UNIVERSITY OF MONTANA GK-12 PROGRAM
Annual Report for 2006

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And with contributions from the 2005 and 2006 cohort
of GK-12 fellows at The University of Montana

1. Highlights and Accomplishments of the University of Montana ECOS (Ecologists, Educators, and Schools) Program From Sept 2005 – Sept 2006.

The **Ecologists, Educators and Schools (ECOS) – Partners in GK-12 Education** Program brings together teachers and administrators in the Missoula Curriculum Consortium (MCC) and University of Montana (UM) faculty to create authentic research experiences for K-12 students using schoolyards and nearby open areas as outdoor research laboratories. Furthermore, ECOS places scientists in residence (two doctoral level graduate students and one undergraduate) to work with partner teachers to develop science demonstration projects related to local ecology and conservation biology. Throughout the academic year and summer, K-12 students and their teachers will interact with UM faculty, postdoctoral scholars, and graduate and undergraduate students conducting research in ecology.

To meet the need for enhanced understanding of environmental sciences in the Northern Rockies, the ECOS Program will 1) develop scientific ways of thinking and understanding in K-12 students through authentic research experiences in their schoolyards and adjacent habitats; 2) promote teaching practices focused on "learning by doing" and inquiry instruction for both teachers and future science faculty (ECOS Fellows); 3) develop and model linkages between educators in the K-16 continuum; and 4) identify project indicators to make the program sustainable at UM, and facilitate transfer to other sites in Montana and around the country.

In this report, we detail the activities and accomplishments since September 2005 of the first cohort of ECOS Fellows and teams who participated from July 1, 20045 – June 30, 2006. We also report on the activities to date of the second cohort of fellows who began their fellowship year on July 1, 2006.

2. ECOS Fellows and Teachers during Sept 2005 – Sept 2006

To recruit fellows and schools for both cohorts of fellows, we have used the same strategy. An ECOS color brochure, informational materials, and application packets were developed for regular and email distribution. An online application process was developed for the teachers in year one, but was not used in the second year due to reticence of the teachers to interact with the web form; therefore in year two, all applicants presented paper applications. To recruit student fellows, our efforts entailed sending announcements over e-mail to all PhD students in the Division of Biological Sciences and College of Forestry and Conservation, and additionally to the Departments of Chemistry and Geology in year 3. We also talked with faculty during faculty meetings, and made announcements in targeted undergraduate courses.

To recruit schools and teachers, we worked with the Missoula County Curriculum Consortium science curriculum coordinator. Through this key contact, we made presentations to the board of superintendents and school principals. A broadcast email with information and application packet went out to all school principals in Missoula County and in surrounding rural school districts, and follow-up calls were made to ensure that principals were distributing information to school site teachers and encouraging them to apply for the program. We also contacted teachers who had participated in previous programs we have run directly, including Montana Partners in Ecology, Montana Teachers Investigate Ecology, and Schoolyard Ecology for Elementary

School Teachers (all programs funded by the NSF). Finally for year 3, we also asked year 1 and 2 teachers to invite interested colleagues to in-service meetings. This strategy proved to be the most successful tool for recruiting enthusiastic new teachers.

Applicants for the fellowships were asked to complete the application materials detailed on our website at www.BioEd.org/Ecos/. Potential fellows were asked to write an essay detailing their interest in participating in ECOS and provide evidence of their academic standing and approval to participate from their academic advisor. All fellows were interviewed by a selection committee; in year 3, current graduate fellows served as members of the interview team. Teachers were asked to describe how Scientists in residence at their schools would advance science education. Once selected, teachers and fellows signed a contract detailing expectations over the academic year for their participation.

In three years of the GK-12 program at the University of Montana, we successfully recruited a very strong pool of PhD fellows representing a wide diversity of environmental science departments and programs across two colleges. Students were recruited from the Organismal Biology and Ecology Program and Integrated Microbiology and Biochemistry Programs in the Division of Biological Sciences graduate programs, the department of Geology (year 3) from the College of Arts and Sciences, and from the Departments of Ecosystem and Conservation Sciences and Wildlife Program (College of Forestry and Conservation). The teachers have between 5 to more than 30 years of teaching experience.

During this reporting period we have worked with two different cohorts of fellow and teacher participants. Both are listed in the tables below.

This cohort of ECOS fellows and teachers began their fellowship year in July 2005.

NAME	ROLE	YEAR IN SCHOOL OR WORK	ECOS TEAM	TIME IN ECOS (MO)	BRIEF DESCRIPTION OF ROLES AND INTERESTS
ECOS Fellows 2005-2006					
Sam Stier	PhD Fellow	2 years	Florence Carlton	3	PhD student in Forestry, studying the opportunities and constraints to biodiversity conservation within the carbon credit market.
Bruce Threlkeld	PhD Fellow	2 years	Lewis and Clark	3	PhD student in Forestry, researching herbaceous layer response to disturbance in mesic forests of northern Idaho and western Montana
Alison Perkins	PhD fellow	<1 year	Hellgate Elem	3	PhD student in Forestry, studying the opportunities for ecological education through television and other informal communication channels
Brooke McBride	PhD fellow	1 year	Target Range	3	PhD student in Integrative Microbiology and Biochemistry, studying the structure and function of arbuscular mycorrhizal fungi.
Joseph Fontaine	PhD fellow	2 years	Florence Carlton	3	PhD student in Fish and Wildlife Biology, researching the influence of juvenile mortality risk on life history, parental care, physiology and population demographics of a song bird community
John S. MacLean	PhD Fellow	1 year	Hellgate Elem	3	PhD student in Geology, documenting the continuation of the Rocky Mountain foothills triangle zone into Montana along the Rocky Mountain Front
Michael Machura	PhD Fellow	1 year	Target Range	3	PhD student in Integrative Microbiology and Biochemistry, studying the effect of habitat disturbance on amphibian populations.
Katie Hailer	PhD Fellow	4 years	Lewis and Clark	3	PhD student in Chemistry, researching changes in cellular processes brought about by chromium oxidized lesions
Carl Rosier	2nd year PhD Fellow	3 years	At-large fellow	15	PhD student in Integrative Microbiology and Biochemistry, researching arbuscular mycorrhizal fungi and working towards expanding ECOS in the University community
Rachel Loehman	2nd year PhD Fellow	5 years	At-large fellow	15	Department of Ecosystem and Conservation Sciences PhD student studying remote sensing to predict vector-borne diseases and working to include geospatial technologies in science education.
Jeff Piotrowski	2nd year PhD fellow	3 years	Special Projects	15	Integrated Microbiology and Biochemistry PhD student working on the ecology of arbuscular mycorrhizal communities and developing curriculum and serving as a mentor for ECOS

