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**PI/PD Name:** Paul R Bierman

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

**Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):** ☐

**REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project** ☒

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**Hispanic or Latino.** A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

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**Black or African American.** A person having origins in any of the black racial groups of Africa.
**Native Hawaiian or Other Pacific Islander.** A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
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**PI/PD Name:** Klaus Keller

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

**Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):** ☐

**REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project** ☒

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**PI/PD Name:** Eric Kirby

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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**PI/PD Name:** Kyle K Nichols

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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**PI/PD Name:** Donna Rizzo

**Gender:** ☐ Male ☒ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
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- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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## List of Suggested Reviewers or Reviewers Not To Include (optional)

**SUGGESTED REVIEWERS:**

**REVIEWERS NOT TO INCLUDE:**

# COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1

**NSF 11-564** **10/19/11**

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

**OISE - PIRE**

| DATE RECEIVED | NUMBER OF COPIES | DIVISION ASSIGNED | FUND CODE | DUNS# (Data Universal Numbering System) | FILE LOCATION |
|---|---|---|---|---|---|
| | | | | **066811191** | |

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

**030179440**

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

**University of Vermont & State Agricultural College**

AWARDEE ORGANIZATION CODE (IF KNOWN)

**0036962000**

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

**University of Vermont & State Agricultural College**
**340 Waterman Building**
**Burlington, VT. 054050160**

NAME OF PRIMARY PLACE OF PERF

**University of Vermont & State Agricultural College**

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

**University of Vermont & State Agricultural College**
**340 Waterman Building**
**Burlington ,VT ,054050160 ,US.**

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Shaping Resilient, Sustainable Landscapes in a Rapidly Developing Nation - Brazil**

| REQUESTED AMOUNT | PROPOSED DURATION (1-60 MONTHS) | REQUESTED STARTING DATE | SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE |
|---|---|---|---|
| $ **2** | **60** months | **12/01/12** | |

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☒ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
**CH**
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
**Department of Geology**

PI/PD FAX NUMBER
**802-656-0045**

PI/PD POSTAL ADDRESS
**Delehanty Hall**
**180 Colchester Ave**
**Burlington, VT 05405**
**United States**

| NAMES (TYPED) | High Degree | Yr of Degree | Telephone Number | Electronic Mail Address |
|---|---|---|---|---|
| PI/PD NAME<br>**Paul R Bierman** | **PhD** | **1993** | **802-656-4411** | **pbierman@uvm.edu** |
| CO-PI/PD<br>**Klaus Keller** | **PhD** | **2000** | **814-865-6718** | **klaus@psu.edu** |
| CO-PI/PD<br>**Eric Kirby** | **PhD** | **2001** | **814-865-0732** | **ekirby@psu.edu** |
| CO-PI/PD<br>**Kyle K Nichols** | **PhD** | **2002** | **518-580-5194** | **knichols@skidmore.edu** |
| CO-PI/PD<br>**Donna Rizzo** | **PhD** | **1994** | **802-656-1495** | **drizzo@cems.uvm.edu** |

# CERTIFICATION PAGE

## Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

## Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

## Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

## Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

## Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

## Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

## Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

## Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:
(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

## Certification Regarding Responsible Conduct of Research (RCR)
## (This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

| AUTHORIZED ORGANIZATIONAL REPRESENTATIVE | SIGNATURE | DATE |
|---|---|---|
| NAME<br>**Julie Macy** | | **12/06/10** |

| TELEPHONE NUMBER | ELECTRONIC MAIL ADDRESS | FAX NUMBER |
|---|---|---|
| | **julie.macy@uvm.edu** | |

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

**Project Summary -** *Shaping Resilient, Sustainable Landscapes in a Rapidly Developing Nation*

Landscapes, the interface between Earth's dynamic surface and human civilization, are a key nexus of sustainability. For example, soil loss from deforestation or agriculture on steep slopes and water pollution from untreated sewage, limit the long-term ability of societies to sustain healthy, thriving populations. Communities built in areas where surface processes are active, including river bottoms and unstable slopes, are routinely devastated by high-magnitude, low-frequency events such as debris flows, floods, and landslides. A predictive understanding of the rate, frequency, and spatial distribution of surface processes is prerequisite to resilient, sustainable development; yet, such scientific and engineering knowledge is not enough. For development to produce more sustainable landscapes, we must understand and respond to the social and economic drivers that place people and their communities in harm's way and cause populations to so damage their environments that civilizations suffer and may even fail.

Brazil, with its diverse landscapes and cultures, expanding science, technology, engineering, and mathematics (STEM) infrastructure, and exceptionally rapid development trajectory, provides the ideal setting both for collaborative sustainability research and for training the next generation of globally fluent scientists, engineers, and teachers. Building upon established collaborations, students, faculty, and K-12 secondary education teachers engaged in this PIRE will use cutting edge geochemical and modeling techniques as well as their expertise in geology, hydrology, engineering, complex systems, economics, and risk analyses to characterize and predict natural and human-induced rates of change at Earth's surface along the climatic, tectonic, cultural, economic, and development gradients that characterize Brazil. They will use these insights to create a series of metrics that identify areas where current development practices are most consilient with natural systems, thus creating a template for development most likely to produce more resilient and sustainable landscapes over the long term.

This PIRE will provide diverse international educational and research (field and laboratory) experiences for 12 graduate students, 9 teachers (K-12), 18 undergraduates, 2 post-docs, and an outreach coordinator. Our goal is to do the science needed to purposefully alter development trajectories so that the environmental impact of development is reduced and the resulting developed landscapes have the least possible impact on the people who inhabit them.

Personnel and Collaborating Institutions - P. Bierman (PI), D. Rizzo and C. Massey (Univ. of Vermont), E. Kirby and K. Keller (Penn State), K. Nichols (Skidmore College), D. Rood (UCSB & Livermore National Laboratory), N. Fernandes (UFRJ, Brazil), S. XXX (Embrapa, Brazil). The University of Vermont has not participated in past PIRE awards.

Intellectual Merit - Our research approaches a fundamental problem in Sustainability Science – how can development proceed in a way that both minimizes human impact on natural systems and makes society resilient to the shifting mosaic of Earth Surface processes? Using geochemical systems and both deterministic and stochastic modeling to estimate the rate, timing, and spatial distribution of surface processes, in concert with economic and development data, identifies areas where development has progressed most sustainably – a model for the future.

Broader Impacts - Broader impacts for this project are significant and varied including: active strategies to recruit and retain undergraduate and graduate students from underrepresented groups, easy web-based access to data critical to a wide variety of disciplines, training the next generation to have a broad, international view of coupled human/natural dynamic systems, and integrating research and education through *Recruitment Seminars*, *International Training Workshops*, and *Professional Short Courses* that disseminate project results to the scientific community including students and faculty.

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For font size and page formatting specifications, see GPG section II.B.2.



*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

## Project Description

### Administrative Summary

Title: *Shaping Resilient, Sustainable Landscapes in a Rapidly Developing Nation - Brazil*
Principle Investigator: *Paul Bierman*
Length of Study: *5 years*
Estimated Total Budget: *$3,900,000 over 5 years*
Lead Institution: *University of Vermont*
Partner Institutions and Key Researchers:

*Federal University of Rio de Janeiro, Brazil: Nelson Fernandes*
*Embrapa (Solos), Brazil: Silvio XXX*
*Pennsylvania State University: Eric Kirby and Klaus Keller*
*Skidmore College: Kyle Nichols*
*UC Santa Barbara & Lawrence Livermore National Laboratory: Dylan Rood*
*Perkins Geology Museum, University of Vermont: Christine Massey*
*University of Vermont, College of Engineering: Donna Rizzo*
*University of Vermont, School of the Environment and Natural Resources: William Keeton*

Additional Funding Opportunities: *US AID and IAI*

*Project Management Plan*

This project is a collaborative venture between 4 US institutions, 2 Brazilian institutions, and 5 PIs of varying rank and experience, all of whom have worked together extensively, co-advising students in different combinations, over the past 10 years. Because we have well-established relationships, project management will be collaborative with US PI meetings every 6 months and monthly scheduled conference calls/web conferences between US and Brazilian researchers. PI Bierman will oversee the entire project as well as cosmogenic isotope sample preparation and interpretation by graduate students. He will manage a part-time project administrator and lead the interaction with foreign collaborators. Co-PI Kirby will lead the portion of the project related to solid Earth/surface process interactions and predictive landscape modeling. Co-PI Rizzo will lead the experimental design, data analysis, complex systems modeling, and engineering considerations. Co-PI Nichols will mentor the Postdoctoral Associate, oversee undergraduate recruiting, and direct short-lived radionuclide measurements and interpretation. Co-PI Keller will lead the risk analysis and minimization research while team member Rood will oversee AMS measurement and data reduction. Outreach coordinator Massey will recruit, advise, and interface with K-12 teachers as they travel to Brazil and then develop curricular modules. Graduate student admission will be coordinated between Vermont and Penn State. Graduate students will have a lead advisor at their institution but will be co-advised by the other project faculty. All active students and faculty involved with the project will gather every July in Brazil before fieldwork and every January at one of the US campuses for *Project Conferences*.

**Research Summary** - *Background and Justification*

Human civilization, despite a massive expansion in technology over the past century, still depends on the hydrosphere and the thin veneer of soil known as the *critical zone,* to provide for the most basic of human needs: food, water, and a place to live. With some suggesting that the ~7 billion humans inhabiting Earth might now be the most active agent of planetary change (Hooke, 1994) – altering Earth's surface, atmosphere, and climate at an unprecedented pace (IPCC, 2007) – understanding and predicting how the thin mantle of soil, weathered rock, and water that covers our planet will respond to human-induced landscape change (development) is critical. Such advances will only come if we gather relevant data and train a community of scientists capable of deducing the rate, spatial distribution, history, and social impact of Earth Surface processes as they relate to society and landscape management (GLD SEES, 2011).

