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Sustainable LA Grand Challenge Five-Year Work Plan (Full Report)

Authors
Gold, Mark
Rauser, Casandra
Herzog, Megan
et al.

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UCLA Grand Challenges

Sustainable LA

SUSTAINABLE LA GRAND CHALLENGE
THRIVING IN A HOTTER LOS ANGELES
FIVE-YEAR WORK PLAN
2015-2020

ABOUT UCLA GRAND CHALLENGES

The UCLA Grand Challenges initiative connects faculty, students and supporters from all disciplines to work together, adopting a holistic approach to solve critical issues. We bring passionate participants together to dream big and think grand about what we can achieve when we set our sights on common goals.

Complex challenges require creative solutions

As a research university, UCLA has the intellectual capital and resources it takes to explore society's most challenging issues. In addition, we are inspired to develop solutions that improve quality of life in the U.S. and around the world. At UCLA, we firmly believe that for every problem there is a solution, and we call upon that optimist spirit throughout this initiative.

It takes a unique approach

UCLA Grand Challenges represent a new paradigm for university research. This new approach involves building a team, creating partnerships across sectors, facilitating collaboration, soliciting new perspectives, producing transformational work, evaluating and reporting on progress. Each Grand Challenge serves to align the creativity and talents of many around one ambitious goal.

What makes UCLA's program so impactful?

This initiative was established in 2012 with the premise that by working together with shared goals, the UCLA community could have an even bigger impact on society's greatest problems. Currently, there are two grand challenges: the Sustainable LA Grand Challenge and the Depression Grand Challenge.

UCLA Grand Challenges

Sustainable LA

SUSTAINABLE LA GRAND CHALLENGE
THRIVING IN A HOTTER LOS ANGELES
FIVE-YEAR WORK PLAN
2015-2020

GOAL: 100% renewable energy, 100% locally sourced water, and enhanced ecosystem health for Los Angeles County by 2050

Authors/Editors:
Mark Gold
Casandra Rauser
Megan Herzog
Jesse Lueders

UCLA Grand Challenges
Office of the Vice Chancellor for Research

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EXECUTIVE SUMMARY

Over the coming decades, environmental challenges could significantly disrupt the economy, human health, and quality of life in Los Angeles County. The latest UCLA research predicts that the Los Angeles of the future will be hotter, with more frequent and dangerous heat waves, increased wildfire risk, and less snowpack to feed local water supplies. It also will be more crowded, with an estimated increase of 1.5 million residents by 2050. A hotter and more populous Los Angeles will put increased pressure on energy, transportation, and water infrastructure, exacerbate public health problems, and stress wildlife habitats. To ensure a thriving future, Los Angeles' response to the challenges ahead must be sustainable—we must be attentive to the interdependencies between three key resources that underpin our economic, social, and environmental wellbeing: the **Energy** that powers the built environment and transportation; the **Water** that supports life and all activity; and the **Ecosystems** that share our landscape and enhance our wellbeing. We need to utilize energy and water resources while protecting and enhancing ecosystems and public health; by doing so, we will secure our long-term welfare and economic prosperity, and preserve our cultural identity.

UCLA GRAND CHALLENGES: **NO GOAL IS TOO GRAND.**

"We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win..."

— John F. Kennedy (1962)

RISING TO THE CHALLENGE: THE UCLA SUSTAINABLE LA GRAND CHALLENGE

Just as Los Angeles turned one of its biggest problems of the 20th century, smog, into one of the world's greatest environmental success stories, Los Angeles must once again seize today's challenges as an opportunity to thrive. In charting a pathway to sustainability, Los Angeles can lead the way for other urban areas facing similar challenges.

Embracing this opportunity, UCLA launched its first Grand Challenge: **Sustainable LA** – *Thriving in a Hotter Los Angeles*, a novel and ambitious campus-wide research endeavor to tackle sustainability in Los Angeles County through innovations in science, technology, and policy. The **Sustainable LA Grand Challenge** ("**Sustainable LA GC**") aligns faculty, researchers, students, partner institutions, managers, policymakers, and community stakeholders around the objective of developing a research-based action plan to achieve three key goals in Los Angeles County by 2050:

1. **Power 100 percent of energy and transportation needs with renewable energy.**
2. **Obtain 100 percent of water supply from sources within Los Angeles County.**
3. **Enhance ecosystem health together with human health and wellbeing — specifically: increase native biodiversity; prevent extinction of native species; integrate development and nature to promote human health; and ensure every resident has access to a green space or natural area within ¼ mile.**

These **Sustainable LA GC** goals are ambitious, but achievable. With nearly 100 years of breakthroughs and innovations, UCLA is uniquely positioned to bring these big ideas to life. UCLA is one of the world's premier research universities, with state-of-the-art campus facilities, globally renowned faculty, and environmentally engaged student-scholars. UCLA researchers are already developing innovative energy management strategies, and deploying transformative new technologies on campus. Our faculty are also pioneers in water treatment, and developed the first reverse osmosis membrane technology that produces freshwater from seawater. In addition, UCLA has some of the world's leading regional climate modeling experts, terrestrial and marine scientists, ecologists, conservation genomicists, remote-sensing practitioners, architects, urban planners, and law and policy experts. Our public health researchers are leading efforts to investigate the relationship between human health and our urban environment, while our innovative environmental humanities research group explores cultural attitudes towards nature.

UCLA has a unique combination of multidisciplinary expertise with a deep knowledge and long history of engagement with energy, water, and ecosystem health issues and stakeholders in Los Angeles County. We are committed to working with partners from other academic institutions, businesses, government, civil society organizations, tribes, and the Los Angeles community to achieve the ambitious **Sustainable LA GC** goals.

A FOUNDATION FOR ACTION: THE FIVE-YEAR WORK PLAN

As outlined in the **Five-Year Work Plan ("Work Plan")**, over the next five years, UCLA faculty, researchers, students, and numerous partners will pursue more than 100 innovative research projects critical to charting a pathway for Los Angeles County to achieve the **Sustainable LA GC** goals by 2050. For organizational purposes, these foundational projects are grouped into three topic areas: Energy, Water, and Ecosystem Health.

Energy

Long-term sustainability for Los Angeles requires dramatically reducing emissions of traditional air pollutants and the greenhouse gases that contribute to global climate change—the majority of which are associated with generating electricity and powering transportation with carbon-based fuels. Powering 100 percent of local energy and transportation needs (including all cars, trucks, buses, rail, aircrafts, buildings, industry, and other sources that consume energy within County borders) with cleaner, renewable energy resources will accomplish these ends.

Over the next five years, UCLA and its partners will undertake critical research projects aimed at developing recommendations for a local renewable energy portfolio that balances cost, consumer requirements, and energy and fuel production, distribution, management, and storage needs, while considering public health, water, and ecosystem health impacts. Researchers across disciplines will work with stakeholders to develop key technologies, policies, and management strategies needed to expand renewable energy generation and fuel production in

ENERGY RESEARCH OBJECTIVES

Objective 1: Expand renewable energy generation

- Characterize an energy resources portfolio for the Los Angeles of 2050
- Identify policies, management strategies, and technologies to expand renewable energy generation and fuel production

Objective 2: Design an integrated system for distribution and storage of renewable energy

Objective 3: Improve management of energy consumption

- Reduce the energy intensity of local transportation
- Reduce building energy consumption and improve demand management

Objective 4: Ensure energy system sustainability

accordance with that vision. This work will include advancements that reduce the cost and increase the feasibility of offshore wind energy, groundbreaking technologies to integrate solar energy harvesting and storage into a wide variety of surfaces found in the built environment, and critical analyses of utility governance structures and the energy market. Researchers also will explore efficient, cost-effective energy infrastructure solutions that support centralized and distributed generation and storage. In tandem, researchers will design strategies to reduce transportation-related energy use while improving transportation reliability and equity, promote building energy efficiency and conservation, better manage electricity demand, and mitigate adverse environmental and public health impacts during Los Angeles' renewable energy transition.

Water

Securing a sustainable local water supply for Los Angeles is also critical. Los Angeles County imports most of its water from climate-vulnerable sources located hundreds of miles away. Instead, water right here in Los Angeles could be put to use to meet local needs and reduce long-term costs. By expanding conservation, eliminating wasteful uses and practices, and expanding green infrastructure, we can match our needs to fit these supplies, thereby avoiding energy-intensive imports and associated ecosystem impacts.

To help chart a path forward, UCLA scholars and partners will explore strategies to both expand local supplies and reduce demand. After calculating a local baseline water balance, researchers will develop innovative and culturally acceptable ways to expand use of traditionally underutilized resources such as groundwater, stormwater, seawater, greywater, and recycled water. New technologies and integrated water management policies will support the wastewater treatment plant of the future. Researchers will evaluate the implications of climate change and disasters to inform the development of a resiliency plan for the County's water supplies. Additionally, researchers will explore conservation and efficiency strategies, such as "smart" water meters that sense water needs, which will allow Los Angeles to thrive while reducing water consumption to 50 gallons per capita per day. Overall, technological and infrastructure improvements and innovations in law and policy will enable a sustainable water management system that provides for Los Angeles' future water needs.

WATER RESEARCH OBJECTIVES

Objective 1: Maximize Local Water Supplies

- Quantify and characterize existing water supplies
- Expand available water supplies
- Encourage adoption of local water sources
- Enhance water supply resilience and sustainability

Objective 2: Reduce Water Consumption

Objective 3: Improve Local Water Resource Management

- Improve water management infrastructure and technology
- Improve water governance and policy

Ecosystem Health

Los Angeles requires thoughtful strategies to ensure that our transition to clean energy and local water also enhances the rich natural environments that define the County as a biodiversity hotspot and contribute to the welfare of all residents. We must also mitigate the threats that climate change and population growth pose to the health of local species and habitats. Restoring, protecting, and enhancing the ecosystems that provide us with many important services, such as clean air, water filtration, flood control, and space for recreation, will result in significant public health and economic benefits, and improve our quality of life.

The first phase of UCLA's research will assess existing patterns of biodiversity, ecosystem health and services, and human attitudes and impacts in Los Angeles County. This data will form the basis for a comprehensive biodiversity atlas. Research will involve the development of new technologies and techniques in aerial and satellite sensing, GIS and geospatial modeling, and conservation genomics, as well as crowd-sourced "citizen science" to fill crucial data gaps and provide an essential foundation for subsequent collaborations. UCLA and its partners will engage in key projects to assess the vulnerability of our ecosystems to climate change, and develop strategies to protect, restore, and manage ecosystems in a way that is compatible with economic development. Other research will assess how to integrate ecosystem health and the built environment effectively through architectural design and landscaping. Additionally, we will study the potential impacts of ecosystem health on humans – both the benefits of exposure to healthy ecosystems, and potential threats such as disease transmission – and develop strategies to ensure that all communities have access to healthy and vibrant green spaces and natural areas. Together with partners and stakeholders, we will develop innovative laws, policies, strategies, and technologies to protect, restore, and revitalize local biodiversity.

ENGAGING THE PUBLIC, PARTNERS, AND STAKEHOLDERS

UCLA cannot tackle Los Angeles' sustainability challenges alone. In addition to interdisciplinary collaboration, the **Sustainable LA GC** serves as a nexus for partnerships between UCLA scholars and other academic institutions, government agencies, private-sector managers and innovators, tribal leaders, civil society organizations, and other entities that have the expertise, experience, and resources necessary to help accomplish the critical research projects outlined in the **Work Plan**. Throughout the research, UCLA will lead a concerted, sustained outreach effort to engage the public and key stakeholders in the **Sustainable LA**

ECOSYSTEM HEALTH RESEARCH OBJECTIVES

Objective 1: Assess Biodiversity and Ecosystem Health

- Establish baseline knowledge of the presence and distribution of ecosystems, habitats, and species in Los Angeles County
- Establish baseline knowledge of attitudes toward biodiversity and ecosystem health in Los Angeles County
- Establish baseline knowledge of ecosystem health and services in Los Angeles County
- Assess the impacts of human activities on ecosystem health in Los Angeles County

Objective 2: Enhance Ecosystem Health and Resiliency

- Evaluate and plan for the impacts of climate change on ecosystems
- Integrate biodiversity and ecosystem health into the built environment
- Restore local ecosystems

Objective 3: Integrate Ecosystem Health and Human Health and Wellbeing

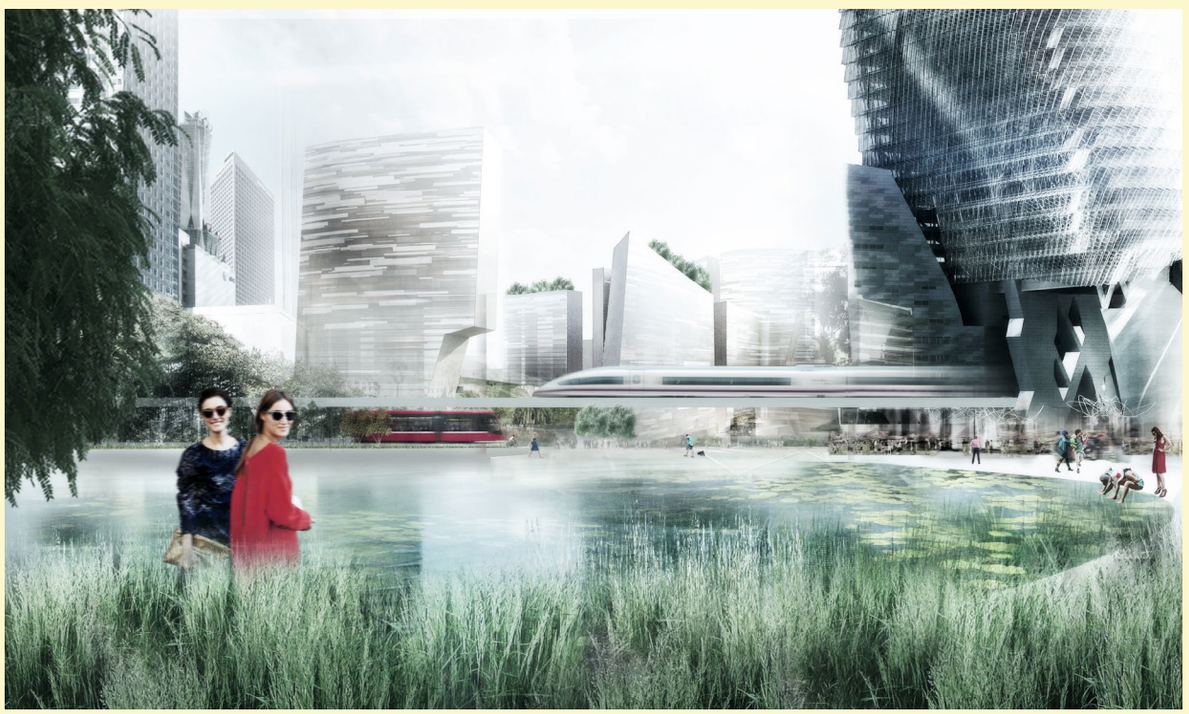
- Assess the relationship between ecosystem health and human health
- Ensure equal access to ecosystem health benefits

GC through workshops, events, speaking engagements, consultations, partnerships with entities sharing common goals, social media, community demonstration projects, interactive education tools, and the use of "citizen science" to gather data.

LEADING THE WAY: THE 2050 SUSTAINABLE LA GRAND CHALLENGE IMPLEMENTATION PLAN

Based on the results of the research outlined in the **Work Plan**, by 2020, UCLA will prepare a **2050 Sustainable LA GC Implementation Plan ("Implementation Plan")** that details transformative technologies, strategies, and policies that would put Los Angeles County on a pathway to achieve the **Sustainable LA GC** goals over the next three decades. The **Implementation Plan** will include key research findings, technology and program designs, and model policies, as well as resultant recommendations for improving critical sectors such as energy generation, transportation, urban planning, water harvesting, and natural resources management. The plan will sequence implementation measures to ensure a smooth transition, and incorporate a framework for monitoring progress and success, including measurable interim goals and a process for regular plan updates every five years.

Building on the engagement mechanisms developed during the **Work Plan** period, UCLA will continue to engage in robust consultation across the diverse communities of Los Angeles County. Stakeholders will actively participate in the development of the **Implementation Plan**, project implementation, and evaluating progress. Media and communication campaigns will ensure all Los Angeles residents and others around the world can follow Los Angeles' progress, learn from our experience, and emulate our successes.



A vision of Los Angeles in 2050. Image designed by Morphosis.

ENVISIONING THE SUSTAINABLE LOS ANGELES OF 2050

We believe the **Sustainable LA GC** will fundamentally transform Los Angeles County. Utilizing renewable energy resources for 100 percent of local energy and transportation needs will involve clean-technology breakthroughs and innovative governance strategies that create economic opportunities for LA residents, dramatically reduce air pollution, and increase quality of life. Advances in planning and engineering will allow Los Angeles to utilize a variety of surfaces in the urban landscape, such as awnings, window blinds, and even house paint, to generate electricity. By 2050, homes and buildings will intelligently regulate the electricity use of all devices, appliances, and electric vehicles. Redesigned transportation infrastructure will support a mass-transit system and shared, self-driving vehicles, helping to reduce stress-inducing traffic congestion, local air pollution, and climate impacts. Walkable, bikeable live-work neighborhoods will be more energy efficient, reduce car dependence, and make Los Angeles County a more pleasant place for all communities and populations.

Transitioning Los Angeles County to 100 percent local water will involve dramatic water use reductions, modernized infrastructure, innovative technologies, and improved management. Twentieth century infrastructure will be replaced with a more energy-efficient system that benefits local habitats at different scales, from household cisterns that capture rainwater, and neighborhood-level "bioswales" that use landscaping to infiltrate and partially treat polluted stormwater, to local water recycling plants and groundwater infiltration projects. Households and businesses will safely reuse greywater from bathroom sinks and washing machines for outdoor irrigation, and utilities will cost-effectively desalinate seawater without harming marine life. Meanwhile, "smart" water management systems that sense landscaping needs and detect leaks will decrease water waste while reducing costs and environmental impacts. Overall, more conscientious water use will encourage a stronger appreciation for water as a precious resource.

At the same time, we will enhance native biodiversity throughout the diverse landscape of Los Angeles County through restoration, preservation, and recovery. In 2050, we envision that Los Angeles County will be characterized by appealing, well-designed urban landscapes that integrate biodiversity for all communities. By planting drought-resistant plants and changing the prevailing cultural norms of green lawns, we can reimagine a landscape for Los Angeles that matches its natural Mediterranean climate and allows native species to flourish. All residents will enjoy access to enhanced green spaces and natural areas that will offer a place for recreation, sequester air pollution, and promote natural water filtration.

Our leadership in the transformation of Los Angeles County will not only facilitate similar transformations in urban areas across the globe but also create worldwide demand for local expertise and products. Through the **Sustainable LA GC**, UCLA and its partners will transform climate change and urban sustainability from a challenge into an opportunity, for Los Angeles and beyond.

Evacuated tube solar water heating installation at UCLA's residence halls.

THE CHALLENGE: THRIVING IN A HOTTER LOS ANGELES

Los Angeles is no stranger to seemingly impossible challenges. Many can recall the dangerous smog of mid-twentieth century Los Angeles that kept children indoors, withered orange groves, and filled emergency rooms. Even as smog alerts disrupted daily life and the local economy, commentators dismissed the problem as too big and too fundamental to solve. In the 1980s, it was the contaminated Santa Monica Bay that drew national attention, with raw sewage spills closing miles of beaches, and a dead zone in the middle of the Bay practically devoid of marine life. On the basis of these and other challenges, many decried Los Angeles as a hopeless example of the destructive environmental and public health consequences of uncontrolled urbanization.

