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PI/PD Name: Jorge A Ramirez

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 ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
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Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
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.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

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PI/PD Name: A S Denning

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: Neil S Grigg

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
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- ☒ None

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PI/PD Name: N. Leroy Poff

Gender: ☒ Male ☐ Female

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

Race: (Select one or more)
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- ☐ Asian
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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

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 09-29

NSF 09-519 **09/14/09**

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.)

DGE - IGERT FULL PROPOSALS

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				785979618	

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

846000545

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

Colorado State University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0013508000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

601 S Howes St
Fort Collins, CO 80523-2002

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

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 **IGERT: WATER - Integrated Water Atmosphere and Ecosystem Education and Research**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **2,728,060**	**60** months	**07/01/10**	**0935521**

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)
IT SZ
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Civil and Environmental Engineering

PI/PD POSTAL ADDRESS

Fort Collins, CO 805231372
United States

PI/PD FAX NUMBER
970-491-7727

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Jorge A Ramirez**	**PhD**	**1988**	**970-491-7621**	**ramirez@engr.colostate.edu**
CO-PI/PD **A S Denning**	**PhD**	**1994**	**970-431-6936**	**denning@atmos.colostate.edu**
CO-PI/PD **Neil S Grigg**	**PhD**	**1969**	**970-491-3369**	**neilg@engr.colostate.edu**
CO-PI/PD **N. Leroy Poff**	**Ph.D**	**1989**	**970-491-2079**	**poff@lamar.colostate.edu**
CO-PI/PD				

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, and lobbying activities (see below), 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 09-29). 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 dislosed 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.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

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

A. Project Summary

IGERT: WATER - Integrated Water, Atmosphere, and Ecosystems Education and Research
Colorado State University
P.I. and Program Director: Jorge A. Ramírez

Intellectual Merit

WATER-IGERT will apply three dimensions of integration to scientific solutions of water–based environmental problems. Integration of disciplines, scales, and problem–sheds will occur through a new problem–focused approach to education and research. Problem–shed integration is necessary because of barriers between the scientific world and the world of action where water–based problems are confronted. The program will lead to the discovery of new, scientific mechanisms for integration of scales and disciplines and to learn how to apply them in the world of action where political, legal, economic, and social forces dominate. The WATER-IGERT program will provide a new generation of Ph.D. students with capabilities to work across disciplines and problem-sheds. The WATER-IGERT program will be based on integrated approach to hydrologic and water resource science and engineering, land-surface-atmosphere interactions, ecosystems science, vulnerability analysis, water management and policy. Students will learn to evaluate and analyze complex non-linear systems interactions, environmental variability, and climate change to develop and apply integrative solutions to pressing current problems.

The program's uniqueness arises because, while many studies have been conducted on the hydrologic cycle, aquatic ecosystems, and harnessing water for human uses, few studies have addressed the persistent influences of human activities on water resources and fluxes. Far fewer have addressed the biospheric feedbacks in the climate system and the hydrologic cycle, and fewer still have addressed the vulnerabilities of hydrologic, ecologic and socio-economic systems to environmental variability and climate change that occur while pressing problems demand action and solutions. The interfaces between human activities and aquatic ecosystems (especially in the arid West) comprise the most critical and least studied issues in the field of water science, issues that are exacerbated by water scarcity.

Broader Impacts

Strengths and uniqueness of our IGERT program are derived from 1) the combination of a large and rich cadre of internationally renowned faculty and scientists in the subject areas, 2) world class research facilities including the Natural Resource Ecology Laboratory, the Graduate Degree Program in Ecology, the Center for Multi-scale Modeling of Atmospheric Processes, the Cooperative Institute for Research in the Atmosphere, the CSU-CHILL National Radar Facility, the Engineering Research Center, the Colorado Climate Center, the Water Center, and the School of Global Environmental Sustainability, 3) the unique methods that we intend to use to integrate the sciences and to give students experience in applying scientific advances to real-world problem-solving, including the development of new multidisciplinary courses in the above fields, 4) the importance and relevance of the major multi-disciplinary focus areas, and, particularly, 5) the strength of the currently existing multi-disciplinary academic and research programs in water engineering and science, atmospheric sciences, ecology, social sciences, and resource management at CSU, 6) our WATER-IGERT team has an exemplary record of providing interdisciplinary education, such as through our WATER-REU Program in Water Research at CSU, the Hydrology Days Conference, the Student Water Symposium, and the Front Range Student Ecology Symposium. Collaboration with federal research agencies and European universities will offer internship. None of the currently funded IGERT programs either address the same research emphasis or possess such potential in multi-disciplinary research in WATER issues.

To increase diversity among recipients of Ph.D. degrees in these fields, a key aspect of WATER-IGERT is collaboration with the Graduate Center for Diversity and Access of the Graduate School, and with its programs including the Louis Stokes Alliance for Minority Participation Bridges to the Doctorate, Alliance for Graduate Education to the Professoriate, Fast Track to Work, McNair Scholars and The Colorado Alliance for Minority Participation (CO-AMP), a state-wide consortium of higher education institutions in Colorado and the Four Corners Region sponsored by the NSF for the purpose of attracting and preparing students for careers in Science, Mathematics, Engineering and Technology (SMET).

Keywords: Environmental Science; Geoscience; Engineering; WATER Science.

TABLE OF CONTENTS

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.

C. Project Description:

1. List of Participants:

DEPARTMENT OF ATMOSPHERIC SCIENCE	
Christian Kummerow	Hydrologic remote sensing, precipitation
Steven Rutledge	Radar meteorology, CHILL radar
SCOTT DENNING[1,2,3]	Atmosphere-biosphere interactions, carbon cycle, climate variability
David Randall	Cloud/climate studies, general circulation, cloud dynamics
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING	
NEIL S. GRIGG[1]	Water resources planning and management
JORGE A. RAMIREZ[1,2,4]	Hydrology; hydrometeorology, land-atmosphere interactions
Mazdak Arabi	Risk analysis in water resources, uncertainty, management
Brian Bledsoe[1]	River mechanics, stream restoration
Pierre Julien	River mechanics erosion and sedimentation
Jeff Niemann	Landscape evolution, fluvial geomorphology
DEPARTMENT OF FOREST, RANGELAND AND WATERSHED STEWARDSHIP	
Lee MacDonald[2]	Landuse hydrology
Melinda Laituri[2]	Hydrology
Stephanie Kampf[2]	Hydrology
David Cooper	Wetland ecosystem studies, wetland restoration & creation
DEPARTMENT OF HUMAN DIMENSIONS OF NATURAL RESOURCES	
Joshua Goldstein	Ecosystem services, conservation finance, ecological economics
Jessica Thompson	Dynamics of interdisciplinary and interagency problem solving
NATURAL RESOURCES ECOLOGY LABORATORY	
Jill Baron[2]	Ecosystem ecology
Dennis Ojima[2]	Climate change; vulnerability anal.; integrated human-ecosystem dynamics
Mike Coughenour[2]	Biosphere-atmosphere interactions
Lara Prihodko	Human dimensions of environmental change, science and policy
Bill Parton[2]	Biometeorology, nutrient cycling
DEPARTMENT OF BIOLOGY	
LEROY POFF[1,5]	Stream and aquatic ecology
Diana H. Wall[6]	Biodiversity and long term sustainability of ecosystems
DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS	
John Loomis[2]	Environmental economics
Christopher Goemans	Population and climate change effects on management of water
DEPARTMENT OF SOIL AND CROP SCIENCES	
Reagan Waskom	Water Center Director
DEPARTMENT OF HISTORY	
Mark Fiege	History of water, ecosystems, and environment of the Rocky Mountains
DEPARTMENT OF POLITICAL SCIENCE	
Michele Betsill	Global environmental governance, politics and climate change
DEPARTMENT OF SOCIOLOGY	
Evan Vlachos	Water and natural resource policy

[1] WATER-IGERT Program P.I.'s are in boldface underlined capital letters.
[2] Faculty of the Graduate Degree Program in Ecology (GDPE)
[3] Director for Education and Outreach, Center for Multiscale Modeling of Atmospheric Processes (CMMAP)
[4] Director, REU Program in WATER Research at CSU
[5] Director, Graduate Degree Program in Ecology (GDPE)
[6] Director, School of Global Environmental Sustainability (SoGES)

2. Vision, Goals, and Thematic Basis:

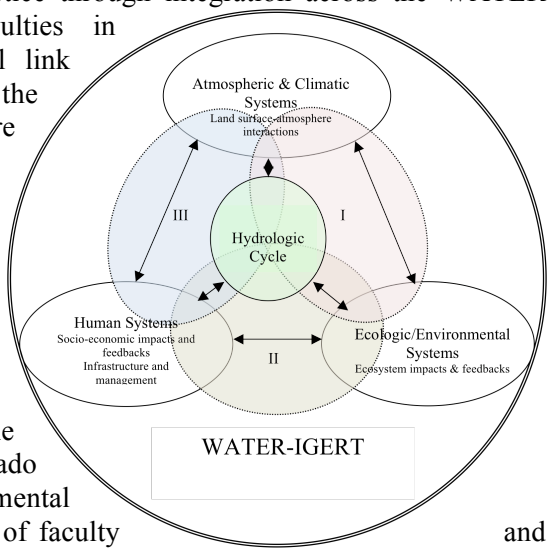
The 21st Century has been called the Century of Water due to growing scarcity of the renewable resource and related problems of managing the resource that sustains life on the planet. As a greenhouse gas, water vapor traps infrared radiation to maintain temperatures suitable for biological processes. The phase changes of water help modulate the global climate. The gravity-driven flow of water on the earth's surface shapes the land surface through fluvial processes. Water has created diverse opportunities for biological evolution through the spatial and temporal variation in its distribution. The ability of humans to manipulate the flow of water has been a basis for survival and prosperity throughout history.

Threatened ecosystems need water to remain healthy and to maintain the biodiversity and functions required to provide ecosystem services to humans. But uncertainties in how much water they need (and for what) introduce policy confusion. Likewise, forecasting regional climate dynamics and population growth is essential for water resources planning, but forecasts often founder due to uncertainty and lack of consensus. Clearly, the challenge to develop policy-relevant science to balance tradeoffs and optimize allocation of water amidst the consequences of hydro-climatic variability demands the integrated work of multiple disciplines.

Water management decisions generate intense social conflicts over spatial and temporal distributions of water and impacts on humans and natural ecosystems. Uncertainty of water availability in space and time leads to needs to store and redistribute water, and climate change exacerbates scientific uncertainty. Water use is increasingly contested, playing out as conflicts between societal needs and ecosystem needs, or as conflicts between political jurisdictions. To reduce this risk and uncertainty, three basic questions must be answered: 1) how can limited fresh water be distributed equitably in a socially acceptable and sustainable framework; 2) What are the relative hydro-climatic, ecological, and societal drawbacks and benefits of required management actions; and 3) How can science provide integrated answers to encourage wise water management decisions across problem-sheds?

Our IGERT Program will focus on these research questions and the scholars it produces will be prepared to transform the conflict-filled water management arena by providing knowledge from integrated research at the interfaces between the atmospheric, hydrologic, ecologic, and policy arenas. The questions are of great importance in ecologically–fragile regions of the United States that are experiencing rapid population growth and are planning to develop new water infrastructure in the face of climate change. Specifically, we will address the **integrated, persistent influence of human activities on water resources;** the **biospheric feedbacks in the climate system and the hydrologic cycle;** and the **vulnerabilities of water resources/hydrologic, ecologic and socio-economic systems to environmental variability and climatic change**.

Our WATER-IGERT will transform science and practice through integration across the WATER disciplines and cooperation among world-class faculties in atmospheric science, hydrology, and ecology. We will link science with policy and management through the interdisciplinary area of planning and management, where Colorado State has broad capability.



OUR IGERT Program will build upon solid academic units and research institutions at Colorado State University (CSU) including: the Natural Resource Ecology Laboratory, the Graduate Degree Program in Ecology, the Center for Multi-scale Modeling of Atmospheric Processes, the Cooperative Institute for Research in the Atmosphere, the CSU-CHILL National Radar Facility, the Engineering Research Center, the Colorado Climate Center, the Water Center, the Colorado Water Institute and the School of Global Environmental Sustainability. Our IGERT program features a rich cadre of faculty and scientists in the subject areas, world class research facilities and programs, unique methods to integrate the sciences and give students experience in applying scientific advances to real-world problem-solving, a

new multidisciplinary *core curriculum* across the fields, and strong existing multi-disciplinary academic and research programs in the program areas.

The organizing concept for our WATER-IGERT (**W**ater, **AT**mosphere, **E**cosystem **E**ducation and **R**esearch) is shown in the diagram that illustrates an *integrative* approach to problems in hydrologic science, land-surface atmosphere interactions, climate science, ecosystems science, vulnerability assessment, water resources management and policy-making. These are to be applied in the context of environmental variability and climatic change at a wide range of spatial and temporal scales. Emphasis will be given to the understanding of how the interactions are modified by and modify eco-hydrological systems, as well as how they are affected by human intervention and by climatic variability and change.

The central, integrating element will be the *hydrologic cycle* as water permeates (and integrates) all the components of the bio-physical climate system including climatic, ecological, and socio-economic and management feedbacks and interactions.

Issues of variability and uncertainty, vulnerability (of human use and ecosystems), and sustainability will be developed both in the *core courses* and in the research themes. Each student will focus on a subset of these components and feedbacks but our WATER-IGERT program will lead to *integration* by propitiating interaction with other students and faculty in team-based multidisciplinary problem solving.

3. Major Research Efforts:

The primary mission of WATER-IGERT is to prepare Ph.D. students to work in an interdisciplinary team-based activity, and our research themes will involve interacting teams of hydrologists, meteorologists, ecologists, and management experts. The Program will feature problem-focused research to bridge basic and applied science by combining fundamental research on scientific problems with application of scientific knowledge to actual resource issues.

Organization of Major Research Themes

Four major research themes will serve as the foundation for WATER-IGERT at CSU. The faculty and graduate students engaged in these themes will be called **Research-Theme Groups**. Research-Theme Groups are defined by and address research questions at the interfaces between(see diagram on page C-2):

I) **H**ydrologic, **a**tmospheric, and **e**cologic systems (HAE):
   a. Coupling atmospheric, ecologic, and hydrologic processes: understanding the two-way interactions between atmospheric and land-surface processes is critical to understanding climate change, vegetation function, and watershed hydrology.
   b. Spatial and temporal scaling issues in hydrologic processes.

II) **H**ydrologic, **e**cologic, and **s**ocio-economic systems (HES):
   a. Defining changes in water, nutrients and sediment transports due to variability and change in climate/weather, land cover/land use, and water resources management.
   b. Developing models to 'optimize' ecosystem resilience and human economic activity that bear on the hydrologic cycle at regional scales

III) **H**ydrologic, **a**tmospheric, and **s**ocio-economic systems (HAS):
   a. Regional, integrated assessment of vulnerability of hydrologic and water resource systems, ecologic, and socio-economic systems to environmental variability and climate change.

The fourth Research Theme arises from the need for integration and synthesis:

IV) **WATER**-Research integration and synthesis
   a. Trade-offs, alternative solutions, adaptation strategies, global feedbacks, global integration.

Examples of specific research topics within each theme are shown next. These and future projects will shape the curriculum of the program, drive the interdisciplinary collaborations among faculty members and scholars, and lead to topics for interdisciplinary Ph.D. theses.

Research Theme I: HAE - Hydrologic, atmospheric, and ecologic systems – Land-atmosphere interactions, ecosystem impacts and feedbacks (S. Denning[7], L. Poff, and J. Ramirez)

[7] Research Theme Group Leader

Student programs in this theme area will equip scientists to interpret and inform science and policy about climate issues and their direct impact on water supplies, management, and ecosystems. For example, climate change is expected to alter water systems management and harm rich but sensitive ecosystems in water-stressed areas (arid West, densely populated Southeast).

- Global change, regional hydrology, and interactive ecosystems
- Feedbacks among climate, hydrology, and ecosystems at regional scales
- Evaluation of spatio-temporal variability of precipitation, soil moisture, and ecosystem function
- Analysis of changes in snowpack and the timing of spring runoff under a changing climate
- Land surface-atmospheric feedbacks on complex dynamics of precipitation and soil moisture

Global Change, Regional Hydrology, and Interactive Ecosystems

Concern about global climate change is increasingly important as a driver of policy decisions at the regional, state, and local levels. Impacts of climate change on ecosystems and water resources in the western United States will depend on changes in the distribution of temperature and precipitation spatially (e.g., mountains vs. basins vs. agriculturally-intensive plains) and seasonally (e.g., summer rains vs. winter snow, timing of spring runoff).

Unfortunately, the current generation of climate models used for global change research cannot accurately predict decadal trends at resolutions approaching those required to understand impacts on western water resources and ecosystems (*IPCC*, 2007). Climate model grid spacing is typically on the order of 200 km, yet in the western US, such an area may include high terrain that develops abundant snowpack feeding a reservoir system, a network of stream and river channels, and lowland cities and farms that draw from the stored water derived from snowmelt. High-resolution models can simulate interactions between climate and regional ecosystems, but must be "driven" from coarse-resolution global models, without the potential for local and regional changes to feed back on the larger scale. The scale mismatch between predictive global climate models and analyses of hydrologic and ecological impacts and feedbacks has been a pernicious problem, and will be a major focus of WATER-IGERT research and teaching.

A dramatically new approach to the representation of clouds and precipitation in global models of weather and climate is being pioneered by the Center for Multiscale Modeling of Atmospheric Processes (CMMAP, http://www.cmmap.org), an NSF Science and Technology Center headquartered at CSU. Global models cannot resolve cloud-scale processes, and therefore use empirical representations to estimate the effects of clouds over hundreds of km using only large-scale information (*Arakawa*, 2004). Ideally, global models would be run with grid spacing of at most a few km, to capture updrafts, cloud formation, and organized circulations that lead to rain and snow. Such calculations have been performed (*Tomita et al*, 2005), but the computational expense is so extreme that only a few weeks can be simulated on the world's fastest computers.

At CMMAP, we have developed a Multiscale Modeling Framework (MMF, *Randall et al*, 2003b) in which ***cloud-resolving submodels are run inside a small fraction of every grid column*** in a global atmospheric model (*Grabowski*, 2001, 2004; *Khairoutdinov and Randall*, 2001; *Jung and Arakawa*, 2005). This approach is analogous to public opinion polling, because it is unnecessary to simulate every cloud in a large-scale grid column, just a representative sub-population. Global simulation with the MMF is hundreds of times more expensive than with traditional coarse-resolution models, but produces a much more realistic climate (*Khairoutdinov et al,* 2005*; Tao et al,* 2007). A critical advantage of the MMF is that it predicts variations of precipitation and cloud processes on scales commensurate with observations in the field and from satellites, which allows direct evaluation against data that is impossible for traditional climate models (*Randall et al*, 2003a; *Demott and Randall*, 2007).

Feedbacks among climate, hydrology, and ecosystems at regional scales

Research by teams of WATER-IGERT scholars and faculty will study regional coupling among atmospheric, hydrologic, and ecological systems under current and future climate regimes. With the advent of km-scale estimates of precipitation and other climate properties from the global MMF, WATER-IGERT students will have a unique opportunity to study land-atmosphere interactions in

response to global climate change. Up to now, cloud-scale predictions from the MMF have been aggregated and passed to the land-surface submodel at the large scale (hundreds of km). WATER-IGERT students will develop and evaluate a coupled land-atmosphere MMF in which a separate instance of the land component model is run in each cloud-resolving cell of the atmospheric component, rather than only at the large scale. This will include treatment of topographic effects on precipitation, heterogeneous vegetation, high-resolution spatio-temporal patterns of soil moisture, ecosystem water stress, photosynthesis, and respiration. The Simple Biosphere Model (SiB) is a land-surface parameterization used to compute biophysical exchanges in climate models and later adapted to include ecosystem metabolism (*Denning et al*, 1996a,b), stable isotopes (Suits et al, 2005), and agriculture (Hanan et al, 2004; Lokupitiya et al, 2009). WATER-IGERT students will use the coupled model to investigate changes in regional snowpack under various climate change scenarios and consequent water availability for agriculture and economic development in the western US. They will evaluate potential changes in atmospheric moisture and circulation in response to regional land-use, urban development, and irrigation of croplands. They will consider changing irrigation demand and agricultural production as a result of projected changes in physical climate as well as atmospheric CO_2 (including physiological responses of crop cultivars) during the next several decades.

Evaluation of simulated spatial and temporal variability of precipitation, soil moisture, and ecosystem function in the western United States

Spatial variations in cloud-scale prediction of precipitation in SiB-MMF simulations of the current climate will be evaluated against observations made over Northern Colorado by the CSU-CHILL radar. Spatial patterns will be analyzed by season and compared with statistical downscaling from the predictions of the large-scale global grid (*Luca et al*, 2001). This analysis will be performed separately with the land model run only on the large-scale grid and with the land model run interactively on the cloud-scale of the MMF. We will evaluate the degree to which interactions between the vegetation, soil moisture, and overlying atmosphere affect the organization of the precipitation patterns (*Kochendorfer and Ramírez*, 2005) and persistence of anomalous moisture regimes.

Analysis of changes in snowpack and the timing of spring runoff under a changing climate

Much of the water that supports agriculture in the western US is derived from melting mountain snowpacks. The accumulation of this snow, and the timing and rate of the spring runoff when it melts, are critical to the ability to capture this water in reservoirs, and to the structure and function of aquatic and riparian ecosystems in the region. Mountain snowpack and the hydrologic dynamics of spring runoff are very likely to change in coming decades in response to global climate change. Teams of WATER-IGERT students and faculty will be uniquely positioned to analyze these changes and their impacts on ecosystems and water resources using the coupled multiscale climate modeling system (SiB-MMF). We will use both the high-resolution output of the coupled MMF and statistical downscaling along topographic gradients to analyze potential changes in mountain snowpacks under climate change. Students will analyze spring runoff patterns and project changes in reservoir storage. They will evaluate the likely impacts of these changes on riparian and aquatic ecosystems, water resource management, and agricultural production in the region. They will work with regional stakeholders to develop scenarios for adapting to impacts of a changing climate on regional hydrology, water resources, and the agricultural economy.

Land Surface-Atmospheric Feedbacks on the Complex Dynamics of Precipitation and Soil Moisture at Seasonal and Longer Time Scales

The western United States is particularly sensitive to inter-annual variability of summer and winter climate. In the most arid regions of the southwest United States, for example, the inter-annual variability of summer precipitation can be larger than the mean summer rainfall itself (e.g., *Higgins et al.,* 1998; *Castro et al.,* 2001). Sustained flood or *drought* conditions over broad areas result from shifts in the large-scale circulation pattern (e.g., *Trenberth and Guillemot*, 1996). Short- or long-term departures from average conditions may adversely affect infrastructure, agricultural production, water supply, and hydroelectric power generation (e.g., *Meehl et al.,* 2000). There is a critical need to understand the causes of inter-annual variability so seasonal forecasts can be improved.

Land Surface, Vegetation, Atmosphere Feedbacks On The Regional Scale

Changes in vegetation and soil processes, both hydrodynamic and thermodynamic, directly affect the surface energy and moisture fluxes into the atmosphere [*e.g., Pielke,* 2001; *Kochendorfer and Ramírez,* 2005]. *Hoffman and Jackson* [2002] propose that as a result of atmospheric-vegetation interactions, anthropogenic impacts can exacerbate declines in precipitation (e.g., *drought*). In the context of climate, soil and vegetation dynamics are as much a part of the climate system as are atmospheric variables [*Hayden*, 1998; *Pielke*, 1998; *Wang and Eltahir*, 2000a, 2000b]. *Eastman et al.*, [2001a,b] showed that land-use change, grazing, and increased CO_2 can significantly alter the regional climate system in the central Great Plains of the United States. For example, the effects of enhanced atmospheric concentrations of CO_2 on plant growth on a seasonal time scale are shown to amplify the radiative effect of enhanced atmospheric CO_2 on the region. The non-linear effect of vegetation-atmospheric feedback on this scale results in a complex spatial and temporal pattern of response. Not only is there a teleconnection of atmospheric conditions to locations distant from where the land feedback occurs, but the landscape at distant locations itself is influenced by the altered weather.

Pan et al. [1995] concluded that soil moisture significantly affects summer rainfall in both *drought* and flood years in the midwest of the United States. *Pan et al*., [1996] concluded that the non-linear soil moisture-atmosphere feedback manifested in such manner that increases in soil moisture enhanced local rainfall when the lower atmosphere was thermodynamically unstable and relatively dry but decreased rainfall when the atmosphere was humid and lacked sufficient thermal forcing to initiate deep cumulus convection. *Segal et al*. [1998] concluded that average rainfall in North America is increased as a result of irrigation. *Kiang and Eltahir* [1999], *Eastman et al*. [2001], *Lu et al*. [2001], and *Wang and Eltahir* [2000a, 2000b] used coupled regional atmospheric-vegetation dynamics models to demonstrate the importance of two-way interaction between the atmosphere and vegetation response. Many other studies support the result that there is a significant effect on the regional- and large-scale climate due to land-surface processes. This research theme will examine the impact of the nonlinear dynamics of land surface feedbacks (*e.g.*, soil moisture, vegetation, etc.) to precipitation on the variability of precipitation and soil moisture at the local and regional-scale. We will use coupled land surface-atmosphere models and conceptual, physically based models (*i.e.*, *Kochendorfer and Ramirez,* 2005), to examine land surface-atmosphere feedbacks in the context of their influence on the intensity, magnitude, duration and spatial extent of floods and droughts. These models will be implemented in a fully coupled manner and the analyses will be performed at a range of spatial and temporal scales such that large-scale forcings (*i.e.*, ENSO, PDO, and others), as well as regional- and local-scale forcings (*i.e.*, land use changes, irrigation, urbanization, etc.) are explicitly accounted for. Particular emphasis will be given to determining the impact of the non-linear feedbacks on the characteristics of the probability distribution of precipitation so that risk-based management and adaptation decisions can be implemented.

Research Theme II: HES - Hydrologic, ecologic, and socio-economic systems – Ecosystem impacts and, Socio-economic impacts, policy-making and adaptation (L. Poff[8], N. Grigg, and J. Ramirez)

Student programs in this theme area will equip scientists to explain and respond to impacts of water management actions on economic and ecologic systems. Given the need to open minds of the public and policy makers about long-term ecosystem damage from natural and human-caused drivers, this area of research is directed at an urgent national need. For example, use changes such as in the Everglades can alter water flows and have large impacts on ecosystems; or climate change and imbalances of demand between agricultural and urban uses present challenges to develop sustainable management of rivers and human wellbeing, especially in the semi-arid and arid west.

- Sustainable water systems for urban uses
- Non-native species invasion and extinction of native species
- Processes governing conversion of grasslands to shrubland
- Balancing economic and ecosystem needs for water in heavily-modified river basins.

[8] Research Theme Group Leader

Non-native Species Invasion and Extinction of Native Species

Climate change has the likely consequence of altering the spatial and temporal distribution of runoff in river networks. Hydrologically-driven fluvial processes sustain the habitat and ecological conditions required by many aquatic and riparian species in river ecosystems (*Poff et al.* 1997). Human-alteration of fluvial dynamics has contributed to the diminishment of many native species and has allowed the establishment and expansion of many non-indigenous ones, some of them being noxious or nuisance. For example, Eurasian saltcedar (*Tamarix* spp.) is a nonnative riparian shrub in the Southwest that has been replacing native cottonwood (*Populus*) in rivers having dams that truncate peak flows needed for cottonwood seedling establishment (*Friedman et al.* 2005). The relationships between runoff and the relative success of saltcedar are now reasonably well understood (*Stromberg et al*. 2007, *Merritt and Poff*, in press), as are its ecological consequences (*Shafroth et al.* 2005). Future climate change will do two things: 1) allow saltcedar to spread northward as temperatures warm, and 2) alter precipitation and modify timing and magnitude of runoff, which will alter fluvial disturbance dynamics that modulate the relative success of these two dominant riparian species. A key question is: given the projected range of climate change in a region, what is the range of alteration in the timing and magnitude of river runoff, and how will this influence the risk of spread of invasive saltcedar and its competitive outcomes with already-established cottonwood species? How might dams in the region be managed "adaptively" to reduce projected saltcedar spread and maintain cottonwood coexistence? And how would new dams interact with a changing climate to moderate the rate and extent of spread of saltcedar?

Similar kinds of questions could be asked for many other species of concern, both native (*e.g.*, endangered species such as salmonids in the Interior West) or invasive pest species (such as the New Zealand mud snail). The physical alteration of the landscape and hydrologic cycle by humans has already extensively modified the hydrologic and sediment flux at the global scale (*Vörösmarty et al.* 2004, *Syvitski et al.* 2005) and has broad regional and continental scale implications for maintaining regional biodiversity and ecosystem function (*Poff et al.* 2007).

WATER-IGERT students would be involved in developing conceptual frameworks that span the ecological, hydrological and economic foundations of sustainability and build models that capture these complexities and feedbacks to support pro-actively both the interrelationships between water resources management and ecosystem sustainability.

By integrating climatological, hydrological, and ecological processes (and uncertainties), an optimization framework could be developed for a given social context and goals or a decision-support system that could allow for proactive multi-objective planning and management for climate change.

Processes Governing Grasslands to Shrubland Conversions

Climate change will change organismic, community, and ecosystem processes. Variability in weather and economic conditions has enhanced uncertainty in the characteristics and land use decisions of rangelands in the Great Plains. The production of forage is highly vulnerable to changes in precipitation. Increases in the frequency of extreme events, trends and variability in precipitation and temperatures enhance the uncertainty in the rangeland systems and the social well being of the region. Today, there is a growing need to develop and implement a regional integrated assessment methodology in order to evaluate the impacts of climate change on these rangeland ecosystems and the human systems that depend on them (*Mangan et al.* 2003).

Our research will develop a regional integrated modeling and assessment system by combining numerical modeling, simulations and field studies of short and long-term effects on biogeochemical cycles and their feedbacks to climate and the consequences of floods and droughts for land managers (*Mangan et al.* 2003). As part of our integration between the natural and human systems will use many of the integration and dissemination tools used by the CSU Cooperative Extension Service. An important product of our project will be the development of a set of written and digital information packages that can be disseminated to resource managers.

This research theme will test the following hypotheses: (a) The complexity of climate change impacts on ecosystem processes and associated societal demands can be effectively analyzed using empirical models that will provide ecological and managerial insight. (b) Reductions in snow melt water inputs in

combination with reductions in spring and or in summer rain, will favor the growth and development of shrubs compared to grasses. This increase in shrub abundance will result in only slight decreases in leaf carbon gain, slight decreases in leaf transpiration, use of deep as opposed to shallow water sources and reductions in the net CO_2 flux of these systems in combination with reductions in soil and plant N cycling. (c) Drought conditions will shift the extent of carbon and water coupling at the plant and at the ecosystem scale.

The overall objectives of this research theme are thus:

- Develop a modeling system that combines both rangeland-level decision-making about production choices and market-level processes that determine net profitability based on an ecosystem model of rangeland ecosystems. We will evaluate use of water, soil fertility, and livestock yields and climate information based on observations, forecasts, and historical scenarios of precipitation.
- Examine the combined effects of climate and vegetation changes on ecosystem processes of rangeland systems in the region.
- Quantify how *in situ* manipulations of winter and summer precipitation will affect organismic, community and ecosystem processes including carbon and water vapor flux.
- Quantify the coupling of carbon and water at the leaf and ecosystem scale and identify the mechanisms that allow shrubs to flourish under drought at the expense of the growth and development of grasses.
- Provide estimates of water vapor flux that can be integrated with atmospheric modeling of precipitation.

Integrative modeling: Our ecosystem modeling will consist of using the CENTURY (DAYCENT version-*Del Grosso et al.* 2002) ecosystem model to evaluate how changes in precipitation regimes affect water, carbon and N fluxes and their feedbacks to atmospheric processes (*Del Grosso et al.* 2002). CENTURY is a general model of the plant-soil ecosystem capable of simulating C and nutrient dynamics for grasslands, forests, croplands, and combined forest-herbaceous systems (e.g., *Sanford et al.*1991, *Del Grosso et al.* 2002, *Mangan et al.* 2003). Under different scenarios of precipitation conditions and associated weather patterns we will use CENTURY to estimate the magnitude of changes water vapor flux, carbon exchange and nitrogen processes. These simulations will be accomplished using existing information plus the findings from our experimental studies and the output will be used to assist land managers in evaluating land use consequences under a range of precipitation regimes.

Field Studies: We will conduct our study at the Central Plains Experimental Range located in the shortgrass steppe of northeastern Colorado. The vegetation of the area is characterized by a mixture of shrubs, *Atriplex canescans* (four wing salt bush) and a herbaceous understory dominated by the C_4 perennial bunchgrass *Bouteloua gracilis* (blue grama). We will chose two sites for our field studies, one that is dominated by grasses and the other that is dominated by shrubs. The shrub-dominated site represents a community that reflects the vegetation change that is often associated by prolonged droughts (*Archer et al.* 1995) while the grass dominated community represents a system that is accustomed to low precipitation but one that could undergo significant changes under drought scenarios. This design will allow us to accurately portray what are the magnitudes of water, carbon and nitrogen processes under short-term drought in a existing grassland and what the magnitudes of biogeochemical fluxes will be like when droughts have been extensive and caused significant vegetation changes. We are thus substituting community-type for temporal changes expected under prolonged drier conditions.

Balancing Economic and Ecosystem Needs for Water in Heavily-modified River Basins.

