UCGIS Education White Paper

Distance Education in GIScience

Introduction

As the Institute for Higher Education Policy (1999) and others point out, distance learning is hardly a recent innovation. Colleges, universities, and commercial enterprises have offered correspondence courses throughout the U.S. since the development of the U.S. Postal Service and rural free delivery. The diffusion of inter-networked computing and two-way interactive video, coinciding with an increasingly competitive higher education market, has led to rapid growth in distance learning in the 1990s, however.

Educators are not of one mind about distance learning. Some celebrate the potential to expand access to higher education to lifelong learners not well served by traditional place-bound courses (e.g., Kellogg Commission, 1999). Others welcome the opportunity to enrich education for both on campus and off campus students by leveraging computers and networks to create a new, more active, more student-centered pedagogy (e.g., Benyon et al., 1997; Browning and Williams, 1997). Still others view distance learning as evidence of a regressive trend toward the automation of higher education and the commercialization of the academy (e.g., Noble, 1998, Gober 1998). Hopes and fears notwithstanding, however, distance learning appears to be here to stay.

The potential benefits, costs, and risks of distance education are certainly not lost on the geographic information science (GISci) community. As the demand for training in geographic information system (GIS) software and education GISci (the fundamental science behind GIS), grows (e.g., Phoenix, 2000), so too does the demand for effective modes of instructional delivery to students, regardless of time, place, or, in some cases, educational background. The early success of commercial distance learning programs such as ESRI’s Virtual Campus attests to this need.

The challenges faced by GIS and GISci classroom educators are by now well known. The technological orientation of the subject, the head-spinning rate at which that technology is evolving, the need for collaboration — not only for creative
innovation in the classroom but merely to keep up—and the realization that many institutions of higher education are not yet equipped to support these instructional requirements in classroom settings, all conspire to confound the efforts of even the most conscientious educators (Kemp et al., 1999; Wright, 1999). But what about teaching GIS and GISci at a distance? The University Consortium for Geographic Information Science (UCGIS) has long been concerned with the broader expansion and improvement of GIS/GISci education (Kemp and Wright, 1997) and is now focusing on issues specific to distance education. The objective of this paper is to examine those issues with respect to the profound impact that they will have on training and education in GIS and GISci, and on the overall effectiveness of colleges and universities with strong programs in GISci. Specific questions and issues to be addressed include the following:

- What are the issues in distance education unique to GIScience that need special attention and leadership by the UCGIS? The primary issue here may not be what GISci can contribute to the development of distance education, but what can distance education uniquely contribute to GISci. As discussed below, distance education has great potential for helping to meet unmet demands for GIS training and GISci education, as well as in GIS certification, and a GISci model curriculum.

- How can the UCGIS better facilitate the sharing of distance education materials (clearinghouses, etc.)?

- How should the UCGIS leverage the potential of Internet2?

- What can be learned from existing distance education programs that focus on GISci, (e.g., Penn State’s World Campus, the University of Southern California’s Distance Learning Certificate in GIS, and individual offerings at schools such as Oregon State University, the University of Colorado at Boulder, etc.)

- How should distance education programs by commercial GIS vendors (such as ESRI’s Virtual Campus) fit in to university efforts? What are the best ways of forming effective partnerships?

Background
The National Center for Education Statistics defines distance education as “education or training courses delivered to remote (off-campus) location(s) via audio, video (live
or prerecorded), or computer technologies, including both synchronous and asynchronous instruction" (NCES, 1999, p. 2). By definition, then, distance education is a set of transactions among students and instructors who are located in different places – an arrangement that should be of special interest to geographers. Distance education may also be asynchronous, where students and instructors are performing their roles at different times. Distance students may work as individuals, or in groups (or “cohorts”, as instructional designers like to say). Instructors may or may not be available for consultation. For example, ESRI’s Virtual Campus (http://campus.esri.com) is an asynchronous, non-instructor-led learning environment in which students work independently. Penn State’s on-line Certificate Program in GIS (http://www.worldcampus.psu.edu/pub/gis/index.shtml), by contrast, is semi-asynchronous (there is a schedule of weekly deliverables, but students can work anytime they wish during the week), instructor-led, and cohort-based. According to Mayadas (1997) the instructor-led, cohort-based model (sometimes called “asynchronous learning networks”) offer the greatest potential for effective distance learning.