History suggests, though, that critics should not write off Los Angeles so easily. Angelenos know that Los Angeles is a place of remarkable innovation, creative problem-solving, and cultural reinvention. It is the home of the space shuttle and the Mars rover, the internet, skateboarding, iconic art and architecture, and Hollywood dream-makers. The diverse, multicultural community that comprises Los Angeles County is united by pride in the natural resources that continually draw people here and provide essential support to a vibrant global metropolis—the Mediterranean climate, the Pacific Coast, sunshine, blue skies, valley winds, shady trees, glittering rivers, deserts, wetlands, and snow-capped peaks.

That is why, when faced with the great environmental challenges of the past century, Los Angeles applied its characteristic ingenuity and passion to the changes essential to its long-term prosperity: developing the first air quality management district before there was a federal Clean Air Act, pioneering revolutionary air and water quality controls, and pulling together as a community to battle for a safe and healthy environment. Los Angeles constructed the country's biggest transit system, made unprecedented investments in pollution-control infrastructure, installed more solar energy generating capacity than any other region, and protected world-famous beaches and urban wilderness. The biggest problem, smog, ultimately generated one of history's greatest environmental success stories. Although there is still more work to be done, Los Angeles has made massive strides in improving local air quality. Governments around the world now look to Los Angeles for guidance on how to address their own pollution problems.

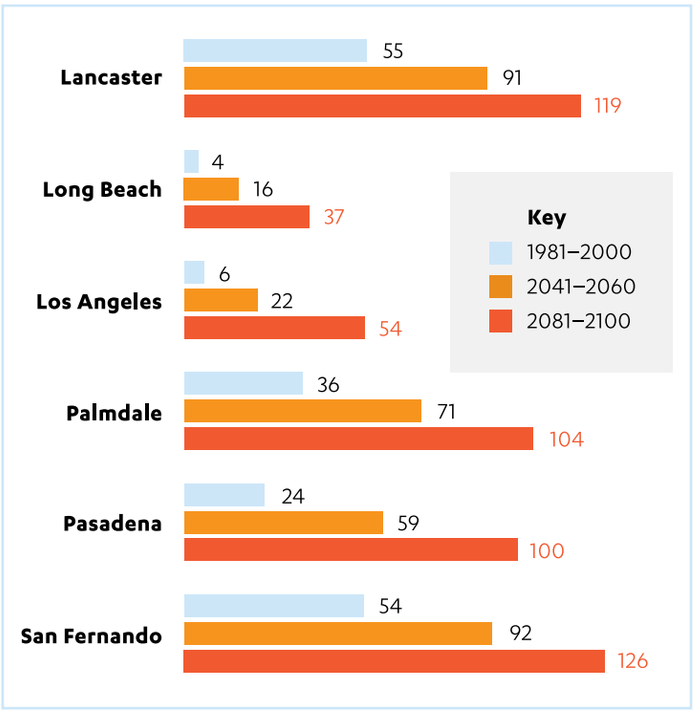
The challenges that Los Angeles County faces today require the same commitment and vision that the region demonstrated while facing the challenges of the last century.

WHAT ARE UCLA GRAND CHALLENGES?

The dreamers and doers, joined together to pursue common goals.

UCLA Grand Challenges are ambitious research endeavors that connect hundreds of faculty, students, community members and leading experts across every field to solve some of societys toughest problems. By setting the sights of many on a common goal, we will have more impact than we ever have had before. The two UCLA Grand Challenges are the biggest, most collaborative, and potentially most transformative efforts UCLA has undertaken to date. The discoveries and scholarship produced are expected to deliver real benefit to California, the nation, and the world.

For more, see **www.grandchallenges.ucla.edu.**

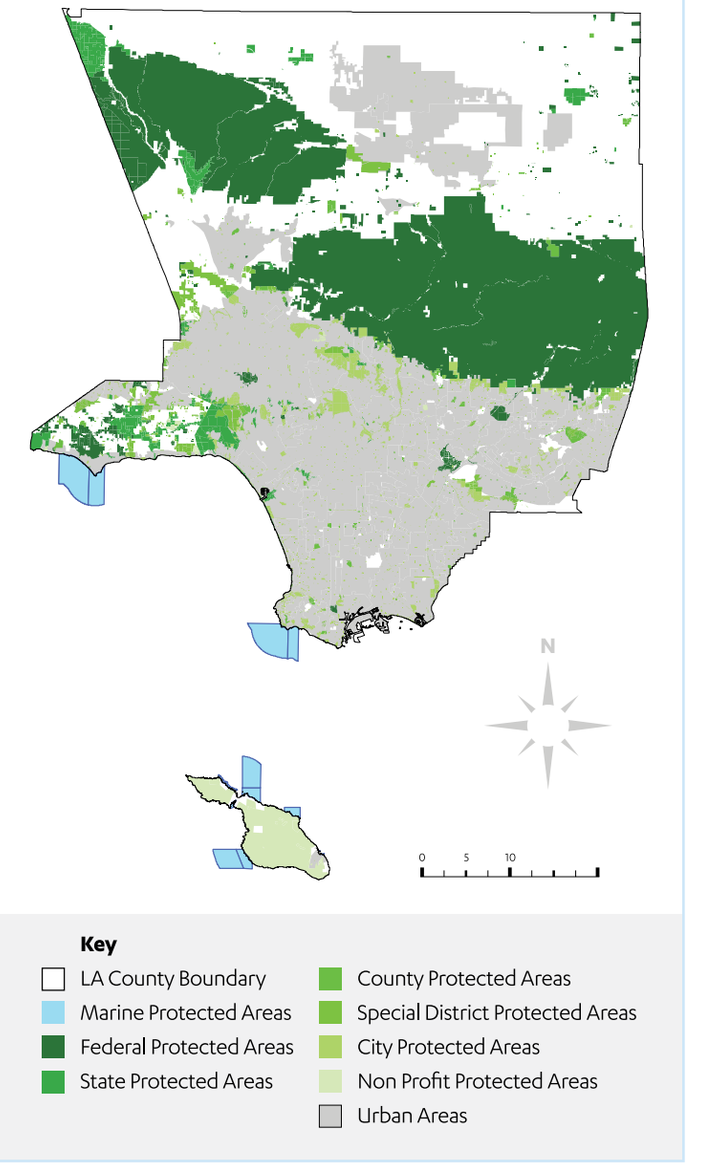


Historical and projected annual average number of extreme heat days in locations across Los Angeles County. Future projections represent a "business as usual" scenario of greenhouse gas emissions. Data from Professor Alex Hall's Climate Change in the Los Angeles Region project.

Due to climate change, the Los Angeles of the future will be hotter, with more frequent and dangerous heat waves, increased wildfire risk, and less snowpack to feed municipal water supplies and riverine habitats. The latest UCLA research predicts that by 2050, average annual temperatures will rise 4-5°F in the Los Angeles region, and many neighborhoods will experience a doubling or tripling of "extreme heat days" (when temperatures exceed 95°F) (Sun, Walton, & Hall, 2012) (see above graph). Meanwhile, snowfall in the region's mountains may reduce by a third or more, and rising temperatures will accelerate snowmelt (Sun et al., 2015). California's recent historic drought, exacerbated by rising temperatures, is a mark of this new environmental reality.

Los Angeles also will be more populous, with an estimated 11.5 million people living, working, and recreating in Los Angeles County by 2050 (DOF, 2014) – people who will need to plug in their refrigerators, air conditioners, vehicles, and personal electronics, and who will need clean water for drinking, cooking, and washing. A hotter and more populous Los Angeles will put increased pressure on our energy, transportation, and water infrastructure, and exacerbate existing air quality and public health problems. It also will stress local wildlife and the natural habitats that provide important services like clean water, clean air, and space for recreation.

If Los Angeles fails to act, the coming changes have the potential to significantly disrupt our economy and quality of life. The pathway forward is uncharted, but it is clear that business as usual is not sustainable. Los Angeles County needs innovative technologies, policies, and strategies to meet increased energy and



The Sustainable LA Grand Challenge boundaries include Los Angeles County and its urban and protected areas.

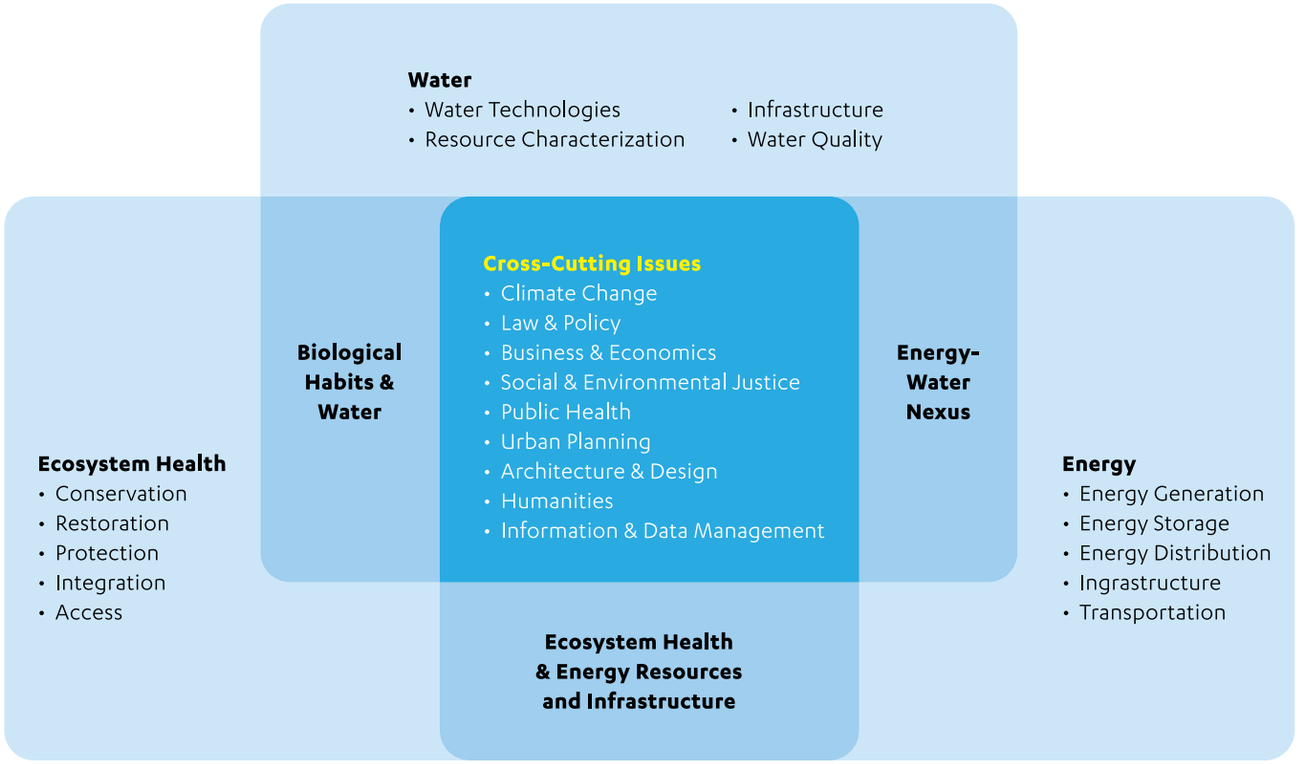
water demand in the context of unprecedented environmental change while protecting human health, preserving natural habitats, ensuring a reliable flow of electricity and clean water, promoting social justice, and mitigating Los Angeles' contribution to climate change – no small task. Revolutionary changes are required, from personal habits, to our homes, streets, office buildings, infrastructure, and regulatory regimes. Los Angeles must once again seize urban challenges as an opportunity to thrive, and lead the way for other metropolitan areas facing similar challenges across the globe.

RISING TO THE CHALLENGE: THE UCLA SUSTAINABLE LA GRAND CHALLENGE

In 2013, embracing the challenges and opportunities facing Los Angeles, UCLA Chancellor Gene Block publicly announced UCLA's premier Grand Challenge: **Sustainable LA** – ***Thriving in a Hotter Los Angeles***

ILLUSTRATING THE ENERGY-WATER-ECOSYSTEM CONNECTION

Energy, water, and ecosystems are connected to each other and to Los Angeles' long-term prosperity. For instance, because Los Angeles lacks the infrastructure to take full advantage of local water supplies, it imports water from distant regions; these imports require enormous amounts of energy, the generation of which releases air pollutants that harm human and ecosystem health, and contribute to global climate change; climate change, in turn, is dramatically harming local water availability and imperiling native species.



(UCLA Grand Challenges, 2013). The **Sustainable LA Grand Challenge** ("**Sustainable LA GC**") is a novel and ambitious campus-wide research endeavor to tackle sustainability in Los Angeles County through innovations in science, technology, policy, and implementation strategies.

The **Sustainable LA GC** team recognizes that Los Angeles' response to the challenges ahead must be *sustainable*. Achieving sustainability in a *hotter and more populous Los Angeles* will require an understanding of the interdependencies between three key resources that underpin our economic, social, and environmental wellbeing: The **Energy** that powers the built environment and transportation; the **Water** that supports life and all activity; and the **Ecosystems** that share our landscape, help shape our culture, and enhance our wellbeing. All three resources are essential to the long-term prosperity of Los Angeles, and all three are deeply intertwined.

To ensure Los Angeles thrives through 2050 and beyond, it is essential that we utilize energy and water resources without harming our regional ecosystems. We must consider climate change and our growing population, while furthering our long-term social welfare, cultural identity, and economic prosperity. To this end, the **Sustainable LA GC** aligns interdisciplinary groups of scholars, partner institutions, and community stakeholders around the objective of developing a research-based plan to create the world's first sustainable megacity. More than 150 UCLA faculty and scholars from across disciplines have committed to working together to develop energy, water, and ecosystem health solutions for Los Angeles.

SUSTAINABILITY DEFINED

The concept of sustainability is rooted in the understanding that human and natural environments are part of a complex, interdependent system. Our sustainable approach to future decision-making and development in Los Angeles County seeks to optimize economic, social, and environmental wellbeing for both present and future generations.

SUSTAINABLE LA GRAND CHALLENGE GOALS

By 2050, Los Angeles County will:

1. **Power 100 percent of energy and transportation needs with renewable energy resources.**[1]
2. **Obtain 100 percent of its water supply from sources located within Los Angeles County.**
3. **Enhance ecosystem health**[2] **together with human health and wellbeing—specifically:**
   - **Increase native biodiversity**[3] **through restoration, preservation, and recovery.**
   - **Prevent extinction of native species.**
   - **Plan and design built environments that integrate nature and promote human health.**
   - **Ensure every resident has access to a green space**[4] **or natural area**[5] **within one-quarter mile.**

WHY THESE GOALS?

The three **Sustainable LA GC** goals are ambitious, but attainable. They are also essential in the face of climate and population changes. Long-term sustainability for Los Angeles requires dramatically reducing our emissions of the greenhouse gases that contribute to global climate change, the majority of which are associated with the carbon-based energy sources used to generate energy and power transportation. At the same time, we must ensure that all communities across the Los Angeles Basin breathe healthy air, while equitably improving the resilience of our energy system in the face of future change and potential disaster, and protecting our regional economy and environment. A sustainable approach to powering 100 percent of local energy and transportation needs (including all cars, buses, trucks, rail, aircrafts, buildings, industry, and other sources that consume energy within the borders of Los Angeles County) with cleaner renewable energy resources will accomplish these ends. While all the renewable energy that serves local consumers need not be generated from resources located within Los Angeles County, Los Angeles should capitalize on its abundant local solar and wind resources as a first priority where it can do so sustainably.

Securing a sustainable water supply for Los Angeles County is also critical. Los Angeles County imports most of its water from sources located hundreds of miles away, which requires enormous amounts of energy and harms aquatic ecosystems in other regions. As evidenced by the epic drought the Western United States is currently experiencing, an import-dependent water supply is not a reliable solution to meet Los Angeles' growing water needs in the hotter decades to come; climate change will increasingly strain the Sierra Nevada Mountains and other import sources. Water lost as stormwater runoff, unused greywater, highly treated wastewater, and groundwater supplies represent curable inefficiencies in Los Angeles' current water supply system that can be put to use to meet growing needs and reduce long-term costs. By expanding conservation and eliminating wasteful uses and practices, we can match our needs to fit these supplies, thereby avoiding the energy-intensive water imports and associated ecosystem impacts that characterize Los Angeles' current water system. Furthermore, projects to restore local water sources and increase the capture and treatment of stormwater and wastewater offer local ecosystem and human health benefits.

As a global diversity hotspot, Los Angeles requires thoughtful strategies to ensure that utilizing clean energy and local water resources does not come at the expense of the rich biodiversity and natural environments that define Los Angeles County and contribute to the welfare of all residents. Additionally, we must prepare for the many ways in which climate change and population growth directly threaten the health of Los Angeles' species, habitats, and human residents. In the face of these changes, we must prevent continued species and habitat losses, and recognize interactions between ecosystem health and human health. Historically, ecosystem health has taken a back seat to development throughout much of Los Angeles. Restoring, protecting, and enhancing the quality of the ecosystems that provide us with many important services, such as clean air, water filtration, flood control, and space for recreation, will result in significant public health and economic benefits, and improve our quality of life. As a co-benefit, achieving the **Sustainable LA GC** goals may help reduce Los Angeles' vulnerability to climate change and disaster by lessening our dependence on centralized energy and water infrastructure, and enhancing the resiliency of local ecosystems to environmental stressors.

[1] *According to the State of California, "renewable energy resources" include the following, subject to certain state regulatory requirements and conditions: biodiesel, biogas, biomass, conduit hydroelectric, digester gas, fuel cells using renewable fuels, geothermal, hydroelectric incremental generation through efficiency improvements, landfill gas, municipal solid waste, ocean wave, ocean thermal, tidal current, photovoltaic, small hydroelectric, solar thermal, and wind (CEC, 2012).*

[2] *Although the term "ecosystem health" is loosely defined, in general, a healthy ecosystem has three attributes: 1) productivity, in terms of the growth and reproduction of biological resources; 2) resilience to disturbances, including climate change; and 3) the ability to function with little or no human involvement.*

[3] *"Biodiversity" describes the variety of all life on earth, including plants, animals, and microorganisms. There is biodiversity within species and populations, as well as across ecosystems. Although biodiversity benefits human health, our economy, and our quality of life, human actions such as developing natural areas and diverting water from rivers have dramatically affected biodiversity and the function of ecosystems. Over the past 50 years, biodiversity loss has been more rapid than at any other time in human history (Millennium Ecosystem Assessment, 2005). Many species are currently in danger of extinction, including some "native" plants and animals that originated in Los Angeles County and are specially adapted to living in this unique environment.*

[4] *"Green space" is land devoid of buildings or other development that is: 1) open to the public, and 2) partly or completely covered with vegetation such as grass, trees, or plants (e.g., parks and community gardens) (EPA, 2014).*

[5] *"Natural area" describes any land or water area — whether publicly or privately owned — that is relatively undisturbed by humans, thus retaining its natural character and capacity to serve as habitat for wildlife (e.g., scenic seashores, old-growth forests, wilderness reserves, and wild rivers) (Harker & Natter, 1995).*

By demonstrating a sustainable path forward for Los Angeles County to thrive for decades to come, we can set a powerful example for other megacities around the world: if Los Angeles – the land of smog, sprawl, freeways, and drought – can do it, any urban area can. The **Sustainable LA GC** goals represent the first steps to transition Los Angeles to sustainability in the face of two critical challenges: climate change and population growth. Nonetheless, even if Los Angeles were to achieve the **Sustainable LA GC** goals, other environmental, social, and economic challenges would remain – for instance, managing trash and other consumer waste, controlling toxic chemicals that threaten human and environmental health, ensuring access to healthy and sustainably grown food, universalizing access to affordable housing, and reducing poverty. While the **Sustainable LA GC** goals touch upon these and other issues, they are not our present focus. For this targeted initiative, we have strategically chosen the three critical resources of energy, water, and ecosystem health. These resources are integrally related to the challenges posed by climate change and an increasing population, and to one another.