Nowhere is the interaction between people and the landscape on which they live more clear than in the developing world where landscapes are rapidly changing in the face of growing populations and increasing mechanization. The contrasts are vivid; satellite dishes hang off homes that discharge raw sewage to streams from which people downstream draw their drinking water. Debris flows tear through channelized streams, ripping homes from their foundations while on steep hill slopes; intensive agriculture catalyzes the loss of fertile topsoil. Human actions are altering the trajectory of natural systems and the response of those systems is, in turn, impacting human communities.

Sustainability, the concept that humans can inhabit the planet in a way that minimizes harm to the environment, optimizes societal resilience to hazards arising from shifts in natural systems, and provides for future generations, is more than a lofty goal – in the face of dramatic population growth and a finite resource base, sustainability is a necessity. Analysis of the historical record is not optimistic – many scholars provide evidence that unsustainable societies collapse (e.g., Diamond, 2007; Montgomery, 2008). They suggest that such collapses were triggered by a variety of proximal mechanisms including economic and social upheavals; however, underlying the demise of many societies including the Greeks, the Romans, and the Maya, was something far simpler - soil erosion, the loss of soil fertility, and thus a lack of food (Montgomery, 2008). Other societies, such as the Minoans, may have met their end when a natural catastrophe (the eruption of Thera and consequent tsunami) destroyed their primary technology (ship building) for which there was no "back up" (Zebrowski, 1999).

Failed societies of the past have in common an important system characteristic – lack of resilience. Resilient systems are diverse, complex, and redundant. They are stable in the face of small perturbations and have the ability to recover from large-magnitude, low-frequency events (Fiksel, 2003). For example, industrial agriculture monocultures are more vulnerable to weather extremes and pest outbreaks than diversified locally-based food systems (Hodge et al., 2001). In short, resilient systems are designed for the long-term and are thus, more sustainable.

A well-trained STEM workforce is critical for accomplishing both applied and basic research needed to steer the course of our global society toward sustainability. This PIRE has three deeply interrelated goals: 1) basic research to understand the rate and spatial distribution of landscape change in Brazil over human and natural timescales, 2) use of that knowledge to develop and implement informed, sustainable, land-use strategies, and 3) training the next generation of STEM researchers and educators in a holistic, interdisciplinary means to implement evidence-based change in landscape management approaches around the world.

**Research Summary** - *Overarching Research Objectives*

*Fig 1. Debris flow damage in Teresopolis, Brazil 2011*

*Step 1. Determining and comparing background and human-induced rates of landscape change*

In order to evaluate and improve landscape-level sustainability, we need data sufficient to compare long-term (background) rates of landscape change to those that result from human activities. PIRE science will focus on two styles of landscape change: 1) low-frequency, high-magnitude events (rock falls, debris flows, and landslides) and 2) the persistent, on-going loss of soil from landscapes by incremental erosion. The former, dramatic natural hazards, kill people and disrupt infrastructure as exemplified by the 2011 events, including debris flows, landslides, and flooding. The latter is incremental and largely unseen, yet can spell disaster over the long term if it impacts the ability of a nation to feed its people (Montgomery, 2008).

To deduce long-term rates of landscape change, we will analyze $^{10}$Be, a cosmogenic nuclide produced at Earth's surface (Bierman and Nichols, 2004). $^{10}$Be in stream sediment can be used at a drainage basin scale to determine landscape rates of sediment generation (e.g. Brown et al., 1995; Bierman and Steig, 1996; Granger et al., 1996). Measured in hillslope soils, $^{10}$Be constrains rates of soil movement down slope (Nichols et al., 2002; Jungers et al., 2010). $^{10}$Be ages of debris flow boulders can be used to estimate recurrence interval of large, damaging flows (e.g. Bierman et al., 1995; Zefuss et al. 2001). A recent compilation of published $^{10}$Be measurements shows how little we know about the background rate of soil formation in South America. PIRE research will fill that gap and provide the information on the geospatial patterns of erosion and soil formation in eastern South America (Portenga and Bierman, 2011).

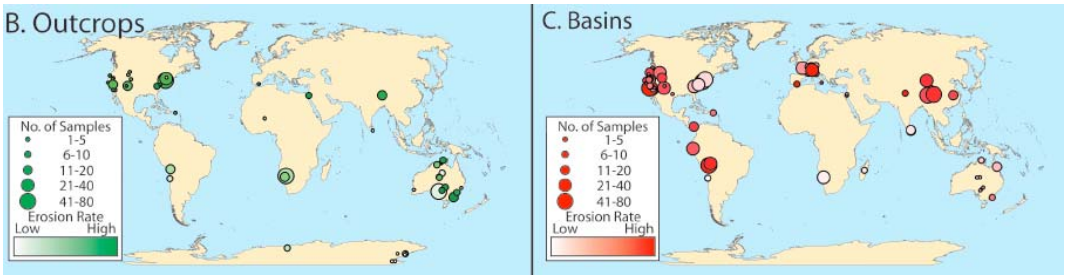


*Fig 2. Compilation (Portenga and Bierman, 2011) of cosmogenically estimated erosion rates*

We will constrain short-term, human-induced rates of landscape change using tools, including analysis of short-lived radionuclides (Fornes, et al, 2005; Mabit et al., 2008), modeling of soil erosion at the plot scale (Porto et al., 2001), and mass balance calculations using sediment yield data. These data directly address the challenges articulated in GLD SEES (2011). *"What is the relative importance of anthropogenic vs. natural changes?* If current rates of soil erosion exceed the rate of soil (sediment) production, the present-day agricultural system is not sustainable.

We will compile maps of historical debris flow and landslide occurrences and visit these areas to sample deposits for dating, using $^{10}$Be and fallout radionuclides. The results will indicate relative risk in different catchments and for different styles of development. By working across climatic gradients, and by incorporating the latest climate predictions into numerical slope stability models, we will strive to predict landscape response to future climate states.

*Step 2. Identifying and quantifying thresholds beyond which a landscape becomes unsustainable*

Identifying and understanding thresholds (tipping points) beyond which changes in system behavior become irreversible on human time scales is critical to determining the sustainability of any development trajectory. PIRE research will focus on two very different thresholds. 1) We will investigate the abrupt physical thresholds that define slope instability and the generation and distribution of the destructive and deadly debris flows that result. Slope stability thresholds are not static; they change as land is developed and deforested (Montgomery et al, 2000) and as climate change alters precipitation patterns (Dehn et al, 2000). Mapping and dating older flows will define hazard zones; stochastic physical models will enable prediction. 2) We will examine less discrete thresholds, for example, how much topsoil must erode before loss of fertility forces farmers to switch crops or abandon fields? Comparison of long-term soil generation rates (measured with $^{10}$Be) with short term soil loss rates is a key sustainability metric.

Smart experimental design will allow us to design spatially representative sampling plans. Brazil is a very large country and our research will be limited in spatial scope and duration. Extrapolation from our study sites to broader spatial and temporal scales, will require the implementation of both physical models and models of population behavior. While some of these models may be deterministic, others will need to incorporate the stochastic properties of transport events and so will consider the emergent behaviors of complex systems. A major goal of the PIRE is to identify a series of *resilient thresholds* – intensities of and styles of land use that allow for development but prevent catastrophic failures of either the human or natural system. In the case of soil loss, a relevant metric might include comparison of long-term soil generation rates (measured with $^{10}$Be) with short term soil loss rates. For debris and flood flows, metrics could include predictions (under varying land use and climate) of the number of people and properties impacted by flows over time.

*Step 3. Designing and implementing more resilient human/landscape during development*

Shaping resilient, sustainable human/landscapes systems in rapidly developing nations requires an understanding of both natural systems and those engineered by humans. Optimal designs take into account both how the land behaves naturally and how it will behave after development – risk and cost-benefit analyses are important as is the grounding of solutions in historical data and mechanistic understanding of landscape processes. Development approaches need to make sense not only scientifically but culturally. We anticipate solutions will vary spatially but that all will incorporate diversity and redundancy (different approaches that lead to the same result, such as reduced soil erosion), trademarks of resilient systems. Our goal, posed in terms of natural hazard reduction and soil sustainability, is to provide strategies that encourage the land use which approaches but does not exceed resilient thresholds. Trickiest to achieve will be implementation– how do we most effectively distribute the knowledge we gain to a population and governance structure different from that of the United States. Such technology transfer will be done in concert with our Brazilian partners, both those in *Embrapa* and at the Federal University. Such an undertaking is ambitious, certainly, but the integration of observations that characterize the response of natural systems, models that enable prediction of future behavior, and assessment of the risks associated with various decision-response scenarios, provides the best chance of preparing the next generation of researchers to solve the mosaic of sustainability science questions. Thus, all PIRE student research (and each PIRE thesis) will explicitly address sustainability in an integrative framework considering.

*Why Brazil?*

Brazil provides an ideal test-bed for determining how best to shape sustainable, resilient landscapes; the country of nearly 200 million people is rapidly developing and industrializing and has one of the fastest-growing, emerging economies in the world. In the midst of this growth and with the resources provided by the expanding economy, now is the time to institute changes that could lead to a more sustainable future. Slightly smaller in area than the United States, Brazil has a diverse suite of climates, rock and soil types, and cultures. There are large cities and small towns where natural hazards impact the population and there are extensive rural areas where the impact of agricultural practices on soil fertility is dramatic. Knowledge of both background and human-induced rates of landscape change in Brazil is limited (e.g. Whittman et al., 2011; Merten et al., 2010) so that PIRE research will make a significant impact. Brazil is easily reached by one flight from the US, the transportation infrastructure allows easy access to the field, political stability provides a safe work environment for PIRE participants, and PI Bierman has established collaborative relationships with Fernandes and other Brazilian scientists.