Distance education is growing rapidly. NCES (1999) reports that in the academic year 1997-'98, about one-third of 2- and 4-year postsecondary institutions in the U.S. offered distance education courses, and one-fifth of institutions planned to start within the next three years. The number of courses available online increased from an estimated 25,730 in 1994-'95 to 54,470 in 1997-'98. Enrollments in 1997-'98 were estimated at 1,661,100, more than twice the number enrolled in 1994-'95 (NCES 1999).

The recent growth of distance education reflects not only the diffusion of Internet usage, but also the changing demographics of higher education. Between 1976 and 1996, the portion of U.S. college and university students aged 18-24 increased only 0.4% when adjusted for population growth. The portion of students aged 25 or older increased 47.5% over the same period, however (US Bureau of the Census, 1998). The average age of the approximately 250 students who have enrolled in the Certificate Program in GIS at Penn State is 37 years. As the Kellogg Commission on the Future of State and Land-Grant Universities has observed:
“With a more diverse and older student population, we need a more diversified set of educational offerings. As people mature and move through successive careers, we need to be there to help them retool and retread, with special courses available at their convenience.” (Kellogg Commission 1999, p. 8)

Distance education clearly offers the potential to make higher education more accessible to lifelong learners. Many people also believe, however, that distance education poses a risk to the quality and integrity of higher education. Demonstrating the effectiveness of distance learning is even more difficult than demonstrating the effectiveness of traditional resident instruction, because distance education (as defined above) is a relatively recent phenomenon. We are still learning how best to foster learning at a distance. It is not surprising, therefore, that the widely cited report *What’s the Difference? A Review of Contemporary Research on the Effectiveness of Distance Learning in Higher Education* (IHEP, 1999) observes the “relative paucity” of reliable research on the effectiveness of distance education.

One of the first things distance educators learn is that they cannot hope for a successful learning experience if they simply put existing courses designed for resident instruction on-line. Faculty members in the School of Education at Oregon State University, for instance, who have begun implementing distance learning technologies, generally agree that simply replicating traditional instructional models in a distance learning context may not be the most effective strategy for teaching and learning in any discipline (Merickel, 1997). The recommendations of the NSF Geoscience Education Working Group (GEWG) include the statement: “uncertainty exists regarding which practices work best in the classroom [and at a distance] to promote better learning about the geosciences. We do not have a sound pedagogical understanding of how students learn about the geosciences effectively at any level. As a result, we rely primarily on anecdotal information” (Geosciences Education Working Group, 1997, p. 1).

Despite the uncertainties associated with distance pedagogy however, educators are approaching consensus that “distance learning can be quality learning” (IHEP, 2000, p. 4). In a review of the current state of knowledge in distance education, Hansen et al. (1997) conclude that:
• with regard to “learner outcomes” distance education is just as effective as traditional education;
• distance learners generally have a more favorable attitude toward distance education that traditional learners, and feel as though they are learning just as much in a distance education mode as in a traditional classroom;
• successful distance education learners tend to be abstract learners who are intrinsically motivated and possess “an internal locus of control”; and
• each form of distance education technology has its own advantages and disadvantages in contributing to the overall quality of the learning experience.

In a similar vein, a report of a year-long faculty seminar at the University of Illinois, composed of both experienced distance educators and critics, concludes that “online teaching and learning can be done with high quality if new approaches are employed which compensates for the limitations of technology, and if professors make the effort to create and maintain the human touch of attentiveness to their students” (University of Illinois Faculty Seminar, 1999, p. 2). In a recent report entitled Quality on the Line: Benchmarks for Success in Internet-Based Distance Education, The Institute for Higher Education Policy outlines 45 characteristics of successful distance education programs, in such categories as institutional support, course development, teaching/learning process, course structure, student support, faculty support, and evaluation and assessment (IHEP, 2000). A compelling case study of the potential to achieve high quality in distance learning is The Open University, which has served over two million off-site students since 1971, and was recently ranked 11th of 98 U.K. higher education Institutions in quality of teaching (Lyall, 1999). There is every reason to believe that the lessons learned by early adopters of distance education can be applied in GIS/GISci education.

