**Environmental Sustainability**

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## A. Executive Summary of Initiative

Human activities have driven far-reaching changes in Earth systems of climate, biosphere, hydrosphere, atmosphere and cryosphere, while depleting natural resources and creating social, economic and political impacts that demand long-term, multi-faceted solutions. The consequences of human-environment interactions and resource impact are felt locally in California's Central Valley and Sierra Nevada, and globally in resource-strained communities, cities, and countries. Environmental Sustainability unites research and education elements at UC Merced involving *coupled ecological and human systems* of the Earth, and the development of sustainable pathways and practices through *integration of basic research and technological solutions across disciplines.* This initiative aligns elements proposed in SAF Round 1 from the Environmental Systems (ES) Graduate Group, the Sierra Nevada Research Institute (SNRI), and the Life and Environmental Sciences (LES) bylaw unit. It also draws from prior ES, LES, and Environmental Engineering (ENVE) strategic plans to build on existing strengths, takes advantage of campus centers and institutes, and links to other proposed initiatives with elements related to the environment and sustainability. We propose strategic growth in a targeted area of **Environmental Sustainability**, consisting of three focal areas: of *1) sustainability science and engineering; 2) health and environment; and 3) communication and society in global change and sustainability.* In the long term, we envision building an interdisciplinary, innovative academic school that would add visibility to the strategic focus of Environmental Sustainability, vertically integrate undergraduate, graduate, and research endeavors, and overcome current academic fragmentation. Eventually, we would like to achieve physical unification of faculty, students, and staff through a new thematic campus building cluster that would support and highlight research, education, and non-academic partnerships around Environmental Sustainability.

## B. Definition of Thematic area

UC Merced's 2009 Strategic Academic Vision identified **Environmental Sustainability** as a key interdisciplinary theme for organizing research initiatives and academic programs. *The goal of this theme is to establish research and educational programs of coupled ecological and human systems that support sustainable use of energy, water, soil, and ecosystems. Addressing threats to human and ecosystem health, loss of biodiversity, and food and water security associated with global change requires integration of basic research and technological solutions across disciplines.* The field of sustainability science examines both fundamental interactions between nature and society, and society's capacity to create and follow sustainable trajectories. Education and communication involving our matriculated students, government and business, and the public are critical components to program success in addition to research and technology development. Thus, our thematic focus on environmental sustainability provides a context and focus for multiple groups and research areas across campus in natural sciences, engineering, management, social sciences, humanities and arts.

*1. Does it fit in one of the nine (9) defined Themes?*

Environmental Sustainability is Theme #5. In this proposal, we outline ongoing and planned focused research areas within this broad theme and with specific elements of Theme #3 (Human Health), #6 (Energy and Energy Systems), and #9 (Life Sciences). We also point out connections with elements of

themes #1 (Disparities: Equity, Diversity, Social Inequality), #4 (Innovation and Entrepreneurship), and # 7 (Information, Computational, and Data Sciences, and Engineering).

*2. Are there other SAF Initiatives that, in your opinion, might contribute to this Theme?*

This initiative is complementary to the proposal from the School of Innovation, Management, and Economics (SIME), particularly in the overlapping areas of innovation, sustainability, technology, environmental management, and resource economics. It links to the initiative in Cognition, Computation, and Human Data Science through the Center for Climate Communication, the Center for Human Adaptive Systems and Environments (CHASE), and other research on human-environment interactions and communication. The California Institute of Drone Engineering Research (CIDER) initiative supports efforts in this proposal related to sustainable agriculture and environmental engineering applications. Initiatives related to public health and infectious diseases from the Health Sciences Research Institute (HSRI) and the Molecular Cell Biology (MCB) group link to our components in health and environment. The systems approach of integrated observation and modeling, and the emerging Systems Ecology theme in Quantitative and Systems Biology (QSB) link to our focus areas of sustainability science, and health and environment. Other links include the emphasis on environmental ethics in the Applied Philosophy strategic initiative, and elements of social, economic, and gender disparities related to environmental resources and sustainability that drive the SAFI 2 proposal on Diversity, Inequalities, and Representation. Initiatives in General Education related to environment and society connect with our undergraduate degree programs and to the UC Merced student body's scientific literacy and sustainability cognizance.

