

The background of the slide is a 7x6 grid of 42 maps of North America. Each map shows the continent with a grid of latitude and longitude lines. The maps display different patterns of energy resource distribution, represented by various colors and textures. The colors include shades of green, yellow, orange, and red, indicating different levels or types of resources. The textures range from solid colors to grid patterns and stippling. The maps are arranged in a regular grid, with the text overlaid in the center.

The Energy and Resources Group

University of California, Berkeley

An Overview

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*310 Barrows Hall
Berkeley, California 94720-3050
Phone: 510.642.1640
Fax: 510.642-1085
<http://erg.berkeley.edu>*

Mission Statement



The Energy and Resources Group envisions a future in which human material needs and the needs of a healthy environment are mutually and sustainably satisfied. ERG's mission is to create, foster and transmit the critical knowledge that can make such a future possible.

Who We Are: A Brief History of ERG

For thirty years, the Energy and Resources Group (ERG) at the University of California at Berkeley has provided its outstanding graduate students and exceptional faculty the scholarly conditions in which to

- study the environmental sciences,
- analyze the social causes of our energy and environmental problems,
- undertake field research in a variety of ecosystems,
- engage in cross cultural learning, and
- devise technical and policy alternatives to unsustainable energy and resource use patterns.

The Berkeley Campus offers exceptional opportunities to learn from outstanding scholars in many disciplines. ERG facilitates the placement of specialized knowledge into the larger integrated perspective. Students and faculty incorporating one another's insights, work on alternative energy technologies, ecological economics, terrestrial ecology, environmental justice, resource conflicts, and society and technology. ERG and the term "activist-scholar" are closely associated: Faculty and students alike are motivated by current and foreseeable problems and are encouraged to take what they learn into the full range of educational, political, and policy processes. In this highly interactive academic environment, feasible paths to social justice, appropriate technologies and ecological integrity begin to emerge.

ERG traces its origins to the Committee on Energy and Resources, which was established in November 1972 under the chairmanship of electrical engineering professor C.K. Birdsall as an Advisory Committee to the Vice-Chancellor Mark N. Christensen. The Committee laid the groundwork for an interdisciplinary program of teaching and research in energy and resources and secured for this purpose the first regular faculty position in Berkeley's history to reside entirely in an interdisciplinary unit. John P. Holdren was appointed to fill that position, as Assistant Professor in the Energy and Resources Program, in summer 1973. The program attained degree-granting status as a Graduate Group in late 1974, and admitted its first graduate students in 1975. Mark Christensen was appointed to the core faculty in 1976, John Harte in 1982, Gene I. Rochlin in 1984, Richard Norgaard in 1987, Catherine Koshland in 1995, Daniel Kammen in 1998, Isha Ray in 2002, Alex Farrell in 2003, and most recently two adjunct professors, Ashok Gadgil and Margaret Torn in 2006. The affiliated faculty meanwhile has grown from its initial membership of fifteen to more than one hundred and fifty. As of Fall 2006, more than 350 degrees have been awarded. The current student population stands at about seventy.

Message from the Chair



Daniel A. Farber

Sho Sato Professor of Law
Director, Environmental Law Program

ERG has been devoted to research and teaching about sustainability long before most people had even heard of the word. ERG had also mastered the art of interdisciplinary thought many years before that became a priority for the NSF and others. (I can't tell you how many meetings I've been to on this campus where this priority was stressed.) The need for interdisciplinary research on issues of sustainability is obvious and many people talk about doing such research; the difference is that ERG has actually been doing it. The result has been a brilliant record of research. And there is another trait that distinguishes ERG: the desire to make this research relevant to real world change. The bottom line is that ERG is one of the most exciting places to work on environment, resource, and energy issues in the world. I know that students will find ERG just as stimulating and exciting as I have.

Biographical Sketch

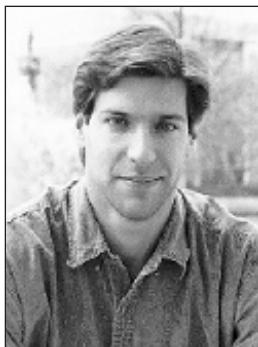
Professor Farber joined the Berkeley Law faculty in 2001, after completing degrees at the University of Illinois in philosophy (BA 1971), sociology (MA 1972), and law (JD 1975). He was a law clerk for Justice John Paul Stevens on the United States Supreme Court. His teaching and writing focus on the areas of constitutional law and environmental law. He has co-authored leading casebooks in both areas, as well as university press books and dozens of law review articles. He has consistently been listed as one of the top ten most-cited legal scholars. His recent research agenda focuses on the legal dimensions of climate change. He was also the founding faculty director of the California Center for Environmental Law and Policy.