**Education Summary**

We have designed an educational environment that builds bridges between different cultures, institutions, ages, experience levels, and expertise. PIRE research will be done in the field and lab by PhD- and MS-level graduate students teamed with undergraduates (recruited nationwide in an REU-like program). All US students will work in collaboration with Brazilian faculty and graduate students during the summer months. PIRE students will be supervised by faculty from three different US institutions – each with different expertise and institutional cultures. K-12 educators will engage in international research and work closely with faculty and graduate students to develop curriculum for dissemination in their schools and across the web to others. The integration of different STEM disciplines including engineering, geochemistry, complex systems modeling, surface Earth geoscience, risk analysis, hydrology, economics, and the nature of our approach will provide a uniquely stimulating environment for the 18 undergraduates, 12 graduate students, 9 teachers, and 2 Postdoctoral Associates supported by this PIRE.

*International Exchanges* – Brazilian partners (students, faculty and professionals) are integral to the educational objectives of this project. The active US project team will travel yearly to Brazil for fieldwork and to share our findings and approach with Brazilian scientists including students and faculty during the *Annual Workshop*. Because Brazil fully funds their doctoral students to spend one research year abroad during dissertation research, UVM, Skidmore, and Penn State will host Brazilian graduate students in our labs at no cost to NSF. The visiting students will generate and interpret data, further diversifying the project team and providing cross-cultural experiences for students associated with the PIs research groups but not directly with the PIRE. Brazilian faculty and graduate students will travel to undergraduate institutions with students involved in the PIRE to give lectures, thus broadening the impact of the PIRE far beyond the 3 core institutions.

*Recruiting and Retaining Members of Under-represented Groups* – Diversifying graduate and faculty ranks in the STEM disciplines is not easy (O'Connell & Holmes, 2011); thus, we have designed an active recruiting/retention program co-led by an experienced undergraduate educator (Nichols) and the PIRE Postdoctoral Associate stationed with Nichols. We will begin by engaging undergraduate STEM faculty at a variety of US undergraduate schools, focusing on those with large under-represented populations (e.g., Historically Black, Latino, and Tribal Colleges and Universities). Project participants

will travel to 6 schools a year and recruit students during two-day, hands-on *Recruitment Seminars* that both introduce us as mentors and teach about the dynamic nature of Earth's surface as it relates to sustainability (human/landscape interaction). During years 2, 3 and 4, we will select a diverse group of 6 undergraduates, representing different schools, backgrounds, and geographic areas to participate in the equivalent of a summer REU. Each undergraduate will engage in a series of distance learning seminars during the spring and will be paired with a graduate student for summer fieldwork in Brazil. All students will participate in the *Annual Project Conference* and *Training Workshop*. We will strive to retain the best undergraduates as graduate students, further diversifying the PIRE.

*Educational Materials Development and Dissemination* – During the first 6 months of the project, all of the PIs and the Postdoctoral Associates will work individually and together to develop educational materials (hand-on activities) at two levels – one for undergraduate education (*Recruitment Seminars*) the other for training professionals including graduate students and faculty both within and outside of the program (*Training Workshops*). In year 5, the faculty and PhD students will develop and present *Short Courses* disseminating our approach and results at relevant professional venues in the US and in Brazil.

*K-12 teacher involvement* – During the core 3 years of the PIRE, we will seek out three highly motivated K-12 teachers to join our team, one each from the areas near Skidmore, UVM, and Penn State. The teachers will begin their involvement during the winter workshop, design a sustainability-related research project appropriate to their expertise in consultation with project faculty and outreach coordinator Massey during the spring, then travel to Brazil during the summer field season to do research and attend the annual workshop. Returning to the US, they will summarize their research and develop curricular material that links their home town to the work they did in Brazil. K-12 teacher involvement leverages PIRE support to broaden the cultural and scientific awareness of the next American generation while personally linking graduate students to pedagogical professionals outside the academy.

Assessment of program – The short- and long-term success of the project depends on comprehensive assessment of the research and educational goals throughout the five years of the PIRE. Each year the PIs will assess the educational goals of the undergraduate and graduate students and make adjustments as necessary. In addition, the PIs will assess the progress of the research and transfer of findings to our Brazilian colleagues and the programs with which they are associated. By assessing the education and scientific programs on an annual basis we will be able to make the adjustments necessary to attain the most benefit during the project and ensure the research and educational training, where appropriate, is sustainable into the future.

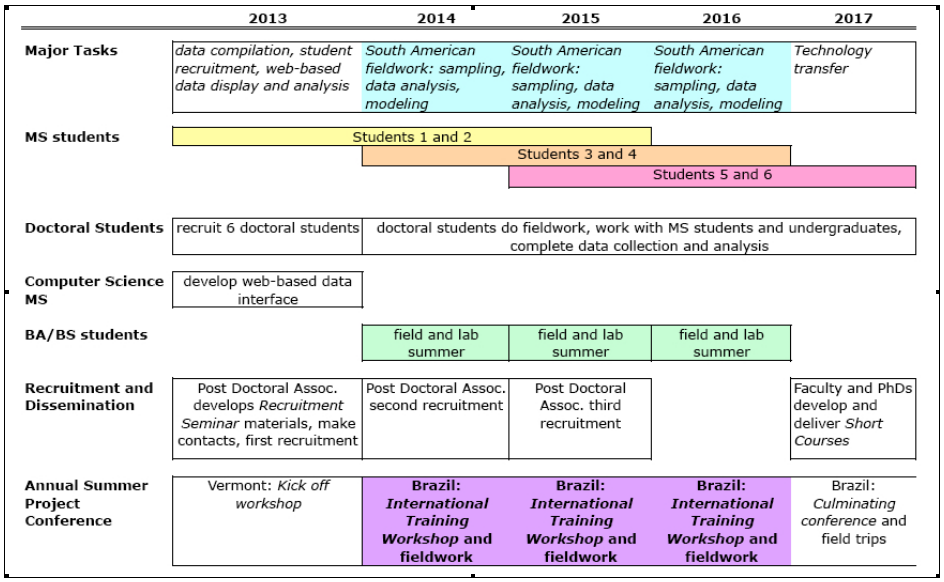


**Fig. 4.** *Project timeline showing phases, major tasks, timing of student recruitment and field/summer conference locations.*

**Paul R. Bierman, Professor of Geology**
**Department of Geology and School of Natural Resources, University of Vermont**

## (i) Professional Preparation

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

## (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 |

## (iii) Publications

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

Graly, J., Bierman, P. R., Reusser, L., and Pavich, M., (2010). Meteoric $^{10}$Be in soil profiles – a global meta-analysis. **Geochimica et Cosmochimica Acta**, doi:10.1016/j.gca.2010.08.036

Reusser, L. J., Graly, J., Bierman, P., and Rood, D. (2010). Calibrating a long-term meteoric $^{10}$Be accumulation rate in soil. **Geophysical Research Letters** 37, L19403. doi: 10.1029/2010GL044751

Reusser, L. and Bierman, P.R. (2010). Tracking fluvial sand through the Waipaoa River Basin, New Zealand, with meteoric $^{10}$Be. **Geology**, v. 38; no. 1; p. 47–50; doi: 10.1130/G30395.1

Jungers, M.C., Bierman, P.R., Matmon, A., Nichols, K., Larsen, J., and Finkel, R. (2009) Tracing hillslope sediment production and transport with in situ and meteoric $^{10}$Be: **Journal of Geophysical Research**, v. 114, doi:10.1029/2008JF001086,

Cox, R. Bierman, P. Jungers, M., and Rakotondrazafy. M. (2009). Erosion rates and sediment sources in Madagascar inferred from $^{10}$Be analysis of lavaka, slope, and river sediment, **Journal of Geology**, v. 117, p. 363–376, DOI:10.1086/598945.

*(b) 5 most significant publications,*

Reusser, L., Bierman, P.R., Pavich, M., Zen, E., Larsen, J., and Finkel, R. (2004) Rapid Late Pleistocene Incision of Atlantic Passive-Margin River Gorges, **SCIENCE**, v. 305, 409-502

Bierman, P. R. and Nichols, K.K. (2004) Rock to sediment - Slope to sea with $^{10}$Be - Rates of landscape change, **Annual Review of Earth Science**. v. 32. p. 215–255

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

Bierman, P. (1994) Using in situ cosmogenic isotopes to estimate rates of landscape evolution: A review from the geomorphic perspective. **Journal of Geophysical Research** (special issue on Tectonics and Topography), 99, B-7, 13,885-13,896.

**(iv) Synergistic Activities**

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 28 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.

Innovations in teaching and training – Development of student-centered, inquiry-based, data collection courses in Geomorphology, Geohydrology, and Interdisciplinary Watershed studies documented in 4 refereed papers in the Journal of Geologic Education (2010, 2003, 1999, 1996). Creation of introductory Earth Hazards class for non-science majors to increase student interest and involvement, documented in refereed lead article in EOS (2003). NSF Directors Distinguished Teaching Scholar award, 2005.

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. Chair, GSA Quaternary & Geomorphology Division (2009)

**(v) Collaborators & Other Affiliations**

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

J. Gosse, Dalhousie Univ; J Briner, Buffalo; D. Dethier, Williams College; P. Davis, Bentley College;; E. Steig, UW; A. Matmon, USGS; M. Pavich, USGS;. K. Nichols, Skidmore; A. Gellis, USGS; J. Larsen, UVM; R. Finkel, LLNL, S. Southworth, USGS, A. Noren, U Minn; D. Rizzo, UVM

*(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 22 MS students

**Klaus Keller**

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## EDUCATION

Technische Universität Berlin: B.S. (Vordiplom) in Environmental Engineering, 1991.