ECOS Undergraduate Fellows 2005-2006					
Corissa Crowder	Undergrad Fellow	3 years	Lewis and Clark	3	Biology major whose goal is to conduct research in conservation biology
Hannah Elliott	Undergrad Fellow	5 years	Hellgate Elem	3	Biology major with a concentration in biology education
Andrew Hoye	Undergrad fellow	3 years	Hellgate Elem	3	Biology major with lab experience in soil ecology
Allison Greene	Undergrad fellow	3 years	Target Range	3	Biology major with an emphasis an Ecology and experience in various field work projects in western Montana
Melissa Maggio	Undergrad fellow	4 years	Florence Carlton	3	Biology major with an emphasis in Botanical Sciences with field experience working with BLM in western Montana.
ECOS Partner Teachers 2005-2006					
Mike Plautz	Teacher and CO-PI	15 years	Hellgate Elem	3	BS in Biology, currently teaching 7th grade general science and enrolled in graduate school of education at UM.
Jo Fix	Teacher	20 years	Hellgate Elem	3	BA in Elementary Education, currently teaching 3rd grade and assisting other elementary teachers in environmental subjects.
Julie Greil	Teacher	17 years	Lewis and Clark	3	BA in Elementary Education, with experience teaching 1st and 2nd grade.
Carol Reeves	Teacher	21 years	Lewis and Clark	3	BS in Elementary Education with a certification in special education, currently teaching 5th grade
Peggy Purdy	Teacher	26 years	Target Range	3	BA in Elementary Education, currently teaching 4th grade.
Debbie Caron	Teacher	27 years	Target Range	3	BA in Elementary Education, currently teaching 4th grade with experience in 2nd through 8th grade teaching
Byron Weber	Teacher	27 years	Florence Carlton	3	BS Biology, with teaching experience ranging from Kindergarten to Highschool
Brent Heist	Teacher	4 years	Florence Carlton	3	BA in Elementary Education, currently teaching 8th grade physical science, reading and art

ECOS schools for the 2005-2006 schoolyear were suburban and rural.

School	Grade Range	Rural Suburban or Urban	Ethnicity*	# of Students	% Free/ Reduced Lunch**	Academic Standing % Proficient by school or district and met AYP***
Lewis and Clark Elementary	K-5	Suburban	AA <1% AI 4.5% H 2.1% W 90% AS 2.3%	473	29%	Reading 89% Math 64% Met AYP
Hellgate Elementary /Middle School	PK-6/ 7-8		AA <1% AI 3.5% H 1% W 91.5% AS 3%	1197	40.7%/ 36.6%	Reading 77%/77% Math 72%/83% Met AYP
Florence Carlton Elementary/Middle	PK-6/ 7-8	Rural	AA 1% AI 1% H <1% W 97 % AS 1%	625	19.9%/ 20.4%	Reading 89%/71% Math 69%/62% Met AYP
Target Range Elementary	PK-6	Rural	W 94 % AS 3.7 %	291	25.7%	Reading 71% Math 66% Met AYP

All data is for most recent year information available 2003-04; Data taken from the Missoula office of public instruction website, www.opi.state.mt.us/

**AA= African American, AI= American Indian, H=Hispanic, W= White, AS= Asian*
***Indicator of Socioeconomic Status*
****AYP= Adequate Yearly Progress per No Child Left Behind*

The following participants were recruited for cohort 3 and began their participation in June 2006.

Name	Year in school	School	Time in ECOS (months)	Brief description of roles and interests
PhD Fellows 2006-2007				
Florence Gardipee	3rd	Arlee Elementary	4	Wildlife Biology PhD students conducting conservation genetics and parasite studies on bison in the Yellowstone ant Grand Teton National Parks.
Matthew Corsi	1st	Arlee Elementary	4	PhD student in Wildlife Biology, studying hybridization and population dynamics of trout in the Jocko River Basin in western Montana
Alison Perkins	2nd	Lewis and Clark Elementary	16	PhD student in Forestry, studying the opportunities for ecological education through television and other informal communication channels
Nathan Gordon	4th	Lewis and Clark Elementary	4	Microbial Ecology PhD students studying previously undescribed microorganisms in hyporheic zones.
Joss McKinnon	3rd	Clinton School	4	PhD students in Forestry, studying soil nutrient stoichiometry as influenced by fire return intervals in ponderosa pine forests.
John S. MacLean	2nd	Clinton School	16	PhD student in Geology, documenting the continuation of the Rocky Mountain foothills triangle zone into Montana along the Rocky Mountain Front
Michael Machura	2nd	Hellgate Elementary	16	PhD student in Integrative Microbiology and Biochemistry, studying the effect of habitat disturbance on amphibian populations.
Mary Bricker	4th	Hellgate Elementary	4	PhD student in Organismal Biology and Ecology studying the role of small mammals in the population dynamics of two grassland forbs.
Rebecca Wahl	3rd	Target Range	4	PhD students in wildlife biology studying movement and population dynamics of the Columbia Spotted frog in western Montana.
Jeff Piotrowski	4th	Target Range	16	Integrated Microbiology and Biochemistry PhD student working on the ecology of arbuscular mycorrhizal communities and developing curriculum and serving as a mentor for ECOS

Special Projects Masters Fellows 2006-2007				
Jennifer Marangelo	2nd	All schools	4	Masters student in Interdiscplinary Studies, studying curriculum development and museum exhibit design, with a concentration in creating live insect exhibitions.
Sarah Bisbing	1st	All schools	4	Masters student in Forestry, studying old growth classification of larch stands in western Montana.

Name	Number of years teaching	School	Time in ECOS (months)	Brief description of roles and interests
Partner Teachers 2006-2007				
Ronda Howlett	11	Arlee Elementary	4	5th grade teacher, interested in incorporating the nearby Jocko River watershed into curricula
Bonnie Barger	30	Arlee Elementary	4	1st grade teacher, interested in plants and insects and other ecological topics to get her young students excited about science.
Christy Meurer	6	Lewis and Clark Elementary	4	1st/2nd grade teacher, personally interested in identifying and drawing local wildflowers and looking to enhance her students' science education opportunities.
Betsy Sharkey	12	Lewis and Clark Elementary	4	1st/2nd grade teacher, experienced in environmental issues in rural settings and looking to improve her ability to teach science in an urban setting.
Amanda McGill	10	Clinton School	4	5th grade teacher, interested in incorporating a nearby river and field into her science curricula
Kathy Kaiser		Clinton School	4	4th grade teacher, interested in giving students outdoor skills and a deeper knowledge of human impacts on the environment
Kathy Meyers	26	Hellgate Elementary	4	5th grade teacher interested in pod ecology and using gardening to teach ecology.
Colleen Cooper	26	Hellgate Elementary	4	5th grade teacher, particularly interested in forestry and other tree-related curricula.
Tara Barba	16	Target Range	4	3rd grade teacher, interested in local ecological topics and issues and increasing her skills of teaching hands-on lessons.
Randee Stephens	15	Target Range	4	6th grade teacher, personally interested in nature conservation issues like preserving old-growth and maintaining clean waters.

ECOS schools for the 2006-2007 schoolyear were urban, suburban and rural.