Issues for GISci

Capitalizing on Current Successes

There is growing evidence that distance education has the potential to deliver rigorous GIS/GISci education. One example is the achievements of students in the distance education GIS certification program at Penn State since January, 1999. Their courses include tutorials based upon a developmental approach. At the outset,
students receive problem scenarios, data sets, and detailed instructions (workflows) on how to use GIS software to solve real-world problems. Students use the GIS software that they have purchased through the program to follow the instructions, then publish illustrated reports in their on-line portfolios to demonstrate that they have completed the assignment. As courses progress, tutorials include less and less detail. By the end of the courses, assignments contain problem statements, data, and only a minimum of instruction. Students are expected to develop and deliver their own workflows, sometimes in collaboration with other students (via threaded discussion, chat, or telephone). Instructors review and comment upon the student workflows. Finally, students enact their own workflows, complete the assigned task, and publish their results in their portfolios. In this way, students learn how to use GIS to solve problems, not just how to operate software. By requiring students to take greater responsibility for their own learning, educators can transform distance from a disadvantage into an advantage. Instructors at Penn State are convinced that these students are learning more effectively than they would in comparable on-campus courses.

A second example is what can be gained by leveraging the new technologies of Internet 2. It should first be recognized that Internet2 will not provide: (1) a replacement for the commercial Internet; (2) faster connections to everywhere for everything; and (3) free bandwidth to universities. However, Internet2 will provide: (1) a means of expediting the development of new technology; (2) a testbed for monitoring/measuring end-to-end bandwidth needs; and (3) the infrastructure for “pioneering” applications such as digital libraries, tele-immersion, digital video, virtual laboratories, and all the “emerging technologies” on the horizon for distance education (Wright et al., 1997). In the Fall of 1999, Oregon State University, in collaboration with Kansas State University and the University of Nebraska, held the first fully-interactive distance education course using the high-speed Internet2 network known as Abilene (see the press release at osu.orst.edu/dept/ncs/newsarch/1999/Nov99/internet.htm). Features of the course included:

- Shared lectures, responsibilities and course planning all done over Internet2 by faculty at the three institutions
- Distributed classrooms connected by digital audio and video
- Advantages:
  - Easier to achieve critical mass of students
- Leveraged complementary research skills
- Disadvantages:
  - Required lots of last-minute adjustments by network experts

Although the course was not about GISci, it is clear that such a course could be implemented with Internet2, drawing on experience with the UCGIS Virtual Seminar, held over the commercial Internet in 1996-'97 and 1998 (Wright, 1999).

**Benefits and Importance to National Needs**
Most will agree that distance education is growing rapidly, along with the adoption of GIS technology and the evolution of GISci as a discipline. Moreover, the adoption of GIS technology continues to increase across commercial, academic and government sectors. It follows that an adequately trained and educated workforce is essential to the appropriate implementation and use of these technologies. UCGIS is composed of outstanding research universities whose mission, in part, is to train and educate (and re-train and re-educate) students in GIS and GISci to meet new employment demands.

As convincing as this may sound in principle, there is a widely known, though poorly documented, unmet demand for education and training in GIS and GISci. Phoenix (2000) reports the following with regard to this:
- The annual demand by professionals for GIS course work is estimated at 75,000.
- The annual demand for students enrolled in universities is estimated to be 50,000.
- There are more 200 programs in the U.S. that offer a certificate in GIS, with an annual graduation rate of 4000.
- The shortfall in the U.S. in producing individuals with an advanced level of GIS education is 3000-4000.
- The shortfall outside the U.S. is even greater.

It is assumed that the demand for distance education is included in these estimates (which mention enrollments in the extension program at UC-Riverside, which is partially distance education), though not explicitly stated.
Therefore, by realizing the potential of distance education, the UCGIS has the power to address a number of national needs (not unlike those identified by Wright et al., 1997, for emerging technologies for GIScience education):

- Strengthening education in GIScience within existing programs of higher education in 2- and 4-year colleges and universities.
- Promoting the development of new programs at other 2- and 4-year colleges and universities, as well as within K-12 education.
- Fostering important cooperative links between GIS software vendors, for-profit educational institutions and academia.
- Extending educational opportunities in GIScience to people who do not have ready geographical access to institutions of higher education.
- Developing specialized and customized programs of "just-in-time" or "course-on-demand" instruction for GIS professionals.
- Providing U.S. students with more competitive technical skills for the national and international marketplace.

There is also the increasing likelihood that organizations such as URISA will be successful in standardizing the knowledge and skill requirements for professional certification in GIS (Obermeyer, submitted). Distance education could be a crucial element of a successful certification standards initiative.

