

Sierra Nevada Research Institute
Strategic Focus and the 2020 Project: Sustainability, Energy, Climate and Communications

The Sierra Nevada Research Institute (SNRI) supports environmental sustainability in California and related regions worldwide through research integrating the natural and social sciences and engineering. SNRI research is relevant to understanding linkages between the Sierra Nevada and the San Joaquin 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.

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.¹ 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 SNRI's 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 21st 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 for research at UC Merced. In using the region as a natural laboratory for research, SNRI is building the 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.² Meeting these goals is critical to a strong economy and desirable quality of life for the region, and can only be accomplished with a strong research capacity focused on environment and sustainability within the state.

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, SNRI 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 programs we can develop expertise on valley problems and we can strengthen partnerships between UC Merced and stakeholders. A unique feature for this program is a focus on communication. Messages about sustainability, including climate change, directly affect perceptions of stakeholders and have consequence for policymaking. To enhance our strengths in these areas, we aim to increase the number of research scientists affiliated with SNRI. We propose five specific areas of growth: water quantity, water quality, air pollution, renewable energy, and risk communication and management, with 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.

Water resources; *strategic hires: systems hydrology, ecohydrology.* 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 ecosystem services in a changing climate.

The Sierra Nevada snowpack provides about 60% of the annual consumptive water use for the State of California. With the previous century of stable weather patterns, the Federal government, State of California and local entities developed a system of rim dams and canals designed to capture snowmelt and

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

² 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.

redistribute it throughout the state. Dam operations rules were designed for flood protection rather than maximizing storage; and supplying adequate water resources is increasingly challenging with multiple low-precipitation years. Most of the snow falls in the forested area of the Sierra Nevada, which due to fire suppression policies has up to four times the tree density versus the early 1900's. Recent catastrophic fires (e.g. Rim fire) have burned thousands of acres, leading to deterioration of snowmelt quantity and quality as well as changes in snowmelt timing. Adapting to climate change involves managing ecosystem services, with water-related ecosystem services being an important focus. The ecohydrology will address these challenges at the water-forest-climate nexus. There is also synergy with UC DANR.

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. Water security for humans in semi-arid regions is founded on adequate water storage. In California, as in many semi-arid regions, that storage is provided by a combination of dams, mountain snowpack and in groundwater reserves. The systems hydrology position will fill the pressing need and opportunity within UC to address these questions in the context of a changing climate and increasing water demand, in California and worldwide. The debate around water security in California involves both "hard" (e.g., new storage and conveyance infrastructure) and "soft" (e.g., institutional arrangements, demand management) solutions. Better information is critical to support both approaches; and UC research and technology development is in a position to meet these challenges. A new systems engineering faculty member will lead that.

Water quality; *strategic hires: emerging treatment technology, water reuse, agroecology.* The San Joaquin Valley depends on groundwater to provide drinking water in rural regions and urban population centers, and to satisfy agricultural demands, particularly in dry years. The overdraft and pollution of Valley groundwater by anthropogenic (nitrate, pesticides) and, due to water management practices, natural (salinity, arsenic, uranium) causes are well-documented, and emerging contaminants are on the rise (fracking "cocktails", pharmaceuticals). With regional climate-change effects, and with the projected growth and inland shift of California's population, water-quality problems related to human health and agricultural sustainability will worsen. Looking forward, the only realistic "new" source of water in the region will be reused wastewater, including that from agricultural drainage. Novel, economical water-treatment systems appropriate for water reuse for human consumption, ecosystem support and irrigation will be in demand. Addressing this problem is part of SNRI's mission, and a foundational aspect of the environmental engineering field, but we currently lack faculty lines for this area of research.