Massachusetts Institute of Technology: M.S. in Civil and Environmental Engineering, 1994.

Technische Universität Berlin: Engineer's Degree in Environmental Engineering, 1995.

Princeton University: M.A. in Civil Engineering and Operations Research, 1998.

Princeton University: Ph.D. in Civil and Environmental Engineering, 2000.

## PROFESSIONAL EXPERIENCE

Penn State, Director of the Center for Climate Risk Management, July 2008 – present.

Macquarie University, Visiting Professor, July 2009 – December 2009.

Penn State, Associate Professor of Geosciences, July 2008 – present.

Penn State, Assistant Professor of Geosciences, January 2002 – June 2008.

Princeton, Research scientist, July 2001 - December 2001.

Princeton, Lecturer, spring term, 2001.

Princeton, Postdoctoral research associate, July 2000 - July 2001.

Gesellschaft für Umwelttechnik, Berlin, engineer, 1995.

## FIVE PUBLICATIONS RELEVANT TO THE PROPOSED PROJECT (OUT OF A TOTAL OF 40 PEER-REVIEWED)

McInerney, D., R. Lempert, and K. Keller What are robust strategies in the face of uncertain climate threshold responses? Accepted for publication in Climatic Change (2011).

Svoboda, T., Klaus Keller, Marlos Goes, and Nancy Tuana: Sulfate Aerosol Geoengineering: The Question of Justice. Public Affairs Quarterly, Public Affairs Quarterly, 25, p. 157-180, (2011).

Goes, M, K. Keller, and N. Tuana: The economics (or lack thereof) of aerosol geoengineering, Climatic Change, published online April 5, DOI 10.1007/s10584-010-9961-z, (2011).

McInerney, D. and K. Keller: Economically optimal risk reduction strategies in the face of uncertain climate thresholds. Climatic Change, 91, 29-41 (2008).

Keller, K., G. Yohe, and M. Schlesinger: Managing the risks of climate thresholds: Uncertainties and needed information. Climatic Change, 91, 5-10 (2008).

## FIVE OTHER PUBLICATIONS

Schienke, E.W., N. Tuana, D. A. Brown, K. J. Davis, K. Keller, J. S. Shortle, M. Stickler, and S. D. Baum: The Role of the NSF Broader Impacts Criterion in Enhancing Research Ethics Pedagogy, Social Epistemology, 23, 317–336 (2009).

Keller, K. and D. McInerney, The dynamics of learning about a climate threshold. Climate Dynamics, 30, 321-332 (2008).

Keller, K., M. G. Hall, S.-R. Kim, D. F. Bradford, and M. Oppenheimer: Avoiding dangerous anthropogenic interference with the climate system. Climatic Change, 73, 227-238 (2005).

Keller, K., B. M. Bolker, and D. F. Bradford: Uncertain climate thresholds and economic optimal growth. Journal of Environmental Economics and Management, 48, 723-741 (2004).

Gruber, N., K. Keller, and R. M. Key: What story is told by oceanic tracer concentrations? Science, 290, 455 (2000).

**SYNERGISTIC ACTIVITIES**

Co-PI on several related ongoing projects that use large-scale observation networks and data-sets to analyze mechanistic hypotheses about climate feedbacks and use this information to inform climate change mitigation and adaptation decisions.

Lead or Co-Principal Investigator on, thus far, 23 grants (e.g., from NSF, DOE, NOAA, EPA, NASA, as well as industry) with a total research budget exceeding 11 million U.S.$.

Editorial board of Climatic Change Letters, Environmental Research Letters, and Earth System Dynamics.

Proposal review panelist for the National Science Foundation, the Department of Energy, and the National Oceanographic and Atmospheric Administration.

Active outreach to K-12, decision-makers, and the general public. My research was covered, for example, by Science, Nature, and Central Daily Times and by movies shown by the Discovery Channel and WPSX. I have given talks to citizens groups, local and regional administrating bodies, as well as kindergarten- and school-classes.

Past member of the Diversity Council of the College of Earth and Mineral Sciences.

Past Diversity representative for the Geosciences Department.

**NON-PSU COLLABORATORS IN THE PAST 48 MONTHS**

(This excludes the member of the editorial boards specified above, as this would be beyond the two-page limit and people who are have died in the meantime)

Applegate, P. (University of Stockholm), Baehr, J. (Hamburg U., Germany), Bhat, S. (Los Alamos), Brennan, C. (U. Victoria, Canada), Bradford, D. (Princeton), Budescu, D. (Fordham), Burton, I. (U. Toronto, Canada), Corfee-Morlot, J. (OECD, France), Crutzen, P. (MPI for chemistry, Germany), Deutsch, C. (UCLA), Duong, M. (CNRS, France), Easterling, D. (NOAA), Finkel, A. (Princeton), Fuessel, H-M. (PIK, Germany), Hall, M. (U. Michigan), Kolstad, C. (UCSB), Laabs, B. J. C. (SUNY Geneseo), Lempert, R. (RAND), Lowell, T. V. (University of Cincinnati), Magadza, C. (University of Zimbabwe, Zimbabwe), Marotzke, J. (MPI, Germany), Matear, R. (CSIRO, Australia), Mastrandrea, M. (Stanford), Matthews, D. (Concordia U., Canada), McInerney, D. (U. Chicago), MacMynowski, D. (Stanford), O'Neill, B. (NCAR), Oppenheimer, M. (Princeton), Patwardhan, A. (IIT, India), Pittock, B. (CSIRO, Australia), Pepper, W. (ICF), Rahman, A. (Bangladesh Centre for Advanced Studies, Bangladesh), Ricciuto, D. (ORNL), Robinson, A. (PIK, Germany), Schlesinger, M. (UIUC), Schmittner, A. (U. Oregon), Saliendra, N.Z. (U. Maryland), Smith, J. (Stratus Consulting), ), Semenov, S. (IGCE, Russia), Smith, S. (JGCRI), Due-Wing, I. (Boston U.), Sukumar, R. (IIS, India), Timmerman, A. (U. Hawaii), Terando, A. (NC State), Tol, R. (ESRI, Dublin), Todorov, A. (Princeton), Suarez, A. (Cuban Environmental Agency) , Ulph, A. (Manchester U., United Kingdom), Urban, N. (Princeton), van Ypersele, J-P. (UCL, Belgium), Xiao, J. (U. New Hampshire), Yamin, F. (University of Sussex, UK), Yohe, G. (Wesleyan University), and Zillman, J. (Bureau of Meteorology, Australia),

**GRADUATE AND POSTGRADUATE ADVISOR**

F. M. M. Morel, graduate advisor, Blake Professor of Geosciences, Princeton University.

D. F. Bradford, postgraduate advisor, Professor of Economics and Public Affairs, Princeton University (deceased).

**POSTDOCTORAL AND RESEARCH ASSOCIATES OF THE PAST FIVE YEARS**

Marlos Goes (NOAA), David McInerney (U. Chicago), Dong-Ha Min (UT, Austin), Ryan Sriver (PSU), Robert Nicholas (PSU), and Nathan Urban (Princeton).

**GRADUATE STUDENTS OF THE PAST FIVE YEARS**

Katherine Brennan (U. Victoria), Joshua Dorin (teacher), Rob Fuller (private), Louise Miltich (private), A. Robinson (PIK), Deneyse Serino (teacher), and Roman Tonkonojenkov (PSU).

**Eric Kirby**
Department of Geosciences
Pennsylvania State University
University Park, PA 16802
ekirby@psu.edu

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**Professional Preparation:**

| | |
|---|---|
| B.A. Geology (1992) | Hamilton College |
| M.S. Geology (1994) | University of New Mexico |
| Ph.D. Geology (2001) | Massachusetts Institute of Technology |
| NSF Post-Doctoral Fellow | UC, Santa Barbara (2001 – 2002) |

**Appointments:**

| | |
|---|---|
| 2010 – 2011 | Humboldt Fellow – University of Potsdam, Germany |
| 2008 | Associate Professor – The Pennsylvania State University |
| 2002 – 2008 | Assistant Professor – The Pennsylvania State University |

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**PUBLICATIONS** (*denotes student author)

**Relevant to current proposal**

*Hu, X., **Kirby, E.**, Pan, B., Ganger, D., and Su, H., 2011, Cosmogenic burial ages reveal sediment reservoir dynamics along the Yellow River, China: *Geology,* v. 39, p. 839-842, doi:10.1130/G32030.1.

*Craddock, W., **Kirby, E.**, Harkins, N., Zhang, H., and Shi, X., 2010, Rapid fluvial incision along the Yellow River during headward basin integration: *Nature Geoscience*, v. 3, p. 209-213, doi:10.1038/ngeo777.

**Kirby, E.**, Johnson, C., Furlong, K., and Heimsath, A., 2007, Transient channel incision along Bolinas Ridge, California: Evidence for differential rock uplift adjacent to the San Andreas fault: *Journal of Geophysical Research, Earth Surface*, 112, F03S07, doi: 10.1029/2006JF000559.

*Harkins, N., **Kirby, E.**, Heimsath, A., Robinson, R., and Reiser, U., Transient fluvial incision in the headwaters of the Yellow River, northeastern Tibet, China: *Journal of Geophysical Research, Earth Surface*, 112, F03S04, doi:10.1029/2006JF000570.

*Duvall, A., **Kirby, E.**, and Burbank, D., Tectonic and lithologic controls on channel profiles and processes in coastal California: *Journal of Geophysical Research: Earth Surface,* v. 109, F03002, doi:10.1029/2003JF000086.