School	Grade Range	Rural Suburban or Urban	Ethnicity* (% of student enrollment)	# of Students	% Free/ Reduced Lunch**	Academic Standing % Proficient by school
Lewis and Clark Elementary	K-5	Suburban	AA 1.3 AI 9.8 H .4 W 84.7 AS 3.7	457	38.95	Reading 82 Math 77
Hellgate Elementary	PK-6	Suburban	AA 1.0 AI 3.7 H 1.7 W 90.1 AS 3.0	393	30.3	Reading 79 Math 82
Target Range Elementary	PK-6	Rural	AA .4 AI 2.8 H 0 W 95.4 AS 1.4	283	35.69	Reading 86 Math 71
Clinton School		Rural	AA 0 AI 2.1 H 0 W 95.9 AS 2.1	146	43.84	Reading 87 Math 86
Arlee Elementary		Rural	AA 0 AI 70.6 H 0 W 29.4 AS 0	228	67.98	Reading 71 Math 68

Most data is for most recent year information available 2005-2006; Data taken from the Missoula office of public instruction website, www.opi.state.mt.us/

**AA= African American, AI= American Indian, H=Hispanic, W= White, AS= Asian*
***Indicator of Socioeconomic Status*
****Combined Percentage Proficient and Advanced in each subject. Data from 2004-2005 AY*
All schools met Adequate Yearly Progress per No Child Left Behind

3. ECOS Demonstration Projects Sept 2005 – Sept 2006

The first four projects were completed by the 2005-2005 ECOS cohort.

Exploring Eco-Diversity in our Community
Hellgate Elementary
Jo Fix, Michael Plautz, John MacLean, Alison Perkins Hannah Elliott, Andrew Hoye

Alison Perkins helps students plant their Native Garden

The Hellgate team successfully constructed four outdoor learning centers, providing students and teachers an opportunity to observe and learn about the variety of ecological systems in their schoolyard. These centers offer specific settings for inquiries that include microbial ecology, plant form and function, biological control of noxious weeds, and geologic effects on macro-ecosystems. The ECOS fellows developed the centers according to their research specialties, and also ensured that they were aligned with the school curriculum and national science standards. In a nutshell, the learning centers are:

Native American Medicinal Plant Garden – A 30 foot long garden consisting of native medicinal plants used by Native Americans.

Insectories – Built during Earth Week with the help of the Missoula County Weed District, they house the knapweed root boring weevil.

Behavioral Ecology Center – this corner of the schoolyard explores the ample evidence for ground squirrel activity, birds, and insects.

Rock Walk – Built during Earth Week, this 0.25 km long sidewalk is divided into a geologic time scale with local rock samples that are 2.7 billion to 75 million years old.

7th grade teacher Mike Plautz helps students analyze vegetation in the insectory

Creating an Outdoor Classroom
Target Range School
Debbie Caron, Peggy Purdy, Allison Greene, Mike Machura, Brooke McBride

Target Range 5th graders inspect soil under the snow in their outdoor classroom

Tracking inquiry at Target Range School

At Target Range School, the ECOS team and students transformed a neglected and unsafe cottonwood grove at the edge of the schoolyard into an outdoor classroom and nature observatory to be enjoyed by the entire school. Local companies, parents, and the Montana College of Technology generously volunteered their time, products, and labor to the project. Currently, the major excavation and landscaping work is complete, with minor aesthetic details remaining. Inquiries completed in the outdoor classroom include tracking studies and tree sampling.

Rediscovering the Discovery Core: Exploring the Outdoors like Lewis and Clark
Lewis and Clark Elementary School
Carol Reeves, Julie Greil, Katie Hailer, Bruce Threlkeld, Corissa Crowder

Bruce Threlkeld shows students how to weed so they can all clean up the outdoor classroom

To promote hands-on science education in schoolyards and adjacent open areas in western Montana, the ECOS team enhanced the native garden, called the Outdoor Discovery Core, at Lewis and Clark Elementary School. This garden became an outdoor laboratory to teach a variety of ecological topics, including plant identification, observation and

New plant signage at Lewis Clark

using a nature field guide. A comprehensive nature guide identifying all of the plants in the Outdoor Discovery Core allows the whole school to benefit from this team's project. Also, 100 plant ID plaques are in place and detailed natural history information was compiled for 12 common species in the garden that were originally identified by Lewis and Clark. Each of the 12 featured plants has a small description taken from the journal of Meriwether Lewis.

Birds, Bats, Bees, and Blossoms: Students and Teachers Exploring Components, Connections, and Changes

Florence Carlton K-12 School

TJ Fontaine, Melissa Maggio, Sam Stier, Brent Heist, and Byron Weber

Florence Carlton's paved trail through their outdoor classroom

The Florence Carlton School has continued last years' improvement of the outdoor classroom, while helping teachers incorporate many ecological aspects of the classroom into their teaching across the K-12 curriculum. The ECOS team wanted all ecological aspects of the OC to be put to use.

After removing abandoned cement slabs, old bed frames, garbage, fencing, and some of the population of knapweed, the team helped the school find a contractor who successfully created a wheelchair-accessible trail through the outdoor classroom. Once the trail was built, an entrance kiosk was installed, over 150 native plants were planted, and plant ID plaques put in place. The team also put together an ecology-based Discovery Booklet that will help teachers organize inquiries and start discussions involving ecological topics that will capture student interest. To go along with the Discovery Booklet, an Inquiry Binder is now available, providing teachers with investigations for the outdoor classroom. The ECOS teams for the current academic year already have identified the themes for their Schoolyard Demonstration Projects. Work has begun to put them in place.

Students at Florence Carlton search for camouflaged pipe cleaners in the outdoor classroom

2006-2007 Demonstration Project Plans

Change on the Range
Target Range School
Tara Barba, Randee Stephens, Jeff Piotrowski, Rebecca Wahl

At Target Range team has chosen ecological change as their theme for the schoolyear and their demonstration project. They plan to enhance and bring together the two previous years' demonstration projects: a native plant garden and a renovated cottonwood grove. To do this, they will connect the two initial projects with a gravel path and install student workbenches that can be used for inquiry and outdoor reflection. In addition, they will work on restoration, solidification, and completion of the current demonstration projects in order to help make them more usable and permanent. Inquiries in these areas will focus on seasonal changes in the schoolyard and comparisons of the types of species and communities found in these two areas.

No Teacher Left Indoors
Lewis and Clark Elementary School
Christy Meurer, Betsy Sharkey, Alison Perkins, Nathan Gordon

The team at Lewis and Clark aim to provide the students and teachers with resources necessary to better utilize their already established schoolyard classroom. While there is great potential for outdoor education, few of the current teachers at Lewis and Clark seem to use this resource regularly. Thus the goal of this project is to provide all teachers with materials and inquiry experiences to empower them in using the schoolyard to enrich and expand their science curricula. The ECOS team will implement a weather station, environmental temperature data loggers, the initial phase of a site-specific herbarium, a personalized scientific inquiry CDs for teachers, and a web-cam highlighting a nearby wetland. These resources will also provide science data for long-term local and global study, while will also equipping Lewis and Clark teachers with information, methods, and resources to enrich and sustain the ODC as a schoolyard laboratory.

Project T.E.D (Teaching Ecological Diversity)
Arlee Elementary School
Bonnie Barger, Ronda Howlett, Matt Corsi, Florence Gardipee

The Arlee team will focus its year on ecological diversity by beginning a schoolyard demonstration project that both commemorates an important teacher that passed away, Ted Hesse, and provides a structurally diverse area for inquiries that also incorporate traditional ecological knowledge. They plan to build on the current mature cottonwood stand by adding hydrophilic plants next to a nearby irrigation ditch, and seedlings of younger cottonwoods and other tree species. In addition a garden will be planted with native plants chosen for their

importance as tribal resources and because of their animal attraction potential. All the plant species in the garden will have an associated informational placard, containing common name, Latin name, and traditional Salish name. Furthermore, 2 bird next boxes and 2 bat boxes will be placed in the cottonwood grove

ESCAPE (Energized Students at Clinton Applying Principles of Ecology)
Clinton Elementary School
Kathy Kaiser, Mandy McGill, John MacLean, Joss McKinnon

The Clinton team will allows students to escape the classroom and utilize the Clinton Schoolyard and natural surroundings in order to introduce ecological concepts which focus on energy. This includes how plants and animals use energy, how they produce energy, where the energy comes from, how energy is balanced, and how abiotic processes involving energy affect habitats and ecosystems. The team will construct a greenhouse and compost station which will provide two outdoor laboratories that will engage students in several energy concepts, including solar energy, photosynthesis and biodegradation.