The economies of many communities in the western United States (and elsewhere) depend greatly on the alteration of the natural hydrologic cycle. Along the Front Range of Colorado, rivers have been fundamental to economic development, both through irrigated agriculture and municipal drinking water supplies. Climate change and projected population growth are introducing new uncertainties into water resources management, and the ecological integrity and water quality of rivers in the region are vulnerable to continued over-allocation of available runoff. Running from the Continental Divide, through Ft. Collins and the Great Plains, the Poudre is such a river.

Many interests and administrative authorities are in the basin, including the Northern Colorado Water Conservancy District, the US Corps of Engineers, and various municipalities. The river has value both as a direct economic asset but also from a recreational perspective, and the continued health of this "working" river is dependent on finding some balance among the multiple competing interests. Scientists are challenged with translating their understanding of the river ecosystem into a language that can be appreciated by the broader public and governmental entities to effectively incorporate that understanding into public policy. A whole basin approach is critical to include not only all political and socio-economic interests but to consider the spatially-distributed sources and causes of water quality impairment and ecological resilience.

This research theme will address the following questions: How are the range of ecosystem goods and services quantitatively related to the river hydrograph? How sensitive are these to inter-annual variability in runoff? What are the magnitudes of uncertainty in spatial and temporal components of ecosystem provision of goods and services? And how do these ecological uncertainties scale relative to those derived from economic analysis? How can these be combined into whole-basin models of the water cycle and its social-ecological dependencies? Are there "limits" of development that create unacceptable risk of collapse of the river corridor? Are these spatially distributed and how do they interact with projected climate change and population growth? Can a "model" framework be developed to transfer to other basins in the West or globally to 'balance' human and ecosystem needs in water-limited settings? Can lessons be learned from this system that are transferrable to other arid-land rivers facing similar pressures?

Research Theme III: HAS - Hydrologic, atmospheric, and socio-economic systems – Vulnerabilities, impacts, adaptation and mitigation (N. Grigg[9], S. Denning, and J. Ramirez)

Student programs in this theme area will equip scientists to anticipate the impacts of climate change on water and economic systems and to provide policy and management advice about response and mitigation strategies. For example, climate change in the Colorado River Basin could diminish critical water supply for a large fraction of the US population.

- Susceptibility of water supply systems to climate change
- Hydrologic-ecologic-socioeconomic vulnerability analysis for drought and climate variability
- Regional hydrologic vulnerability and hydrologic extremes
- Coupling among stakeholder sectors and ecological outcomes in a regulated river: droughts
-

Hydrologic-Ecologic-Socioeconomic Vulnerability Analysis to Drought and Climate Variability

Water management systems are designed for mean climatic conditions and a certain range of variability; however, vulnerabilities are found at climatic extremes (*e.g.*, floods and droughts). Three categories of vulnerabilities can be identified: 1) meteorological and climatological vulnerabilities; 2) hydrologic system and design vulnerabilities; and 3) geographical and societal vulnerabilities. In the context of water resource systems, meteorological vulnerabilities are associated with the magnitude, frequency and timing of storms and with the magnitude, spatial extent, frequency and duration of droughts. Hydrologic system and design vulnerabilities are associated with the physical design, operating rules, and institutional settings. Societal and geographical vulnerabilities are associated with relative levels of demand with respect to supply, water quality, agricultural needs, hydroelectricity, and protection of fragile ecosystems from rapidly changing socio-economic environments.

Later, we explain use of the Cache La Poudre River as a venue to study drought effects on water supply, fisheries, wildlife, ecological integrity, and recreation. This river is a primary source of drinking water and irrigation water and is used widely for recreation. Also, it is amenable to study due to its extensive hydrologic, geomorphic, and ecological data. Other examples of western water problems with similar issues include the Platte River system, the Colorado River endangered species, and the California Bay-Delta water issues. In each of these, there is a convergence of hydrologic and ecological issues with

[9] Research Theme Group leader

economic and political pressures of scarce water supply, drought, and pressure to use the water resources to meet conflicting demands in the regions.

The overarching objective of this research theme will be a hydrologically and ecologically focused vulnerability analysis. While climate variability and change will affect ecosystems and water quality, human actions to mitigate their consequences are expected to be the primary driver influencing system response. Given the importance of uncertainty and variability in future climate variability and land-use change, a major emphasis will be in designing hydrologic and water resources modeling to allow propagation of these uncertainties through to ecologic modeling and decision making.

Deliverables

1. We will develop regional-scale hydrologic models for vulnerability analysis that include eco-hydrological optimality hypothesis for vegetation (*e.g.*, *Kochendorfer and Ramírez*, 1996, 2000).
2. An evaluation of the uncertainty and its implications leading to a probabilistic statement of spatially distributed vulnerability will be the *ultimate product of the research*.
3. A value-of-information analysis based on Bayesian decision theory will be conducted to look at the decision to invest in adaptation or mitigation strategies (*e.g.* to protect against drought).
4. A model of damages and investment costs will be constructed based on past integrated impact studies and other available economic information. Uncertainty in the parameters of the physically based statistical-dynamical hydrologic/ecologic model will be based on both subjective analysis and rigorous uncertainty analysis of model results of the hydrologic modeling study. Methods such as first-order second-moment analysis of uncertainty and Monte Carlo simulation will be used (*e.g.*, *Kochendorfer and Ramírez*, 1996).

<u>*Regional Hydrologic Vulnerability and Hydrologic Extremes*</u>

Vulnerabilities are found at the extremes of climate. Most natural and human systems are well adapted to or designed for mean climatic conditions and a certain range of variability. With regard to water resources, climate extremes typically are thought of in terms of their manifestations as floods and droughts. An essential task of evaluating regional hydrologic vulnerabilities to floods and droughts is the quantification of the potential changes in the frequency, magnitude and duration of these extreme events as a result of climate variability and change. Of particular importance to this task is the fact, demonstrated by *Katz and Brown* (1992), that change in the frequency of extreme events is most dependent on the variability rather than the mean of climate parameters.

Hydrologic extreme events span the range of temporal scales, from flash floods to decadal droughts. Consequently, a correspondingly wide range of atmospheric time scales must be modeled if changes in hydrologic extremes are to be captured. Both synoptic weather events and inter-annual variability of climate must be modeled. Previous studies of the ability of GCMs to represent daily to inter-annual variability of precipitation and temperature suggest that they do a mixed job at best (*Mearns et al* 1990, *Rind et al* 1989). However, indications are that improvements in the simulation of variability can be achieved with improved representations of atmosphere-ocean and atmosphere-land surface coupling. In particular, the onset, persistence and magnitude of simulated drought are highly sensitive to the representation of ground hydrology (*Rind et al* 1990, *Oglesby* 1991).

To fully explore the implications of climate variability to regional hydrologic vulnerability, one must examine how the remaining uncertainty propagates through hydrology to uncertainties in *indices of vulnerability* of human and natural systems. One such index would be the likelihood of failure of a water resource system, which is an issue of increasing concern for water supply utilities.

Vulnerability of a system is a function of the system's *resilience* and *robustness* with respect to the inherent variability of the main design variables. Thus, in order to address vulnerability issues, it is not sufficient to quantify the potential effects on the mean values of hydrological, ecological, and meteorological variables of interest, but most important, it is necessary to quantify the changes in the inherent variability of those variables. It is not just the changes in the mean that are important but also the changes in the variance. *Robustness* refers to the relative insensitivity of the system to errors in the estimates of design variables, and is always associated with a given probability level. A system is said to be robust at probability level p if, with probability p, the optimal design, based on erroneous estimates of

the design variables, is identical to the optimal design based on the true design variables. *Resilience* is the ability of a given system to operate under a range of conditions (variability) such that the *present value of the cost of failure* is low, and expectedly lower than the cost of preventing the failure by modifying the original design.

For any hydrologic, ecologic, or societal system, one can determine a well-defined region, *Sus(t),* in an *n*-dimensional space of climatic, hydrologic, ecosystem and economic variables within which the given system is sustainable. At the same time, under the current conditions, one can define a feasible region, *Feas(t),* in the same *n*-dimensional space that is feasible under the current conditions. For example, the set of climate variables that is feasible under present conditions. An index of this system's current vulnerability, *V(t),* can be defined as the probability that climate will, in any year under the current climate and associated pattern of variability, bring the set of variables defining our *n*-dimensional space outside of the region of sustainability.

In the context of impacts on hydrological quantities (*e.g.,* water availability) predicted changes in their mean and variance are but imperfect estimates of their true mean and variance under which the given systems will operate in the future. Thus, a major component of vulnerability analysis is the determination of the uncertainty associated with given predictions of changes and associated potential impacts.

As mentioned before, categories of vulnerabilities of water resource systems can be identified as:

1. Meteorological and climatological vulnerabilities;
2. Hydrologic system and design vulnerabilities; and,
3. Geographical and societal vulnerabilities.

Taking these into account, measures or indices of vulnerability can be defined that are functions of:

1. the ratio of storage volume to available water supply which measures the ability to withstand prolonged drought or flooding;
2. the ratio of consumptive use to available water supply which measures the vulnerability to water shortages;
3. the ratio of hydroelectric supply to total electricity supply which measures vulnerability to water shortages;
4. the ratio of groundwater overdrafts to total groundwater withdrawals which measures vulnerability to changes in water availability; and
5. the ratio of the 5% percentile of discharge to the 95% percentile of discharge measuring vulnerabilities to discharge variability.

Coupling Among Stakeholder Sectors and Ecological Outcomes in a Regulated River System: Droughts

Our perceptions of droughts and the tools available to predict their severity and reliability are rapidly evolving. A growing body of evidence from tree ring studies in the Colorado River and other Western U.S. river basins suggests that much more serious droughts than any found in the modern records occurred during earlier centuries (*e.g., Young* 1995). Similarly, models accounting for the effects of non-stationarity and persistence on drought risk estimation provide improved estimates of return period and failure risk (*Douglas et al.* 2002, *Chen and Rao* 2002). As new data and models become available, strategies for managing and mitigating drought impacts are simultaneously evolving from a reactive, crisis management approach to more proactive risk management approaches. At the same time, an emphasis on drought as a "socio-economic" phenomenon underscores a number of important concerns such as (a) changing social environments because of urbanization, sprawl, increasing densities or changing economic activities that contribute to increasing vulnerability to drought of larger segments of population; (b) increasingly complex responses to drought as more interdependent systems are affected and the calls for more integrated, long-range planning are becoming more vocal; and (c) responses to drought which also require broader mobilization of institutions and people in order to accommodate adaptive policies for resource scarcities, climatic vagaries, and the uncertainty of future environments.

We suggest that there is now an unprecedented opportunity to integrate detailed drought scenarios developed through advanced hydrologic and ecological modeling with risk-based decision tools to explore coupling among key stakeholder groups and aquatic systems during extended 'dry spells.' We propose to assess responses to scenario-based modeling of environmental consequences associated with

water allocation choices in decision-makers and non-technical stakeholders in the South Platte River Basin with a focus on the Cache La Poudre River watershed. The Cache La Poudre is a regulated river system with an array of competing demands from agricultural uses, a rapidly growing urban population, a large number of diverse recreational users, and environmental organizations concerned with alterations to the natural flow regime (*sensu* Poff et al. 1997). The Cache La Poudre originates in largely pristine alpine headwaters and experiences numerous diversions as it traverses National Forest, rangelands, broad glacial valleys, canyons, and ultimately the eastern plains. In many ways the Cache La Poudre is a microcosm that typifies the complex constraints and vulnerabilities facing scores of river systems in the western US. The Cache La Poudre watershed is an ideal context for the proposed research given that it is: (1) a primary source of drinking water for the City of Fort Collins and Greeley (and proposed transbasin diversion to Denver area) and irrigation water for the eastern plains of north central Colorado, (2) home to commercial recreational companies with whom we are collaborating and widely valued for its fishery and diverse recreational opportunities, (3) characterized in an existing water allocation decision support system, and (4) a system where the PIs have compiled extensive base of hydrologic, climatic, geomorphic, and ecological data.

The conceptual approach entails generating a variety of drought descriptors and a spectrum of realistic drought scenarios with linked outcomes, and exploring how key sectors respond to different types of information, the responses of other sectors (agricultural, urban, environment, recreational industry), and ecological consequences. Key goals of this research are to: (1) use the best-available forecasting tools to simulate drought impacts and consequences including environmental, ecological, social, and economic aspects, and (2) explore the socio-political, economic, and technological interactions involved in risk management tools that place greater emphasis on anticipatory and participatory drought preparedness, planning, and mitigation. The research will focus on analysis and mitigation of drought effects on the quantity and quality of water with implications for drinking water supply, fisheries, wildlife, ecological integrity, recreation, and tourism industries in the Cache La Poudre River watershed. We will also examine how stakeholder perceptions of nature as resilient, random, ephemeral, or constant (*Holling* 1995) affect coping mechanisms and responses to the various drought-outcome scenarios. For example, some stakeholders recognize that ecological processes in rivers are controlled by flow variability and low flows are an inherent part of the pattern of variability. While extreme conditions may cause high mortality rates among plant and animal species, such periods are nevertheless recognized as one of the components controlling the long-term functioning of river systems. Other sectors value constancy (e.g. consistently large populations of legal-sized fish) which can result in 'anti-drought' conditions: the augmentation of flows in regulated rivers at times when the rivers would naturally experience low or no flow (*McMahon and Finlayson* 2003). Ultimately we intend to identify opportunities for and mechanisms leading to agricultural-urban-recreational-environmental collaboration, appropriate institutional mobilization, responding to socio-economic challenges, restoring nature flow regime variability, and working towards an integrated framework of drought planning and management.

Drought scenarios will be linked to specific economic and ecological outcomes that are contingent on the spatial and temporal allocation decisions of individual and multiple sectors. Mock drought scenarios will facilitate stakeholder envisioning of likely impacts on agricultural production, municipal water supply, the recreational industry (whitewater boating, fishing, tourism), instream flows, and ecological processes resulting from sector decisions.

We will use different types of drought characterization information, and the assistance of local collaborating agencies to identify the response to drought in the Cache La Poudre watershed for each sector. This analysis will identify decisions, concerns, preferred information type(s), and causal linkages controlling sector response for each drought scenario. We will then identify relationships between and among each sector, observe how stakeholders make choices, and ask why they made them. This approach will identify cause-effect relationships among sectors and reveal the sensitivity, vulnerability, and potential dominance of disparate sectors in each drought scenario. Furthermore, we will identify which ecological outcomes most influence decisions of the various sectors and how stakeholders' views of nature and their understanding of drought as a natural part of system variability affect responses to these outcomes.

We will examine how adaptive responses cluster and translate to other sectors and elucidate the complex set of coping mechanisms that exists within and among sectors. Identification of response spectra and causal linkages will lead to an assessment of adaptive potential in the watershed system. Feedback from this process will be used to develop innovative and generalized tools for improved characterization, interpretation, and mitigation of potential drought impacts. These tools will include development of an "impact matrix" approach that is akin to a payoff matrix from financial risk (*Hoag et al.* 2002).

Research Theme IV: WATER-Research Integration and Synthesis (M. Betsill[10], D. Ojima, S. Denning, N. Grigg, L. Poff, and J. Ramirez)

Research Themes I, II, and III are complementary and overlap in content but with different emphasis (see diagram on page C-2). Therefore, student programs in Research Theme IV will focus on integration and synthesis activities that bring students together from the three themes to work in a collaborative, interdisciplinary mode to develop *"integrative solutions"*, and articulate trade-offs and alternative pathways. See details in Section *4. Education and Training*.

4. Education and Training:

The WATER-IGERT will produce Ph.D. scientists to work at the interfaces between hydrology, atmospheric science, ecosystem science, and socio-economics (see diagram on page C-2) to incorporate environmental feedbacks, climate variability and scientific uncertainty into scientific and policy analysis. The program plan addresses the *primary barriers* to this, which lie in the inherent cultural and educational differences between disciplines and in the rigid administrative structures derived from (mono)-disciplinary cultures. The WATER-IGERT will confront these barriers by using problem-based research with facilitative arrangements among participating faculty and water industry scientists.

The WATER-IGERT will give high priority to dissolving *communication* and *cultural barriers* among students and faculty from the physical sciences, engineering, ecology, and social sciences. To break barriers of narrowly focused Ph.D. programs with few interdisciplinary courses, WATER-IGERT will enroll scholars in *gateway courses* to address the communication barriers between sciences across each of the interfaces (I, II, and III in diagram), as well as to provide common and necessary knowledge background. Second, WATER-IGERT scholars will enroll in *new* interdisciplinary *core courses* to address cutting-edge issues at the interfaces of the sciences and policy. To achieve integration and synthesis, our WATER-IGERT will enrich these courses with regular colloquia and research seminars; host a yearly conference, research workshops, and outside visitors; provide training in ethical and stewardship issues as well as a course/seminar in communication and culture; and develop internships and mentoring opportunities by scientists working in national laboratories, agencies, and leading edge firms.

WATER-IGERT scholars will require three years to complete their courses and research training programs (see table below). The first three semesters will focus on academic activities, including *gateway* and *core* courses (discussed later) and participation in interdisciplinary problem-focused **research teams** working within theme areas throughout their studies. This will expose students to real-world research problems that will increase in complexity and sophistication as they advance. This will also enhance the *broader impacts* of the program because 1) participating practitioners will also learn in the process and 2) students will influence colleagues with different experience and skills.

In addition to their coursework, IGERT scholars will receive rich programs of education and training through participation in research teams. Three of the Research-Theme Groups (I, II, and III) will focus on crosscutting research issues. Each group will consist of WATER-IGERT students working in the interface areas (see diagram on page C-2 for areas I, II, III), their WATER co-advisors, an agency or stakeholder mentor (*i.e.*, scientist in residence or resource manager in residence), and WATER faculty. Each Research-Theme Group will be led and coordinated by a core of three faculty members and at least one PI according to the fields involved as indicated in the section on Research Themes above. Within each Research-Theme Group, research teams will be organized to focus on specific multi-disciplinary

[10] Research Theme Group leaders

problems at the corresponding interfaces (e.g., HAE, or HES, or HAS). For example, Research-Theme Group II may have a research team working on *Non-native Species Invasion and Extinction of Native Species*, and another working on *Balancing Economic and Ecosystem Needs for Water in Heavily-modified River Basins*. Research-Theme Groups will structure the PhD research into *integrative*, multidisciplinary team-based activities of WATER-IGERT "cohorts" that focus on scientific, as well as problem-focused questions with policy linkages. The work of WATER-IGERT teams at the interface areas (I, II, III) will provide in-depth interdisciplinary work that focuses on integration among theme areas. The WATER-IGERT program will also take scholars beyond this level of integration to consider problems even more holistically within the entire Research-Theme Group and across Theme groups.

Each WATER-IGERT scholar will work on an interdisciplinary problem-focused research team under the direct supervision of a program faculty mentor. These teams will be driven by students with faculty supervision to tackle semester-long *integrative* activities that focus on real-world problems (such as those listed in "Major Research Themes") from a multi-disciplinary point of view (engineering, social science/management, atmospheric science, ecosystem science). The problems may draw from the pool of problems tackled in Theme Areas I, II, and III to drive the analysis of systems problems toward more complexity. The teams will produce scientific assessments that define the knowledge and knowledge gaps, recommend action and approach solutions based on a clear resolution of scientific uncertainty and vulnerability. These scientific assessments will be truly unique because problems within the three theme areas, such as climatic and hydrologic change, have become politicized as interest groups have taken polarized positions. The polarized positions tend to diminish public and policy-maker confidence in scientific reports. The objectivity and fresh thinking that will derive from the IGERT program will bring new perspectives to these problems. Scientific assessment is difficult enough within disciplinary areas, but among the areas addressed by this proposal it is much more difficult as scientists from different fields try to synthesize conclusions about complex and often-conflicting issues. Each student will be challenged to use a multi-disciplinary perspective to convince stakeholders to understand and accommodate a different point of view. WATER-IGERT scholars will play the roles of senior science staff, with faculty mentors and scientists from outside of CSU playing the policy-oriented roles of agency directors. Faculty and other experts who play stakeholder roles will be prepared to contribute in substantive ways to student research experiences. This semester-long *integrating activity* will occur annually during the fall semester with a shifting theme or regional focus. These activities will be complemented by study of research papers, expository seminars, research-level seminars, and research projects planned by a faculty mentor.

Under the leadership of the faculty coordinators, each Research-Theme Group will organize a research seminar series of 4 lectures or research workshops during the spring semester that all WATER-IGERT scholars will be required to attend. The resulting set of 12 weekly seminars every spring constitutes an added level of broad *integration* of research and education across all Research Themes. As a result of this integration:

- Scholars gain wider knowledge of research related to their interests
- Theme Groups build a sense of community to overcome cultural differences between fields
- Students and faculty sponsors are situated/forced to work in multi-disciplinary setting to examine priorities and tradeoffs implicit in solving complex, scientific-political-management issues
- A critical mass of students enhances the seminar series and workshops
- New WATER-IGERT scholars can be recruited
- Themes provide a structure for meaningful, directed advising and mentoring of students.

In addition to the integrating activities described above, a highlight of WATER-IGERT Group activities at the Research-Theme IV level will be an annual spring symposium, which will be coordinated with the annual Hydrology Days conference, and the Front Range Student Ecology Symposium. The WATER-IGERT symposium will be given by WATER-IGERT members, outside researchers and world-renowned guest speakers, and it will be organized around a theme of wide interest to WATER-IGERT and be open to the entire academic, research, and professional community.

Finally, in addition to the fall semester integrating activities of the research teams, and the spring semester research seminars, IGERT students will participate in an annual Program Seminar/Workshop. During this one-day event, faculty and invited speakers will discuss multidisciplinary water issues, with

an emphasis on linkages between systems and multi-disciplinary approaches to problem solving. This workshop will provide a forum for students to present their dissertation proposals, progress reports, and final defenses and enable all students in the program to follow and learn from the work of their peers through regular and dynamic interaction. Participation by faculty and outside committee members will invigorate discussions and provide solid feedback to student presenters. This interaction will help establish expectations for quality across the program.

As students develop their research studies and sharpen them in the IGERT activities, they will present their results at seminars and scientific conferences including:

- National annual meetings of the American Geophysical Union, American Meteorological Society, Ecological Society of America, American Society of Civil Engineering, etc.
- Annual AGU Hydrology Days – http://hydrologydays.colostate.edu/
- Annual Front Range Student Ecology Symposium – http://lamar.colostate.edu/~ecosys

Recruiting plan

During the first year of the program, we will recruit 7 scholars, and our recruitment strategy will be targeted in order to ensure that we have at least 2 scholars in each of the Research Themes. As indicated in the diagram below, during the subsequent years of the program we intend to recruit 5, 7, 5, and 4 scholars.

WATER-IGERT								
Active Students per year								
Year	**First Year**	**Second Year**	**Third Year**	**Fourth Year**	**Fifth Year**	**Sixth Year**	**Seventh Year**	**New students per year**
1	IGERT - 7	IGERT - 7	IGERT - 7					7
2		IGERT - 5	IGERT - 5	IGERT - 5				5
3			IGERT - 7	IGERT - 7	IGERT - 7			7
4				IGERT - 5	IGERT - 5	IGERT - 5		5
5					IGERT - 4	IGERT - 4	IGERT - 4	4
Totals		12	19	17	16	9	4	**28**

WATER-IGERT internships

Advanced WATER-IGERT scholars will be encouraged to undertake internships in national laboratories, agencies and leading–edge private-sector firms. The internships will typically occur during the third year of each WATER-IGERT student experience. Some internships will be paid and some unpaid, depending on each situation. Support for the paid internships will normally be split between WATER-IGERT and the sponsoring agency or firm and will be negotiated on the basis of each experience. Advanced WATER-IGERT students will also be encouraged to gain teaching experience through teaching assistantships in their home departments, freeing up IGERT funds for beginning students. To provide further leverage for the IGERT funds, all third-year WATER-IGERT scholars will be partially (i.e., 50%) or fully funded by research assistantships[11].

National and international institutions as well as leading edge consulting firms with close ties to scientific work in federal and international agencies have agreed[12] to host WATER-IGERT students for up to a year including the US Forest Service[13] (Fort Collins), NCAR[14] (Boulder), NASA GSFC[15], the USDA-ARS[16] (Fort Collins), the Biological Resources Division of the USGS[17] (Fort Collins), the USBR[18]

[11] See details in budget explanation page
[12] Letters of support and agreement from USFS, USGS, USBR, NASA, NCAR, USDA, USBR, ETH-Z, CIMA, RTi are on file
[13] Contact person: Dr. Thomas C. Brown, Economist
[14] Contact person: Dr. Gordon, Bonan, Head, Terrestrial Sciences Section
[15] Contact person: Dr. G. James Collatz, Biospheric Science Branch
[16] Contact person: Dr. Tim Green, Hydrologist
[17] Contact person: Dr. Mark Shasby, USGS Fort Collins Science Center

(Denver), Riverside Technology, Inc. RTi[19], the Institute of Environmental Engineering, Swiss Federal Institute of Technology, ETH-Zurich, Switzerland, and the Interuniversity Center for Environmental Research and Monitoring (CIMA), University of Genoa, Italy. In particular, the foreign universities have multidisciplinary programs with foci similar to those of the proposed IGERT program, and the ongoing collaboration among CSU faculty and those foreign institutions is strong.

The WATER-IGERT will also assist students in participation in other educational opportunities that occur in the Rocky Mountain area, including:

- Annual water conferences/workshops held around Colorado:
  - Colorado Water Congress held in Denver each January;
  - South Platte Forum held each October;
  - Arkansas River Forum held in February; and
  - Colorado Water Workshop held in Gunnison, Colorado, each July.
  - Rocky Mountain Hydraulic Laboratory Annual meeting
- Mentoring undergraduates participating in the WATER-REU Program at CSU.

Organization of student committees

While each student will select a graduate committee according to university regulations, at least two members will be WATER-IGERT faculty associates from two different departments and associated with the specific multidisciplinary project in which the student is involved. Also, and very important, a unique aspect of this program is that a member of the graduate committee must be from an external federal or local research agency or leading-edge firm in the specific area of emphasis in which the student is involved. These committee members will receive university appointments as faculty-affiliates in the student's home department to enable their participation. These committee members will be selected carefully to ensure that their work is on the cutting-edge of each research theme area. These members may also participate in our IGERT program assessment (see discussion later).

Additional advising and mentoring will take place as part of the Research Theme Group activities as detailed above. Each Research Theme Group will have at least four designated faculty mentors including representatives from hydrologic science and engineering, atmospheric science, biology/ecology, and social science.

Curriculum

Gateway Courses. Entering WATER-IGERT scholars will be required to take *gateway* courses in fields relevant to their research theme areas and complementary to their disciplines in order to provide students with a common core of knowledge across multiple disciplines relevant to their research areas. Because CSU has a rich variety of graduate level WATER-related courses in place, *gateway* courses will be selected from existing course offerings in the departments of Civil and Environmental Engineering, Atmospheric Science, Biology, the Graduate Degree Program in Ecology, and departments in the social and policy sciences[20]. These *gateway* courses will provide a basic level of language and knowledge in particular fields and serve as mechanisms for introducing faculty to students from different departments. Students will be required to take two *gateway* courses from complementary disciplines during their first two semesters (see table below). For example, a WATER-IGERT student in Research Theme I whose background is atmospheric science would be required to take a *gateway* course in hydrologic science and a *gateway* course in ecosystem science.

Core Courses. WATER-IGERT will develop a *core curriculum* that takes an earth system science perspective with hydrology as an integrative element. The curriculum will include courses to address multidisciplinary problems in each research theme, with one new required *core course* for students in each Research Theme area. To address issues of vulnerability and resilience, each *core course* will specifically address the scientific and mathematical expertise required to approach interdisciplinary problems in the presence of spatio-temporal variability and uncertainty, non-linearity, and complexity. The new *core courses* will explicitly address relevant issues such as:

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[18] Contact person: Dr. David Raff, Hydrologist

[19] Contact person: Dr. Larry Brazil, Hydrologist, President and CEO

[20] Departments of Economics, Agr. & Resource Economics, English, History, Political Science, Sociology, Communication

Research Theme I - Hydrologic, atmospheric, and ecologic systems

- Hydro-climatology and land surface-atmosphere interactions, integrating climate, hydrology, and their mutual feedbacks at the land surface at different spatial and temporal scales.
- Physics and spatial variability of precipitation and evaporation scale invariant and scale dependent statistical theories of rainfall, role of topography, soil moisture, and vegetation in regional evaporation and transpiration through the boundary layer.
- Scaling, regionalization and spatially distributed modeling: integrating the linkages between hydrology, geomorphology and vegetation dynamics in spatially distributed modeling.

Research Theme II - Hydrologic, ecologic, and socio-economic systems

- Eco-hydrology and ecosystem function; soil moisture dynamics in water-limited ecosystems.
- Hydro-geomorphology, focusing on the structure and dynamics of landforms and channel networks as well as their interactions with hydrologic, climatic, and vegetation processes.
- Riverine resilience and sustainability in the face of global change (combining hydraulics and sediment transport with aquatic habitat and stream flow requirements for ecosystem function). Combine with human dimensions that include social/economic valuation of rivers and regulatory/governance context.

Research Theme III - Hydrologic, atmospheric, and socio-economic systems

- Human dimensions of climate change
- Socio-economic linkages among hydrologic-atmospheric-economic systems
- Knowledge requirements to inform policy, including uncertainties of climatic non-stationarity

Research Theme IV - WATER-Research integration and synthesis

- Communication across disciplinary boundaries: integration and synthesis
- Scaling and fluctuations in fluid/environmental dynamics, introducing the concepts of geometric, dynamic and statistical scaling invariance in hydrologic, atmospheric, and biological systems.
- Complexity, fractals, and scaling.
- Exploratory space-time data analysis, emphasizing methods of data analysis and visualization.

The development of these courses will be a collaborative and joint effort of the PIs, and other IGERT faculty associates will be invited to participate, therefore offering an additional opportunity for integration across the disciplines.

The instruction and research in both the *gateway* courses and the *core courses* will be facilitated by the use of two multi-media classrooms, which will be made available to the WATER-IGERT program. These facilities will have student workstations, video conferencing capability, smart boards, and all appropriate software. They will serve as a focal point for WATER-IGERT scholars and faculty to congregate and work on both introductory and advanced projects during their graduate careers. In addition, their cyber infrastructure allows collaboration via real-time audio and video communication among multipoint locations and organizations, and meets NSF requirements for Collaboration Conferencing Systems.

PhD students at CSU are required to complete 30 credits of coursework in addition to 12 credits of dissertation work. The table below illustrates how WATER-IGERT scholars will meet those requirements. WATER-IGERT scholars will be required to enroll in 2 *gateway* courses and 2 *core* courses for a total of 12 credits; the remaining 18 credits will be used to satisfy any departmental requirements. This will be accomplished enrolling in a minimum of 9 credits of course work per semester.

<table>
<tr><th colspan="6">WATER-IGERT Educational and Research Progression</th></tr>
<tr><td colspan="6">Semester</td></tr>
<tr><td>First</td><td>Second</td><td>Third</td><td>Fourth</td><td>Fifth</td><td>Sixth</td></tr>
<tr><td colspan="4">Departmental Requirements</td><td></td><td></td></tr>
<tr><td></td><td colspan="3">WATER Core Courses</td><td></td><td></td></tr>
<tr><td colspan="2">Gateway Courses</td><td colspan="4">WATER Dissertation Research</td></tr>
</table>

Training in Research Ethics. The *core curriculum* will include a seminar-course on ethics and communication in scientific research to address issues related to WATER science and to prepare students

to break down cultural and institutional barriers. The ethics content will be based on a seminar-course on Ethics in Science and Engineering organized at CSU by the Program Director of WATER-IGERT for the WATER-REU at CSU. The communications content will break new ground in addressing changing patterns of communication and the need to explain complex scientific issues to citizens and political leaders. It will be modeled, in part, on successful science-communication programs, such as the Ecological Society of America's Aldo Leopold Leadership Program (of which co-PI Poff is a graduate).

Seminars and Workshops. The Annual WATER-IGERT symposium will be coordinated with: 1) the annual Hydrology Days conference (http://HydrologyDays.ColoState.edu), organized every spring by the WATER-IGERT Program Director; and 2) the Front Range Student Ecology Symposium (http://lamar.colostate.edu/~ecosym), organized every spring by students of the Graduate Degree Program in Ecology. We will invite world-class speakers engaged in interdisciplinary research in WATER science. In addition, as indicated earlier, we will have a *Research Seminar Series* organized by each Research-Theme Group; and an annual research theme workshop.

Other Teaching/Research Activities. Every summer, WATER-IGERT scholars will interact with Scholars participating in the WATER-REU Program at CSU that is directed by the PI of WATER-IGERT (http://WaterREU.ColoState.edu/). The REU Program is in its third three-year phase. Many faculty members participating in this IGERT have been Faculty Mentors in the REU Program. Therefore, not only there will be continuity and integration across the undergraduate/graduate education/research continuum but, more importantly, this interaction will allow our WATER-IGERT scholars to train in the transfer of knowledge via teaching and mentoring of undergraduates. Scholars will also participate in the associated three-day, WATER-IGERT recruitment workshop for undergraduates in their junior year, which will be organized every summer (see Recruitment section below).

In summary, in addition to the activities of the research teams and research-theme groups, students will participate in all general WATER-IGERT activities over the entire academic year including:

- Required and research-specific *gateway* and *core* courses
- Required weekly seminars in the spring
- Annual WATER-IGERT Symposium
- Annual Program Seminar/Workshop
- Seminar courses on Ethics and Communication
- Participation in recruitment workshop for undergraduates every summer
- Interaction with REU scholars every summer

These general activities will provide students with breadth of knowledge, exposure to different research activities and different modes of cooperation, and an understanding of the role of their individual research projects in a broader context.