Who We Are: Core Faculty



John Harte

holds a joint professorship in the Energy and Resources Group and the Ecosystem Sciences Division of the College of Natural Resources. He received a BA from Harvard University in 1961 and a Ph.D. in theoretical physics from the University of Wisconsin in 1965. He was a NSF Postdoctoral Fellow at CERN, Geneva, during 1965-66 and a Postdoctoral Fellow at the University of California, Lawrence Berkeley Laboratory, during 1966-68. During the next 5 years, he was Assistant Professor of Physics at Yale University and has been at Berkeley since 1973. Harte is a Fellow of the American Physical Society, and in 1990 was awarded a Pew Scholars Prize in Conservation and the Environment. In 1993 he was awarded a Guggenheim Fellowship and was elected to the California Academy of Sciences. In 1998 he was appointed a Phi Beta Kappa Distinguished Lecturer and a Distinguished Ecologist Lecturer at Colorado State University. He is the 2001 recipient of the Leo Szilard prize from the American Physical Society, and has served on six National Academy of Sciences Committees. He has authored over 150 scientific publications, including six books, on topics including biodiversity, climate change, biogeochemistry, and energy and water resources.



Dan Kammen,

the Class of 1935 Distinguished Professor of Energy, received his undergraduate and doctorate degrees in physics at Cornell and then Harvard. While a post-doctoral fellow at Caltech and then back at Harvard he worked on renewable energy technologies and environmental resource management, as well as risk analysis. Prior to coming to Berkeley, he was an Assistant Professor of Public and International Affairs in the Woodrow Wilson School of Public and International Affairs at Princeton University where he helped to develop and then chair the interdisciplinary Science, Technology, and Environmental Policy (STEP) Program. At Berkeley he is the founding director of the Renewable and Appropriate Energy Laboratory (RAEL: <http://rael.berkeley.edu/>) and co-director of the Berkeley Institute of the Environment. His work is highly interdisciplinary, and includes technical, economic, social, policy, and environmental analysis and activism of energy production and use. His focus is on renewable energy, energy policy, and development. His field projects are focused in Africa.

Who We Are: Core Faculty



Catherine P. Koshland

is the Wood-Calvert Professor in Engineering at the University of California, Berkeley, and Professor in Energy and Resources and in Public Health (Environmental Health Sciences). She currently serves as the Vice-Provost for Academic Planning and Facilities. In 2006, she completed 12 years of service as a director and Secretary of the Combustion Institute. She serves on the editorial board of Combustion, Science and Technology. In 1999, she joined a distinguished group when she presented the Nineteenth Annual Steven Manly Memorial Lecturer at the University of California at Santa Barbara. At Berkeley, during 2002-2003, she was the Chair of the Academic Senate; she served as Vice-Chair from January 2001-July 2002. She has been a member of the Integrated Human Exposure Committee of the EPA's Science Advisory Board since 2001. Professor Koshland graduated with a B. A. in Fine Arts from Haverford College, studied painting at the New York School of Drawing, Painting and Sculpture, and received her M.S. in 1978 and her Ph.D. in 1985 in Mechanical Engineering from Stanford University. She joined the U.C. Berkeley faculty in 1984. She teaches engineering, energy and environmental health, emphasizing mechanistic approaches as well as a systems perspective.



Richard B. Norgaard

is Professor of Energy and Resources Group. He received his B.A. in economics from the University of California at Berkeley, M.S. in agricultural economics from Oregon State University, and Ph.D. in economics from the University of Chicago in 1971. Among the founders of the field of ecological economics, his recent research addresses how environmental problems challenge scientific understanding and the policy process, how ecologists and economists understand systems differently, and how globalization affects environmental governance. He is the author of one book, coauthor or editor of three additional books, and has over 100 other publications spanning the fields of environment and development, tropical forestry and agriculture, environmental epistemology, energy economics, and ecological economics. Though an eclectic scholar, he is also among the 1000 economists in the world most cited by other economists. He has field experience in the Brazilian Amazon, Alaska, and Vietnam with minor forays in other parts of the globe. Dr. Norgaard is a member of the Environmental Economics Advisory Committee of the Science Advisory Board of the U.S. Environmental Protection Agency, serves on the Board of the American Institute of Biological Sciences, and has served as President of the International Society for Ecological Economics (1998-2001).