Ecos for Kids!
Masters Special Project Fellow
Sarah Bisbing

The overriding goal of Sarah Bisbing's project is to engage children in ecological investigations at the earliest possible point in their education by developing "ECOS for Kids!", a traveling test kit and website. As it stands, the online ECOS Natural History Guide is extremely comprehensive, easy to access, and easy to follow. The guide, however, is not geared toward early elementary students (K-3). Sarah will begin her project be creating a series of test kits for use in the classroom. These kits will be interactive displays, posters, and worksheets that would allow early elementary children to learn about ecology and natural history in a manner more accessible to their age group. The kits will then guide Sarah in the creation of kids portion of the ECOS Natural History Guide website. The ECOS for Kids! section of the Guide will be interactive, colorful, and more basic in its means of identifying a plant.

4. ECOS Training and Institutes

During the last year, ECOS staff and collaborators have offered a variety of training and professional development opportunities for teachers and fellows. Each fellowship year begins with a 4 -day orientation where the ECOS program was described in more detail and expectations were discussed. During these orientations, fellows were introduced to ECOS Program projects, such as the Natural History Guide for Schoolyards in the Northern Rockies and the ECOS curricula.

New fellows and teachers attend two one-week training institutes during the summer. The goals of these institutes were to build the school teams, introduce the teams to inquiry investigations in Ecology, and to plan for the upcoming school year. During the first institute in July, school teams were formed. Each was comprised of two teachers, two PhD fellows, and one undergraduate student. As part of the institute kick-off, each fellow prepared a poster to describe their research to the ECOS teachers and fellow students. Then student teams made PowerPoint presentations illustrating how their expertise could be linked to the national science standards. The institute also featured extensive field experiences. One day was spent conducting an open inquiry in a local natural area near Missoula, MT. Each school team developed a researchable question, devised a plan to collect preliminary data, conducted the investigation, and then presented their results at the end of the day. During the remaining days of the institute, ECOS leaders led investigations with all the fellows in each participating schoolyard. Throughout the institute, teams planned for the upcoming schoolyear. During the second institute in August, each team presented an investigation they had designed for their schoolyard. Teams also had planning time each day, and by the end of the institute, teams presented a proposal for an ecological teaching demonstration project for their school.

Biology 595 – Conservation and Ecological Education Seminar: During the academic year, ECOS fellows are required to take a graduate seminar on conservation and ecological education. The seminar meets for two hours once per week for the entire academic year. The objectives of the seminar are to: 1) Determine the status of education about issues in conservation biology, ecology, and biodiversity, at all levels of education, from k-12, university, graduate, and adult education; 2) Explore appropriate teaching strategies for ecology and conservation education; 3) Review the literature to assess what strategies in conservation and ecological education have and have not worked by looking at selected case studies from local, regional, national and international scales; 4) Explore the roles of scientists and science educators in developing ecological and conservation literacy; and 5) Outline opportunities for improving the status of conservation and ecological education. The format is a combination of lectures and student-led discussion. Each week, the discussion leader(s) prepares an outline based on a short review of the recent literature. After a 20 – 30 minute overview of the topic, the presenter leads a discussion of the papers with all seminar participants. The last hour of each seminar is reserved to talk about ECOS implementation in local schools.

The institutes, workshops, in-service meetings and special events hosted by ECOS during this award period are listed in the table below.

ECOS-Wide Events AY 2005-2006, summer 2006				
Event	**Date**	**Location**	**Participants**	**Brief Agenda**
In service Meeting	11/5	UM	fellows, teachers and staff	ECOS teachers: teaching tips Jeff Piotrowski: Traveling Herbarium Project Team Planning
In service Meeting	2/3	UM	fellows, teachers and staff	Team Planning Dr. Bill Grannath: Bringing microscopy into the classroom Ecological Footprint Investigation
In service Meeting	4/12	UM and Hellgate Elementary	fellows, teachers and staff	Rachel Loehman, Montana Weed District and Forest Service: Knapweed Biocontrol Insectories
ECOS Reception	5/14	UM	05-06 and 06-07 fellows, advisors, teachers, staff	Welcome to ECOS and thank you for your hard work
Writing Retreat	5/15-5/18	Boulder Hot Springs	05-06 PhD fellows	Led by Diane Smith, science writer, who intensely mentored manuscript writing
Orientation	6/5-6/8	UM	06-07 fellows and staff	Led by Carol Brewer: Introduction to ECOS Program Being a successful fellow Teaching and Planning for the ECOS year
Institute 1	6/19-6/23	Greenough Park, UM, Demonstration project sites	05-06 fellows, teachers and staff	Pre-fellowship assessment Ecological Investigations Group discussion ECOS and National Science Standards PhD Fellows present research Team planning
Institute 2	8/14-8/18	UM, Hellgate and Florence Carlton	05-06 fellows, teachers and staff	Traditional Ecological Knowledge ECOS Nature Guide Team planning and presentations

5. Outreach through ECOS Web Site, Publications, Newsletters, and Brochures

A goal of ECOS is to broadly disseminate the results of our GK-12 project. To accomplish this goal, fellows have been mentored in writing a chapter of their dissertation for an education audience, and to prepare them for presentation at national conference and publication in education journals. Many fellows also presented and published their work this past summer. ECOS staff also have contributed to the dissemination of the ECOS project through brochures, posters, and a regular newsletter. ECOS presentations are listed in the following table.

Posters, presentations and products

Title	Date	Authors	Journal or Meeting	Brief Description
Article submission: ”Using Microclimate to Predict Schoolyard Plant Distribution"	5/06	Joseph Fontaine	The Science Teacher	Describing an inquiry from Florence Carlton School
Poster: Using cartoon illustrations to explain complex process in ecology	10/2005 03/2006 04/2006 08/2006	B. McBride	UM Board of Regents Convention, NSF, UM Graduate Conference, ESA	Explaining carbon in soils with cartoons
Presentation: No Child Left Indoors! Connecting Scientists with Educators	03/2006	B. McBride, A. Perkins, D. Oberbillig	Montana Environmental Education Association	A summary of ECOS and demonstration of three inquiries
Presentation: Teacher-Fellow partnership in ECOS: success and challenges	04/2006	B. McBride, D. Oberbillig	NSF	Skit illustrating how ECOS has overcome barriers and differences between teachers and fellows
Poster: ECOS: UM GK-12 Program	04/2006	2005-2006 fellows and directors	NSF	Summary of roles of ECOS fellows
Poster: Sustaining the impact of Scientist Educator partnerships: Montana ECOS	08/2006	2005-2006 fellows and directors	Ecological Society of America	Explanation of how ECOS has made itself sustainable in the community, primarily through demonstration projects and the website