**Other recent publications**

*Craddock, W.H., **Kirby, E.** Zheng, D., and Lui, J., 2011, Tectonic setting of Cretaceous basins on the NE Tibetan Plateau: Insights from the Jungong basin: Basin Research, doi: 10.1111/j.1365-2117.2011.00515.x.

**Kirby, E.** and Ouimet, W., 2011, Tectonic geomorphology along the eastern margin of Tibet: Insights into the pattern and processes of active deformation adjacent to the Sichuan Basin, *in*, Gloaguen, R. and Ratschbacher, L., eds., *Growth and Collapse of the Tibetan Plateau*: Geological Society, London, Special Publications, v. 353, p. 165-168. doi: 10.1144/SP353.9.

Wang, W., Zhang, P., **Kirby, E.**, Wang, L., Zhang, G., Zheng, D., and Chia, C., 2011, A revised chronology for Tertiary sedimentation in the Sikouzi basin: Implications for the tectonic evolution of the northeastern corner of the Tibetan Plateau: *Tectonophysics*, v. 505, p. 100-114.

*Harkins, N.W., **Kirby, E.,** Shi, X., Wang, E., Burbank, D., and Chun, F., 2010, Millennial slip-

rates along the eastern Kunlun fault: Implications for the dynamics of intracontinental deformation in Asia: *Lithosphere*, v.2, p. 247-266., doi: 10.1130/L85.1.

*Regalla, C., Fisher, D., and **Kirby, E.**, 2010, Timing and magnitude of shortening within the inner fore arc of the Japan Trench: *Journal of Geophysical Research*, v. 115, doi:10.1029/2009JB006603.

## SYNERGISTIC ACTIVITIES

I am have been intimately involved in the development of an ArcGIS-based tool for analysis of river gradients and topographic data. We hosted a short course at 2007 GSA Annual Meeting entitled *New tools for Quantitative Geomorphology: Extraction and interpretation of stream profiles from digital topographic data*. The tool has been made freely available to colleagues at other institutions for use in research and instructional environments (http://www.geomorphtools.org).

I am currently serving as an Associate Editor for *Tectonics* (2004-2012), for *GSA Bulletin* (2007-2012), and Geology (2009-2012); I begin a 4-year term as Science Editor for Lithosphere in January, 2012. I co-led of a GSA field trip in Eastern California (2008), co-organized a recent NSF workshop on Future Directions in Research in Tibet (2010), and I have been an invited participant in recent science planning workshops (Earthscope, 2009; MARGINS, 2010).

## COLLABORATORS

Doug Burbank (UCSB), Sue Brantley (PSU), Paul Bierman (UVM), Clark Burchfiel (MIT), Marin Clark (Michigan), Nancye Dawers (Tulane), Ken Deuker (Wyoming), Ken Farley (Caltech), Kevin Furlong (PSU), Carmala Garzione (Rochester), John Gosse (Dalhousie), Arjun Heimsath (ASU), Matt Heizler (NMT), Kip Hodges (ASU), Chen Jie (UCSB), Karl Karlstrom (UNM), Eric McDonald (DRI), Peter Molnar (Colorado), Tom Parsons (USGS), Fred Phillips (NMT), Marith Reheis (USGS), Pete Reiners (Yale), Gerard Roe (Washington), Wiki Royden (MIT), Kamini Singha (PSU), Rudy Slingerland (PSU), J. Doug Walker (Kansas), Kelin Whipple (ASU).

## GRADUATE AND POSTDOCTORAL ADVISORS

Doug Burbank (Postdoctoral advisor – UCSB)
Clark Burchfiel and Kelin Whipple (Ph.D. advisors – MIT)
Karl Karlstrom (M.S. advisor – UNM)

## STUDENTS AND POSTDOCTORAL ASSOCIATES

*M.S.* – Tye Numelin (2005), Charlie Angerman (2006), Andrea Mullen (2007), Will Hoffman (2009), Shi Xuhua (2011), Russell Rosenberg (current), Nooreen Meghani (starting Jan. 2012)
*Ph.D.* – Nate Harkins (2008), Bill Craddock (2011), Nicole West (current), Shi Xuhua (current)
*Postdoc* – Will Ouimet (2007)

Total students: 11 Total postdocs: 1

## BIOGRAPHICAL SKETCH

**Kyle K. Nichols**
**Department of Geosciences, Skidmore College, Saratoga Springs, NY 12866**

### A. Professional Preparation

| | | |
|---|---|---|
| University of Washington | Geological Sciences | BA, 1996 |
| University of Vermont | Geology | MS, 2000 |
| University of Vermont | Natural Resources | PhD, 2002 |

### B. Professional Experience

| | | |
|---|---|---|
| 2008 – present | Associate Professor and Chair of Geosciences | Skidmore College |
| 2002 – 2008 | Assistant Professor of Geosciences | Skidmore College |
| 1997 – 2002 | Research and Teaching Assistant | University of Vermont |

### C. Publications

i. Most relevant to proposed research

Nichols, K.K., Bierman, P.R., Finkel, R., Larsen, J., 2005, Long-term sediment generation rates for the Rio Chagres basin; evidence from cosmogenic $^{10}$Be: in The Rio Chagres, Panama: A Multidisciplinary Profile of a Tropical Watershed, R.S. Harmon, ed., p. 297-313.

Nichols, K.K., Bierman, P.R., Caffee, M.W., Finkel, R., and Larsen, J., 2005, Cosmogenically enabled sediment budgeting: Geology, v. 33, 133-136.

Nichols, K.K., Bierman, P.R., Eppes, M.C., Caffee, M.W., Finkel, R., and Larsen, J., 2007, Long-term erosion and deposition of a Mojave Desert piedmont: Implications of sediment supply and climate change: Quaternary Research, v. 68, p. 151-161.

Jungers, M. C., Bierman, P.R., Matmon, A., Nichols, K., Larsen, J., and Finkel, R., 2009, Tracing hillslope sediment production and transport with in situ and meteoric $^{10}$Be: Journal of Geophysical Research, Earth Surface, v. 114, F04020, doi:10.1029/2008JF001086.

Bierman, P.R., Nichols, K.K, 2004, Rock to sediment, Slope to sea with 10-Be, Rates of landscape change: Annual Reviews of Earth and Planetary Sciences, v. 32, p. 215-255.

ii. Other significant publications

Nichols, K.K., Bierman, P.R., Foniri, W.R., Gillespie, A.R., Caffee, M., Finkel, R., 2006, Dates and rates of arid region geomorphic processes from analysis of cosmogenic nuclides: GSA Today, v. 16, n. 8, p. 4-11.

Nichols, K.K., Bierman, P.R., Eppes, M.C., Caffee, M.W., Finkel, R., and Larsen, J., 2005, Late Quaternary history of the Chemehuevi Mountain piedmont, Mojave Desert, deciphered using $^{10}$Be and $^{26}$Al: American Journal of Science, v. 305, p. 345-368.

Nichols, K. K., Bierman, P. R., Hooke, R. L., Clapp, E., Caffee, M., 2002, Quantifying sediment transport on desert piedmonts using $^{10}$Be and $^{26}$Al: Geomorphology, v. 45, p. 105-126.

Matmon, A., Nichols, K.K., Finkel, R., 2006, Isotopic insights into smoothening of abandoned fan surfaces, southern California: Quaternary Research, v. 66, p. 109-118.

Clapp, E.M., Bierman, P.R., Nichols, K.K., Pavich, M., Caffee, M., 2001, Rates of sediment supply to arroyos from upland erosion determined using in situ produced cosmogenic $^{10}$Be and $^{26}$Al: Quaternary Research, v. 55, no. 2, p. 235-245.

## D. Synergistic Activities

1. ***Service to geoscience community*** – Co-technical program chair of the 2005 Northeastern GSA meeting and Local organizing committee member of the 2003, 11th Symposium on Water Rock Interactions.
2. ***Interdisciplinary education*** – Co-founder of the GIS Center for Interdisciplinary Research at Skidmore College.
3. ***Outreach*** – Environmental Science Coordinator of Skidmore College's *Water Resource Initiative.*
4. ***Innovations in teaching*** – Co-author of two manuscripts published in *Journal of Geoscience Education*. One describes (2003) a service-learning hydrology project (lead author with several undergraduate co-authors) and the other (1999) describes winter geohydrology projects (co-author).
5. ***Campus community leader*** – Co-author of the Science Vision for Skidmore and mentor for the New Faculty Learning Community that helps junior faculty balance life and workload.

