

## PROJECT SUMMARY

---

### *Bringing Relevance to Earth Science Introductory Curricula through Images Showing Human/Landscape Interaction*

Anyone who has taught an introductory Physical Geology or Geography course knows how hard it is to keep students interested, attentive, and engaged. Despite the significance of Earth Science to diverse, important, and contemporary topics (including geologic hazards, land-use management, and resource extraction), students view much of the material presented at the introductory level as irrelevant and disconnected from their lives. Without perceived relevance, Earth Science is often a marginalized curriculum, fewer students pursue Earth Science majors than other sciences, and the applied-science literacy of the college-age population as a whole suffers.

Using both current and historical photographic imagery, and the stories these images convey, we seek to address directly the *problem* that Earth Science is considered irrelevant by today's students. Images linking human actions and surface processes allow students to understand the importance and concept of change over time while adding a human element to the learning process. Our approach follows directly from discoveries we have made teaching with a digital image archive of landscape change catalyzed by five years of NSF funding ([www.uvm.edu/perkins/landscape](http://www.uvm.edu/perkins/landscape)). In this proposal, we seek support to develop the first 4 "proof of concept" learning modules that teach fundamental concepts in Earth Science by demonstrating their relevance to society. In short, our work will attempt to solve the problem of perceived irrelevancy by using images to link major topics in Earth Science to the human condition.

Our *objective* is to demonstrate that student interest, attention, and learning all increase when Earth Science is taught and learned visually in the context of the human experience. We expect the *outcome* of this work will be students who recognize the relevance of Earth Science as a discipline and its ability to inform debate on a variety of pertinent societal issues.

We will *accomplish* our objective by developing, testing, and evaluating 4 modules, each focused on different ways in which the Earth and people interact. *Flows and Floods* illustrates the complex relationship between people and moving water in order to convey basic concepts in river behavior including channel migration and flood frequency. *Sliding Slopes* uses imagery of human-induced erosion and landsliding as a catalyst for understanding the physical behavior of Earth materials. *Rocks and People* focuses on resources people take from the Earth and the environmental and landscape consequences of such extraction. *Plants from a Stone* exposes linkages between the solid Earth and the plants that cover its surface, focusing on geochemistry and biotic/abiotic interactions. Each module will include image-rich interactive web-based introductory learning tools as well as a PowerPoint template and accompanying active learning exercises for use in the classroom.

This project targets the Earth Science (Geology and Geography) student *population* at the introductory level in order to make the broadest possible impact. *Collaborations* with other institutions and with the University of Vermont Center for Teaching and Learning will assure that the materials we develop are tested using a cross-section of the student population. Assuming that evaluation of these "proof of concept" modules is favorable, we will apply for support to develop additional modules for national testing, evaluation, and implementation.

***Intellectual merit*** – Developing educational materials that explicitly use photographic imagery to provide temporal scale, human context, and societal relevance is an innovative approach to teaching Earth Science at the introductory level. The PI and others involved in the proposal have demonstrated expertise in teaching, development of educational resources, and the technology needed to deliver effectively such content-rich educational materials.

***Broader impacts*** – Using imagery of human-Earth interaction as a catalyst for engaging students will have significant broader impacts. Generating educational materials that are less abstract and more relevant to daily occurrences in students' lives will allow those who learn visually and those whose interests lie outside the sciences to become more engaged personally and scientifically. Working closely with faculty and staff, graduate students will be key players in the development of these educational materials. Such intensive student/faculty interaction will develop the human resources infrastructure in both science and education.

## Introduction

Over the past decade, numerous studies and many working groups have repeatedly identified Earth Science and the consideration of Earth as a system as societally important and of great relevance to students at a variety of academic levels (Kelley and Burks, 2003; Shaver and Wood, 2004; NESTA, 1987; AGU, 1996; Yuretich et al., 2001). As a result of this attention, there have been calls for innovative curricular development emphasizing student involvement in the learning process and the use of active research and the research process as catalysts for learning (St. John and Callahan, 2003; AGU, 1996, Yuretich et al., 2001). However, both anecdotal reports and statistically-based findings suggest that students consider much of Earth Science presented at the introductory level is irrelevant and disconnected from their lives (Kanfoush, 2003; Chaudhri and Kaur, 2003; Miller, 2002; Yuretich et al., 2001).

Such a disconnect between student perception and reality is perhaps less surprising when one considers both the spatial and temporal scales at which most Earth Science is taught and the level of abstraction typical of diagrams used to illustrate germane topics. For example, open just about any introductory textbook and examine the chapter on rivers. There you will find block diagrams of rivers classifying stream morphology and demonstrating lateral migration. There is little consideration of scale, no reference to time, and the diagrams are typically devoid of people or represent them and their constructs only schematically. What a contrast to images we see almost daily in the media. We see people's homes inundated by floods, buildings collapsing as lateral migration undercuts developed river banks, and livestock stranded by rising floodwaters. All of these images present direct tangible links between Earth Science and the human condition.