Poster: An Interactive natural history database to support a GK12 program	08/2006	P. Alaback, J. Burnham, C. Brewer	ESA	Explanation of the new online natural history guide
Poster: Teaching herbaria in GK12 education	08/2006	J. Piotrowski, P. Alaback. A. Roberson, C. Brewer	ESA	Jeff Piotrowki's special project of creating a traveling herbaria accompanied by curricula
Poster: Ecologists and Students explore plant diversity in the schoolyard: a fourth grade introduction to experimental design	08/206	M. Machura, B. McBride, A. Greene, C. Brewer	ESA	An inquiry developed by these fellows
Observe Nature in 2005-2006	12/2005			Nature art calendar featuring student and adult artwork along with monthly phenology information
Be a Naturalist in 2006-2007	9/2006			Academic year nature art calendar featuring student and adult artwork along with monthly phenology information
Fall Newsletter	09/2005	ECOS staff		Newsletters include Schoolyard updates, curriculum ideas and news from the staff
Winter Newsletter	12/2005	ECOS staff		
Spring Newsletter	3/2006	ECOS staff		
Summer Newsletter	8/2006	ECOS staff		
Brochure 3rd edition	3/2006	ECOS staff		Defines ECOS objectives, mission statement and results of the program

6. ECOS Staff and Resources

The ECOS Web Site: An important dissemination tool is the ECOS website. At www.BioEd.org/ECOS, one can find information about ECOS, bios of fellows and teachers, descriptions of ECOS schools and the demonstration projects, and all the forms and assessment tools we have developed. Of broad interest is all of the curriculum materials fellows have created to lead ecological inquiries in the schoolyard. To date, nearly 50 ecological inquiries are available at http://www.bioed.org/ecos/Inquiries/inquiries.aspx.

NAME	ROLE	YEAR IN SCHOOL/ WORK	MONTHS IN ECOS	BRIEF DESCRIPTION INTERESTS
ECOS Staff				
Carol Brewer	Project Director, Professor of Biology, Associate Dean in College of Arts & Sciences	13 years at UM	34	PhD in Botany. Her areas of research are plant physiological ecology and functional plant morphology; and ecological and conservation education.
Paul Alaback	Project Co-director and Associate Professor of Forestry	13 years at UM	34	PhD in Forest Science. His research centers on structure and function of forests and their relation to wildlife across a range of scales.
Dave Oberbillig	Co-PI, mentors teams and leads Conservation Education seminar	11 years	34	10th thru 12h grade teacher at Hellgate High School. Holds a BS in Biology and M Ed; currently he teaches Integrated Biological and Ecological Sciences and Ecology
Jen Marangelo	Program Coordinator	1 year/10 years at UM	16	Master's student in Interdisciplinary Studies, studying museum exhibit design and curriculum development
Josh Burnham	Web development & Technology support	8 years	34	BA in Political Science, currently studying for a BA in Journalism.
Kim Notin	Office assistant and graduate student in Forestry	2 years at UM	25	Recent MS graduate from the Department of Society and Conservation, studying social learning in protected area management.

Technical Support: ECOS participants have three computer stations for their use in the ECOS office. These computers are networked to the internet and have a broad array of software available. ECOS participants also have access to a slide scanner and a document scanner at the computer stations, poster printer, and color printer. ECOS also purchased two new Macintosh computer with software for capturing video images so that fellows can create video clips illustrating their work in the participating schools. Moreover, we purchased a video projector for use in making presentations about ECOS, and for use in ECOS related courses and institutes.

Equipment and Supplies: The ECOS office maintains a wide assortment of supplies and equipment for loan to fellows and local schools. This equipment has been collected through the support of past ecology education grants and a grant from the Howard Hughes Medical Institute. Fellows, teachers and students can use a variety of weather sensors, field microscopes, general ecology field gear (tapes, compasses, etc.), and some specialized instrumentation such as portable infrared gas analyzers. We plan to continue to enhance the equipment available for ecological investigations throughout our project.

7. Donations from Community Members

Many members of our community contributed time, materials and funds to help implement the demonstrations projects this year. They are listed in the two tables below.

EKO COMPOST TURNS DIRT INTO SOIL	Thank you for donating compost for Hellgate Elementary's Native plant garden
Marijka Wessner and Morgon Valiant Missoula County Weed District	Thank you for your continued support of building insectories at Hellgate and Target Range Schools
Nancy Sturdevant US. Forest Service	Thank you for your continued support of building insectories at Hellgate and Target Range Schools
Margaret Manning	Thank you for your support and advice in the enhancement of the garden at Lewis and Clark
BLM Dillon Field Office	Thank you for donating the kiosk for the Outdoor Classroom at Florence Carlton School
Marilyn Marler	Thank you for helping choose plants for the outdoor classroom at Florence Carlton
Dave Zinke JTL Group, Inc.	Thank you for donating and delivering gravel
MontanaTech THE UNIVERSITY OF MONTANA **Tim Lytile** Montana College of Technology	Thank you for donating heavy equipment, physical landscaping and landscape design consultation.
Mr. Rickenau Target Range School parent	Thank your for tree pruning, operation of landscaping equipment, donation of time.

Harold McGaughey	Thank you for the landscape design consultation, blueprints.
Jim Cook	Thank you for donating and delivering woodchips.
Star Rental	Thank you for donating a Bobcat for additional landscaping.

Many members of our community contribute to the high quality science education of children, helping us insure that no child is left indoors.

	Montana DNRC Sue Clark, Rob Gustafson and Ken Parks *Thank you for donating your time and expertise to the Big Sky high school burn experiment*	Missoula County Extension Service *Thank you all for your cooperation on the Target Range demonstratio*	Bitterroot Restoration Inc. Len Balleck *Thank you for donating materials for the restoration of Target*	Madeline Mazurski of the Missoula Native Plant Society *Thank you for providing landscaping advice at*	Missoula County Conservation District *Thank you for your kind donation towards the development of Florence*	National Wildlife Federation *Thank you for working with Florence Carlton in developing their*	EKO Compost *Thank you for donating compost to Target Range School*	JTL Group, Inc. *Thank you for donating a truck and driver to deliver compost to Target Range School*	Rainmaker Sprinkler Supply, Co. *Thank you for providing irrigation equipment to Target Range School*

8. Assessment

2005-2006 ECOS participants
End-of-year interview results summary

ECOS assessment activities have been ongoing since the first fellows were recruited. Tools were developed that asked all participants to report on their comfort with various science topics, and to describe their goals for participating in ECOS. An end-of-institute reflection also was conducted. We have contracted with Dr. Deborah Morris, Director of Program Development at Florida Community College in Jacksonville, FL to be our external program evaluator. Dr. Morris has extensive experience in education assessment, having recently evaluated Workshop Biology at the University of Oregon (Funded by the Howard Hughes Medical Institute) and Project TIEE (Teaching Issues and Experiments in Ecology), a joint project of Hampshire College and the Ecological Society of America (funded by the National Science Foundation). Currently, data from the surveys are being entered into a database by staff at UM and will be forwarded to Dr. Morris for analysis in the coming months. All of the ECOS assessment tools are available on our website.

