Earth and Environmental Systems Institute
A Strategic Plan for 2008-2013

Executive Summary

Humans are changing the Earth's climate and environment at an unprecedented rate. Scientists have begun to refer to a new age – the Anthropocene – the age of significant human impact on land, air, water, ice, and biota. To survive and flourish as a species despite this impact, we must learn to "earthcast" – to predict how the climate and environment will change in the future based on observations from the past and present, and, importantly, based upon our knowledge of humans. A strict reliance upon discipline-based knowledge and approaches will not teach us how to earthcast. The Earth and Environmental Systems Institute is strategically positioned to lead in creating new knowledge, new approaches, and newly trained scientists, engineers, and social scientists in this area. EESI promotes the following vision:

> *EESI will build an extraordinary community of people who cross boundaries to understand the earth system, how it affects people, and how people affect it.*

To achieve this Vision, we articulate the following targeted activities, organized with respect to the overarching goals of the College of EMS.

Goal 1) Enhance the undergraduate program

1.1. Each year, EESI will fund an EMS undergraduate to be the EMS Environmental Student Ambassador (ESA) who seeks to promote environmental science for the general public or greater University community, or who helps EMS implement new environmental policies.

1.2. EESI will annually fund an EESI Environmental Faculty Ambassador (EFA) who seeks to promote environmental science for the general public.

Goal 2) Evolve into an increasingly diverse college

2.1. EESI will emphasize the growth in diversity of environmental scientists in EMS by promoting an interdisciplinary research and education program with students and faculty members at the University of Puerto Rico.

2.2. EESI will promote new paradigms in graduate degree-granting programs by pursuing Dual Degree programs with international institutions.

Goal 3) Empower exciting new disciplinary and interdisciplinary knowledge

3.1. EESI will hire an eco-hydrologist.

3.2. EESI will hire a hydro-meteorologist.

3.3. EESI will hire an earth system ecologist.

3.4. EESI will support efforts to hire EMS faculty to investigate the environmental implications of new energy strategies.

3.5. EESI will promote vibrant Centers and Initiatives to stimulate

promising interdisciplinary areas of research, education, and outreach.

3.6. EESI will promote a Center or Initiative to lead in the investigation of the Water Environment.

3.7. EESI will fund interdisciplinary EESI Environmental Scholars to promote interdisciplinary graduate student opportunities in environmental science, engineering, and social science.

3.8. EESI will participate in the development of an Energy and Environment Laboratory (EEL) to promote shared laboratory and field equipment for energy and the environmental sciences and education.

3.9. EESI will help to develop local field opportunities for environmental research and education.

3.10. EESI will grow the Environmental Computing Facility to provide state-of-the-art computing, data storage, and cyberinfrastructure for environmental science.

3.11. EESI will promote events and spaces to stimulate interaction among EMS disciplinary scientists.

3.12. EESI will nurture fixed-term faculty through establishment of a Research Faculty Award in the Environmental Sciences and Engineering.

3.13. EESI will nurture staff who encourage interdisciplinary program development and promote environmental outreach to non-scientists.

Goal 4) Engage in outreach programs which educate and inform stakeholders including students and faculty, community members, elected officials, and policy makers

4.1. EESI will sponsor and support EarthTalks, an environmental seminar series that focuses on environmental issues for the University and broader communities.

4.2. EESI will hire a cyberinfrastructure specialist to create and manage the EESI website as an interactive cyberinfrastructure to inform and advertise EESI to the outer community as well as knit together the EMS community of environmental scientists.