THE RESEARCH & RECOMMENDATIONS

UCLA faculty and scholars from a breadth of disciplines collaborated through four interdisciplinary research committees for nearly a year to identify multidisciplinary research questions critical to charting a pathway for Los Angeles County to achieve **100-percent renewable energy, 100-percent locally sourced water, and enhanced ecosystem health by 2050**. The process was overseen by a Steering Committee, with substantive input from an external Scholarly and Technical Advisory Committee composed of a dozen of the nation's leading sustainability scholars and professionals (*see Appendix for committee rosters*). The result of their efforts is this document, the **Five-Year Work Plan** ("**Work Plan**").

As outlined in this **Work Plan**, over the next five years, UCLA and its partners will tackle technological, built-environment, scientific, health, policy, and social challenges in three key research areas: **Energy, Water, and Ecosystem Health**.

Among other objectives, UCLA scholars will endeavor throughout this research to:

- Develop and demonstrate breakthrough technologies in energy generation, transmission, management, and storage, as well as water harvesting, conservation, efficiency, and recycling.
- Modernize the collection and analysis of real-time data on energy and water usage.
- Fill critical data gaps in our understanding of how Los Angeles' energy system, water system, and ecosystems function.
- Conceptualize effective, equity-promoting, and economically stimulating policies to transform energy and water management, infrastructure, socio-cultural norms, and consumer behavior.
- Identify innovative strategies to improve human health and wellbeing within buildings and neighborhoods while expanding renewable energy generation and local water use.
- Develop urban-planning and transportation policies that would substantially reduce greenhouse gas emissions, pollution, and adverse human health impacts.
- Characterize the impacts of climate change and their relationship to achieving the **Sustainable LA GC** goals.
- Devise effective protection and restoration recommendations for local habitats, species, and ecosystem services most susceptible to disruption by climate change impacts, energy and water harvesting, and urban development.
- Formulate model laws, policies, and programs to ensure that all communities and populations benefit from healthy ecosystems.
- Explore potential solutions at all scales, and evaluate the inherent technical and policy choices motivating distributed and centralized approaches.

Training Tomorrow's Leaders

Working side-by-side with faculty on cross-cutting research projects will provide a unique learning opportunity for UCLA's students and researchers. Students will gain the real-world, interdisciplinary experience necessary to thrive in an increasingly environmentally stressed economy, as well as confidence that they can use their training to contribute to building a better world. The **Sustainable LA GC** will train the leaders of tomorrow, who will take these skills with them wherever they go, multiplying Los Angeles' successes across the globe.

Nexus for Partnerships

UCLA cannot take on this challenge without partnering across sectors, facilitating collaboration, soliciting new perspectives, and producing solutions that work for business, government, and communities locally and beyond. In addition to cross-campus and student-researcher collaborations, the **Sustainable LA GC** will be a nexus for partnerships between UCLA scholars and other academic institutions, government agencies, private-sector managers and innovators, tribal leaders, and community organizations that have the expertise, experience, and resources necessary to help accomplish the critical research objectives outlined in this **Work Plan**. Throughout the research, UCLA will engage in a concerted, sustained communication and outreach effort to incorporate the public and key stakeholders through workshops, events, speaking engagements, consultations, partnerships with entities sharing common goals, social media, community demonstration projects, and the use of "citizen science" to gather data. UCLA will create networks of discussion and consultation across Los Angeles County's diverse communities to inform our work, solicit input, and ensure that all communities and populations benefit from and contribute to a closing of the environmental health gap. Looking ahead, the partnerships and commitments UCLA develops over the next five years will help to further future implementation of measures to achieve the **Sustainable LA GC** goals.

2050 Sustainable LA GC Implementation Plan

The fruits of our research will guide our development, together with our research partners and key stakeholders, of the *2050* **Sustainable LA GC Implementation Plan ("Implementation Plan")**, a comprehensive research-based action plan that will guide Los Angeles managers and policymakers along a 30-year pathway to achievement of the **Sustainable LA GC** goals. Recommended actions will build on our research findings, and input from key stakeholders will be incorporated in all aspects of plan development and design to ensure feasibility and widespread support. As discussed more below in *Next Steps*, the **Implementation Plan** will include key research findings, discussion of transition management, an engagement plan, an evaluation framework, and a process for regular plan updates every five years.

ENVISIONING THE SUSTAINABLE LOS ANGELES OF 2050

We envision that execution of the ***Work Plan*** and subsequent ***Implementation Plan*** will fundamentally transform Los Angeles. Sustainably utilizing renewable energy resources for 100 percent of local energy and transportation needs will involve game-changing technologies, innovative policies, and new ways of mobility and conducting daily life – all of which will transform our urban fabric. Advances in planning and engineering will allow Los Angeles to utilize a variety of surfaces in the urban landscape, such as awnings, window blinds, and even house paint, to generate electricity. More affordable homes and buildings will intelligently regulate the electricity use of all devices, appliances, and electric vehicles. Redesigned transportation infrastructure will support a mass-transit system and shared, self-driving vehicles, helping to reduce local air pollution and climate impacts. Walkable, bikeable live-work neighborhoods will be better suited to multi-species habitation, increased energy efficiency, reduced car dependence, and make Los Angeles County a more pleasant place for all communities and populations.

Transforming Los Angeles County into a major urban area that meets 100 percent of its water use needs locally will involve dramatic water use reductions, modernized water delivery infrastructure, water recycling, and improved water management. Twentieth century infrastructure will be replaced with a more energy-efficient system that benefits local habitats at different scales, from household cisterns that capture rainwater, and neighborhood-level "bioswales" that use landscaping to infiltrate and partially treat polluted stormwater, to local water recycling plants and groundwater infiltration projects. Households and businesses will safely reuse greywater from bathroom sinks, showers, and washing machines for outdoor irrigation and toilet flushing, and utilities will cost-effectively desalinate seawater without harming marine life. Buildings and open spaces will be designed to capture and re-infiltrate water, and roads, rivers, and flood prevention systems will be redesigned to maximize groundwater connections and opportunities for reuse, relinking natural hydrological connections separated by urban conventions. Meanwhile, "smart" water management systems that sense landscaping water needs, provide real time water use information, and detect leaks will decrease water waste, reduce costs, and lessen environmental impacts. More intentional and conscientious use of water will encourage a stronger cultural appreciation for water as a resource to be valued and protected because every drop matters.

At the same time, we will enhance native biodiversity throughout the diverse landscape of Los Angeles County through restoration,

The Los Angeles River is now the subject of a $1.2 billion revitalization campaign that is expected to improve its ecological, cultural, and economic value.

HIGHLIGHTS OF UCLA'S EXCELLENCE IN SUSTAINABILITY RESEARCH

- Pioneering advances in reverse osmosis technologies for water desalination and water purification
- Leading conservation genomics research group
- Contributing authors to the Intergovernmental Panel on Climate Change reports
- Record-breaking solar cell efficiency and reliability research
- Catalyzing contributors to the city of Los Angeles' first Sustainable City pLAn
- Prominent climate change and environmental law and policy programs
- Progressive architecture and urban design program
- Cutting-edge energy storage and hybrid supercapacitor innovations
- Integrative cross-disciplinary water resources group
- Leading voices on health effects of pollution and climate change in urban spaces
- Advanced development of alternative fuels to power electricity and transportation
- Pioneering environmental humanities core group
- Top transportation policy and planning program contributing regularly to regional practices
- Prominent designers of decision support tools for policymakers and civic leaders in the area of environmental sustainability
- Leading climate scientists assessing impacts of glacial melt, surface water hydrology, and ecosystem health

preservation, and recovery, and foster those non-native, non-invasive species that have become an integral part of our regional ecosystems. We will prevent extinction and decline of native species, while expanding benefits for human health and wellbeing and creating appealing, well-designed urban landscapes that integrate biodiversity for all communities. By planting drought-resistant trees and plants and changing the prevailing cultural norms of green lawns and open spaces, we can reimagine a landscape for Los Angeles that matches its natural Mediterranean climate. Residents will reap the health benefits and recreational opportunities associated with improved access to healthy urban ecosystems and natural environments.

Overall, the **Sustainable LA GC** will outline a pathway to promote human health and welfare, incorporate cultural values across diverse communities, and benefit a vibrant local economy rich with opportunities for all Angelenos. Our leadership will not only facilitate similar transformations in urban areas across the globe, but also create worldwide demand for local expertise and products. We will transform climate change and urban sustainability from a challenge into an opportunity, for Los Angeles and beyond.

WE CAN DO THIS, HERE, NOW

The challenges posed by a hotter Los Angeles are monumental and daunting, but, like the environmental challenges of Los Angeles' past, possible to solve. Indeed, Los Angeles is an ideal candidate to serve as a model for the city of the future. With around 10 million residents and 88 individual cities, Los Angeles County is the country's most populous county and its second densest metropolitan region. Density without a single dominant urban core presents unique opportunities for sustainable planning and development. Los Angeles is also a unique microcosm in

UCLA cityLAB's Backyard BI(h)OME.

that the region stretches along a gradient from urbanity to wilderness. For these reasons, solutions implemented here are eminently exportable.

Other cities facing similar challenges are making ambitious investments in sustainability, too. For example, cities within the C40 Cities Climate Leadership Group – including Los Angeles – are now working to address climate and sustainability issues; however, no city has yet taken on the large-scale, coordinated efforts that will result from the **Sustainable LA GC**. By assessing the capabilities of currently available technologies and strategies, and targeting areas where new research is needed, UCLA and its partners can help Los Angeles become the first major urban metropolis to achieve the ambitious targets proposed by the **Sustainable LA GC**.

The political and economic climate is ripe for grand action. The state's historic drought is highlighting the need for local water purveyors to change their assumptions about water availability and management going forward. At the municipal level, the City of Los Angeles has released its first *Sustainable City pLAn*, committing the city to enhance local water supply, increase renewable-energy generation, and reduce air emissions to historic lows. Los Angeles and other cities have set ambitious targets for water use, including the City of Santa Monica's goal for a 100-percent sustainable and renewable water supply by 2020. Notably, the Los Angeles River is now the subject of a $1.2 billion revitalization campaign that is expected to improve its ecological, cultural, and economic value.

At the state level, California has some of the most ambitious climate and energy policies in the world, and a commitment to renewing infrastructure. California's groundbreaking Global Warming Solutions Act of 2006 requires the state to reduce its climate emissions to 1990 levels by 2020. Executive orders extend this emission-reduction goal to 40 percent below 1990 levels by 2030 and 80 percent below 1990 levels by 2050. Furthermore, Governor Brown recently committed California to generate half of its electricity from renewable resources, double energy efficiency savings, and cut vehicle petroleum use in half by 2030. These policies and associated implementation strategies will push Los Angeles to make significant investments in renewable energy and decarbonization.

California is making significant investments in water, as well. In early 2014, the governor declared a state of emergency as a result of ongoing drought, and released the California Water Action Plan to serve as roadmap for efficient water management in the state. In September 2014, the legislature passed a package of bills to regulate groundwater resources for the first time in the state's history. The following month, voters approved Proposition 1, allocating $7.5 billion for water supply infrastructure, including recycling and pollution-control projects expected to benefit Los Angeles substantially. In April 2015, the governor mandated a 25-percent reduction in potable urban water uses, effective through February of 2016.

The federal government is also working to increase climate resilience and control energy-sector pollution, and recently took steps to stabilize the health of public lands in our region. In 2014, President Obama designated 350,000 acres of the Angeles and San Bernardino National Forests as a national monument. Additionally, the federal government is considering redesignating mountainous areas surrounding the San Fernando Valley as a new National Recreation Area, which would involve

study and classification of ecosystem health. Recent momentum in urban conservation presents a valuable opportunity to integrate ecosystem health goals into Los Angeles' future planning efforts.

WHY UCLA?

UCLA, one of the world's premier research universities, is in a unique position to facilitate Los Angeles' transformation. With strong capabilities in the areas of climate change mitigation and adaptation, renewable energy, energy efficiency, water quality and supply, transportation, urban planning, architecture, urban design, environmental health and conservation, law and policy, and social and ecosystem sciences, our faculty are exceptionally qualified to deliver the technology breakthroughs, policy innovations, and comprehensive strategies needed to help Los Angeles proactively and sustainably meet its challenges. Our diverse and talented students – undergraduate, graduate, and postdoctoral scholars – are among the world's brightest and most engaged, and our world-class campus facilities will serve as a test bed to demonstrate many of the new technologies, policies, and implementation strategies we will develop.

UCLA experts are regularly engaged with government, tribal, non-profit, business, and community entities across Los Angeles County and have demonstrated commitment to guiding Los Angeles on a path to future sustainability. In 2012, UCLA developed *Vision 2021* LA, a model sustainability plan to provoke conversation among mayoral and city council candidates about the future of the City of Los Angeles, and drive the development of a sustainable city plan (Gold et al., 2012). Climate change models from UCLA have shaped strategies for resiliency and water management in the city and informed the state's climate strategy (City of Los Angeles, 2015; CNRA, 2014). Our faculty created a resiliency series for Los Angeles County Department of Public Health professionals to aid them in effectively responding to climate-specific issues in their neighborhoods. Recently, researchers have developed policies and recommendations for sea-level rise adaptation, groundwater management, greenhouse gas reduction, and electric vehicle promotion. This year, UCLA's Institute of the Environment and Sustainability released an Environmental Report Card for Los Angeles County – the first of its kind for a U.S. metropolitan area – detailing historic and recent environmental achievements and outlining the many areas where further improvements are required (IoES, 2015).

The challenges ahead will require everyone in our community to invest their talents, knowledge, passion, and resources into building the sustainable Los Angeles of the future. UCLA is committed to investing in its remarkable home and helping Los Angeles realize a better future. We invite the people of Los Angeles and supporters from around the world to join us in contributing to the achievement of the **Sustainable LA GC** goals.

NAVIGATING THIS DOCUMENT

The following three sections describe more than 100 critical research projects we aim to address, along with our partners, over the next five years in the areas of **Energy, Water,** and **Ecosystem Health**, with the end goal of developing a feasible **Implementation Plan** that will allow Los Angeles to thrive in 2050 and beyond. Each section begins with a narrative description of the "Challenge" Los Angeles faces in terms of energy, water, or ecosystem health, followed by potential "Solutions" that will help realize the sustainability goal, and an overview of how research proposed in the **Work Plan** would help to achieve those solutions.

Individual **research projects** are briefly described in bullet-point form. Some of the projects listed are quite complex, and will involve multiple phases or sub-projects. Many require interdisciplinary research teams and/or partnerships with outside entities. Projects are organized into broad **Objectives** and **Sub-objectives** to illustrate how projects relate and build upon one another. In addition, several **Research Highlights** within each section provide details about the methods, goals, deliverables, and cost of selected projects or combined efforts. These research highlights serve as illustrative examples, and do not signify prioritization.

*To learn more about the **Sustainable LA GC**, specific research projects, or partnering opportunities please email* **SustainableLA@ucla.edu**. *For giving opportunities, please contact Todd Thaxton at* **tthaxton@support.ucla.edu**.


AHEAD

ENERGY

THE ENERGY CHALLENGE

With abundant sunlight and wind resources, and a mild climate year-round, Los Angeles is better positioned for renewable energy than many other major metropolises in the world. Yet renewable energy resources such as wind and solar currently provide only around 22 percent of Los Angeles County's electricity (IoES, 2015). Los Angeles has long relied on carbon-based energy sources – coal, petroleum, and natural gas – to power much of its transportation and to supply energy to its homes and businesses. Transportation and electricity generation are the key drivers of Los Angeles' climate emissions, and the biggest hurdles to meeting ambitious long-term state and local climate goals (IoES, 2015). Burning carbon-based energy sources in vehicles, buildings, and power plants also releases dangerous air pollutants that contribute to asthma, cancer, heart disease, adverse birth outcomes, and premature death, and disproportionately burden nearby communities and ecosystems (Lim et al., 2012; Pope & Dockery, 2006; Ramanathan et al., 2001). Despite great historical improvements in air quality, Los Angeles still has some of the worst ozone smog and particulate pollution in the country (IoES, 2015) (see table to the left).

Sector	Emissions (MT CO2e)	Percent of Inventory
Building Energy	38,900,762	39.2%
On-Road Transportation	33,226,317	33.5%
Stationary Sources	19,516,169	19.7%
Solid Waste	4,327,123	4.4%
Water Conveyance	1,117,283	1.1%
Ports	1,059,131	1.1%
Off-Road Transporation	515,044	0.5%
Wastewater Treatment	443,832	0.4%
Agriculture	26,105	0.03%
Los Angeles World Airport	2,760	0.0%
Total	**99,134,526**	

Greenhouse gas emissions (CO_2) by sector in LA County in 2010. Source: Table adapted from 2015 Environmental Report Card for Los Angeles County (IoES, 2015).

Vehicles are responsible for the vast majority of Los Angeles' notorious air quality problems and, as Los Angeles greens its electricity supply, a growing portion of local climate emissions (IoES, 2015). Most Angelenos travel via petroleum-fueled personal automobiles (City of Los Angeles, 2015), and many local bus fleets are fueled by natural gas, which, although cleaner than gasoline or diesel, still contributes to pollution. Transportation choices are greatly influenced by the county's built environment. As the poster-child of sprawl, Los Angeles hosts more "extreme commuters" than other urban areas; and without a strong downtown core, transit patterns are decentralized (Cuff, 2011). A preponderance of low-rise residential and commercial structures increases overall energy consumption (see table below).

Over the coming decades, population growth, rising temperatures, electrified transportation, and water needs will put increased pressure

		Total	Drove Alone Car, Truck, or Van	Carpooled Car, Truck, or Van	Public Transportation Excl. Taxicab
		Estimate	*Estimate*	*Estimate*	*Estimate*
	Workers +16 Years Old	**4,492,244**	**3,264,307**	**449,897**	**311,794**
Time to Travel to Work	Less than 10 minutes	7.5%	7.0%	6.4%	0.7%
	10 to 14 minutes	11.2%	11.6%	10.9%	2.9%
	15 to 19 minutes	13.8%	14.7%	13.4%	4.2%
	20 to 24 minutes	14.4%	15.2%	14.7%	6.7%
	25 to 29 minutes	5.5%	6.0%	4.5%	2.2%
	30 to 34 minutes	17.3%	17.5%	17.8%	20.1%
	35 to 44 minutes	7.7%	7.9%	7.8%	8.6%
	45 to 59 minutes	10.0%	9.8%	10.8%	15.2%
	60 or more minutes	12.6%	10.3%	13.7%	39.5%
	Mean travel time to work (min)	30.0	28.5	30.9	50.0

Los Angeles County travel times and modes of transportation to work in 2013. Source: Table adapted from 2015 Environmental Report Card for Los Angeles County (IoES, 2015).