Report of Interview of all Participants
Prepared by Dr. Deborah Morris

Introduction

Evaluation of ECOS in its second year focused on the following questions:

1. What has been the impact of the project on its participants, the Fellows and teachers?
2. How are they interpreting and enacting their responsibilities within the project?
3. How are project processes supporting achievement of project goals?
4. How is the project supporting sustained change in schools and the larger educational community?

During Year 2 of ECOS, teams of Fellows and teachers worked in four K-12 schools in the Missoula area. Each team consisted of two Ph.D. Fellows, one or two undergraduate Fellows, and two teachers. The main ECOS project report provides data on the participants and schools. Fellows' responsibilities included working with the teachers to develop and implement inquiry-based lessons (with a requirement of 20 hours per week, including out-of-class development and in-class implementation), creating or extending an outdoor classroom demonstration project at the school site, keeping logs and submitting monthly reports, participate in regular ECOS Institutes and an education seminar at the university, and prepare a dissertation chapter that would potentially be publishable in an education journal. Teachers' responsibilities included working with the Fellows in their classrooms and on the demonstration project, keeping logs and contributing to the monthly reports, and participating in the ECOS Institutes. Three Ph.D. Fellows who had participated in Year 1 continued into Year 2 to assist with special projects.

Overall, enhanced recruiting, management, and learning processes implemented by the project staff appear to have improved project outcomes even above those achieved in the project's successful first year. School teams got off to a faster start this year, worked together more effectively, and were more productive, providing a solid foundation for continuing the project in year 3. Additional enhancements will be used in the coming year to continue improving the project's overall impact.

Methods

Multiple data collection methods, including interviews, surveys, and analysis of project products were used to triangulate on the project outcomes and provide a complete picture of the participants' experiences and their impact. The project staff received relevant summaries of evaluation data to supplement their observations and provide for ongoing process improvement throughout the year. The following table summarizes the evaluation methods, populations, timelines, and process for establishing the reliability and/or validity of the data.

Evaluation Methods

	Method/instrument	**Population**	**When completed**	**Reliability/validity**
Interviews	Semi-structured interviews (in person)	Ph.D. Fellows (n=11)	Pre-Yr 2 (Aug-Sep 05)	Entire population interviewed; participants reviewed compiled results
			Post-Yr 2 (May 06)	
	Semi-structured interviews (phone)	Teachers (n=8)	Pre-Yr 2 (Aug-Sep 05)	
			Post-Yr 2 (July 06)	
Surveys	Self-assessment of relevant knowledge and skills	Ph.D. Fellows (n=7)	Pre-Yr 2	Surveys administered and coded by project support staff; self-report data checked against staff observations
		Teachers (n=8)	Pre-Yr 2	
	Institute evaluation and mid-term project feedback form	Ph.D. Fellows (n=8)	Nov 05 Institute	
		Teachers (n=8)	Nov 05 Institute	
		UG Fellows (n=5)	Nov 05 Institute	
		Ph.D. Fellows (n=7)	Feb 06 Institute	
		Teachers (n=8)	Feb 06 Institute	
		UG Fellows (n=4)	Feb 06 Institute	

Analysis of products	Monthly reports	Ph.D. Fellows and teachers (n=16)	Monthly	Self-report data checked against staff observations
	Evaluation of lesson plans using an evaluator-designed rubric	School teams (n=4)	Ongoing	Content validity of rubric based on science education literature
	Demonstration projects final reports	School teams (n=4)	May-June 06	Sites observed by project staff

The project evaluator was on site for observations and interviews during the August 2005 Institute and the May 2006 writing workshop for Ph.D. Fellows. The evaluator also maintained regular phone and email contact with the PI and project staff during the year, and met with the staff during the NSF GK12 meeting in Washington D.C. The project evaluator has no responsibility for implementation of any project activities and does not participate in project planning, but does discuss evaluation results and possible strategies for improvement with the project staff.

Results

This section provides a thematically-organized summary of Year 2 results incorporating evaluation data from all sources. Major themes identified through analyses of these data include the work patterns of the Fellow-teacher teams, the ways in which the teams developed inquiry-based lesson plans to fit with the existing school curriculum, the strategies used to develop and implement the demonstration projects, and the ability of the participants to understand and respond to the project's requirements and processes.

Key findings from this year of the project include its impact on Fellows' learning and professional growth, its impact on teachers and their students, and the availability of high-quality educational products and resources for continued use in the schools. Results in each of these areas are summarized below – a more extended report of results has been provided to the project staff.

Team work patterns

All of the teams but one reported working together very effectively to achieve their goals. At one school, the two undergraduate Fellows dropped out midway through the year, and the two graduate Fellows never really achieved agreement on how to structure their effort in the school. Neither of the teachers at this school noted any significant problems, however, aside from one commenting that it "took some time" to work out communication strategies but that this ended up working well. All members of the teams at the other three schools reported highly effective working relationships and a minimum of personality conflict.

The Fellows became integrated into their schools much more quickly this year and got started developing and implementing inquiries much sooner. At only one school (the same one described above) did the Fellows spend any significant amount of time observing (about a month) before starting to lead activities. At the other three schools, the Fellows began conducting activities almost immediately. At one school, the Fellows worked initially with their ECOS teachers but also with other teachers at the school – involving other teachers was a deliberate goal of the ECOS teachers at this school.

The Fellows were naturally somewhat more critical of their own efforts than were the teachers, but all of the Fellows said they felt they had accomplished something very positive and significant in their schools. The teachers were unanimous in their appreciation of the Fellows' contributions and were extremely pleased with their knowledge, professionalism, and ability to work well with students.

The more effective work patterns of the school teams observed this year may have been due to the project's ability to recruit participants whose interests were strongly in tune with the project goals. One indicator of this is the relatively high level of interest and experience in inquiry-based learning reported on the pre-survey by this year's Ph.D. Fellows, an area that was rated considerably lower by last year's Fellows at the beginning of the year. Additionally, only three Ph.D. Fellows and no teachers mentioned any dissatisfaction with project reporting processes, which had been a major source of contention the prior year; these processes thus presented no barrier to the development of effective working relationships or team productivity.

Development of inquiry-based lesson plans

One of the issues all teams had to deal with was how to relate inquiries the Fellows developed to the teachers' curriculum. Each team dealt with this issue in a slightly different manner, and all but one said they were successful. The Fellows who described collaboration and communication challenges mentioned previously also disagreed about the way in which their inquiries should relate to the curriculum – one wanted to "do their own thing," and develop a separate but coherent series of investigations, while the other wanted to fit their activities into the curriculum. Again, neither of the teachers mentioned this as an issue. The other three teams found a good balance between connecting the Fellows' activities to the teachers' lessons, and conducting activities that were essentially separate from what the teachers were doing. This allowed the Fellows to have some freedom in addressing important scientific concepts and processes that the teachers might not otherwise have addressed. One team noted that, even when an inquiry was not originally designed to fit into the established curriculum, the teachers regularly followed up on the concepts in later lessons, even making connections to other subjects.

At least three of the school teams developed the same activities for different grade levels, investigating the same scientific principles but in greater depth or with less structure for older students. The Fellows at the school in which they explicitly worked with more than one set of teachers, across grade levels from 1st to 8th, made this is key focus of their work; both ECOS teachers commented on the effectiveness of the Fellows at redesigning inquiries to be appropriate for multiple grade levels.