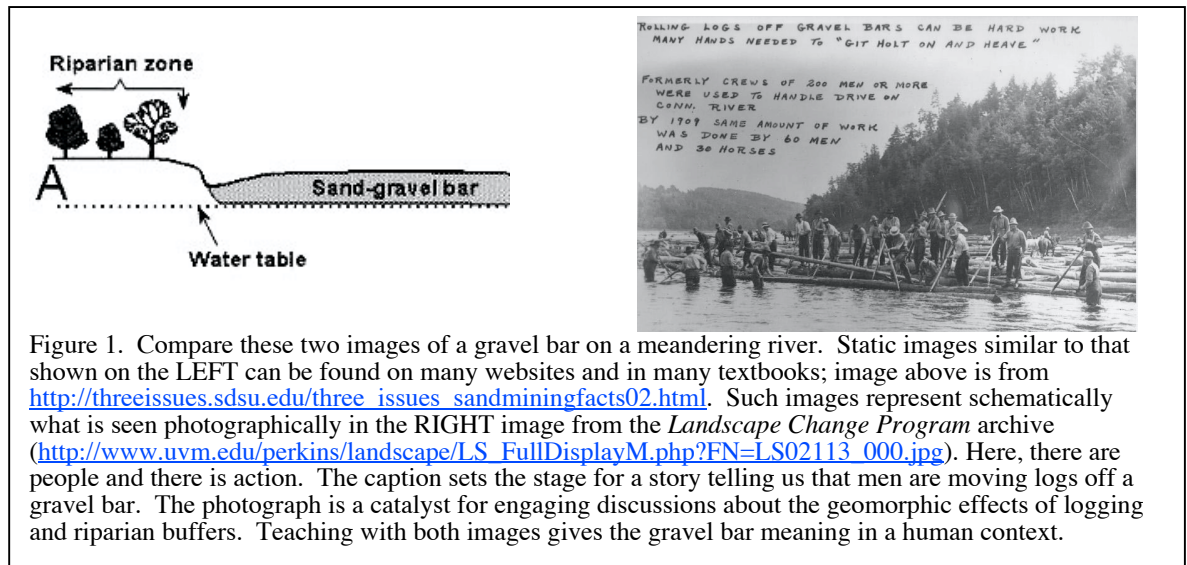


Figure 1. Compare these two images of a gravel bar on a meandering river. Static images similar to that shown on the LEFT can be found on many websites and in many textbooks; image above is from [http://threeissues.sdsu.edu/three\\_issues\\_sandminingfacts02.html](http://threeissues.sdsu.edu/three_issues_sandminingfacts02.html). Such images represent schematically what is seen photographically in the RIGHT image from the *Landscape Change Program* archive ([http://www.uvm.edu/perkins/landscape/LS\\_FullDisplayM.php?FN=LS02113\\_000.jpg](http://www.uvm.edu/perkins/landscape/LS_FullDisplayM.php?FN=LS02113_000.jpg)). Here, there are people and there is action. The caption sets the stage for a story telling us that men are moving logs off a gravel bar. The photograph is a catalyst for engaging discussions about the geomorphic effects of logging and riparian buffers. Teaching with both images gives the gravel bar meaning in a human context.

This proposal requests support for a “proof-of-concept” project designed specifically to address directly student misconceptions about relevance. We will build learning modules based on photographs and stories rather than words and abstractions to demonstrate the direct connection between people’s lives and Earth processes and materials.

## Goals and Objectives

The objective of our work is to demonstrate the scientific and educational feasibility of using image-centered topical modules to catalyze student learning and increase student perception that Earth Science is relevant to their lives. The immediate goal of this “proof of concept” project is to create four learning modules that engage introductory geology and physical geography students by using photographic imagery depicting the interaction between people and the landscapes upon which they live and work. The need for such engaging curricular materials has been identified by Yuretich et al., (2001), NSF (1996), and AGU (1996).

## Expected Outcomes

We expect the following outcomes from the project outlined in this proposal.

1. Working as a team and using best practices for web-based and classroom pedagogy, we will prototype and test a series of learning modules that use images of people interacting with the Earth as a catalyst for teaching basic principles in Earth Science. Our proposal responds directly to a national need for more effective and relevant teaching tools (NSF, 1996; AGU 1996).
2. Using embedded assessment tools based on the principal of pre- and post-testing, we will provide a credible evaluation of the impact of our prototype modules on student learning and student perceptions of relevance.
3. As we have a track record of doing (Butler et al. 2003; Nichols et al. 2003; Gran et al. 1999; Clapp et al., 1996), students, faculty and staff associated with this project will disseminate our methods and prototype modules to the professional community. We will report, at meetings and in peer-reviewed journals, both pedagogical approaches and evaluation results.
4. Successful completion of this “proof-of-concept” phase will result in submission of a larger follow-up proposal to expand module development to additional topics for eventual distribution on a national scale.

## Detailed Project Plan





This project will address the problem that many students believe that the educational materials used for introductory geology have little connection their lives (Kanfoush, 2003; Chaudhri and Kaur, 2003; Miller, 2002; Yuretich et al., 2001). In order to address this problem, we plan to develop, as a “proof of concept”, a series of four learning modules that approach various fundamental themes in geology. These modules will differ from any already available in that they will have as their centerpiece the use of imagery and information connecting society to the geologic themes about which the students are learning.

The modules will each have a different theme (Table 1). Each module will include an introductory web-based learning tool, an in-class component that will include participatory learning exercises and a PowerPoint template communicating major themes, and a concluding web-based tool that provides closure and allows the students to self-assess how much they have learned. Embedded in the web-based tools will be questions that allow us as developers and the faculty who use the modules means of assessing student learning and identifying how well common misconceptions have been addressed.