Who We Are: Core Faculty



Gene Rochlin, Emeritus

received his Ph.D. in physics from the University of Chicago in 1966. Having retrained in political science at MIT and Harvard in 1973-74, his subsequent research interests in the cultural, social, political, and organizational implications and consequences of technology have extended to studies of nuclear power and nuclear waste management, nuclear proliferation, and the politics and political economy of energy and environmental policy. As part of his work on large technical systems, he is a principle of the Berkeley High Reliability Project, a multidisciplinary team that has studied the organizational aspects of safety-critical systems such as nuclear power operations and air traffic control. His recent book about the short-term effects and long-term consequences of the increasingly widespread “embedding” of computers as structural elements or organizations, and the attendant creation of new modes of dependence and vulnerability has led to a growing involvement in studies of the potential terrorist threat not only to IT systems per se, but to the many critical systems in society that have come to depend upon them for operational reliability and security. He also teaches courses on the principles, theories, and methods of social studies of science and technology, as well as on social theories of risk. Expanded information on his research and courses can be found at <http://socrates.berkeley.edu/~rochlin/>.



Isha Ray

joined the faculty of the Energy and Resources Group in January 2002. She has a BA in Philosophy, Politics and Economics from Somerville College, Oxford University, and a Ph.D. in Applied Economics from the Food Research Institute at Stanford University. Before coming to ERG, she was an analyst on economics and institutions at the Turkey office of the International Water Management Institute, and then a Ciriacy-Wantrup Postdoctoral Fellow at UCB’s Geography Department. Professor Ray’s research interests are the politics and economics of water, on-farm water use, common property resource management, transnational river conflicts and access to water for the rural and urban poor – especially in developing countries. She teaches courses on research methods in the social sciences, and on development and environment studies. In addition to research and teaching, she has extensive work experience in the non-profit sector on sustainable rural development in India, and international development- and freshwater-related issues.

Who We Are: Adjunct Faculty



Margaret Torn

is a staff scientist in the Earth Science Division at Lawrence Berkeley National Laboratory, where she heads the climate change and carbon management program. She is a biogeochemist who works on the relationship between land use and climate change. She has strong interests in global-change science and its societal implications. She is particularly well known for her work on soil-organic matter dynamics and the role of soils in ecosystem functioning.

Who We Are: Students

ERG's approximately 70 graduate students are geographically and ethnically diverse. About half are in the two masters-degree programs and half in the Ph.D. program. The students come from a wide variety of disciplinary backgrounds in engineering, natural sciences, social sciences, and the humanities; the characteristics they have in common are an ability to cross disciplinary boundaries, an interest in the complex problems at the interface of technology and society, and the intellectual credentials to survive a highly competitive admissions process. Graduates of the program are employed across the United States and around the world in governmental and international agencies, legislative staff positions, national laboratories, public and private utilities, other energy and resource companies, consulting firms, public-interest organizations, and universities.

The students profiled below are typical of the ERG community. Any selection of students in the ERG program would show a broad cross section of interests and experience, community service and technical expertise.



Jaquelin Cochran (*left*). Development programs impact people within a community in different ways. Learning how to assess and understand the significance of these differences has been the motivation for Ms. Cochran's research at ERG. Her dissertation research addresses the meaning of equity in a rainwater harvesting project in rural India. Ms. Cochran lived with villagers for close to a year in order to ascertain their perceptions of fairness in allocating the costs and benefits associated with their rainwater harvesting project. Prior to ERG, Ms. Cochran was both a Peace Corps Volunteer with an energy-efficiency NGO in Poland and a consultant on utility rate design.

Rebecca Ghanadan (*below*) came to ERG with a BS in chemistry and a range of field research around issues of resources and the environment.