The Strategic Plan for the Earth and Environmental Systems Institute 2008-2013

Introduction. Humans are changing the Earth's climate and environment at an unprecedented rate. Scientists now refer to a new age – the Anthropocene – the age of significant human impact on land, air, water, ice, and biota. To survive and flourish as a species despite this impact, we must learn to "earthcast" – to predict how the climate and environment will change in the future based on observations from the past and present, and, importantly, based upon our knowledge of humans. A strict reliance upon discipline-based knowledge and approaches will not teach us how to earthcast. The Earth and Environmental Systems Institute is strategically positioned to lead in creating new knowledge, new approaches, and newly trained scientists, engineers, and social scientists in this area. EESI promotes the following vision:

> *EESI will build an extraordinary community of people who cross boundaries to understand the earth system, how it affects people, and how people affect it.*

Rationale. Several large changes have taken place nationally and globally that affect EESI's growth and leadership. These changes have informed this Strategic plan and are delineated below.

First, huge advances have been made in sensing and analytical technologies for the environmental sciences. To date, EESI has been successful in promoting small field-oriented programs to utilize environmental sensors and to provide computational and data storage needs for EESI faculty and students. However, at present no infrastructure is maintained on campus that specifically promotes the growth of environmental research that requires laboratory instruments, sensors, and field equipment. EMS and Penn State need a larger presence in the development and utilization of environmental sensors and environmental instrumentation.

Second, the new sensing and analytical technologies have coupled with new interdisciplinary programs and computer technologies to increase the availability of environmental data to physical and social scientists as well as nonscientists. Despite these new developments, our ability to synthesize such cross-disciplinary data into new scientific understanding and relate it to human needs is currently lagging our ability to collect and store such data. A need exists to promote interdisciplinary training, create interactions, and provide computer facilities that promote the synthesis of cross-disciplinary environmental data into useful understanding for societal decision-making. EESI is strategically positioned to encourage such synthesis within EMS.

Third, as information technology provides more information and accelerates the pace of research, faculty time has become the limiting quantity within the university in creating new knowledge. University faculty and staff are now bombarded with demands and opportunities while simultaneously experiencing new reporting requirements. A need exists to promote environments for faculty to continue to be creative. This need is tightly coupled to the need to develop a campus-wide

infrastructure that supports environmental science and education as described above. Such an infrastructure would indirectly save time and promote opportunities for environmental faculty.

Fourth, demographic changes have caused an increase in the diversity of the United States population, especially with respect to the growth of the Hispanic American sector, at the same time that jobs are increasingly outsourced to other countries. Given that environmental problems are both global and local, jobs will continue to be available in the U.S. in the environmental fields. While non-Caucasian populations have traditionally been under-represented in the environmental sciences, opportunities exist in attracting more of these students into environmental sciences as job opportunities are maintained or grown.

To respond to these structural changes, we have identified steps to move forward, as described in the rest of this document, based on the goals of the College of EMS:

> ***Goal 1)*** *The nurturing of an undergraduate program that engages a diverse ensemble of students in active service learning, problem solving, e-learning, and international experience.*
> ***Goal 2)*** *The evolution of an increasingly diverse college that enjoys the same richness of thought and experiences that empower broader society.*
> ***Goal 3)*** *Empowerment of faculty and graduate students to develop exciting new disciplinary and interdisciplinary knowledge at the leading edge.*
> ***Goal 4)*** *Engagement in outreach programs which educate and inform stakeholders including students and faculty, community members, elected officials, and policy makers.*

In general, the vision and mission of EESI emphasizes graduate research and education and relates most directly to Goal 3. Specific strategic activities that have been envisioned for EESI during the timeframe 2008-2013 are described in the ensuing pages, organized for each Goal. Two appendices describe budgetary needs and proposed faculty hires.

Goal 1) The nurturing of an undergraduate program that engages a diverse ensemble of students in active service learning, problem solving, e-learning, and international experience.

1.1 ***Each year, EESI will fund an EMS undergraduate to be the EESI Environmental Student Ambassador (ESA) who seeks to promote environmental science for the general public or greater University community, or who helps EMS implement new environmental policies.*** To choose this undergraduate, EESI will annually run a cross-college competition to facilitate an environmental outreach effort by and for EMS students. Students will be encouraged to pursue activities that might include the following: improvement of the environmental footprint of the College or the University; development of K-12 outreach activities; internships with policy makers, etc. Activities in collaboration with University units (e.g. Office of the Physical Plant) or student clubs (e.g. EcoAction) will be encouraged. These activities will engender a culture of action to improve the environment. Mentoring of the EMS Environmental Student Ambassador by the Environmental Faculty Ambassador (EFA, see below) will be encouraged. The ESA and EFA may choose different objectives for their focus but EESI will encourage the EFA to mentor the ESA.