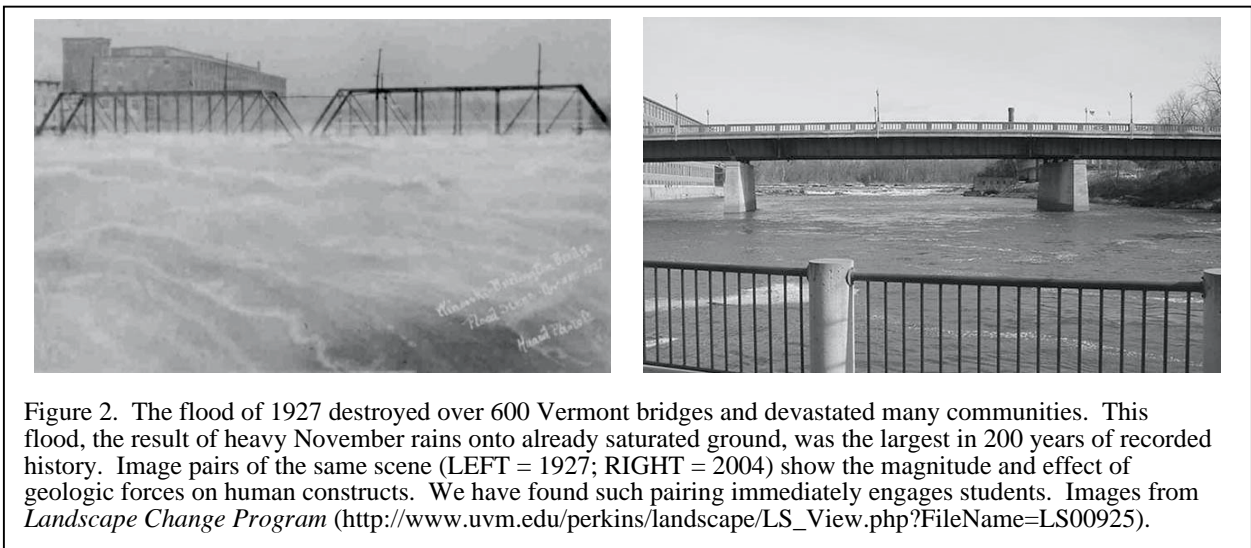
The modules will have at their core images of humans interacting with Earth systems. For example, the *Sliding Slopes* module will use imagery of erosion and landsliding as well as physical modeling as a catalyst for understanding the physical behavior of Earth materials. The introductory web resource will test student’s prior knowledge of mass movements, concepts of stress and strain, and the effect of slope failures on society. The resource will then offer imagery examples of how landslides are triggered both naturally and by human activities. Throughout the exercise, students will be interpreting images in order to focus their attention on slope stability and society. The classroom portion of the module will center on a series of stories (case studies) illustrated by imagery and designed to engage student interest. Integral to the classroom portion will be a hands-on exercise demonstrating the importance of pore pressure (water) in controlling whether slopes stand or fail. In small classes, this activity could be done by every student; in large classes, it would be a demonstration. The concluding web resource will reinforce both factual and reasoning skills developed earlier in the module, stressing higher-order thinking and amalgamation of disparate ideas into a coherent understanding of the physical properties of Earth materials.

We will obtain imagery for the modules from public image archives including the *Landscape Change Program*, an NSF-funded, on-line ([uvm.edu/perkins/landscape](http://uvm.edu/perkins/landscape)) digital archive of historic landscape images. Within the *Landscape Change Program*, are thousands of images depicting human-landscape interaction and geologic processes in action. For example, there are images of river

**Table 1. Themes of learning modules we will develop**

Example Image	Title	Major Topics	Student Learning Outcomes
	<b>Flows and Floods</b> <i>People look on as a dam and bridge, only 2 years old, are swept away in the '27 flood.</i>	<i>channel geometry runoff processes flood hazard flood frequency flood mitigation</i>	<i>Understand relation between precipitation, runoff and floods. Apply knowledge of channel geometries to relate flood hazard, frequency, and the viability of mitigation approaches.</i>
	<b>Sliding Slopes</b> <i>Landslide, triggered by pipe leak, removes a major road almost destroying a home.</i>	<i>material properties stress and strain pore pressure landscape clues slide hazards</i>	<i>Understand basic material properties, stress, and strain. Apply knowledge of earth materials and landscape response to predict sites and times of landslide hazard and societal effects.</i>
	<b>Rocks and People</b> <i>In 1937, talc miners working in old ocean crust freely inhaled rock dust.</i>	<i>rock types tectonic settings economic materials environment effects mining techniques</i>	<i>Understand how rock types &amp; tectonic settings are related and economic materials are extracted. Use this information to explain how mining affects people and their environs.</i>
	<b>Plants from a Stone</b> <i>Outcrops hold 12,000 year old striations but little more than lichen cover.</i>	<i>rock weathering rock geochemistry nutrient cycles plant communities disturbance</i>	<i>Understand elemental make-up of major rock types and plant nutrients. Use knowledge to explain geologic control on plant distribution and agricultural practices.</i>

channel change caused by flooding, of landslides resulting from clear cutting, and of the barren landscapes that result from mining hard rocks and smelting ores. An increasing number of the historic images in the archive are paired with current photographs of the same scene allowing students to see change over time, a demonstration of just how active earth processes are on very human timescales (Figure 2).



The production of the learning modules will be done by teams. Our project staff will include two science graduate students, Geology and Natural Resource Professor Bierman, education staff member Massey, and an educational multimedia developer from the University of Vermont Center for Teaching and Learning. We have recruited four faculty from outside the project team to fact-check and test the learning modules at different Colleges and Universities with the goal of understanding how well the modules work for different students in different settings.

Planning for the modules will start during the spring semester of 2005 when the teams will meet and the graduate students will work for credit with faculty and staff to begin schematic design of both the web and classroom resources. During summer 2005, graduate students will work full time gathering content and imagery to flesh out the two modules for which each will have primary responsibility. Working closely with the graduate students will be the multimedia developer, who will implement a consistent design theme in all of the modules. During the summer, the graduate students will be closely supervised by education staffer Massey and Geology faculty Bierman. We will have regular weekly meetings to exchange ideas and ensure steady progress.

By the end of the summer, the modules will be ready for review by the four outside faculty. Their comments will be incorporated early in the fall semester and the modules will then be ready for distribution and testing. This testing phase will occur during the 2005-2006 academic year and will see the modules tested first in both PI Bierman's Introductory Earth Hazards and Geomorphology classes in fall 2005. The latter is a 30-person class; the former has enrollments between 160 and 240 students. In early winter 2005, modules revised in response to the first in-class testing (at UVM) will be made available to the outside faculty reviewers for use and testing in their classrooms over the spring semester (see attached letters of commitment).

By the end of spring semester 2006, each module will have been tested by at least five different classes at four different institutions. The modules will have been tested with both Introductory Geology and Geography students. Because the modules will be available on the web and because we will be advertising their availability at national conferences and through geoeducation list serves, we anticipate that other faculty not originally identified in this proposal will also use and evaluate the learning modules. Since the web portions of the modules will include embedded assessment tools, with automated but individually anonymous reporting directly to UVM, we will gather additional effectiveness data from these *ad hoc* testers.