Finally, there is the potential of distance education to contribute to the successful implementation of the UCGIS Model Curriculum. The Model Curriculum seems likely to demand a breadth and depth of faculty expertise that few individual departments possess (Marble, 1999). Several departments from different universities, joined together in credit-sharing consortia, might be much more effective in offering students the courses needed to satisfy the curriculum. By definition, these would be distance courses. Advanced GIScience courses offered synchronously through two-way interactive video, or asynchronously on-line, offer the potential to achieve economies of scale necessary to ensure their viability. A distributed model curriculum also poses opportunities for collaboration in GIScience education that until now have only been realized in GIScience research projects. Ultimately, the act of formalizing and distributing the content of the Model Curriculum sets the stage for peer review of GIScience education, tried and true method of quality assurance with which GIScience researchers are so familiar.
Gaps in Research: Opportunities for the UCGIS

There are several important issues regarding the effectiveness of distance learning that require further investigation and validation. Some of these include intellectual property rights (does an instructor really own what he/she puts online?), how best to retain online students (drop-out rates from distance education courses are often higher than those in traditional classrooms), assessing the benefits of various technologies (especially with regard to how they may support the education process rather than dictate it). However, there are issues specific to GISci that are currently not being addressed at all in the literature, such as the following:

**Rigorous research in the pedagogy of GISci education, specifically for education at a distance, needs to encouraged, accepted and developed rigorously.** Pedagogy is here defined simply as the art and science of teaching. An active pedagogy is further defined as a student-centered approach that involves students actively in their own learning, assures their involvement with the material (i.e., their world), and teaches skills for problem-solving, rather than merely instilling information for occasional regurgitation (Moser and Hanson, 1996; Chalkley and Harwood, 1998; Healey, 1998). Pedagogy must be guided by some theoretical framework, which provides criteria for effective, intuitive instruction (Jenkins, 1998; Shephard, 1998; White and Weight, 1999). Models employing constructivist theories and stressing collaborative learning should be explored (Bruffee, 1993; Hurley et al., 1999; Palloff and Pratt, 1999).

**More research attention should be devoted to the interaction of multiple technologies (such as the interaction between GIS and remote sensing/image processing).** Current research (on learning with technology) focuses mostly on the impact of individual technologies. There are few studies that examine more than one technology (and the synergistic effects of certain technologies) in addressing specific education outcomes and student groups (Institute for Higher Education Policy, 1999).

**More research efforts need to address the general effectiveness of “digital libraries,” as well as the effectiveness of “digital geospatial libraries” for education.** While the brick-and-mortar library is an integral part of the
teaching/learning process on university campuses, particularly for graduate students, are current digital libraries measuring up to the same objectives? Anecdotal evidence suggests that the potential of some distance education courses has been impeded by the limited variety of books and journals available from the digital library (Institute for Higher Education Policy, 1999), as well as the quality and ease-of-access of data from geospatial clearinghouses.

Research is needed to assess what training and support are most effective in encouraging faculty to make use of new technologies (Foote, 1999a). Much research focuses on learner outcomes, but does not address the issue of how to support faculty innovations in distance education.

Research is needed into the best cost and funding models for distance education in GISci, which requires students to use even more technology than many other distance courses (e.g., GIS and remote sensing software, GPS receivers, geospatial data sets and imagery, etc.).

Recommendations and Action Items

Universities, especially UCGIS member institutions, are best suited to deliver GIScience education through asynchronous learning networks. UCGIS should encourage institutions to leverage this advantage, ideally in partnership with vendors. It should also be noted that hybrid distance/resident programs offer the potential to deliver the best of both worlds. In conclusion, the following recommendations and associated action items are suggested for consideration:

1. Develop prototypes for on-line courses in advanced GISci (short term, 1-3 years). The goal of this initiative is to extend opportunities afforded by distance-education into full, university-level courses in GIS. Rather than beginning with introductory courses which are already well served in most programs, the goal here would be to create specialized upper-division courses that are not now offered widely outside of the largest programs. Courses in areas such terrain modeling, animation, real-time GIS, and hydrological modeling to name just a few, would enrich the curricula in programs where such classes are not now offered. As UCGIS is already a consortium of top universities and affiliates,
sharing common goals about GISci education, it is uniquely positioned to begin work on this immediately.