Agroecology on sustainable water use bridges both water quantity and quality, and can use the region to address questions at the interface of production agriculture and water security. For example, the current leaching of nitrate and other residues from agricultural production into regional groundwater is unsustainable, and new solutions to these problems are needed. Further, it is hoped that ongoing restoration of valley ecosystems can be compatible with production agriculture; however there remain several open questions around the resiliency of restored ecosystems to agricultural residues. Finally, adaptation of agriculture and the economies and communities that it sustains to proposed shifts of land and water use for expanded fracking for oil recovery pose additional serious questions for regional sustainability. The position can develop valuable synergies with the UC Division of Agriculture and Natural Resources (DANR) and Fresno State.

Air pollution; *strategic hires: system engineer, atmospheric scientist;* synergy with MIST, HSRI, Blum Center. UC Merced has started building research capabilities in this area; but the potential for research excellence remains largely unrealized. We can build on the recently initiated research aimed at understanding and mitigating air quality problems in the Central Valley and Sierra Nevada. 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 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.

Adding two faculty members with expertise in management and technology in air quality engineering would provide a focus on engineering design of systems, technology for air pollution control, or 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.

Renewable energy; strategic hires: system engineer, alternative energy; synergy with technology management. Renewable energy systems, e.g. solar, wind, hydro and biomass, are expected to 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.³ 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.

Social impact: communication and management of environmental risk; strategic hires: cognitive scientist (linguistics or communications), resource management (environmental anthropology or sociology), sustainability and society; Synergy with Cognitive Science and MIST. 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 them can

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

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.

A cognitive-science (linguistics or communications background preferred) hire will study how humans formulate and communicate messages around sustainability, including framing effects or the use and understanding of visualization tools, and the differential impact communication can have on social groups. A resource-management (e.g., environmental sociology or environmental anthropology) hire will closely examine how humans are managing resources, such as land or water, and how they are approaching policies around social conflict. This could include an emphasis on technological innovation in the context of managing and disseminating information about resources and risks therein.

Natural disasters and ecosystem change are fundamental processes that occur without human influence, but often are affected by and affect humans and their social organizations. Technical solutions currently exist for many environmental problems, but they cannot be implemented without considering human dimensions of the environment, including diverse values, understandings, and perceived needs of various constituencies. A mid-career or senior faculty member in the area of sustainability and society would be invaluable to the SNRI and UC Merced, providing leadership in research and educational efforts in this area. As noted in the Sierra Nevada Ecosystem Project, such research might encompass approaches to integrative adaptive management, or alternatively, consider diverse issues such as environmental justice and the place of “clumsy institutions” in environmental politics and policy. This position in SSHA would build the social sciences core at UC Merced in the broad area of sustainability social sciences. This combination of positions would create a core of excellence that could contribute to the research agenda of SNRI as well as the management program. This position would contribute greatly to the development of a cross-school undergraduate minor and/or major in resource management. This combination of positions would create a core of excellence that will catapult UC Merced to become a thought leader in sustainability.

Staff and space needs. To support current and proposed research levels, SNRI will need to expand its space and provide additional services. Mirroring the proposed activities, staff members for research support (accounting and personnel) as well as an outreach coordinator to oversee stakeholder interactions and communications are needed. We anticipate the need for three new staff members in accounting, personnel, communication/outreach to stakeholders. As mentioned above, SNRI also plans to increase the number of affiliated research scientists. To accommodate staff and affiliated faculty, we need a contiguous suite of 12 offices (15,600 sq. ft.) and an adjacent seminar room (600 sq. ft) that includes projector, screen, sound, seminar table, and chairs.

Metrics for gauging success. A successful effort will engage faculty across schools and graduate groups, provide opportunities for disciplinary and interdisciplinary advanced degrees, and undergraduate research. SNRI has a track record of productive faculty and researchers, and of fostering collaborations across disciplines. Averaged over a four-year period, research awards to SNRI faculty amounted to 41% of the campus total. Raising UC Merced’s research profile locally and (inter)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. Specific metrics include: i) amount and source of extramural funding; particularly multi-disciplinary collaboration; ii) number and citations of faculty and student peer-reviewed publications; iii) engagement of students, postdocs, researchers, faculty, iv) demand for information from stakeholders, especially decision makers (e.g., talks, white papers, research results); and v) number and type of general-media coverage of research.