The learning activities provided at the ECOS Institutes probably contributed to the teams' success in developing inquiries this year. All participants rated all aspects of the mid-year Institute very highly (average 3.7 for teachers and 3.6 for Ph.D. Fellows, on a 4-point scale). All of the teachers and most of the Fellows commented on the usefulness of the Institutes, with the

teachers in particular saying that they were often hesitant about taking time away from school but were always very glad to have had the Institutes. The Ph.D. Fellows also participated in the year-long ECOS seminar, which their comments indicated was an even more valuable experience than the previous year. Strategies such as the Fellows' poster session at the initial Institute were successful at providing an opportunity for Fellows and teachers to learn about each others' areas of expertise, laying a good foundation for collaboration. All participants also commented that the Institutes gave them sufficient time and structure to plan how they would work together, something that first-year participants occasionally found lacking.

Development of outdoor classroom demonstration projects

As with the integration of the Fellows into their schools, the demonstration projects got off to a much faster start this year, and all teams made good progress. This cannot entirely be attributed to the teams' ability to build on projects started in Year 1, since all but one outdoor classroom were completely new, and the fourth (the Lewis & Clark Outdoor Discovery Core) added some entirely new features. Although there was an ECOS team at Target Range in both Year 1 and Year 2, the Year 2 team did not continue work on the same demonstration project but started a new one. The improved progress on the demonstration projects is more likely due to improved structure and guidance provided by the project staff, as well as to the strong working relationships of the teams.

Although none of the teams felt they had completed their projects by the end of the school year, all were pleased with their progress. While all admitted their plans were perhaps more ambitious than was realistic, this was much less of an issue than the previous year. At the three schools that will have ECOS teams in the coming year, the teachers all believed that the new teams will continue and expand upon their work.

Impact on Fellows

All of this year's regular graduate Fellows (those who were part of a school team) said that their participation in ECOS had met or exceeded their expectations and had enabled them to achieve their original goals for participating. Significant learning reported by the Fellows in interviews and on surveys directly related to the project's major goals included an improved ability to communicate about science with non-scientific audiences; an increased awareness of how much science even children are able to do; an increased familiarity with the challenges and issues faced by schools; and stronger commitments to staying involved in science education and school outreach. All of the Fellows said they gained experience and confidence in communicating about science to non-scientists, and that this had even improved their approach to their own research. Even those who said they already had significant skills in this area felt they had gained an even greater breadth of expertise.

Although none said they had changed their career goals significantly (which was not a goal of the project) with most still planning a career as an academic scientist, all said they felt more confident and competent to continue a professional relationship with K-12 educators. Five of the eight did say they planned to stay involved in pre-college science education in the future. For some, this had always been a goal and was solidified by their participation in ECOS; for others, ECOS "opened their eyes" to this possibility. All of these Fellows said they expected to be more effective in any outreach efforts they pursued because of their ECOS experience.

All also said they felt they had gained significant teaching skills, including a better understanding of inquiry and what it takes for people to learn about science. Two who had previous teaching experience said that their ECOS experience was more productive than their previous experience, since they had a greater leadership role in the classroom and had more responsibility for leading activities. Two others talked specifically about the value of learning to develop a lesson to get a particular point across, and said they felt more confident about their ability to know that any lesson they developed would be effective. Several also mentioned seeing parallels between their ECOS experience and college teaching, that the principles of student engagement and active learning were the same no matter what age group they were dealing with.

The teachers also noted similar growth in the Fellows over the course of the year, with several noting that they felt the Fellows had gained an appreciation for how challenging, yet how rewarding, it could be to engage students' interest and help them achieve educational goals. Several teachers commented that the Fellows were initially a bit apprehensive about working with kids, but gained confidence rapidly. Many said they were impressed with the Fellows' grasp of inquiry and their ability to design good learning activities for their students, with several commenting that they saw their Fellows really improve in their ability to put together an effective lesson.

The three first-year Fellows who continued into the second year to work on special projects also reported that they felt they had achieved their goals for the year, but often felt disconnected from the project since they were not in a school or part of a team. The project staff already plans to have the second-year continuing Fellows to work more closely with the new school teams; this should facilitate greater continuity and institutionalization of the effective practices that they helped to initiate in the schools this past year, and help them continue to feel a real commitment to the project.

One concern of the project is that the Fellows' doctoral advisors understand and support their students' participation in the project. All of the Fellows said they felt their advisors were supportive, but mostly because of the fellowship funding provided by ECOS, not because they saw the value of the project. None said they encountered any resistance from their advisors or committees, although one was asked to do her ECOS chapter as an appendix to her dissertation, rather than a full chapter. One Fellow said she felt her advisor and committee did recognize the value of learning to communicate with non-scientists, while another said she encountered real resistance to the idea that scientists should care about education – though mostly from others in her department, not her own advisor or committee. The others said that their committee either didn't know or didn't really care about their ECOS work, being more concerned about the progress of their scientific research. One said that they believed ECOS was becoming more known and respected within the university community and that hopefully it was a matter of time before more faculty would see its value.

Impact on teachers and students

This year's ECOS teachers started out with varying levels of experience and expertise in teaching science. All were able to comment on something that they had learned as a result of working with the Fellows; responses included becoming more confident in doing inquiry, both in the classroom and outdoors; learning how to do science with easy, uncomplicated, low-tech materials and processes; learning how to access primary science literature; becoming more familiar with local community resources; and gaining science content knowledge, which, as one

teacher put it, is never an option with traditional school inservice training. Other specific comments included:

- One teacher commented that he felt empowered by the fact that the activities the Fellows developed, and the science on which they were based, were accessible to him; he became more confident in being the "expert" in class.
- One teacher said she realized from watching the Fellows struggle to communicate on an appropriate level that it "wasn't just her" having these difficulties, that these were tough concepts but that with effort, she could have success as well.
- One teacher felt that the Fellows were able to ask more probing questions and extend the kids' thinking past what the teachers might have been able to do themselves.

The teachers all believed that their students had gained a great deal from having the Fellows in their classes and from participating in the inquiries they developed. Some of the examples they provided included:

- Several teachers commented that Fellows enabled the students to really learn things while outdoors and move beyond "playing games." Students didn't really look at things the same way afterwards, and were able to make more focused and scientifically-based observations.
- Most teachers said that their students learned lots of terminology – for example, one first grade class was effectively using terms such as "migratory," "intevertebrate," and "abiotic."
- Several teachers said they sometimes thought the Fellows' activities would be too advanced for their students, but they got it. In another first grade class, the students figured out how to modify one variable in an experiment and see what happens, and got the idea that this is how science works. The teacher went on to describe how the outdoor classroom allowed them to see these variables in the real world.
- At all the schools, the Fellows developed great relationships with kids, even eating lunch with them in at least one school; the kids got to know Fellows as people. One teacher said that the Fellows ended up being like "rock stars" – the kids were enthralled by science because of the Fellows' aura. At the schools where a female Fellow was in residence, the teachers noted that this provided an excellent role model for female students.

