<sub>2</sub>O* activities kit. Both have been used extensively since their release in 2004–2006, as exemplified by data from the online ordering system serving teachers in the Boulder Valley School District. During each of the past four school years, the kits were used by about 30–40% of Boulder Valley fifth-grade teachers ( $n = 41$  teachers in 2010–2011, 37 in 2011–2012,

#### Box 2. Comments received on the *My H<sub>2</sub>O* inquiry-based learning kit.

“The activities are age appropriate, standards are met and, perhaps most importantly, the kids are engaged and learning!” – SVVSD Teacher.

“The curriculum and kit go perfectly with the material that I teach”. – BVSD Teacher.

“[T]his kit is a wonderful tool to fill our Earth science standards in grades 3–5”. – SVVSD Science Coordinator.

“[F]un and engaging activities that can induce higher level thinking in students...by discussing issues that are happening right here in Colorado”. – Educator, Wild Bear Mountain Ecology Center, Nederland, Colorado.

41 in 2012–2013 and 34 in 2013–2014). “It is getting quite a lot of use for an optional kit”, reported Samantha Messier, Boulder Valley Director of Science and Social Studies.

NWT researchers also leverage these materials to support various educational outreach opportunities, including field trips and teacher training. The use of the book is especially helpful for graduate students engaging in outreach activities, where paperback books are gifted to participants. For example, graduate students collaborate with local summer science programmes and public events for youth and families, including the Longmont Water Festival, the Boulder Water Festival, the NCAR-Wild Bear Earth Day event, the Boulder Climate Change Rally and the Annual “Open House” at the Institute for Arctic and Alpine Research (INSTAAR) which hosts about 180 middle school students in inquiry-based activities at INSTAAR and nearby Boulder Creek.

New uses for this integrated approach continue to be invented. One Boulder Valley school, Creekside Elementary, is planning to use the book, kit and curriculum to support an after-school programme in outdoor education for the Fall semester of 2015. Creekside is a Title I school with 50% of the student body identifying as ethnic (Snyder and Dillow 2012) and a sizable percentage of students from non-English speaking, immigrant families (Patrick Eichelmann, pers. comm.). *My H<sub>2</sub>O* was also featured in 2015 at the first annual “STEM Night” of a local school catering to self-directed learners (Excel Academy Charter School, Jefferson County Public School District).

### Applying an integrated approach beyond the local scale

The first book took an integrated approach to support educational goals in a local community. As the effectiveness of the approach was evidenced through application in local schools, other goals were identified. Groups involved in environmental and watershed education saw opportunities to serve additional audiences by tailoring the narrative and associated curriculum to a new region or a broader scale. Aspects of the first book that were incorporated to promote local environmental empathy needed to be revised to realise these new opportunities. For example, the first book specifically identified Barker Reservoir above the City of Boulder. Groups that expressed interest in a new edition, with less specific references to local landmarks, included state-wide educational programmes associated with the Colorado State Parks as well as non-profit nature organisations that oversee books available at the gift shops associated with National Parks. At the same time, the potential for content revisions was brought forward, such as including groundwater as a component of the hydrologic cycle. These revisions were valuable in supporting the relevant science standards used by teachers in the classroom.

To reach a broader audience while retaining the integration of STEM fields with reading and art, a team of NWT

researchers began working with the author and publisher of *My Water Comes from the Mountains* to develop a new edition of the book. The geographic focus was expanded to include the Rocky Mountains as a whole, literally painting a broader picture of the hydrologic system. While the first book featured student artwork from classrooms east of the Continental Divide, artwork in the new edition came from elementary schools throughout the Colorado River basin, in Montana, Wyoming, Idaho, New Mexico and west of the Continental Divide in Colorado. Student artwork and comments generated through a variety of classroom activities were incorporated into the new edition, and a larger selection were archived on the NWT website (<http://culter.colorado.edu/MyWater/>) in a format searchable by state, school or student's first name. These activities were headed by an INSTAAR graduate student (Lindsey Weber) with support from the teacher who co-authored the *My H<sub>2</sub>O* curriculum (Kenneth Nova).

The new edition, *My Water Comes from the Rocky Mountains*, published in 2009, features a map of North America showing where water originating on each side of the Continental Divide enters the Pacific Ocean or the Gulf of Mexico. Participating teachers and schools received classroom sets of the new edition.