All intellectual and physical resources needed to complete this work are available at the University of Vermont. Staff and faculty associated with this project have extensive expertise in student-centered, inquiry-based education and the development of educational materials. The UVM Center for Teaching and Learning has worked with dozens of faculty to develop innovative education tools. By the time this project begins, the *Landscape Change Program* archive will have acquired more than 10,000 images of landscapes with four NSF REU interns completing work this summer; we will mine this archive for the most germane and striking images to use in the learning modules. The *Landscape Change Program* has G-4 power book computers that will be dedicated to the students working on this project. In fall 2004, the Geology Department is moving to a new building, with state-of-the-art technology including new computing labs and technology-equipped classrooms for teaching. Development and testing of our learning modules will occur in this environment as well as in the Center for Teaching and Learning laboratory.

#### **Experience, Capabilities, and Responsibilities of the Principal Investigator and Co-PI**

**Paul Bierman (PI)** – Bierman, a full Professor in Geology, has taught courses related to Earth surface processes at the University of Vermont since 1993. He will lead the project, participating in the design of all curricular materials. Bierman will supervise graduate students involved in the project and ensure the timely and high quality publication of the results. His expertise in such a role is shown by the success of his 240-person, innovative Earth Hazards course as documented in a cover story for EOS (Butler et al., 2003) as well as three articles detailing new, inquiry-based teaching methods in the Journal of Geoscience Education (Nichols et al., 2003; Gran et al., 1999; Clapp et al., 1996). Each article was first-authored by a graduate student working with Bierman both to develop the learning tools and prepare the paper.

**Christine Massey (Co-PI)** – Massey, a geologist and educator, has 6 years of experience as a Museum Education Specialist working within both the Geology and Education Departments at the University of Vermont. Massey will manage the day-to-day operation of the project coordinating the students and multimedia software developer; she will reduce all evaluation data statistically. Massey will provide educational methods expertise and linkages to the Vermont education community. Her

expertise in such a role is documented by her 10 years directing a residential program for inquiry-based science education as well as 11 professional abstracts related to Geoscience education. Massey is currently directing the Perkins digitization project, which has created over 12,000 images of the Perkins Museum collections (<http://www.uvm.edu/perkins>).

**Center for Teaching and Learning, University of Vermont** – The Center for Teaching and Learning is dedicated to improving the student experience by providing both physical and intellectual resources to faculty engaged in curricular reform and innovative teaching. At the Center, a professional staff member whose specialty is educational multimedia application development, will work with the graduate students, Bierman, and Massey, to implement, streamline, and ensure a consistent approach to the presentation of material. This web developer will embed the assessment tools in the web modules and implement the data reporting system.

The Center for Teaching and Learning works closely with faculty to analyze their instructional needs and goals, and use the appropriate technology and delivery system to meet those goals. The center's services range from developing academic websites, designing online courses/course elements (custom and WebCT), and developing software applications for course enhancement. Multimedia services include production and authoring of professional quality video, digital mastering, and editing of professional quality audio and video recordings for instructional purposes and delivery via the web or DVD. This Center's facility is equipped to help faculty, students, and staff create digital resources that will enhance the quality of learning for all students.

### **Evaluation Plan**

Dr. Cathryn Manduca, director of SERC (Science Education Resource Center) at Carleton College, will serve as a consultant to the project, organizing and directing the evaluation process (her CV is included). Manduca, is well known for her work on Geoscience education. Her group has developed extensive materials (<http://serc.Carleton.edu/NAGTWorkshops/webdesign/>) related to design of effective web-based learning materials. In 2004, Manduca served as the external project evaluator for the *Landscape Change Program* and so is familiar with the image archive and the University of Vermont.

We will engage in both formative evaluation and testing of the modules during their development as well as a summative evaluation of their impact at the project's conclusion. Formative evaluation will involve: 1) initial review of each module for accuracy by at least 2 faculty beyond the development team, 2) piloting of each module at UVM and subsequent revision; and 3) testing of each module at 4 institutions beyond UVM Geology. These will be different types of academic institutions in different parts of the country; thus, we expect their students will have different interests and experiences. We will use two approaches during formative evaluation. To evaluate the usability of each module, we will develop a set of evaluation questions related to the mechanics of using the module, accessing the images, and finding information. This questionnaire will be provided to both students and faculty involved in the testing runs. Second, we will further develop the list of key learning outcomes for each module listed schematically in Table 1 of this proposal. The specific outcomes will be used to design assessments embedded in the pre- and post-activity web-based exercises. The results of the pre- and post-tests will be used in the formative stage of development to guide refinement of the modules. Later testing data (after initial module refinement is complete) will form the basis of our summative analysis of the impact of the materials. Differences between pre- and post-test results will define module impact both on student learning and on the students' perception of relevance - our stated project goals.

Evaluation and project timeline:

- January '05 – funding begins, Bierman and Massey select graduate student team members
- March '05 – first Manduca visit to meet team, establish design criteria, and consider pre- and post-test question development
- May-August '05 – development of draft modules at UVM
- August '05 – external faculty review of modules

September '05 – module revision  
October '05 - May '06 module testing; phase 1, fall at UVM; phase 2, spring at other schools  
December '05 – second Manduca visit to Vermont, guiding revision with pre and post test data  
June '06 – evaluation data reduction at UVM by Massey  
Fall '06 – final summative evaluation report delivery by Manduca

#### Outside faculty evaluators

Dr. Beverly Wemple – Geography Department, University of Vermont  
Dr. Helen Mango – Geology Department, Caselton State College  
Dr. David Dethier – Geology Department, Williams College  
Dr. Douglas Clark – Geology Department, Western Washington State University

Because this is a *proof of concept* project, we have limited the scope of our outside evaluation team both in number and geographic focus choosing instead to compare the modules in different disciplines and in different types of schools. We have included a geographer (Wemple) as well as a faculty member with broad interests and expertise at a State College (Mango). Dethier will provide evaluation from the vantage point of a liberal arts institution whereas Clark's students will indicate how well our concept works at a mid-size University on the west coast.