For Ms. Ghanadan, ERG, allows her to pursue her interest in interconnections: between energy and society, as well as between developing and more developed countries. Combining techniques from energy analysis, geography and development studies, Ms. Ghanadan's dissertation focuses on infrastructure and basic services in Africa, particularly prospects for improving electricity access in a context of privatization and market reforms. As an ERG student, she has worked closely with NGOs, utilities, and the World Bank and has been involved in



Who We Are: Students

on-the-ground field studies in Tanzania, Kenya, and South Africa. Ms. Ghanadan can also be found hiking in Point Reyes National Seashore or at the Montreal Jazz Festival with her husband and lively ERG friends.



Charles Kirubi (*center, foreground*). Consuming over one million tons of fuelwood annually for cooking and heating water, approximately 20,000 schools in Kenya significantly contribute to the degradation of forests. In response, Mr. Kirubi initiated and managed a revolving fund credit scheme under RETAP, a non-profit, where he trained and supported schools to adopt improved institutional woodstoves as well as tree planting. As team leader from 1998 to 2004, Mr. Kirubi and his team installed improved stoves in about 300 schools and planted over 200,000 trees specifically for fuelwood supply to schools. By 2005, about 50 schools had become self-sufficient in fuelwood supply, thus no longer harvesting trees for fuelwood from the fast-diminishing indigenous forests. In recognition of this Eco-Schools Project, Mr. Kirubi was awarded the Ashden Trust of Renewable Energy (2001). Mr. Kirubi's PhD interests revolve around energy poverty, micro-enterprises and sustainable livelihoods in East Africa.

Richard Plevin earned BS and MS degrees in Computer Science in the early eighties and worked as a software engineer until returning to academia in 2004. He completed his ERG masters degree in 2006. Immediately prior to starting at ERG, he spent eight months in Thailand volunteering with a small non-profit to promote the use of renewable energy, and studying bioenergy and waste-to-energy systems. Mr. Plevin's current research concerns the environmental consequences of different biofuel production pathways, the measurement and modeling of these environmental effects using combined life-cycle and economic analyses, and policies that ensure climate benefits from the use of biofuels.



Who We Are: Students



Carla Peterman developed an interest in market-based mechanisms to mitigate climate change while pursuing an MS in Environmental Change and Management, and an MBA at Oxford University, England. She expanded her business skills and knowledge of the electricity sector by working as an investment banker for the Power group at Lehman Brothers. At ERG, Ms. Peterman is continuing her research in this area, focusing on California energy policies. In Summer 2006, Ms. Peterman interned at the California Public Utilities Commission (CPUC). At the CPUC she worked on an ongoing two-phase electric sector climate change proceeding. The first part of the proceeding is to determine whether California should establish an Environmental Performance Standard (EPS) for generation serving CA, and the second phase is implementing a cap on greenhouse gases for electric utilities.

Tiffany Shih completed her undergraduate degree in biology with a focus on conservation.

After graduating, she performed ecological field research in Costa Rica and subsequently interned at a non-profit organization aimed at promoting sustainable social and business practices. Her overarching goal is to further understand the connection between ecosystem dynamics and human well-being, and the social obstacles that may impede this connection. Specifically, she is interested in using economic tools to study how policies or ecological disturbances effect the ability of humans to obtain their needs in a comprehensive and equitable fashion.



Sintana Vergara (*foreground*) completed her undergraduate degree in Environmental Engineering and came to ERG to learn new ways to solve environmental problems from multiple perspectives. Ms. Vergara has worked on two projects involving Point of Use (POU) water treatment technologies aimed at increasing access to safe drinking water in the developing world. In Bangladesh, she and four colleagues studied behavioral factors associated with treating water before consumption: why people choose to treat their water, and why one method is chosen over another. In Mexico, Ms. Vergara worked to determine where the “UV Tube,” a household-scale treatment technology using ultraviolet light to disinfect water, was appropriate and needed. Ms. Vergara is also interested in

conservation, development and renewables, and loves the freedom ERG provides to explore all her interests.

Positions Held by Recent ERG Graduates

Universities: Adjunct Professor, Norwegian University; Asst. Prof., Oberlin College; Asst. Prof., UC Santa Cruz; Asst. Prof. Arizona State U.; Energy Manager, Stanford University; Professor, National University of Mexico; Asst. Prof. of Environmental Justice, UC Berkeley; GIS Programmer Analyst, UC Santa Cruz; Asst. Prof. Cal State Hayward; Assistant Professor, Rutgers University; Assoc. Prof. UC Santa Cruz; Climate Change Policy Consultant, University of Minnesota; Asst. Prof. University of Toronto; Chair, Resource Economics, Humboldt University, Berlin; Asst. Prof. Sonoma State University; Lecturer, UC Berkeley; Asst. Professor U. of Colorado; Asst. Prof., Brown U; Asst. Prof. Georgetown U; Prof. and Chair of Environmental Studies at Randolph-Macon College; Assoc. Prof., U. of Wisconsin.