### Applying an integrated approach that emphasised environmental empathy in the Four Corners region

While *My Water Comes from the Rocky Mountains* was in development, a gap in the reach of this new edition was recognised. The Four Corners region, where Colorado borders on New Mexico, Arizona and Utah, is home to a sparse population at the foot of the San Juan Mountains. The San Juan Mountains harbour the headwaters of five of Colorado's main rivers, but water rights are complicated in this region, due to a long history of agricultural use and extractive industries. The future of water resources in the face of a changing climate and increased drought is even more tenuous in the Four Corners region than in other parts of the Rockies. Already, many Four Corners residents do not have access to dependable, high quality water supplies, especially on tribal lands. New and developing reservoir projects controlled in part by local tribes and the federal government will change the dynamic of water rights and water availability going forward. Part of the mining legacy in this region is metal loading in alpine streams from over 1500 abandoned mines, and prolific modern drilling for natural gas will further complicate these issues.

The unique attributes of the relatively rural communities in the Four Corners, combined with the heightened need for awareness of water issues in this region, suggested the need for a third edition in the *My Water* series. The idea for a *San Juan Mountains* edition resonated with educators contacted in the region. Teachers helped identify adaptations required to adjust the wildlife and plant species highlighted in the book to the specific ecosystems present in the San Juans, and strategic modifications to the text and illustrations adapted the book to the region.

These adaptations enhanced the effectiveness of the book for development of an appreciation of the San Juan Mountains by regional schoolchildren and their families. *My Water Comes from the San Juan Mountains* was the product of a collaboration between NWT scientists, the non-profit Mountain Studies Institute (MSI) and southern Colorado educators from Fort Lewis College, Durango public schools and the San Juan Board of Cooperative Educational Services (BOCES), a group that works with nine school districts in southwestern Colorado to provide specialised educational services for all students.

Despite differences in ecology and culture, the regions served by the *My Water* books share similar water resource issues. Issues in water quality, conservation, storm-water management and wastewater treatment are core concepts to communicate to youth. By expanding the *My Water* education series to the Four Corners area of Colorado, NWT scientists, MSI and partners sought to stimulate scientific interest, environmental literacy and watershed stewardship within traditionally under-served communities. Goals of extending the series to serve these communities included: (1) to build capacity for delivering customised, place-based watershed science programmes, (2) to develop standards-based teacher training programmes and web-based teaching resources, (3) to train teachers and environmental educators in watershed science content and issues based on relevant and current watershed issues and (4) to reach 8000 students and other participants through contact programmes for environmental monitoring and service throughout the Four Corners region.

### ***My H<sub>2</sub>O* in the Four Corners region**

To support these goals, a region-specific edition of the curriculum and activities kit was developed by a Fort Lewis College professor (Mary Ann Goff) for distribution to local schools in Durango and other communities served by the San Juan BOCES. Partnering with the San Juan BOCES was key to getting books and kits into these schools. To date, books, curricula and kits have been distributed to 23 schools in five counties in the Four Corners region, over 1600 books have been gifted to children in the region and a novel programme for training teachers has been developed. The training programme, called *Forests to Faucets: My Water Comes from the San Juan Mountains*, offers place-based workshops that rotate through river basins in the area to highlight the water sources, infrastructure and issues relevant to each basin of the San Juan and Dolores watersheds (Figure 2). Each workshop focuses on opportunities to connect students with hands-on activities tailored to their local watershed while addressing current educational standards (Box 3). In 2012, the workshop explored the Upper Animas watershed, where the mineralised geology affects water quality from both natural sources and human activities. In 2013, the workshop focused on the San Juan River and Pagosa Springs community, highlighting the current forest die-off from the spruce beetle epidemic as well as local

opportunities for geothermal energy use. In 2014, the programme led teachers through the Mancos and Dolores watersheds to explore water resources bridging ancient Puebloan settlements, drought-affected aspen forests and modern agricultural uses. Online access to workshop materials, tour maps and contacts for local water resource managers will be enhanced in 2015, when an interactive Geographic Information System tool called *Story Map* will be added with links and information allowing teachers to recreate these tours across all three basins. *Forests to Faucets* and related teacher workshops were developed by MSI in collaboration with the San Juan Mountains Association and the Southwest Water Conservation District's Water Information Program. Support for materials, printing and other teacher workshop costs has been provided by local resource agencies and non-profits including the Southwest Water Conservation District, La Plata Electric Association, Coutts and Clark Western Foundation and Trout Unlimited Five River Chapter.

In evaluating the *San Juans* edition and teacher workshops, educators have been very pleased. On average, participants rated the workshop and instructors at 4.8 out of 5.0. All participants responded "yes" to questions of whether the materials were engaging, interesting and increased their understanding of water issues. When asked about the greatest value of the workshop, participants named new information sources, hands-on activities, visits to water and wastewater facilities, increased knowledge and "A better, much needed, understanding of water treatment and sewage treatment, from expert speakers".