#### **Dissemination Plan**

As a *proof of concept* project, our dissemination plan is academic, rather than commercial. We will continue to publish our educational findings and methods in peer-reviewed journals as we have done in the past (Butler et al., 2003; Nichols et al., 2003; Gran et al., 1999; Clapp et al., 1996) as well as present such findings at professional meetings. Our audience is teachers at the college level; thus, publication in geoeducation journals, submission to DLESE and/or NSDL, and presentation of our products at national geologic meetings are appropriate venues for dissemination. Indeed, we have budgeted for the project team to attend the 2005 Geological Society of America meeting where we would expect to make several different presentations.

The learning modules we develop will be resident on the *Landscape Change Program* website at the University of Vermont, free and publicly accessible. They will be described using appropriate metadata, as we are currently doing for the entire landscape change archive. Formal dissemination will be supplemented by word-of-mouth exchange of information, catalyzed in part by the four external reviewers we have enlisted for this project.

## REFERENCES CITED

---

- AGU, 1996, Spheres of Influence: Shaping the Future of Earth Systems Sciences Education workshop report [http://www.agu.org/sci\\_soc/spheres/intro.htm](http://www.agu.org/sci_soc/spheres/intro.htm)
- Bierman, P., Massey, C., and Hilke, J., 2004, The *landscape change program*: a community digital archive of Vermont landscape imagery, Vermont Geological Society winter meeting.
- Butler, E., Bierman, P.R., Gadja, R., 2003, Making geoscience interesting and relevant in a large lecture class, EOS, vol. 84, n 47, p 517, 522.
- Chaudhri, R. and Kaur, P., 2003, The status of geoscience education in the school curriculum. Current Science, v. 84, n. 5, p.1-2.
- Clapp, E., Bierman, P., Church, A. B., Larsen, P. L., Schuck, R. A. and Hanzas, J. P., 1996, Teaching Geohydrology through analysis of groundwater resources and glacial geology, northwestern Vermont. Journal of Geoscience Education. 44, 45-51.
- Gran, S. Nichols, K., and Bierman, P. R., 1999, Teaching winter using frozen lakes and snowy mountains, Journal of Geoscience Education. v. 47, p. 420-427.
- Kanfoush, S. L., 2003, Teaching the relevance of geology to non-science undergraduates through the use of major-specific projects: preliminary results, Abstracts and Programs, Geological Society of America, Northeast Section, paper No. 33-1
- Kelley, P. H. and Burks, R. J., 2004, The Importance of Teaching Earth Science in the Public Schools, Geological Society of America Position Statement, <http://www.geosociety.org/aboutus/position4.htm>
- Mallard, L.D., Massey, C.A., and Bierman, P.R., 2000, Vermont students gather digital images of human-induced landscape change, Geological Society of America Abstracts with Programs, 31 (7), A-421.
- Massey, C., Hilke, J., and Bierman, P.R., 2003, Landscape metamorphism in Vermont: building an image archive of the past and present with students, historical societies, and towns. Geological Society of America Abstracts with Programs. v. 35, n. 67693.
- Miller, M., 2002, Optional seminars bring small-class experiences to students in large-enrollment geology courses, *J. Geosci. Educ.*, 50, 308-311.
- NESTA, 1987, The Importance of Earth Science Education, statement by the National Earth Science Teachers Association, <http://www.nestanet.org/>
- Nichols, K.K., Bierman, P.R., Persico, L., Bosley, A., Melillo, P., and Kurfis, J., 2003, Quantifying land use and urban run off changes through service learning hydrology projects. Journal of Geoscience Education, v. 51, n. 4, p.365-372.
- NSF, 1996, Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology (NSF 96-139), Arlington, VA.
- Persico, L. P., Mallard, L. D., Bierman, P. R., and Massey, C. A., 2000, Forest to farmland and back again: a changing Vermont landscape: Geological Society of America Abstracts with Programs, 32 (7), A-24. (National)
- Shaver, D. B. and Wood, J. F., 2001, Geology in the National Park Service, Geotimes, p. 14-19.
- St. John, K. and Callahan, J., 2003, Making geology relevant to non-science majors through the Environmental Site Assessment Project Journal of Geoscience Education, v. 51, n. 4
- Yuretich, R.F., Khan, S.A., Leckie, R.M., and Clement, J.J., 2001, Active-learning methods to improve student performance and scientific interest in a large introductory oceanography course, *J. Geosci. Educ.*, 49, 111-119.

**Paul R. Bierman, Professor of Geology**  
**Department of Geology, University of Vermont, Burlington, VT 05405**

**(i) Professional Preparation**

- Ph.D., 1993, Geology, University of Washington, Seattle, WA with A. Gillespie  
"Cosmogenic Isotopes and the Evolution of Granitic Landforms"  
MS, 1990, Geology, University of Washington, Seattle, WA with A. Gillespie  
"Accuracy and Precision of Rock Varnish Cation Ratio Dating"  
BA, 1985, Geology and Environmental Studies, Williams College, Williamstown, MA  
"Deglaciation of Northwestern Massachusetts" (cum laude and senior thesis)

**(ii) Appointments**

- 2002-present Professor Univ. Vermont, Geology and Natural Resources  
1998-2002 Associate Professor Univ. Vermont, Geology and Natural Resources  
1993-1998 Assistant Professor Univ. of Vermont  
1992-1993 Lecturer University of Washington  
1993 Visiting Researcher University of Adelaide  
1987-1992 Research and Teaching Assistant University of Washington  
1985-1987 Hydrogeologist and Project Manager Alliance Tech., Bedford, MA  
1985-1987 Instructor Museum of Science, Boston

**(iii) Publications**

*(i) 5 publications most closely related to the proposed project*

- Butler, E., Bierman, P.R., Gadsby, R. (2003) Making geoscience interesting and relevant in a large lecture class, **EOS**, vol. 84, n 47, p 517-522.  
Bierman, P.R. (2000) Henry's Land, in **The Earth Around Us: Maintaining a Livable Planet**, J. Schniederman, ed., Freeman, p. 47-56.  
Gran, S. Nichols, K., and Bierman, P. R., (1999) Teaching winter using frozen lakes and snowy mountains, **Journal of Geoscience Education**. v. 47, p. 420-427.  
Bierman, P., Lini, A., Davis, P.T., Southon, J., Baldwin, L., Church, A. and Zehfuss, P. (1997) Post-glacial ponds and alluvial fans: recorders of Holocene landscape history. **GSA Today**. 7 (10) p. 1-8.  
Clapp, E., Bierman, P., Church, A. B., Larsen, P. L., Schuck, R. A. and Hanzas, J. P. (1996) Teaching Geohydrology through analysis of groundwater resources and glacial geology, northwestern Vermont. **J. Geoscience Education**. 44, 45-51.