National Labs and Think Tanks: Project Leader, National Renewable Energy Laboratory; Staff Scientist, LBNL (2); Principal Research Associate, LBNL; NSF Postdoctoral Fellow, Santa Fe Institute; Senior Research Associate, LBNL; Energy Analysis, LBNL.

Governmental and International Agencies: Program Manager, Climate Change, Global Environment Facility; Technical Secretary, Comision Nacional para el Ahooro, Mexico; AAAS Congressional Fellow, Washington, DC; Portland Energy Conservation, Inc.; Biologist, USEPA; Environmental Sciences Lecturer, California Energy Commission; Senior Fellow and Coordinator, Center for Interdisciplinary Studies in Environment and Development, India; Plan and Policy Analyst at the National Energy Policy Office, Bangkok; Environmental Scientist, USEPA(2); Science Program Manager, CALFED Bay-Delta Program.

Public Interest Organizations: Executive Director, Rockwood Social Change Leadership Program; Project Manager, Coastal Conservancy, San Francisco; Environmental Scientist, SF Estuary Institute; Executive Director, American Red Cross, Montana; Senior Assoc. Institutions and Governance Program, World Resources Institute; Scientist, The Nature Conservancy; Program Officer, Winrock International; Manager, Downstream Strategies; Policy Director, Bay Area Transportation and Land Use Coalition; Executive Director, Recycled Paper Coalition; Groundwater Services, Inc.; Executive Director, Alternatives for Community and Environment; Director, Clean Vehicles Program, California Operations; Program Manager, Climate Change Program , The World Bank; Manager, Renewable Energy Program, Winrock International, Nepal; Policy Analyst, Greenpeace Clean Energy Now!; Program Officer, Energy Foundation; Program Director, Center for Genetics and Society; Deputy Program Manager, Oceans, Environmental Defense Fund; Energy Specialist, World Bank.

Energy Supply Industries: VP, Product Management, Ecos Technologies; Associate Director, Sustainable Resources Group Intl., Inc.; Principal, ICF Energy Solutions; Sr. Project Manager, PG&E; President, sustainable Energy Advantage, LLC; President, Altertec, Inc., Guatemala; Energy Efficiency Program Manager, Opinion Dynamics Corporation; Environmental Advisor to the President of Minera Alumbreira, Ltd., Argentina; Vice President, Bevilacqua-Knight, Inc.; Environmental Analyst, Arc Ecology; President, Schott Applied Power Corporation; Energy Engineer, Taylor Engineering.

Energy & Environmental Consulting: Consultant, Silicon Energy; Independent Consultant; Associate, MRW Associates; Senior Consultant, Quantum Consulting Inc.; Consultant, i2 Technologies; Consultant, Hagler Bailly Consulting; Consultant & Translator; Consultant, Swedish National Energy Administration; Ecological Economist, Fisheries Program, Ecotrust; Sustainable Energy Consultant.

Other: High school teacher for environmental studies; President CEO, Woodland Park Zoo; Writer/Journalist/Educator; Teacher (2); Editor, EPRI Journal; Senior Software Manager, Arescom, Inc.

ERG's approach to instruction has had a major impact on the way introductory interdisciplinary environmental science is taught in America.

ERG courses address important subjects not otherwise available on the Berkeley campus, and they attract a diverse audience from outside ERG; ER100 draws undergraduates from a wide variety of majors; ER102 is a required course in the undergraduate Environmental Sciences major as well as in ERG, and also draws upper-division undergraduates and first-year graduate students from a variety of science and engineering majors; ER120 draws a mixture of ERG and engineering students; ER280 draws political science and political economy of industrial societies students, as well as students from the Colleges of Engineering and of Natural Resources; the graduate courses draw, in addition to ERG's own students, primarily graduate students from engineering, public policy, the College of Natural Resources, and the business school. Evaluations of the courses and their instructors have been very positive.

