

**Strategic Focus: Sustainability, Energy, Climate and Communications**  
**Sierra Nevada Research Institute**

**Executive Summary.** UC Merced contributes to a sustainable future in California and related regions worldwide in part through research integrating the natural and social sciences and engineering. Faculty and other researchers affiliated with the Sierra Nevada Research Institute (SNRI) carry out research that is relevant to understanding linkages between the Sierra Nevada and the Central Valley, a region that leads the nation in agricultural production and many natural resource and recreational sectors. Despite its importance, the region's health and sustainability face increased threats from rapid population growth, competition for natural resources, changing climate and land use, and air, water and soil pollution. We offer a multidisciplinary approach that will enable UC Merced to sustain and expand research that supports California's vital infrastructure and resources, including water and energy, and to develop new and more effective ways of evaluating and communicating information about risk management and resource sustainability. This strategic initiative outlines six specific areas of growth that build on core strengths at UC Merced: i) agricultural sustainability; ii) renewable energy; iii) climate and atmosphere; iv) ecosystem services; v) risk communication and management; and vi) environment and health. These areas represent opportunities within the UC system, are central to building a sustainable future for California, and finding solutions for such resource issues will serve as a model for sustainability in other areas of the world. This proposal complements that submitted jointly through the Life and Environmental Sciences faculty cluster and the Environmental Systems Graduate Group, primarily through its focus on engineering and sustainability solutions as well as science.

**Definition of Thematic Area.** Sustainability has long been identified as a major research theme at UC Merced, from early planning documents to the Strategic Academic Vision for UC Merced.<sup>1</sup> The first goal in our Vision document is: "Build an integrated research and educational program on ecological systems, energy, water and other natural resources, climate change and security threats associated with global change that will help build a sustainable environment." Reaching this goal requires continued development and expansion of our environment and sustainability research portfolio.

Globally, the entwined challenges of resource demands of a population of seven billion and growing coupled with rising temperatures will define the 21<sup>st</sup> century. Locally, the rapidly growing, four million plus population of the San Joaquin Valley combined with unsustainable energy use and an unhealthy environment offer immediate challenges and opportunities for research at UC Merced. SNRI faculty and others at UC Merced use the region as a natural laboratory for research, and build knowledge to address the regional challenges of transitioning to a more sustainable future. The state has a strong commitment to reducing greenhouse-gas emissions, transitioning away from fossil fuels to renewable energy, maintaining water security in a changing climate, and improving the environmental quality of the Central Valley.<sup>2</sup> Meeting these goals is critical to a strong economy and desirable quality of life for the region, and cannot be accomplished without a strong research capacity focused on environment and sustainability within the state.

This initiative directly addresses two themes identified by the Strategic Academic Focusing working group: i) Environmental Sustainability; and ii) Energy and Energy Systems. It is synergistic

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<sup>1</sup> <http://academicpersonnel.ucmerced.edu/pdf/090421-strategic-academic-vision.pdf>

<sup>2</sup> See for example, AB 32 and plans implementing this legislation. See also parallel major UC initiatives around these goals, such as the newly launched UC Berkeley Energy and Climate Institute.

with i) Disparities: Equity, Diversity, Social Inequality; ii) Human Health; iii) Innovation and Entrepreneurship; iv) Information, Computational, and Data Sciences, and Engineering; and v) Life Sciences.

**Intellectual Content of the Initiative.** We propose that UC Merced add a group of faculty across schools and graduate groups to advance this vision. With this core group of faculty, UC Merced can stand out as a leader in sustainability in the UC system and become a catalyst of change for the Central Valley and beyond. Through our multidisciplinary research and graduate students we can develop expertise on Valley problems and we can strengthen partnerships between UC Merced and stakeholders and decision makers. A unique feature for this program is a focus on communication. Messages about sustainability, including climate change, directly affect perceptions of stakeholders and have consequences for policymaking. We propose six specific areas of growth: i) agricultural sustainability; ii) renewable energy; iii) climate and atmosphere; iv) ecosystem services; v) risk communication and management, and vi) environment and health. These areas are central to the goal of building the knowledge base required to provide sustainable energy to fuel California and sustainable ecosystems to provide the services (e.g., water) needed for a secure future.