*(ii) 5 significant publications,*

- Bierman, P. R. and Nichols, K.K. (2004) Rock to sediment - Slope to sea with  $^{10}\text{Be}$  - Rates of landscape change, **Ann. Review of Earth Science**. v. 32. p. 215-255  
Bierman, P.R., Caffee, M.W., Davis, P.T., Marsella, K., Pavich, M., Colgan, P., Mickelson, D., and Larsen, J. (2003) Understanding the rates and timing of Earth surface processes using in-situ produced cosmogenic  $^{10}\text{Be}$ , in: Beryllium: Mineralogy, Petrology, and Geochemistry, **Rev. in Mineralogy**, Ed. E. Grew.  
Noren, A., Bierman, P.R., Steig, E., Lini, A., and Southon, J., (2002), Millennial scale storminess variability in the northeastern United States during the Holocene epoch, **NATURE**, v. 419, 821-824.  
Bierman, P. and Caffee, M. (2001) Steady state rates of rock surface erosion and sediment production across the hyperarid Namib desert and the Namibian escarpment, southern Africa. **American Journal of Science**. v. 301, (4-5), p. 326-358.

Bierman, P. and Steig, E. (1996) Estimating rates of denudation and sediment transport using cosmogenic isotope abundances in sediment. **Earth Surface Processes and Landforms**, 21, 125-139.

**(iv) Synergistic Activities**

Innovations in teaching and training – Development of student-centered, inquiry-based, data collection courses in Geomorphology and Geohydrology documented in 3 refereed papers in the Journal of Geologic Education (2003, 1999, 1996). Creation of introductory Earth Hazards class for non-science majors with integrated discussion sections to increase student interest and involvement, documented in refereed lead article in EOS (2003).

Development of data bases to support research and education -- Creation of web-based Landscape Change archive with thousands of images of human/landscape interaction dating back to 1850. Used for research and K-16 education.  
<http://www.uvm.edu/perkins/landscape/>

Service learning and service to community -- Urban hydrology projects with classes and interns working with Burlington city government to document loss of greenspace and increase in run off from campus neighborhoods. Documented in Nichols et al. (2003, Journal of Geologic Education). Associate Editor, Geology and GSAB; editorial board, DLESE.

Development and refinement of research tools – Fundamental work with graduate students developing and refining use of cosmogenic nuclides for monitoring rates of surface processes. Five major review publications (1994, 1998, 2001, 2003, 2004) and 26 refereed articles and book chapters with new cosmogenic data. Developed tools for reconstructing Holocene paleostorminess history of New England under NSF CAREER support. Donath Medal for Research by Young Scientist, Geological Society of America, 1996.

**(v) Collaborators & Other Affiliations**

(a) Collaborators and Co-Editors (48 months)

D. Dethier, Williams College; D. Clark, WWU; P. Davis, Bentley College; M. Caffee, Purdue; E. Steig, UW; J. Southon, UCI; Y. Enzel, Hebrew U.; A. Matmon, USGS; M. Pavich, USGS; P. Colgan, Northeastern; D. Mickelson, UW; C. Duncan, U Mass; K. Nichols, Skidmore; A. Gellis, USGS; E. Clapp, Sevee & Mahar; A. Elwein, USGS; P. Schroeder, U Georgia; N. Melear, U Georgia; M. Kashgarian, LLNL; K. Marsella, Skidmore; J. Larsen, UVM; R. Finkel, LLNL; L. Persico, UNM; T. Schildgen, MIT; K. Klepeis, UVM; M. McGee, UVM; S. Wright, UVM; S. Southworth, USGS; N. Porat, IGS; Amit, R., IGS; O. Crouvi, IGS; J. Briner, CU; G. Miller, CU, K. Jennings, USFS, S. Brown, OSU; A. Lini, UVM; A. Noren, U Minn; S. Gran, UW; D. Rizzo, UVM; P. Zehfuss, UW; J. Lekach, IGS.

(b) Graduate and Postdoctoral Advisors.

Alan Gillespie, University of Washington, graduate advisor  
Rowl Twidale, University of Adelaide, postdoctoral sponsor

(c) Thesis Advisor and Postgraduate-Scholar Sponsor.

A. Matmon, Postdoctoral advisor, USGS; K. Nichols, Doctoral advisor, Skidmore College; E. Clapp, Doctoral advisor, Sevee and Mahar; L. Reusser, Doctoral advisor, University of Vermont; primary advisor, 4 PhD. and 16 MS students

**Christine Ann Massey**  
Museum Education Specialist  
Department of Education, University of Vermont, Burlington, VT 05405-0122  
Office: (802) 656-1344 Email: [christine.massey@uvm.edu](mailto:christine.massey@uvm.edu)

(i) **Professional Preparation**

Carleton College	Geology (with Natural History and German)	B.A.	1986
University of Washington	Geology	M.S.	1995

(ii) **Appointments**

1998-present Museum Education Specialist Perkins Museum, Univ. of Vermont (UVM)  
1995-present Adjunct Lecturer University of Vermont  
1995-present Director Science & Technology Governor's Institute for VT H.S. Students  
1996-1998 K-12 Outreach Coordinator Perkins Museum, University of Vermont  
1993-1995 Environmental Consulting Geologist WH&N, Burlington, VT  
1989-1993 Research and Teaching Assistant (Geology/Chemistry/Environmental Sciences/Northwest Center for Research on Women) Univ. of WA  
1988-1989 Hydrologic Field Assistant U. S. Geological Survey, Menlo Park, CA  
1986-1987 Naturalist Intern Foothill Horizons Outdoor Educ. Center, Sonora, CA

(iii) **Publications** (*5 related to this project*)

Massey, C. A., Hilke, J., and Bierman, P. R., (2003). Landscape Metamorphism in Vermont: Building an Image Archive of the Past and Present with Students, Historical Societies, and Towns. **Geological Society of America—2003 National Mtg. Abstracts with Programs**, 35 (6), p 121, (<http://serc.carleton.edu/NAGTWorkshops/gsa03/activities/1874.html>).