1.2 ***EESI will fund a new program, the EESI Environmental Faculty Ambassador (EFA)***. In concert with the development of the ESA, EESI will fund an annual Environmental Faculty Ambassador (EFA). Faculty and staff within EESI will be eligible to become the EFA. EESI personnel who achieve EFA status will receive funding to enable an outreach activity that can significantly impact the education of the public or cross-disciplinary education of scientists about environmental change. EFA funding can be used for pure outreach or research/education activities that benefit the EMS outreach mission. Funding could also be used as salary for the faculty member in support of a new and significant outreach effort. The funding will be awarded annually on a competitive basis. One aspect of the job of the EFA will be to mentor the undergraduate who serves that year as the Environmental Student Ambassador (see above). The EFA and ESA may, however, have different foci for their outreach endeavors.

Goal 2) The evolution of an increasingly diverse college that enjoys the same richness of thought and experiences that empower broader society.

2.1 ***EESI will emphasize the growth in diversity of environmental scientists at Penn State by promoting an interdisciplinary research and education program with University of Puerto Rico.*** The faculties of the University of Puerto Rico-Mayaguez (UPRM) and the Department of Geosciences (PSU) have worked with EESI to complete a memorandum of understanding (MOU) establishing a graduate educational program in Geosciences. The program will involve three years of MS degree pursuit at UPRM,

funded by resources at UPRM, but incorporating involvement in the masters work by a PSU faculty committee member. Upon satisfactory completion of the MS degree, the student will enter PSU and complete the Geosciences PhD degree requirements under the mentorship of the same faculty member, using resources from EESI to support stipend and tuition. It is envisioned that a faculty member from UPR will generally be involved in the PhD research. The program will cooperatively provide an advanced education in geosciences with a goal for students to complete a six-year program of study that otherwise could require seven or eight years. EESI will work to implement this program and to extend the program to encompass other disciplines within EMS beyond geo-sciences. The program will be augmented by using resources to foster undergraduate internships for students from UPR, to position PSU faculty to work at UPR or to present workshops, and to promote investigations of tropical climate and environments.

2.2 ***EESI will promote new paradigms in graduate degree-granting programs by pursuing Dual Degree programs with international institutions.*** As the U.S. economy has become increasingly globalized, pressures mount on students to perform interactively upon the international stage. Many opportunities for foreign internships and travel already exist. EESI will seek to develop and explore a new paradigm for such international relationships: a Dual Degree program that would simultaneously award degrees at Penn State and at a university abroad. Such a program would enable the placement of PSU students into international settings in an approach that would benefit both institutions and the student.

<u>Goal 3) Empowerment of faculty and graduate students to develop exciting new disciplinary and interdisciplinary knowledge at the leading edge.</u>

To lead in interdisciplinary science and education requires hiring agile, creative faculty members who cross boundaries. The interfaces of interest are always moving as new ideas and tools become available. Hiring of faculty is therefore the highest priority to enable the development of new knowledge to interpret the ever-changing environment. Boundary-crossing activities by these faculty members must also be promoted. We have identified faculty hiring initiatives and institutional initiatives to create the most intellectually vibrant environmental institute.

3.1 ***EESI will hire an eco-hydrologist***. As human populations grow, the need for water grows rapidly. Often, populations grow fastest precisely where water is least plentiful. Furthermore, as climate and the availability of water change across the planet, mis-matches between the spatial distribution of human need and water availability will grow. We must understand the coupled biology, chemistry, and physics that control the water cycle as well as how humans and policy decisions interact with or impact the water cycle. A priority for EESI is the hiring of an ecohydrologist who

can integrate understanding of life systems and human impacts on the water cycle. (See Appendix for further discussion).