**1. *Agricultural sustainability.*** Irrigated agriculture in the Western U.S. depends on runoff from mountain watersheds, with much of this runoff coming in spring from melting snow that accumulated over winter. Warming temperatures are resulting in a shift from snow to rain and earlier snowmelt, which affects the timing of water availability for downstream agriculture and stresses seasonal water-storage capabilities. Warming and/or fire suppression pose additional and potentially even larger challenges to water security by increasing growing-season length, leaf area, and ultimately evapotranspiration of mountain forests. Much of the current runoff from the Sierra Nevada and other mountains comes from snow-dominated landscapes, where cold winter temperatures also limit the growing season. The movement upslope of the rain-snow transition elevation (approximately 300 m for 2°C warming) will be accompanied by a longer growing season, resulting in more annual evapotranspiration and thus less runoff. These looming reductions in runoff are especially problematic for perennial crops, which are increasingly replacing annual crops in California's San Joaquin Valley. Problems are exacerbated in dry periods, such as 2012-14, and warming and increasing precipitation variability will only make matters worse. Groundwater pumping or building additional dams for storage may provide some of the solution, but there may be less-costly measures that can be implemented in the near term. UC Merced has a leadership role within UC for water research, using the Sierra Nevada-Central Valley region as a natural laboratory. We can build on that foundation to develop research excellence in areas around agroecosystems and water security in a changing climate. Water security is the reliable availability of an acceptable quantity and quality of water for health, livelihoods, and production, coupled with an acceptable level of water-related risks. The debate around water security in California involves advocates for both "hard" (e.g., new storage and conveyance infrastructure) and "soft" (e.g., institutional arrangements, demand management) solutions to water-supply challenges. A role for UC is to build the knowledge base for better information that can support both hard and soft approaches, and on research and development to provide this better information.

**2. *Renewable energy.*** Renewable energy systems (e.g., solar, wind, hydro and biomass) will play a major role in sustaining the economy and in improving environmental quality in California, the nation, and the world. The state has identified critical needs for research,

development and demonstration, including: i) energy efficient technologies; ii) renewable generation; iii) clean fossil generation; iv) transportation fuels and vehicles; and v) bioenergy.<sup>3</sup> Major, immediate efforts to focus investments, including research, away from further fossil fuel development toward these technologies are critical to address the state's mandate to reduce greenhouse gas emissions to 1990 levels by 2020. Even more daunting is the goal to bring greenhouse-gas emissions 80% below 1990 levels by 2050. While the state has achieved small reductions in emissions in the period 2000-present, we do not yet have a clear path to meet 2020 and 2050 goals. Using the region as a laboratory, there are research opportunities in integrating renewable technologies with production agriculture, including, biomass, wind, and solar. There are opportunities to expand small hydro and optimize large-scale hydro generation. Strong consideration should be given to recruiting a senior faculty member who could lead a Renewable Energy Research Institute, with the purpose of enabling and facilitating research that reduces fossil fuel use in the region. The campus could use SNRI's well-recognized trademark to nurture formation of such an institute, with the goal of launching it as a stand-alone institute within 3 years. We should also investigate research needs and formation of an institute around planning and design for energy-efficient infrastructure and buildings. This would support opportunities for expanding engineering to include civil/architectural, to complement environmental engineering; and it would enable new opportunities in the areas of policy and management. Positions for this focus are not identified in the current proposal, but it is an opportunity that merits further investigation.

**3. *Climate and Atmospheres.*** UC Merced plays a leadership role in multiple aspects of climate within the UC system and nationwide. Our climate applications work fills a critical niche in the UC system, connecting fundamental climate science with climate impacts, mitigation, and adaptation. The Sierra Nevada and Central Valley offer outstanding opportunities as natural laboratories for research. Together, they offer the research infrastructure and settings to study many of the challenges facing the nation and the world. For example, the snow-dominated hydrology and dense forests of the Sierra Nevada makes the range particularly vulnerable to catastrophic wildfire and other impacts of climate change. The vast Central Valley, heavily developed for irrigated agriculture, has extensive areas with declining groundwater levels, water-quality problems, and crops that are sensitive to temperature shifts. The climate of the Sierra Nevada and Central Valley have generally received much less research attention than in coastal California, and the need for new knowledge and technology transfer is very large.