5. Organization, Management and Institutional Commitment:

Award Management

The PIs and Colorado State administrators have managed and participated in a number of complex interdisciplinary research projects and are cognizant of the need to organize an effective management system. The IGERT program will be managed by an integrated faculty group comprised of a PI and three Co-PIs representing the atmospheric, ecological, and management disciplines. In addition, the team has organized cross-campus collaboration through the Water Center at CSU, which will be the home of the IGERT program. This arrangement will organize and ensure strong involvement of faculty in the social and other policy sciences, which are integral to the success of the program. In particular, the team has arranged for strong participation by faculty from political science, economics, natural resources systems management, history, and related fields. The involvement of the Water Center will also ensure the entry of new scientists from the involved fields to participation in IGERT.

A WATER-IGERT Administrative Assistant will be in charge of project financial record keeping, logistical support for organizing the annual meetings and workshops, advertising, coordinating with the partnering agencies and companies, etc.

Two boards will provide advisory guidance to the project. An *internal* IGERT *Faculty Advisory Board* will be created, chaired by the WATER-IGERT Director. The advisory board membership will

include the WATER-IGERT Co-PIs and representatives of the major disciplinary fields (physical sciences, ecology, policy sciences, human dimensions, engineering, and agriculture). The *internal Advisory Board* will evaluate and select student applicants, oversee record keeping assuring that students meet the program specifications and providing data for reports to NSF, organize special seminars, and organize and participate in the assessment activities. An *external* IGERT Advisory Board will be formed to provide guidance and objective assessments of the effectiveness of the program. This board will convene annually at CSU Hydrology Days to assess the milestone achievements and at the mid-point of the program it will prepare an overall assessment in conjunction with scientists in the Research Theme areas and directors and/or key participants in other IGERT programs.

WATER-IGERT student applications will be submitted to the academic department in which the student desires to major with a notice of interest in the IGERT program. In addition, applications of students to participating departments that appear to qualify for the IGERT program will also be identified. The WATER-IGERT *Faculty Advisory Board* will evaluate all WATER-IGERT applications. The applicants will be ranked according to academic potential, interdisciplinary commitment, and diversity objectives at three times during each selection cycle (January 31, March 15, and April 30), and offers will be made to those who both rank at the top of the listing and meet the program's need to balance the representation in the different research themes. Once a student is identified as an IGERT candidate, the department will make an offer of admission and financial support.

All WATER-IGERT scholars, and their advisors, will convene at the beginning of each fall semester in a formal orientation, in which the goals, objectives and expectations of the IGERT program will be clearly explained. Special IGERT sessions will be organized as part of the annual Hydrology Days and the annual CSU Front Range Student Ecology Symposium.

Institutional Resource Commitments

Colorado State University is deeply committed to the WATER-IGERT program, and this commitment is manifested in tangible ways by offering matching funds, facilities, faculty release time and other support that will leverage the NSF funds.

A) Faculty release time – faculty time for advising students will be provided by CSU as well as for administering the program through the CSU Water Center. In addition, the PI's commitment will be equivalent to two months per year, of which one month will be supported by faculty release time.

B) Facilities/Equipment/Administrative – The university units and national and foreign institutions that will participate in this IGERT are home to internationally renowned, state-of-the-art laboratory and computing facilities, which will be engaged in the student research:

Vice-President for Research:

- The CSU Water Center located the Engineering Building will accommodate the WATER-IGERT program. This location has new space to be identified with WATER-IGERT, including an office for the IGERT program staff and administration, a conference room and computer and file space.

College of Engineering:

- Atmospheric Science:
  - Center for Multi-scale Modeling of Atmospheric Processes (CMMAP)
  - CSU-CHILL National Radar Facility and the Colorado Climate Center at CSU
- Civil and Environmental Engineering:
  - Engineering Research Center (ERC)
  - Hydrologic Science Laboratory
- Cooperative Institute for Research in the Atmosphere (CIRA) and the Center for Geosciences
- Engineering Network Services Access Grid Middleware nodes: 1) Viking Electronic classroom and 2) Sun Electronic classroom

College of Natural Sciences

- Center for Science, Mathematics and Technology Education (CSMATE)
- Graduate Degree Program in Ecology (co-housed in Warner College of Natural Resources)

Warner College of Natural Resources

- Graduate Degree Program in Ecology (co-housed in College of Natural Sciences)
- Natural Resources Ecology Laboratory (NREL) and the Shortgrass-steppe LTER

School of Global Environmental Sustainability
College of Agricultural Sciences
- Agricultural Research, Development and Education Center (ARDEC)
- Eleven experiment stations located around Colorado

Foreign Universities and Federal Research Agencies
- Agreements to host IGERT students in internship programs.

C) Other contributions – Matching Funds
- A portion of the Director's salary will be committed by the Vice-President for Research.
- Each faculty participant will contribute a portion of salary from their research workload.
- A cost share fund will be implemented consisting of 1/3, 1/3, 1/3 from the participating departments, colleges, and the Provost and Vice President for Research in the amount of $105,000/yr for 5 years for a total of $525,000. This cost share fund will be used by the WATER-IGERT program to:
  - cost share 50% of the stipend of each WATER-IGERT student's third year. This will allow us to support additional WATER-IGERT students (28 students over five years, as opposed to 15).
  - provide research assistantships to up to 4 scholars from underrepresented groups to do MS work at CSU to bridge to the WATER-IGERT program (see Recruitment and Retention section).
- The Graduate School has committed up to 10 "tuition premiums" per year for all out-of-state IGERT participants and it will pay for the out-of-state portion of the tuition. Each tuition premium is valued at $11,652 per year. The "tuition premiums" contributed by the Graduate School will imply an additional $118,562 that we will use to support additional WATER-IGERT scholars.
- The contributions outlined above are equivalent to more than 25% of the total requested amount allowing our WATER-IGERT to increase in almost 50% the number of scholars benefiting from the program, as well as to extend in 40% (to 7 years) the duration of the program.

Most important, because of CSU's strategic interest in water education and research, CSU is committed to ensuring that WATER-IGERT will be sustained once NSF funding ends, as indicated in the institutional letters of support.

6. Performance Assessment/Project Evaluation

WATER-IGERT recognizes the importance of effective program assessment and the team has prepared an assessment plan that includes both formative and summative evaluation.

The process of evaluation must begin with identification of baselines. To establish those baselines we will administer a questionnaire to all entering WATER-IGERT scholars in order to gather demographic data and establish the participants' perception of WATER research issues (*e.g.*, barriers and opportunities for multi-disciplinary education in WATER, etc.). Regular informal evaluations of the program will be conducted throughout the program including brief discussion sessions during which participants will be encouraged to provide assessment and constructive criticism of WATER-IGERT. Opportunity will be provided for anonymous written comments from the participants. At the end of the program, exit interviews will include a written evaluation to measure outcomes of the IGERT experience. A program to follow up each student for a period of 5 years after graduation will be implemented.

We also will implement *internal* and *external* audits of effectiveness. It will be during these *internal* and *external* assessments that we will address the central effectiveness question of the project: "to what extent are we equipping graduate students to work at the interface of the program disciplines in a transformative and integrative way?" *Internal* program assessments will be scheduled every year at a retreat during which the program will be evaluated also by other quantitative metrics, like those listed below, and by facilitated focus groups of the program participants including WATER-IGERT students, faculty, and representatives from the collaborating agencies. The weighted judgments of these program participants will give us new insights into our success and the efficacy of the project methods. At the mid-point of the program, an overall assessment will be conducted via an *external evaluation team*. This

team will comprise the External IGERT Advisory Board, scientists in the Research Theme areas and directors and/or key participants in other IGERT programs.

Finally, during the annual WATER-IGERT Symposium, Hydrology Days and the Front Range Student Ecology Symposium, external judges will be asked to evaluate the topic, content and presentation of the IGERT students. IGERT-WATER faculty will review these evaluations, as well as those of the faculty advisors and IGERT students themselves.

A partial list of traditional metrics to evaluate the program includes:

- level of collaborative work among faculty in involved disciplines
- joint publications in major journals
- new multidisciplinary courses developed
- quality of students recruited to the program
- qualified underrepresented students recruited to the program
- active participants in the Research Theme Groups
- seminars organized
- workshops offered and the external participation they attract
- presentations delivered at professional meetings
- leveraged internships arranged with participating agencies and industries,
- career outcomes of WATER-IGERT graduates.

7. Recruitment, Mentoring, and Retention

The team recognizes that recruiting IGERT scholars requires a careful process that involves targeting locations of promising candidates, rather than a blanket program of advertising. Accordingly, we will implement a recruitment program comprising posters and internet postings on the WATER-IGERT webpage as well as targeted mailings to all related departments, research universities, and selected four-year colleges; advertisements in selected professional newsletters and magazines, and at relevant national and international meetings; and announcements on electronic bulletin boards. Particular efforts will be made to solicit applications from institutions with large populations of under-represented groups and Colorado State's strong linkages with several minority institutions will greatly assist us here. As an additional recruitment tool, each summer we will organize a three-day workshop for undergraduates in their junior year. This workshop will be coordinated with the activities of the WATER-REU Program at CSU. In addition to research activities, there will be an introduction to graduate studies at CSU, lectures by WATER-IGERT faculty, and workshops on ethics, communication and international perspectives.

We will make strong emphasis on retention of all students. As part of this effort, each WATER-IGERT scholar will be assigned a *student mentor* from his or her home department to give IGERT scholars an avenue to make connections with students other than those in their cohort of WATER-IGERT scholars. Additional mentoring will come from the faculty members teaching the WATER-IGERT core courses as well as the WATER-IGERT faculty advisors.

Recruitment and Retention of Underrepresented Groups

CSU is strongly committed to attracting and supporting members of underrepresented groups. The Graduate School has created the Graduate Center for Diversity and Access to help recruit, retain, and graduate traditionally underrepresented students. The Center is home to the Louis Stokes Alliance for Minority Participation Bridges to the Doctorate, the Alliance for Graduate Education to the Professoriate, Fast Track to Work, McNair Scholars, and our own professional development programs. Our PEAKS program supports underrepresented students in the engineering and natural sciences; the McNair fellowship is a national program for students from low-income groups; the Fast Track To Work program supports students in computer science, engineering, mathematics, and statistics; and the Colorado Alliance for Minority Participation (CO-AMP) for undergraduates promotes science, mathematics, engineering, and technology and our Bridge to the Doctorate program. As a result, the number of underrepresented students at CSU has increased steadily over the past decade. CSU graduate students pursuing degrees in science, technology, engineering and mathematics (STEM) comprise 50.2% of the total graduate population. Out of 3,655 graduate students enrolled as of Fall 2008, 23.8% are STEM MS students and 26.4% are STEM PhD students. Underrepresented minority students account for 5.7% of all

graduate students in STEM programs. Since 1999 the number of underrepresented minorities pursuing STEM graduate degrees has increased by 82.7%. The most dramatic increase in graduate underrepresented minority enrollment has been observed in the number of Hispanic students enrolled in STEM PhD programs, from 7 in 1999 to 33 in 2008.

We will work within these programs[21] to recruit underrepresented students by means of fully funded WATER-IGERT fellowships. The Colorado Alliance for Minority Participation (CO-AMP) will be especially helpful in these efforts. It is a statewide consortium of higher education institutions in Colorado and the Four Corners Region, sponsored by NSF for the purpose of attracting and preparing students for careers in Science, Technology, Engineering and Mathematics. Through collaboration among twelve institutions throughout Colorado, four American Indian tribes, industry, governmental laboratories and professional organizations, its goal is to double the number of students from under-represented groups earning baccalaureate and graduate degrees in science, technology, engineering and mathematics (STEM). In addition, CSU has formed partnerships with Historically Black Colleges and Universities and with Hispanic Serving Institutions including Southern University in Louisiana and the University of Texas at Brownsville. These relationships include faculty and student exchanges, curricula exchanges, and joint research ventures; and they will lead to the recruitment of minority students into our IGERT.

In order to enhance the likelihood that students from under-represented groups enroll in our WATER-IGERT program we will specifically target undergraduate students at CSU-Pueblo and Fort Lewis College (both part of the CSU System), as well as at Southern University and University of Texas Brownsville to recruit them to come to CSU to pursue MS degrees in WATER disciplines as a bridge to entering the WATER-IGERT program. As indicated in the Institutional Commitment section, part of CSU's cost share will be devoted to providing full support through research assistantships including stipend and tuition for up to 4 undergraduates to do their MS work at CSU prior to entering fully funded PhD WATER-IGERT work. These students will interact with other students and faculty from the program, and participate in all WATER-IGERT seminars and workshops. In addition to stipend and tuition from matching funds, we will also provide travel funds so that they can attend national conferences. At the completion of their MS degrees, students will transition to the PhD WATER-IGERT program. Assuming that their MS work will take two years, we will recruit one MS student during years 1 and 2, and two MS students during year 3 of the program. This recruitment plan ensures that at least 15% of the WATER-IGERT scholars will be from under-represented groups.

8. Recent Traineeship Experience:

Previous IGERT Programs at CSU

CSU has received IGERT funding in the past for the PRogram for Interdisciplinary Mathematics, Ecology, and Statistics (PRIMES) program (NSF-IGERT Grant DGE-#0221595) and a new IGERT Program in Multidisciplinary Approaches to Sustainable Bioenergy (MAS BioEnergy, NSF-IGERT Grant DGE-#0801707). The PRIMES program is no longer funded by NSF and the MAS BioEnergy program is in its first year of funding.

PRIMES inculcated a culture of interdisciplinary research in quantitative ecology at CSU, bringing together a broad spectrum of interdisciplinary researchers from across CSU to collaborate on PhD student education and research. PRIMES continues to educate and train graduate students from a diverse set of backgrounds in quantitative ecology. PRIMES has supported 50 students and involves 34 faculty and scientists from mathematics, statistics and ecology disciplines at CSU. Over 100 publications have resulted from PRIMES research activities. Furthermore, CSU faculty have won several large research grants through interactions started by PRIMES. The key PRIMES faculty recently won a large proposal to organize an interdisciplinary undergraduate training program for biology and math. PRIMES supported a high percentage of females and 4 students from underrepresented minorities. The PRIMES program has been recognized as one of the truly innovative IGERTs and a model for a number of other IGERT projects. One of its prime legacies on the CSU campus is the bringing together the diverse research community to tackle interdisciplinary projects, and many CSU faculty involved in PRIMES will continue

[21] See Section 10. Recruitment and Retention history for a quantification of the effectiveness of these programs.

their interactions in the WATER-IGERT.

The MAS BioEnergy program is designed to prepare PhD graduates with a full understanding of the interdisciplinary technical challenges facing the emerging bio-energy industry. A broad spectrum of students has been involved in the program since its inception last year. The MAS BioEnergy program has brought together very different departments to collaborate in graduate training, is piloting a new interdisciplinary course (Bioenergy Technology), and is developing extra-university program elements (e.g., policy workshop, graduate internships).

Other Programs with Undergraduate and Graduate Trainee Components

JORGE A. RAMÍREZ
NSF award: EEC-9619782
Amount: $231,565.00
Period: 06/01/1997 – 05/30/1999
Title: REU: Research Experiences for Undergraduates Program in Water Research at CSU
P.I.: JORGE A. RAMIREZ, Civil Engineering Department, CSU
Co-P.I.'s: JUDY HANNAH, Earth Resources Department, CSU
DAN SMITH, Soil and Crop Science Department, CSU

NSF award: EAR-0097560
Amount: $283,687.00
Period: 04/01/2001 – 03/31/2004
Title: REU: Research Experiences for Undergraduates Program in Water Research at CSU
P.I.: JORGE A. RAMIREZ, Civil Engineering Department, CSU
Co-P.I.: JUDY HANNAH, Earth Resources Department, CSU

NSF award: EAR-0552526
Amount: $316,551.00
Period: 06/01/2006 – 05/31/2009
Title: REU: Research Experiences for Undergraduates Program in Water Research at CSU
P.I.: JORGE A. RAMIREZ, Civil Engineering Department, CSU
Co-P.I.s: ELLEN WOHL AND SARA RATHBURN, Geosciences Department, CSU

The REU program in Water Research at CSU hosted 15 undergraduate students for eight weeks during the summers of 1997–1999, 2001–2003, and 2006- for a total of more than 130 students. Our website address is: http://WaterREU.ColoState.edu/ . Faculty advisors for the REU program were affiliated with 4 colleges: Engineering, Natural Resources, Agricultural Sciences, and Natural Sciences. Seven academic departments and a research laboratory are represented: Civil Engineering, Atmospheric Science, Chemical Engineering, Watershed Stewardship, Geosciences, Soil and Crop Sciences, Fishery and Wildlife Biology, Biology, and the Natural Resources Ecology Laboratory.

During the eight-week program, students participated in individual and group activities aimed at providing an integrated, multidisciplinary and encompassing research experience in water sciences. These activities included participation in guided, individual, basic and applied research on water issues and group activities, including field trips, seminars by invited speakers, and workshops. In addition, students prepared a final report on their research projects, which they presented to all students and faculty advisors at the end of the REU program.

Many of the REU students also participated in the annual Student Water Symposium, sponsored by The Water Center at CSU in the Fall semesters and in the AGU Hydrology Days. Many of our REU students earned awards at these meetings including Undergraduate Best Oral Presentation award, and Undergraduate Best Poster Presentation award. Several of our REU students have co-authored papers with their REU Faculty mentors, which they presented at national conferences and later published in refereed journals.

Post-experience tracking of students suggests some major successes. Several students each year enrolled in graduate programs at CSU after graduation, most to work with their REU mentors. We know

that about half entered other graduate programs, and most indicated the intent to go on to graduate. Several students changed their undergraduate major or added a second major or minor in a water-related field after their REU experiences. Several students each year continued their research for a senior thesis during the subsequent year. Post-experience questionnaires indicate a high level of satisfaction with the program, consistent affirmation or increase in interest in water-related issues, and increased intent to attend graduate school or pursue careers in water-related fields.

NSF award: DEB-0308414
Amount: $1,694,994.00
Period: 09/15/2003 – 02/29/2008
Title: Modeling Complex Interactions of Overlapping River and Road Networks in a Changing Landscape
P.I.: John Loomis, CSU
Co-P.I.'s: Melinda Laituri, Earth Resources Department, CSU, Jorge A. Ramirez, Civil Engineering Department, CSU
Ellen Wohl, Earth Resources, CSU

For information on scientific results, please browse:
http://www.cnr.colostate.edu/outreach/biocomplexity.

Contributions to Human Resource Development:

Participation by graduate students has provided extensive interdisciplinary and multidisciplinary cross training. Graduate students in planning and economics were exposed to methods and data from hydrology and aquatic ecology, and had an opportunity to incorporate those data in their models. Aquatic ecology students were provided opportunities to work with hydrologists to collect field level data and incorporate those into their GIS landscape level analyses. Two of the graduate students (U of Puerto Rico and CSU), one post-doc (UPR) and nearly all the undergraduates participating in the REU were from underrepresented groups in the fields of hydrology, aquatic ecology, economics and land use planning. In particular, the REU opportunity to participate in field data collection has provided an awareness of this type of research and opportunities for graduate education and careers in these fields. Many of those REU students were participating in the REU Program In Water Research at CSU mentioned above. The collaboration with the Thompson Valley School District and Big Thompson Watershed Forum in Colorado has provided opportunities to share the information developed with high school teachers and students.

NSF award: EAR-0444053
Amount: $120,000.00
Period: 06/07/2005 – 05/31/2008
Title: Quantifying the complex hydrologic response of an ephemeral stream
P.I.: Jorge A Ramirez, CSU
Co-P.I.'s: Stan Schumm, CSU

The goal of this research is to quantify the hydrologic response of a desert ephemeral wash in the southwestern United States to seasonally distinct storm patterns. Our site is Yuma Wash, located on the U.S. Army Yuma Proving Grounds (YPG) in Yuma, Arizona. The specific aim is to understand how water is partitioned in time and space over different geomorphic surfaces and their associated vegetative communities and soil types in response to frontal, convective, and tropical cyclonic precipitation. This project is a collaborative project with the DoD's ARO.

Training and Development:

One PhD candidate, one MS student, one undergraduate work-study student, and three field technicians have been trained and are actively involved in the above tasks. It is anticipated that this initial effort to build an instrumentation infrastructure in Yuma Wash, AZ will provide long-term access for the scientific community to hydrological data for an arid region.

9. Other Resources and Connections - International Collaboration:

Several international institutions with which we have existing agreements of cooperation will provide additional opportunities for our WATER-IGERT scholars to participate in internships. The Institute of Environmental Engineering of the Swiss Federal Institute of Technology in Zurich, under the leadership of Professor Paolo Burlando[22], provided a letter of support and agreement to participate in the activities described in this proposal. Similar opportunities will be available at the Center for Environmental Research and Monitoring (CIMA) of the University of Genoa, Italy. Currently, the Hydrology Program of Civil Engineering at CSU and the Atmospheric Science Department at CSU have a formal agreement of cooperation with CIMA[23]. This agreement has been in place since 1999, and it has been very successful and has led to student and faculty exchanges, that will continue and be strengthened as a result of the WATER-IGERT.

[22] Letter of support on file.
[23] Memorandum of agreement on file.

10. Recruitment and Retention History:

The number of underrepresented students at CSU has increased steadily over the past decade. CSU graduate students pursuing degrees in science, technology, engineering and mathematics (STEM) comprise 50.2% of the total graduate population. Out of 3,655 graduate students enrolled as of Fall 2008, 23.8% are STEM MS students and 26.4% are STEM PhD students. Underrepresented minority students account for 5.7% of all graduate students in STEM programs. Since 1999 the number of underrepresented minorities pursuing STEM graduate degrees has increased by 82.7%. The most dramatic increase in graduate underrepresented minority enrollment has been observed in the number of Hispanic students enrolled in STEM PhD programs: as of 1999 there were 7 Hispanic PhD students enrolled and by 2008 there were 33.

Civil and Environmental Engineering Department

The Department recognizes that a diverse student body, faculty, and staff result in a diversity of ideas and better solutions for complex problems. In addition, engineers must be prepared to work in a global society. One of the goals of the Department of Civil and Environmental Engineering is excellence in research and in graduate programs. Both funded and unfunded research make important contributions to the body of knowledge. Funded research, however, helps the program recruit the best and brightest graduate students. The department promotes students that have the highest probability of contributing to the department's research program, becoming leaders in their fields, and completing their programs successfully. The department has implemented a number of differential incentives for graduate student recruitment and retention.

- The Department provides scholarships or fellowships for Ph.D. students and M.S. students.
- The Department offers approximately 15 GTAs each year. The large majority of these GTA's are awarded to US Citizens. This year of the 12 GTAs awarded to US Citizens, 6 were awarded to women.
- The Department organizes a graduate visit day in the spring each year. This has been a highly successful activity to recruit students. The Department awards travel scholarships for highly qualified students to visit CSU either during graduate visit day or during other periods.
- The Department works closely with the Women and Minorities in Engineering program in order to coordinate efforts for recruiting from underrepresented groups.
- Over the last three years the department has been successful in increasing the number of women in the PhD program. The number of women in our PhD program has increased from 8 to 14 during the last three years.
- Over the last three years the Department has implemented a program of offering scholarships of $4,000 for new Ph.D. students in the water area (partly funded by the Borland endowment) that has contributed to the increase of women Ph.D. students. Last year the Department made a concerted effort to coordinate the GTA offers with the scholarships to our highly qualified applicants. As a result, we increased our acceptance rate from this pool of top students from about 50% to about 75%. Given the success of these measures, we intend to secure additional funds in order to continue to increase our diverse population of students and continue to attract and retain highly qualified students.

Department of Civil and Environmental Engineering

Colorado State University					
Provide data on US citizens and permanent residents only for the past 3 academic years for each participating department in the proposed IGERT.					
PhD-granting Department or Equivalent	**Civil and Environmental Engineering Department**				
	W	**Min**	**D**	**Other**	**Total**
No. applicants to PhD program	14	13	u/k	20	33
No. applicants accepted by program	9	6	u/k	8	20
No. that matriculated	5	3	u/k	6	11
No. students who withdrew	0	0	u/k	0	0
No. PhDs awarded	4	8	u/k	2	13
No. currently enrolled	11	9	u/k	21	36

Provide employment information (employer, position) for all US citizens or permanent residents who have received PhD in department during past 3 years. Add additional lines as needed. Enter "unknown" in cases when you are unsure of place of employment and/or position.

	Employer Name	**Position**
Student #1	US Bureau of Reclamation - Denver	Hydraulic Engineer
Student #2	Colorado State University - Fort Collins	Research Scientist
Student #3	University of Utah	Assistant Professor
Student #4	Martin & Martin Consulting - Golden	Hydraulic Engineer
Student #5	Engineering Analytics - Fort Collins	Project Manager
Student #6	Oklahoma State University	Assistant Professor
Student #7	USDA-ARS Hydraulics Lab., Stillwater, OK	Research Scientist
Student #8	Engineering Analytics - Fort Collins	Geotechnical Engineer
Student #9	u/k	u/k
Student #10	u/k	u/k
Student #11	Cal Poly (California State Univ) - Pomona	Assistant Professor
Student #12	Paul C. Rizzo Associates, Inc. - Pittsburgh	Assistant Project Engineer
Student #13	Institute for Arctic and Alpine Research - Boulder	Research Scientist

Legend: W-women; Min-minorities; D-persons with disabilities

Department of Atmospheric Science

Colorado State University					
Provide data on US citizens and permanent residents only for the past 3 academic years for each participating department in the proposed IGERT					
PhD-granting department	**Atmospheric Science Department**				
	W	**Min**	**D**	**Other**	**Total**
No. of applicants to PhD program	13	2	0	30	43
Number of applicants accepted by program	4	0	0	7	11
No. that matriculated	2	0	0	5	7
No. of students who withdrew	0	0	0	0	0
No. of PhDs awarded	6	1	0	14	20
No. currently enrolled	11	0	0	23	34

Provide employment information (employer, position) for all US citizens or permanent residents who have received PhD in department during past 3 years. Add additional lines as needed. Enter "unknown" in cases when you are unsure of place of employment and/or position

	Employer Name	**Position**
Student #1	Colorado State University	Research Scientist
Student #2	unknown	
Student #3	University of Reading	Professor
Student #4	NOAA	unknown
Student #5	unknown	
Student #6	University of Reading	Assistant Professor
Student #7	SUNY	unknown
Student #8	CIRES	Post Doc
Student #9	unknown	
Student #10	unknown	
Student #11	SUNY	Assistant Professor
Student #12	unknown	
Student #13	Cooperative Institute for Research and Atmosphere	Affiliated Scientist
Student #14	Colorado State University	Research Scientist
Student #15	unknown	
Student #16	unknown	
Student #17	unknown	
Student #18	Texas A&M	unknown
Student #19	Univ. of Southern Alabama	Assistant Professor
Student #20	Colorado State University	Post Doc

Legend: **W**-women, **Min**-minorities, **D**-persons with disabilities

Graduate Degree Program in Ecology

Colorado State University - 2007					
Provide data on US citizens and permanent residents only for the past 3 academic years for each participating department in the proposed IGERT.					
PhD-granting Department or Equivalent	**Graduate Degree Program in Ecology**				
	W	**Min**	**D**	**Other**	**Total**
No. applicants to PhD program	20	1	0	27	47
No. applicants accepted by program	15	0	0	2	17
No. that matriculated	15	0	0	2	17
No. students who withdrew	2	0	0	1	3
No. PhDs awarded	6	0	0	6	12
No. currently enrolled	33	1	0	22	55
Provide employment info (employer, position) for all US citizens or permanent residents who have received PhD in department during past 3 years. Add additional lines as needed. Enter "unknown" in cases when you are unsure of place of employment and/or position.					
Legend: W-women; Min-minorities; D-persons with disabilities; *PhD					

Colorado State University - 2008					
Provide data on US citizens and permanent residents only for the past 3 academic years for each participating department in the proposed IGERT.					
PhD-granting Department or Equivalent	**Graduate Degree Program in Ecology**				
	W	**Min**	**D**	**Other**	**Total**
No. applicants to PhD program	19	2	0	16	35
No. applicants accepted by program	5	1	0	9	14
No. that matriculated	6	1	0	8	14
No. students who withdrew	0	0	0	0	0
No. PhDs awarded	3	0	0	4	7
No. currently enrolled	35	2	0	23	58
Provide employment info (employer, position) for all US citizens or permanent residents who have received PhD in department during past 3 years. Add additional lines as needed. Enter "unknown" in cases when you are unsure of place of employment and/or position.					
Legend: W-women; Min-minorities; D-persons with disabilities; *PhD					

Colorado State University - 2009					
Provide data on US citizens and permanent residents only for the past 3 academic years for each participating department in the proposed IGERT.					
PhD-granting Department or Equivalent	**Graduate Degree Program in Ecology**				
	W	**Min**	**D**	**Other**	**Total**
No. applicants to PhD program	30	4	1	22	52
No. applicants accepted by program	9	2	1	5	14
No. that matriculated	9	2	1	4	13
No. students who withdrew	0	0	0	0	0
No. PhDs awarded	2	0	0	2	4
No. currently enrolled	43	3	0	22	65
Provide employment info (employer, position) for all US citizens or permanent residents who have received PhD in department during past 3 years. Add additional lines as needed. Enter "unknown" in cases when you are unsure of place of employment and/or position.					
Legend: W-women; Min-minorities; D-persons with disabilities: *PhD					

Department of Biology

Colorado State University					
PhD-granting Department or Equivalent-2007	**Department of Biology**				
PhD-Domestic/perm. Residents only	W	Min	D	Other	Total
No. applicants to PhD program	32	7	0	16	48
No. applicants to be accepted by program	6	2	0	3	9
No. that matriculated	3	1	0	3	6
No. students who withdrew	0	0	0	0	0
No. PhDs awarded	3	0	0	0	3
No. currently enrolled	31	4	0	24	55
Colorado State University					
PhD-granting Department or Equivalent-2008	**Department of Biology**				
	W	Min	D	Other	Total
No. applicants to PhD program	22	8	0	12	34
No. applicants to be accepted by program	4	1	0	6	10
No. that matriculated	2	1	0	5	7
No. students who withdrew	0	0	0	2	2
No. PhDs awarded	3	0	0	1	4
No. currently enrolled	24	4	0	26	50
Colorado State University					
PhD-granting Department or Equivalent-2009	**Department of Biology**				
	W	Min	D	Other	Total
No. applicants to PhD program	20	4	0	22	42
No. applicants to be accepted by program	9	2	0	3	12
No. that matriculated	8	2	0	3	11
No. students who withdrew	0	0	0	1	1
No. PhDs awarded	0	0	0	1	1
No. currently enrolled	15	2	0	26	41

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NAME: Jorge A. Ramírez **POSITION TITLE: Professor**

Department of Civil Engineering
Colorado State University
Fort Collins, Colorado 80523-1372

(970) 491-7621 (office)
(970) 491-5048 (secretary)
(970) 491-7727 (fax)

Jorge.Ramirez@ColoState.edu

A. Education

Massachusetts Institute of Technology	Hydrometeorology	Ph.D., 1988
Massachusetts Institute of Technology	Hydrology Water Resources	M.S., 1982
School of Mines, National University of Colombia, Medellin, CO	Civil Engineering	B.S., 1981

B. Appointments/Professional Experience

2005 - Professor, Department of Civil Engineering, Colorado State University

1996 - 05 Associate Professor, Department of Civil Engineering, Colorado State University

1990 - 96 Assistant Professor, Department of Civil Engineering, Colorado State University

C. Relevant Publications

1. Kochendorfer, J.P. and Ramirez, J.A., 2008. Ecohydrological controls on vegetation density and evapotranspiration partitioning across the climatic gradients of the central United States. *Hydrol. Earth Syst. Sci. Discuss.*, 5, 649–700.
2. Kochendorfer, J.P. and Ramirez, J.A., 2008. Modeling the monthly mean soil water balance with a statistical-dynamical ecohydrology model as coupled to a two-component canopy model. *Hydrol. Earth Syst. Sci. Discuss.*, 5, 579–648.
3. Trujillo, Ernesto, Ramirez, J.A. and K. Elder, 2007: Topographic, Meteorologic, and Canopy Controls on the Scaling Characteristics of the Spatial Distribution of Snow Depth Fields. *Water Resources Research. doi:10.1029/2006WR005317*
4. Ramírez, J.A., M. Hobbins, and T. C. Brown, 2005: Observational evidence of the complementary relationship in regional evaporation lends strong support for Bouchet's hypothesis, *Geophys. Res. Lett., 32, L15401, doi:10.1029/2005GL023549.*
5. Kochendorfer, J. P. and J. A. Ramírez, 2005: The Impact of Land Atmosphere Interactions in the Temporal Variability of Soil Moisture. *Journal of Hydrometeorology. Vol 6. No. 1, 53-67.*

D. Other Related Publications

6. Hobbins, M., J. A. Ramírez, and T. C. Brown, 2004: Trends in Pan Evaporation and Actual Evaporation Across the Conterminous U.S.: Paradoxical or Complementary? *Geophysical Research Letters. Vol 31, L13503.*
7. Barton, S. and J.A. Ramirez, 2004: Combined Effects of ENSO and PDO on Seasonal Water Supply in the Columbia River Basin. *J. of Water Resources Planning and Management, **130**(4), pp. 281–289.*
8. Molnár, P. and J. A. Ramírez, 2001. Recent trends in precipitation and streamflow in the Rio Puerco Basin. *Journal of Climate. **14**, 2317-2328.*
9. Hobbins, M. T., J. A. Ramírez, and T. C. Brown, 2001: The Complementary Relationship In Estimation Of Regional Evapotranspiration: An Enhanced Advection-Aridity Model. *Water Res. Research. **37**(5), 1389-1403.*
10. Ramírez, J. A. and S. Senarath, 2000: A Statistical-Dynamical Parameterization of Canopy Interception and Land Surface-Atmosphere Interactions. *Journal of Climate. **13**, 4050-4063*

E. Synergistic Activities

- Member:
  - Executive Committee of Interdisciplinary Graduate Degree Program in Ecology, CSU
  - Faculty Advisory Board of Bridge to the Doctorate Program, CSU
  - Scientific Organizing Committee: European Geophysical Society, Plinius Conference on Mediterranean Storms. October 16-18, 2000. Siena, Italy
  - Elected Member – Executive Committee of the Consortium of Universities for the Advancement of Hydrologic Science, Inc. – CUAHSI – 2001 - 2004
- Director, REU Program in Water Research at CSU, 1997 – 1999, 2001 – 2003 and 2006 - 2010. Over 130 students involved (http://WaterREU.ColoState.edu/).
- Organizer of Annual Hydrology Days Conference since 1990 (http://HydrologyDays.ColoState.edu/)
- Advisor for twelve (nine current) Ph.D. students in the *Hydrologic Sciences and Engineering* division of Civil Engineering. Served/serving on over 20 Ph.D. committees for students in engineering and science.