## E. List of Collaborators and Advisors

Paul Bierman, Univ. Vermont
Marc Caffee, Purdue Univ.
Martha Eppes, UNC Charlotte
Robert Finkel, Lawrence Livermore Lab
Alan Gillespie, Univ. Washington
Bruce Harrison, New Mexico Tech
Matthew Jungers, Arizona State University Ari Matmon, Hebrew University
Robert Webb, USGS

**Graduate Advisor**
Paul Bierman, Univ. Vermont

**Undergraduates Theses Advised Last Six Years (no graduate students)**
David Stein-Cowan, 2010 – Geomorphic effects of 19th Century Adirondack Logging
Matthew Shrensel, 2009 – Long Term Erosion Rates across Panama: A GIS approach Lindsay Bourgoine, 2009 – Digging in: Examining soil composition of Cerro Punta, Panamá
Jeff Narva, 2008 – Buffer mapping of Kayaderosseras Creek
Melissa Ng, 2008 – Hydrology of the Kayaderosseras Creek Watershed
Kim Rich, 2008 – Pediment modification of Namibia
Thomas Arnold, 2007 – Flash Flood Caused by Railway Embankment Failure
Allison Stafford, 2007 – Hydrology of the Wilton Sand Plain
Erin Black, 2006 – Turbidity of the Kayaderosseras Creek Watershed
Megan Chadwick, 2006 – Buffers on the Battenkill: Mapping Riparian Zones Using GIS
Michael Cleveland, 2006 – Long-term Erosion Rates of the Grand Canyon Using $^{10}$Be
Davin Lyons, 2006 – Holocene Climate Change of Keuka Lake, Finger Lakes Region
Derek Eaton, 2005 – Initiation and Growth Processes of the Miller Brook Gully, VT
Daniel Feuer, 2005 – GIS Analysis of Tributary Basins in the Colorado River Basin
Luca Peppe, 2005 – Reinterpretation of the Deglacial History, Kayaderosseras Valley
Veronica Russell, 2005 – History of the Goldstone Piedmont, Fort Irwin, CA, Using $^{10}$Be

# DONNA M. RIZZO

## (I) PROFESSIONAL PREPARATION:

| Institution and Location | Major | Degree & Year |
|---|---|---|
| University of Connecticut, Storrs | Civil Engineering | B.S., 1984 |
| University of Florence, Italy | Art and Archeology | N.A., 1985 |
| University of California, Irvine | Civil Engineering | M.S., 1990 |
| University of Vermont, Burlington | Civil & Environmental Engineering | Ph.D., 1994 |

## (II) APPOINTMENTS:

2002-present **Associate Professor**, Department of Civil & Environmental Engineering, and Dept. of Computer Science, University of Vermont, Burlington, VT.

1995-2002 **Co-founder**, Subterranean Research, Inc., Burlington, VT.

1991-1994 **Research Assistant**, University of Vermont, Burlington, VT. *Research*: geohydrologic site characterization, artificial neural networks, optimal groundwater remediation design, highly-parallel implementation of numerical methods for geohydrological applications.

1992-1995 **Instructor & PC Laboratory Instructor**, Princeton Transport Code Short Course, with G. F. Pinder, S. Stothoff, J. Guarnaccia, and G. Karatzas; and IBM PC Applications in Ground Water Pollution & Hydrology Short Course, by R. W. Cleary, M. Ungs, and G. Pinder.

1992-1994 **Participating Guest**, Lawrence Livermore National Laboratory, Livermore CA.

1986-1990 **Research Assistant and Graduate Teaching Assistant**, University of California, Irvine, CA. *Research*: mathematical modeling multi-phase flow & transport in unsaturated soils.

1986-1988 **Civil Engineer**, Born Barrett & Associates, Civil Engineering & Consulting, CA.

1984-1986 **Civil Engineer**, State of Connecticut Department of Environmental Protection.

## (III) 10 SELECTED PUBLICATIONS:


Mouser, P.J., D.M. Rizzo, G. Druschel, S.E. Morales, P. O'Grady, N.J. Hayden and L. Stevens, "Microbial Community Profiles Enhance Detection of Groundwater Contamination from Leaking Waste Disposal Sites", *Water Resources Research*, Accepted, 2010.

Besaw, LE., D.M. Rizzo, M. Kline, K.L. Underwood, J.J. Doris, L.A. Morrissey and K. Pelletier, "Stream Classification using Hierarchical Artificial Neural Networks: A fluvial Hazard Management Tool", *Journal of Hydrology*, doi:10.1016/j.jhydrol.2009.04.007, 2009.

Kollat, J.B., P. M. Reed, and D.M. Rizzo, "Addressing Model Bias and Uncertainty in Three-dimensional Groundwater Transport Forecasts for a Physical Aquifer Experiment", Geophysical Research Letters, 35, L17402, doi: 10.1029/2008GL035021, 2008.

McBride, M., D.M. Rizzo, W.C. Hession. "Riparian Reforestation and Channel Change: A Case Study of Two Small Tributaries to Sleepers River, Northeastern Vermont, USA", Geomorphology, 102 (3-4) 445-459, doi: 10.1016/j.geomorph.2008.05.008, 2008.

Besaw, L.E. and D.M. Rizzo, "Spatial Prediction and Stochastic Conditional Simulation using Artificial Neural Networks", *Water Resources Research*, 43, W11409, DOI: 10.1029/2006WR005509, 2007.

Clark, J.S., D.M. Rizzo, M.C. Watzin, and W.C. Hession, "Geomorphic Condition of Fish Habitat in Streams: An Analysis Using Hydraulic Modeling and Geostatistics", *River Research and Applications*, 23, DOI: 10.1002/rra.1085, 2007.

Mouser, P.J., D.M. Rizzo, W.F.M. Röling, B.M. and van Breukelen. "A multivariate geostatistical approach to spatial representation of groundwater contamination using hydrochemistry and microbial community profiles". *Environmental Science & Technology*. 39 (19) pp. 7551-7559. 2005.

Rizzo, D.M. and D.E. Dougherty, "Artificial Neural Networks in Subsurface Characterization", Book Chapter in *Artificial Neural Networks in Hydrology*, R.S. Govindaraju and A.R. Rao (eds.), pp. 111-133, 2000.

Rizzo, D.M. and D.E. Dougherty, "Characterization of aquifer properties using artificial neural networks: Neural Kriging", *Water Resources Research*, 30 (2), pp. 483-497, 1994.

Rizzo, D.M. and D.E. Dougherty, "Design Optimization for Multiple Management Period Groundwater Remediation", *Water Resources Research*, 32 (8), pp.2549-2561, 1996.

**(V) SYNERGISTIC ACTIVITIES**

Dr. Rizzo and has over 15 years of experience with optimization methods and 20 years of groundwater and modeling experience. Her tenure-track position is more recent, yet she has a strong record of accomplishment in research and development, having procured five Small Business Innovation Research (SBIR) grants from the Federal government (NSF, DOE and USDA) during the five years that she co-founded a small business. She was PI for DOE funded SBIR Phase I and Phase II projects that developed tools for rapid joint inversion and imaging of multiple geophysical and geotechnical data types to characterize subsurface fluids and media. Her optimization work includes projects at the Lawrence Livermore National Lab, published in Water Resources Research in 1996. She is known for work on the use of artificial neural networks on subsurface problems, including interpolation, inversion and nonparametric statistical methods. She has experience improving code performance, direct development involvement in optimization codes that use linear programming, simulated annealing, outer approximation, Gauss-Newton, tabu and genetic methods; and was one of 15 people selected in a national competition to attend a 12-week workshop at the Advanced Computing Laboratory at Los Alamos National Laboratory, Spring, 1993.

NSF undergraduate education projects:

- NSF DBI, Undergraduate Mentoring in Environmental Biology: Diversity & Excellence in Environmental Biology. L. Stevens (PI), D. Rizzo (co-PI). 07/04-06/09.
- NSF EEC – Engineering Education: A Systems Approach to Civil and Environmental Engineering Education: Integrating Systems Thinking, Inquiry-Based Learning and Catamount Community Service-Learning Projects. N. Hayden (PI), Rizzo, Dewoolkar and Sadek (co-PI). 09/05- 10/08.

Broadening underrepresented groups in science, mathematics, engineering and technology

- Secured $300,000 endowment in undergraduate research fellowships (Barrett Foundation)
- 1995-present: organizer, committee member Annual Design TASC (Technology And Science Connection) competition, high school students
- Faculty advisor, UVM chapter of the Society for Women Engineers
- Attended workshops focusing on promoting women in science and engineering;

Service to the scientific and engineering community

- Vice Chair, ASCE Task Committee on Long Term Monitoring Optimization
- Experience in consulting firms
- Developed multidisciplinary research programs for a private high school
- Worked with the Federal Emergency Management Agency during 1998 VT floods
- Peer review for EPA, NSF and DOE

Transfer of knowledge, Patented software

- APPRIZE, U. S. Patent 6,067,340. “Three-Dimensional Stochastic Tomography with Upscaling”, a key technology in Subterranean Research’s JEDII™ software. Combines simulation, stochastic filtering, and a unique “data-driven zonation” method to improve parameter estimation.

**(VI) COLLABORATORS & OTHER AFFILIATIONS**

*(a) Collaborators and Co-editors (other than students or advisors)*

Christopher J. Bianchi (Applied Research Associates), Paul Bierman (UVM), David E. Dougherty (Subterranean Research, Inc.), Greg Druschel (UVM), Sara Gran (U. Washington), W. Cully Hession (Virginia Tech), Peter S. Huyakorn (HydroGeoLogic, Inc.), Virginia M. Johnson (LLNL), George P. Karatzas (University of Crete), Barbara Minsker (University of Illinois), George F. Pinder (UVM), Patrick Reed (Penn State), Leah L. Rogers (LLNL), Lori Stevens (UVM), Mary C. Watzin (UVM).

*(b) Graduate and Postdoctoral Advisors*

M.S. ***Gary L. Guymon***, University of California, Irvine, CA
Ph.D. ***David E. Dougherty***, University of Vermont, Burlington, VT

*(c) Thesis Advisor* for **11 M.S.** (Current: D. Grover, K. Jones, and C. Savidge; Graduated: R. Butryn, M. Lee, J. Clark, L. Besaw, J. Doris, Z. Li, C. Mark and P. Sullivan) and **7 Ph.D.** (Current: A. Pechenick, N. Fytilis, A. Pearce and B. Mathon; Graduated: P. Mouser, L. Besaw and M. McBride) students.