3.2 ***EESI will hire a hydrometeorologist***. In recent years, the sensitivity of local weather to global climate shifts has become a topic of great importance when considering "winners" and "losers" in climate change. Given the ever-growing pressures on water resources, we must understand the impacts of climate variations and change on local water supplies translated through variations in local weather phenomena. To do this, EESI will hire a hydrometeorologist who can translate global variations in climate into local variations in weather and consequent water sources. (See Appendix for further discussion).

3.3 ***EESI will hire an earth system ecologist***. Over half of the surface of the earth has been transformed by humans. Geologists sometimes now refer to the current era as the Anthropocene, because humans are a geological force that impact erosion on the planet. Furthermore, as we are forced to develop new strategies for energy use, many of these choices will drive changes in land use at large scales. We must be able to integrate understanding of land surface changes over both spatial and temporal scales. To do this, EESI should hire an earth system ecologist to bring such approaches as applied remote sensing and land surface modeling into EMS. (See Appendix for further discussion).

3.4 ***EESI will support efforts to hire EMS environment-energy-related faculty*** to investigate and understand the environmental implications of new energy strategies. Many of the new and old strategies for energy utilization will impact the climate and environment. In fact, it has sometimes been stated that we do not have an energy problem unless we are also worried about the impact of our energy choices on the environment. EESI is committed to helping to hire faculty who study the environmental impacts of energy strategies.

3.5 ***EESI will promote a vibrant set of interdisciplinary Centers and Initiatives*** to stimulate promising interdisciplinary areas of research. Centers and Initiatives will be chosen on a public competitive basis every three years and as appropriate. Center and Initiative funding will be appropriate for the level of activity. Centers and initiatives will use their funding as needed, but may consider the possibility of funding postdocs or student scholarships that rotate among Center or Initiative members as well as many other activities.

3.6 ***EESI will promote a Center or Initiative to lead in the investigation of the Water Environment***. This center should facilitate interaction on campus among all scientists and engineers working on questions related to the water cycle and water use and with respect to water policy.

3.7 ***EESI will fund interdisciplinary EESI Environmental Scholars for graduate students*** in EMS departmental programs, in Inter-

departmental Graduate Programs, and in Dual Degree programs who work with more than one EESI faculty member to pursue inter-disciplinary environmental science and social science.

3.8 ***EESI will promote the development of an Energy and Environment Laboratory (EEL)*** in coordination with other campus entities (for example, PSIEE) to promote the acquisition, maintenance, and growth of shared laboratory analytical facilities and shared field equipment and sensors for science and education for energy and the environment. In particular, EESI will promote i) the development of laboratories for environmental analysis; and ii) the development and use of sensor technology and field-deployable equipment for environmental measurement and analysis.

3.9 ***EESI will help develop local field opportunities for environmental research and education.*** Students need exposure to emerging sensing technologies that integrate real-time data analysis through innovations in environmental cyberinfrastructure. Local field sites enable both research and education. Such sites could include but are not limited to the Meteorology field site, the Shale Hills Critical Zone Observatory, and the National Acid Deposition Project site at Scotia Range. Such local field sites could become exemplars of environmental science for their use of state-of-the-art sensing technologies and cyber-infrastructure. Where possible, co-localization of environmental technologies such as eddy flux towers, meteorological analysis facilities, water measurements, and geophysical instrumentation should be facilitated.

3.10 ***The EESI Environmental Computing Facility will be maintained and improved to provide state-of-the-art computing and data storage capabilities*** that encourage faculty interactions as well as development of environmental-based cyberinfrastructure in collaboration with EMS departments. Much of the research in EESI is computationally intensive or requires large data storage. EESI must continue to provide state-of-the-art computational facilities and mass storage for research and education. The relationship with GEaRS—Graduate Education and Research Services -- should be fostered on campus appropriately so as to be able to provide state-of-the-art computational facilities. EESI should seek to purchase new clusters for computationally intensive science every 2-3 years by augmenting with EESI funds those EESI associates who have received extramural funding for computing and data storage.