F. Recent Awards

2008 Citation for Excellence in Refereeing - Water Resources Research, American Geophysical Union

2008 Inspire Integrity Award Nomination, National Society of Collegiate Scholars

2006-2009 Chair-Borland Professor of Hydrology–Civil and Environmental Engineering Department, CSU

2005 George T. Abell Outstanding Mid-career Faculty Award of the College of Engineering, CSU

2004 Best Research Paper Award, ASCE Journal of Hydrologic Engineering, ASCE Environmental and Water Resources Institute.

2002 Outstanding Faculty Performance Award for Research, Teaching and Service, Civil Engineering

2000 Water Center Award for Outstanding Contributions to Interdisciplinary Education and Research, CSU

G. Recent Collaborators

Laj Ahuja – USDA-ARS; Tom Brown – USFS-RMFRES; Paul Box – CSIRO, Australia; Bill Cotton – CSU; Paolo Burlando – ETH-Zurich, Switzerland; Alan Covich – U. Georgia; Tim Green – USDA-ARS; Judy L. Hannah – CSU; Pierre Julien – CSU; Luca Lanza – University of Genoa; Melinda Laituri – CSU; John Loomis – CSU; Lee MacDonald – CSU; Dennis Ojima – NREL; Roger A. Pielke – CSU; Georgio Roth – University of Genoa; Jose D. Salas – CSU; David Sailor – Tulane University; Fred Scatena – U. Penn; Franco Siccardi – University of Genoa; Danny Smith – CSU; Tom Vonderhaar – CSU; Ellen Wohl – CSU; David Woolhiser - CSU.

H. Graduate and Postgraduate Advisees

Dan Epstein, Gamal Allam, Fritz Fiedler, Peter Molnar, Claudio Meier, Michael Hobbins, Michael Kane, Saul Marin, Marco Polo Rivero, Luc Claessens, Sharika Senarath, John P. Kochendorfer, Saovaluk Sima-Aree, Judith Sunantara, Charles G. Wolff, June Lea Beagler, Matthew C. Carney, Dana Moore, Rosalía Rojas, Bijaya Aryal, Todd Entrekin, Matthew Bryan Fader, Matthew Gray, Cliff Hao Li, Gregory Peacock, Marco Polo Rivero, Kurt Staller, Janis Wilson Strunk, Steve Barton, Abel Genovez, Dyvia Srivastava, Marcel Zibognon, Boo-sik Kang, Romano Foti, Ernesto Trujillo, Jose Manuel Molina, Rahul Rajagopal, David Raff, Susan Howe, Rob Erskine, Raul Passerini, Nancy Brown.

I. Graduate and Postgraduate Advisors

Professor Rafael Bras, Civil and Environmental Engineering Department; M.I.T. Cambridge, MA.

A. Scott Denning

Department of Atmospheric Science, Colorado State University, Fort Collins, CO 80523-1371
(970)491-6936 Scott.Denning@ColoState.edu FAX 491-8693

Education:

B.A., Geological Sciences, 1984. University of Maine, Orono, Maine.
M.S., Atmospheric Science, 1993. Colorado State University, Ft. Collins, Colo.
Ph.D. Atmospheric Science, 1994. Colorado State University, Ft. Collins, Colo.

Professional Positions:

2009– : ***Professor**, Department of Atmospheric Science, Colorado State University.*
2006– : ***Director of Education & Diversity**, Center for Multiscale Modeling of Atmospheric Processes*
2004-2008: ***Chair, Science Steering Group***, North American Carbon Program,
2002-2005: ***Editor**, Journal of Climate,.*
2003–2009 : ***Associate Professor**, Department of Atmospheric Science, Colorado State University.*
1998–2003: ***Assistant Professor**, Department of Atmospheric Science, Colorado State University.*
1996–98: ***Assistant Professor**, Donald Bren School of Environmental Science and Management, University of California, Santa Barbara.*

Selected Publications (from a list of over 70):

Denning, A.S., I.Y. Fung and D.A. Randall, 1995: Latitudinal gradient of atmospheric CO2 due to seasonal exchange with land biota. *Nature*, **376**, 240-243. (Cited 187 times)

Denning, A. S., J. G. Collatz, C. Zhang, D. A. Randall, J. A. Berry, P. J. Sellers, G. D. Colello, and D. A.Dazlich, 1996. Simulations of terrestrial carbon metabolism and atmospheric CO2 in a general circulation model. Part 1: Surface carbon fluxes. *Tellus*, **48B**, 521-542.

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Schuh, A. E., **A. S. Denning**, M. Uliasz, K. D. Corbin, 2009. Seeing the Forest through the Trees: Recoveringblarge scale carbon flux biases in the midst of small scale variability. *Jour. Geophys. Res.*, doi:10.1029/2008JG000842. (Cited 0 times)

Synergistic Activities

Director of Education and Diversity, CMMAP: Work with schools, teachers, and a team of education/outreach professionals, to develop, evaluate, and disseminate a wide range of climate change materials to a diverse audience including K-12, undergraduate, and graduate students, stakeholders, and the general public.

Collaborators/Co-Authors:

A. Alkhaled, S. Aoki, C. Aulagnier, D.F. Baker, I. Baker, P. Bakwin, D.J. Bergmann, C. Bernacchi, J.A. Berry, H. Boesch, G.B. Bonan, P. Bousquet, J. Brandt, M. Branson, L. Bruhwiler, G.G. Burba, P.J. Cameron-Smith, Y.-H. Chen, F. Chevallier, J.H. Christensen, P. Ciais, B.J. Connor, K.D. Corbin, D. Crisp, H.R. daRocha, K.J. Davis, P.L. DeCola, F. Delage, S.C. Doney, D. Dragoni, M. Fischer. R.J. Francey, S.R. Freitas, I.Y. Fung, C. Geels, M. Goulden, K.R. Gurney, N.P. Hanan, M. Heimann, A. Hirsch, R. Imasu, G. Inoue, D.J. Jacob, J. John, D.B.A. Jones, A. Jordan, J. Kaduk, U. Karstens, S.R. Kawa, J. Kleist, M.C. Krol, C. Lac, R.L. Langenfelds, T. Lauvaux, R.M. Law, D.M. Lawrence, O. Leonard, S.-J. Lin, J. Lloyd, R.S. Lokupitiya, E. Lokupitiya, M. Longo, L. Lu, T. Machida, T. Maki, S. Maksyutov, K. Masarie, E. McGrath-Spangler, T. Meyers, A.M. Michalak, J.B. Miller, C.E. Miller, S. Miller, T. Nakazawa, J. Neff, M.E. Nicholls, G.-Y. Niu, Y. Niwa, D. O'Brien, K.W. Oleson, S.C. Olsen, R. Onishi, B. Pak, N. Parazoo, K. Paustian, S. Pawson, W. Peters, P. Peylin, G. Pieterse, M. Prather, L. Prihodko, M. Ramonet, J.T. Randerson, P. Rayner, L. Rivier, C. Rodenbeck, S.W. Running, T. Rutishauser, S. Saatchi, R.J. Salawitch, S.P. Sander, C. Sarrat, M. Satoh, K. Schaefer, R.J. Scholes, A.E. Schuh, B. Sen, S. Serrar, O. Shibistova, M.A. Silva-Dias, P. Silva-Dias, L.P. Steele, B. Stephens, C.J. Still, R. Stockli, N.S. Suits, P. Suntharalingam, A.E. Suyker, A. Suyker, B.C. Sweeney, S. Taguchi, M. Takigawa, P.P. Tans, P.E. Thornton, C. Toon, M. Uliasz, R. Vautard, S.B. Verma, A.T. Vermuelen, N. Vinnichenko, E.A. Walter-Shea, J.-W. Wang, P.O. Wennberg, J. Whitaker, C.A. Williams, S.C. Wofsy, D. Worthy, Z.-L. Yang, X. Yi, Y.L. Yung, N. Zhang, Z. Zhu, D. Zupanski, M. Zupanski.

Graduate Advisors and Postdoctoral Sponsors:

David A. Randall, Colorado State University (both graduate and postdoc advisor, 1990-1996). Still at CSU Department of Atmospheric Science

Thesis Advisor and Postgraduate-Scholar Sponsor (17 grad students and 1 PostDoc sponsored):
Kevin Gurney; now at Purdue University; Neil Suits (former PostDoc, now at Montana State, Billings); Lara Prihodko (now at NREL, CSU); Kevin Schaefer (now at CIRES, CU Boulder); Katherine Corbin (now at CSIRO Aspendale, Australia); Andrew Schuh (still at CSU as Research Scientist); Ni Zhang (now at GFDL, Princeton); Theresa Krebs (private industry); Joanne Skidmore (private industry)
Jun Liu (Univ of Chicago); Jih-Wang Wang (now at Univ of Colorado); Andrew Philpott (now at NOAA in upstate NY somewhere); Nicholas Parazoo (still at CSU in PhD program); Ian Baker (Still at CSU PhD program); Erica McGrath-Spangler (still at CSU in PhD program); Anna Harper (still at CSU in PhD program); Parker Kraus (still at CSU in M.S. program); Isaac Medina (still at CSU in M.S. program)

Biographical Sketch

NEIL S. GRIGG, Co-Principal Investigator
Department of Civil and Environmental Engineering
Colorado State University
Ft Collins CO 80523
Tel: 970-491-3369; Fax: 970-491-7727; email: neilg@engr.colostate.edu

a. Professional Preparation

Institution	Major	Degree	Year
US Military Academy	General	B. S.	1961
Auburn University	Civil Engineering	M. S.	1965
Colorado State University	Civil Engineering	Ph. D.	1969

b. Appointments:

1982–Present: Colorado State University (Professor of Civil Engineering, 1982–; Department Head, 1991–2000; Director, Colorado Water Resources Research Institute, 1988–1991; Director, Water Center, 1995-1997; Director, International School for Water Resources, 1986–1992).

1988–Present: River Master of Pecos River, U.S. Supreme Court case No.65

1977–1982: State of North Carolina and NC State U (Director of UNC Water Resources Research Institute, 1977-82; Assistant Secretary for Natural Resources, 1979–1982; Director of Division of Environmental Management, 1979–1980)

1972–1977: Colorado State University (Assoc Prof of Civil Engineering; 1972–1977; Director of International Education, 1976–77)

1969–1972: University of Denver (Assistant Professor of Civil and Environmental Engineering, 1969–72; Assistant Dean of Engineering, 1970-2)

1968–1976: Co-founder and Vice-President of Sellards & Grigg Inc

1964–1969: Graduate student and consulting engineer

1961–1964: US Army Corps of Engineers, active duty, Germany

c. Publications:

1. Publications related to project (all with **Neil S. Grigg** as author)
   - Water and Wastewater Workforce: Planning, Design, and Action for Organizational Excellence. AWWA Press. Denver. 2009.
   - Total Water Management: leadership practices for a sustainable future AWWA Press. 2008.
   - Integrated Water Resources Management: Balancing Views and Improving Practice. Water International. 33(3)1–20. 2008.
   - Water Manager's Handbook: A guide to the water industry. 2005. Aquamedia Publications.
   - Water Sector Structure, Size and Demographics. ASCE JWRPM, 2007.

2. Additional publications (all with **Neil S. Grigg** as author, except as shown)

Grigg, Neil S. 2009. Water and wastewater workforce: The case for better data. JAWWA. August.

Alternative Futures for the Water Industry: Technology, Organization, and Public Expectations. Journal of the New England Water Works Association. 122(4)303-310.

Establishing a Water Law Framework: The Colombia Example. Water International: Journal of International Water Resources Association. 2008. L. MacDonnell sr author.

Workforce Development and Knowledge Management in Water Utilities. JAWWA. 2006.

Colorado's Water: Science and Management, History and Politics Aquamedia Publications. 2003.

d. Synergistic activities

- Supreme Court appointment as River Master of Pecos River
- Extensive involvement in water industry, expert member of American Water Works Association Research panel on infrastructure.
- Current work in water industry research (funded projects with AWWA Research Foundation) and involvement in water industry issues, including participation in national workshops and networks.
- Active teaching, research, and practice on water industry systems and management, including industry structure, privatization, managed competition, regulation, and case studies. Published texts and invited as speaker on water industry management.
- Service in urban water industry as official, consultant, researcher. (12 years on City of Fort Collins Water Board, state official regulating water industry; Board of Directors of two national public works and water associations; consultant to cities and states.

e. Collaborators

(i) Collaborators: Marvin Criswell (CSU), Scott Denning (CSU), Darrell Fontane (CSU), LeRoy Poff (CSU), Jorge Ramirez (CSU), Tom Siller (CSU), Evan C. Vlachos. (CSU).
(ii) Graduate Advisors: Cornelius Shih, University of Alabama, Huntsville; Daryl Simons (CSU, now deceased).
(iii) Thesis Advisor: Alison Adams (Tampa Bay Water); David Stewart (Stewart Environmental Engineering), Ken Knox (URS), Peter Rogers (Univ Texas/Tyler). Total thesis students advised—45.

N. LeROY POFF
Department of Biology
Colorado State University
Fort Collins, CO 80523-1878

PH: 970-491-2079 (office)
PH: 970-491-2414 (lab)
FAX: 970-491-0649
E-mail: poff@lamar.colostate.edu

A. PROFESSIONAL PREPARATION:

Hendrix College	Biology	B.A., 1978
Indiana University, Bloomington	Environmental Science	M.S., 1983
Colorado State University	Biology	Ph.D., 1989
University of Maryland	Ecology	Post-doc, 1990-1992

B. APPOINTMENTS:

Full Professor, Colorado State University, July 2007.
Director, Graduate Degree Program in Ecology, CSU, September 2008-present.
Associate Professor, CSU, Dept. Biology, July 2002-present.
Assistant Professor, CSU, Dept. Biology, July 1997-2002.
Research Scientist, University of Maryland, Dept. Zoology, 1992-1997.
Senior Scientist, Trout Unlimited, Arlington VA, 1996-1997.

C. PUBLICATIONS (of >80 peer-reviewed journal articles):

Five Most Relevant

Merritt, D.A., and **N.L. Poff**. 2009. Shifting dominance of riparian *Populus* and *Tamarix* along gradients of flow alteration in western US rivers. ***Ecol. Appl.*** (In Press)

Poff, N.L., J. Olden, D. Merritt, and D. Pepin. 2007. Homogenization of regional river dynamics by dams and global biodiversity implications. ***Proc. Nat. Acad. Sci.*** 104:5732-5737.

Arthington, A.H., S.E. Bunn, **N.L. Poff**, and R.J. Naiman. 2006. The challenge of providing environmental flow rules to sustain river ecosystems. ***Ecol. Appl.*** 16:1311-1318.

Poff, N.L., J.D. Allan, M.A. Palmer, D.D. Hart, B.D. Richter, A.H. Arthington, K.H. Rogers, J.L. Meyer, and J.A. Stanford, and. 2003. River flows and water wars? Emerging science for environmental decision-making. ***Frontiers Ecol. Environm.*** 1:298-306.

Baron, J.S., **N.L. Poff**, P.L. Angermeier, C.N. Dahm, P.H. Gleick, N.G. Hairston, Jr., R.B. Jackson, C.A. Johnston, B.G. Richter, and A.D. Steinman. 2002. Meeting ecological and societal needs for freshwater. ***Ecol. Appl.*** 12:1247-1260.

Five Additional

Poff N.L., Richter B., Arthington A.H., and 15 others. 2009. The Ecological Limits of Hydrologic Alteration (ELOHA): a new framework for developing regional environmental flow standards. *Freshwater Biology*, (In Press).

Poff, N.L., J.D. Allan, M. B. Bain, J.R. Karr, K.L. Prestegaard, B. Richter, R. Sparks, and J. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. ***BioScience*** 47:769-784.

Poff, N.L., B.D. Bledsoe, and C.O. Cuhaciyan. 2006. Hydrologic variation with land use across the contiguous United States: geomorphic and ecological consequences for stream ecosystems. ***Geomorphology*** 79:264-285.

Poff, N.L., and D.D. Hart. 2002. How dams vary and why it matters for the emerging science of dam removal. ***BioScience*** 52: 659-668.

Sala, O.E., F.S. Chapin III, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R. Jackson, A. Kinzig, R. Leemans, D. Lodge, H.A. Mooney, M. Oesterheld, **N.L. Poff**, M.T. Sykes, B.H. Walker, M. Walker, and D.H. Wall. 2000. Global biodiversity scenarios for the year 2100. ***Science*** 287:1770-1774.

D. SYNERGISTIC ACTIVITIES:

President, North American Benthological Society June 2006 - June 2007.
Monfort Professor, Colorado State University, 2005-2007.
Editorships:

- Editorial Board, *Freshwater Biology* , 1996-present.
- Associate Editor, *Limnology & Oceanography*, 1999-2000.

Aldo Leopold Leadership Program Fellow (Ecological Society of America), 2004
Member:

- NRC Committee on USGS Water Resources Research, 2001-2006.
- Advisory Committee for International Conference on Environmental Flows, September 3-6, 2007 in Brisbane, Australia.
- "Adaptive Management Forum," CALFED projects, 2001-2003.
- Scientific Review Team, King Co. (WA) "Normative Flows Project" 2002-2005.
- Scientific and Technical Advisory Committee, American Rivers, 2001-2003.

Plenary Presentations

"The natural flow regime and river restoration", Government-sponsored symposium on river restoration in Spain, Madrid, September 2006.
"Aquatic Habitats – Analysis and Restoraion", 5th International Symposium on Ecohydraulics, Madrid, Spain, September 12-17, 2004.
"Advanced Intrepretation of Ecological Data and Ecosystem Management: Scaling from Genes to Ecosystems", 4th Conference of the International Society for Ecological Informatics (ISEI), Busan (Pusan), Korea, October 24-28, 2004.
"Nature of flow variability in rivers", 9th International Symposium on River Research & Applications, Albury, NSW, Australia, July 7-10, 2003.

E. COLLABORATORS and CO-AUTHORS:

Dave Allan, U. Michigan
Paul Angermeier, VirginiaTech
Angela Arthington, Griffith U., Australia
Stuart Bunn, Griffith U., Australia
Tom Dunne, UC Santa Barbara
David Hart, U. Maine
Sam Lake, Monash U., Australia
Judy Meyer, U. Georgia
Bob Naiman, U. Washington
John Nestler, US Corps Eng.
Margaret Palmer, U. Maryland
Cathy Pringle, U. Georgia
Brian Richter, Nature Cons.
Jack Stanford, U. Montana
Charles Vorosmarty, CUNY New York

Graduate and Postdoctoral Advisores.

Graduate Advisor: J.V. Ward, EAWAG, Switzerland (retired)
Post Doctoral Advisor: J.D. Allan, University of Michigan

Thesis Advisor and Postgraduate-Scholar Sponsor.

Postgraduate-Scholar Sponsor
Dr. Lindsay Reynolds, current USGS postdoc
Dr. Julie Zimmerman, CSU funds, 2006-2007 (now The Nature Conservancy)
Dr. Nicole Vieira, USGS post-doc 2004-2005 (now Colorado Division of Wildlife)
Dr. David Merritt , TNC DHSmith Fellow 1999-2002 (now US Forest Service)
Dr. Todd A. Wellnitz, CSU and NSF funds, 1997-2001 (now Univ. Wisc. Eu Claire)
Dr. David Lytle, TNC DHSmith Fellow 2001 (now Oregon St. University)
Dr. Nicolas Lamouroux, post-doc 1998 (now CEMAGREF, Lyon France)

Number of MS graduate students supervised: 4 graduated
Number of PhD graduate students supervised: 4 graduated, 4 active
PhD placements: Debra Finn (now post-doc at Oregon State), Julian Olden (Assistant Professor, U. Washington)

Jill S. Baron
Ecologist, U.S. Geological Survey, and Senior Research Scientist, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, jill@nrel.colostate.edu, 970-491-1968.

Academic Training:

Cornell University	Botany, Geology	B.S., 1976
University of Wisconsin-Madison	Land Resources	M.S., 1979
Colorado State University	Ecosystem Ecology	Ph.D., 1991

Appointments

1996-present Research Ecologist, U.S. Geological Survey Biological Research Division, Fort Collins, CO
1986-present Senior Scientist, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO
1993-1996 Research Ecologist, National Biological Survey/Service, 1976-1993
1993-1997 Research Biologist, National Park Service

Five Related Publications:

Elser, J.J., T. Anderson, J.S. Baron, A-K Bergström, M. Kyle, K.R. Nydick, L. Steger, D.O. Hessen. Atmospheric nitrogen deposition alters lake N:P stoichiometry and alters phytoplankton nutrient limitation. In press, Science

Elser, J.J., M. Kyle, L. Steger, K.R. Nydick, and J.S. Baron. 2009. Nutrient availability and phytoplankton nutrient limitation across a gradient of atmospheric nitrogen deposition. In press: Ecology.

Baron, J.S., T.W. Schmidt, M.D. Hartman. 2009. Climate-Induced Changes in High Elevation Stream Nitrate Dynamics. Global Change Biology 15:1777-1789

Baron, J.S. (Editor). 2002. Rocky Mountain Futures: an ecological perspective. Island Press, Covelo, CA.

McKnight, D.M., R. Harnish, R.L. Wershaw, J.S. Baron, and S. Shiff. 1997. Chemical characteristics of particulate and dissolved organic material in Loch Vale Watershed, Rocky Mountain National Park. Biogeochemistry 36:99-124.

Five Other Publications

Baron, J.S. L. Gunderson, C. Allen, E. Fleishman, D. McKenzie, L. Meyerson, J. Oropeza, N. Stephenson. 2009. Options for National Parks and Reserves for Adapting to Climate Change. Environmental Management DOI 10.1007/s00267-009-9296-6.

Bowman, W.D., C. C. Cleveland, L. Halada, J. Hreško, J. S. Baron. 2008. Negative impact of nitrogen deposition on soil buffering capacity. Nature GeoSciences 1:767-770. doi:10.1038/ngeo339

Hartman, M.D., J.S. Baron, D.S. Ojima. 2007. Application of a coupled ecosystem-chemical equilibrium model, DayCent-Chem, to stream and soil chemistry in an alpine watershed. Ecol. Modeling 200:493-510.

Nydick, KR, BM Lafrancois, JS Baron, and BM Johnson. 2004. Nitrogen regulation of algal biomass, productivity, and composition in small mountain lakes. Canadian Journal of Fisheries & Aquatic Science 61:1256-1268.

Baron, J. (Editor). 1992. Biogeochemistry of a Subalpine Ecosystem: Loch Vale Watershed. Ecological Studies Series 90, Springer-Verlag, New York.

Synergistic Activities:

Related to Climate Change: US Climate Change Science Program Lead Author, Science and Assessment Project 4.4; Adaptations of National Parks to Climate Change, 2006-2007; Department of Interior Climate Change Task Force member, 2007; USGS Climate Change Science Advisory Council Member 2007-2009; GAO Climate Change Expert Panel Member, contributor to report on how US land management agencies should respond to climate change, 2007

Member, USGS Science Strategy Team, 2006; Director, John Wesley Powell Center for Earth System Science Synthesis and Analysis, 2009-2011

National Center for Ecological Analysis and Synthesis, Science Advisory Board 2005-2008

Grand Canyon Monitoring and Research Center/Glen Canyon Dam Adaptive Management Program Science Advisory Board, 2001-2009.

Ecological Society of America: Editor-in-Chief, *Issues in Ecology* 2007-2010; Associate Editor, *Ecological Applications* 2002-2008. Governing Board, Ecological Society of America, 2001-2003 (Secretary), 1997-1999 (Member-at-Large), Program Chair, Ecological Society of America Annual Meetings 1995-1996

Selected Honors

Department of Interior Awards: Meritorious Service, 2002; National Biological Survey Superior Achievement, 1995; Outstanding National Park Service Washington Office Research Scientist 1991; Outstanding Contributions to Biological Division USGS, 1999, 2000, 2001, Exceptional Performance 2007.

Certified Professional Senior Ecologist: 2001-2012

Keynote/Plenary Speaker: Wrigley Lecturer at Arizona State Univ. Global Institute of Sustainability, 2006; GLOCHAMORE meeting on effects of climate change along altitudinal gradients in mountain ecosystems, 2005; Gordon Research Conference on Catchment Science, 2005; Colorado College Unveiling of State of the Rockies Report Card, 2004; 4th Annual Science Symposium, St. Olaf College, 2003; North American Diatom Symposium,1999.

Collaborators, Co-authors, and Co-Editors

C. Allen (USGS), W. Bowman (CU), V. Burkett (USGS), D. Campbell (USGS), C. Cleveland (U MT), D. Clow (USGS), R. Conant (CSU), C.T. Driscoll (Syracuse U.), J. Elser (ASU), D. Fagre (USGS), E. Fleishman (NCEAS), A. Fountain (PSU), M. Goldhaber (USGS), L. Gunderson (Emory), J. Hicke (UID), J. Holloway (USGS), S. Kampf (CSU), L. Joyce (USFS), S. Julius (EPA), B. Keller (NOAA), C. Millar (USFS), D. McKenzie (USFS), D. McKnight (CU), L. Meyerson (URI), C. Millar (USFS), D. Ojima (CSU), W. Parton (CSU), M. Palmer (UMD), D. Peterson (USFS), T.C. Peterson (UNC), T. Schmidt (USGS), N. Stephenson (USGS), J.T. Stoddard (EPA), C. Tague (UCSB), D. Theobald (CSU), M. Wallenstein (CSU), J. West (EPA), E. Wohl (CSU), A. Wolfe (U Alberta).

Thesis Advisors J.H. Gibson, W. Lindsey, R.G. Woodmansee.

Thesis Advisor and Post-graduate Scholar Sponsor (13 total students, 3 total post-doctoral scholars). Since 2005: Brenda Moraska (Lafrancois), 2003, Ph.D., now with National Park Service; Koren Nydick, Ph.D. 2003, Director, Mountain Studies Institute; Kathryn Muldoon, M.Sc., 2005, consulting; Sanjay Advani, M. Sc., 2005, consulting; Jill Oropeza, M.Sc. 2008, City of Fort Collins; Laura Landrum, post-doctoral fellow 2003-2005, NCAR; Lindsey Christensen, post-doctoral fellow 2005-2008; Melannie Hartman, Ph.D. current; Karen Galles, Ph.D., current, Brooke Osborne, M.S. current.

Michele M. Betsill
Associate Professor, Department of Political Science,
Colorado State University, Fort Collins, CO 80523
970.491.5270; 970.491.2490 (fax); m.betsill@colostate.edu

Professional Preparation

DePauw University	French/Communication	BA 1989
University of Denver	International Studies	MA 1991
University of Colorado-Boulder	Political Science	MA 1997
University of Colorado-Boulder	Political Science	PhD 2000
Harvard University	Kennedy School of Government	1999-2000

Appointments

2006-present	Colorado State University, Associate Professor of Political Science
2006-2007	National Center for Atmospheric Research, Visiting Scientist, Institute for the Study of Society and the Environment
2000-2006	Colorado State University, Assistant Professor of Political Science
1999-2000	Harvard, Post-doctoral Fellow, John F. Kennedy School of Government
1997-1999	University of Colorado-Boulder, Instructor, Political Science
1994-1998	National Center for Atmospheric Research, Research Associate, Environmental and Societal Impacts Group

Publications

Liliana B. Andonova, Michele M. Betsill, and Harriet Bulkeley. 2009. Transnational Climate Governance. *Global Environmental Politics* 9 (2): 52-73.

Michele M. Betsill and Barry G. Rabe. 2009. Climate Change and Multi-Level Governance: The emerging state and local roles. In *Towards Sustainable Communities, 2nd edition*, (D. A. Mazmanian and M. E. Kraft, eds). Cambridge: The MIT Press, pp. 201-226.

Michele M. Betsill. 2007. Regional Governance of Global Climate Change: The North American Free Trade Agreement, *Global Environmental Politics* 7(2): 11-27.

Michele M. Betsill and Harriet Bulkeley. 2004. Transnational Networks and Global Environmental Governance: The Cities for Climate Protection Program, *International Studies Quarterly* 48: 471-493.

Michele M. Betsill. 2004. Global Climate Policy: Making Progress or Spinning Wheels? in *The Global Environment: Institutions, Law and Policy, 2nd edition* (Regina Axelrod, David Downie and Norman Vig, eds.), Washington, DC: CQ Press, pp. 103-124.

Additional

Michele M. Betsill. 2008. NGOs and the Kyoto Protocol Negotiations: 1997 to 1997, in *NGO Diplomacy: The Influence of Nongovernmental Organizations in International Environmental Negotiations* (Michele M. Betsill and Elisabeth Corell, eds.), Cambridge, MA: The MIT Press, pp. 43-66.

Michele M. Betsill and Harriet Bulkeley. 2006, Cities and the Multilevel Governance of Global Climate Change. *Global Governance* 12 (2): 141-159.

Harriet Bulkeley and Michele M. Betsill. 2003 (re-issued in paperback 2005), *Cities and Climate Change: Urban Sustainability and Global Environmental Governance*, London: Routledge.

Synergistic Activities

Coordinator and Instructor (2009), Graduate Student Summer Colloquium, Center for Multi-scale Modelling of Atmospheric Processes, Colorado State University. Organized a four-day course on climate change policy and the science-policy interface for atmospheric science graduate students.

Founder and Co-leader, (2008-present), Environmental Governance Working Group, Colorado State University. Created a network of more than 70 faculty working on environmental governance related research.

Member, Scientific Steering Committee, Earth System Governance Project (2008-present). Responsible for developing and implementing a science plan for a new core program under the International Human Dimensions Programme for Global Environmental Change.

NGO Diplomacy project (2000-2007). In collaboration with Elisabeth Corell, developed an analytical framework for assessing the influence of NGOs in international environmental negotiations across negotiations. Held a workshop at the Swedish Institute for International Affairs that brought together academic researchers and NGO practitioners and included a half-day public forum that drew a number of diplomats, parliamentarians, NGOs and students.

Mentor (2004-present) for Claudia Holgate (Monash University, South Africa) through the START Advanced Institute on Urbanization and the Global Carbon Cycle. START (SysTem for Analysis, Research and Training) is a program co-sponsored by the International Geosphere Biosphere Program, the International Human Dimensions Programme on Global Environmental Change and the World Climate Research Program to enhance research capacity in developing countries.