UCLA's Smart Grid Energy Research Center Professor Rajit Gadh.

on Los Angeles' energy system. Los Angeles County must accommodate an estimated 1.5 million additional people, as well as the added cooling needs associated with a projected 4-5°F increase in local average annual temperature (DOF, 2014; Sun, Walton, & Hall, 2015). Our existing electricity infrastructure is designed to compensate for increased demand by adding more energy from carbon-based-fuel-fired power plants. This system is already economically and environmentally costly, and costs will only increase. Reducing energy consumption through traditional mechanisms will not be enough to prevent future power outages and unmet energy demand, nor will it adequately mitigate the harmful air pollutants and climate emissions wreaking havoc on our health and environment.

For these reasons, the **Sustainable LA GC** commits to the goal of transitioning Los Angeles to **100-percent renewable energy sources by 2050** in a way that thoughtfully considers interactions among energy and water supply systems, ecosystems, human health, and the local economy. The challenge of powering Los Angeles County with renewable energy resources is monumental. In addition to Los Angeles' large stock of existing buildings and industrial sources, ships, planes, trucks, and other vehicles travel into and out of Los Angeles County every day. Large-scale transformations of the local built environment and transportation infrastructure are required, together with small-scale residential architecture innovations and neighborhood conservation efforts. We must devise innovative ways to use integrated land-use planning to reduce the energy intensity of transportation, and encourage walking, biking, and the use of public transit and shared transportation networks, while using the existing transportation system more efficiently. Innovation in energy generation, fuel production, transmission, large- and small-scale storage, distribution, system management, conservation, and efficiency are also vital. To accommodate a fully renewable energy system, Los Angeles will need a smarter, more flexible, and more resilient electricity grid that can facilitate new peaks, new types of energy storage, and energy from solar, wind, tidal, wave, ocean thermal, and geothermal energy sources, as well as biogas and renewable fuels. Los Angeles should also evaluate the role that non-renewable energy sources such as nuclear power and natural gas may play in its clean-energy transition.

In tandem with new technologies and a re-imagination of urban infrastructure, sophisticated new policy, behavior, and management tools must be developed. We need more effective policies and strategies to manage and reduce local energy consumption. Additionally, and perhaps most critically, we need to identify policies and market mechanisms that will facilitate the transition to renewable energy resources and fuels despite substantial investments in Los Angeles' existing energy system. Implementing technological and policy innovations will require a reshaping of Los Angeles' physical and governance infrastructures.

SOLUTIONS

In 2050, we envision that the electricity generation mix for Los Angeles utilities will incorporate innovative renewable energy projects that take maximum advantage of Los Angeles County's local wind and solar resources, while balancing wildlife habitat and water needs. Advances in urban planning, architecture, and engineering will allow Los Angeles to utilize surfaces in the urban landscape, such as awnings, window blinds,

ENERGY RESEARCH HIGHLIGHT 1: RENEWABLE ENERGY POTENTIAL FOR LOS ANGELES

UCLA researchers aim to develop a long-term plan for a Los Angeles County energy portfolio that balances accessible and economical renewable energy resources; energy distribution, management and storage needs; and end-user requirements. This plan will include both centralized and distributed energy generation and fuel production options, and will be attentive to water generation and treatment, public health, and ecosystem health needs to ensure that Los Angeles is a desirable and thriving community.

As a first step, UCLA engineers will work with key partners at other California universities, local utilities, regulatory entities, and key industry experts to characterize available energy resources, user needs, and energy distribution and management requirements in Los Angeles County using existing data and parameters. The assessment of available local renewable energy generation resources will include solar and wind energy, which are of great local abundance. The research team will determine the viability of these options given various technical considerations, including electricity and fuel costs, system, topographic limitations, climate change, and land-use constraints. Researchers also will determine how centralized and distributed energy storage can and should be deployed to provide power to the grid as needed, taking into consideration response time, grid needs, and user needs. Additionally, researchers will evaluate how much renewable fuel (e.g., advanced biofuels, biogas, renewable gas) can be produced for the Los Angeles market, including through local production of renewable gas.

Within four months, researchers will produce a draft report for review. This project will serve as a cornerstone for generating a plan for Los Angeles County's 2050 energy portfolio that achieves other **Sustainable LA GC** objectives.

The estimated cost of this six-month project is $300,000 for coordination, research, production, and dissemination of a report that uses existing data to characterize the key renewable energy resources and technologies available to Los Angeles.

and house paint, to generate electricity, while providing other benefits such as shade over parking lots, sidewalks, and other hard, heat-radiating surfaces. Clean-technology breakthroughs and innovative governance strategies will create economic opportunities for Los Angeles residents and minimize the public health burden of carbon-based fuel combustion.

To facilitate increased renewable energy generation, we envision that homes and buildings will automatically and intelligently regulate the electricity use of all devices, appliances, and vehicles. Electric vehicles and other distributed storage solutions will inject power back into the grid when and where energy is most needed. Additionally, we will propose

new policies and strategies that Los Angeles utilities and governments can deploy to manage and reduce consumer energy demand, encourage distributed generation and storage, and reduce the energy intensity of transportation. Redesigned transportation infrastructure will support a zero-emission mass-transit system and self-driving vehicles, helping to reduce local air pollution and climate impacts. Shared transportation networks will contribute to improved transportation reliability and equitable access to transportation throughout the county. Redesigned buildings and walkable, bikeable live-work neighborhoods will be more energy efficient, reduce car dependence, and make Los Angeles County a more pleasant place for all communities and populations.

Researchers at UCLA are already engaged in developing transformative new energy technologies, policies, and management strategies that can help Los Angeles achieve the **Sustainable LA GC** goals. Indeed, the UCLA campus is a proving ground for some of the technological solutions that will enable Los Angeles to expand renewable energy generation and enhance grid reliability. For instance, UCLA's Energy Innovation Lab investigates breakthrough technologies for grid-scale energy generation and storage, while UCLA's Smart Grid Energy Research Center (SMERC) is deploying new electric vehicle technologies in UCLA campus housing. Although a variety of entities throughout the world are engaged in exciting energy and transportation research, no other institution can boast UCLA's combination of deep expertise in engineering, technology assessment, urban planning, architecture, environmental sciences, and energy, climate, and transportation law and policy, with our deep knowledge of, and long history of engagement with Los Angeles County's energy system and diverse communities.

ENERGY RESEARCH HIGHLIGHT 2: LARGE-SCALE SOLAR ENERGY STORAGE FOR CITIES OF THE FUTURE

In Southern California, solar energy is by far the most abundant renewable energy option. The challenge with utilizing solar energy is that it is only produced during the day, while the demand for electricity continues into the night. Therefore, the greatest obstacle to incorporating solar power into Los Angeles County's energy portfolio is low-cost, large-scale solar energy storage that will provide reliable power 24 hours per day. The most cost-effective method for large-scale on-demand solar energy is concentrating solar power (CSP) combined with thermal energy storage.

UCLA Professor Richard Wirz and his research group have pioneered a new approach to large-scale solar-energy storage through the use of low-cost elemental fluids in a modular, single-tank design for the thermal storage and heat transfer system. This system can operate at a wide range of temperatures (50–1300°C), and reduces the cost of thermal energy storage systems by up to 70%. This results in an over 90% reduction in energy storage costs when compared to the prohibitively expensive conventional chemical batteries that are currently used with solar panels. This innovative energy storage technology is perfectly suited to capture the abundant solar energy that Southern California receives nearly every day of the year, and allows renewable solar power to respond to the County's on-demand energy needs, eliminating the need for fossil fuels.

The estimated cost of this five-year project is $2,800,000 to build and operate a utility-scale demonstration at an existing Los Angeles area solar power plant.

ENERGY RESEARCH HIGHLIGHT 3: SOLAR ENERGY HARVESTING AND STORAGE IN A SINGLE DEVICE

Solar energy is the most abundant clean energy source in the world. **Sustainable LA GC** provides a unique opportunity to tap this resource and significantly enhance energy self-sufficiency in Los Angeles County.

Professors Yang and Dunn in UCLA's Materials Science and Engineering Department propose an innovative multi-year research program based on the pioneering technology under development in their respective laboratories in the areas of photovoltaics and batteries. Their goal is to integrate the two technologies into a single device that converts sunlight into energy, and makes that energy available immediately or stores it for future use. Currently, the technology for integrating photovoltaics and batteries is at an embryonic stage. Flexible photovoltaics and batteries have been demonstrated individually, but not as an integrated device. Moreover, the manufacture of large-area flexible devices has yet to be realized. The latest technology developed by Professors Yang and Dunn, who are leaders in their respective fields, enable the development of combined solar harvesting and storage devices with a flexible, thin-film structure. These features are key to integrating the device into architectural elements such as window coverings, awnings, and panels in commercial and public buildings, public spaces, and homes. Development of this breakthrough technology will enable energy harvesting and storage to become part of our daily lives.

The estimated cost of this four-year project is $1,000,000 to develop flexible prototype devices that can serve as the basis for start-up companies.

FIVE-YEAR ENERGY WORK PLAN

UCLA and its partners will undertake critical energy and transportation research projects over the next five years aimed at filling knowledge gaps and informing the optimum energy transition plan for Los Angeles. First, we will develop a long-term plan for a local energy portfolio that balances accessible renewable resources; energy and fuel distribution, management, and storage needs; and end-user requirements. Our multidisciplinary team will then work with stakeholders and partners to research and develop key technologies, policies, and management strategies needed to expand renewable energy generation in accordance with that plan and the **Sustainable LA GC** goals. This work will include research related to the development of an integrated electricity and fuel infrastructure and a local smart grid, as well as groundbreaking technologies and policies to integrate solar energy harvesting and storage into a wide variety of surfaces found in the built environment. In tandem, researchers focused on improving management of energy consumption will design strategies to reduce the energy intensity of

ENERGY RESEARCH HIGHLIGHT 4: SMART HOMES AND BUSINESSES

As the population surges and the use of electric vehicles expands, reducing energy consumption through traditional energy conservation approaches will not be enough to prevent power outages in Los Angeles. To address this reliability challenge, researchers at UCLA's Smart Grid Energy Research Center (SMERC) are exploring technologies to integrate automated "demand response" systems into homes and commercial buildings. Demand response measures incentivize consumers to change their normal electricity consumption habits in order to alleviate periods of high electricity demand and take pressure off of the electricity grid. Utilities ultimately can use these technologies to regulate the energy use of appliances, electronics, and electric vehicles intelligently and efficiently.

SMERC is currently developing demand response algorithms for "smart appliances" that can automatically curtail their energy use when they receive a utility's signal, helping to alleviate periods of high energy demand. These algorithms can adjust a home or building's electricity load according to dynamic constraints such as the price of electricity. SMERC has fitted dozens of electrical appliances such as air conditioners and refrigerators and over 200 electric vehicle charging stations with the demand response technology. SMERC is also developing scalable mechanisms to network smart appliances with smart electricity meters and electric vehicles.

The demand response systems under development at SMERC are scalable energy solutions that can reduce Los Angeles' energy demand, prevent power outages, and enable the use of renewable energy at night with reduced energy storage requirements.

The estimated cost of this 12-month project is $485,000 for research, technology deployment and demonstrations, data analysis, and publications that would utilize dynamic data from instrumented smart grid technologies within homes in UCLA and the City of Los Angeles to optimize load control of electric vehicles and battery storage, renewable energy, and appliances for the electric grid operator.

transportation, promote building energy efficiency and conservation, and better manage electricity demand in Los Angeles. Additionally, UCLA's public health, policy, and environmental science researchers will work collaboratively with partners and stakeholders to evaluate the broader implications of transitioning to 100-percent renewable energy, and explore strategies to enhance public health and mitigate adverse environmental impacts during Los Angeles' renewable energy transition.

Objective 1: Expand renewable energy generation

a) Characterize an energy resources portfolio for the Los Angeles of 2050

- Analyze Los Angeles County's 2050 **renewable energy potential** utilizing existing data and considering key renewable energy resources, user needs, energy distribution and management requirements, cost, land-use constraints, and other critical parameters (*see Energy Research Highlight 1*).
- Quantify the potential for the utilization of **renewable fuels** (e.g., advanced biofuels, biogas, renewable gas)[6] across sectors, including residential, commercial, industrial, and transportation such as shipping, rail, and air transit given that supplies of these fuels are limited, but that a gas network and grid already exist.
- Evaluate the roles of **electricity and renewable fuels** in fueling a more sustainable transportation system for Los Angeles, considering the integration of Los Angeles' transportation system with intrastate, interstate, and international transportation systems, as well as integration across ground, air, and sea transportation.
- Map potential sites for **renewable energy infrastructure**, such as building components and roadbeds for solar and vibration harvesting, optimal sites to capture and utilize waste heat, and valleys for wind turbines, with added consideration for view-sheds and sight lines, design, and equitable distribution across neighborhoods.
- Construct **energy demand scenarios** for Los Angeles County by location, sector, and type of energy to enable long-term planning.
- Evaluate the potential role of **non-renewable energy resources and technologies** (e.g., nuclear energy, carbon-based fuels, carbon capture and sequestration) in Los Angeles' renewable energy transition and beyond 2050 in the event that certain sectors such as aircraft, seaports, or trucking cannot economically meet the goal of transitioning to 100-percent renewable energy by 2050.

b) Identify policies, management strategies, and technologies to expand renewable energy generation and fuel production

- Achieve key technological breakthroughs in **renewable energy generation** to take advantage of the copious resources in Los Angeles County, such as improving technologies for solar and wind energy harvesting and integrating energy generation and storage into materials in our homes and businesses (see Energy Research Highlights 2 & 3).

[6] *"Advanced biofuels" includes fuels manufactured from algae and certain other feedstocks, and is distinguished from conventional biofuels (e.g., corn ethanol), the production of which may threaten food supplies and biodiversity, and produce limited greenhouse gas emissions savings over the full life cycle of the fuel. "Biogas" includes gases produced from raw waste materials such as sewage, livestock manure, landfill waste, or food waste. "Renewable gas" is biogas that is conditioned to be the same quality as natural gas, meaning it can be injected directly into gas pipelines.*

- Develop **renewable gas and biofuel technologies** that will greatly reduce greenhouse gas emissions in LA County, such as innovations to turn captured carbon dioxide into biofuels for vehicles.
- Determine how utilities might be incentivized or mandated to utilize **renewable energy resources** instead of existing non-renewable generation assets (such as carbon-based-fuel-fired power plants), and how this transition would impact ratepayers.
- Evaluate the role of **utility governance structures** and **local, state, and federal regulators** in shifting to increased use of renewable energy resources.
- Identify the **local policies and institutions** necessary and appropriate to promote centralized and distributed renewable energy generation and storage, taking into account factors such as efficiency, feasibility, environmental and socioeconomic impacts, land-use and zoning regulations, and cost, as well existing state policies.
- Determine how the **energy market system** could be redesigned to enable residents with renewable energy generation or storage systems (such as awnings and window blinds that harvest solar power for homes, or electric vehicles with energy-storing batteries) to become energy buyers and sellers, while protecting low-income households from adverse economic impacts.
- Identify **policy and regulatory changes** necessary to catalyze LA County's transition to renewable gas and fuels from the the current energy mix.
- Develop **regulatory and market incentives** to increase advanced renewable fuel supplies.

Objective 2: Design an integrated system for distribution and storage of renewable energy

- Design the efficient, cost-effective **transmission and distribution management strategies and technologies** necessary to support centralized and distributed energy generation and storage, including large-scale storage solutions.
- Evaluate the potential of electric vehicles to provide **smart-grid balancing services** by providing dynamic energy storage that can help match electricity demand with the times the wind is blowing and the sun is shining.
- Design small **"microgrids"** powered by renewable energy and energy storage devices that can detach from the regional grid

ENERGY RESEARCH HIGHLIGHT 5: IMPROVING TRANSPORTATION RELIABILITY IN LOW-INCOME NEIGHBORHOODS

For low-income individuals, access to reliable transportation can make a substantial difference in employment earnings. Although public bus lines are the most popular form of transportation for long distance commutes in low income communities, taxi services historically have been the primary source of reliable automobile mobility for those without access to a car in Los Angeles. As Transportation Network Companies (e.g., Uber, Lyft) and other alternative transportation services mature and move down the cost curve, there is an opportunity to substantially improve transportation reliability and equitable access to transportation in Los Angeles' low-income communities.

UCLA researchers will engage in an economic analysis and regulatory review of options to improve transportation for individuals in low-income neighborhoods, while promoting alternative modes of travel, such as Transportation Network Companies, that decrease the number of vehicles on the road. If private-sector economics do not support low-cost, reliable transportation options, researchers will explore whether regulators may turn to a non-profit model or subsidies that could allow these services to be cost-effective in low-income communities. This work will contribute to the development of recommendations for relevant governing agencies such as the California Public Utilities Commission and the Los Angeles County Metropolitan Transportation Authority.

The estimated cost of this 12-month project is $250,000 for collaborative economic and regulatory analytical work across the disciplines of transportation, business, economics, and sociology.

and continue to provide electricity to homes and buildings during power outages and other grid emergencies.

- Identify the **voltage and frequency control systems** needed to dynamically adapt to the changing energy transmission associated with renewable generation, which is more variable than generation from traditional power plants.
- Develop the technologies and management strategies necessary to implement a **local smart grid** that will enhance efficiency, satisfy consumers, and facilitate distributed energy generation and storage solutions (e.g., smart electric-vehicle charging infrastructure and appliances that automatically regulate their energy use) (*see Energy Research Highlight 4*).

Objective 3: Improve management of energy consumption

a) **Reduce the energy intensity of local transportation**

- Determine how Los Angeles' **transportation infrastructure**—including roads, freeways, and refueling stations—should be redesigned and retrofitted to reduce the energy use associated with transportation.
- Evaluate whether **higher density development** offers a better route to reducing transportation-related energy consumption than the current single-family residential makeup of Los Angeles.
- Design **live-work communities and walkable neighborhoods** that benefit all stakeholders by reducing car dependence and foster social interaction, cultural vibrancy, and community wellbeing.
- Develop networked **smart traffic control** devices utilizing sensor technologies that intelligently respond to traffic and reduce congestion.
- Identify **transportation performance metrics** that are superior to congestion reduction as indicators of transportation sustainability.
- Determine what infrastructure is necessary to incorporate a much larger **electrified vehicle fleet** into the grid (e.g., to allow "smart-charging" of electric vehicles through a mobile phone app that monitors the changing price of electricity and the time needed to charge your vehicle).
- Develop local policies for Los Angeles governments to encourage **active transportation** such as walking and biking, mass transportation, transit-sharing, and alternative-fuel vehicles.
- Evaluate the role of new models of transportation, including **driverless vehicles and "transportation network companies"** such as Uber, in reducing congestion (*see Energy Research Highlight 5*).

b) **Reduce building energy consumption and improve demand management**

- Determine which energy **efficiency and conservation programs and messaging strategies** are most effective and appropriate for various consumer groups (e.g., commercial consumers, low-income residents, high-income residents, different age and ethnic groups).
- Identify the **energy consumption of existing buildings and building types** in Los Angeles, and quantify its sensitivity to temperature change.
- Develop neighborhood-specific **distributed renewable energy cogeneration and trigeneration** approaches in appropriate areas throughout Los Angeles County.
- Design **energy efficiency retrofit programs** for high-consumption buildings and building types that take into consideration diverse building occupants and improve the appearance of Los Angeles' neighborhoods and skyline.