UC Merced has started building research capabilities in the area of air pollution, but the potential for research excellence remains largely unrealized. The San Joaquin Valley has the distinction of having the worst air quality in the nation. Regional population is growing more rapidly than in any other air basin in the state, bringing increased vehicle miles traveled and urbanization. Climate-change impacts are also expected to worsen air pollution in the region (e.g., through effects on wildfire, dust, atmospheric chemistry). These factors counteract progress in emission reductions. Poor air quality affects the region's public health, economy, and general quality of life. These problems make the Central Valley and Sierra Nevada region an excellent natural laboratory for air pollution and environmental health research. Further, research can have important, direct impacts on public policy and environmental justice, which is highly complementary to the air pollution research in the

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<sup>3</sup> Energy Action Plan, 2008 Update. <http://www.energy.ca.gov/2008publications/CEC-100-2008-001/CEC-100-2008-001.PDF>

new UCM Blum Center for Developing Economies. Air pollution sources are diverse and only partially understood. While there is a good general knowledge of health effects in the region, details of causes, mechanisms, and mitigation impacts are poorly known. UCM has a pivotal role to play in developing the science of air pollution, its health effects and engineering solutions. Areas of opportunity include management and technology in air quality engineering, technology for air pollution control, and modeling and impacts of air pollution. California's Central Valley is also an excellent natural laboratory for research to devise air pollution control systems. Organic and inorganic particulates, persistent organic pollutants, and precursor gases for ozone formation are produced during routine agricultural practices and weekday commutes. These pollutants are lofted into the atmosphere to interact with other chemicals or microbes and are eventually deposited in the respiratory systems of humans and animals, as well as on plant leaves. The resulting effects on human and ecosystem health are devastating.

**4. *Ecosystem services.*** UC Merced is poised to play a leadership role in the ecology and ecosystem science community in California and the nation. Global change and population growth strongly impact how ecosystems function, the services they provide (such as pollination), and consequently, the strategies for mitigation and adaptation. Again, the Sierra Nevada and Central Valley offer outstanding opportunities as natural laboratories for research. Ecosystems are undergoing rapid change in response to the dual pressures of climate change and land use change, both driven by aspects of population growth. Sierra Nevada forests, which are both critical habitats for diverse fauna and the source of much of California's water supply, are now especially vulnerable to catastrophic wildfire. Extended dry periods under a more variable and changing climate will further stress these ecosystems, through greater evaporative demand, greater susceptibility to pests and disease vectors, and shifting fire and recovery patterns. Over the next few decades the Central Valley will undergo extensive and enormous ecosystem restorations activities, involving investments of several billion dollars. Water now used for agriculture will be diverted to sustain wetlands and riparian areas, and new entities will be established to manage these large tracts of land. In both the Sierra Nevada and Central Valley, the scientific knowledge base for ecosystem management is weak. Yet the potential ecosystem services to be derived from these areas is enormous and absolutely critical to the state's economy and quality of life.

**5. *Risk communication and management.*** The way messages about natural resources and sustainability are framed and disseminated has direct but differential impacts on diverse stakeholders' perceptions and attitudes related to important issues around protecting and managing resources, such as water, soil, and air. This in turn influences policies and programs related to energy, land use, wildfire management, water treatment, and air quality. The Sierra Nevada-Central Valley region is rich in resources, but threats to these resources are rapidly increasing because of population growth, inappropriate land use, and excessive automobile use, in addition to negative impacts of climate change. Effective communication of risks and viable approaches to addressing those risks can support decision making by the general public and key stakeholders, including government officials, for the sustainable management of precious resources. Research on environmental risk communication, with relevance to environmental and resource economics, policy and management, is sorely needed to develop appropriate markets, incentives, institutions, capacity building, social attitudes, and ecosystem sustainability. Sustainable development of the Central Valley in response to population pressures poses challenges for transportation, air quality, public health, land use, energy, cultural heritage, and their intersections with political, social, and

cultural values. UC Merced is in the perfect position to develop exciting, viable new research programs and collaborations to objectively educate a wide range of stakeholders, including public officials and the general public, about resources and how to manage them and associated risks.

**6. Environment and Health.** Climate change is a critical public health problem that the major public health organizations of the world are now addressing. Climate change makes many existing diseases and conditions worse, and it can also help introduce new pests and pathogens into regions. As the earth warms, oceans expand and sea level rises, floods, droughts and wildfires become more frequent and intense, and heat waves and hurricanes become more severe. The most vulnerable people—children, the elderly, the poor, and those with underlying health conditions—are at increased risk for health effects from climate change. Climate change also stresses our health care infrastructure and delivery systems.<sup>4</sup>

Some of the greatest threats to human health are emerging infectious diseases of animal origin that may be transmitted to humans. 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.