Collaborators & Other Affiliations

Collaborators:

Liliana Andonova (Colby College, US)
Steinar Andreson (Fridtjof Nansens Institute, Norway)
Frank Biermann (Vrije Universiteit, Amsterdam, The Netherlands)
Randall Boone (Colorado State University, US)
Han Bruyninckx (Leuven University, Belgium)
Harriet Bulkeley (Durham University, UK)
Stanley Burgiel (The Nature Conservancy, US)
Jennifer Clapp (University of Waterloo, Canada)
Elisabeth Corell (Independent researcher, Sweden)
Felix Dodds (Stakeholder Forum, UK)
Ingemar Elander (Örebro University, Sweden)
Maria Fernandez-Gimenez (Colorado State University, US)
Kathleen Galvin (Colorado State University, US)
Michael Granberg (Örebro University, Sweden)
Kathryn Hochstetler (University of New Mexico, US)
Claudia Holgate (Monash University, South Africa)
David Humphreys (Open University, UK)
Sarah Knuth (University of California-Berkeley, US)
Gabriela Kutting (Rutgers-Newark, US)
Jill Lackett (Colorado State University, US)
Melinda Laituri (Colorado State University, US)
Brandi Nagle (Penn State University, US)
Dennis Ojima (Colorado State University, US)
Paul Parker (University of Waterloo, Canada)
Bradley Parks (Millennium Challenge Corporation)
Matthew Paterson (University of Ottawa, Canada)
K.S. Rajan (University of Tokyo, Japan)
J. Timmons Roberts (College of William and Mary)
Patricia Romero-Lankao (National Center for Atmospheric Research, US)
Ian Rowlands (University of Waterloo, Canada)
Henrik Selin (Boston University)
Tora Skodvin (Centre for International Climate and Environmental Research-Oslo, Norway)
Christopher Steuer (ICF International)
Dimitris Stevis (Colorado State University, US)
Sofie Storbjörk (Linköpings Universitet, Sweden)
Larry Swatuk (University of Botswana)
Philip Thornton (International Livestock Research Institute, Nairobi, Kenya)
Stacy Vandeveer (University of New Hampshire)
Tom Veldkamp (Wageningen University, The Netherlands))
Jorgen Wettestad (Fridtjof Nansens Institute, Norway)
Brent Yarnal (Penn State University, US)

Graduate and Postdoctoral Advisors:

Nina Tannenwald (Brown University)
Steve Chan (University of Colorado-Boulder)
Susan E. Clarke (University of Colorado-Boulder)
Sven Steinmo (University of Colorado-Boulder)
Michael Glantz (National Center for Atmospheric Research)
Bill Clark (Harvard University)

Thesis Advisor and Postgraduate-Scholar Sponsor:

Kristy Hollinger (MA 2006, current affiliation unknown)
Nicole Detraz (MA 2005; PhD 2009)
Joseph Baker (MA 2004; current affiliation unknown)

Brian P. Bledsoe
Associate Professor
Department of Civil and Environmental Engineering
Colorado State University
Campus Delivery 1320, Fort Collins, CO 80524 USA
Voice: 970.491.8410, Fax: 970.491.7727, Email: brian.bledsoe@colostate.edu

Education

Georgia Institute of Technology	Mechanical Engineering	B.M.E. 1987
North Carolina State University	Forestry / Environmental Science	M.S. 1993
Colorado State University	Civil Engineering	Ph.D. 1999

Professional Experience

2007 – present Associate Professor, Dept. of Civil and Environmental Engineering, Colorado State University, Fort Collins, CO 80523.
2002 – 2007 Assistant Professor, Dept. of Civil and Environmental Engineering, Colorado State University, Fort Collins, CO 80523.
2000 – 2001 Research Assistant Professor, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO 80523.
1999 – 2000 Research Associate, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO 80523.
1997 – 1999 Research Assistant, Dept. of Civil Engineering, Colorado State University Fort Collins, CO 80523.
1994 – 1997 Nonpoint Source Program Coordinator / Environmental Engineer II, North Carolina Dept. of Environment and Natural Resources, Division of Water Quality, Raleigh, NC 27626.
1991 - 1993 Graduate Research and Teaching Assistant--North Carolina State University

Publications

5 Most Closely Related Publications (*graduate advisee)

1. Poff, N.L., B.D. Richter, A.H. Arthington, S.E. Bunn, R.J. Naiman, E. Kendy, M. Acreman, C. Apse, B. P. Bledsoe, M.C. Freeman, J. Henriksen, R.B. Jacobson, J.G. Kennen, D.M. Merritt, J.H. O'Keeffe, J.D. Olden, K. Rogers, R.E. Tharme, and A. Warner. In Press. The Ecological Limits of Hydrologic Alteration (ELOHA): A New Framework for Developing Regional Environmental Flow Standards. Freshwater Biology.
2. David, G.C., B.P. Bledsoe, D.M. Merritt, and E.E. Wohl. 2008. Impacts of Ski Slope Development on Stream Channel Morphology in the White River National Forest, CO. Geomorphology 103:375-388, doi:10.1016/j.geomorph.2008.07.003.
3. Craig, L.S., M.A. Palmer, D.C. Richardson, S. Filoso, E.S. Bernhardt, B.P. Bledsoe, M.W. Doyle, P.M. Groffman, B. Hassett, S.S. Kaushal, P.M. Mayer, S.M. Smith, and P.R. Wilcock. 2008. Stream Restoration Strategies for Reducing River Nitrogen Loads. Frontiers in Ecology & Environment 6, doi:10.1890/070080.
4. *Flores, A.N., B.P. Bledsoe, *C.O. Cuhaciyan, E.E. Wohl. 2006. Channel-Reach Morphology Dependence on Energy, Scale, and Hydroclimatic Processes with Implications for Prediction Using Geospatial Data. Water Resources Research 42, W06412, doi:10.1029/2005WR004226.
5. *Sanborn, S.C. and B.P. Bledsoe. 2006. Predicting Streamflow Regime Metrics for Ungauged Streams in Colorado, Washington, and Oregon. Journal of Hydrology 325:241-261.

(ii) 5 Other Significant Publications (*graduate advisee)

1. *Carney, S.K., B.P. Bledsoe, D. Gessler. 2006. Representing the Bed Roughness of Coarse-Grained Streams in Computational Fluid Dynamics. Earth Surface Processes and Landforms 31:736-749.
2. Poff, N.L., B.P. Bledsoe, *C.O. Cuhaciyan. 2006. Hydrologic Alterations Due to Differential Land Use Across the Contiguous United States: Geomorphic and Ecological Consequences for Stream Ecosystems. Geomorphology 79:264-285.
3. Bledsoe, B.P. 2002. Stream Erosion Potential Associated with Stormwater Management Strategies. ASCE Journal of Water Resources Planning and Management 128:451-455.

4. Bledsoe, B.P. and C.C. Watson. 2001. Effects of Urbanization on Channel Instability. Journal of the American Water Resources Association 37:255-270.
5. Bledsoe, B.P. and C.C. Watson. 2001. Logistic Analysis of Channel Pattern Thresholds: Meandering, Braiding and Incising. Geomorphology 38:281-300.

Synergistic Activities

- Fulbright Scholar in Chile,2008. Fulbright Scholar grant at the Centro EULA de Chile, Universidad de Concepción in Chile: conducted river research, lectured on watershed management, and participated in an interdisciplinary seminar focused on hydropower and environmental flows that balance ecosystem and human needs.
- Advising Faculty in the Graduate Degree Program in Ecology Faculty, Colorado State University
- Member of American Geophysical Union, American Society of Civil Engineers, American Water Resources Association, North American Benthological Society, American Society for Engineering Education, and the American Ecological Engineering Society,
- Reviewer for Water Resources Research, J. of Hydraulic Engineering, J. of Hydrologic Engineering, J. of the American Water Resources Association, J. of the North American Benthological Society, J. of Environmental Quality, Freshwater Biology, and J. of Hydrology
- Volunteer for the Women and Minorities in Engineering Program, Colorado Alliance of Minority Participation Research Conference, and Native American Student Services Summer Youth Experience at Colorado State University

Collaborators & Other Affiliations

(i) Collaborators and Other Affiliations (last 48 months): Paul Angermeier (Virginia Tech), Rebecca Atadero (CSU), Jill Baron (NREL, CSU), Derek Booth (Univ. of Washington), Ken Carlson (CSU), Jose Chavez (CSU), Martin Doyle (UNC-Chapel Hill), Alejandro Dussaillant (Universidad de Concepción, Chile), Omnia El-Hakim (CSU), Neil Grigg (CSU), Evelyn Habit (Universidad de Concepción, Chile), Cully Hession (Virginia Tech), Jennifer Hoeting (CSU), Terri Hogue (UCLA), Philip Kaufmann (US EPA), Matt Kondolf (Cal-Berkeley), Jim Loftis (CSU), Larry MacDonnell (UC-Boulder), Claudio Meier (Universidad de Concepción, Chile), David Merritt (USFS), Chris Myrick (CSU), Jeff Niemann (CSU), Vladimir Novotny (Northeastern Univ.), Julian Olden (Univ of Washington), Margaret Palmer (Univ. of Maryland), Oscar Parra (Universidad de Concepción, Chile), LeRoy Poff (CSU), David Raff (USBOR), Jorge Ramirez (CSU), Larry Roesner (CSU), Jose Salas (CSU), Eric Stein (So. Cal. Coastal Water Res. Proj.), Eric Stein (So. Cal. Coastal Water Res. Proj.), David Tarboton (Utah State Univ.), Colin Thorne (Univ. of Nottingham), Chris Thornton (CSU), Karan Venayagamoorthy (CSU), Evan Vlachos (CSU), Chester Watson (CSU), Ellen Wohl (CSU), Steven Wright (Univ. of Michigan).

(ii) Thesis Advisor and Postgraduate-Scholar Advisor:
M.S. Advisor - Dr. Ted Shear, Restoration Ecology Program, Department of Forestry, North Carolina State University
Ph.D. Advisors - Drs. Chester Watson and Neil Grigg, CSU Department of Civil Engineering, Dr. Ellen Wohl, CSU Department of Geociences, Dr. LeRoy Poff, CSU Department of Biology

(iii) Graduate and Post Doctoral Advisees (last 5 years out of 26 graduate and 3 post-doctoral advisees): Daniel Baker; Michael Brown; Andrew Bryden; Christopher Cuhaciyan; Erick Carlson; Shaun Carney; William DeRosset; David Dust; Alejandro Flores; Brian Haines; Robert Hawley; Elaina Holburn; Blair Hurst; John Meyer; Gabriel Miller, Radley Ott, Kevin Pilgrim, Jennifer Mueller Price; David Raff; Stephen Sanborn; Ben Snyder; Steven Yochum

David J. Cooper
Senior Research Scientist/Associate Professor
Forest, Rangeland and Watershed Stewardship
Colorado State University
Fort Collins, Colorado, 80523

davidc@cnr.colostate.edu
phone: 970-491-5430
fax: 970-491-1965

Academic Training

University of Colorado	Biology	Ph.D. 1983
University of Colorado	Biology	B.A. 1975

Professional Experience

2002-	Senior Research Scientist/Associate Professor, Department of Forest, Rangeland and Watershed Stewardship, Colorado State University
1996-	Advising Faculty, Graduate Degree Program in Ecology, Colorado State University, Fort Collins, Colorado 80523.
1992-2002	Research Scientist, Department of Earth Resources, Colorado State University
1987-1992	Assistant Research Professor. Department of Environmental Sciences and Engineering Ecology. Colorado School of Mines, Golden, CO.
1986-1992	Associate Professor Adjunct. University of Colorado at Denver, Denver, CO.
1984-1986	Summer Faculty; The Center For Northern Studies, Wolcott, Vermont.

Selected Awards and Honors

National Park Service, Intermountain regional director's award, 2004

National Park Service, Great Sand Dunes National Monument, Special Achievement Award, 2004

National Park Service, Water Resources Division, Certification of Appreciation, 2004.

The Nature Conservancy, Colorado Conservation Award. 1993.

US Senate Environment Committee, presentation during Clean Water Act reauthorization hearings, 1993.

US Senate Environment Committee, presentation during wetland delineation hearings, 1991.

EPA Region VIII, Outstanding Achievement Award. 1989.

Five Publications in Support of this Proposal

Sanderson, J. and D. J. Cooper. 2008**.** Ground water discharge by evapotranspiration in wetlands of an arid intermountain basin. *Journal of Hydrology*, 351: 344-359.

Shaw, J. and D. J. Cooper. 2008. Watershed and stream reach characteristics controlling riparian vegetation in semiarid ephemeral stream networks. *Journal of Hydrology* 350: 68-82.

Bilyeu, D. M., D. J. Cooper and N. T. Hobbs**.** 2007. Assessing effects of large herbivores on shrubs: tests of scaling factors for utilization rates from shoot-level measurements. *Journal of Applied Ecology* 44:168-176.

Westbrook, C.J., D.J. Cooper, B.W. Baker. 2006. Beaver dams and overbank floods influence groundwater-surface water interactions of a Rocky Mountain riparian area. *Water Resources Research* 42: W06404, doi:10.1029/2005WR004560.

Cooper D.J., J. Dickens, N. T. Hobbs, L. Christensen, L. A. Landrum. 2006. Hydrologic, geomorphic and climate controls on willow establishment in Rocky Mountain National Park, Colorado. *Hydrological Processes* 20: 1845-1864.

Five Other Publications

Birken, A. and D. J. Cooper. 2006. Processes of *Tamarix* invasion and floodplain development during the 20th century along the lower Green River. *Ecological Applications* 16: 1103-1120.

Williams, C.A. and D.J. Cooper. 2005**.** Mechanisms of riparian cottonwood decline along regulated rivers**.** *Ecosystems* 12**:** 382-395.

Andersen, D.C. and D.J. Cooper. 2000. Plant-herbivore-hydroperiod interactions: effects of native mammals on floodplain tree recruitment. *Ecological Applications* 10:1384-1399.

DeWine, J*. and D. J. Cooper. 2009. Habitat Overlap and Facilitation in Tamarisk and Box elder Stands: Implications for Tamarisk Control Using Native Plants. *Restoration Ecology* doi: 10.1111/j.1526-100X.2008.00494.x

Cooper, D.J., D.C. Andersen, R.A. Chimner. 2003. Multiple pathways for woody plant establishment on floodplains at local to regional scales. *Journal of Ecology* 91:182-196.

Synergistic Activities

Rocky Mountain Network National Parks, National Park Service, Science Advisory Panel.

Sierra Network National Parks, Inventory and Monitoring Program, science advisor.

Collaborators: Douglas Andersen (USGS), Bruce Baker (USGS), Lee MacDonald (Colorado State University), David M. Merritt (US Forest Service), Jack Schmidt (Utah State University), Cherie Westbrook (University of Saskatchewan), Scott Woods (University of Montana)

Graduate Students: Katie Driver, Lindsay Reynolds, Joanna Lemly, Cherie Westbrook, Jeremy Shaw, Lindsay Patterson, Danielle Bilyeu, Krista Northcott, John DeWine, Evan Wolf, Adam Birken, Edward Gage, Joyce Dickens, Christopher Williams, Rod Chimner, Scott Woods, Fred Wurster, Christopher Arp, David M. Merritt, Donald D'Amico, Shaunda K. Wenger, Patsy Barry, Craig Severn, Alison Deans, Jennifer McCurty, Brick Smith, Kelli Schuter

Thesis Advisor: John W. Marr (University of Colorado) (deceased).

Dr. Mark Fiege
Department of History
Colorado State University
Fort Collins, Colorado 80523
970-491-6468
mark.fiege@colostate.edu

(a) Professional Preparation

Western Washington University	History	B.A.	1981
Washington State University	History	M.A.	1985
University of Utah	History	Ph.D.	1994

(b) Appointments

William E. Morgan Chair of Liberal Arts, Colorado State University	2008-present
Walter Hines Page Fellow, National Humanities Center	2005-2006
Associate Professor of History, Department of History, Colorado State University	2000-present
Assistant Professor of History, Department of History, Colorado State University	1994-2000

(c.i) Publications

Mark Fiege, *Irrigated Eden: The Making of an Agricultural Landscape in the American West* (Seattle: University of Washington Press, 1999), pp. i-323 (co-winner Charles A. Weyerhauser Award, Forest History Society, for best book on forest and conservation history; winner Best Book Award, Idaho Library Association)

Mark Fiege, "The Weedy West: Mobile Nature, Boundaries, and Common Space in the Montana Landscape," *Western Historical Quarterly* 36 (Spring 2005), pp. 22-47 (winner of four best article prizes: Wayne D. Rasmussen Award, Agricultural History Society; Alice Hamilton Prize, American Society for Environmental History; Theodore C. Blegen Award, Forest History Society; Oscar O. Winther Award, Western History Association)

Mark Fiege, "Irrigation," In: *Encyclopedia of World Environmental History*, 3 vols., ed. Shepard Krech, John McNeil, and Carolyn Merchant (New York: Routledge, 2004), vol. 2, pp. 705-710

Mark Fiege, "Private Property and the Ecological Commons in the American West," in *Everyday America: Cultural Landscape Studies after J.B. Jackson*, ed. Chris Wilson and Paul Groth (Berkeley: University of California Press, 2003), pp. 219-331, 343-346

Mark Fiege, "Creating a Hybrid Landscape: Irrigated Agriculture in Idaho," *Illahee: Journal for the Northwest Environment* 11 (Spring/Summer 1995): 60-76; republished as: Mark Fiege, "Creating a Hybrid Landscape: Irrigated Agriculture in Idaho," in *Northwest Lands, Northwest Peoples: Readings in Environmental History*, ed. Dale Goble and Paul Hirt (Seattle: University of Washington Press, 1999), pp. 362-388

(c.ii) Publications

Mark Fiege, *The Republic of Nature: Chapters in the Environmental History of the United States, from the Pequot War to Hubbert's Peak* (draft book manuscript under review at University of Washington Press, projected publication date 2011), pp. 1-520

Mark Fiege, "The Atomic Scientists, the Sense of Wonder, and the Bomb," *Environmental History* 12 (July 2007), pp. 578-613

Mark Fiege, "Gettysburg and the Organic Nature of the American Civil War," in *Natural Enemy, Natural Ally: Toward an Environmental History of War*, ed. Richard P. Tucker and Edmund Russell (Corvallis: Oregon State University Press, 2004), pp. 93-109

Mark Fiege, "Wildlife and Irrigation Systems Along the Snake River, Idaho," in *Transactions of the Fifty-seventh North American Wildlife and Natural Resources Conference*, ed. Richard E. McCabe (Washington, D.C.: Wildlife Management Institute, 1992), pp. 724-732

Louis Swanson, Tony Cheng, Charles Davis, and **Mark Fiege**, *Forest and Rangeland Management in the Intermountain West: Emerging Opportunities for Collaboration* (Fort Collins: Colorado Institute of Public Policy at Colorado State University, 2006), pp. 1-15

(d) Synergistic Activities

Co-Founder and current Director, Center for Public History and Archaeology, College of Liberal Arts, Colorado State University

Member, Water and Agricultural Resources Archive advisory committee, Morgan Library, Colorado State University

Collaborator with Principal Investigator Dr. David Cooper, Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University, "Comparative Ecology and Environmental History of Natural and Anthropogenic Meadows, Tatra Mountains (Poland and Slovakia) and Rocky Mountains (USA)," under the supervision of Dr. Ben Bobowski, National Park Service, Rocky Mountain National Park

Principal Investigator with Research Associate Maren Bzdek, Center for Public History and Archaeology, Colorado State University, "National Park Service Administrative and Environmental History of Livestock Grazing," under the supervision of Chris Ford, Grant-Kohrs National Historic Site, Deer Lodge, Montana

Principal Investigator with Research Associate Maren Bzdek and Research Assistant Cori Knudten, "Environmental History of Pecos National Historic Site," under the supervision of Dr. Bob Spude, Dr. Rob Bennett, and Dr. Jeff Albright, National Park Service

(e) Collaborators and Other Affiliations

My graduate adviser and postdoctoral sponsor:

Dr. Richard White, Department of History, Stanford University (doctoral adviser)

Dr. William Cronon, Department of History, University of Wisconsin (book editor and adviser)

My graduate students:

Dr. Craig Boardman, John Glenn School of Public Affairs, Ohio State University (M.A. program adviser)

Dr. Brian Collier, Institute for Educational Initiatives, Notre Dame University (M.A. program adviser)

Dr. Sean Crotty, Department of Political Science, University of Missouri, Columbia (M.A. thesis adviser)

In addition to Boardman, Collier, and Crotty, advised a total of 28 M.A. history graduate students (thesis and non-thesis) during the years 1994-2009

Collaborators and Co-Editors

Dr. Jeff Albright	Dr. Charles Davis
Dr. Rob Bennetts	Chris Ford, M.A.
Dr. Ben Bobowski	Cori Knudten, M.A.
Maren Bzdek, M.A.	Dr. Bob Spude
Dr. Tony Cheng	Dr. Louis Swanson
Dr. David Cooper	

Joshua Howard Goldstein
Department of Human Dimensions of Natural Resources
Warner College of Natural Resources
Colorado State University
Fort Collins, CO 80523
Email: joshua.goldstein@colostate.edu; Phone: (970) 491-5220

(a) Professional Preparation

Williams College	Biology	B.A. 2000
Stanford University	Environment & Resources	Ph.D. 2007
Stanford University	Postdoctoral Researcher: Conservation Policy & Finance	July 2007 – July 2008

(b) Appointments

Assistant Professor, Human Dimensions of Natural Resources August 2008 – Present
Colorado State University

(c) Publications

Closely Related Publications

Daily, G. C., Polasky, S., **Goldstein, J.H.**, Kareiva, P.M., Mooney, H.A., Pejchar, L., Ricketts, T.H., Salzman, J., and Shallenberger, R. (2009). Ecosystem services in decision-making: time to deliver. *Frontiers in Ecology and Environment* 1(7): 21-28.

Nelson, E., Mendoza, G., Regetz, J., Polasky, S., Tallis, H., Cameron, D.R., Chan, K.M.A., Daily, G., **Goldstein, J.,** Kareiva, P., Lonsdorf, E., Naidoo, R., Ricketts, T.H., and Shaw, M.R. (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and Environment* 1(7): 4-11.

Goldstein, J.H., Pejchar, L., and Daily, G.C. (2008). Using return-on-investment to guide restoration: a case study from Hawaii. *Conservation Letters* 1(5): 236-243.

Fischer, J., Brosi, B., Daily, G.C., Ehrlich, P.R., Goldman, R., **Goldstein, J.H.**, Manning, A.D., Mooney, H.A., Pejchar, L., Ranganathan, J., and Tallis, H. (2008). Should agricultural policies encourage land-sparing or wildlife-friendly farming? *Frontiers in Ecology and Environment* 6, DOI: 10.1890/070019.

Goldstein, J. H., Daily, G.C., Friday, J.B., Matson, P.A., Naylor, R.L., and Vitousek, P. 2006. Business strategies for conservation on private lands: koa forestry as a case study. *Proceedings of the National Academy of Sciences* 103(26): 10140-10145.

Other Significant Publications

Chan, K.M.A., **Goldstein, J.H.,** Satterfield, T., Hannahs, N., Kikiloi, K., Naidoo, R., and Woodside, U. (In Press). Cultural services and existence value. Chapter 12 in: Kareiva, P., Daily, G., Ricketts, T., Tallis, H., and Polasky. S (eds.). *The Theory and Practice of Ecosystem Service Valuation*. Oxford University Press.

Polasky, S., Caldarone, G., Duarte, T.K., **Goldstein, J.**, Hannahs, N., Ricketts, T., and Tallis, H. (In Press). Putting InVEST to work: conservation, management, and tradeoffs. Chapter 14 in: Kareiva, P., Daily, G., Ricketts, T., Tallis, H., and Polasky. S (eds.). *The Theory and Practice of Ecosystem Service Valuation*. Oxford University Press.

Pejchar, L., **Goldstein, J.H.,** and Daily, G.C. 2007. Making restoration profitable on private land: Koa forestry on Hawaii Island. Chapter 25 in: Aronson, J., Milton, S., and Blignaut, J. (editors) *Restoring Natural Capital: Science, Business, and Practice*. Island Press, Washington, D. C.

(d) Synergistic Activities

Policy Involvement: Participated on a Steering Committee that proposed ideas for new conservation incentives for private landowners in the State of Hawaii to align conservation and economic opportunities. Co-led writing of final report submitted to the Legislature in 2007.

Policy Involvement: Developing a forest-based carbon offset program for the State of Hawaii. This collaborative work involves colleagues from Stanford University, The Nature Conservancy, United States Forest Service, private landowners, an energy utility company, and other stakeholders. Co-edited a technical report submitted to the State of Hawaii's Greenhouse Gas Emissions Reduction Task Force on the potential contribution of emissions reduction from native forest restoration in helping to meet the State's climate goals.

Education: Developed new courses on ecosystem services at the undergraduate and graduate levels.

Outreach: Gave invited presentations on ecosystem services to the China Protected Areas Leadership Alliance, the United States Forest Service, R2 Region, and a group of local leaders from San Cristobal de las Casas (Mexico). Co-led a workshop on ecosystem services in Cerro Punta, Panama involving conservation partners from Costa Rica and Panama.

(e) Collaborators & Other Affiliations

Collaborators and Co-Editors: Berry Brosi (Stanford University), Dick Cameron (The Nature Conservancy), Kai Chan (Univ. of British Columbia), Gretchen Daily (Stanford University), Paul Ehrlich (Stanford University), Joern Fischer (Australian National University), James Friday (Univ. of Hawaii, Manoa), Rebecca Goldman (The Nature Conservancy), Neil Hannahs (Kamehameha Schools), Peter Kareiva (The Nature Conservancy), Kekuewa Kikiloi (Kamehameha Schools), Eric Lonsdorf (Lincoln Park Zoo), Adrian Manning (Australian National University), Pamela Matson (Stanford University), Guillermo Mendoza (Army Corps of Engineers), Hal Mooney (Stanford University), Robin Naidoo (World Wildlife Fund), Erik Nelson (Stanford University), Rosamond Naylor (Stanford University), Liba Pejchar (Colorado State University), Stephen Polasky (Univ. of Minnesota), Jai Ranganathan (Univ. of California, Santa Barbara), James Regetz (National Center for Ecological Analysis and Synthesis), Taylor Ricketts (World Wildlife Fund), James Salzman (Duke University), Terre Satterfield (Univ. of British Columbia), Robert Shallenberger (The Nature Conservancy), Rebecca Shaw (The Nature Conservancy), Heather Tallis (Stanford University), Peter Vitousek (Stanford University), Ulalia Woodside (Kamehameha Schools).

Graduate and Postdoctoral Advisors: Gretchen Daily (primary Ph.D. advisor and postdoctoral advisor; Stanford University), Pamela Matson (Stanford University), Rosamond Naylor (Stanford University), Peter Vitousek (Stanford University)

Thesis Advisor and Postgraduate-Scholar Sponsor: Megan Christensen (M.Sc. candidate), Esther Duke (M.Sc. candidate).

Pierre Y. Julien, Ph.D., P. Eng.

Professor of Civil and Environmental Engineering
Colorado State University
Fort Collins, Colorado
Tel: (970)-491-8450, Fax (970)-491-7008, email: Pierre@engr.colostate.edu

Professional Preparation

B.Sc. Civil Engineering, Laval University, Canada, 1977
M.Sc. Civil Engineering, Laval University, Canada, 1979
Ph.D. Civil Engineering, Laval University, Canada, 1983

Appointments

Tenured Full Professor, Dept. of Civil Engineering, CSU, 1995-present.
Coordinator - Hydraulics and Wind Engineering Div., Dept. of Civil Engineering, CSU, 1997-
Associate Dean for International Research and Development, 2006-07.

Publications

Recent publications most relevant to proposed research

Leon, C., P.Y. Julien and D.C. Baird, "Case Study: Equivalent Widths of the Middle Rio Grande, New Mexico" ,Journal of Hydraulic Engineering, ASCE, Vol.135, No. 4, 2009, pp. 306-315.

Velleux, M.L., J.F. England Jr. and P.Y. Julien, "TREX: Spatially Distributed Model to Assess Watershed Contaminant Transport and Fate", Journal of Science in the Total Environment, Vol. 404, 2008, pp. 113-128.

Rojas, R., P.Y. Julien, M. Velleux and B.E. Johnson, "Grid Size Effect on Watershed Soil Erosion Models", Journal of Hydrologic Engineering, ASCE, Vol. 134, No. 9, 2008, pp.

Guo, J. and P.Y. Julien, "Applications of the Modified Log-wake Law in Open Channels", Journal of Applied Fluid Mechanics, Vol. 1, No. 2, 2008, pp. 17-23. ISSN 1735-3645. Available at www.jafmonline.net.

England, J.F. Jr., Velleux, M.L. and Julien, P.Y. "Two-dimensional simulations of extreme floods on a large watershed", Journal of Hydrology, 347(1-2), 2007, pp. 229-241. doi:10.1016/j.jhydrol.2007.09.034.

Other relevant publications

Park, S.K., P. Y. Julien, U. Ji and J.F. Ruff, "Case-study: Pier Scour Protection for the Gupo and Subway Bridges on the Lower Nakdong River, South Korea" , Journal of Hydraulic Engineering, ASCE, Vol.134, No. 11, 2008, pp.1639-1650.

Bhowmik, N., E.V. Richardson and P.Y. Julien, "Daryl B. Simons - Hydraulic Engineer - Researcher and Educator", Forum Article, Journal of Hydraulic Engineering, ASCE, Vol. 134, No. 3, 2008, pp. 287-294.

Kane, B. and P.Y. Julien, "Specific Degradation of Watersheds", International Journal of Sediment Research, Vol. 22, No. 2, 2007, pp. 114-119.

Synergistic Activities

- Editor 2002-05, ASCE- Journal of Hydraulic Engineering and Member of the Environmental Water Resources Institute Council (EWRI).
- Professional engineer registration and member of the Ordre des Ingénieurs, Québec, Canada (P. Eng. License # 32325).
- Member of the UNESCO IHP-International Sediment Initiative.

• Life member of the U.S. Committee on Irrigation and Drainage (USCID) and the United States Society on Dams (USSD), formerly, the U.S. Committee on Large Dams (USCOLD).
• Member of the American Society of Civil Engineers (ASCE # 239111), the American Society of Agricultural Engineers (ASAE # 21687), the International Association for Hydraulic Research (IAHR # 5149), the American Geophysical Union (AGU), the American Society on Engineering Education (ASEE), and the International Water Resources Association (IWRA).

Recent Collaborators:
Drew Baird, US Bureau of Reclamation Albuquerque, Will Clements, CSU, Cassie Clumpp, US Bureau of Reclamation, Phil Combs, ERDC-WES, Jim Dunne, EPA Region VIII, Linda Figueroa, Colorado School of Mines, Marcel Frenette Laval University Canada, Chris Gorbach, US Bureau of Reclamation Albuquerque, Blair Greimann, US Bureau of Reclamation, Don Macalady, Colorado School of Mines, Roger Pielke, CSU, Jorge Ramirez, CSU, E.V. Richardson, Ayres and Associates, Jean Rousselle, Ecole Polytechnique Montreal Canada, Jose Salas, CSU, Charles Shackelford, CSU, Daryl Simons, Simons and Associates, Sally Sutton, CSU, Tom VonderHaar, CSU, Tom Wildeman, Colorado School of Mines, Ellen Wohl, CSU, Sandra Woods, CSU, Ted Yang, CSU.

Graduate Advisers: Marcel Frenette (M.Sc. and Ph.D.) Laval University, Canada. Post-doc Advisor: Daryl B. Simons, Colorado State University.

Thesis Adviser and Postgraduate-Scholar Sponsor
Ph.D. advisees: Total number of Ph.D. students advised including current advisees - 40.
In recent years: D. Molnar (Noss), Ph.D.('97); B. Johnson, Ph.D.('97); J. Guo, Ph.D., ('98); J. Jorgeson, Ph.D. ('99); A. Sharma, Ph.D., ('00); G. Richard, Ph.D., ('01); R. Rojas, Ph.D. ('02); S. Akalin, Ph.D. ('02); B. Bounvilay, Ph.D. ('02); C. Leon, Ph.D. ('03); B. Kane, Ph.D. ('03); M. Velleux, Ph.D. ('05); J. England, Ph.D. ('06), U. Ji ('06), Y.H. Shin ('07), S. Shah Fairbank ('08), and the following are in progress: K.M. Lim, J. Halgren, M. Weinhold, J. Kim, S.D. An, C. Bernedo, P. O'Brien, A. Jazuri and N. Shazwani.

M.S. and M.Eng. advisees: Total number of M.S. students advised including current advisees – 42.
In recent years: K. Klimek, M.S. ('97); C. Leon, M.S. ('98); T. Bauer, M.S., ('99); H. Hussain, M.S., ('99); J. Spah, M.S. ('99); L. Tysdal, M.S. ('99); M. Weinhold, M.S., ('01); M. Sixta M.S. ('03); J. Duncan ('03); A. Mendelsberg ('03); J. Albert ('04); F. Jay ('05); S. Novak ('05); D. Kang ('05); S. Shah ('05); C. Vensel ('05); L. Babbitt ('05), H.S. Kim ('06), T. Randall ('06), A. Gingerich ('06), A. Leblanc ('07), A. Larsen ('07), N. Friesen ('07), L.Shawcross ('08), S. Parker ('08), D. Oliphant ('08), and C. Michalos ('09).

Post-Graduate Scholars hosted/sponsored in the last 5 years:
Dr. Rosalia Rojas-CG-AR/EPA-HSRC, Prof. H.S. Lee, Hanbat University, South Korea Prof. Sang-Kil Park Pusan National University, Prof. Hyun-Suk Shin, Pusan National University, Prof. Suk-Hwan Jang, Daejin University, Vice-Pres. Chao Liu, Yangzhou University, China, J. Montoya, Universidad Valencia, Spain, Prof. C.K. Jun, Kangwon University, South Korea, Anna Paris, University of Trento, Italy, Duangrudee Kositgittiwong, KMUTT, Thailand.

Biographical Sketch, STEPHANIE K. KAMPF

Assistant Professor, Department of Forest, Rangeland, and Watershed Stewardship
Colorado State University, Fort Collins, CO 80523-1472
phone 970-491-0931 • fax 970-491-6754 • email skampf@warnercnr.colostate.edu

i. Professional Preparation

Williams College	Geosciences	B.A. 1998
University of Nevada, Reno	Hydrogeology	M.S. 2002
University of Washington	Civil and Environmental Engineering	Ph.D. 2006

ii. Appointments

January, 2007-present, Assistant Professor of Watershed Science, Colorado State University

iii. Publications

Related to proposal

Mirus, B., K. Loague, J. VanderKwaak, S. Kampf, S. Burges, 2009. A hypothetical reality of Tarrawarra-like hydrologic response. *Hydrological Processes* doi:10.1002/hyp.7241.

Kampf, S.K. and S.J. Burges, 2007a. A framework for classifying and comparing distributed hillslope and catchment hydrologic models. *Water Resources Research*. 43, W05423, doi:10.1029/2006WR005370.