**Strategies and Requirements to Meet This Goal:**

- Develop, publicize, and test one special-topic course in Advanced GIScience.
- Once again, based on the experience of the initial short course, develop a conceptual framework (perhaps in collaboration with researchers in the education field) for how courses of this sort should be developed.

2. Develop a Summer Assembly workshop or panel discussion (to be led by members of the Distance Education working group) focusing on distance education within the broader contexts of education, research, and society *(short term, 1-3 years)*. Suggested topics include:

- How have the other education priorities developed in a distance education context, and how will developments in distance education affect these priorities in the future?
- What is the relevance of the ten UCGIS research priorities to distance education?
- What is the role of distance education and emerging technologies in the interaction between academics and society and/or the interaction between educational policy and society?
- What mechanisms are most appropriate for reconvening the UCGIS virtual seminar? For example, the focus of the next seminar might be on how certain disciplines intersect with the ten research priorities, such as spatial analysis in forestry, scale in urban planning, etc.

**Strategies and Requirements to Meet This Goal:**

- Publicize the plan for the workshop/panel and enlist participants.
- Convene the workshop/panel at a Summer Assembly.
- Reconvene the virtual seminar with a different focus, using next-generation technologies, and sponsored by a different UCGIS institution (UCSB and OrSt were previous hosts).
3. **Encourage member institutions to build on-campus inter-departmental linkages which reflect common interests in distance education (short term, 1-3 years).** A survey of member institutions on the quality and extent of distance education offerings within member departments and the measurement of interdepartmental activities should be performed with the aim of identifying successful approaches. There needs to be a very broad understanding of exactly what it takes to create effective and successful distance learning environments, involving much more than merely putting one’s syllabus and lecture notes on the web.

4. **Create a clearinghouse for distributed, collaborative curriculum materials in fields related to GIScience.** The clearinghouse should contribute additional resources to an already existing effort funded by the NSF, the Digital Library for Earth System Education (DLESE) (short term, 1-3 years).

The emphasis here will be placed on multiple disciplines, extending the idea of the Virtual Geography Department (Foote, 1999b) and the Geographer’s Craft (Foote, 1997), and the NCGIA Core Curriculum in GIScience to the allied fields of business, education, engineering, forestry, geology, statistics, urban planning (others may be suggested, such as ESRI’s Arc Lessons or Bentley Systems’ Education Network). The site will also alert users to the existence of the Virtual Geography and Geographers’ Craft pages (some geographers still do not know of these), and help them to make sense of the resources resident there. As with the Virtual Geography Department, the primary goal is to promote the distribution of high quality curriculum materials that can be used across the Internet by students and faculty anywhere in the world. A clearinghouse will allow faculty to share the time and expense of developing hypermedia and multimedia curriculum materials and to benefit from materials that might not otherwise be made available commercially. Such collaborations will also allow faculty to experiment with new types of on-line, interactive materials that promote collaborative problem solving.
**Strategies and Requirements to Meet This Goal:**

- Create a UCGIS Clearinghouse Web space sponsored by a participating university.
- Create an inventory of existing Web-based materials in these other fields (surf the web, contact other institutions or key educators/researchers in these allied fields for information on web-based curricula).
- Compile information and upload links to Web clearinghouse.

5. **Compile and create teaching modules for distance learning GIS courses to help instructors deal with effectively with television cameras, audio equipment, and enhanced classrooms, video conferencing capabilities (medium term, 3-5 years).** Not only students but instructors as well, need to be served by distance education. Instructors need to be made aware of the latest available technology for distance education, such as digital video and satellite conferencing systems, and to learn how to comfortably and effectively employ them for their own courses.

**Strategies and Requirements to Meet This Goal:**

- Identify all the different technologies available at or to UCGIS institutions (e.g., video communication over the Internet what enables one-one-to-one teaching or technical support, educational satellites, television studios, classrooms equipped with Ethernet and LCD projectors, etc.)
- Create “how-to” workbooks and associated web pages on how to best employ these tools (surf the web and compile this information, contact media centers at institutions by phone or email, and compile the information).
- Convene workshops at UCGIS and other professional meetings to address basic training, and to allow faculty to share their experiences.