- Develop guidelines to ensure **new buildings** are energy efficient, including guidelines regarding retrofits of existing buildings upon sale and solar energy generation requirements.
- Design dynamic electricity pricing and other policies to **encourage conservation and shift consumer demand** to times when the wind is blowing and the sun is shining, while protecting low-income households from price spikes.

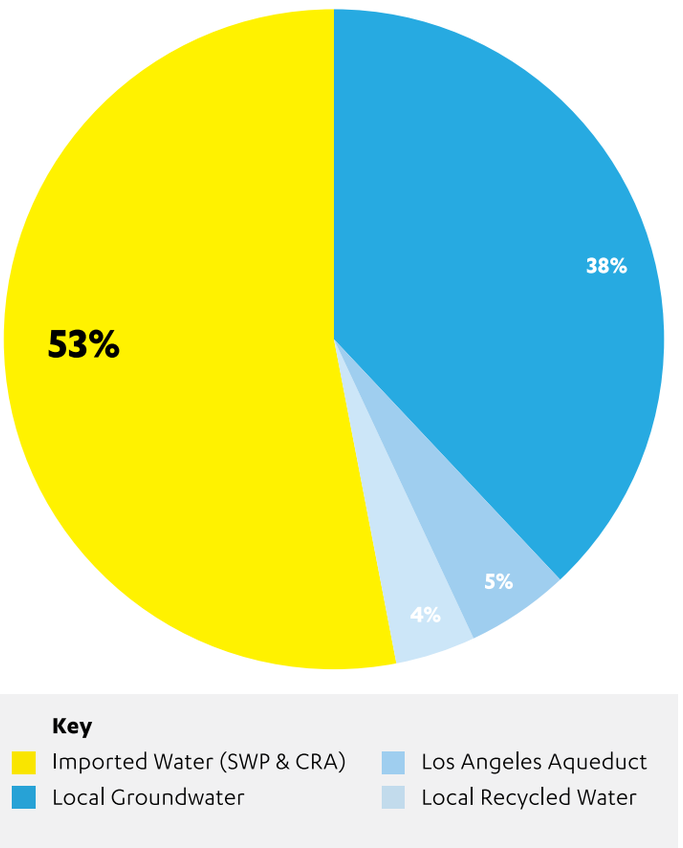
Objective 4: Ensure energy system sustainability

- Develop strategies that will **minimize and mitigate human exposure** to air pollution sources, including trucks, ships, and aircraft, during the transition to renewable energy resources.
- Characterize and compare **alternative 2050 energy resources portfolio scenarios**, including a scenario where Los Angeles County utilizes renewable energy resources for 100 percent of local energy and transportation needs, considering the following types of impacts: 1) **public health impacts** at the sub-neighborhood, neighborhood, and county scale; 2) **environmental impacts**, including total greenhouse gas emissions within and outside Los Angeles County; and 3) **economic impacts**, including costs to taxpayers and ratepayers.
- Assess the **near-roadway public health impacts** experienced by people who live in housing located near major traffic or public transportation corridors or hubs.
- Evaluate the **ecosystem health impacts** of energy generation, fuel, transmission, and distribution infrastructure, both locally and outside Los Angeles County, such as the impact of solar and wind generating facilities on bird populations.
- Identify strategies that could assist utilities in **siting energy generation, fuel, transmission, and distribution infrastructure** to reduce greenhouse gas emissions and air pollution, and enhance disaster resilience, while also mitigating other potential environmental problems such as visual blight, species losses, habitat degradation, water usage, and waste disposal.
- Evaluate and develop strategies to minimize the environmental and public health impacts of **renewable fuel production and renewable fuel use** in transportation and buildings.

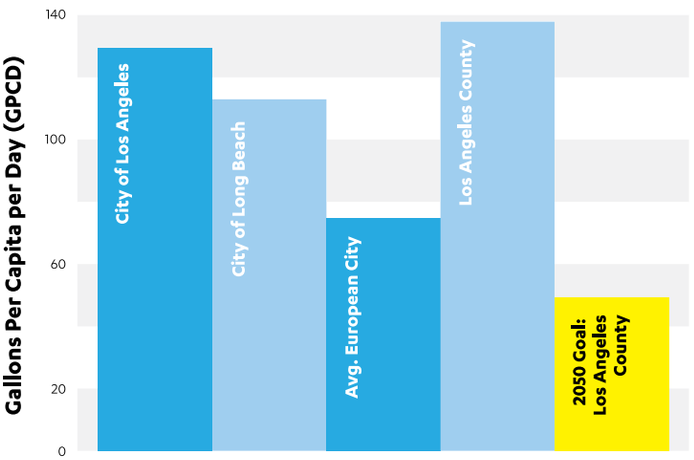
WATER

THE WATER CHALLENGE

Los Angeles' current water procurement and use practices are unsustainable. Los Angeles County as a whole imports nearly 60 percent of its water, and the City of Los Angeles almost 90 percent, from sources hundreds of miles away (IoES, 2015). These deliveries strain water supplies in other regions and require enormous amounts of energy. In fact, 18 to 20 percent of California's energy consumption is used for water delivery, treatment, and end uses (Klein et al., 2005), a statistic that is more disturbing given the fact that Los Angeles has not maximized its available local water resources. Only 32 to 38 percent of the county's water is locally sourced (see chart below). Uncaptured rainfall and other useable water drains into the ocean, while groundwater aquifers that could store this water are far below capacity. Recycled water is substantially underutilized, too, accounting for only about 5 to 8 percent of Los Angeles County's present water supply (IoES, 2015). This is largely the result of misconceptions about the health of recycled water and the capital cost of treatment facilities and distribution systems.



Sources of water for Los Angeles County in 2013. The Metropolitan Water District imports water from the Bay-Delta via the State Water Project (SWP) and from the Colorado River via the Colorado River Aqueduct (CRA). Source: Figure adapted from 2015 Environmental Report Card for Los Angeles County (IoES, 2015).



Potable consumptive water demand in the cities of Los Angeles and Long Beach compared to the average European City, and a comparison between Los Angeles County in 2013 and in 2050. The goal is to reduce the number of Gallons Per Capita per Day to 50 in Los Angeles County by 2050. Source: 2015 Environmental Report Card for Los Angeles County (IoES, 2015).

At the same time, many local water uses, including irrigation of lawns and other water-intensive landscaping, are conspicuously wasteful given Los Angeles County's naturally semi-arid climate. The average person's water consumption in Los Angeles County in 2013 was approximately 139 gallons per capita per day (GPCD), nearly twice the 76-GPCD level of the average European city (IoES, 2015) (see chart above). Moreover, increasingly scarce water resources are unevenly distributed; poor communities in Los Angeles use less water but spend a higher proportion of their income on water than their wealthy counterparts (Mini, 2013). In the face of California's historic multi-year drought, an unprecedented mandatory 25-percent reduction in statewide urban water use (Cal. Exec., 2015), and other stressors associated with increased development, energy use, and climate change, Los Angeles has a critical need for practical, sustainablve solutions that maximize local water supplies and limit water demands.

The **Sustainable LA GC** team is committed to sustainably transitioning Los Angeles County to **100-percent locally sourced water**. Achieving this goal will require us to overcome several significant barriers. Some are technological; Los Angeles will need to upgrade its existing infrastructure and technologies, including those used to extract groundwater from underground aquifers, capture the stormwater that would otherwise flow along streets and into storm drains during a rainstorm, and recycle wastewater. Lack of information is another hurdle. Because

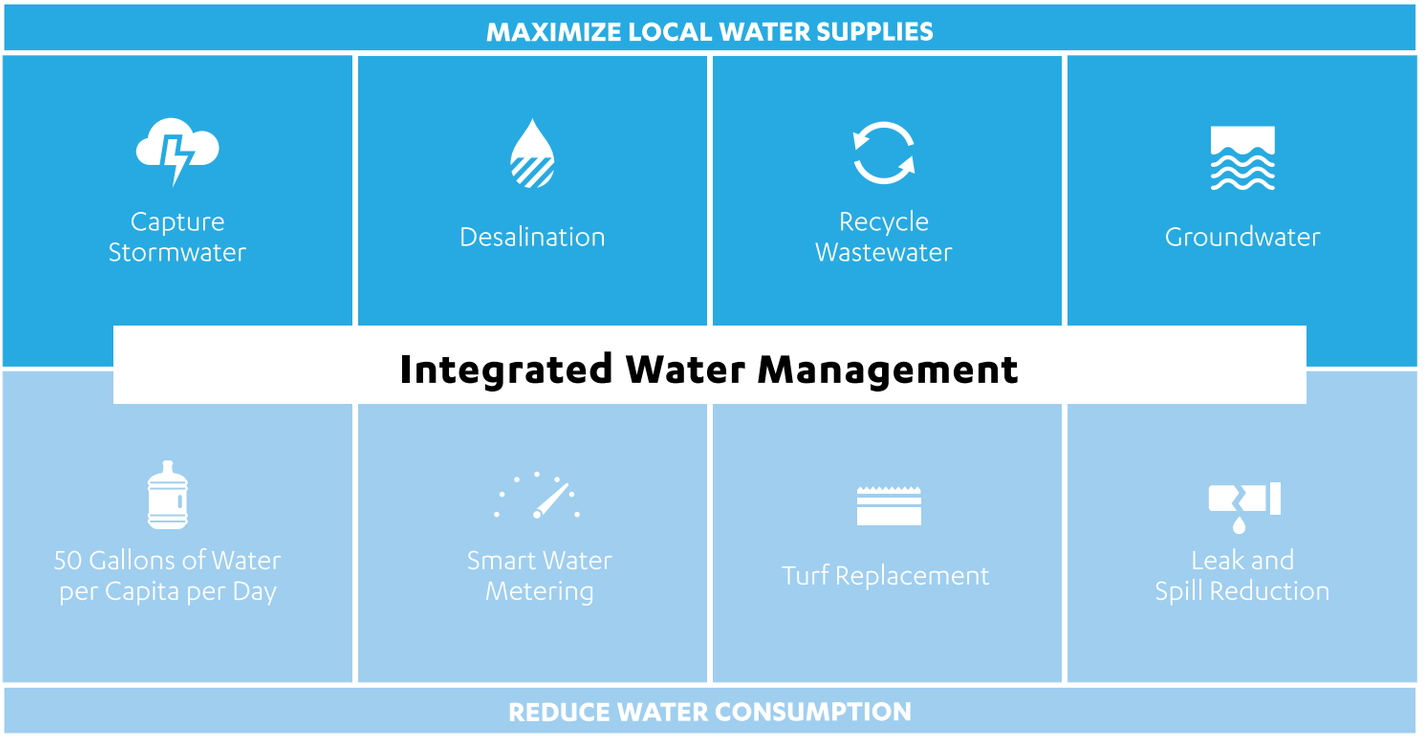
of key data gaps, including information on groundwater availability and safe yield, and the water uses of different sectors and districts, the full extent of Los Angeles' water challenges remains unknown. The need for inexpensive real-time smart and dual water meters for residences and businesses has never been greater. Water management and policy present additional barriers. A fragmented network of public and private suppliers manages water deliveries, with oversight from multiple government entities with diverse budgets and responsibilities. Water rights are inefficiently assigned according to policies over a century old. Cultural expectations and habits stand in the way, as well: wasteful water uses are symbols of wealth and status, and many water users are not conscious of the impacts of their water use.

SOLUTIONS

Los Angeles can secure a sustainable and reliable water supply by meeting 100 percent of its needs with water resources located right here in Los Angeles County. Achieving this goal will require breakthrough technologies in water harvesting, conservation, efficiency, and recycling, supported by policies and financing strategies that promote their adoption. In addition, social and cultural perceptions of water—including the pervasive assumption that landscapes should be green and the association of water-intensive lawns with wealth—must be reshaped to match Los Angeles' sustainability needs. To achieve the **Sustainable LA GC** goals, the public needs to recognize the value of all water regardless of its source, be it a recycling facility, an aquifer, rainfall, or snowmelt.

New research is needed to survey state and local water rights and management regimes for inefficiencies, misalignments, and other areas for improvement. Related inquiries must explore economic issues, including ways to shape water rate structures to encourage conservation. Better understanding of how built, natural, and cultural systems interact with local water management will enable managers and policymakers to satisfy residents' water needs more efficiently and effectively. Together, these combined research initiatives will guide efforts to create new conservation norms and shift regulatory and hard-infrastructure systems toward sustainability.

Twentieth century infrastructure will be replaced with a more integrated, distributed, and energy-efficient system that provides enhanced water quality and supply, greatly decreased water waste, enhanced system resiliency, improved flood control, increased open space, watershed protection, and biological habitat benefits. In 2050, we envision that Los Angeles communities will utilize distributed and decentralized systems to treat wastewater and stormwater at different scales, from household cisterns that capture rainwater, and neighborhood-level "bioswales" that use landscaping to infiltrate and partially treat stormwater, to local water recycling plants and groundwater infiltration projects. Groundwater, stormwater, and recycled water management will be focused on maximizing the recharge and sustainable yield of local aquifers, while remediating groundwater pollution. Systems that allow households and businesses to reuse lightly used greywater from bathroom sinks, showers, and washing machines will be ubiquitous, reducing our demand on potable water for outdoor irrigation and toilet flushing. Meanwhile, "smart" water management systems that intelligently monitor real-time flows, sense landscaping water needs, and detect leaks for utilities will decrease water waste, reduce costs, and lessen environmental impacts. In addition, we will desalinate seawater without harming marine life and in a manner that utilizes the osmotic energy potential of concentrated seawater and wastewater. Overall, these integrated approaches will



UCLA Professor Eric Hoek's low-energy, fouling-resistant nanotechnology membranes for desalination and wastewater treatment.

reduce the greenhouse gas emissions associated with our water treatment and supply systems, generate renewable energy from biogas and advanced biofuels, and capture and reuse nutrients that would otherwise contribute to water pollution. Water management innovations and benefits will span geographical areas and income groups to emphasize shared accountability and encourage greater cross-cultural recognition of the value of water resources.

UCLA is uniquely situated to undertake the research necessary to realize this future. Our faculty are pioneers in water treatment. UCLA developed the first reverse osmosis membrane technology that produces freshwater from seawater, and we are continually making strides towards developing improved membranes that are more energy-efficient and that more effectively remove pollutants, treatment byproducts, and dissolved solids. Technological breakthroughs like these enable a complete re-envisioning of water treatment and water management in Los Angeles. In addition, UCLA has some of the world's leading experts in local and regional climate modeling and hydrological modeling of water supplies, as well as experts in the fields of snow hydrology and paleoclimatology. Our faculty also have expertise in building technologies, sewage treatment, greywater, stormwater, recycled water, contaminants, and water policy.

FIVE-YEAR WATER WORK PLAN

Over the next five years, UCLA scholars and partners will pursue critical research on strategies to both expand local supplies and reduce demand. After calculating a baseline of available supplies, researchers will develop innovative ways to expand use of traditionally underutilized resources such as groundwater, stormwater, seawater, greywater, and recycled water. At the same time, researchers will explore conservation and efficiency strategies that would allow Los Angeles to thrive using substantially less water, with the target of reducing consumption to 50 GPCD by 2050. Tying together these advances in water supply and conservation, we will design, together with our partners and stakeholder input, a sustainable water management system that integrates

WATER RESEARCH HIGHLIGHT 1: THE WASTEWATER TREATMENT PLANT OF THE FUTURE

While today's water treatment plants typically do little more than treat municipal sewage and industrial wastewaters to environmental standards established over 40 years ago, the wastewater treatment plants of the future will have a much more ambitious mission. These plants will extract up to 90 percent of the wastewater as fresh reusable water and produce two grades of clean water: one to meet indirect and/or direct potable reuse requirements, and another for use in landscape irrigation and other recycled water applications. Additionally, the plants will generate electricity by converting the biosolids extracted from wastewater into biogas, which will sustain the plant's operations and produce excess power for other applications. They also will harvest valuable nitrogen and phosphorous nutrients found in wastewater by transforming them into liquid and solid fertilizer products. Moreover, future treatment plants will work synergistically with nearby seawater and brackish water desalination plants by combining the small amount of non-reusable water from the treatment plant with desalination plant brine and subjecting the mixture to an osmotic energy recovery technology that dilutes the brine to a seawater-level salt concentration and produces electricity. This will minimize the environmental impacts of discharging desalination plant brines to ocean and fresh surface waters, and recover about one-half of the energy required to power the desalination plant.

The technologies required to enable this revolutionary transformation in urban water resource management include advanced reverse osmosis and pressure-retarded osmosis membrane materials, as well as next generation pre- and post-treatment technologies for seawater and wastewater treatment, including membrane filtration, disinfection, and oxidation process technologies. All of these technologies are commercially available, but need to be engineered and integrated into the envisioned treatment plan and tested at commercial scale. These technological innovations have been in development at UCLA for over a decade in the departments of Civil & Environmental, Chemical & Biomolecular, and Mechanical & Aerospace Engineering, and will be complemented by the world-class policy, sociology, and economic expertise of other UCLA faculty.

This project will take five years at a cost of $2,000,000 for modeling and laboratory research; $5,000,000 for the design, deployment and assessment of pilot prototype treatment plants; and $8,000,000 for integration of the demonstration-scale treatment plant with desalination plant brine for osmotic energy recovery.

technological and infrastructure improvements and innovations in law and policy to provide for Los Angeles' future water needs. Implementation of this improved water resources management framework will transform how Los Angeles uses and values water.

Objective 1: Maximize Local Water Supplies

a) Quantify and characterize existing water supplies

- Establish a **baseline** water balance for Los Angeles County's water use and total available water supplies, including models of flow, interactions between supplies and demands, and the maximum storage and sustainable yield of supplies.
- Better understand the **interactions between water quality and supply** to ensure that water supplies are clean and suited for their intended uses, and that local water uses do not negatively impact **ecosystem health and human health**.

b) Expand available water supplies

- Develop and demonstrate improved technologies for **groundwater** monitoring, treatment, management, and extraction to enable increased sustainable use of groundwater resources.
- Develop and demonstrate improved technologies for the capture, treatment, and use of **stormwater and greywater** at all scales, from households to cities.
- Develop and demonstrate technologies for **seawater desalination** that reduce associated cost, energy demand, greenhouse gas emissions, and impacts to marine wildlife and coastal ecosystems.

WATER RESEARCH HIGHLIGHT 2: THE FUTURE OF LOS ANGELES' WATER RESOURCES IN A CHANGING CLIMATE

UCLA Professor Alex Hall has been developing innovative techniques to "downscale" global climate model information to scales that incorporate the fine-scale climate dynamics of mountainous regions and produce physically credible high-resolution projections of future climate. Connected to the right tools, these projections can provide information about changes in water flows on a watershed-by-watershed scale. As part of the **Sustainable LA GC** project, Dr. Hall will build on existing climate projections for the Los Angeles region and the Sierra Nevada to quantify the water available to Los Angeles from these key sources in the future under climate change.

The Future of Water Resources in the LA Region project will connect Dr. Hall's high-resolution climate projections with a hydrologic modeling tool that simulates how water flows over and just below the land surface, and a water resources planning tool, which simulates water flows into human-made infrastructure and can be used to test water management scenarios. The project team will analyze how projected changes in climate will affect LA's local and imported water budget in 2041–2060 and 2081–2100. This information is essential for assessing the costs and benefits of decreasing our dependence on imported water, which is expected to be less reliable as the climate changes, and increasing our dependence on local water, which is expected to remain relatively stable overall. Over the LA basin, the assessment will look at changes in overall precipitation and runoff as well as changes in the character of individual precipitation events. Climate research to date suggests that future precipitation events in California will become less frequent but more intense, and we must characterize these changes at the local scale if the LA region is to rely on its own stormwater.