### **Beyond formal education: distribution for use in informal educational settings**

Extending the *My Water* series to include editions that focus more broadly on the Rocky Mountains or that highlight an under-served region like the Four Corners expanded the audience for outreach on water resource issues. Integrated approaches for childhood STEM education have been applied successfully in informal educational settings, such as those that occur during family trips to parks and other outdoor activities. *My Water Comes from the Rocky Mountains* is now selling in venues that serve a broad audience and originally passed over the first edition because the content was too specific to the Boulder watershed. The *Rocky Mountains* edition is a steady seller in Colorado parks, including all venues where books are sold in Rocky Mountain National Park. It has also been selected for distribution by the Rocky Mountain Nature Association and Books West, two specialty book wholesalers who sell titles directly to many smaller independent bookstores, state parks and other venues throughout the Rocky Mountain region. *My Water Comes from the San Juan Mountains* has achieved similar attention from these specialty wholesalers. Having these books readily available to children and their families in bookstores, park gift shops and libraries expands the audience for "alpine ecology and experiential education" that was the target of the original NWT field course for educators.



Figure 2. Training workshops have allowed teachers to experience activities that can be adapted to the classroom to meet state-specific education standards (a, b) and gain place-specific knowledge through field trips (c). Photos provided courtesy of MSI.

Both new editions now benefit from reaching a much wider and diverse audience than they did through distribution to schools alone. The success of these new editions also contributes to the overall success of the SCBS.

### *My Water, Mi Agua*

The future of the *My Water* series may follow the multi-lingual model adopted by more recent books in the SCBS lineup (Table 1). There is substantial interest in a Spanish

language edition in much of the Rocky Mountain region. MSI has identified goals of a Spanish language edition as integrating children's earth science literature within English as a Second Language (ESL) educational programmes. Unique attributes of the Spanish-language culture could be addressed by using artwork and comments developed by ESL students in bilingual elementary schools. *My Water, Mi Agua* could represent a full-spectrum approach to advancing environmental education in communities like the Four Corners region, supporting place-based collaboratives to

#### Box 3. Colorado state educational standards addressed by *My Water* curricula.

Several educational standards are addressed by each activity in the *My Water* curriculum, such as these two examples from the *Forests to Faucets* programme developed to extend lessons from the third book in the series, *My Water Comes from the San Juan Mountains*.

KEY: Numerical listings refer to Colorado Standard and Grade Level Expectation for each grade and content area; e.g., Third Grade 3.1 Earth Science refers to expectations for third-grade students (ages 8–9) studying the first concept in Earth Systems Science.

##### Activity (1) MAP YOUR SHED

Third Grade Science 3.1 Earth Science: Earth's materials can be broken down and/or combined into different materials such as rocks, minerals, rock cycle, formation of soil and sand – some of which are usable resources for human activity.

Fourth Grade 2.3 Life Science: There is interaction and interdependence between and among living and nonliving components of ecosystems.

Fifth Grade 3.2 Earth Science: Earth's surface changes constantly through a variety of processes and forces.

Sixth Grade 3.1 Earth Science: Water on Earth is distributed and circulated through oceans, glaciers, rivers, ground water and the atmosphere.

Third Grade 2.1 Geography: Use various types of geographic tools to develop spatial thinking.

Fourth Grade 2.1 Geography: Use several types of geographic tools to answer questions about the geography of Colorado.

Fifth Grade 2.1 Geography: Use various geographic tools and sources to answer questions about the geography of the United States.

Sixth Grade 2.1 Geography: Use geographic tools to solve problems.

##### Activity (2) SAN JUAN MOUNTAINS CORNUCOPIA: WEB OF LIFE

Fourth Grade 2.1, 2.3 Life Science: All living things share similar characteristics, but they have differences that can be described and classified. There is interaction and interdependence between and among living and nonliving components of ecosystems.

Fifth Grade 2.1, 3.1 Life Science, Earth Science: All organisms have structures and systems with separate functions. Earth and Sun provide a diversity of renewable and nonrenewable resources.

Sixth Grade 2.2 Life Science: Organisms interact with each other and their environment in various ways that create a flow of energy and cycling of matter within an ecosystem.

Table 1. Titles in the SCBS. H = hard cover, P = paperback binding. LTER Site = Long Term Ecological Research Site hosting researchers/research programmes supporting the subject of this book.