3.11 ***EESI will seek funding to promote spaces and events to stimulate interaction among students, associates and affiliates.*** Such space and events will promote the interaction of EESI Environmental Scholars, EESI associates and affiliates, and Environmental Faculty and Student Ambassadors. Initiatives with respect to *space* could

include the provision of the premier facility for a Think Tank for Transformative Earth, Energy, and Material Sciences (TEEMS) specifically for environmental scientists. The current layout of EESI's facility in the Earth and Energy Sciences building must be improved to develop spaces that promote inter-disciplinarity among faculty, staff, and students. Significant funding could be sought to revamp the second floor of EESI to accommodate better utilization of space in the context of new efforts such as TEEMS. Alternatively, EES space could be reconfigured to attract EESI Associates to move their base of operations to EES. *Interactive and interdisciplinary events* pursued by EESI could include the Environmental Chemistry Student Symposium, an annual forum run by and for environmental students on campus. This symposium could be broadened to include all environmental sciences on campus and could be run in concert with the Penn State Institutes of Energy and Environment. Other such opportunities should be promoted.

3.12 ***EESI will nurture fixed-term faculty by developing and promoting an occasional award for excellent research/education/outreach performed by fixed term faculty and by providing professional development funds for these faculty.*** Particular and specific needs are felt by fixed-term faculty; EESI seeks to provide the best home possible to enable these faculty to promote the goals of the University, College, and Institute. An award targeted toward research faculty will heighten the awareness of the College community about the contributions made by these scholars and reward them for excellence.

3.13 ***EESI will nurture staff who specialize in interdisciplinary programs and outreach to non-scientists.*** For example, if the right person is available, EESI will hire a facilitator to promote EESI activities among scientists and nonscientists. If no such person is found, resources will be put into promotion of EESI activities within the College, University, and international community through match monies, seed grants, or other support that are supervised by EESI's staff and faculty. Funding will be made available for staff to take courses in areas related to desktop publishing, website design and maintenance, and other areas of relevant interest to enable and promote interdisciplinary science and education. Staff development or hiring will be encouraged in these areas. Funding for staff to promote outreach activities will also be sought.

Goal 4) Engage in outreach programs which educate and inform stakeholders including students and faculty, community members, elected officials, and policy makers

4.1. EESI will sponsor and support EarthTalks, an environmental seminar series that focuses on environmental issues for the University and broader communities. EarthTalks will be sponsored by EESI and spearheaded by one EESI affiliate or group of affiliates each year. In general, it is envisioned that

a topic of general, cross-cutting interest will be chosen, and that a faculty committee will plan a series of seminars that include speakers from both within and outside the community. The series is held on Mondays – the only day of the week when no EMS departments hold a seminar series.

4.2. EESI will hire a cyberinfrastructure specialist to transform the EESI website into a cyberinfrastructure that promotes interactivity. The website will include data portals, a literature clearinghouse, search tools, FAQ, information about grassroots environmental activities, content information system, and more information about both tenure line and fixed term faculty. The website will become a content management system that both knits together the EMS environmental community and also educates the international and national communities about activities within EMS.