**C. Intellectual components of the Initiative**
*Why is this area(s) important?*

The combination of global change and human population growth jeopardizes environmental, ecological, and agricultural systems, creating new threats to human health, ecosystem viability, and food, water, and energy security. Human societies and natural ecosystems globally depend on our ability to manage resource consumption and mitigate adverse environmental impacts, which requires combining basic research, applied technologies, effective communication, and research translation to stakeholders and policy-makers. UC Merced is uniquely poised to advance basic science and applied solutions in Environmental Sustainability from its existing base of transdisciplinary faculty research, interdisciplinary graduate and undergraduate degree programs, and cross-unit research institutes and centers.

*What are the current key areas/achievements in this field, and those going forward?*

For decades, scientists have documented human disruption of the Earth's climate system and its subsequent impacts on chemical and biological cycles. Anthropogenic impacts on the environmental are global, but their consequences are felt regionally and locally in coupled human-environment systems that affect water supplies, agricultural yields, air quality, fisheries, and ecosystems. Faculty in ES, SNRI, and LES have a strong track record of research and successful extramural funding in collaborative projects and as individual investigators related to the impacts of global change on water, soil, ecosystems, and biodiversity. We have a base of faculty working in both basic research in environmental genomics and biogeosciences, and in applied areas of environmental engineering, sustainability, and management, in addition to partnerships with government agencies and local stakeholders. The ES Graduate Group and SNRI are the intellectual center on our campus for research and graduate education in the areas of environmental and sustainable systems, and link to existing undergraduate programs in Environmental Engineering, Earth Systems Science, Environmental Science and Sustainability (minor), and Biological Sciences (Ecology and Evolutionary Biology emphasis).

Going forward, we intend to build on our foundational strengths by focusing on three emergent areas with the theme of Environmental Sustainability: sustainability science and engineering; health and environment; and communication and society. These emergent areas build on existing faculty and research cores in water, soil, and climate science, sustainable energy, and ecology, ecosystems, and biodiversity, while building integration with management, policy, and communication.

**D. UCM's Role in this Theme**

*The UCM Campus' unique position in this particular field and current strengths on campus*

Faculty in the ES graduate group and affiliated with the SNRI share a common interest in the study of natural and human-impacted environmental systems and the services they provide – their functioning, health, and sustainability on a planet experiencing rapid climate and ecosystem change. The scope of research within the group falls within the cross-cutting areas of:

- 1. Water, soil, air and climate science and engineering
- 2. Ecology, ecosystems and biodiversity
- 3. Sustainable energy systems
- 4. Natural resource science, economics, policy and management

These areas are central to the mission of the campus and address broader societal needs. Research of existing faculty is mostly within the first three areas; the last area is currently being developed jointly with management faculty in the SOE as part of the proposed graduate program in Management of Innovation, Sustainability and Technology (MIST). Each area above has significant potential for growth of high-impact research that integrates science, engineering, and social sciences.

This academic year, we are completing a cluster of faculty searches under the theme of Global Change Science, with hires in Evolutionary Biology (LES), Ecological Theory/Modeling (LES), and Ecological Engineering (SOE). In addition, we are completing a senior-level search in Natural Resource Management of Public Lands and Protected Areas (units: SOE and LES) that was authorized from the prior Provost's strategic initiative. The addition of new LES faculty strengthens faculty cohesion within that unit, and the Ecological Engineering position contributes to area 1. The Natural Resource Management faculty member is viewed as a founding leader in area 4 to jump start the growth of this important cross-unit, transdisciplinary area.

*Potential research areas of expansion*

<u>1. Sustainability Science and Engineering</u>

Long-term water and food security is threatened by climatic effects on agriculture, an issue of paramount interest to the Central Valley and the State. Regionally around UC Merced and California in general, agriculture, ranching, timber and nature tourism play important roles in our economy and society, but directly impact the sustainable use of water, soil, land, and energy. A major strength of our current academic and research programs is the strong integration of science and engineering that supports close coupling of science-based engineering, technology, and management solutions. Specific areas of strategic development are:

a. Biodiversity and Ecosystem Science and Services: Global change and population growth strongly impacts ecosystem function and services, and consequently, the strategies for environmental mitigation and adaptation. Areas of potential research related to ecosystem services could include global change impacts on: quantity, quality, and timing of water and hydropower resources; ecosystem productivity and carbon storage; agricultural productivity and sustainability; and wildlife habitat quality and maintenance of biodiversity. Opportunities include field and experimental research methods, and modeling across

different spatial and temporal scales, and adaptive management and regional planning for sustainable ecosystem functioning and services.