The model framework development, production, and analysis of climate simulations, and production of the final report will take four years, and cost $3,000,000 in total.

- Design an integrated water management policy framework to facilitate an **optimized water supply system** including treatment, distribution, and groundwater management.
- Develop recommendations of legal changes to the **water rights system** that would enhance sustainable yields from both adjudicated and non-adjudicated local groundwater supplies. Recommendations will include mechanisms to reward agencies that maximize recycled water and stormwater infiltration with greater water pumping rights.
- Develop and demonstrate technologies to enable installation of an **optimized drinking water production and wastewater reclamation/reuse system** for Los Angeles County that produces energy and recovers nutrients for beneficial uses (*see Water Research Highlight 1*).

c) **Encourage adoption of local water sources**

- Establish a **baseline of cultural perceptions** about water, water use, stormwater, greywater, recycled water, and treating polluted groundwater for consumption. Engage communities to craft culturally acceptable, effective solutions to **increase demand for recycled water, stormwater, and greywater**.
- Develop recommendations of **regulatory changes** that would facilitate the capture and use of stormwater, greywater, and recycled water, such as legalizing direct use of highly treated recycled water with appropriate public health protections.

d) **Enhance water supply resilience and sustainability**

- Characterize the implications of **climate change** for Los Angeles County's water supply and infrastructure, including the effects of sea-level rise on groundwater aquifers, changes in the available quantities and sources of local water supplies and imported sources, and impacts on riparian, wetland, and terrestrial ecosystems (*see Water Research Highlight 2*).
- Assess the effects of climate change on **local precipitation variability**, especially heavy precipitation events, and how this variability will affect local water supplies and plans for increased stormwater capture.

- Use **paleo-climate proxies** to characterize the full range of climate variability in the Los Angeles region, the Sierra Nevada Mountains, and the Colorado River Basin.
- Quantify the vulnerability of water supplies to **disaster**, including seismic activity, flooding, fires, and fire suppression, to inform choices among various potential approaches to achieving the **Sustainable LA GC** goals.

WATER RESEARCH HIGHLIGHT 3: THRIVING ON 50 GALLONS PER DAY

The average per capita water consumption in Los Angeles County was approximately 139 gallons per capita per day (GPCD) in 2013, nearly twice the consumption of the average European city: 76 GPCD. Los Angeles County's current consumption level is unsustainable, particular in light of present drought conditions and climate change. Our local and state leaders are responding: In October 2014, Mayor Eric Garcetti set a goal for the City of Los Angeles to reduce its consumption to 104 GPCD by the year 2017 (IoES, 2015). In April 2015, responding to historic drought conditions, Governor Brown mandated a statewide 25-percent reduction in water use from urban communities (Cal. Exec., 2015).

Sustainable LA GC builds on these initiatives by aiming to achieve a 50-GPCD average water consumption level in Los Angeles County by 2050 through a comprehensive water efficiency and conservation program. Researchers will investigate available water conservation technologies, ranging from water-efficient fixtures and appliances, to smart and dual water meters that provide residents, businesses, and government agencies with real-time consumption data regarding indoor and outdoor uses. In addition, we will assess the potential local efficacy of conservation incentive strategies including rate structures, net zero water requirements for new and redevelopment, and rebate programs for lawn replacement. UCLA researchers will analyze current and historic water consumption patterns on a per-parcel basis to determine which conservation efforts have been most effective for different communities, businesses, and socioeconomic groups. Researchers will also compare conservation programs and public attitudes about water from areas with much lower per capita water consumption to determine which strategies already in use elsewhere can be applied to reduce consumption in Los Angeles. Using the information compiled by these research efforts, researchers will design a water conservation program to reduce per capita water consumption to 50 GPCD by 2050.

This project is estimated to take 24 months to complete, at a cost of $850,000 to design an innovative community-specific water conservation program for Los Angeles County that is based on effective conservation technologies and behaviors.

- Develop a **climate and disaster resiliency plan** for Los Angeles County's water supplies.
- Perform a **sustainability assessment** using a variety of methodologies to assess and evaluate the health, safety, environmental, economic, social, and cultural impacts of new water technologies, products, processes, and management approaches.

WATER RESEARCH HIGHLIGHT 4: REVOLUTIONIZING MANAGEMENT OF LOS ANGELES COUNTY'S LOCAL WATER RESOURCES

Los Angeles County currently imports about 58 percent of its water supply from the Sierra Nevada and Rocky Mountains. As for local resources, Los Angeles obtains about one-third of its supply from groundwater, and only five to eight percent from recycled water (IoES, 2015). Los Angeles County's reliance on imported water is not sustainable, and underscores the need for Los Angeles to optimize management of its local water sources.

There are many potential water supply scenarios that could lead Los Angeles County to 100-percent water self-sufficiency while reducing average consumption to 50 GPCD. Conservation, water recycling, stormwater capture, clean-up of polluted groundwater, greywater reuse, and desalination of brackish groundwater or seawater all offer pathways toward this goal. It remains to be determined what combination of these approaches will provide Los Angeles County with the most reliable supply while also maximizing water quality, flood control, wildlife habitat, recreation, and the economic benefits of these beneficial uses.

Working with local water supply, flood control, sanitation, and other agencies, researchers will obtain and analyze data on available supplies, treatment costs, energy use, greenhouse gas emissions, infrastructure costs, consumption, groundwater basin characteristics, governance, environmental impacts, and land use to better understand the costs and benefits of various approaches, both in comparison to one another and to continued use of imported water. Based on the results of these analyses, researchers will develop a suite of alternative water supply scenarios that would enable Los Angeles County to transition to a sustainable and reliable local water supply while ensuring water quality standards are met. If implemented, any of these alternatives would dramatically transform water management in Los Angeles.

This project is estimated to take two and one-half years to complete, at a cost of $1,600,000 to evaluate the optimum water resource portfolio for Los Angeles County.

Objective 2: Reduce Water Consumption

- Assess countywide **water use patterns** by land use, parcel size, household income, temperature and rainfall patterns, and other key factors.
- Develop **future water demand scenarios**, incorporating assumptions of climate change, population growth, and changing water use patterns, to enable effective long-term planning.
- Compare water conservation strategies and public attitudes about water in Los Angeles County with **best practices** from other cities, countries, and communities with lower per capita water consumption.
- Determine the **historic efficacy of conservation programs** (e.g., consumer education, water rate restructuring, utility rebates, conservation ordinances, enforcement of water use restrictions) at reducing water demand in local user groups and sectors.
- Identify and understand the culturally appropriate **shifts in public perception** needed to facilitate the adoption of indoor conservation technologies and less water-intensive landscaping of yards, parks, and open spaces in Los Angeles County.
- Develop and demonstrate innovative **leak detection and repair technologies** for drinking water distribution systems.
- Create **scenarios demonstrating how reduced water consumption** relates to patterns of daily life, quality of life, household economies, and new residential landscapes.
- Design a **comprehensive water conservation program** that compiles innovative technologies, water pricing incentives, legal requirements, and other culturally appropriate approaches to reduce water consumption in Los Angeles County (*see Water Research Highlight 3*).

Objective 3: Improve Local Water Resource Management

a) **Improve water management infrastructure and technology**

- Examine the social, institutional, legal, political, and economic drivers of, and barriers to **water technology design, development, and ultimate adoption**.
- Develop a thorough description of the **institutional architecture of water management** in Los Angeles County, including regulations, procedures, funding levels, and water use by sector.
- Quantify and understand the **tradeoffs between distributed wastewater treatment** and centralized treatment and reinjection into aquifers, in terms of cost, effectiveness, water availability, and equity impacts.
- Develop and demonstrate improved **"smart" water technology** that senses water needs in buildings, yards, parks, and other landscaped areas and distributes water accordingly for greatest efficiency at both the parcel and sub-neighborhood level.
- Develop, assess, and optimize **integrated, sustainable water management approaches** that pair conservation with the combined use of groundwater, recycled water, stormwater, greywater, and desalination sources (*see Water Research Highlight 4*).
- Design sustainable funding mechanisms and strategies for research, development, and deployment of **improvements to aging water infrastructure** and local integrated water management approaches, taking into consideration the fact that most water infrastructure is publicly owned and subject to public-sector budgets.

- Evaluate whether and how additional **private capital** should be incorporated into water infrastructure and management projects, and develop new **cost-benefit models and financing structures** that are suited to multi-benefit, integrated water infrastructure and management projects to encourage investment.

b) Improve water governance and policy

- Assess the **strengths and weaknesses of federal, state, and local laws and policies** that address water issues in Los Angeles County (including land-use plans), with particular attention to their interactions and any barriers to their full deployment.
- Identify potential legal and policy mechanisms to enhance local **water governance and management**.
- Assess the policy governance and infrastructure implications of **decoupling** Los Angeles County's water systems from water systems in other regions.
- Analyze how water managers and suppliers respond to constraints such as scarcity, cost, and water quality standards, and how **changing economics** might incentivize improvements in water resource management (e.g., leading utilities to make greater investments in efficiency improvements or distributed infrastructure).

ECOSYSTEM HEALTH

THE ECOSYSTEM HEALTH CHALLENGE

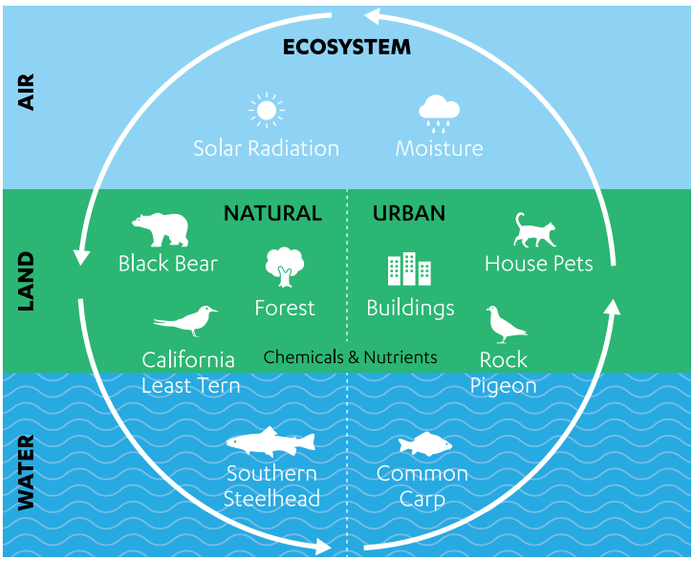
Despite expansive suburban and urban development, Los Angeles County is home to a rich diversity of species and ecological communities, many of which are found nowhere else in the world. Yet, much about Los Angeles' local species, habitats, and ecosystems remains unknown. Urban field biology has largely been ignored over the past century. As a result, we have only a tentative (and often anecdotal) accounting of the species that live in our urban environment, let alone an understanding of how to manage and conserve them. Birds have received the greatest attention, and researchers have carried out partial surveys of trees and some insect groups, but few data exist for most species. We do know that about six-dozen local native species are listed as threatened or endangered, including the El Segundo blue butterfly and the Southern California steelhead (CDFW, 2015). Healthy, native-dominated ecosystems now exist primarily in pockets, most often in protected mountain areas—including the nation's largest urban national park, the Santa Monica Mountains National Recreation Area. At the same time, Los Angeles has become an unplanned sanctuary for plant and animal species that are endangered in their original habitats, such as the Green-Cheeked Amazon parrot. Other species introduced to the area by humans, such as palm trees, have vastly increased local biodiversity and generated novel ecosystems whose functioning we are only beginning to understand.

There is also a considerable knowledge gap concerning how the socio-cultural values and practices of Los Angeles County's diverse, globally-derived human population relate to ecosystems. In particular, the relationship between ecosystem health and public health in Los Angeles is not well understood. Evidence suggests that contact with nature positively affects human health, and natural areas—particularly green spaces like parks, undeveloped natural areas, or blue spaces like rivers and ocean coasts—have been associated with a wide range of health benefits (James et al., 2015; Nieuwenhuijsen et al., 2014). Additionally, the recreational activities afforded by nature may increase positive social interactions, possibly supplying further health benefits. Again, however, key data are missing regarding the makeup and distribution of local ecosystems, and the services and benefits that these environments offer to Los Angeles communities.

Lack of baseline knowledge inhibits efforts to enhance ecosystem health and resiliency, and better integrate ecosystem health and human health and wellbeing – which are increasingly crucial to ensure Los Angeles can thrive in a hotter, more populous future. By 2050, the county's population is expected to grow from 10.1 to 11.5 million people (DOF, 2014). The associated energy, water, and development pressures have the potential to stress ecosystem health, making it essential for us to find new ways to effectively integrate the built environment and the natural landscape. More people also means increased demand for park space. Although the city of Los Angeles has 15,710 acres of parkland and is home to the largest municipal park in the United States (LA Almanac, 2015), the amount of park space per person within Los Angeles neighborhoods is low compared to other major cities (TPL, 2015).

Climate change presents additional challenges, as well as additional unknowns. While it is clear that hotter temperatures, reduced snowmelt, and increased wildfire risk add to the suite of environmental stressors already facing Los Angeles' species and ecosystems, how particular species will be impacted – and what can be done to limit or prevent these impacts – is largely unknown. Even where we have projections of likely impacts on species and ecosystems, planners and policymakers have been slow to integrate that knowledge into solutions that can enhance local resiliency. Environmental changes are affecting human wellbeing, too. Ecological imbalances, combined with climate change, are already promoting the local emergence and spread of previously unseen diseases such as West Nile Virus (Harrigan et al., 2014), while pollution and changes in pollen production are worsening respiratory ailments that disproportionately affect children (Declet-Barreto & Alcorn, 2015; O'Connor et al., 2008). The need to better coordinate ecosystem health and human health has never been more urgent.

Ecosystem: Biological communities of interacting organisms and their physical environment.



Population	Rank (Out of 75)	Parkscore (Max 100)	Park Land %	Spending per Capita	Playgrounds per 10,000 Residents	Access for Households Under 75% Median City Income (% served*)	Access for Households 75–125% Median City Income (% served*)	Access for Households Over 125% Median City Income (% served*)
LOS ANGELES								
3,867,396	51	46	14.2%	$67.62	1	59%	56%	48%
LONG BEACH								
468,425	18	63.5	10.1%	$162.25	1.2	86%	84%	77%

*Inside 1/2 mile dynamic park buffer

The Trust for Public Land ParkScore® 2015 data on park access and quality for the cities of Los Angeles and Long Beach. The Sustainable LA GC aims to provide every resident with access to a green space or natural area within ¼ mile of their home by 2050. Source: Trust for Public Land, http://parkscore.tpl.org.

For these reasons, **Sustainable LA GC** commits to the goal of **enhancing ecosystem health by 2050** in a way that improves public health and human wellbeing throughout the ecologically and culturally diverse urban area of Los Angeles County. Specifically, **Sustainable LA GC** will promote the enhancement of ecosystem health through achievement of four key sub-goals: 1) increase native biodiversity through restoration, preservation, and recovery; 2) prevent extinction of native species; 3) plan and design built environments that integrate nature and promote human health; and 4) ensure every resident has access to a green space or natural area within one-quarter mile. Achievement of these goals in the diverse landscape of species and habitat throughout Los Angeles County requires tailored management strategies to address the different needs of particular areas, habitats, and ecosystems. Historically, ecosystem health has taken a back seat to development throughout much of Los Angeles County. The laws most frequently used to protect and enhance biodiversity, including the Federal and California Endangered Species Acts, are ill-suited to managing continued pressures for land development at the urban fringe because they focus on the recovery of individual species rather than healthy ecosystems as a whole. Our challenge will be to develop new policies and strategies to integrate local biodiversity into the urban fabric as our population grows, in a way that improves our human relationship with nature.

SOLUTIONS

Planning the future of Los Angeles' ecosystems will require an examination of the biological, cultural, and legal dimensions of biodiversity and ecosystem health and their relationship to human health and wellbeing throughout Los Angeles County. A critical first step will be to ascertain the range of species currently inhabiting the area (see above table). This requires innovative techniques for rapidly assessing the species present in an area, tracking wildlife as it traverses the urban matrix, identifying critical habitat islands and patches, and mapping current and future ecosystem health. We also need to understand the gradient of different environments in Los Angeles County – from individual properties and managed public spaces, to vestigial open spaces and protected areas – including the biodiversity and ecosystem health of each, and the impacts of proximity to and interaction with other environments.

Additionally, plans for Los Angeles' ecosystem future must consider the cultural component of biodiversity – that is, what species and ecosystems are favored by Los Angeles communities and cultures, and how human preferences and activities have historically shaped the gradient of landscapes and ecosystems. Public education is also vital, and must be integrated with efforts to enhance biodiversity. For example, relying on native hawks and owls as a strategy to reduce urban rodent populations requires both bringing back the birds and educating the public about their role in the health of their urban ecosystem. New, creative solutions that support biodiversity and ecosystem health are required, including designs for infill structures appropriate to existing backyards and alleys, building regulations that address bird migration, pollinators, and urban agriculture, and improved management strategies to increase the biological connectivity of protected areas.

In 2050, we envision that the health of ecosystems in Los Angeles County will be inextricably intertwined with human health and wellbeing at all levels. Urban planning will emphasize the creative use of open space to encourage native biodiversity, and buffer native species and their critical habitats from the impacts of climate change and an increasing human population. Urban areas will feature expanded open spaces, and will prominently emphasize the integration of biodiversity into the built environment. We envision that all residents will enjoy access to green spaces and natural areas (see above table), which will provide mutual benefits for humans and ecosystems by offering a place for recreation

and exercise, reducing surrounding heat levels, sequestering air pollution, providing a sanctuary for flora and fauna, reducing polluted stormwater runoff, and promoting natural water filtration. Los Angeles will serve as an example that can guide efforts to enhance ecosystem health in other semi-arid urban areas worldwide.

UCLA is the ideal institution to lead the multidisciplinary research effort necessary to realize this future. We have some of the world's top terrestrial and marine conservation scientists, ecologists, conservation genomicists, ecological modeling experts, and remote-sensing and geographic information systems (GIS) practitioners. The campus offers state-of-the-art facilities for genomics, remote-sensing, GIS, and computational data storage, analysis, and modeling. Additionally, UCLA has a leading research group in environmental humanities, emphasizing the historical and contemporary institutional and cultural frameworks that shape ideas, attitudes, and policies about urban space, humans' relation to nature, and biodiversity. Our researchers in public health are leading efforts to better understand and prepare for the consequences of climate change, and investigate the relationship between human health and our urban and natural environments, while our law and policy experts have expertise in natural resource conservation and land use.