Both the Fellows and the teachers commented in interviews on whether they believed teachers would continue to use the materials and resources developed through ECOS. Fellows at two of the schools felt that their teachers were already very inquiry-oriented in their practice and were not likely to make any substantive changes in the way they teach science. One Fellow said that the teacher he worked with could easily have created the inquiries himself, while another commented that the teachers at their school were both "veteran, successful" teachers with well-established patterns of practice. The teachers at both of these schools, however, all said they had learned many important new ideas from the Fellows, had gained materials and resources they had not had before, and would definitely continue to use the ECOS materials in the future. Fellows at the other two schools, on the other hand, felt they were leaving their teachers with a plethora of new ideas and experiences that would help them try more new things in the future.

One group had previously had a strong emphasis on science, but was less inquiry-oriented; for the other, science was not a major emphasis at their school and inquiry was really a new thing (as one Fellow put it, they had pretty much "stuck to the textbook"). Teachers at these schools all said they would continue using the ECOS resources and would use them to support investigative, inquiry-oriented activities for their students. Overall, there was more agreement between the Fellows and the teachers this year regarding the likelihood that teachers would continue to use ECOS materials, compared with the previous year.

Project products

The two major categories of products developed by ECOS participants that were intended to remain as resources beyond the end of the project were classroom inquiries and the demonstration projects at each school. The set of classroom inquiries developed by the Year 2 Fellows in collaboration with the teachers includes activities to be done indoors and outdoors, including many that are conducted in an outdoor classroom developed or enhanced as a demonstration project.

To better understand the quality of the inquiries that were developed and their value as a lasting educational resource, each of the lesson plans was evaluated using a rubric that focused on four major issues: whether the activity was truly inquiry-oriented in the sense of being open-ended and not overly directed or "cookbook;" whether it allowed student to gather and work with real data; whether it provided an authentic experience with core scientific principles; and whether it explicitly connected to students' prior knowledge and/or local or current ecological issues. Each lesson plan was rated as either "strong," "acceptable," or "weak" on each dimension. All but one of the 21 lesson plans developed in Year 2 (95%) could be rated at least "acceptable" on all dimensions, with the following percentages receiving a "strong" rating in each category: 9 (42%) in inquiry orientation, 16 (76%) in data collection, 16 (76%) in authenticity/science principles, and 17 (80%) in relevance/prior knowledge. These findings indicate a very high quality set of educational materials that are now available for future use, not only by ECOS teachers but others as well.

The key factor in the first category, inquiry orientation, was whether the activity was truly open-ended, with the outcome known neither by the teachers nor the students, or whether it engaged students in a guided exploration/investigation with a more pre-determined outcome. Activities meeting the second criterion typically took the form of games or activities designed to teach students to use a particular scientific technique, such as mapping, sampling, or using dichotomous keys. These can be extremely valuable learning experiences and are an important part of any curriculum, which is why they received an "acceptable" rating. The "strong" inquiries met all of the major criteria generally accepted in the science education literature and state/national standards for truly open-ended scientific investigations. These are typically more difficult and time-consuming to conduct, especially in the early grades (and, as one Fellow pointed out, less comfortable for teachers), so the fact that almost half of the inquiries developed this year met this criteria is noteworthy.

One of the major strengths of the inquiries developed in Year 2 is their focus on connecting to what children already know about the world, and on starting with observations that raise questions in children's minds. Almost all of the lesson plans lay out a preparatory activity in which the teacher asks questions of the students to elicit their current understanding of the topic or related topics, their recent observations (often in the outdoor classroom), and their

hypotheses about their experiences and observations. Whether the children then ask their own questions and design their own investigations, or are guided through this process by the teachers, this emphasis on prior knowledge and questioning sets the stage for a very effective learning experience.

The demonstration projects have enabled the teams of Fellows and teachers to create a lasting resource that has large-scale visibility in the school and the community, and has required them to leverage their grant funds with support available from the community. Those that focused on enhancements to existing outdoor classrooms, such as the Lewis & Clark Discovery Core, will increase the likelihood that these resources will be used by both ECOS teachers and other teachers at the school in a manner that supports effective science education. The new projects – the outdoor classroom at Target Range, the various learning centers at Hellgate, and the very ambitious nature walk at Florence-Carlton – are providing teachers with opportunities to do outdoor ecological inquiries they have not had previously. The involvement of community groups, such as the support of the Missoula Weed Board for the insectery at Hellgate and the major commitments of labor and materials from many organizations to the site at Florence-Carlton, increases the likelihood that these projects will be sustained far beyond the grant period.

Summary and Recommendations

Key findings from Year 2 of ECOS can be summarized as follows:

- Roles and work patterns within the school teams were established much more quickly at the beginning of this year than the previous year, and the teams for the most part worked very well together throughout the year.
- Ph.D. Fellows all said they had gained skills in communicating about science to non-scientists, in learning how to put together effective learning experiences, as well as the value of these skills in their future careers.
- Ph.D. Fellows who worked with teachers who had not previously had an emphasis on science inquiry in their classrooms felt these teachers had gained a great deal of knowledge about how to do inquiry from their participation in ECOS. Similarly, the teachers all felt that the Fellows had an excellent grasp of inquiry and had developed some very effective learning activities.
- Both Fellows and teachers ended the year believing that the teachers would be able to use ECOS materials in the future, although the Fellows were somewhat more skeptical of the teachers' willingness to make extensive changes in their practice.
- Teachers felt that their students gained a great deal of scientific content knowledge and investigation skills, appropriate for their grade level, as well as a real excitement about science and ecology.
- Ph.D. Fellows continued to encounter little resistance, but also little interest or support, from their doctoral advisors and committees regarding their participation in ECOS and their investigations into student learning.
- Most of the Fellows said they now hope to keep education and outreach a central part of their career, and had gained the skills and confidence they need to follow through on this goal. Teachers felt that the Fellows had really gained a good understanding of the challenges facing K-12 schools and students today.

The goals of ECOS are thus being achieved even more successfully than in the project's first year. Teachers are gaining curriculum they can use, and Fellows are gaining a sense of the importance of K-12 education and the desire to stay connected with it. The project staff is continuing to refine project processes to facilitate the teams' work in the schools in the coming year. For example, plans are already in place to connect the continuing Fellows to the schools more strongly than was done in Year 2. The modifications made for Year 2 should be continued as these clearly made the project more effective this year.

During Year 3, the ECOS staff should:

- Visit classrooms occasionally to enable teams to easily share their progress and discuss ways for ensuring a high level of collaboration between Fellows and teachers in implementing ECOS activities. This would be a good role for the continuing Fellows as well as for the PIs.
- Continue the ECOS Institutes and the seminar taken by the graduate Fellows with the modifications made in Year 2, and any new enhancements suggested by project participants, as appropriate.
- Continue using the reporting processes that were used in Year 2 – these provided good information about the teams' progress throughout the year, and were not seen as "busywork" by the vast majority of participants. If possible, develop the expectations and timeline for new requirements in collaboration with the participants.
- Continue exploring new ways for the project participants to collaborate across schools and with other members of the community, and to tell their success stories. The ECOS Newsletters and website are highly effective for this purpose – as the project develops even more successful products and resources, the need for communication and dissemination grows.

ECOS is well on its way to having a lasting impact on the University, the local school system, and its surrounding community. The project's design supports ongoing learning and collaboration among the participants, and with ongoing dialog between the participants and project staff, will be able to continually refine its approach.