b. Sustainable systems engineering: Adaptive capacity to global change and resource use is best addressed with engineered solutions from a systems approach. For example, water security relies on availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks. Mitigating effects of soil or air quality degradation on human and ecosystem health demands systems-based technology solutions. The development of sustainable energy systems underpins and connects sustainable use of water, soil, and air resources. Systems engineers can integrate research and technology development with management implementation, and communication to policy-makers and stakeholders. This focus connects in the energy area with current research of the UC Advanced Solar Technologies Institute (UC Solar), a multi-campus research institute lead by UC Merced that is developing state-of-the-art solar energy generation technologies, facilitating system integration at residential, community and utility scales, and examining solar energy economics and policy.

c. Land surface processes and anthropogenic impacts: Environmental processes involving the Earth's surface are key to understanding impacts of climate change and to sustainable use of land, soil, and oceans. Areas of research emphasis include interactions among physical, hydrologic, biogeochemical, and geological processes with climate change, such as landform/landscape evolution, geochronology, forecasting and impact assessment; hydrologic-ecosystem processes involving changing water, nutrient, or contaminant fluxes; ecological disturbance (e.g., wildfire, insect outbreak, drought-related mortality) and post-disturbance changes in erosion, run-off and succession influenced by global change.

2. Health and Environment

The economic impacts of pathogens on agriculture and the food industry, the threat of bioterrorism, natural disasters, and the increasing need to ensure clean and safe air and water are some of the compelling examples of how fundamental research in Health and Environment directly connects to social, economic, and political impacts both locally and globally. Microbial life and the biogeochemical processes they underpin are key drivers of, and rapid responders to, global environmental change and its impact on humans.

Specific target areas that build on existing strengths are:

a. Environmental microbiology and microbial ecology: Microbial communities play important roles in nearly all of the issues outlined above and below, from sustaining productivity of managed and natural lands, to treatment and bioremediation of contaminated waters, to their emergence as infectious agents. An improved understanding of the various positive and negative feedback responses of microbial processes to global change is essential to fundamental understanding and mitigation of global change impacts on health. This challenge is complicated, however, by the vast diversity of microorganisms in the environment and the dynamic nature of microbial genomes and communities. Interdisciplinary and novel approaches to understanding and utilizing microbially-mediated processes that influence health and environment include such fields as microbial genomics, ecology and evolution of microbial communities, geomicrobiology, environmental symbiosis and pathogenesis that can be studied with field, laboratory, analytical, and simulation methods.

b. Ecology and evolution of infectious disease: Emerging infectious diseases that may be transmitted to humans from animals (i.e., zoonoses) and environmental reservoirs provide one of the most unpredictable and significant threats to human health (e.g., HIV, SARS, and Valley Fever). Climate change is expected to affect transmission of infectious diseases through altered range or abundance of animal reservoirs or insect vectors, and prolonged transmission cycles, resulting in increased incidence of diseases such as

Hantavirus, Lyme disease, and West Nile virus. Parallel threats for crops evolved alongside key agricultural systems (e.g., wheat rust, diseases of bananas), and longstanding threats are acknowledged in the evolution of antibiotic resistance in part due to prophylactic use in agriculture. We aim to understand population dynamics and genetics of reservoir species, hosts, pathogens and their interactions, as well as to address cultural, social, behavioral, and economic dimensions of healthy ecosystems. The program builds on existing strengths in ES, LES, and in HSRI, the environment and health group, and the infectious disease and immunity group.

3. Communication and Society in Global Change and Sustainability

Implementation of science and engineering solutions for resource sustainability requires that different segments of society understand and accept information, adopt new technologies, and change their practices. Communication and society aspects of sustainability offer multiple, unique opportunities for local research in the Sierra Nevada and Central Valley region that apply globally. Sustainable development in response to population pressures poses multiple challenges, for transportation, air quality, public health, land use, energy, cultural heritage, and their intersections with political, social, and cultural values. Research in this area may encompass approaches to integrative adaptive management, or alternatively, consider diverse issues such as environmental justice and the intersection of environmental sustainability research with politics and policy. Growth in this area will build connections between cognitive sciences and management, and natural sciences and engineering, through the interface with the new Center for Climate Communication spawned in SNRI.

Other research and learning opportunities exist through co-curricular activities (e.g., with the Office of Student Life) and mapping of human activities such as land use and resources through time (e.g., with SpARC and Library). For non-majors, complementary programs in General Education such as Writing in the Disciplines and Information Literacy with the Library are key to creating a public able to stay abreast of rapidly changing issues and equipped to make informed decisions about sustainable resource use.