Kampf, S.K. and S.J. Burges, 2007b. Parameter estimation for a physics-based distributed hydrologic model using measured outflow fluxes and internal moisture states. *Water Resources Research* 43, W12414, doi:10.1029/2006WR005605.

Kampf, S.K. and S.W. Tyler, 2006. Spatial characterization of evaporation and land surface energy fluxes at the Salar de Atacama, Northern Chile using ASTER image classification. *Advances in Water Resources* 29: 336-354.

Kampf, S.K., S.W. Tyler, C. Ortiz, J.F. Muñoz, and P. Adkins, 2005. Evaporation and land surface energy budget at the Salar de Atacama, Northern Chile. *Journal of Hydrology* 310, pp. 236-252.

Selected other publications

Handcock, R.N., Gillespie, A., Cherkauer, K.A., Kay, J.E., Burges, S.J., Kampf, S.K., 2006. TIR remote sensing of stream temperatures at multiple spatial scales. *Remote Sensing of Environment.* 100, pp. 427-440.

Kay, J.E., S.K. Kampf, R.N. Handcock, K.A. Cherkauer, A.R. Gillespie, and S.J. Burges, 2005. Accuracy of lake and stream temperatures determined from thermal-infrared imagery. *Journal of the American Water Resources Association,* October, pp. 1161-1175.

Kampf, S.K., M. Salazar, and S.W. Tyler, 2002. Preliminary investigations of effluent drainage from mining heap leach facilities. *Vadose Zone Journal* 1:186-196.

iv. Synergistic Activities

(a) Teaching:

WR/CIVE 524 Modeling Watershed Hydrology: Developed all new course content in this graduate level course that introduces students to major concepts and skills in hydrologic modeling with an emphasis on the conceptual foundation of existing models.

WR 416 Land Use Hydrology: Updated course content for this senior level hydrology course.

WR 304 Principles of Watershed Management: Developed all new course content in this service course, which provides an introduction to hydrology and watershed management. Class exercises were organized around understanding the hydrology and management of the local watershed.

GR 210 Physical Geography: Designing course to provide a broad introduction to physical geography for incoming students. Creating interactive class activities that will be posted as a publicly accessible resource for other geography instructors.

WR 440 Watershed Problem Analysis: Instruction of hydraulic design portion of this senior capstone course.

WR 420 Waterhsed Practicum: Lead instructor or participant in this field course introducing students to water-related issues around the state of Colorado.

(b) Service:

Peer reviewing for National Science Foundation, Water Resources Research, Journal of Hydrology, Advances in Water Resources, Journal of Hydrometeorology, Hydrological Processes, Ecohydrology, Climatic Change, Journal of Water Resources Planning and Management, Restoration Ecology, Journal of the American Water Resource Association

v. Collaborators & Other Affiliations

(a) Collaborators:

Colorado State University: Jill Baron, Bill Bauerle, David Cooper, Steven Fassnacht, Dennis Harry, Julia Klein, Michael Lefsky, LeRoy Poff, Ellen Wohl
University of Washington: Nicoleta Cristea, Alan Gillespie
Stanford University: Keith Loague, Ben Mirus
Natural Resource Consulting Engineers: Jordan Lanini
Purdue University: Keith Cherkauer
CSIRO, Australia: Rebecca Handcock
National Center for Atmospheric Research: Jennifer Kay
Universidad Católica de Chile: José Muñoz, Cristian Ortiz

(b) Graduate advisors:

PhD, Stephen J. Burges, University of Washington
MS, Scott Tyler, University of Nevada, Reno

(c) Thesis advisor and postgraduate-scholar sponsor:

(i) Postdoctoral associate (1): Peter Furey
(ii) MS students (2): Eric Richer, Pedro Lopez

Biographical Sketch

Dr. Christian D. Kummerow

a. Professional Preparation

University of California	Physics	A.B. 1982
University of Minnesota	Atmospheric Physics	Ph.D. 1987

b. Appointments

2000-present; Associate Professor, Colorado State University
1991 – 2000; Research Scientist, NASA/GSFC
1988 – 1991; Research Scientist, Universities Space Research Association, NASA/GSFC
1987 – 1988; Research Scientist, General Sciences Corporation, NASA/GSFC

c. Publications

(i) Related Publications

Kummerow, C., Y. Hong, W. S. Olson, S. Yang, R. F. Adler, J. McCollum, R. Ferraro, G. Petty, D. –B. Shin, and T. T. Wilheit, 2001. The evolution of the Goddard Profiling Algorithm (GPROF) for rainfall estimation from passive microwave sensors, *J. of Appl. Meteorol.*, **40**, 1801-1820.

Bell, T., P. Kundu and C. Kummerow, 2001. Sampling errors of SSM/I and TRMM rainfall averages: comparison with error estimates from surface data and a simple model, *J. Appl. Meteorol.*, **40**, 938-954.

Kummerow, C., J. Simpson, O. Thiele, W. Barnes, A.T.C. Chang, E. Stocker, R. F. Adler, A. Hou, R. Kakar, F. Wentz, P. Ashcroft, T. Kozu, Y. Hong, K. Okamoto, T. Iguchi, H. Kuroiwa, E. Im, Z. Haddad, G. Huffman, T. Krishnamurti, B. Ferrier, W.S. Olson, E. Zipser, E.A. Smith, T.T. Wilheit, G. North, K. Nakamura, 2000. The status of the tropical rainfall measuring mission (TRMM) after two years in orbit, *J. of Appl. Meteorol.*, **39**, 1965-1982.

Hou, A. Y., D. V. Ledvina, A. M. da Silva, S. Q. Zhang, J. Joiner, R. M. Atlas, G. J. Huffman and C. D. Kummerow, 2000. Assimilation of SSM/I-derived surface rainfall and total precipitable water for improving the GEOS analysis for climate studies, *Mon. Wea. Rev.*, **128**(3), 509-537.

Kummerow, C., 1998. Beamfilling errors in passive microwave rainfall retrievals, *J. Appl. Meteorol.*, **37**, 356-370.

(ii) Other significant publications

Viltard, N, C. Kummerow, W. S. Olson, and Y. Hong, 2000. Combined use of the radar and radiometer of TRMM to estimate the influence of drop size distribution on rain retrievals, *J. Appl. Meteorol.*, **39**, 2103-2114.

Roberti, L. and C. Kummerow, 1999. Monte Carlo calculations of polarized microwave radiation emerging from cloud structures, *J. Geophys. Res.*, **104**, 2093-2104.

Hong, Y., C. Kummerow, and W. S. Olson, 1999. Separation of convective/stratiform precipitation using microwave brightness temperature, *J. Appl. Meteorol.*, **38**, 1195-1213.

Kummerow, C., W. S. Olson and L. Giglio, 1996. A simplified scheme for obtaining precipitation and vertical hydrometeor profiles from passive microwave sensors, *IEEE Trans. on Geosci. and Remote Sensing*, **34**, 1213-1232.

Kummerow, C. and L. Giglio, 1995. A method for combining passive microwave and infrared observations, *J. Atmos. Ocean Tech.*, **12**, 33-45.

d. Synergistic Activities

(i) TRMM project scientist
(ii) Eddington radiative transfer code
(iii) Distribution of rainfall products and algorithmic code to U.S. and foreign researchers
(iv) Chaired and organized numerous scientific conferences and meetings including: The 3rd Int'l Asia-Pacific Environmental Remote Sensing Symposium on Microwave Remote Sensing of the Atmosphere and Environment III; The 7th International Conference on Precipitation; The 8th Scientific Assembly of the International Association of Meteorology and Atmospheric Sciences; TRMM Scientific Team Meeting; Various Global Precipitation Mission meetings

e. Collaborators and Other Affiliations

(i) Collaborators

Adler, Robert F., NASA/GSFC; *Ashcroft, P.*, Remote Sensing Systems; *Atlas, Robert*, NASA/GSFC; *Baptista, J.P.V. Polares*, European Space Agency/ESTEC, Netherlands; *Barnes, W.*; NASA/GSFC; *Bauer, Peter*, ECMWF; *Bell, Thomas L.*, NASA/GSFC; *Berg, Wesley*, Colorado State University; *Chang, A. T. C.*, NASA/GSFC; *Cifelli, Robert*, Colorado State University; *Correa-Torres, Ricardo*, Florida State University; *da Silva, Arlindo M.*, NASA/GSFC; *Ferraro, R.*, NOAA/NESDIS; *Ferrier, B.*, University of Maryland; *Gage, Kenneth*, NOAA; *Haddad, Z.*, Jet Propulsion Laboratory; *Haferman, Jeffrey*, Fleet Numerical Meteorology and Oceanography Center; *Halverson, J.*, NASA/GSFC; *Hong, Ye*, The Aerospace Corporation; *Hou, Arthur*, NASA/GSFC; *Huffman, G.*, Science Systems and Applications, Inc.; *Iguchi, T.*, Communications Research Laboratory, Japan; *Im, Eastwood*, Jet Propulsion Laboratory; *Kakar, Ramesh*, NASA Headquarters; *Khain, A.*, The Hebrew University of Jerusalem, Israel; *Kozu, T.*, Shimane University, Japan; *Krajewski, Witold*, The University of Iowa; *Krishnamurti, T. N.*, Florida State University; *Marzano, Frank*, Universita dell Aquila, Italy; *Meneghini, R.*, NASA/GSFC; *Mugnai, Albert; Nakamura, K.*, Nagoya University, Japan; *North, G.*, Texas A&M University; *Okamoto, K.*, Communications Research Laboratory, Japan; *Olson, William*, Joint Center for Earth Systems Technology, University of Maryland; *Panegrossi, Guilia*, University of Wisconsin; *Petty, G.*, University of Wisconsin; *Shin, Dong-Bin*, Colorado State University; *Simpson, Joanne*, NASA/GSFC; *Smith, Eric A.*, NASA/GSFC; *Stocker, Erich*, NASA/GSFC; *Tao, W. K.*, NASA/GSFC; *Tokay, Ali*, NASA/GSFC; *Turk, F. Joseph*, Naval Research Laboratory; *Viltard, Nicolas*, CETP, France; *Wentz, F.*, Remote Sensing Systems; *Williams, Christopher*, NOAA; *Wilheit, Thomas T.*, Texas A&M University; *Yang, Song*, Joint Center for Earth Systems Technology, University of Maryland; *Zipser, E.*, University of Utah

(ii) Graduate and Postdoctoral Advisors

James A. Weinman, NASA/GSFC – on sabbatical at the University of Washington

(iii) Thesis Advisor and Postgraduate-Scholar Sponsor

Sean Miner, Sarah Finn, Anita Rapp	M.S. graduate student – in progress
Philip Poyner	M.S., 2002, U.S. Air Force
Brian Griffith	Ph.D. graduate student – in progress
Alessandro Battaglia	postdoctoral, University of Ferrara, Italy
Carlos Morales	postdoctoral, Universidade de São Paulo
Hirohiko Masunaga	postdoctoral, Colorado State University

MELINDA JEAN LAITURI
Associate Professor, Department of Forest, Rangeland, and Watershed Stewardship
Associate Dean, Academic Affairs, Warner College of Natural Resources
Colorado State University
Ft. Collins, CO 80523 USA
Phone: 970/491-0292
E-mail: mell@cnr.colostate.edu

I. Professional Preparation

University of California, Berkeley	Geography	BA	1979
California State University, Chico	Hydrology	MS	1985
University of Arizona, Tucson	Geography	PhD	1993
University of Auckland, New Zealand	Post Doctoral Fellow		1993 – 1994

II. Appointments

2006-present	Associate Dean Academic Affairs, Warner College of Natural Resources
2005-2006	Program Officer, Geography and Regional Science, National Science Foundation
2001-present	Associate Professor, Dept. of Forest, Rangeland, and Watershed Stewardship, Colorado State University
1995-2001	Assistant Professor, Dept. of Earth Resources, Colorado State University
1994-1995	Lecturer, Dept. of Geography, University of Auckland, New Zealand

III. Selected Publications

Five publications related to this proposal

Laituri, M. and Kodrich, K. 2008. On Line Disaster Response Community: People as Sensors of High Magnitude Disaster Using Internet GIS. *Sensors*, 8, 3037-3055. http://www.mdpi.org/sensors/papers/s8053037.pdf

Kodrich, K. and Laituri, M. 2006. The Tsunami and the Internet: The Role of New Media Technologies in Disaster Awareness and Relief. *International Journal of Technology, Knowledge and Society*, 1(3): 53-62.

Alessa, L., Laituri, M., and Barton, M. 2006. An "All Hands" Call to the Social Science Community: Establishing a Community Framework for Complexity Modeling Using Agent Based Models and Cyberinfrastructure. *Journal of Artificial Societies and Social Simulation* 9(4) <http://jasss.soc.surrey.ac.uk/9/4/6.html>

Flanagan, C. and Laituri, M. 2004. Local cultural knowledge and water resource management: the Wind Rivers Indian Reservation, *Environmental Management* 33(2) February:262-270. http://www.springerlink.com/content/q9nh453lggme0c4w/fulltext.pdf

Laituri, M. 2003. The issue of access: an assessment guide for evaluating public participation geographic information science case studies, *Journal of the Urban and Regional Information Systems Association vol. 15, APA II, 25 - 31.* http://www.urisa.org/files/Laiturivol15apa2-3.pdf

Additional publications related to this proposal

Laituri, M. and Harvey, L.E. 1995. Bridging the space between indigenous ecological knowledge and New Zealand conservation management using GIS, In: Nature Conservation: The Role of Networks, D. Saunders, J. Craig, and E. Mattiske, eds., NSW: Surrey Beatty and Sons, pp. 122-31.

Hochstetler, K. and M. Laituri, Methods in International Environmental Politics. In Palgrave Advances in International Environmental Politics, edited by Michele Betsill, Kathryn Hochstetler, and Dimitris Stevis. Hampshire, UK: Palgrave MacMillan, 2006. Pages 82-109.

Laituri,M. 2000, Cultural perspectives of floods, In E. Wohl, ed., Inland Flood Hazards: Human, Riparian and Aquatic Communities, Cambridge University Press, pp. 451-68.

IV. Synergistic Activities

Each year my graduate geographic information systems (GIS) students partner with a selected organization or group to develop online, demonstration projects using GIS. The outcome of these activities can be found at the following sites:

- Colorado State University (CSU) and Poudre School District (PSD) Spatial Information Technologies and Geographic Education Partnership, http://welcome.warnercnr.colostate.edu/avprojects/csu-psd/

Hands on GIS projects for K-12 teachers to use in their classroom to meet the science, math and geography education standards.

- Colorado State University (CSU) and GLOBE Spatial Information Technologies and Geographic Education Partnership, http://welcome.warnercnr.colostate.edu/avprojects/globe/

Demonstration geospatial projects that use GLOBE data from schools around the world the give examples of how spatial data can be analyzed and described for scientific inquiry.

- National Science Foundation Biocomplexity Education, Puerto Rico: El Yunque National Forest, http://biocomplexity.warnercnr.colostate.edu/nr505_biocomplexity.htm

Demonstration geospatial projects that include GIS, geovisualization, and agent-based modeling for use by teachers and resource managers to understand biocomplexity science.

- GIS and the National Park Service: A joint project with Warner College of Natural Resources, Colorado State University, http://welcome.warnercnr.colostate.edu/static_pages/avprojects/web/nps07/

Demonstration geospatial projects that provide examples of how National Park Service data can be used by different audiences to better understand resource management issues.

V. Collaborators and Other Affiliations

T. Crowl, Dept of Biology, Utah State University; T. Nygeres, Geography Department, U of Washington; J. Ramirez, Civil Engineer Dept, Colorado State University; F. Scatena, U of Penn

VI. Graduate and Postdoctoral Advisors

Andrew Kirby, Arizona State University
Chris Cocklin, Melbourne University

VII. Thesis Advisor and Postgraduate Scholar Sponsor

Graduate students: 30 advised
Diane Abendroth, NPS, Cory Bolen, NPS, Angie Henn, USFS, Karin Howland, Dept of Wildlife, Ryan Jensen, CSU, Matt Lineal, CSU, Cinda Murdock, USGS, Chris Peltz, USGS, Jill Terlaak, CSU, Alisa Wade, U of Montana, Kristie Vanden Bosch, Boulder County, Shelley Street, CSU, Bao Tran, CSU, Karen Weinbaum, UCB, Erin Poston, CSIRO, Brent Read, Private Consultant, Kirk Sherrill, CSU

John B. Loomis, Professor
Department of Agricultural and Resource Economics
Colorado State University, Fort Collins, CO 80523-1172
(970) 491-2485 Email: jloomis@lamar.colostate.edu

EDUCATION

California State University, Northridge	Economics	B.A.	8/75
California State University, Northridge	Economics	M.A.	1/77
Colorado State University	Economics	Ph.D.	8/80 to 12/83

APPOINTMENTS

8/93 to present: Professor, Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO.

8/85 to 7/93: Associate Professor, Division of Environmental Studies & Department of Agricultural Economics, University of California, Davis, CA.

3/80 to 7/85: Economist, U.S. Department of Interior, U.S. Fish and Wildlife Service, Ft. Collins, CO.

PROJECT RELATED PUBLICATIONS

Loehman, E. and **J. Loomis**. 2008 Instream Flow as a Public Good: Possibilities for Economic Organization and Voluntary Local Provision. *Review of Agricultural Economics.* , 30(3): 445-456.

Loomis, J. Importance of Including Use and Passive Use Values in River and Lake Restoration. *Journal of Contemporary Water Research and Education,* #134: 4-8. July 2006.

Scheierling, S., **J.Loomis** and R. Young. 2006.. Irrigation Water Demand: A Meta-Analysis of Price Elasticities. *Water Resources Research*, Vol 42, W01411: 1-9.

Loomis, J., A. Smith and P. Huszar. 2005. Estimating the Economic Benefits of Maintaining Residential Lake Levels at an Irrigation Reservoir: A Contingent Valuation Study. *Water Resources Research*, Vol 41, W0805: 1-9.

Loomis, J. P. Kent, E. Strange, K. Fausch, and A. Covich. .Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey. *Ecological Economics.* 33, pp. 103-117. With Paula Kent, 2000.

OTHER SIGNIFICANT PUBLICATIONS

Loomis, J. Water Transfer and Major Environmental Provisions of the Central Valley Project Improvement Act: A Preliminary Economic Evaluation. *Water Resources Research*, Volume 30(6):1865-1871, June 1994.

Hoehn, J. and **J. Loomis.** 1993. Substitution Effects in the Valuation of Multiple Environmental Programs. *Journal of Environmental Economics and Management*: 25: 56-75.

Loomis, J. and G. Helfand 2001. *Environmental Policy Analysis for Decision Making*. Kluwer Academic Publishers.

Loomis, J. *Integrated Public Lands Management: Principles and Applications to National Forests, Parks and Wildlife Refuges, and BLM Lands*. Columbia University Press, New York, NY. 1993. 2nd Edition. 2002.

Loomis, J. Vertically Summing Public Good Demand Curves: An Empirical Comparison of Economic versus Political Jurisdictions. *Land Economics*, 76 (2): 312-321. 2000

Synergistic Activities

Our methodological advances in non-market valuation are widely used. My coauthor and I were one of the first economists to introduce count data travel cost models, an approach that has become the

standard for trip frequency demand models of water based recreation. My coauthors and I were instrumental in adapting an approach to estimate confidence intervals with discrete choice contingent valuation. This technique was widely used in the 1990's.

My research on recreation valuation has been utilized by federal agencies such as the U.S. Forest Service (USFS) for their land management plans. My non-market valuation has been funded and utilized by agencies such as the U.S. Bureau of Land Management (BLM) for their land use plans in Wyoming. I was funded to perform a non-market economic analysis of two high profile dam removal with the results being included in the two agencies Environmental Impact Statements (U.S. Army Corps of Engineers and the National Park Service). I have been repeatedly invited to participate as an instructor for the BLM and USFS agency training sessions.

As a result of my research demonstrating that environmental values could be monetized, environmental and conservation organizations (The Wilderness Society, Trout Unlimited, Environmental Defense) now use non-market valuation and two of these have hired economists (one of which was a Ph.D. student of mine).

Collaborators and Other Affiliations

Collaborators and Co-Editors
John Bergstrom, University of Georgia
Craig Bond, Colorado State University
Thomas Brown, USDA Forest Service
Lynne Caughlan, U.S. Geological Survey
Patricia Champ, USDA Forest Service
Alan Covich, University of Georgia
Steve Davies, Colorado State University
Armando Gonzalez-Caban, USDA Forest Service
David Harpman, U.S. Bureau of Reclamation
Gloria Helfand, University of Michigan
John Hoehn, Michigan State University
Thomas Holmes, USDA Forest Service
Robert Kling, Colorado State University
Lynne Koontz, U.S. Geological Survey
Kreg Lindberg, Oregon State University
Edna Loehman, Purdue University
Gregory Poe, Cornell University
Douglas Rideout, Colorado State University
Randy Rosenberger, Oregon State University
Susanne Scheierling, World Bank
Andy Seidl, Colorado State University,
Douglass Shaw, Texas A&M
Stephan Weiler, Colorado State University
Robert Young, Colorado State University

Graduate Advisors and Postdoctoral Sponsors

Bryon Allen, Wilson Research; Christopher Bastian, University of Wyoming; Joseph Cooper, USDA Economic Research Service; Peter Fix, University of Alaska; Kelly Giraud, University of New Hampshire; Juan Marcos Gonzalez, Research Triangle Park; Michelle Haefele, The Wilderness Society Julie Mueller, Northern Arizona University; Mary Riddel, University of Nevada-Las Vegas; Brian Roach, Tufts University; Robert Richardson, Michigan State University; Randy Rosenberger, Oregon State University; Sabina L. Shaikh, University of Chicago; Ram Shrestha, Center for Disease Control; Douglas White, CIGAR, Latin America.

JEFFREY D. NIEMANN
Associate Professor, Faoro Professor of Water Resources
Department of Civil and Environmental Engineering
Colorado State University

PROFESSIONAL PREPARATION

University of Colorado, Boulder	Civil Engineering	B.S. (1993)
Massachusetts Institute of Technology	Civil & Environ. Engineering	M.S. (1997)
Massachusetts Institute of Technology	Civil & Environ. Engineering	Ph.D. (2001)

PROFESSIONAL EXPERIENCE

Associate Professor, Dept. of Civil and Environmental Engineering, Colorado State University, Fort Collins (2009-present)

Assistant Professor, Dept. of Civil and Environmental Engineering, Colorado State University, Fort Collins (2003-2009)

Assistant Professor, Dept. of Civil and Environmental Engineering, Pennsylvania State University, University Park (2000-2003)

Research Assistant, Massachusetts Institute of Technology, Cambridge (1994-2000)

Consultant, U.S. Environmental Protection Agency, Kathmandu, Nepal, and Dhaka, Bangladesh (July 1995)

Research Assistant, International Institute for Applied Systems Analysis, Laxenburg, Austria (1993-1994)

Undergraduate Research Assistant, Center for Advanced Decision Support for Water and Environmental Systems, Boulder, Colorado (1992-1993)

RELATED PUBLICATIONS

Coleman, M.L, J.D. Niemann, and E.P. Jacobs, 2009, "Reconstruction of Hillslope and Valley Paleotopography by Application of a Geomorphic Model," *Computers and Geosciences*, 35, 1776-1784, doi:10.1016/j.cageo.2008.07.006.

Mejia, A.I., and J.D. Niemann, 2008, "Identification and Characterization of Dendritic, Parallel, Pinnate, Rectangular, and Trellis Networks Based on Deviations from Planform Self-Similarity," *Journal of Geophysical Research*, 113, F02015, doi:10.1029/2007JF000781.

Tripp, D.R., and J.D. Niemann, 2008, "Evaluating the Parameter Identifiability and Structural Validity of a Probability-Distributed Model for Soil Moisture," *Journal of Hydrology*, 353, 93-108, doi: 10.1016/j.jhydrol.2008.01.028.

Perry, M.A., and J.D. Niemann, 2008, "Generation of Soil Moisture Patterns at the Catchment Scale by EOF Interpolation," *Hydrology and Earth System Science*, 12, 39-53.

Huang, X., and J.D. Niemann, 2006, "Modeling the Potential Impacts of Groundwater Hydrology on Long-Term Landscape Evolution," *Earth Surface Processes and Landforms*, 31(14), 1802-1823, doi: 10.1002/esp.1369.

OTHER PUBLICATIONS

Huang, X., and J.D. Niemann, 2006, "An Evaluation of the Geomorphically Effective Event for Fluvial Processes Over Long Periods," *Journal of Geophysical Research*, 111, F03015, doi:10.1029/2006JF000477.

Niemann, J.D., and L.E. Hasbargen, 2005, "A Comparison of Experimental and Natural Drainage Basin Morphology Across a Range of Scales," *Journal of Geophysical Research*, 110, F04017, doi:10.1029/2004JF000204.

Niemann, J.D., and E.A.B. Eltahir, 2005, "Sensitivity of Regional Water Balance Components to Climatic Changes, With Application to the Illinois River Basin," *Water Resources Research*, 41, W07014, doi:10.1029/2004WR003893.

Veneziano, D., and J.D. Niemann, 2000, "Self-Similarity of Fluvial Erosion Topography: 1. Mathematical Conditions and Physical Origin," *Water Resources Research*, 36(7): 1923-1936.

Veneziano, D., R.L. Bras, and J.D. Niemann, 1996, "Nonlinearity and Self-Similarity of Rainfall in Time and a Stochastic Model," *Journal of Geophysical Research*, 101(D21): 26371-26392.

SYNERGISTIC ACTIVITIES

Collaborator, Boulder Creek Critical Zone Observatory, National Science Foundation (September 2008 – present)

Member, Hydrologic Focus Group, Community Surface Dynamics Model Project, National Science Foundation (November 2007 – present)

Member, Surface Processes Working Group, Community Surface Dynamics Model Project, National Science Foundation (November 2007 – present)

Colorado State University Representative to the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (2005-present)

COLLABORATORS

Timothy Gates, Dept. of Civil and Environmental Engineering, Colorado State University, *John Labadie*, Dept. of Civil and Environmental Engineering, Colorado State University,

GRADUATE ADVISOR

Rafael L. Bras, Dept. of Civil and Environmental Engineering, Massachusetts Institute of Technology

GRADUATE STUDENTS ADVISED

Michael Coleman, Colorado State University, *Jon Cullor*, United States Peace Corps, *Jorge Gironás*, Universidad de Santiago de Chile, *Niklas Hallberg*, Current affiliation unknown, *Xiangjiang Huang*, Ayres Associates, *Amin Haghnegahdar*, University of Waterloo, *Summer Jawson*, Alaska Department of Environmental Conservation, *Ki Chul Jung*, Colorado State University, *Brandon Lehman*, Colorado State University, *Alfonso Mejia*, Dept. of Civil Engineering, University of Maryland, *Joshua Melliger*, U.S. Army Corps of Engineers, *Valerie Mino*, Current Affiliation Unknown, *Mark Perry*, Colorado Division of Water Resources, *Morgan Ruark*, CH2M-Hill, *Gregory Steed*, Colorado State University, *Nancy Steinberger*, Federal Emergency Management Agency, *Hua Su*, Current affiliation unknown, *Danielle Tripp*, W.W. Wheeler and Associates

Total Number of Graduate Students Advised: 18
Current Number of Graduate Students Advised: 5

Name: Dennis Shoji Ojima

Natural Resource Ecology Laboratory, B231 NESB, CSU, Fort Collins, CO 80525, Campus phone: 970 491 1976. Email: dojima@nrel.colostate.edu

The H. John Heinz III Center for Science, Economics, and the Environment. 900 17th Street NW, Washington DC, 20006. 202 552 4705, E-mail: ojima@heinzctr.org

Academic Training:

Pomona College	Botany	B.A.	1975
University of Florida	Plant Ecology	M.Ag.	1978
Colorado State University	Ecosystem Science	Ph.D.	1987

Professional Experience:

2009-	Professor	Department of Forestry, Rangelands, and Watershed Stewardship, CSU
2007-	Senior Scholar	The H John Heinz III Center for Science, Economics and the Environment
2005-2006	Interim Director	Natural Resource Ecology Laboratory, CSU
1996-present	Sr. Research Scientist	Natural Resource Ecology Laboratory, CSU
1993-1996	Research Scientist	Natural Resource Ecology Laboratory, CSU
1992-present	Assistant Professor	Rangeland Ecosystem Science Dept., CSU
1990-1991	Visiting Scientist	Office for Interdisciplinary Earth Studies, UCAR
1988-1990	Programme Officer	International Geosphere-Biosphere Programme

Selected Peer-Reviewed Publications (out of 77):

Ojima, D.S., W.J. Parton, D.S. Schimel, J.M.O. Scurlock and T.G.F. Kittel. 1993. Modeling the effects of climatic and CO_2 changes on grassland storage of soil C. Water, Air and Soil Pollution 70:643-657.

Ojima, D., L. Garcia, E. Elgaali, K. Miller, T.G.F. Kittel, and J. Lackett. 1999. Potential Climate Change Impacts on Water Resources in the Great Plains. Journal of the American Water Resources Association 35(6):1443-1454.

Schimel, D.S., J.M. Melillo, H. Tian, A.D. McGuire, D. Kicklighter, T. Kittel, N. Rosenbloom, S. Running, P. Thornton, D. Ojima, W. Parton, R. Kelly, M. Sykes, R. Neilson, Brian Rizzo, and L. Pitelka. 2000. Contribution of increasing CO2 and climate to carbon storage by ecosystems in the United States. Science 287: (5460) 2004-2006.

Ojima, D.S., T. Chuluun, B. Bolortsetseg, C.J. Tucker and J. Hicke. 2004. Eurasian land use impacts on rangeland productivity. Pp. 293-301 In R. DeFries and G.P. Asner (eds.) Ecosystem Interactions with Land Use Change. AGU Press.

Raupach MR, Rayner PJ, Barrett DJ, DeFries RS, Heimann M, Ojima DS, Quegan S, Schmullius CC. 2005. Model-data synthesis in terrestrial carbon observation: methods, data requirements and data uncertainty specifications. Global Change Biology 11:378-397.

Parton WJ, Gutmann MP, Williams SA, Easter M, Ojima D. 2005. Ecological impact of historical land-use patterns in the Great Plains: A methodological assessment. Ecological Applications 15: 1915-1928

Parton W, Tappan G, Ojima D, Tschakert P. 2005. Ecological impact of historical and future land-use patterns in Senegal. Journal of Arid Environments 59: 605-623

Del Grosso SJ, Mosier AR, Parton WJ, Ojima DS. 2005. DAYCENT model analysis of past and contemporary soil N2O and net greenhouse gas flux for major crops in the USA. Soil & Tillage Research 83: 9-24

Del Grosso SJ, Parton WJ, Mosier AR, Holland EA, Pendall E, Schimel DS, Ojima DS. 2005. Modeling soil CO2 emissions from ecosystems. Biogeochemistry 73: 71-91

Hobbs RJ, Arico S, Aronson J, Baron JS, Bridgewater P, Cramer VA, Epstein PR, Ewel JJ, Klink CA, Lugo AE, Norton D, Ojima D, Richardson DM, Sanderson EW, Valladares F, Vila M, Zamora R, Zobel M. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography 15: 1-7

Synergistic Activities:

Aldo Leopold Leadership Fellow, 1999 - Present

Memberships:

- Scientific Technical Advisory Panel to GEF Desertification Panel 2004-2006
- Northern Eurasian Ecosystem Science Partnership Initiative Science Steering Committee Member
- International Global Observation Land (IGOL) Working Group Member 2004 – 2007
- IGBP Scientific Steering Committee Member 2005-2006
- International Human Dimensions Programme Scientific Steering Committee Member 2005-2006
- US National SCOPE Committee Member 2005-
- Ecological Society of America Board Member 2005 - 2007
- Ecological Society of America Board Member (Member-at-Large) 2005-2007
- US SCOPE Committee Member (2005-2008)

Committees:

- Convener of the Central Great Plains Regional Assessment, 1997-2001
- Global Land Project, Co-Chairman, 2005 -2006
- US CCSP Carbon Cycle Science Working Group Committee 2009 –
- National Research Committee on NASA Applications Review 2005-2007
- US National Research Council Committee on Human Dimensions of Global Change 2009 –

Professional Recognition:

Dr. Ojima is also member on the U.S. National SCOPE Committee and past member-at-large on the Governing Board of the Ecological Society of America (2005-2007). He as been honored recently as a member of the team awarded the 2005 Zayed International Prize for the Environment for his contributions to the Millennium Ecosystem Assessment. He is a recipient of the 2007 Nobel Peace Prize awarded to the IPCC contributors.

Collaborators

Arico S, Aronson J, Baron JS, Barrett DJ, Bridgewater P, Cramer VA, DeFries RS, Del Grosso SJ, Easter M, Epstein PR, Ewel JJ, Gutmann MP, Heimann M, Holland EA, Hobbs RJ, Klink CA, Lugo AE, Mosier AR, Norton D, Parton WJ, Pendall E, Quegan S, Raupach MR, Rayner PJ, Richardson DM, Sanderson EW, Schimel DS, Schmullius CC, Tappan G, Tschakert P, Valladares F, Vila M, Williams SA, Zamora R, Zobel M.

David Allan Randall

A. PROFESSIONAL PREPARATION:

B.S., 1971, Aeronautical and Astronautical Engineering, The Ohio State University.
M.S., 1971, Aeronautical and Astronautical Engineering, The Ohio State University.
Ph.D., 1976, Atmospheric Sciences, University of California, Los Angeles (Professor A. Arakawa, advising).