Massey, C. A., Elvin, D. W., and Mora-Klepeis, G., (2002). Digitizing the Collections of the Perkins Geology Museum to Support On-line Learning Applications about Vermont Geology, **Geological Society of America—2002 National Mtg. Abstracts with Programs**, 34 (6), p. 455.

Massey, C. A. (2001). Digital databases at the Perkins Geology Museum, **Geological Society of America—2001 National Mtg. Abstracts with Programs**, 33 (7), A-122.

Massey, C. A., Mallard, L. D., Bierman, P. R., (2000). Digital archive of human-induced landscape change with K-16 students in Vermont, **Geological Society of America—2000 National Mtg. Abstracts with Programs**, 32 (7), A-204.

Massey, C. and Snyder, S., (1999). Geologic field trips sites for teachers in Northwestern Vermont. In Wright, S. F. ed., **New England Intercollegiate Geologic Conference Guidebook**, 91, 159-177.

**Publications** (*5 other*)

Massey, C. A. (2004). Town-gown Geology: Preservation of Sites in NW Vermont. **Geological Society of America—Northeastern Section (39th Annual) and Southeastern Section (53rd Annual) Joint Mtg. (March 25–27, 2004) Abstracts with Programs**, p. 116.

Massey, C. A., (1998). Earth Science Week. **Connect: Teacher's Innovations in K-8 Science, Math and Technology**, 12, 1, 26.

Massey, C. A., (1998). Learning through inquiry and community service--The Science & Technology Institute for Vermont high school students. **Geological Society of America--1998 National Mtg. Abstracts with Programs**, 30, 7, A-350.

Massey, C. A., (1997). Environmental Science and Technology Institute for Elementary Teachers and Education Majors in Vermont. **Geological Society of America--1997 National Mtg. Abstracts with Programs**, 29, 6, A-301.

Massey, C. A., (1996). Thrust faults, plankton tows, wastewater, and SEMs: Vermont Earth and Environmental Science for K-12 students and teachers. **Geological Society of America--1996 National Mtg. Abstracts with Programs**, 28, 7, A-476.

(iv) **Synergistic Activities**

Perkins Digital Image Archives

- Coordinate and direct activities for the Institute for Museum and Library Services (IMLS)-funded project to digitize the collections of the Perkins Museum and for the NSF-funded Landscape Change Program (<http://www.uvm.edu/perkins>).
- Participate in digital library conferences/meetings: Digital Library for Earth System Education (DLESE), WebWise (IMLS-sponsored), NE Document Conservation Center (NEDCC), National Science Digital Library (NSDL), and UVM Digitization Center.

Formal Science Education

- Teach *Intro. Geology*, *Fire and Ice*, and *Geology of Nat. Parks* courses through the Continuing Education Division at the University of Vermont; *Regional Geology to Geology Majors*; and *Science in Vermont* to Elementary Teachers and Educ. Majors.

Informal Science Education

- Direct summer science programs at the UVM Perkins Geology Museum including: *Governor's Institute on Science and Technology* for capable high school students, *Summer Science Adventure for Girls and for Boys* in middle school, and *Environmental Science Day Camp* for elementary students.
- Facilitated outreach for Perkins Museum visits, tours, teacher geology resource needs, and teacher professional development.
- Coordinate the *JASON Project* in Vermont (interdisciplinary, multi-media, supplementary science curriculum for grades 4-9).

Service and Equity Training

- Three-year appointment on the UVM *President's Commission on the Status of Women*.
- Short course participant in *Engaging Middle School Girls in Math & Science*, *Diversity at UVM*, *Equity Workshop for K-12 Educators*, *Accessibility to Websites*, and *Lead-Scientist Institute on Systemic Reform of Elementary Science Education*.
- Science-By-Mail* volunteer scientist mentoring elementary students (1992-2000).

Professional Memberships

- GSA, AGU, NAGT, AWG, Vermont Geological Society (Vice President-1999; Education Chair-2000 to present), and Vermont Science Teacher's Association.

(v) **Collaborators and Other Affiliations**

(a) *Collaborators (last 48 months)*: Russell Agne (UVM Education), Paul Bierman (UVM Geology and Natural Resources), Barry Doolan (UVM Geology), David Elvin (VT Info. Systems, Inc.), Jens Hilke (UVM Geology), Laura Mallard (Appalachian State Univ.), Charlotte Mehrtens (UVM Geology), Gabriela Mora-Klepeis (UVM Geology), Jean Olson (Governor's Institutes of VT), and Shelley Snyder (Mt. Abraham H.S.).

(b) *Graduate Advisors*: Minze Stuiver (Quaternary Research Center/Geology) and Pieter Grootes (Quaternary Research) University of Washington.

(c) *Thesis Advisor Sponsor (1 grad; 2 undergrad; 4 high school)*:

Graduates: Eric Butler, UVM Teaching Geology M.A. *Landscape Change Project in Shelburne*, 2004.

Undergraduates: Allison Brigham, UVM Education BA, *Final Project for EDSS course*, 2002; Jill Wagner, UVM Env. Studies BA, *Env. Education at Burlington High School*, 1997.

High School Students

Christian Fox, The Gailor School, *Making Geologic Maps*, 2002-2003;

Maggie Holmes, CVU High School, *Different learning styles to learn science*, 2002;

Kate Elvin, CVU High School, *Water levels in the Lake Champlain Basin*, 2001;

Katherine Meyer, CVU High Sch., *Science Learning for Middle Sch. Girls and Boys*, 1999.