Appendix I. Budget Requests

2008/2009

$30,000 permanent salary requested to partially cover the costs of hiring an interdisciplinary program coordinator/ professional writer to help EESI disseminate information about the work of EMS faculty and students in the environmental sciences

2009/2010

$40,000 permanent salary to hire two of the targeted faculty positions as shared positions with Meteorology, Geo-sciences, or Geography

$200,000 in associated start-up costs for the two targeted faculty

2010/2011

$20,000 permanent salary to hire the third targeted faculty position as a shared position with Meteorology, Geosciences or Geography

$100,000 in associated start-up costs for the targeted faculty

$12,000 for the Environmental Faculty and Student Ambassadors

$10,000 to fund the diversity-building program with University of Puerto Rico

2011/2012

$200,000 to renovate the second floor of EESI for interdisciplinary initiatives such as TEEMS

$12,000 for the Environmental Faculty and Student Ambassadors

$10,000 to fund the diversity-building program with University of Puerto Rico

2012/2013

$12,000 for the Environmental Faculty and Student Ambassadors

$10,000 to fund the diversity-building program with University of Puerto Rico

Appendix II. Targets for Faculty Hiring

EESI Ecohydrology Position

Ecohydrology focuses on how ecosystems respond to and affect the spatial and temporal availability of water. Research areas include, for example, controls on stream discharge and/or water availability, plant physiology related to water availability, and nutrient availability and pollution. These topics can and should be considered from the watershed to regional scales, with explicit attention to water policy and resource management. Experience with remote sensing, spatially explicit modeling, and/or field-based data collection would be helpful and would enable linkages between large-scale climate modelers and field researchers at intermediate watershed scales. A faculty member hired in this position could find an academic home in Geography, Geosciences, or Meteorology.

Significance of the area

Research in this area is strategically important: hydrology is a weak-link in global-scale predictions of climate change. Interactions between eco- and water-systems have significant and pervasive implications for understanding future ecosystem change and distribution. Enabling the cross-scale translation of knowledge among various stakeholders and scientists interested in water-related issues would substantially advance ecosystem science in the face of climate change. Environmental management of aquatic resources also has an important human dimension, as water determines the carrying capacity of various ecosystems. This is a field that links global implications with local-scale changes.

Relationships to other areas

There is currently no one on campus linking physical hydrologic processes with ecosystem services. Opportunities for cross-College collaboration are large and include ties to the PSU Cooperative Wetlands Center, the PSU Center for Watershed Stewardship, the Interdepartmental Program in Ecology, the College of Agriculture, and the College of Engineering. Within EESI, a newly hired person in this area could interface with many of the existing centers, including the Center for Energy and Environmental Risk, the Earth System Science Center, and the Penn State Ice and Climate Research Center. Ecohydrology is a key area of research for predicting human change on the environment and vice versa, and has ties to ecology, hydrology, climate change, policy, economics, and engineering.

Budget considerations

At the junior level, salary is likely to be commensurate with other junior salaries in EMS departments of Geosciences, Geography or Meteorology. Start up costs will likely range between $150K and $300K depending on the level of field-based science the researcher is conducting.

EESI Hydrometeorology Position

Changes in the local water cycle
The impacts of global climate change on people and the environment will dominate societal planning for years to come. In this context, the sensitivity of local weather to global climate shifts has gained importance in considering "winners" and "losers" in climate change. Marginal (or vulnerable) communities are especially sensitive to changes in the status quo and water is a fundamental need for all communities. Pressures on water resources are growing, due in some places to decreasing supplies, and in other places, to increasing population or development.

To address the link between global climate variations and regional water variability, EESI must hire a hydrometeorologist who can translate global variations in climate onto local or regional weather phenomena and water supplies and resources.

Candidate profile
This scholar needs an inter-disciplinary foundation as well as a comprehensive understanding of weather and climate interactions modulating water. A scholar in this area would need to be a bridge between meteorologists and climatologists, hydrologists and climate modelers, as well as social scientists in relevant foci. Indeed, he/she may span current disciplinary boundaries and have a second area of experience such as meteorology or hydrology. Innovative application of quantitative statistics and translation of these results across disciplines are also desirable. Familiarity with risk and decision theory research would be an attractive attribute for a successful candidate.

This scholar would join a growing interdisciplinary team of scientists who employ quantitative methods to address issues of science, engineering, economics, finance and policy relating to weather and climate variations.