FIVE-YEAR ECOSYSTEM HEALTH WORK PLAN

Over the next five years, UCLA scholars and partners will engage in critical research related to healthy, vibrant, and resilient ecosystems that also improve human health and wellbeing. In the first phase of our research, we will assess existing patterns of biodiversity and ecosystem health in Los Angeles County, as well as the drivers of these patterns. This research will involve the development of new technologies and assessment techniques, as well as crowd-sourced "citizen science." The resulting baseline knowledge about the presence and distribution of species and ecosystems, ecosystem health and services, and human attitudes and impacts will fill crucial data gaps and provide an essential foundation for future projects. We will also engage in key research related to enhancing ecosystem health and resiliency, and better integrating ecosystem health and human health. Researchers will develop innovative laws, policies, and wildlife management strategies to restore, protect, and revitalize local biodiversity and ecosystems in a way that is compatible with economic development, incorporating projections of the impacts of climate change, population growth, development, and other environmental stressors. Meanwhile, architects and planners will collaborate to develop innovative and affordable building and infrastructure designs that serve the needs of both humans and wildlife, while protecting local habitats. Other research will study the potential impacts of ecosystem health on humans – both the positive impacts of exposure to healthy ecosystems, and potential threats such as pathogens and disease transmission – and develop strategies to ensure that all communities have access to the benefits of healthy and vibrant ecosystems.

ECOSYSTEM HEALTH RESEARCH HIGHLIGHT 1: LOS ANGELES CONSERVATION GENOMICS

California, and particularly Southern California, is home to the largest set of threatened and endangered plants and animals in the continental United States, making it the most urbanized area to be designated one of Conservation International's global Biodiversity Hotspots (CEPF, 2015). An essential objective of the **Sustainable LA GC** is to document the presence and distribution of species – endangered or common, native or invasive – across Los Angeles. Accomplishing this requires data about the size of rare species populations in urban open spaces, and how effectively species move between parks, across thoroughfares, and across neighborhoods.

Historically, documenting the movements, population sizes, and persistence of species in an urban setting has been all but impossible. Genomics has fundamentally changed that. Just as the toolkit of human genomics has played a critical role battling disease, so has genomic analysis of wild plants and animals served to unlock the secrets of how species move across landscapes. Using conservation genomics, we will engage a core group of biodiversity scientists and urban ecologists, including our superb faculty at UCLA and our partners at the Natural History Museum, The Nature Conservancy, the National Park Service, and municipal, county, and state parks, to identify a set of 60 ecologically diverse species that persist in and around the urban matrix of Los Angeles. We will conduct fieldwork, collect DNA samples, conduct genomic sequencing, and use cutting edge environmental modeling to determine how and at what population sizes species persist, and how their probability of persistence will change as the climate shifts over the coming decades. The results of this research will transform wildlife management in Los Angeles County and beyond by enhancing the ability of agencies to make land acquisition, restoration, use, and management decisions that build resilience into the most vulnerable of local habitats and ecosystems.

This project will take four years to complete, at a total cost of $3,000,000 to perform a genomics evaluation of targeted species in Los Angeles County to inform conservation and restoration strategies.

Objective 1: Assess Biodiversity and Ecosystem Health

a) Establish baseline knowledge of the presence and distribution of ecosystems, habitats, and species in Los Angeles County

- Develop new rapid-sampling and analytic approaches in **aerial and satellite remote sensing and GIS and geospatial modeling** for mapping biodiversity and identifying vulnerable species and critical habitat.

ECOSYSTEM HEALTH RESEARCH HIGHLIGHT 2: CREATING A BIODIVERSITY ATLAS FOR LOS ANGELES COUNTY

Understanding the biological and socio-cultural dimensions of urban biodiversity is a central challenge for conservation, and will become more complicated as cities continue to grow over the coming decades. To enhance our understanding of the biological and cultural dimensions of local biodiversity, UCLA researchers will develop an interactive, web-based Biodiversity Atlas for Los Angeles County.

The biological component of the Atlas will document: 1) patterns of species richness, 2) past, present, and future distributions of habitats, ecosystems, wildlife corridors, and endangered species, and 3) biodiversity health assessments. The cultural component of the Atlas will present the results of a cross-cultural survey of human attitudes toward the range of species included in the biological survey. The survey will generally assess residents' knowledge of and attitudes toward biodiversity, including biases toward certain species and against others, attitudes toward uses of public natural spaces, the historical, cultural, and religious backgrounds that influence current attitudes, and local practices that impact biodiversity, including gardening, pet-keeping, and other activities. The survey will also explore the effects of age and socioeconomic status, two factors that may crucially shape knowledge and attitudes.

This unique resource will serve as an authoritative database of knowledge of local ecosystems and species. Los Angeles residents and other members of the public will be able to access, interact with, and contribute to the Atlas online via a Google Earth interface. The combination of biological and socio-cultural information will provide a baseline from which to design innovative plans for Los Angeles' future biodiversity.

This project is estimated to take three years at a cost of $900,000 to complete the biodiversity and cultural assessments necessary to develop the interactive atlas.

- Develop new rapid-sampling and analytic approaches in **genomics** for identifying species, quantifying intraspecies genetic diversity, recognizing species vulnerable to local extinction, and understanding gene flow and migration corridors between populations throughout the urban-to-wildland matrix (see Ecosystem Health Research Highlight 1).
- Work with local stakeholders to develop internet-based **"citizen science" portals and knowledge archives** that allow members of the public and other stakeholders to participate in collecting and assessing information on animal and plant populations in Los Angeles.
- Utilizing newly developed assessment tools and new and existing data, establish a **baseline of the presence and distribution of Los Angeles' ecosystems, habitats, and species** (see Ecosystem Health Research Highlight 2).

b) Establish baseline knowledge of attitudes toward biodiversity and ecosystem health in Los Angeles County

- Develop and conduct surveys throughout Los Angeles' diverse socio-economic and cultural communities to map residents' **knowledge** of, **attitude** toward, and **perceptions** of particular species, biodiversity, and ecosystem health *(see Ecosystem Health Research Highlight 2)*.

c) Establish baseline knowledge of ecosystem health and services in Los Angeles County

- Develop new, more accurate **methods of analyzing and quantifying ecosystem health** and function across urban and natural areas.
- Develop better metrics to assess **ecosystem services** (i.e., the benefits that habitats and wildlife provide to humans, such as water

filtration, clean air, and space for recreation), and conduct analyses of these services for plants, soil, pollinators, urban predators and their prey, and other key aspects of ecosystem health in Los Angeles.

- Develop integrative, state-of-the-art **atmosphere, ocean, and land models** to facilitate holistic and quantitative assessments of ecosystem function.
- Utilizing newly developed assessment tools and new and existing data, establish a **baseline of ecosystem health and services** in Los Angeles County *(see Ecosystem Health Research Highlight 2)*.

d) Assess the impacts of human activities on ecosystem health in Los Angeles County

- Understand the key **human activities that affect biodiversity** in Los Angeles, including development, gardening, pet-keeping, vegetation clearance, food preparation, outdoor recreation, and activities related to fire suppression.
- Assess the **impacts of non-native species** on native ecosystems in Los Angeles County, as well as local ecosystems' capacity to serve as a remote sanctuary for non-native, non-invasive threatened and endangered species that have made Los Angeles their home.
- Assess the **impacts of renewable energy technologies and infrastructure** on terrestrial, aquatic, coastal, and marine ecosystems, native species, and critical habitat.
- Assess the **impacts of local water capture, treatment, and management** practices on terrestrial, aquatic, coastal, and marine ecosystems, and characterize any **ancillary benefits of new water management strategies** for ecosystem health and services.

ECOSYSTEM HEALTH RESEARCH HIGHLIGHT 3: REIMAGINING THE LAWN

Keeping lawns and outdoor landscapes green accounts for over 50 percent of home water use in Los Angeles. California's record drought has inspired unprecedented efforts to financially incentivize the transformation of Los Angeles' green urban and suburban landscapes with more climate-appropriate alternatives such as Mediterranean landscaping, permeable pavers (e.g., cut stone or porous concrete blocks that allow water to seep through), and artificial turf; but the consequences of these transformations are poorly understood.

Researchers will quantify the impacts of various landscaping approaches in terms of water conservation and quality, flood control, greenhouse gas emissions, local climate effects (e.g., temperature increase), ecosystem health, and economic benefits. The study will determine the potential of each landscaping approach to enhance our urban ecosystems. The study results will better inform water agencies' financial allocations for turf-removal projects, and provide water-conscious consumers with recommendations of the landscape features, plant species, and lawn-conversion approaches that should be incorporated into outdoor landscaping.

The estimated cost of this five-year project is $1,020,000, including $750,000 over two years for an assessment, and $90,000 thereafter for longitudinal assessment of the effects of diverse landscaping strategies implemented to conserve water in Los Angeles County.

Objective 2: Enhance Ecosystem Health and Resiliency

a) Evaluate and plan for the impacts of climate change on ecosystems

- Assess the **implications of climate change** for local plant and animal species, habitats, and ecosystems, including the effects of elevated temperatures, increased fire risk, reduced soil health, and moisture stress; the effects of sea-level rise on coastal habitats and ecosystems; and the effects of ocean acidification and hypoxia on coastal and marine species.
- Assess the implications of climate change for **air pollution and public health** in Los Angeles, and evaluate the role of vegetation in air pollution reduction in both the natural and built environment.
- Develop models to predict the **future abundance and distribution of species, habitats, and ecosystems** in Los Angeles considering climate change, development patterns, expected population change, and other factors.
- Assess the **vulnerability** of Los Angeles County's habitats and ecosystems to climate change, and develop strategies to incorporate ecosystem health planning into local **climate adaptation and mitigation efforts.** This includes evaluations on how the installation of physical structures to protect habitats, such as swales, buffers, and tidal gates affect ecosystem health.
- Develop **land acquisition and restoration priorities, land-use management recommendations, and water and energy project siting criteria** that will enhance ecosystem health considering projected climate and population changes.

b) Integrate biodiversity and ecosystem health into the built environment

- Assess the capacity of the current built environment to accommodate ecosystem health enhancements (e.g., through changes in residential landscaping), and develop **new designs for the built environment that would enhance biodiversity and ecosystem health** at a range of scales, from the single-family house, to the apartment tower, streetscape, and commercial core (see Ecosystem Health Research Highlight 3).
- Redesign the **urban architectural landscape** at the neighborhood and county scale considering projected population growth and habitat protection and contiguity.
- Develop ways to incorporate **cultural preferences**, including preferences for non-native species, into designing a healthy and biodiverse built environment.

c) Restore local ecosystems

- Develop and demonstrate **new restoration ecology technologies** for terrestrial, estuarine, and coastal environments to protect and enhance critical habitat, preserve endangered species, and enhance ecosystem services.
- Identify and assess the **strengths and weaknesses of the federal, state, and local laws and policies** that aim to protect biodiversity and enhance ecosystem health in southern California, including their interactions and any barriers to their full deployment.
- Design **analytic tools, model policies, and new metrics to better inform policymakers'** decisions on the adaptive strategies and technologies necessary to preserve local native species and critical

ECOSYSTEM HEALTH RESEARCH HIGHLIGHT 4: GREEN SPACE, PARKS, AND THE WELLBEING OF CHILDREN IN LOS ANGELES

Many Los Angeles residents lack access to quality green spaces and natural areas, which are associated with a wide range of health benefits such as improved birth outcomes, enhanced cognitive development, better mental health, and longer life expectancy (James et al., 2015). UCLA researchers will use a natural experiment to investigate the impact of access to green spaces on child health. With parental consent, we will enroll in a study 1,000 children living within one km of a planned new park, with two control groups organized by age and located in similar socio-demographic neighborhoods: (1) 1,000 children who are already well-served by nearby parks, and (2) 1,000 children with poor access. Comparing these groups will address a key scientific question: whether the association of green spaces and natural areas to positive health outcomes represents a case of reverse causation, because wealthier, healthier, and more active families choose to live near recreational resources.

This study will incorporate state-of-the-art assessment tools, including images from the Rapid Eye satellite, which can comprehensively characterize the green space in Los Angeles at a five-meter resolution, and a new method developed at UCLA: using Google Maps Street View to conduct detailed audits of local recreational resources. We will also create a mobile phone application that empowers citizen scientists to rate the quality of nearby green spaces and natural areas, and feeds ratings into a UCLA database. Using momentary assessment tools that we have developed for mobile phones, we will evaluate the physical activity, geographic activity patterns, and momentary mental wellbeing of the children in the three study groups. We also will apply advanced development tests to assess potential impacts on the children's cognitive growth.

We expect the results of this study will demonstrate the critical role that green spaces and natural areas play in the physical and mental wellbeing of children in Los Angeles, lending further support to local efforts to improve ecosystem health.

This project will take four years to complete, at a cost of $3,500,000 to assess green space, park quality, and access in every neighborhood of Los Angeles, and to study the natural experiment of a new park opening in an underserviced area as compared to two control groups.

habitat. The resultant **policy and legal recommendations** will strengthen ecosystem health and biodiversity protections.

- Develop, in collaboration with local environmental experts and community stakeholders, **restoration and revitalization plans** for targeted critical habitats such as the Santa Monica Mountains, Griffith Park, the Rim of the Valley Corridor, and the Los Angeles River, San Gabriel River, Topanga Creek, and Malibu Creek watersheds to preserve and enhance native biodiversity, and, in the case of watersheds, attain water quality standards and optimize beneficial water uses.

Objective 3: Integrate Ecosystem Health and Human Health and Wellbeing

a) Assess the relationship between ecosystem health and human health

- Develop a comprehensive framework for assessing how ecosystem health impacts human health and wellbeing in Los Angeles, including (but not limited to) the impacts of air and water quality, the spread of infectious diseases, physical activity, and mental health.
- Quantify the **human health benefits of natural areas, green spaces, and urban farms** in Los Angeles and evaluate how these benefits could be maximized through new policies, programs, and conservation strategies (see Ecosystem Health Research Highlight 4).
- Assess and quantify how the incorporation of specific **active recreation features** (e.g., bike paths, trails, playgrounds) into urban restoration and habitat enhancement efforts like the Los Angeles River Revitalization Plan impact human use and enjoyment of natural resources, particularly for traditionally underserved populations.
- Evaluate the human health and economic impacts of projected climate-related **changes in the incidence of vector-borne diseases**, and work with local planners and policymakers to incorporate this knowledge into solutions that will enhance resiliency.
- Develop and promote **policies, laws, conservation strategies, and other programs** to simultaneously advance ecosystem health and human health and wellbeing, particularly for traditionally underserved populations.

b) Ensure equal access to ecosystem health benefits

- Map different communities' **access to green spaces and natural areas, and use and enjoyment of natural resources and species** throughout Los Angeles County.
- Assess and map **disparities in access to the human health benefits of healthy ecosystems** across Los Angeles populations and neighborhoods.
- Formulate **equity-promoting policies, financing strategies, and plans** to ensure that all communities and populations benefit from, and contribute to ecosystem health in Los Angeles County, including local government and private organization programs to develop and promote natural areas and green spaces in high-need areas.


PIER
CAFE

NEXT STEPS

The ambitious, cutting-edge, policy-relevant research projects compiled in this **Work Plan** represent an unprecedented scale of scholarly vision and interdisciplinary collaboration. UCLA is ready and eager to spearhead this research and the next stages of the **Sustainable LA GC** effort.

Some of the most critical and foundational research projects in each of the three topic areas are already underway with UCLA faculty leadership, student research assistance, and generous funding from the campus and external partners who share UCLA's commitment to the **Sustainable LA GC** goals. Additionally, a team of expert staff dedicated to the **Sustainable LA GC** is actively engaged in efforts to: inspire on-campus engagement; mobilize faculty and scholars through facilitated collaboration; connect teams of researchers and outside partners to pursue critical work; promote research to potential funders; and develop research funding criteria for projects that will be funded internally. The **Sustainable LA GC** team is also working diligently with affiliated faculty and scholars to compile detailed and funding-targeted research proposals specific to each project outlined in this document.

Within the next year, we will release an **Education Plan** and **Communication & Engagement Plan** that detail how the **Sustainable LA GC** will engage students, the public, and key stakeholders. In addition, we will refine strategies to obtain the substantial funding needed to complete and implement the **Work Plan**, and to develop strategic collaborative partnerships to ensure progress towards meeting the **Sustainable LA GC** goals. Furthermore, as research ramps up, we are beginning to lay the groundwork for development of the **Implementation Plan**.

EDUCATION PLAN

Since its inception, the UCLA Grand Challenges initiative has had student immersion experiences at its core. Anticipated student immersion strategies include: integrating new knowledge and discoveries directly into the curriculum in real-time, providing students with research experiences directly tied to the Grand Challenges work, and offering students non-research practical experiences on and off campus that are directly relevant to the Grand Challenges' goals. The ultimate aim of these strategies is to provide the real-world, confidence-building, interdisciplinary experience necessary to prepare UCLA students to be the problem-solvers of the future.

In the case of the **Sustainable LA GC**, our vision is to integrate undergraduate, graduate, and postdoctoral scholars into meaningful educational and training experiences that are driven by the **Work Plan** and **Implementation Plan**. The signature student immersion experience is the **Grand Challenges Undergraduate Research Scholars Program** (GC-URSP), created in partnership with UCLA's Undergraduate Research Centers and the Institute of the Environment and Sustainability. In the 2014-15 academic year, 250 undergraduate applicants vied for 50 slots in the year-long GC-URSP. Enrolled students from 28 different majors were each matched with a **Sustainable LA GC** affiliated faculty member, and engaged weekly in that faculty member's research. These students also met together weekly for a companion course with lectures and practical exercises designed to enhance their understanding of

sustainability issues and the importance of working across disciplines to solve major societal problems. Their participation in the course and concurrent research experience offered them a unique opportunity to build their research, teamwork, and communication skills. The course was an overwhelming success for both the students and the faculty mentors, and is repeating in the 2015-16 academic year.

In addition to the GC-URSP course, UCLA Chancellor Block taught a Fiat Lux seminar on Grand Challenges for 22 undergraduate students in Winter 2015. The UCLA Fiat Lux seminars are designed to provide students with an intimate learning experience aimed at inspiring meaningful

discussion on a topic chosen by the instructor. Chancellor Block's Grand Challenges seminar featured guest faculty speakers from the **Sustainable LA GC** team.

In Summer 2015, we awarded our first **Sustainable LA GC** summer fellowships to support graduate students and postdoctoral scholars working on projects that will advance the **Sustainable LA GC** goals. Ten fellows worked on critical projects ranging from developing a water budget and water balance model for Los Angeles County, to engaging in an energy balance assessment that will ultimately serve as a basis for recommending an optimum energy portfolio for the County. Notably, two fellows worked directly with the Los Angeles Mayor's Office of Sustainability on projects related to electric vehicle infrastructure and energy and water usage prediction tools that can inform conservation and retrofit efforts. The products of the summer fellows' work will form the foundation for continued research in all three **Sustainable LA GC** topic areas.

Building on the meaningful student immersion experiences we have already implemented, we intend to develop a formal **Education Plan** outlining the strategies that will ensure the **Sustainable LA GC** meets its overarching goals for student immersion. The **Education Plan** will address how we will interweave our discoveries into the curriculum, facilitate targeted research training opportunities across disciplines, support UCLA's existing sustainability-related educational programs such as the Education for Sustainable Living Program, and provide fellowship funding for talented students to pursue their degrees while contributing to **Sustainable LA GC** projects relevant to their interests.

COMMUNICATION & ENGAGEMENT PLAN

An important factor in the success of the **Sustainable LA GC** is stakeholder engagement, awareness, and support. Staff and affiliated faculty are actively engaged in public outreach and communication. In 2015, the **Sustainable LA GC** was the feature of numerous public events, meetings with local, state, and national elected officials, UCLA community and alumni events, and a robust social media campaign. Over the next year, we will develop a formal **Communication & Engagement Plan**. This plan will identify key stakeholders (including collaborators, partners, and community beneficiaries), and outline our strategies for engaging them over the next five years and throughout the development of the **Implementation Plan**. We expect to include strategies such as stakeholder workshops, speaking opportunities, events, organizational partnerships, and the inclusion of "citizen science" in our research projects.