**UC Merced's role.** This plan identifies areas of strategic growth for research and education where UC Merced can fill critical niches within the UC system and also develop collaboration with colleagues from other campuses. Most of these are areas in which UC Merced can be out in front nationally, as well, and all have a great importance to the future of the state. The approach is to look forward to sustainable solutions, building on the decades of research on identifying environmental, economic, and resource-management problems. Following is a summary of UC Merced's strengths in relation to the proposed intellectual components of this proposal:

1. **Agricultural sustainability.** This builds on our leadership in water and climate science and policy, particularly around Sierra Nevada questions and those in similar areas in the Western US and elsewhere. Extending this to the Central Valley ecosystems and agriculture is thus an opportunity to both leverage these strengths and build a complementary area of excellence.
2. **Renewable energy.** UC Merced has multiple faculty working in this area, and this needs a strategic focus to bring these programs to regional and national prominence. One example is the UC Solar multi-campus research unit. While our foundation in renewable energy is excellent, this area needs a more core faculty in order to take advantage of emerging opportunities in the state and nationally. This is an absolutely critical area for California's energy future as we move to decarbonize the economy, as per state goals.

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<sup>4</sup> <http://www.niehs.nih.gov/research/programs/geh/climatechange/>

3. **Climate and atmosphere.** UC Merced has a strong core group working on applied climate science, primarily related to water and fire. As the state, nation and world search for climate solutions, numerous opportunities for research in related areas are emerging.
4. **Ecosystem services.** UC Merced has several core faculty in ecology and ecosystem science, and is wrapping up a 4-position cluster hire in related areas. We can thus make strategic additions to this group as opportunities arise.
5. **Risk communication and management.** This area builds on the intersection of two strong graduate groups: Cognitive and Information Science and Environmental Systems.
6. **Environment and health.** UC Merced is building core strength in cellular and molecular biology, in ecology and evolutionary biology, and in public health. This area will leverage those emerging strengths and expand into areas that are central to understanding the impacts of climate change on health and other perturbations to our regional and global environment. The program builds on existing strengths in Environmental Systems, the environment and health, and the infectious disease and immunity groups in the Health Science Research Institute and Life and Environmental Sciences unit.

**Faculty participation.** To be successful, this effort needs to engage faculty across schools and graduate groups, providing opportunities for disciplinary and interdisciplinary advanced degrees and undergraduate research opportunities. SNRI has a track record of productive faculty and researchers, fostering collaborations across disciplines, and using the strengths in SNRI to strategically build centers. Averaged over a recent 4-year period, awards to SNRI faculty amounted to 41% of total campus research awards. Raising UC Merced's research profile locally and nationally will attract faculty and students. Several research projects are collaborative with colleagues from other campuses and government organizations, significantly expanding the impact of SNRI.

Graduate programs that are expected to participate in the strategic directions defined under this umbrella include Environmental Systems, Cognitive and Information Sciences, Social Sciences (i.e., Public Health, Economics), World Cultures (i.e., Interdisciplinary Humanities) and a future management degree. Over one-third of UC Merced's undergraduate programs are expected to participate directly in this initiative and others will benefit indirectly.

Proposed initiatives in management within UC Merced will provide critical synergies for the areas outlined in this proposal.

There is some degree of overlap and a larger degree of synergy between the intellectual components identified here and the plan submitted under Life and Environmental Sciences, School of Natural Sciences, and the Environmental Systems Graduate Group. There remains a good potential to merge those areas under the initiative outlined in this plan.

Another example of synergy is with faculty in philosophy who propose to initiate ethics education in science and engineering to provide specialized training in applied ethics. This would support the proposed initiative in risk communication and management, the renewable energy area, and other intellectual components in this plan.

The Fall 2013 version of this plan included input from Martha Conklin, Roger Bales, Elliott Campbell, Michael Dawson, Henry Forman, Qinghua Guo, Tom Harmon, Stephen Hart, Dan Hirtleman, Kathleen Hull, Paul Maglio, Teenie Matlock, Erik Rolland, Josh Viers, and Leroy Westerling. This revised version was prepared by Martha Conklin, with comments from several SNRI faculty and colleagues drafting other strategic initiatives.

**Special programmatic needs.** No special needs have yet been identified. Each of the strategic areas will require addition of one or more faculty, plus staff, space and startup funds.