The most likely home for this hire would be in the Department of Meteorology (College of Earth & Mineral Sciences), but the candidate should be encouraged to work across disciplines both within and outside of the home college. This faculty member would also help to build links with the larger University community working on problems in climate variability or change and in quantitative risk assessment and would add strength and intellectual breadth to our rapidly growing undergraduate and graduate programs. Penn State’s leading position in earth and atmospheric sciences and the range of these disciplines within the University should enable us to secure the premier position on climate-modulated weather variability and risk.

EESI Earth Systems Ecology Position

Earth systems ecologists study the complex interactions among organisms and their environment, and seek to understand the relationships among environmental subsystems. This understanding is critical for the development of predictive or diagnostic models on how ecosystems will respond to anthropogenic forces such as land use/land cover change or global climate change, particularly at regional and global scales. Understanding these complex interactions requires a scientist who can integrate academic disciplines, research techniques, and scales. Of particular interest would be a scientist who analyzes the ecological, geophysical (e.g. soil, oceans and atmosphere), and social/economic drivers of environmental change using remote sensing from space. Ideally, such a candidate would be able to couple the geospatial information on Earth surface characteristics with regional and global scale models (either biogeochemical ecosystem models or larger geophysical global carbon models). Advancement of regional or global models requires the scientific capacity to couple and integrate process-level understanding from experimental and observational studies with regionally scaled remote sensing technology. Candidates who link to policy and decision-makers would add a dimension critical to Earth systems research. EMS is fertile ground for such a scientist. The home of this person could be Geography, Geosciences or Meterology depending on the background and research interest of the individual.

Institutional setting

EMS and Penn State have demonstrated excellence in research and education focused on the abiotic components of ecosystems and their role in past and future climate change. Geochemistry, hydrology, atmospheric and climate dynamics are good examples of programs that span departments and colleges. Similar strengths have been demonstrated with respect to the biotic component of ecosystems such as molecular biology, plant ecology and plant physiology, as well as biogeochemistry and nutrient cycling. Despite these strengths, Penn State currently lacks scientists who can synthesize these elements in ecology over large spatial scales. Building on these strengths by including an earth systems ecologist with skills in remote sensing and regional/global models would place Penn State at the forefront of Earth systems analysis of global climate change. Of similar importance is the need for a scientist who can bridge between natural scientists and social scientists to model the impact of humans on the earth system.

There are great opportunities for an Earth systems ecologist who works at regional or global scales to participate and lead new research in core programs in EESI, EMS, and at Penn State. For example, new methods that link process-level understanding of global atmospheric and/or oceanic circulation, ecosystem interaction, and remotely sensed ecosystem responses and human systems are needed to diagnose mechanisms governing the current carbon cycle and to predict future climate-carbon interactions. Penn State's new initiative in energy research

is also largely driven by the impacts of energy systems on global climate. Modeling and assessment of proposed large-scale carbon sequestration initiatives will require spatially explicit large scale models of coupled human-environment systems to understand the effects on global climate, ecosystem structure and function (e.g. biodiversity, biogeochemistry), air and water quality, and human economic and political systems.

Relationship to other proposals

The committee that focuses upon the inter-relationship between EMS and the Interdepartmental Graduate Degree Program in Ecology has identified this area of research as a significant gap in Penn State's research capacity in ecosystems ecology. Addition of a faculty member with expertise in ecosystem science, remote sensing, and/or human systems will foster collaboration among ecologists, biologists, and physical scientists across EMS, College of Agricultural Sciences, and Eberly College of Science. There is also great potential for synergistic research with several new research centers at Penn State such as the DOE National Institute for Climatic Change Research administered in EMS or the Center For Infectious Disease Dynamics in ECoS.

Potential for external funding

There is a strong and expanding potential for external research funding to support this initiative under global change and regional assessment research budgets of many agencies (EPA, NSF, USDA, NASA, DOE, NOAA, USGS) as well as private industry. New initiatives that focus on the Dynamics of Coupled Natural and Human Systems, and Carbon and Water in the Earth System at NSF are also growing opportunities.