Title	Language-binding	Author	Illustrator	ISBN	Published	LTER site
The Lost Seal	English-H	D. McKnight	D. Emerling	978-0-9723422-7-8	July 2006	McMurdo
Sea Secrets: Tiny Clues to a Big Mystery	English-H	M. M. Cerullo and B. E. Simmons	K. Carlson	978-0-9779603-9-2	September 2008	Palmer Station
My Water Comes From the Rocky Mountains	English-H	T. Fourment	D. Emerling	978-0-9817700-0-0	August 2009	Niwot Ridge
My Water Comes From the Rocky Mountains	English-P	T. Fourment	D. Emerling	978-0-9817700-1-7	August 2009	Niwot Ridge
My Water Comes From the San Juan Mountains	English-H	T. Fourment, K. Nydick, G. Gianniny and M. A. Goff	D. Emerling	978-0-9817700-2-4	August 2009	Niwot Ridge
My Water Comes From the San Juan Mountains	English-P	T. Fourment, K. Nydick, G. Gianniny and M. A. Goff	D. Emerling	978-0-9817700-3-1	August 2009	Niwot Ridge
One Night in the Everglades	Spanish-H	L. Larsen	J. Mihran Turley	978-0-9817700-4-8	June 2012	Everglades
Una Noche en los Everglades	English-H	L. Larsen, A. Ribbi and R. Jaffe	J. Mihran Turley	978-0-9817700-8-6	June 2012	Everglades
And The Tide Comes In...	English-H	M. Alber	J. Mihran Turley	978-0-9817700-5-5	December 2012	Georgia Coastal
Exploring a Georgia Salt Marsh						
Kupe and the Corals	English-H	J. L. Padilla-Gamiño	M. Leggitt	978-1-58979-753-6	August 2014	Moorea
Kupe and the Corals / Kupe y los Corales	English-Spanish-P	J. L. Padilla-Gamiño	M. Leggitt	978-1-58979-776-5	August 2014	Moorea
Kupe and the Corals / No Kupe a me nā Ko'a	English-Hawaiian-P	J. L. Padilla-Gamiño	M. Leggitt	978-1-58979-778-9	August 2014	Moorea
Kupe et les Coraux / Kupe' e te To'a	French-Tahitian-P	J. L. Padilla-Gamiño	M. Leggitt	978-1-58979-779-6	August 2014	Moorea
Kupe and the Corals / Kupe' e te To'a	English-Tahitian-P	J. L. Padilla-Gamiño	M. Leggitt	978-1-58979-780-2	August 2014	Moorea
Kupe et les Coraux / Kupe ke te Toka	French-Paumotu-E	J. L. Padilla-Gamiño	M. Leggitt	978-1-58979-777-2	August 2014	Moorea

address issues of diversity and environmental justice. Experiences with *My Water, Mi Agua* could help underserved populations develop connections to and understanding of their watersheds. In the dialogue surrounding resource use and climate, these audiences need to understand the real threats to their environmental resources.

In addition to this focused, regional outcome, the development of online resources and training could extend *My Water, Mi Agua* to a much larger audience of teachers. Watershed issues share similarities across regions. With the increasing number of place-based educational activities developed for this series comes the potential to pick and choose a subset of activities that would appear tailored for almost any region. Online resources could facilitate this designer approach that would increase the scale of regions served while addressing certain issues specific to each locale.

### Summary and conclusions

The *My Water* books present an integrated, experiential approach to education of schoolchildren about water resource principles related to real-world issues. This integrated approach originated from the activities in a summer field course for teachers who, it was hoped, would disseminate their new knowledge to many classrooms. One teacher took the next step by portraying this integration in a book for use in the classroom and for broader distribution within the region served by the field course. Now, online materials like *Story Maps* are increasing the reach of the *My Water* curriculum to include educators unable to participate in trainings or access activity kits through local school districts. Thus, NWT research was connected by educators and community leaders to the goals and agendas for enhancing education on watershed processes and issues.

While the only formal assessment was in the development of the *My H<sub>2</sub>O* curriculum, the continued use of the books and materials by teachers and the public is evidence of their value as an educational resource. Involving teachers throughout the process of book and curriculum development likely increased the value of these resources. Funding and logistical support for each incremental step in the development of these resources resulted in sustained impact in the local region, as well as broad impact through availability in public venues such as the National Parks. This process also involved graduate student training on several levels, from leading a field-day to writing a curriculum. Graduate students who took leads in this process began their postgraduate careers with the National Park Service (Flanagan) and the Denver Water Board (Weber). These successes also illustrate the utility of the project.

The *My Water* series of books and curricula has helped educators make water resource science relevant for their students by offering regionally appropriate narratives and activities. Subsequent books in the SCBS have adopted this model, and curricula are in development for several of these books. The LTER Network has initiated the

Education Digital Library Project (EDLP) to review, curate and disseminate the next generation of curricula stemming from LTER research and outreach efforts. We recommend that the SCBS and EDLP be considered as complimentary resources for developing a collection of LTER educational products that are scientifically sound and pedagogically effective for teaching young audiences.

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Amy Rinehart, a third-generation book publisher, is the series editor for the LTER Schoolyard Children's Book Series.

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