# BIOGRAPHICAL SKETCH – William S. Keeton

**ADDRESS:** Rubenstein School of Environment and Natural Resources
343 George D. Aiken Center for Natural Resources
University of Vermont
Burlington, VT 05405 USA
Phone: 802-656-2518 Email: william.keeton@uvm.edu
Website: www.uvm.edu/envnr/wkeeton

## EDUCATION

2000 Ph.D. Forest Ecology. University of Washington, College of Forest Resources, Seattle, WA
1994 M.E.S. Conservation Biology. Yale University, Schl. of Forestry and Env. Science, New Haven, CT
1990 B.S. Natural Resources. Cornell University, College of Ag. and Life Sciences, Ithaca, NY

## CURRENT APPOINTMENTS

2007-present Associate Professor of Forest Ecology and Forestry. Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT.
2010-present Chair, UVM Undergraduate Forestry Program
2007-present Co-Chair, UVM Graduate Program in Forest and Wildlife Science
2001-present Lead scientist, Vermont Forest Ecosystem Management Demonstration Project
2008-present Lead scientist, University of Vermont Carbon Dynamics Laboratory (www.uvm.edu/cdl)
2008 -present Fulbright Senior Specialist, U.S. Fulbright Scholarship Program
2008-present The Nature Conservancy, Vermont Chapter, Science Advisory Board
2009-present Co-Chair, Vermont Climate Collaborative, Agriculture, Forestry, and Waste Working Group
2007-present Vermont Monitoring Cooperative, Science Advisory Committee
2009 –present New England Society of American Foresters, Chair of Silviculture Group
2009- present Belgian Research Programme for Earth Observation (STEREO II), Remote sensing of ecosystem impacts in mountain environments, Advisory Committee
2007-present Deputy Chair, International Union of Forest Res. Organizations, Old-growth Forest Working Group
2009-present IUCN (World Conservation Union), Commission on Ecosystem Management

## CLOSELY RELATED PUBLICATIONS:

Keeton, W.S., A. A. Whitman, G.G. McGee, and C.L. Goodale. 2010. Late-successional biomass development in northern hardwood-conifer forests of the northeastern United States. Forest Science (in press)

Keeton, W. S., M. Chernyavskyy, G. Gratzer, M. Main-Knorn, M. Shpylchak, and Y. Bihun. 2010. Structural characteristics and aboveground biomass of old-growth spruce-fir stands in the eastern Carpathian Mountains, Ukraine. Plant Biosystems 144: 1-12.

Nunery, J.S. and W.S. Keeton. 2010. Forest carbon storage in the northeastern United States: net effects of harvesting frequency, post-harvest retention, and wood products. Forest Ecology and Management 259:1363-1375.

Keeton, W.S., C.E. Kraft, and D.R. Warren. 2007. Mature and old-growth riparian forests: structure, dynamics, and effects on Adirondack stream habitats. Ecological Applications 17: 852-868

Keeton, W.S. 2006. Managing for late-successional/old-growth characteristics in northern hardwood-conifer forests. Forest Ecology and Management 235: 129-142.

## OTHER RELEVANT PUBLICATIONS:

Schwenk, W.S., T.M. Donovan, W. S. Keeton, and J. S. Nunery. 2011. Carbon storage, timber production, and wildlife occurrence: comparing forest ecosystem services using multi-criteria decision analysis. Ecological Applications. Accepted.

Kraft, C., D. Warren, W.S. Keeton. 2011. Identifying the spatial pattern of wood distribution in northeastern North American streams. Geomorphology 135: 1-7

Stovall, J., W.S. Keeton, and C.E. Kraft. 2009. Late-successional riparian forest structure results in heterogeneous periphyton distributions in low-order streams. Canadian Journal of Forest Research 29: 2343-2354.

Curzon, M.T. and W.S. Keeton. 2010. Spatial characteristics of canopy disturbances in riparian old-growth hemlock-northern hardwood forests, Adirondack Mountains, New York, USA. Canadian Journal of Forest Research 40:67-80.

Warren, D.R., C.E. Kraft, W.S. Keeton, J.S. Nunery, and G.E. Likens. 2009. Dynamics of wood recruitment in streams of the northeastern U.S. Forest Ecology and Management 258:804-813.

## SYNERGISTIC ACTIVITIES:

*Fulbright Senior Specialist,* U.S. Fulbright Scholarship Program. Fulbright Scholar advising Ukrainian agencies on forest carbon quantification and management in the Carpathian Mountain region.

*P.I.:* Global meta-analysis of temperate old-growth forests, focusing on carbon storage dynamics, 2008-present.

*P.I.:* USDA McIntire-Stennis Forest Research Program. 2008-2011. Evaluation of options for forestland owner participation in carbon markets: forest management alternatives and institutional and economic constraints– $111,850.

*P.I.* Northeastern States Research Cooperative. 2011-2014. Effects of long-term forest recovery pathways and management history on carbon sequestration and co-varying ecosystem services. $72,223.

*P.I.* Trust for Mutual Understanding. 2011-2013. Capacity building for community-based forest carbon and bioenergy projects in western Ukraine. Keeton, W.S. (P.I.) and C. Danks (Co-PI). $20,000.

*P.I.* Northeastern States Research Cooperative. 2010-2013. Evaluating supply and demand of northern forest branded carbon credits. $109,500.

*Co-P.I.* Northeastern States Research Cooperative. 2010-2013. Evaluating the influence of riparian forest structure on stream ecosystems across the northern forest. $149,568.

*P.I.* Northeastern States Research Cooperative. 2009-2012. Biomass fuel harvesting in the northern forest: effects on stand structural complexity and in-situ forest carbon storage. $92,056.

*Professional activities:* Forest Guild Working Group on Climate Change and Forest Carbon; Green Mountain National Forest Climate Change Advisory Committee; Vermont Governor's Advisory Panel on Carbon Markets; Vermont State Legislature, Biomass Energy Working Group, Vermont Roundtable on Parcelization and Forest Fragmentation

## COLLABORATORS

**Collaborators in the past 48 months:**

Scott Swenck, Charles Kerchner, Cecilia Danks, Jennifer C. Jenkins, Clifford E. Kraft, Gregory McGee, Christine Goodale, Gene Likens, Dana Warren, Brian Beckage, Tim Perkins, Georg Gratzer, Patrick Hostert, David Ray, Robert Seymour, Mark Twery, Teri Donovan, Mykola Chernyavskyy, Yurih Bihun, Tom Spies, David Lindenmayer, Mark Swanson, Jerry F. Franklin, Tobias Kuemmerle, Mark Ashton, Brian Foster, Gene Likens, David Foster, David Ray

**Graduate and Postdoctoral Advisor:** Jerry F. Franklin, University of Washington

**Thesis Advisor and Postgraduate Advisor in Past Five Years:**

Charles Kerchner, Dima Karabchuk, Jared Nunery, Katie Manaras, Heather McKenny, Erin Copeland, Jeremy Stovall, Miranda Curzon, Brian Foster, Caitlin Littlefield, Anna Mika, Sabina Burrascano, Thomas Buchholz, Emily Russel-Roy, Amanda Egan

**Christine Ann Massey, Education Specialist**

Department of Education, University of Vermont, Burlington, VT 05405-0122

(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 | Adjunct Instructor Education Department, Univ. of Vermont (UVM) |
| 1998-present | Museum Education Specialist Perkins Museum, Univ. of Vermont (UVM) |
| 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. and Bierman, P.R. (2007). Teachers and kids dig old photos, **National Association for Gifted Children Journal**.

Bierman, P. R., Massey, C., and Manduca, C. (2006). Reconsidering the Textbook, **EOS**, v. 87, n. 30, p. 316.

Bierman, P., Massey, C., and Manduca, C. (2006) The Textbook: Dead? Or Alive! **Geological Society of America Abstracts with Programs**

Massey, C., Bierman, P., Lavoie, J.P., Manduca, C., Berrizbeitia, I., Henry, J., (2005), Learning visually with historic "geo-images". **Geological Society of America Abstracts with Programs.**

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.

**Significant Publications** *(5 other)*

Pearce, A., Bierman, P., Druschel, G., Massey, C., Rizzo, D., Watzin, M. and Wemple, B. (2007) Teaching a New Generation of Students: Developing an Interdisciplinary Watershed Field Course, **Eos. Trans. AGU**

Bierman, P.R., Howe, J., Stanley-Mann, E., Peabody, M., Hilke, J., and Massey, C.A., (2005). Old landscape images record landscape change through time **GSA Today**. V. 15, n. 4, 10:1130/1052-5173(2005)015, p.1 –6

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,

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.

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.

(iv) **Synergistic Activities**

Assessement and Development of Image Archives and Educational Webware

-Coordinate and direct educational materials development and assessment activities for the *Landscape Change Program*, NSF-funded project to collect and display images of Vermont. Directed assessment of web pages and site structure (www.uvm.edu/landscape).

-Coordinated assessment and revision of educational materials developed for *Learning Landscapes*, an NSF-funded project to teach about Geomorphology with images. Directed assessment of web pages and site structure (www.uvm.edu/~lcplearn).

-Coordinated and direct activities for the Institute for Museum and Library Services (IMLS)-funded project to digitize the collections of the Perkins Museum (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 and *Environmental Science Day Camp* for elementary students.

-Facilitated outreach for Perkins Museum visits, tours, teacher geology resource needs, and teacher professional development.

-Coordinated 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.),

(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 Geology M.A. *Landscape Change 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.