6. **Develop or refine a unique pedagogy for distance education GISci courses delivered asynchronously (medium term, 3-5 years).**

**Strategies and Requirements to Meet This Goal:**
• Implement the pedagogy and model by developing innovative, Web-based teaching tools for a single GISci course (which is to serve as testbed). This is critical for UCGIS to undertake. Colleagues in education may develop good pedagogical models but will they necessarily be appropriate for all aspects of a GIS or GISci course?

• Transform the information/data retrieved from databases and sites found on the web, as well as from the text, into interactive learning experiences for the students by way of a set of web-based interactive form that will entice students to ask questions as they prepare they gather data (much of it may be from the web), perform GIS analyses, and try to interpret their data and the whole process.

• Develop strong evaluation tools and adoption strategies to disseminate the results of the project on a national scale. Evaluate and assess the effectiveness of the pedagogy and Web-based innovations so that recommendations can be made to others needing to develop Web-based courses as well as to regional and national education consortia that are beginning to devise standards electronic delivery of instruction.

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http://www.colorado.edu/geography/virtdept/library/activeped/activeped.html

National Center for Education Statistics, 1999. *Distance Education at Postsecondary Education Institutions: 1997-98*,

http://www.firstmonday.dk/issues/issue3_1/noble/index.html,


University of Illinois Faculty Seminar, 1999. *Teaching at an Internet Distance: The Pedagogy of Online Teaching and Learning*.


**Further Reading**
- considers ethical implications of distance learning in geography

DiBiase, D., in press, 2000. Is distance teaching more work or less work? *American Journal of Distance Education*.
- analyzes the results of a study during which the author and his teaching assistants the time and tasks involved in teaching two similar courses: one on-line, the other the classroom.

**For Further Visitation on the Web**
Alexandria Digital Library (ADL) and Alexandria Digital Earth ProtoType (ADEPT)
http://www.alexandria.ucsb.edu/
Bentley Education Network
http://www.benbentley.com
Chronicle of Higher Education: Distance Education
http://chronicle.com/distance
A Critic of Distance Education
http://chronicle.com/free/v46/i30/30a00101.htm
Cutting-edge Internet 2 Class Demonstrated at SC99
Digital Library for Earth System Education (DLESE)
http://www.dlese.org
ESRI ArcLessons
http://gis.esri.com/industries/k-12/arclessons/arclessons.cfm
ESRI Virtual Campus
http://campus.esri.com
GPS/GIS Technology Program, Distance Ed, Johnston Community College (NC)
http://gis.johnston.cc.nc.us/
International Network for Learning and Teaching Geography in Higher Education
http://www.inlt.org
Internet2
http://www.internet2.edu
Mastering Educational Technology for Academe (META)
http://osu.orst.edu/meta/
NCGIA Core Curriculum in GIScience
http://www.ncgia.ucsb.edu/curricula/giscc
Not-So-Distant Learners (Chronicle of Higher Ed. article about on-campus students and distance learning)
http://chronicle.com/data/articles.dir/art-44.dir/issue-29.dir/29a02901.htm
Oregon State University Distance Offerings in GIS
http://dusk.geo.orst.edu/gis
OSU Statewide (Oregon State University)
http://statewide.orst.edu
Penn State World Campus, Certificate in GIS
http://www.worldcampus.psu.edu/pub/gis/index.shtml
UCGIS Education Committee
http://www.ucgis.org/f2aeduca.html
UNIGIS program
http://www.unigis.org
University of California-Riverside, Online GIS Courses in Association with ESRI
http://www.unex.ucr.edu/gis/online.html
University of Oregon Distance Education
http://distanceeducation.uoregon.edu/
University of Southern California Distance Learning Certificate Program in GIS
http://www.usc.edu/dept/geography/learngis/
Virtual Geography Department Resource Page:
http://www.colorado.edu/geography/virtdept/resources/contents.htm

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Editors:
Dawn Wright, Department of Geosciences, Oregon State University,
dawn@dusk.geo.orst.edu

David DiBiase, Department of Geography, Penn State University,
dibiase@psu.edu

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Additional Working Group Members (in alphabetical order):
Ken Foote, Department of Geography, University of Colorado-Boulder,
k.foote@colorado.edu

Karen Kemp, Environmental Studies Program, University of Redlands,
kemp@uor.edu

Cherri Pancake, Department of Computer Science, Oregon State University,
pancake@nacse.org

Richard Wright, Department of Geography, San Diego State University,
wright@typhoon.sdsu.edu

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