*How will investment in this area make our program distinctive/competitive when compared to programs within UC and other research universities?*

Currently at UC Merced, the ES graduate group and SNRI occupy a unique position bridging science and engineering, and incorporating relevant elements of social and cognitive sciences. Our undergraduate degree programs in Earth Systems Science, Biological Sciences, and Environmental Engineering are delivered by faculty from different schools and academic units. At established universities, inter- or multi-disciplinary programs in environmental research are often amalgams of traditional disciplinary departments. Strategic development of Environmental Sustainability would vertically integrate research among faculty, professional staff and post-doctoral scholars, graduate student training, undergraduate degree programs, and public engagement, education, and outreach, as well as horizontally linking research and academic programs across schools and institutes. The lack of barriers enables us to leverage a relatively small group of faculty to innovate in new ways, discover connections between disparate fields, shorten paths from basic research to application, respond rapidly to new funding opportunities, establish unique academic program and training opportunities, and communicate and translate research beyond the university.

A landmark, bold move for UC Merced could take this theme a step further to establish an integrative school (e.g., *School of the Anthropocene)* that leverages the interdisciplinary goals of UC Merced and innovates within the UC System, nationally, and internationally to meet our interlocking mission of research, teaching, and service. This proposed transdisciplinary, innovative school would add visibility to the strategic focus of Environmental Sustainability, and overcome current academic fragmentation and poorly defined resource streams (three schools, multiple academic units) that create barriers for leveraging resources such as graduate student funding, staff support, appropriate research and office

space, and faculty efforts in teaching, graduate student mentoring, and program administration. Physical unification of faculty, students, and staff in a thematic campus building cluster would support and highlight research, education, and non-academic partnerships around Environmental Sustainability. Both physical integration and administrative unification through this new School would create a hub for research and solutions to environmental problems and sustainable resource use in the Central Valley and beyond.

**E. What bylaw units/grad groups might participate, and how would they participate?**

| Academic Units | Graduate Programs | Undergraduate Degrees | Research Institutes & Centers |
|---|---|---|---|
| Life & Environmental Sciences (LES) | Environmental Systems (ES) | Environmental Engineering (ENVE); Mechanical Engineering (ME) | Sierra Nevada Research Institute (SNRI), Vernal Pools & Grassland Reserve |
| Engineering (Environmental, Mechanical, Materials) | | Earth Systems Science (ESS); Environmental Science and Sustainability (ESSu minor) | Center for Information Technology Research in the Interest of Society (CITRIS); UC Solar |
| Cognitive and Information Sciences (CIS) | Cognitive and Information Sciences (CIS) | Cognitive Science (COGS) | Center for Climate Communication |
| Molecular Cell Biology (MCB) | Quantitative and Systems Biology (QSB) | Biological Sciences / Ecology/Evolutionary Biology (BIO/EEB) | Health Sciences Research Institute (HSRI) |
| Management (future) | Management (future) | Management (MGMT) | Spatial Analysis and Research Center (SpARC) |

Faculty in ES and SNRI hold appointments mostly in the Schools of Natural Sciences (SNS) and Engineering (SOE), primarily in the LES academic unit in SNS and in the Environmental Engineering group in SOE, with affiliates from the groups indicated above. Faculty associated with this initiative teach in a range of undergraduate programs, primarily Environmental Engineering, Mechanical Engineering, Earth Systems Science, Biological Sciences, Environmental Science and Sustainability (minor). Faculty and students would participate in this imitative through the ES Graduate Group, the undergraduate degrees and graduate programs indicated above, SNRI, and related institutes and centers.

**F. General description of special programmatic needs (specialized space requirements, special library collections, etc.).**

Faculty in ES/SNRI/LES have diverse space needs, including a mixture of high-performance analytical laboratory space (i.e., one pass air, fume hoods, access to services, emergency backup power), shared instrumentation labs, space for processing environmental samples (water, soil, air, biota), instrument development and electronic labs, and computational and visualization studies. A current critical need is for an environmental research facility consisting of a greenhouse complex, growth chambers, and related indoor and outdoor experimental areas. Environmental research mixes experiments and observations in natural systems, semi-controlled outdoor settings, and controlled laboratories. ES faculty currently work extensively in both field and lab settings, but are limited by the lack of a high-performance environmental research facility. Further, ample and easily accessed storage space for field equipment and supplies is desperately needed. Such a facility would allow space and conditions necessary for excellence in basic and applied research in Environmental Sustainability, which requires a tight linkage between experiments in the lab and observations in the field.