**Cathryn Allen Manduca**

Science Education Resource Center, Carleton College  
One North College Street, Northfield, MN 55057  
(507) 646-4425 (office)

Email: [cmanduca@carleton.edu](mailto:cmanduca@carleton.edu)

**Professional Preparation**

Williams College	Geology	B.A., 1980
California Institute of Technology	Geology	M.S., 1982
California Institute of Technology	Geology	Ph.D., 1988

**Appointments**

2002 -	Director, Science Education Resource Center
1999-2001	DLESE Outreach Coordinator
1994-2000	Coordinator, Keck Geology Consortium
1995-1997	Asst. Prof. of Science at Rochester Community College
1994	Asst. Prof. of Physics at St. Olaf College
1992-2001	Research Associate in Geology at Carleton College
1989-1992	Asst. Prof. of Geology at Carleton College

**Publications** *Publications related to this project*

Manduca, C., *Sharing Teaching Materials and More: New Opportunities for Placing DLESE Resources in Context*, 2003, Geological Society of America, Abs with Programs v. 35, no. 6, p 568.

Manduca, C.A. and S. Fox, *Displaying Resources in Context: Using Digital Libraries to Support Changes in Undergraduate Education*, 2003, Proceedings from the Joint Conference on Digital Libraries, Houston, Texas.

Manduca, C.A., McMartin, F., and D.W. Mogk, eds., *The National SMETE Digital Library: Pathways to Progress*. 2001, Report from UCAR to the National Science Foundation, Grant # 00-816100 [available online at: <http://www.nsd.org/community/documents.php>].

Manduca, C.A. and D.W. Mogk, *The Digital Library for Earth System Education: A Community Plan*, 2000, Final report from the University of Oklahoma to the National Science Foundation, Grant #99-06648, 44 pp. [Available online at: <http://www.dlese.org/documents/plans/index.html>].

Marlino, M.R., Sumner, T., Fulker, D., Manduca, C.A. and D. Mogk., *The Digital Library for Earth System Education: Building Community, Building the Library: Communications of the ACM*, v. 44, no. 5, 2001.

**Other publications**

Manduca, C.A., Mogk, D.W., and N. Stillings, *Developing Collaborations Between Learning Scientists and Geoscience Educators*, 2003, Proceedings from the Fourth International Geoscience Education Conference, Calgary, Alberta, Canada.

Manduca, C.A., and D.W. Mogk, *Using Data in Undergraduate Science Classroom*, 2003, Report from Carleton College to the National Science Foundation, Grant #0127298 [available online at: <http://serc.carleton.edu/usingdata>].

Manduca, C.A., *Undergraduates Learning Science Through Research - The Keck Geology Consortium Undergraduate Research Program*, *Geotimes*, v. 42, no. 10, p. 27-30, 1996.

Manduca, C.A., *Living with Karst: Maintaining a Clean Water Supply in Olmsted County, MN*, 2000, *The Earth Around Us*, Schneiderman, J.S. ed., W.H. Freeman.

Ireton, F.W., Manduca, C.A., and D.W. Mogk, *Towards a Coherent Plan for Undergraduate Earth Science Education: A Systems Approach*, *Journal of College Science Teaching*, v. 26, no. 5, p. 304-308, 1997.

### **Synergistic Activities**

1. *NSDL and DLESE Committees*: DLESE Data Access Working Group (2000- ); NSDL Community and Services Standing Committee (2002- ); NSDL Coordinating Committee, Chair (2000-2001); DLESE Steering Committee, Chair (1999-2001), DLESE Annual Meeting, Program Chair (2001).
2. *Co-convenor of national geoscience education workshops and co-editor of proceedings including*: *Teaching Geoscience with Visualizations* (2004); *Designing Effective Web-based Learning Resources* (2003); *Bringing Research on Learning to the Geosciences* (2002); *Teaching Quantitative Skills in a Geoscience Context* (2002); *Earth System Education Partnerships with Research Institutions* (2001); *Portal to the Future: A Digital Library for Earth System Education* (1999); *Spheres of Influence-Shaping the Future of Earth System Science Education* (1996).
3. *Organization of workshops sessions at professional society meetings including*: *Building Strong Geoscience Departments: Examples that Work* (AGU, Fall 2003); *Using Data to Teach Earth Processes: An Illustrated Community Discussion* (GSA, Fall 2003); *Towards a Better Understanding of the Complicated Earth: Insights from Geologic Research, Education, and Cognitive Science* (GSA, Fall 2002); *Enhancing Diversity in the Geosciences* (AGU, Spring 2000); *Digital Library for Earth System Education Workshop* (AGU, Fall, 2000).
4. *Professional Society activities*: National Association of Geoscience Teachers: Distinguished Lecturer (2000-2001), National Officer (2001-2002), President (2003). American Geophysical Union: Excellence in Geophysical Education Prize (2004), Committee on Education and Human Resources (1998-2002). Project Kaleidoscope: Networking Advisory Board (2002- ), Sigma Xi: Education Advisory Council (1997- ), Executive Committee (2000-2001, 1997-1998), Long Range Planning Committee (1996-1999).

### **Collaborators & Other Affiliations**

Dave Fulker (UCAR), Laura Guertin (Pennsylvania State University, Delaware County), Heather Macdonald (College of William and Mary), Mary Marlino (UCAR), Flora McMartin (University of California, Berkeley), Dorothy Merritts, (Franklin & Marshall College), Bob MacKay (Clark College), Dave Mogk (Montana State University), Sam Patterson (Carleton), Randall Richardson (University of Arizona), Martin Ruzek (USRA), Mary Savina (Carleton College), Jill Schneiderman (Vassar College), David Simpson (IRIS), John Snow (University of Oklahoma), Neil Stillings (Hampshire College) Tamara Sumner (University of Colorado), Basil Tikoff (University of Wisconsin), Barb Tewksbury (Hamilton College).

**Graduate Advisors:** Leon T. Silver and Hugh P. Taylor, California Institute of Technology

**Thesis Advisor and Postgraduate-Scholar Sponsor:** None