In addition to securing the participation of critical stakeholders, the **Communication & Engagement Plan** will identify strategies to promote general awareness about, and build public support for, the **Sustainable LA GC**. A final goal of the **Communication & Engagement Plan** is educating the public about the energy, water, and ecosystem health challenges currently facing Los Angeles. Using culturally conscious communication materials and approaches, we will demonstrate how everyone in our community can make a difference. Public support is critical to effecting the regulatory and behavioral changes that will be outlined in the **Implementation Plan**. We will detail how interested members of the public and potential partners can become involved in the research and help realize the **Sustainable LA GC** goals.

LEADING BY EXAMPLE

As an important and influential member of the Los Angeles community, UCLA will participate in achieving the **Sustainable LA GC** goals through its own actions on our own campus. Many of our campus projects will contribute to sustainability while also serving as test beds for new technologies and strategies, or as living laboratory research projects for student immersion experiences. An example of one living laboratory project was the pilot of the UCLA Water Technology Research Center's ultra-filtration/reverse-osmosis water-cleaning system at the campus cogeneration plant. Another example is the ongoing research on smart electric vehicle charging stations by UCLA's Smart Grid Research Center. This project has more than 100 charging stations installed on campus supporting sustainable commuters, while simultaneously evaluating how electric vehicles and their batteries can support the grid.

"Failure to take constructive action is not an option...Water scarcity is likely to be one of the most severe consequences of population growth and climate change and Los Angeles is particularly vulnerable because of our arid climate and reliance on imported water."

— UCLA Chancellor Gene Block

Although UCLA still has a long way to go in creating a campus that meets the **Sustainable LA GC** goals, we already have made great historical strides. In energy, even with remarkable campus growth over the past two decades, UCLA's greenhouse gas emissions have remained almost level due in large part to investments in energy efficiency. In 2014 we surpassed the 2020 goal of reducing our emissions below 1990 levels through a combination of efficiency, renewables and offsets. We have a 42-megawatt cogeneration plant that is partially fueled by gas from a local landfill. The plant produces a majority of our electricity and emits just one-half the carbon dioxide per kilowatt-hour as the power mix of Los Angeles. Through these efforts and strategies to increase onsite biogas and other renewables, we are making progress towards meeting the 2025 carbon neutrality goal set forth by the University of California President, Janet Napolitano.

The campus has also reduced annual water use by over 100 million gallons since 2000, bringing UCLA about half way to our 2020 target of a 20-percent reduction in potable water use per capita – a goal mandated by the University of California Office of the President for each campus. An intramural field turf conversion project completed in 2015 is projected to save 6.5 million gallons of water a year, while the planned installation of a cogeneration plant water filtration system in 2016 will save 17.3 million gallons annually. Our current approach to water conservation includes water recycling, high-efficiency fixtures such as ultra-low flow urinals, drought tolerant landscaping, and smart climatologically-based irrigation and drip irrigation. UCLA currently captures and reuses 51.1 million gallons of water from autoclaves and other equipment per year.

UCLA has excelled in its efforts to provide sustainable transportation options, and was recognized with the Governor's Environmental & Economic Leadership Award in 2015. We have reduced the employee drive-alone rate to 53 percent, far below the County's 73-percent average, and encouraged 80 percent of student commuters to use sustainable transportation modes. UCLA's transportation efforts over the last 30 years have saved almost 260 million vehicle miles traveled and over 105,000 metric tons of greenhouse gas emissions. Even as our campus has grown, traffic volume has decreased. We stopped building additional parking a decade ago. Our alternative fuel vehicle program continues to reduce emissions, and UCLA's campus shuttle program was among the first in the nation to transition to 100-percent compressed natural gas. The campus is being retrofitted with enhanced bicycle and pedestrian facilities, including innovative green bike lanes, contra-flow bike lanes, "road diets," and the first ever bike counter on a university campus.

With regard to ecosystem health, UCLA keeps an inventory of campus plants, and has conducted various animal surveys through several living laboratory projects and applied student research. In partnership with the Santa Monica Bay Foundation, UCLA hosts a native plant restoration project on Stone Canyon Creek, a small creek that runs through the north end of campus, and another restoration project is under

Drought-tolerant green rooftop on UCLA's Court of Sciences Student Center

consideration for the Sage Hill area of campus. We have transitioned a number of campus common areas to drought-tolerant landscaping, with additional transitions planned. The campus has also made a strong commitment to reducing waste, with a goal of achieving zero waste by 2020. This commitment has a significantly positive effect on the health of our campus population and ecosystem, and that of the region.

The **Implementation Plan** will include specific recommendations regarding UCLA campus sustainability. In the interim, we will continue working concertedly to realize existing campus-wide and University of California System-wide goals.

LAYING THE GROUNDWORK FOR IMPLEMENTATION

By 2020, UCLA researchers from across campus and their partners will have joined together in collaborative efforts to achieve numerous technological breakthroughs, expand the horizons of social and environmental science, generate innovative management and financing models, identify effective tools and incentives for public education, engagement, and behavior change, and break new ground in policy, urban planning, and design. Researchers will have identified solutions to transform renewable energy generation, storage, distribution, and management in Los Angeles County. Significant advancements in water harvesting, treatment, efficiency, conservation, and recycling will allow for the development of a new sustainable, integrated water management system. Researchers also will have compiled a massive database of native species and critical habitat, and devised new ways to measure ecosystem health, assess the potential impacts of climate change and energy and water development, and protect critical habitat. Proposed new policies, management methods, messaging strategies, and urban planning approaches will be available to help Los Angeles meet the challenges of a hotter, more populous future and also improve the quality of life for all of the County's 11.5 million residents by 2050.

"This monumental collaboration has the potential to transform the region, make a major contribution to efforts to cut greenhouse gas pollution, and inspire the world."

— Greg Dotson and Erin Auel, Center for American Progress, November 2014

The completed **Work Plan** research will form the basis for a comprehensive **Implementation Plan** that UCLA will develop in collaboration with key partners and stakeholders. The **Sustainable LA GC** team has already begun to identify scholars with expertise in policy, finance, business, management, and communications who will work closely with researchers, partners, and stakeholders to produce and sequence the recommendations that will inform the **Implementation Plan**. Recommended actions will build on our research findings and span all scales, geographies, and political boundaries in Los Angeles County. We will engage key stakeholders – including other academic institutions, regulatory agencies, elected officials, utilities, landowners, urban planners, business leaders, community organizations, neighborhood associations, and others – in the development and design of all aspects of the **Implementation Plan** to ensure feasibility and widespread support.

Among other components, the **Implementation Plan** will include:

- The **key findings**, technology and program designs, and model policies developed over the course of our five-year intensive research effort, as well as resultant **recommendations** for Los Angeles County and its 88 cities.
- Discussion of **transition management**, including the sequencing and prioritization of implementation measures, as well as strategies to respond to potential challenges Los Angeles may face during the transition period.
- A **stakeholder engagement and outreach strategy**, building on the relationships developed over the course of the **Work Plan**. Among other objectives, the strategy will: ensure stakeholders participate in implementation throughout the process and at all levels; describe how individuals and neighborhood groups can take action to further the **Sustainable LA GC** goals; and establish public education programs and media campaigns to ensure all Los Angeles residents and other interested parties around the world can follow Los Angeles' progress, learn from our experience, and emulate our successes.
- An **evaluation framework** for monitoring progress and success, including progress milestones, measurable interim goals, and mechanisms to collect and assess data and feedback from the public. Adaptive management mechanisms will outline a process for **regular updates** to the plan every five years.

Once executed, the **Implementation Plan** will provide Los Angeles County with a pathway to 100-percent renewable energy and locally sourced water, while restoring and revitalizing our natural and urban environments, allowing residents, species, and ecosystems to ***thrive in a hotter Los Angeles.***


Victory Park


Promenade

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SUSTAINABLE LA GRAND CHALLENGE STEERING (S), RESEARCH (R), AND SCHOLARLY AND TECHNICAL ADVISORY (ST) COMMITTEE MEMBERS:

Richard Ambrose (R), UCLA Fielding School of Public Health
Christopher Boone (ST), Arizona State University
Christy Brigham (ST), California State University, Northridge and National Park Service
Ann Carlson (R), UCLA School of Law
Mikhail Chester (ST), Arizona State University
Dana Cuff (R), UCLA School of the Arts and Architecture
J.R. DeShazo (R), UCLA Luskin School of Public Affairs
Rajit Gadh (R), UCLA Henry Samueli School of Engineering and Applied Science
Jay Famiglietti (ST), Jet Propulsion Laboratory and University of California, Irvine
Tom Gillespie (R), UCLA Division of Social Sciences
Hilary Godwin (S), (R), UCLA Fielding School of Public Health
Alex Hall (S), (R), UCLA Division of Physical Sciences
Ursula Heise (R), UCLA Division of Humanities
Eric Hoek (R), Water Planet Inc. and UCLA Henry Samueli School of Engineering and Applied Science
Cara Horowitz (S), (R), UCLA School of Law
Diana Huffaker (R), UCLA Henry Samueli School of Engineering and Applied Science
Mark Z. Jacobson (ST), Stanford University
Mike Jerrett (R), UCLA Fielding School of Public Health
Alexandra Klass (ST), University of Minnesota
Christine Lee (R), California Institute of Technology Jet Propulsion Laboratory
Dennis Lettenmaier (R), UCLA Division of Social Sciences
Steve Margulis (R), UCLA Henry Samueli School of Engineering and Applied Science
Juan Matute (R), UCLA Luskin School of Public Affairs
Rob McConnell (ST), University of Southern California
Gregory Okin (R), UCLA Division of Social Sciences
Ted Parson (R), UCLA School of Law
Suzanne Paulson (R), UCLA Division of Physical Sciences
Stephanie Pincetl (R), UCLA School of Physical Sciences
Michelle Popowitz (S), UCLA Office of the Vice Chancellor for Research
Gaurav Sant (R), UCLA Henry Samueli School of Engineering and Applied Science
Ben Schwegler (ST), Walt Disney Imagineering and Stanford University
Brad Shaffer (S), (R), UCLA Division of Life Sciences
David Spence (ST), University of Texas, Austin
Nancy Sutley (ST), Los Angeles Department of Water and Power
Richard Wirz (S), (R), UCLA Henry Samueli School of Engineering and Applied Science
Eui-Sung Yi (R), UCLA Now Institute and Morphosis
Maite Zubiaurre (R), Division of Humanities

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OTHER CONTRIBUTORS:

Bridget Ackeifi, Morphosis
Jazmin Barajas, UCLA OVCR
Christina Batteate, UCLA Sustainable Technology and Policy Program
Bruce Dunn, UCLA Henry Samueli School of Engineering and Applied Science
Michael Elliott, UCLA OVCR
Felicia Federico, UCLA Institute of the Environment and Sustainability
Cristina Garcia Fernandez, Universidad Complutense de Madrid
Amy Hawkins, UCLA OVCR
Ann Hirsch, UCLA Division of Life Sciences and David Geffen School of Medicine
Tzung Hsiai, UCLA Henry Samueli School of Engineering and Applied Science and David Geffen School of Medicine
Kelsey Jessup, UCLA Luskin Center for Innovation
Nurit Katz, UCLA Facilities Management
Rachel Kennison, UCLA Division of Undergraduate Education
Adrienne Lavine, UCLA Henry Samueli School of Engineering and Applied Science
Thom Mayne, UCLA Now Institute and Morphosis
Trisha Nguyen, UCLA OVCR
Cully Nordby, UCLA Institute of the Environment and Sustainability
Paul Ong, UCLA Luskin School of Public Affairs
Nikki Parrish, UCLA Sustainable LA Grand Challenge
Katharine Reich, UCLA Center for Climate Change Solutions
Nancy Reifel, UCLA School of Dentistry and Division of Social Sciences
Jill Sweitzer, UCLA OVCR
Aradhna Tripati, Division of Physical Sciences
Justus Winn-Howard, UCLA OVCR
Sarah Wyman, UCLA OVCR
Yang Yang, UCLA Henry Samueli School of Engineering and Applied Science

PHOTO AND FIGURE CREDITS:

Mark Esguerra, p. 4
Morphosis, p. 7
Nurit Katz, p. 8
Alex Hall and Katharine Reich, p. 11
Felicia Federico, p. 11
UCLA, p. 16, 39
cityLAB UCLA, p. 17
Gaston Hinostroza, p. 19
IoES 2015 Environmental Report Card, p. 20, 28
Rajit Gadh, p. 21
Katie Mika, p. 33
Source Data: Trust for Public Land, p. 37
Jake Dobkin, p. 42
Unknown, p. 43
Alison Hewitt/UCLA Newsroom, p. 46

APPENDIX

STEERING COMMITTEE

Hilary Godwin
Spatial & Discipline Integration Committee

Richard Wirz
Energy Committee

Mark Gold
Water Committee

Michelle Popowitz
Office of the Vice Chancellor for Research

Alex Hall
Water Committee

Cassie Rauser
Office of the Vice Chancellor for Research

Cara Horowitz
Ecosystem Health Committee

Brad Shaffer
Ecosystem Health Committee

INTERDISCIPLINARY RESEARCH COMMITTEES

ENERGY COMMITTEE

Ann Carlson
Energy Systems, Climate Change & Environmental Law & Policy

Suzanne Paulson
Characterization of Air Quality & Effects on Health & Climate

JR DeShazo
Energy & Water Economics & Policy

Richard Wirz
Alternative Energy Generation & Storage

Rajit Gadh
Smart Grid Energy Management & Delivery

WATER COMMITTEE

Diana Huffaker
High-efficiency Nanotech-based Photovoltaics

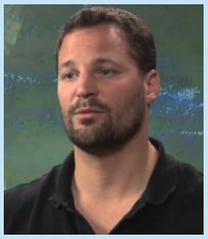
Mark Gold
Water Policy & Coastal Resource Management

Gregory Okin
Physical Geography, Soil, Dust & Renewable Energy

Alex Hall
Climate Science & Regional Climate Modeling

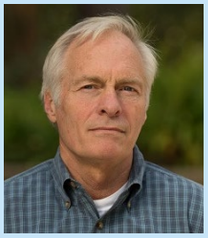
APPENDIX

WATER COMMITTEE (CONT'D)



Eric Hoek
Nano-membranes, Sewage Treatment & Recycled Water

Christine Lee
Remote Sensing for Water Quality Monitoring



Dennis Lettenmaier
Hydrology & Hydrology Climate Interactions

Steve Margulis
Hydrologic Processes & Climate Change

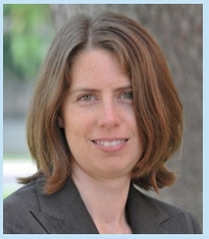
Maite Zubiaurre
Cultural Diversity in Attitudes about Refuse

ECOSYSTEM HEALTH COMMITTEE

Richard Ambrose
Coastal Environmental Assessment & Restoration

Tom Gillespie
Biogeography & Remote Sensing

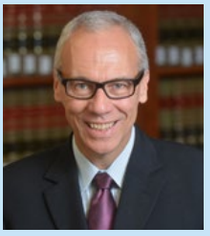
Ursula Heise
Biodiversity & Environmental Humanities



Cara Horowitz
Environmental Law & Policy

Mike Jerrett
Geographic Exposure Modeling & Land Use Characterization

Brad Shaffer
Applied Ecosystem Conservation



Ted Parson
Environmental Law & Science Policy

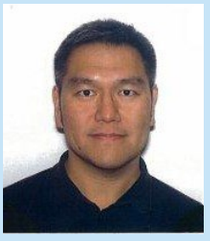
Stephanie Pincetl
Energy & Water Use Policy

SPATIAL & DISCIPLINE INTEGRATION COMMITTEE

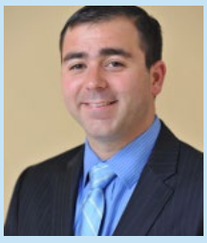
Dana Cuff
Urban Design, Sensing Technologies & Architecture

Gaurav Sant
Sustainable Construction Materials

Hilary Godwin
Public Health Impacts of Climate Change



Eui-Sung Yi
Architecture & Strategic Urban Design



Juan Matute
Sustainable Transportation & Land Use

EXTERNAL SCHOLARLY AND TECHNICAL ADVISORY COMMITTEE

CHRISTOPHER BOONE

Arizona State University

Dean, School of Sustainability and Professor, School of Human Evolution & Social Change, College of Liberal Arts & Sciences

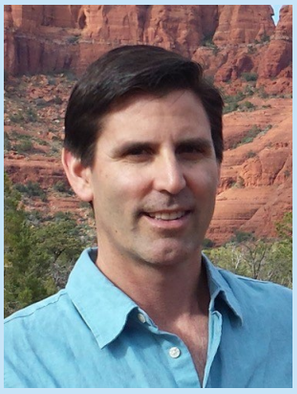
Urban geography, environmental justice and public health with respect to global environmental change

MIKHAIL CHESTER

Arizona State University

Assistant Professor, Civil, Environmental & Sustainable Engineering and Affiliate Faculty, School of Sustainability

Energy and environmental life cycle assessment; resilient infrastructure and climate change



MARK Z. JACOBSON

Stanford University

Professor, Civil & Environmental Engineering and Senior Fellow, Stanford Woods Institute for the Environment

Mapping of alternative energy future; computer modeling and analysis of atmospheric impacts of energy technologies

ROB MCCONNELL

University of Southern California

Professor, Preventive Medicine and Director, Children's Environmental Health Center

Health impacts of air pollution and environmental health policy

DAVID SPENCE

University of Texas, Austin

Professor, Business, Government & Society and Law

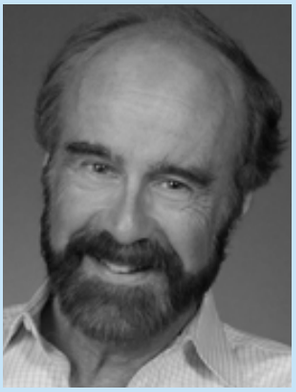
Law and politics of energy regulation and economic regulation in the public utility industry

CHRISTY BRIGHAM

CSU, Northridge

Chief of Planning, Science and Resource Management, Santa Monica Mountains National Recreation Area and Adjunct Professor, Biology

Restoration ecology and impacts of invasive species on native biodiversity



BEN SCHWEGLER

Walt Disney Imagineering and Stanford University

Vice President & Chief Scientist, Walt Disney Imagineering Research & Development; Adjunct Professor, Civil & Environmental Engineering

Sustainable design and engineering of the built environment; novel water treatment technologies

JAY FAMIGLIETTI

Jet Propulsion Laboratory and University of California, Irvine

Senior Water Scientist, NASA JPL and Professor, Civil & Environmental Engineering and Earth System Science

Hydrology and climate change with focus on groundwater

NANCY SUTLEY

Los Angeles Department of Water and Power

Chief Sustainability and Economic Development Officer

Environmental policy, public health and the environment, and energy and climate change issues

ALEXANDRA KLASS

University of Minnesota

Professor, Law and Resident Fellow, Institute on the Environment

Energy law, environmental law, natural resources law, tort law, and property law

Sustainable LA Grand Challenge
c/o UCLA Grand Challenges
2248 Murphy Hall
Los Angeles, CA 90095-1405
Tel: (310) 206-4337
SustainableLA@ucla.edu
www.grandchallenges.ucla.edu