B. APPOINTMENTS:

07/88 - Present: Professor, Department of Atmospheric Science, Colorado State University
09/79 - 06/88: Meteorologist, Global Modeling and Simulation Branch, NASA/Goddard Space Flight Center.
09/76 - 09/79: Assistant Professor, Department of Meteorology, Massachusetts Institute of Technology.

C. PUBLICATIONS:

Five Most Relevant Refereed Publications

Randall, D. A., M. Khairoutdinov, A. Arakawa, and W. Grabowski, 2003: Breaking the cloud-parameterization deadlock. *Bull. Amer. Meteor. Soc*., **84**, 1547-1564.

Khairoutdinov, M., D. A. Randall, and C. DeMott, 2005: Simulation of the atmospheric general circulation using a cloud-resolving model as a super-parameteriztion of physical processes. *J. Atmos. Sci.*, **62**, 2136-2154.

Randall, D. A., and M. J. Suarez, 1984: On the Dynamics of Stratocumulus Formation and Dissipation. *J. Atmos. Sci.*, **41**, 3052 - 3057.

Kelly, M. A., and D. A. Randall, 2001: The effects of the vertical distribution of water vapor on the strength of the Walker Circulation. *J. Climate* , **14**, 3944-3964.

Kelly, M. A., D. A. Randall, and G. L. Stephens, 1999: A simple radiative-convective model with a hydrologic cycle and interactive clouds. *Quart. J. Roy. Met. Soc.*, **125**, 837-869.

Five Significant Refereed Publications

Randall, D. A., and D.-M. Pan, 1993: Implementation of the Arakawa-Schubert cumulus parameterization with a prognostic closure. In *Cumulus Parameterization*, a Meteorological Monograph published by the American Meteorological Society, K. Emanuel and D. Raymond, Eds., pp. 137 - 144.

Randall, D. A., M. E. Schlesinger, V. Galin, V. Meleshko, J.-J. Morcrette, and R. Wetherald, 2006: Cloud Feedbacks. In "*Frontiers in the Science of Climate Modeling*," J. T. Kiehl and V. Ramanathan, Eds., Cambridge University Press, pp. 217-250.

Randall, D. A., 1987: Turbulent Fluxes of Liquid Water and Buoyancy in Partly Cloudy Layers. *J. Atmos. Sci.*, **44**, 850-858.

Fowler, D. A. and D. A. Randall, 1996: Liquid and ice cloud microphysics in athe CSU General Circulation Model. Part 2: Simulation of the Earth's radiation budget. *J. Climate*, **9**, 530-560.

Lappen, C.-L, and D. A. Randall, 2001: Towards a unified parameterization of the boundary layer and moist convection. Part I. A new type of mass-flux model. *J. Atmos. Sci.*, **58**, 2021-2036.

D. SYNERGISTIC ACTIVITIES:

1. Director, Center for Multiscale Modeling of Atmospheric Processes (CMMA), an NSF Science and Technology Center, 2006-.
2. Member, GEWEX (Global Energy and Water Cycle) Scientific Steering Group.
3. From 1995 to 2005, Chief Editor of the *Journal of Climate*.
4. Active participant in the Atmospheric Model Working Group (AMWG) for the Community Climate System Model (CCSM).
5. Active participant in and former Chair of the GEWEX Cloud Systems Study (GCSS).

6. Co-Chair of the FIRE Science Team continuously for 19 years, and Chair of the ARM Science Team for 3 years.
7. Member, Biological and Environmental Research Advisory Committee, U.S. Dept. of Energy.

E. COLLABORATORS & OTHER AFFILIATIONS:

i)Collaborators

Howard Barker, Meterological Service of Canada; Joseph Berry, Carnegie Institute of Washington; Maurice Blackmon, NCAR; Lahouari Bounoua, NASA GSFC; Mark Branson, Colorado State University; Robert Cess, State University of New York; Eugene Clothiaux, The Pennsylvania State University; Jason Cole, The Pennsylvania State University; J. Collatz, NASA GSFC; G. Collelo, Carnegie Institute of Washington; Douglas Cripe, Colorado State University; Judith Curry, University of Colorado; A.Scott Denning, Colorado State University; Ping Ding, Stanford University; Zachary Eitzen, Colorado State University; Christopher Field, Carnegie Institute of Washington; Laura Fowler, Colorado State University; Inez Fung, University of California Berkeley; Steve Ghan, Battelle Pacific Northwest Lab; Patrick Haertel, University of North Dakota.; Ross Heikes, Colorado State University; S. Iacobellis, Scripps Institute of Oceaonography; Kayo Ide, University of California, Los Angeles; Tommy Jensen, University of Hawaii; Christopher Justice, University of Virginia; Michael Kelly, TASC; Cara-Lyn Lappen, Colorado State University; Sietse Los, NASA GSFC; J. M. Slingo, University of Reading; Ching-Hoh Moeng, NCAR; Dzong-Ming Pan, unknown; Petri Raisanen, Rossby Centre, SMHI, Sweden; Todd Ringler, Colorado State University; William Rossow, NASA GISS; Steven Rutledge, Colorado State University; Piers Sellers, NASA Johnson Space Flight Center; Qingqiu Shao, unknown; Richard Somerville, University of California San Diego; Graeme Stephens, Colorado State University; Bjorn Stevens, University of California, Los Angeles; Compton Tucker, NASA GSFC; Roger Wakimoto, University of California, Los Angeles; Junyi Wang, unknown; Bruce Wielicki, NASA Langley Research Center; KuanMan Xu, NASA Langley Research Center; Changan Zhang, Kenan Systems Corp.

ii)Graduate & Postdoctoral Advisors

Prof. Akio Arakawa, University of California, Los Angeles

iii) Thesis Advisor & Postgraduate Scholar Sponsor

Anning Cheng, Colorado State University; Donald Dazlich, Colorado State University; Zachary Eitzen, Colorado State University; Ross Heikes, Colorado State University; Michael Kelly, Johns Hopkins Applied Physics Lab; Cara-Lyn Lappen, Colorado State University; Daniel Lindsey, Colorado State University; Kevin Schaefer, Colorado State University; Justin Shaw, unknown; Kiran Sonnad, unknown; Cristiana Stan, Colorado State University; Michael Toy, Colorado State University; Stefan Tulich, Colorado State University; Maike Ahlgrim, Colorado State University; James Benjamin, Colorado State University; Takanobu Yamaguchi, Colorado State University; Luke van Roeckel, Colorado State University; Grant Firl, Colorado State University; Rachel McCrary, Colorado State University; Melissa Burt, Colorado State University.

Jessica L. Thompson

Assistant Professor
Human Dimensions of Natural Resources
Colorado State University
202 Forestry
Fort Collins, CO 80523-1480
(970) 491-2801
jes@cnr.colostate.edu

I. PROFESSIONAL PREPARATION

Northern Michigan University, Communication Studies,		B.S. 2001
University of Utah, Department of Communication (Environment & Media)		M.S. 2003
University of Utah, Adaptive Management of Environmental Systems	Graduate Certificate	2004
University of Utah, Department of Communication (Environment & Conflict)		Ph.D. 2007

II. ACADEMIC APPOINTMENTS

8/2007 – Present	Assistant Professor, Human Dimensions of Natural Resources, Colorado State University
8/2001 – 5/2007	Graduate Teaching Fellow, Department of Communication, University of Utah
8/2005 – 5/2007	I.G.E.R.T. Teaching Assistant, College of Engineering, Enhanced Engineering Education, University of Utah
5/2003 – 2/2006	Interdisciplinary Research Assistant, Salt Lake Valley Urban Airshed Project (NSF Biocomplexity Award ATM 02157658)
8/2003 – 11/2005	Research Assistant, Department of Energy Southwest Sequestration Project

III. PUBLICATIONS

Thompson, J.L. (2009). Building collective communication competence in interdisciplinary research teams. *Journal of Applied Communication Research, 37*(3), 278-297.

Pataki, D.E., Emmi, P.C., Forster, C.B., Mills, J.I., Pardyjak, E.R., Peterson, T.R., **Thompson, J.L.**, Dudley-Murphy, E. (2009). An integrated approach to improving fossil fuel emissions scenarios with urban ecosystem studies. *Ecological Complexity 6*(1), 1-14.

Thompson, J.L., Forster, C.B., Werner, C., & Peterson, T.R. (2009/forthcoming). Mediated Modeling: Using Collaborative Processes to Integrate Scientist and Stakeholder Knowledge about Greenhouse Gas Emissions in an Urban Ecosystem. *Society & Natural Resources*.

Thompson, J.L. (2008). *Interdisciplinary research team dynamics: A systems approach to understanding communication and collaboration in complex teams*. Saarbruecken, Germany: VDM Verlag Publishing.

Peterson, T.R. & **Thompson, J.L.** (2008). Environmental risk communication: responding to challenges of complexity and uncertainty. In R.L. Heath & D. O'Hair (Eds.), *The handbook of crisis and risk communication* (pp. 593-608). New York: Routledge Publishing.

Cantrill, J. G., **Thompson, J.L**., Rochester, G. & Garrett, E. (2007). Exploring a sense of self-in-place to explain the impulse for urban sprawl. (*Environmental Communication: A Journal of Nature and Culture*, 1(2).

Durfee, J.L. (2006). "Social change" and "status quo" framing effects on risk perception: An exploratory experiment. *Science Communication, 27*(4), 459-495.

Durfee, J. L. & Corbett, J.B. (2005). Context and controversy: Global warming coverage. *Nieman Reports, 59*(4), 88-89.

Corbett, J.B. & **Durfee, J.L**. (2004). Testing public (un)certainty of science: Media representations of global warming. *Science Communication, 26*(2), 129-151.

IV. SYNERGISTIC ACTIVITIES

Multi-disciplinary Model Building Activities – Thompson has worked with experts in systems modeling, hydrology, urban planning and physics to develop dynamic systems models of the urban airshed (NSF-sponsored Salt Lake Valley Airshed Project), carbon dioxide sequestration (DOE-sponsored Southwest Sequestration Project) and of interdisciplinary team dynamics in her dissertation research. Thompson also collaborated with a hydrologist and physicist to develop an interactive game to teach the concepts of systems dynamics. The Ice Cream Game was invented in July 2004 and has been used as an experiential learning tool in public participation workshops, undergraduate and graduate classes and at departmental faculty retreats. She is also the lead-PI on a National Park Service funded project to identify multi-jurisdictional adaptation strategies responding to climate change on federal lands. Thompson is collaborating with an interdisciplinary and inter-organizational team of climate change experts and public lands managers.

Collaborative Publishing – Thompson has collaborated with her undergraduate advisor, James Cantrill to publish two research articles on urban sprawl and sense-of-self-in-place. Thompson has collaborated with her thesis advisor, Julia Corbett to publish two research articles on public understanding of science related to global warming. Thompson has worked with her doctoral chair, Tarla Rai Peterson, on many projects, most recently they completed a book chapter on environmental risk communication. She has also worked with Craig Forster and Carol Werner to complete a manuscript analyzing the utility of mediated modeling in public participation projects, a manuscript on the Ice Cream Game, and a manuscript on interdisciplinary research team dynamics.

Multi-disciplinary Teaching – Thompson has co-taught three classes in the College of Engineering at the University of Utah. The courses were a series of seminars designed for graduate students in mechanical, chemical or biological engineering. The first course, Creativity introduced students to various problem-solving and creative thinking exercises. The second course, Communication & Teamwork was a service-learning approach to understanding communication competence and teamwork skills in an engineering context, and the third course investigated issues of Ethics & Leadership in the private and public sector.

V. COLLABORATORS & OTHER AFFILIATIONS

a) Collaborators and Co-Editors.
James Cantrill (Northern Michigan University), Julia Corbett (University of Utah), Philip Emmi (University of Utah), Steven Fassnacht (Colorado State University), Maria Fernandez-Gimenez (Colorado State University), Craig Forster (University of Utah), Damon Hall (Texas A&M University), Melinda Laituri (Colorado State University), Stacy Langsdale (Army Corps of Engineers – Institute for Water Resources), James Mills (University of Utah), Todd Norton (Washington State University), Eric Pardyjak (University of Utah), Diane Pataki (University of California, Irvine), Tarla Rai Peterson (Texas A&M University), Stephaie Pincetl (UCLA), Robin Reid (Colorado State University), Sarah Schweizer (Colorado State University), Leigh Welling (National Park Service), Carol Werner (University of Utah)

b) Graduate and Postdoctoral Advisors.
Ph.D. – Tarla Rai Peterson, Texas A & M University
M.S. – Julia B. Corbett, University of Utah

c) Thesis Advisees and Postgraduate-Scholar Sponsor.
Sarah Schweizer, Colorado State University; Ashley Cobb, Colorado State University; Shawn Davis, Colorado State University

DIANA HARRISON WALL

PROFESSIONAL PREPARATION

University of Kentucky, Lexington, KY	Biology	B.A., 1965
University of Kentucky, Lexington, KY	Plant Pathology	Ph.D., 1971

APPOINTMENTS

2009	University Distinguished Professor
2008-present	Director, School of Global Environmental Sustainabilty
2006-present	Professor, Department of Biology, Colorado State University, Ft. Collins
1993-present	Senior Research Scientist, Natural Resource Ecology Laboratory, CSU
1993-2006	Professor, Rangeland Ecosystem Science, CSU
1993-2005	Director, Natural Resource Ecology Laboratory, CSU
2001	Interim Dean, College of Natural Resources, CSU
1993-2000	Associate Dean for Research, College of Natural Resources, CSU
1993	Professor, Dept. Nematology, University of California, Riverside
1990-1993	Associate Professor and Associate Nematologist, Dept. Nematology, UC Riverside
1982-1990	Associate Research Nematologist, Dept. Nematology, UC Riverside
1988-1989	Associate Program Director, Ecology Program, NSF, Washington, D.C.
1986-1988	Associate Director, Drylands Research Institute, UC Riverside

FIVE PUBLICATIONS MOST CLOSELY RELATED TO PROJECT

Barrett, J. E., R. A. Virginia, D. H**. Wall**, P. T. Doran, A. G. Fountain, K. A. Welch and W. B. Lyons. 2008. Persistent effects of a discrete warming event on a polar desert ecosystem. *Global Change Biology* 14:2249-2261. doi:10.1111/j.1365-2486.2008.01641.x

Carpenter, S. R., V. Armbrust, P. Arzberger, F. S. Chapin III, J. Elser, E. Hackett, A. R. Ives, P. Kareiva, M. Leibold, P. Lundberg, M. Magel, N. Merchant, W. Murdoch, M. Palmer, D. Peters, S. Pickett, K. Smith, D. H. **Wall**, A. Zimmerman. 2009. Synthesis must be accelerated in Ecology and Environmental Sciences. *BioScience* 59:699-701.

Sala, O. E., F. S. Chapin III, J. J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L. F. Huenneke, R. B. Jackson, A. Kinzig, R. Leemans, D. M. Lodge, H. A. Mooney, M. Oesterheld, N. L. Poff, M. T. Sykes, B. H. Walker, M. Walker, and D. H. **Wall**. 2000. Global biodiversity scenarios for the year 2100. *Science* 287: 1770-1774.

Wall, D. H., M. A. Bradford, et al. 2008. Global decomposition experiment shows soil animal impacts on decomposition are climate dependent. *Global Change Biology* 14:1-17.

Wall, D.H. 2007. Global Change tipping points: Above- and below-ground biotic interactions in a low diversity ecosystem. *Philosophical Transactions of the Royal Society B, Biological Sciences*, 362:2291-2306, doi: 10.1098/rstb.2006.1950.

FIVE OTHER PUBLICATIONS

Adhikari, B., D. H. **Wall**, B. J. Adams. 2009. Desiccation survival in an Antarctic nematode: Molecular analysis using expressed sequenced tags. *BMC Genomics.* 10:69.

Dobson, A., D. Lodge, J. Alder, G. S. Cumming, J. Keymer, J. McGlade, H. Mooney, J. A. Rusak, O. Sala, V. Wolters D. **Wall,** R. Winfree and M. A. Xenopoulos. 2006. Habitat loss, trophic collapse and the decline of ecosystem services. *Ecology*, 87: 1915-1924.

Doran, P. T., J. C. Priscu, W. B. Lyons, J. E. Walsh, A. G. Fountain, D. M. McKnight, D. L. Moorhead, R. A. Virginia, D.H. **Wall**, G. D. Clow, C. H. Fritsen, C. P. McKay, and A. N. Parsons. 2002. Antarctic climate cooling and terrestrial ecosystem response. *Nature* 415: 517-520.

Palumbi, S. R., P. A. Sandifer, J. D. Allan, M. W. Beck, D. G. Fautin, M. J. Fogarty, B. S. Halpern, L. S. Incxe, J. Leong, E. Norse, J. J.Stachowicz and D. H. **Wall**. 2009. Managing for ocean biodiversity: creating a national biodiversity conservation agenda to sustain marine ecosystem services. *Frontiers in Ecology and the Environment* 7, doi:10.1890/070135.

Wall, D.H**.** (ed.) 2004. Sustaining Biodiversity and Ecosystem Services in Soil and Sediments. Island Press, Washington, D.C.

SYNERGISTIC ACTIVITIES

Communication of Science: Organizer, "A Symposium for the International Polar Year," Fort Collins Public Library Lecture Series, Fort Collins, Colorado, Feb-June, 2007; Co-chair, Aldo Leopold Leadership Program/Ecological Society of America Workshop - Bridging the Worlds of Science and Journalism: Working with the Media, Memphis, Tennessee.

Teaching and Training: Ph.D. Course-Invited Lecturer, "Soil Ecology: Crossing the Frontier between Below- and Above-Ground", 2007, Wageningen, The Netherlands**.**

Service: Member, NRC Polar Research Board; Co-Lead Author and Co-chair, Implications for Achieving the Millennium Development Goals, Chapter Committee of the Millennium Ecosystem Assessment.

COLLABORATORS & OTHER AFFILIATIONS

Collaborators and Co-authors: B. J. Adams, BYU; J. Alder, UBC, Canada; S.S. Bamforth, Tulane U; R.D. Bardgett, Lancaster U; J.E. Barrett, Virginia Tech; V. Behan-Pelletier, Ag. Canada; M.P. Berg, Vrije U., the Netherlands; M. B. Blaauw, Wageningen U; S.W. Blecker, Idaho State U.; M. Burkins, New Hampshire; L. Brussaard, Wageningen U., Netherlands; A.E. Carey, Ohio State U.; Steve Carpenter, U. Wisc; S.C. Cary, U. Delaware; D. Clow, USGS; D.C. Coleman, U. Georgia; P. Convey, British Antarctic Survey (BAS); A.P. Covich, U. Georgia; J.W. Crawford, U. Abertay, U.K.; B. Csatho, Ohio State U.; J.S. Cumming, U. Cape Town, South Africa; G. de Deyn, the Netherlands; P.C. de Ruiter, Wageningen U., Netherlands; A. Dobson, Princeton; P. Doran, U. Ill., Chicago; A. Fitter, U. York, U.K.; A.G. Fountain, Portland State U; C.H. Fritsen, Desert Res. Inst.; P.J. Gregory, Scottish Crop Inst.; D.J. Grinev, U. Abertay, U.K.; A.L. Hacker, U. Waikato, N.Z.; I.D. Hogg, U. Waikato, N.Z.; H.W. Hunt, CSU; J.A. Ippolito, CSU; S.N. Johnson, Scottish Crop Inst., U.K.; J. Keymer, Priceton; J. Klironomos, U. Guelph, Canada; P. Lavelle, France; G. Li, CSU; D. Lodge, U. Notre Dame; W. B. Lyons, Ohio State U; R.W. Mankin, Center for Med., Ag., and Vet. Entomology; J.G. Masters, CABI Bioscience, U.K.; J. McGlade, College of London; C.P. McKay, NASA Ames; D. McKnight, U. Colo; K. Melville, CSU; J. C. Moore, CSU; H. Mooney, Stanford; D. Moorhead, U Toledo; P.J. Murray, Inst. of Grassland and Environ. Res., U.K.; K.A. Norvell, student, CSU; T. Nylen, USGS; T. O'Donnell, U. Newcastle; A.N. Parsons, NERC; E.A. Paul, CSU; D. Porazinska, U of Florida; K. Poveda, Germany; L.E. Powers, USAID; J. Priscu, Montana State U; P. Robertson, Mich. State Univ; A. Rusak, Notre Dame; O. Sala, Brown U.; D. Schroter, Potsdam Inst., Germany; H. Setala, U. Helsinki; R.S. Sletten, U. Washington; P.V.R. Snelgrove, Memorial U New Foundland; M. Tranter, U Bristol; C. Tremper, Ohio State U.; A. Treonis, U Richmond; W. van der Putten, The Netherlands; R.A. Virginia, Dartmouth; J.E. Walsh, U. Alaska; D.A. Wardle, Swedish U. Ag. Science; K.A. Welch, Ohio State U.; R. Winfree, Princeton; V. Wolters, Germany; M.A. Xenopolous, Notre Dame; X. Zhang, U. Abertay, U.K.

Large numbers of collaborators derived from the following publications:

Co-Lead author 2005. Implications for Achieving the Millennium Development Goals. In *Millennium Ecosystem Assessment.Policy Responses: Findings of the Responses Working Group*. pp. 549-584. Island Press, Washington D.C.

Co-author 2005. Polar Systems. *Millennium Ecosystem Assessment. Current State and Trends.* Pp. 717-743. Island Press, Washington, D.C.

Lead P.I. on NSF OPP Victoria Land Workshop grant, leading to 2006 special issue of *Soil Biology and Biochemistry* vol. 38.

GRADUATE AND POSTDOCTORAL ADVISORS

Advisors: R. A. Chapman, Deceased; Post Doc, R. Mankau, UC Riverside, Retired

THESIS ADVISOR

Graduate Students: A. Child, U. Denver, E. Courtright, NMSU, N. DeCrappeo, USGS; S. Spaulding, U. Colo, M. St. John, Landcare Inst, NZ; A. Treonis, Univ. of Richmond; current: K. Seaver, T. Smith, Z. Sylvain, R. Townsend, and J. Zhou. Total graduate students advised: 10

Postdoctoral scholar sponsor: G. Adams & A. Parsons, NERC, UK; E. Broos, not employed; R.K. Niles, Private business; J. Nkem, GIFOR, Burkina Faso, West Africa; A. O. Overhoff, business, Germany; L.E. Powers, US AID, Washington, DC; D. Porazinska, Univ. of Florida; E. Ayres, CSU; B. Simmons , E Georgia State College; Uffe Nielsen, current. Total postdoctoral scholars advised: 10

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Colorado State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jorge A Ramirez

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jorge A Ramirez - PI**	0.00	1.00	1.00	$ **25,778**	$
2. **A S Denning - Co-PI**	0.00	1.00	0.00	**11,666**	
3. **Neil S Grigg - Co-PI**	0.00	1.00	0.00	**16,000**	
4. **N. Leroy Poff - Co-PI**	0.00	1.00	0.00	**8,767**	
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**4**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	4.00	1.00	**62,211**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**18,000**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**80,211**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**20,694**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**100,905**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,400**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **210,000**					
2. TRAVEL **10,500**					
3. SUBSISTENCE **0**					
4. OTHER **73,500**					
TOTAL NUMBER OF PARTICIPANTS (**7**) TOTAL PARTICIPANT COSTS				**294,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**19,000**	
TOTAL OTHER DIRECT COSTS				**20,500**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**420,805**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Partial reimbursement allowance (Rate: 8.0000, Base: 347307)**					
TOTAL INDIRECT COSTS (F&A)				**27,785**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**448,590**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **448,590**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jorge A Ramirez

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Colorado State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jorge A Ramirez

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jorge A Ramirez - PI**	0.00	1.00	0.00	$ **13,404**	$
2. **A S Denning - Co-PI**	0.00	0.00	0.00	**0**	
3. **Neil S Grigg - Co-PI**	0.00	0.00	0.00	**0**	
4. **N. Leroy Poff - Co-PI**	0.00	0.00	0.00	**0**	
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**4**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	1.00	0.00	**13,404**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**18,720**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**32,124**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**8,404**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**40,528**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,300**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **360,000**					
2. TRAVEL **18,000**					
3. SUBSISTENCE **0**					
4. OTHER **126,000**					
TOTAL NUMBER OF PARTICIPANTS (**12**) TOTAL PARTICIPANT COSTS				**504,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**3,000**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**9,000**	
TOTAL OTHER DIRECT COSTS				**13,500**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**562,328**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Partial reimbursement allowance (Rate: 8.0000, Base: 436328)**					
TOTAL INDIRECT COSTS (F&A)				**34,906**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**597,234**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **597,234**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jorge A Ramirez

ORG. REP. NAME*

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Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

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PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Colorado State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jorge A Ramirez

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jorge A Ramirez - PI**	0.00	1.00	0.00	$ **13,941**	$
2. **A S Denning - Co-PI**	0.00	0.00	0.00	**0**	
3. **Neil S Grigg - Co-PI**	0.00	0.00	0.00	**0**	
4. **N. Leroy Poff - Co-PI**	0.00	0.00	0.00	**0**	
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**4**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	1.00	0.00	**13,941**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**19,469**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**33,410**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**8,863**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**42,273**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,300**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **360,000**					
2. TRAVEL **18,000**					
3. SUBSISTENCE **0**					
4. OTHER **126,000**					
TOTAL NUMBER OF PARTICIPANTS (**12**) TOTAL PARTICIPANT COSTS				**504,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**2,800**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**10,000**	
TOTAL OTHER DIRECT COSTS				**14,300**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**564,873**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Partial reimbursement allowance (Rate: 8.0000, Base: 438873)**					
TOTAL INDIRECT COSTS (F&A)				**35,110**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**599,983**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **599,983**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jorge A Ramirez

ORG. REP. NAME*

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 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 4

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Colorado State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jorge A Ramirez

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jorge A Ramirez - PI**	0.00	1.00	0.00	$ **14,498**	$
2. **A S Denning - Co-PI**	0.00	0.00	0.00	**0**	
3. **Neil S Grigg - Co-PI**	0.00	0.00	0.00	**0**	
4. **N. Leroy Poff - Co-PI**	0.00	0.00	0.00	**0**	
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**4**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	1.00	0.00	**14,498**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**20,248**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**34,746**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**9,391**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**44,137**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,300**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **360,000**					
2. TRAVEL **18,000**					
3. SUBSISTENCE **0**					
4. OTHER **126,000**					
TOTAL NUMBER OF PARTICIPANTS (**12**) TOTAL PARTICIPANT COSTS				**504,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**1,900**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**9,000**	
TOTAL OTHER DIRECT COSTS				**12,400**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**564,837**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Partial reimbursement allowance (Rate: 8.0000, Base: 438837)**					
TOTAL INDIRECT COSTS (F&A)				**35,107**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**599,944**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **599,944**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jorge A Ramirez

ORG. REP. NAME*

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 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 5

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Colorado State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jorge A Ramirez

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jorge A Ramirez - PI**	0.00	1.00	0.00	$ **15,078**	$
2. **A S Denning - Co-PI**	0.00	0.00	0.00	**0**	
3. **Neil S Grigg - Co-PI**	0.00	0.00	0.00	**0**	
4. **N. Leroy Poff - Co-PI**	0.00	0.00	0.00	**0**	
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**4**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	1.00	0.00	**15,078**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**21,057**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**36,135**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**9,947**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**46,082**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,300**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **270,000**					
2. TRAVEL **13,500**					
3. SUBSISTENCE **0**					
4. OTHER **94,500**					
TOTAL NUMBER OF PARTICIPANTS (**9**) TOTAL PARTICIPANT COSTS				**378,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**14,700**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**9,000**	
TOTAL OTHER DIRECT COSTS				**25,200**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**453,582**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Partial reimbursement allowance (Rate: 8.0000, Base: 359082)**					
TOTAL INDIRECT COSTS (F&A)				**28,727**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**482,309**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **482,309**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jorge A Ramirez

ORG. REP. NAME*

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 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Colorado State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jorge A Ramirez

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jorge A Ramirez - PI**	0.00	5.00	1.00	$ **82,699**	$
2. **A S Denning - Co-PI**	0.00	1.00	0.00	**11,666**	
3. **Neil S Grigg - Co-PI**	0.00	1.00	0.00	**16,000**	
4. **N. Leroy Poff - Co-PI**	0.00	1.00	0.00	**8,767**	
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**4**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	8.00	1.00	**119,132**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**5**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	30.00	0.00	0.00	**97,494**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**216,626**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**57,299**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**273,925**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**22,600**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **1,560,000**					
2. TRAVEL **78,000**					
3. SUBSISTENCE **0**					
4. OTHER **546,000**					
TOTAL NUMBER OF PARTICIPANTS (**52**) TOTAL PARTICIPANT COSTS				**2,184,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**7,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**22,400**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**56,000**	
TOTAL OTHER DIRECT COSTS				**85,900**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**2,566,425**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**161,635**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**2,728,060**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **2,728,060**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jorge A Ramirez

ORG. REP. NAME*

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Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification for First Year (and subsequent)

Salaries	**Amount**
Faculty time for development of 4 new courses (4 months total)	$49,323
Fringe benefits[1] at 25.8%	$12,725

Our proposal considers the development of 5 new courses (1 per research theme, 1 in new mathematics/statistics, and 1 in ethics and communication). The amount of faculty time required for development of each course is 2 months. We are requesting a total of 4 months of faculty salary for course development from IGERT funds; the additional 6 months required will come from faculty release time provided by the participating departments.

Program Director Salary[2] (1 month)	$12,888
Fringe benefits[1] at 25.8%	$3325

The Program director will commit 2 months of the calendar year per year. We are requesting 1 month per year from IGERT funds; the other month will come from faculty release provided by the department.

Assistant Program Manager[1] (12 months at $3000/mo at ½ time)	$18,000
Fringe benefits[1] at 25.8%	$4644

The Assistant Program Manager will be responsible for record keeping both financial and academic, preparation and mailing of the recruiting and advertising materials, communication with contacts at collaborating institutions, preparation and administration of evaluation instruments, coordination of all student activities, logistical support with WATER symposium, invited speakers, external reviews, etc.

Domestic Travel $5400

Travel of Program Director to IGERT orientation meeting in Washington, DC during the first year. Assumes $1100/traveler.

Travel of Program Director, Assistant Manager, and one graduate student to annual IGERT meeting at NSF in Washington, DC. Assumes $1100/traveler.

In addition, $1000 for travel to and from minority institutions (e.g., CSU-Pueblo, Fort Lewis College) for recruitment purposes.

Note: All travel costs include airfare, ground transportation, lodging, per diem and registration fees if needed.

Participant Support

Stipend (7 students @ $30000/student)	$210,000

Our program will fund 7 students during year 1 of the program, 12 students per year during years 2, 3, and 4. During year 5 we will fund 9 students. The total number of individuals funded during the five-year program is 28. See *Participant Support Explanation* below for additional details.

Travel (7 students @ $1500/student)	$10,500

Attend and present papers at annual meetings of AGU, AMS, ESA, etc. (One meeting per student per year)

Cost of Education (7 students @ $10,500/student)	$73,500

See *Participant Support Explanation* below for additional details.

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[1] Fringe benefit rates for each of the five years are: 25.8%, 26.2%, 26.5%, 27%, and 27.5% in each of the five years

[2] Salary increases of 4% per year have been assumed

Other Direct Costs

Material and supplies $1500
This cost includes purchase of software licenses (e.g., Matlab, GIS, etc.)

Cost of Facilitator for Program Reviews ($1000/event) $1000
Internal reviews occur annually. During year three there will be an external review also; for that year, this cost will be $2000.

Honoraria for external Advisory Board members and external reviewers ($1000/member) $3000
We will invite 3 experts, one each on each of the three research themes to be on the External Advisory Board, which will meet annually at the time of the WATER-IGERT symposium in the spring.

Invited Speakers for annual symposium ($1500/speaker) $3000
We will invite 2 internationally recognized speakers for the Annual WATER Symposium

Journal publication charges 0
We assume that each student will publish at least 2 papers as a result of their PhD work. Total budgeted over 5 years is $22,400 for 56 publications. Publication charges start in the second year. Charges for year 2 $3000, year 3 $2800, $1900 for year 4, and $14700 for the last year.

WATER-IGERT Symposium $2000
The IGERT Symposium will be coordinated with Hydrology Days to take advantage of economies of scale.

Recruitment $5000
This item will be for organizing the summer recruitment workshop. The recruitment workshop will be coordinated with the WATER-REU program. Amount to be used as needed over 5 years.

Advertising costs (posters, ads, flyers, etc.). Amount to be used as needed over 5 years. $5000

Indirect Cost

Partial reimbursement of indirect costs at a rate of 8% $27,785
Indirect costs were computed based on total direct costs, including participant support but excluding the cost of education allowance: 0.08*$347,307.

IGERT Special Allocation - Yr1

Faculty Salaries	$49,322
Fringe	$12,725
Travel	$1,100
F&A	$5,052
Total	**$68,199**

Participant Support - Explanation

Each IGERT student will take three years to finish the program. We will provide full IGERT support for the first two years, and require that the faculty advisors provide support for the final year as a way of leveraging IGERT funds. Doing so allows us to support 28 students over five years, as opposed to 15 if we support them on IGERT funds for the full three years each.

The university has committed $525,000[3] in matching funds for WATER-IGERT. To make it attractive for faculty to participate in the IGERT program, $420,000 will be used to cost share 50% of the cost of support for the third and final year of each student. The additional $105,000 will be used to support up to 4 minority students during their MS work as indicated in the Recruitment and Retention section of the proposal. As indicated in the attached institutional commitment form, the university match is split as follows: 1/3 from the two colleges (Engineering and Natural Sciences), 1/3 from the departments, and 1/3 from the Office of the Provost and the Office of the Vice-President for Research. The distribution of this Institutional Commitment appears in the next page.