Curriculum Vitae

# DYLAN H. ROOD

## a. Professional Preparation

Wesleyan University, Earth and Environmental Science, B.A., 2002
University of California at Santa Barbara, Geological Sciences, Ph.D., 2010
University of California, Irvine, postdoctoral research and undergraduate teaching, 2010-present
Lawrence Livermore National Laboratory, postdoctoral research, 2010-present

## b. Appointments

***Post Doctoral Research Staff Member***, Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, 2010-present

***NSF Earth Sciences Postdoctoral Fellow***, University of California at Irvine, 2010-present

***Assistant Researcher***, Earth Research Institute, University of California at Santa Barbara, 2010-present

***Lawrence Scholar***, Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, (Mentors: Dr. Bob Finkel and Dr. Tom Brown), 2006-2010

***Teaching Assistant***, Undergraduate courses: Introduction to Field Methods, Optical Mineralogy, and Sedimentary Petrology, Department of Earth Science, University of California at Santa Barbara, 2003-2005

***Teaching Assistant***, Summer Field School, Department of Earth Science, University of California at Santa Barbara, 2003, 2005

***Postgraduate Researcher***, Institute for Crustal Studies, University of California at Santa Barbara, 2002

## Awards and Honors

PLS AEED SPOT Award for "Exceptional Postdoctoral Achievement of Publishing Many Papers in 2010-2011," Lawrence Livermore National Laboratory, 2011

NSF EAR Postdoctoral Fellowship, 2010

Top Student Presenter, Seismological Society of America Annual Meeting, 2009 (recognized in *Seismological Research Letters*)

Honorable Mention, AAAS Student Poster Competition, 2007 (recognized in the April 20, 2007, issue of *Science* and abstract published on AAAS website)

Student Employee Graduate Research Fellowship, Lawrence Livermore National Laboratory, 2006

Outstanding Graduate Oral Presentation Award, Geological Society of America, 2005

Graduate Student Research Grant, Geological Society of America, 2004

Glicken Award, Department of Geological Sciences, University of California at Santa Barbara, 2004

## c. Selected Publications (i) Publications related to the present proposal


**Rood, D.H.**, Hall, S., Guilderson, T.P., Finkel, R.C., Brown, T.A., 2010, Challenges and opportunities in high-precision Be-10 measurements at CAMS, *Nuclear Instruments and Methods B: Beam Interactions with Materials and Atoms*, 268, 7-8, 730-732, doi:10.1016/j.nimb.2009.10.016.

Reusser, L. J., Graly, J., Bierman, P., and **Rood, D.**, 2010, Calibrating a long-term meteoric $^{10}$Be accumulation rate in soil, *Geophysical Research Letters*, 37, L19403, doi: 10.1029/2010GL044751.

Moon, S., Chamberlain, C.P., Le, K., Levine, N., **Rood, D.H.**, Hilley, G., 2011, Climatic control of denudation in the deglaciated landscape of the Washington Cascades, *Nature Geoscience*, 4, 469-473, doi:10.1038/NGEO1159.

West, N., Kirby, E., Bierman, P., **Rood, D.**, 2011, Preliminary estimates of regolith generation and mobility in the Susquehanna Shale Hills Critical Zone Observatory, Pennsylvania, using meteoric $^{10}$Be, *Applied Geochemistry*, 26, S146-S148.

**Rood, D.H.**, Burbank, D.W., Finkel, R.C., 2011, Chronology of glaciations in the Sierra Nevada, California from $^{10}$Be surface exposure dating, *Quaternary Science Reviews*, 30, 646-661, doi:10.1016/j.quascirev.2010.12.001.

**(ii) Five additional related publications**

**Rood, D.H.**, Burbank, D.W., Finkel, R.C., 2011, Spatiotemporal patterns of fault slip rates across the central Sierra Nevada Frontal Fault Zone, *Earth and Planetery Science Letters*, 301, 457-468, doi:10.1016/j.epsl.2010.11.006.

Young, N.E., Briner, J.P., Stewart, H.A.M., Axford, Y., Csatho, B., **Rood, D.H.**, Finkel, R.C., 2011, The response of Jakobshavn Isbræ to Holocene climate change, *Geology*, 39, 2, 131–134, doi:10.1130/G31399.1.

Corbett, L.B., Young, N.E., Bierman, P.R., Briner, J.P, Neumann, T.A., Graly, J.A., **Rood, D.H.**, 2011, $^{10}$Be concentrations in bedrock and boulder samples resulting from early Holocene ice retreat near Jokobshavn Isfjord, western Greenland, *Quaternary Science Reviews*, 30, 13-14, 1739-1749.

Amidon, W.H., **Rood, D.H.**, and Farley, K.A., 2009, Cosmogenic $^{3}$He and $^{21}$Ne production rates calibrated against $^{10}$Be in minerals from the Coso volcanic field, *Earth and Planetary Science Letters*, 280, 194-204, doi:10.1016/j.epsl.2009.01.031.

Behr, W.M., **Rood, D.H.**, Fletcher, K.E., Guzman, N., Finkel, R., Hanks, T.C., Hudnut, K.W., Kendrick, K.J., Platt, J.P., Sharp, W.D., Weldon, R.J., Yule, J.D., 2010, Uncertainties in slip rate estimates for the Mission Creek strand of the southern San Andreas fault at Biskra Palms Oasis, southern California, *Geological Society of America Bulletin*, 122, 9-10, 1360-1377, doi:10.1130/B30020.1.

**d. Synergistic Activities**

(1) Instructor for undergraduate course, Natural Disasters, at University of California, Irvine

(2) Participation in recruitment of underrepresented undergraduate students to participate in Earth science research at University of California, Irvine

(3) Co-supervisor for graduate student researcher at Earth Research Institute, University of California, Santa Barbara

(4) Calibration of production rates for cosmogenic $^{10}$Be, $^{26}$Al, and $^{36}$Cl for a wide variety of Earth science applications

(5) Development of high-precision $^{10}$Be and AMS measurements for the geosciences

**e. Selected Collaborators and Affiliations**

Finkel, Bob (UCB)
Burbank, Doug (UCSB)
Hanks, Tom (USGS)
Kendrick, Katherine (USGS)
Simpson, Dave (URS)
Hall, Sarah (McGill)
Farber, Dan (LLNL/UCSC)
Whitney, John (USGS)
Prentice, Carol (USGS)
Kelson, Keith (Fugro-WLA)
Ritz, Jeff (U. Montpellier)
Balco, Greg (BGC)
Purvance, Matt (UNR)
Stirling, Mark (GNS)
Briner, Jason (SUNY Buffalo)
Ramelli, Alan (UNR)
Brune, Jim (UNR)
Grant Ludwig, Lisa (UCI)
Hudnut, Ken (USGS)
Hilley, George (Stanford)
Amidon, Willy (Middlebury)
Farley, Ken (Caltech)
Guilderson, Tom (LLNL)
Brown, Tom (LLNL)
Johnson, Joanne (BAS)
Stone, John (UW)
Anooshehpoor, Rasool (NRC)
Gosse, John (Dalhousie)
Sharp, Warren (BGC)
Bierman, Paul (UVM)
Refsnider, Kurt (CU Boulder)
Amos, Colin (UCB)

**Doctoral Advisors**

Douglas Burbank, University of California, Santa Barbara
Robert Finkel, University of California, Berkeley & Lawrence Livermore National Laboratory

**Postdoctoral Advisors**

Lisa Grant Ludwig, University of California, Irvine
Jim Brune, University of Nevada, Reno

# Current and Pending Support

**(See GPG Section II.C.2.h for guidance on information to include on this form.)**

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

| Investigator: Paul Bierman | Other agencies (including NSF) to which this proposal has been/will be submitted. |
|---|---|

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Interpreting the Interstates

Source of Support: National Endowment for the Humanities
Total Award Amount: $ 200,000 Total Award Period Covered: 10/15/10 - 09/15/13
Location of Project: Vermont
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.25

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Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Landscape Imagery: a catalyst for formal and informal science education

Source of Support: NSF - Directors Teaching Scholar Award
Total Award Amount: $ 306,496 Total Award Period Covered: 08/01/05 - 07/31/11
Location of Project: Vermont
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

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Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: The Textbook Reconsidered - Creating the Shortbook of Geomorphology, collaborative

Source of Support: NSF - CCLI
Total Award Amount: $ 201,977 Total Award Period Covered: 10/01/08 - 09/30/11
Location of Project: Vermont, Washington
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

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Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Detrital cosmochronology of the Greenland Ice Sheet

Source of Support: NSF - Arctic Sciences
Total Award Amount: $ 273,052 Total Award Period Covered: 09/15/07 - 08/31/11
Location of Project: Greenland
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.50

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Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Deciphering 6 My of the Greenland Ice Sheet History using in situ 10Be from marine sediment cores

Source of Support: NSF-ANS
Total Award Amount: $ 324,611 Total Award Period Covered: 07/01/10 - 06/30/12
Location of Project: Greenland
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Summ: 0.25

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

# Current and Pending Support

**(See GPG Section II.C.2.h for guidance on information to include on this form.)**

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

| Investigator: Paul Bierman | Other agencies (including NSF) to which this proposal has been/will be submitted. |
|---|---|

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Synchronizing the North American Varve Chronology and the Greeland Ice Core Record using meteoric 10Be Flux

Source of Support: NSF-EAR-GLOBAL CHANGE, AGS

Total Award Amount: $ 125,390 Total Award Period Covered: 07/01/11 - 06/30/14

Location of Project: Vermont, Connecticut, California

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.25

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Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Innovative modeling of Streamflow, Sediment Loads and Sources Integrating ANNs, Isotopic Tracers, and Remote Sensing

Source of Support: NSF Hydrologic Sciences

Total Award Amount: $ 418,786 Total Award Period Covered: 07/01/11 - 06/01/14

Location of Project: Vermont

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.20

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Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Deciphering connections between land management, soil erosion, and sediment yield in large river basins

Source of Support: NSF Hydrologic Sciences

Total Award Amount: $ 188,942 Total Award Period Covered: 01/01/12 - 12/30/14

Location of Project: Vermont, China

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.23

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Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

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Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.