In addition, the office of the Vice Provost for Graduate Affairs[4] has committed up to 10 "tuition premiums" per year for the duration of the program for all out-of-state IGERT participants. That is, the Graduate School will pay for the out-of-state portion of the tuition. Each "tuition premium" is valued at $11,652 per year for a full-time student. In-state tuition and fees at CSU are $6,463.80 per year. The above "tuition premiums" contributed by the Graduate School will imply up to an additional $113,013 that we will use to support 4 additional students admitted during the last year of the project for the 2 extra years (see table below).

These funds will also be used for cost sharing of the internships at the federal and state agencies, and private firms as indicated in the proposal.

Distribution of funding sources. The table below indicates how the different funding sources will be distributed. Blue shades indicate NSF funds; therefore, 24 students will be supported on IGERT funds for 2 years per student, and 4 students for one year during the fifth year of the program. The different shades of blue indicate new students. Green shades indicate CSU funds (i.e., institutional matching funds and PI funds); therefore, CSU funds will be used for support of 32 student years. Observe that the program extends two years beyond the five years of NSF funding. The increase of students funded from 15 to 28 and the two-year extension of the program are possible because of the institutional matching and cost share provided.

WATER-IGERT							
NSF and CSU funds					**CSU funds**		
Active Students per year							
First Year	**Second Year**	**Third Year**	**Fourth Year**	**Fifth Year**	**Sixth Year**	**Seventh Year**	**New students per year**
NSF - 7	NSF - 7	Match/PI - 7					7
	NSF - 5	NSF - 5	Match/PI - 5				5
		NSF - 7	NSF - 7	Match/PI - 7			7
			NSF - 5	NSF - 5	Match/PI - 5		5
				NSF - 4	Match - 4	Match/PI - 4	4
7	12	19	17	16	9	4	**28**

[3] See institutional commitment letters

[4] See letter of commitment included with the proposal

Current and Pending Support

Investigator: Jorge Ramirez

Other agencies to which this proposal has been/will be submitted.
N/A

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: The system-wide water quality impacts of watershed disturbance

Source of Support: USDA-USFS-Rocky Mtn. Rsrch Station - CO

Total Award Amount: $28,500 **Total Award Period Covered:** 9/1/2004 **to** 8/31/2009

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0 **Sumr:** 0.25

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Quantifying the Complex Hydrologic Response of Anephemeral Desert Wash

Source of Support: DOD-ARMY-ARO-Army Research Office

Total Award Amount: $18,335 **Total Award Period Covered:** 5/1/2005 **to** 11/30/2009

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0.25 **Sumr:** 0

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Quantifying the complex hydrologic response of an ephemeral desert wash

Source of Support: DOD-ARMY-ARO-Army Research Office

Total Award Amount: $259,434 **Total Award Period Covered:** 5/1/2005 **to** 11/30/2009

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0.5 **Sumr:** 0

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Quantifying the Complex Hydrologic Response of Anephemeral Desert Wash

Source of Support: DOD-ARMY-ARO-Army Research Office

Total Award Amount: $46,665 **Total Award Period Covered:** 5/1/2005 **to** 11/30/2009

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0.5 **Sumr:** 0

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Quantifying the complex hydrologic response of an ephemeral system

Source of Support: NSF-GEO-Geosciences

Total Award Amount: $120,430 **Total Award Period Covered:** 6/7/2005 **to** 5/31/2009

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0 **Sumr:** 0.5

Current and Pending Support

Investigator: Jorge Ramirez

Other agencies to which this proposal has been/will be submitted.
N/A

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Vulnerability of the United States Water Supply System to Shortage

Source of Support: USDA-USFS-Rocky Mtn. Rsrch Station - CO

Total Award Amount: $154,140 **Total Award Period Covered:** 9/19/2005 **to** 9/1/2010

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0 **Sumr:** 0.5

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: CG/AR Micro-scale Hydrologic Modeling

Source of Support: DOD - US Department of Defense

Total Award Amount: $0 **Total Award Period Covered:** 5/1/2006 **to** 4/30/2011

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0 **Sumr:** 0

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Reu Site: Research Experiences for Undergraduates: Program in Water Research at Colorado State University

Source of Support: NSF-EHR-Education & Human Resources

Total Award Amount: $316,551 **Total Award Period Covered:** 6/1/2006 **to** 11/30/2009

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0.5 **Sumr:** 0

Support: ☐ **Current** ☑ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Vulnerability Analysis of Western Water Resources to Climate Variability and Change

Source of Support: US Bureau of Reclamation (USBR)

Total Award Amount: $120,000 **Total Award Period Covered:** 10/1/2009 **to** 9/30/2010

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** **Sumr:**

Support: ☐ **Current** ☑ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: IGERT-WATER: Integrated Water Atmosphere and Ecosystem Education and Research -- THIS PROPOSAL

Source of Support: NSF - National Science Foundation

Total Award Amount: $2,728,060 **Total Award Period Covered:** 7/1/2010 **to** 6/30/2015

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0.2 **Sumr:** 1

Current and Pending Support

Other agencies to which this proposal has been/will be submitted.

Investigator: A. Scott Denning

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Atmospheric Modeling, Assimilation and Source-Sink Estimation for the Carbon Cycle

Source of Support: National Aeronautics and Space Administration

Total Award Amount: $1,000,474 **Total Award Period Covered:** 6/23/2006 **to** 6/22/2011

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0 **Sumr:** 1

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Center for Multi-Scale Modeling of Atmospheric Processes (CMMAP)

Source of Support: National Science Foundation- Cooperative Agreement

Total Award Amount: $338,072 **Total Award Period Covered:** 7/1/2006 **to** 6/30/2011

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0.5 **Sumr:** 1

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Multi-year Regional Syntheses of Atmospheric Flux and Mixing Ratio Measurements in Support of the North American Carbon Program

Source of Support: Department of Energy

Total Award Amount: $489,860 **Total Award Period Covered:** 9/1/2006 **to** 8/31/2010

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0 **Sumr:** 0.5

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Data Fusion to Determine North American Sources and Sinks of Carbon Dioxide at High Spatial and Temporal Resolution from 2004 to 2008

Source of Support: National Oceanic and Atmospheric Administration

Total Award Amount: $407,967 **Total Award Period Covered:** 10/1/2007 **to** 4/30/2011

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 1 **Sumr:** 0

Support: ☑ **Current** ☐ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Modeling the Global Atmospheric Carbon Cycle in Preparation for OCO Data

Source of Support: National Aeronautics and Space Administration

Total Award Amount: $282,622 **Total Award Period Covered:** 5/15/2008 **to** 5/14/2011

Project Location: Colorado State University

Person Months Per Year Committed to the Project Cal: 0 **Acad:** 0.5 **Sumr:** 0

Current and Pending Support

Other agencies to which this proposal has been/will be submitted.

Investigator: A. Scott Denning

Support: ☐ **Current** ☑ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: A Global High-Resolution Fossil Fuel CO2 Inventory and Assimilation System to Advance Carbon Science, Climate Science, and Decision Support

Source of Support: National Science Foundation

Total Award Amount: $439,641 **Total Award Period Covered:** 9/15/2009 **to** 9/14/2012

Project Location: Colorado State University

Person Months Per Year Committed to the Project **Cal:** 0 **Acad:** 1 **Sumr:** 0

Support: ☐ **Current** ☑ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Amazon Basin: Ecophysiology Coupling with Multiscale Circulation

Source of Support: National Science Foundation

Total Award Amount: $553,670 **Total Award Period Covered:** 1/1/2010 **to** 12/31/2013

Project Location: Colorado State University

Person Months Per Year Committed to the Project **Cal:** 0 **Acad:** 1 **Sumr:** 1

Support: ☐ **Current** ☑ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: Land Atmosphere Exchanges of Carbon, Water, and Energy Across Croplands in North America

Source of Support: Department of Energy (NICCR)

Total Award Amount: $125,000 **Total Award Period Covered:** 4/1/2010 **to** 3/31/2011

Project Location: Colorado State University

Person Months Per Year Committed to the Project **Cal:** 0 **Acad:** 0.5 **Sumr:** 0

Support: ☐ **Current** ☑ **Pending** ☐ **To Be Submitted** ☐ ***Transfer of Support**

Project/Proposal Title: IGERT-WATER: Integrated Water Atmosphere and Ecosystem Education and Research -- THIS PROPOSAL

Source of Support: National Science Foundation

Total Award Amount: $2,728,060 **Total Award Period Covered:** 7/1/2010 **to** 6/30/2015

Project Location: Colorado State University

Person Months Per Year Committed to the Project **Cal:** 0 **Acad:** 0 **Sumr:** 0.2

Current and pending support

Neil S. Grigg

Support	Current
Project title	Secondary Impacts of Corrosion Control on Hydraulic Equipment
Source of support	AwwaRF
Total award amount	$125,000
Total award period covered	January 1, 2007 to December 31, 2009
Location of project	Colorado State University
Person–months per year	0.50
Cal	0
AY	0.50
Summer	0

Support	Pending
Project title	IGERT- WATER: Integrated Water Atmosphere and Ecosystem Education and Research (THIS PROPOSAL)
Source of support	NSF
Total award amount	$2,728,060
Total award period covered	July 1, 2010 to June 30, 2015
Location of project	Colorado State University
Person–months per year	1.0 (Yr 1 only)
Cal	0
AY	0
Summer	1.0

Support	Pending
Project title	Integration of Cost of Failure with Asset Risk Management
Source of support	Water Research Foundation
Total award amount	$150,000
Total award period covered	October 1, 2009 to September 30, 2011
Location of project	Colorado State University
Person–months per year	1.5
Cal	0
AY	1.5
Summer	0

Support	Pending
Project title	Analysis of Performance of Dual Distribution Systems
Source of support	Water Research Foundation
Total award amount	$150,000
Total award period covered	October 1, 2009 to September 30, 2011
Location of project	Colorado State University
Person–months per year	1.5
Cal	0
AY	1.5
Summer	0

Current and Pending Support

(See GPG Section II.D.8 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: N. LeRoy Poff	Other agencies (including NSF) to which this proposal has been/will be submitted. N/A

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

Project/Proposal Title:

Modeling future distribution of invasive species in rivers under different scenarios of climate change and dam operations

Source of Support: US Environmental Protection Agency (STAR)

Total Award Amount: $599,925 Total Award Period Covered: 07/01/08 – 06/30/11

Location of Project: Western US

Person-Months Per Year Committed to the Project. Cal: 0 Acad: 1.5 Sumr: 0

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

Project/Proposal Title:

Effects of water management and climate change on dynamics of native and invasive wetland and riparian species

Source of Support: US Geological Service

Total Award Amount: $150,889 Total Award Period Covered: 07/01/09 – 10/31/10

Location of Project: Western US

Person-Months Per Year Committed to the Project. Cal: 0 Acad: 0 Sumr: 0

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

Project/Proposal Title: Watershed To Local Scale Characteristics And Function Of Intermittent And Ephemeral Streams On Military Lands (David Cooper PI)

Source of Support: Strategic Environmental Research and Development Program

Total Award Amount: $1,300,000 (Poff 30,000) Total Award Period Covered: 11/01/09 – 10/31/12

Location of Project: Western US

Person-Months Per Year Committed to the Project. Cal: 0 Acad: 1.0 Sumr: 0

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

Project/Proposal Title:

Impact of Climate Change and Variability on the Nation's Water Quality and Ecosystem State
Charles Vorosmarty PI

Source of Support: US Environmental Protection Agency (STAR)

Total Award Amount: $799,554 (Poff 129,999) Total Award Period Covered: 10/01/09 – 09/30/12

Location of Project: continental United States

Person-Months Per Year Committed to the Project. Cal:0 Acad: 0.5 Sumr: 0

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

Project/Proposal Title:

IGERT-WATER: Integrated Water Atmosphere and Ecosystem Education and Research – THIS PROPOSAL

Source of Support: National Science Foundation

Total Award Amount: $2,728,060 Total Award Period Covered: 7/1/2010 – 6/30/2015

Location of Project: Colorado State University

Person-Months Per Year Committed to the Project. Cal: 0 Acad: 0 Sumr: 1 (Yr 1)

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

Facilities:

The university units and national institutions that will participate in this IGERT are home to internationally renowned, state-of-the-art laboratory and computing facilities, which will be engaged in the educational and research experience of our WATER-IGERT students.

Colorado State University provides a rich research and educational setting in terms of facilities, equipment, and other resources. The university employs over 100 faculty in 22 separate departments that apply their disciplines to WATER topics and these faculty teach a large number of graduate-level courses which are supported by research-level facilities (see partial list below).

The CSU Water Center facilitates interdisciplinary water research and teaching on campus. It coordinates with the NSF REU program in WATER and a USDA Water and Environment Science Fellows program, as well as the Colorado Water Resources Research Institute, which has close connections with many water agencies and districts within the state and region, including their field and laboratory facilities.

Fort Collins is home to six major Federal natural resource research laboratories/centers. The National Park Service, the U.S. Forest Service, the Agricultural Research Service, the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and the Natural Resources Conservation Service employ approximately 800 professionals, many of whom work in water-related fields. Access to such an extensive amount of expertise greatly fosters the synthesis of data and information surrounding the field of WATER sciences.

These CSU facilities and those of the participating agencies and private firms, as specified in their letters of support and in the body of the proposal, will be available to our WATER-IGERT students. A partial list of these facilities follows:

Vice-President for Research:

- The Water Center at Colorado State University

  The CSU Water Center located in the E-wing of Engineering Building will accommodate the new WATER-IGERT program. This location has new space that will be identified with the WATER-IGERT program, including an office for the IGERT program staff and administration, a conference room and computer and file space.
- Facilities of the Academic Computing Network Services

College of Engineering:

- State-of-the-Art Computing facilities of Engineering Network Services
- Atmospheric Science:
  - Center for Multi-scale Modeling of Atmospheric Processes (CMMAP)
  - CSU-CHILL National Radar Facility
  - Colorado Climate Center at CSU
- Civil and Environmental Engineering:
  - Engineering Research Center (ERC)
  - Hydrology Computer Laboratory
  - GIS Laboratory
- Cooperative Institute for Research in the Atmosphere (CIRA)
  - Center for Geosciences
  - Flash Flood Laboratory

College of Natural Sciences

- Center for Science, Mathematics and Technology Education (CSMATE)

Warner College of Natural Resources

- Natural Resources Ecology Laboratory (NREL)
- Shortgrass-steppe LTER
- Water quality laboratory
- Groundwater hydrology laboratory

College of Agricultural Sciences

- Agricultural Research, Development and Education Center (ARDEC)
- Eleven experiment stations located around Colorado

Colorado State University

September 11, 2009

Office of the President
102 Administration Building
Fort Collins, Colorado 80523-0100
(970) 491-6211
FAX: (970) 491-0501
www.colostate.edu

Program Director - IGERT
Division of Graduate Education
National Science Foundation
4201 Wilson Blvd
Arlington, VA 22230 USA

Dear IGERT Program Director:

Colorado State University has a long history of excellence in water science and engineering and in graduate education and research focused on societal needs. The **WATER**-IGERT program will build on our world-renowned programs in water, climate and the environment in the Departments of Civil and Environmental Engineering and Atmospheric Science to and help the College and University shape and reach our strategic goals, equip a new generation of PhD students and young faculty with unique interdisciplinary, integrative and transformative perspectives across the water science and policy arenas.

Colorado State University strongly supports the proposed "**WATER**-IGERT: Integrated **W**ater, **AT**mosphere, **E**cosystem **E**ducation and **R**esearch" Program. The focus of the program on transformative interdisciplinary education and research is aligned perfectly with our strategic goals in water, climate and the environment, which are areas of excellence within the College of Engineering in particular. The **WATER**-IGERT Program will serve as an integrator and motivator for current activities in our college such as the REU Program in WATER Research, the International School for Water Resources and the Center for Multi-scale Modeling of Atmospheric Processes.

We also expect that the **WATER**-IGERT Program will strengthen our ability to recruit and retain high quality graduate students to our PhD programs and help with faculty recruitment and retention. Colorado State University is strongly committed to recruiting and retaining graduate students from underrepresented groups, and thus we are especially supportive of those components of the **WATER**-IGERT program.

To demonstrate our commitment to the goals of **WATER**-IGERT, Colorado State University will provide a total cost share commitment of $525,000. This cost share will be provided as a blend of cash and in-kind contributions as follows:

- We commit to provide the Dr. Jorge A Ramirez as PI release from part of his teaching load to work effectively with faculty, students, and the IGERT Faculty Advisory Board.
- We will provide the administrative and facility support that is explained in the proposal. In addition, we will provide computing facilities, conference facilities, and substantial administrative time from my office.
- The Departments of Atmospheric Science and of Civil and Environmental Engineering together with the College of Engineering commit matching funds on the order of 8-9% of the total budget. This match commitment will complement those from the Department of Biology, the College of Natural Sciences, the Office of the Provost and the Office of the Vice President for Research for a total commitment in excess of $525,000 during the five years of the program. This financial commitment will allow the program to increase by almost 50% the number of PhD students who will be able to participate, and to extend its duration by 40%.
- We will support the **WATER**-IGERT leadership team in its efforts to attain the permanent base-operating budget it will need to sustain operations beyond this grant.

Please feel free to contact me for any additional information regarding our commitment to the **WATER**-IGERT.

Sincerely,

Anthony A Frank

Dr. Anthony A. Frank
President

Dr. Peter K. Dorhout, Ph. D.
Vice Provost for Graduate Affairs
Assistant Vice President for Research
Professor of Inorganic and Materials Chemistry
970-491-6817
Peter.Dorhout@colostate.edu

The Graduate School - MC 1005
Fort Collins, Colorado 80523-1005
Telephone: (970) 491-6817
FAX: (970) 491-2194
E-mail: gschool@grad.Colostate.EDU
http://graduateschool.colostate.edu

9 September 2009

Dr. Jorge A Ramirez
Department of Civil and Environmental Engineering
Colorado State University

Dear Dr. Ramirez,

I am pleased that your proposed NSF IGERT project titled "**WATER**-IGERT: Integrated **W**ater, **AT**mospheric, **E**cosystem Education and **R**esearch" was favorably received at the preproposal stage, and the Graduate School is eager to support the **WATER**-IGERT program. An important part of our strategic plan for the next decade is to enhance our ability to offer interdisciplinary graduate training as well as research opportunities. What you are proposing fits very well with the emerging strategic plan for the University and the Graduate School. The **WATER**-IGERT training program is innovative and clearly will accomplish the goals set forth by NSF in the IGERT program.

As part of the university strategic plan, growth in new, integrative, multidisciplinary graduate programs is an emphasis for the institution for the next decade. University leadership seeks to invest in critical research and education areas such as the environment, water and climate, energy, health, and disease prevention and your program fits well within that strategy. To that end, we are very interested in investing funds to leverage NSF grants such as your proposed **WATER**-IGERT to launch new interdisciplinary programs. Therefore, you should count on up to 10 non-resident tuition premiums (the difference between resident and non-resident tuition – currently valued at $11,652 per year for a full-time student) per year for the life of the grant for each new, first year graduate student who matriculates into your program and is supported by IGERT funds. Moreover, it is my intent to continue this tuition premium support *after the life of the grant* for every new, first year graduate student funded as a research assistant by any research grant, as a show of continuing commitment from our office to this new program.

As you are aware, the Graduate School is committed to strengthening the pool of underrepresented graduate students who are entering our graduate programs, and we are committed to sustaining those students through to graduation, with an emphasis on the PhD. We have created the Graduate Center for Diversity and Access, GCDA, led by our Associate Vice Provost, Dr. Jodie Hanzlik, to help programs recruit, retain, and graduate students who have been traditionally underrepresented in graduate school opportunities. The Center is home to a number of student programs including the Louis Stokes Alliance for Minority Participation Bridges to the Doctorate, Alliance for Graduate Education to the Professoriate, Fast Track to Work, McNair Scholars, and our own professional development programs. We offer workshops, professional meetings, and travel opportunities for graduate students and have developed a network of regional and national recruiting partners who are looking for supportive graduate school homes for their students. This center not only encourages students at CSU but also supports faculty and staff as they seek to broaden the impacts of their research and service to our citizens. I expect that your IGERT project will take full advantage of what we have to offer.

Sincerely,

Dr. Peter K. Dorhout
Vice Provost for Graduate Affairs

Colorado State University

College of Engineering
Office of the Dean
Fort Collins, Colorado 80523-1301
(970) 491-3366
FAX: (970) 491-5569
www.engr.colostate.edu

September 6, 2009

Program Director - IGERT
Division of Graduate Education
National Science Foundation
4201 Wilson Blvd
Arlington, VA 22230 USA

Dear IGERT Program Director:

The College of Engineering and its departments of Atmospheric Science and Civil and Environmental Engineering strongly support the proposed "**WATER**-IGERT: Integrated **W**ater, **AT**mosphere, **E**cosystem **E**ducation and **R**esearch" Program. The focus of the program on transformative interdisciplinary education and research is aligned perfectly with our strategic goals in water, climate and the environment, which are areas of excellence within the college. The **WATER**-IGERT Program will serve as an integrator and motivator for current activities in our college such as the REU Program in WATER Research, the International School for Water Resources, and the Center for Multi-scale Modeling of Atmospheric Processes.

CSU has a long history of excellence in **WATER** science and in graduate education and research focused on societal needs. The **WATER**-IGERT program will build on our world-renowned programs in water, climate and the environment in the departments of Civil and Environmental Engineering and Atmospheric Science to and help the College and University shape and reach our strategic goals, equip a new generation of PhD students and young faculty with unique interdisciplinary, integrative and transformative perspectives across the water science and policy arenas.

We also expect that the **WATER**-IGERT Program will strengthen our ability to recruit and retain high quality graduate students to our PhD programs and help with faculty recruitment and retention. Our College is strongly committed to recruiting and retaining graduate students from underrepresented groups, and thus we are especially supportive of those components of the **WATER**-IGERT program.

To add to the strength of the program we have pledged the following categories of institutional support :

- We commit to provide the PI (Dr. Jorge A Ramirez) with release from part of his teaching load to work effectively with faculty, students, and the IGERT Faculty Advisory Board.
- The Departments and College will provide the administrative and facility support that is explained in the proposal. In addition, we will provide computing facilities, conference facilities, and substantial administrative time from my office.
- The departments of Atmospheric Science and of Civil and Environmental Engineering together with the College of Engineering commit matching funds on the order of 8-9% of the total budget. This match commitment will complement those from the Department of Biology, the College of Natural Sciences, the Office of the Provost and the Office of the Vice-president for Research for a total commitment in excess of $525,000 during the five years of the program. This financial commitment will allow the program to increase by almost 50% the number of PhD students who will be able to participate, and to extend its duration by 40%.
- We will support the **WATER**-IGERT leadership team in negotiations with the CSU Council of Deans and the upper administration for the permanent base-operating budget it will need to sustain operations beyond this grant.

Sincerely,

Sandra Woods

Sandra L. Woods, Dean
College of Engineering

USDA United States Department of Agriculture | Forest Service | Rocky Mountain Research Station | 240 W. Prospect Road Fort Collins, CO 80526-2098

File Code: 4000
Date: SEP 14 2009

Program Director
IGERT, Division of Graduate Education
National Science Foundation
4201 Wilson Blvd
Arlington,, VA 22230

Dear Program Director,

The Rocky Mountain Research Station (RMRS) heartedly endorses the WATER-IGERT proposal presented by Dr. Jorge Ramirez. The RMRS is part of the research branch of the U.S. Forest Service, with headquarters and research facilities in Fort Collins, Colorado. The Station maintains laboratories in Fort Collins as well as three nearby experimental forests. Station scientists conduct ecologic, hydrologic, and socio-economic research relevant to management of public lands. Because federal lands are the source of much of the nation's water supply (indeed, research conducted jointly with Colorado State University (CSU) shows that federal lands contribute 66% of the water supply of the 11 western contiguous states, and 78% of Colorado's water supply), the Station has a primary focus on the interactions between vegetation and water flow, with much current emphasis on how climatic variations will affect both vegetation and streamflow.

RMRS scientists commonly work jointly with university professors and their students. CSU is an important cooperator with the Station; many of the Station scientists are faculty affiliates at CSU and serve on graduate committees. Often this cooperation involves formal agreements providing funds for research projects. Over the past four years, for example, the Station provided $1.5 million per year in research funds to CSU. We view the IGERT proposal as an opportunity to leverage our funding to provide enhanced opportunities for research relevant to management of public lands. Specifically, we anticipate making data available and providing laboratory facilities, access to experimental forests, an entree to federal land managers, participation as scientists in residence on IGERT projects, and the possibly of internship opportunities for IGERT students.

Sincerely,

G. SAM FOSTER
Station Director

cc: Thomas C Brown, Cindy S Swanson, Jorge Ramirez

United States Department of Agriculture
Research, Education and Economics
Agricultural Research Service

September 2, 2009

SUBJECT: WATER – IGERT:
Integrated Water, Atmosphere, and Ecosystems Education and Research

TO: Program Director – IGERT; Division of Graduate Education
National Science Foundation
4201 Wilson Blvd; Arlington, VA 22230 USA

CC: Dr. Jorge Ramirez
Department of Civil and Environmental Engineering
Colorado State University

FROM: Timothy R. Green
USDA-ARS, Agricultural Systems Research Unit
Email: Tim.Green@ars.usda.gov

This letter offers our strongest support of the IGERT proposal by Professor Jorge Ramirez and others at Colorado State University. We are very interested in hosting WATER-IGERT graduate students at our USDA-ARS laboratory ("Research Unit"). Dr. Kelly Elder at the USDA Forest Service (FS) in Fort Collins, CO has also agreed to collaborate in this effort. The USDA-ARS/FS offers an excellent environment for graduate students to gain research experience linking fundamental science issues to applications. We have extensive collaboration with universities nationally and internationally, as well as other federal agencies. We are addressing forest, range, and agricultural land management related to natural resources conservation, including water quantity and quality. Research approaches include high-resolution spatial measurements of water, snow, soil and plant variables to explore spatial scaling of system state variables and fluxes. Field measurements are used to develop and test computer models of agricultural landscapes, including process interactions in space and time.

We would work directly with WATER-IGERT graduate students on topics of mutual interest, and ARS/FS would house the students in our facilities located immediately south of Colorado State University. An office cubical, phone, and desktop computer would be provided for all work-related activities, and the student would have access to our labs (*e.g.*, Hydraulics, Soil Physics, and Plant Physiology) along with basic supplies for laboratory and field work. Some access is restricted to US citizens.

Any period of time is possible for the internship, but our preference is the full 12 months. This allows the student to do substantial work toward a Ph.D. that would benefit the student and the collaboration between ARS/FS and the university. We have agency-approved, standard methods of recruitment that are effective and meet all EEO requirements. Our track record is very good regarding recruitment and retention of ethnic minorities and women into scientific research.

Beyond these in-kind contributions, some financial assistance may be possible to assist with the student's stipend through a Specific Cooperative Agreement. However, our financial situation is uncertain in the coming year, so a dollar commitment is not possible at this time.

WATER-IGERT can provide a wonderful opportunity for Ph.D. students to interact in real ways with the outside world, thus shaping the content of Ph.D. research. It would be our pleasure to join in this effort.

Sincerely,

T R Green

Timothy R. Green (on behalf of myself and Kelly Elder, USDA-FS)

RIVERSIDE

September 9, 2009

Program Director – IGERT
Division of Graduate Education
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230 USA

To Whom It May Concern:

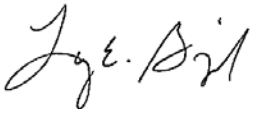
Riverside Technology, inc. (Riverside) is pleased to provide this letter in support of Colorado State University (CSU) to establish an IGERT Program to provide funding for educating and training of PhD students.

Riverside is a Fort Collins, Colorado-based consulting firm specializing in water resources engineering, management and planning with over twenty years experience developing and implementing water resource management systems for national and international organizations including governments, organizations and the private sector. Internationally, Riverside has extensive experience in water resources management including hydro-meteorological information system development in India, Bangladesh, Central and Southeast Asia, Latin America, and the Nile River Basin. Riverside staff expertise includes a variety of related disciplines such as decision support systems, modeling, data networks, river hydraulics, land suitability for irrigation and irrigation water management; institutional development and support for community based water resources management; and irrigation systems rehabilitation. Riverside has extensive capabilities in Geographical Information Systems (GIS) and remote sensing, and specializes in applying these technologies in irrigation, flood inundation mapping, and water resources management. In 2003, Riverside was awarded the second of two contracts to support the National Weather Service's (NWS) Advanced Hydrologic Prediction Service (AHPS) program, the first was awarded to Riverside in 1997.

In support of the IGERT Program, Riverside would be happy to sponsor one or more student interns at the corporate office in Fort Collins, Colorado, for summer internships as well as 6- and/or 12-month internships. Riverside also would provide professional mentors with many years of experience in various fields to students involved in the IGERT Program. As Riverside is located only minutes from the CSU campus, this arrangement could be beneficial for both Riverside and CSU. Riverside holds several government contracts, and could provide assistance in locating an internship at a government agency.

Many of Riverside's current employees are graduates of CSU, and look for ways to provide support to the university. I personally have been a Faculty Affiliate in the Department of Civil and Environmental Engineering at CSU since 1991, and Riverside sponsors a yearly corporate scholarship for students in the Department of Civil Engineering. Riverside would welcome this opportunity to assist CSU in obtaining this IGERT funding. Please contact me with any questions you may have at Larry.Brazil@riverside.com or by phone at 970-484-7573.

Sincerely,
Riverside Technology, inc.



Larry E. Brazil, Ph.D., P.E.
President

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Fort Collins Science Center
2150 Centre Ave., Bldg. C
Fort Collins, CO 80526-8118

September 11, 2009

Program Director - IGERT, Division of Graduate Education
National Science Foundation,
4201 Wilson Blvd
Arlington, VA 22230 USA

Dear Program Director:

The USGS Fort Collins Science Center is pleased to support this proposal for the WATER-IGERT program at Colorado State University. Our Center has many interdisciplinary research teams that focus on real-world problems of Department of Interior agencies and we could provide internship opportunities for advanced PhD students.

The Fort Collins Science Center is a nationally and internationally recognized USGS science center that provides ecological systems-oriented solutions to support the complex environmental decisions faced by our key customers. These interdisciplinary solutions integrate long-term, strategically focused research; short-term tactical research; predictive modeling; Web applications and information science; and technical assistance that deliver critical information to resource management agencies. Several of our current scientific focus areas could provide appropriate internship opportunities.

Environmental Flows and River Restoration. Scientists working in this focus area integrate hydrology and hydraulics including groundwater and surface water, demand for water (agricultural, municipal, recreational), fluvial geomorphology, river and riparian ecology, and aquatic habitat modeling to explain and predict patterns and variation in the way river ecosystems respond to alterations of the channel, streamflow, sediment regime, landscape processes, and climate change.

Social/Economic Decision Tools. When considering changes in land and water management practices, managers must consider the social and economic effects of these changes within the management planning process. Scientists in this focus area (1) conduct economic research to evaluate the market and nonmarket values and effects of current and proposed changes in public land and water management practices, including wildlife management, endangered species protection, habitat restoration and conservation, climate change, and invasive species; (2) assess the economic value of natural resource management issues; and (3) integrate biological, social, and economic analyses in an effort to understand how humans are affected by environmental management decisions and how human activities interact with natural resource management.

Invasive Species. As a lead member of the recently formed collaborative, the USGS National Institute of Invasive Species Science, the Center will develop collaborative approaches for detecting, monitoring, assessing, and forecasting the spread of invasive species to meet the science information needs of resource managers and the public. A primary thrust is the integration of high-performance modeling and space-based observations in a web-based data management and modeling tool to identify vulnerable habitats and forecast the spread of invasive species at multiple spatial scales.

We look forward to partnering with Colorado State University in this effort and providing internship opportunities at our research Center.

Sincerely,

Dave Hamilton
Center Director, Fort Collins Science Center

United States Department of the Interior

BUREAU OF RECLAMATION
PO Box 25007
Denver, Colorado 80225-000

IN REPLY REFER TO:

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September 9, 2009

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VIA ELECTRONIC MAIL

Program Director – IGERT, Division of Graduate Education
National Science Foundation
4201 Wilson Blvd
Arlington, VA 22230

Dear Program Director:

The Research and Development Office of the Bureau of Reclamation (Reclamation) intends to support the National Science Foundation (NSF) Integrative Graduate Education and Research Traineeship (IGERT) proposal being submitted by Professor Jorge Ramirez at Colorado State University contingent upon grant award. Our planned contribution consists of:

1) Helping to select an intern that will participate with Reclamation,

2) Providing the student with internship opportunities through the Research and Development Office at the Federal Center in Denver, Colorado consistent with the NSF IGERT award system,

3) Providing computational facilities commensurate with the needs of the student and project,

4) Helping to define a relevant research question that is consistent with Reclamation's mission and the interest of the student,

5) Providing communication, access, and interactions with Reclamation staff along a path jointly selected by the intern and Reclamation to achieve the highest possibility of success.

David Raff, Ph.D., P.E. will serve as Reclamation's coordinator on this activity. Dr. Raff will ensure effective integration with Reclamation's mission objectives and provide mentoring to the intern.

Sincerely,

Curtis A. Brown
Director, Research and Development