Thanks to the distribution of syllabi and problem-sets, as well as the work of ERG graduates who have gone on to teach at other institutions, a number of ERG courses have served as models for similar courses at other universities. ERG100 has influenced offerings at MIT, Stanford, and Princeton; versions of ER102 are offered at Maryland, Illinois, and UC Santa Cruz; ER292 has been adopted at several universities.

Courses

ER100	Energy and Society (Prof. Kammen)
ER102	Quantitative Aspects of Global Environmental Problems (Prof. Harte)
ER120	Renewable Resources for Electric Generation (Prof. Kammen)
ERC130	Analysis of Environmental Data (Prof. Kirchner) (Cross listed with EPS C120)
ER151	The Politics of Energy and the Environment (Staff)
ER170/270	Environmental Classics (Profs. Kammen & Ray)
ERC180	Ecological Economics in Historical Context (Prof. Norgaard) (Cross listed with Envecon C180)
ER200	Interdisciplinary Methods (Profs. Norgaard & Farrell)
ERC202	Modeling Ecological and Meteorological Phenomena (Profs. Harte & Powell) (Cross listed with Integbi C271 & ESPM C211)
ERC205	Quantitative Methods for Ecological and Environmental Modeling (Profs. Harte & Powell) (Cross listed with IB C205 & ESPM C205)
ERC226	Photovoltaic Materials: Modern Technology in the Context of a Growing Renewable Energy Market (Prof. Kammen) (Cross listed with Mat Sci C226)
ER254	Electrical Power Systems (Prof. Farrell)
ER 273	Research methods in Social Science (Prof. Ray)
ER275	Water and Development (Prof. Ray)
ER280	Energy Economics
ER292A	Tools of the Trade (Prof. Kammen/Milman)
ER292B	Tricks of the Trade
ERC293A	Technology and Sustainability
ER295	Energy and Resources Colloquium (Prof. Kammen)
	Doctoral Seminar
	Masters Seminar

What We Do: Research

ERG provides a dynamic research environment in which students, core faculty, and affiliate faculty communicate and collaborate freely and actively. This rich and diverse network of scholarship is represented in ERG's broad research themes. Most of these themes are not "fields" as defined by traditional academic departments. They have emerged through ERG's integrative approach to research, and through applying our research to energy and resource problems at home and abroad.

Ecological Economics

Richard Norgaard

Technology, Development and Society

Dan Kammen

Catherine Koshland

Isha Ray



Global Change Science

John Harte

Dan Kammen

Margaret Torn

Governance Challenges

Dan Kammen

Catherine Koshland

Consumption, Resources Use and Equity

Dan Kammen

Isha Ray

Catherine Koshland

Ecological Economics

Ecology and economics underlie two dominant and diametrically opposed analyses of the human dilemma. From an ecological perspective, economic activity needs to be restrained and redirected to sustain ecosystems and maintain their resilience. From an economic perspective, ever greater economic activity is necessary to meet the needs of the poor and expand economic opportunities for all. In spite of this prescriptive contradiction, both economics and ecology address complex systems. Ecology draws on economics for some of its concepts and frameworks, and economics looks to evolutionary and ecological thinking occasionally. Yet neither economics nor ecology include both systems in their analyses, so neither is in a position to make prescriptive arguments about our future. For these reasons, the field of ecological economics has arisen to generate new and richer understandings of the dynamics between economic and ecological systems to better inform politics and policy.

ERG faculty and students have already contributed to the emerging field of ecological economics in several ways and the exceptional community of faculty and structure of ERG give Berkeley a strong comparative advantage in ecological economics research in the future. Some promising new directions include: 1) expanding ecological and evolutionary models to include economic systems; 2) applying expanded models to critical issues including biodiversity loss, climate change, new technologies, and globalization; 3) enlarging our understanding of values and valuation processes in the resolution of environmental conflicts; and 4) drawing lessons from the history of economics and ecology, to guide the development of practice for ecological economics.

Technology, Development and Society

At different places on earth, resources such as energy and water are both critically scarce and wastefully consumed, while resource supply systems and use patterns create some of the most significant environmental impacts that we face. These impacts range from air pollution to water shortages, and from deforestation to global climate change. The outcomes are the result of myriad individual and collective choices, combined with the technological capabilities we have developed. ERG research on technology, development and society focuses on understanding those choices, developing the tools for making more informed choices, and applying those tools to expand the range of technologies that can improve people's lives while sustaining the environment.

Key issues include the urgent need to use land, energy and water more efficiently and more equitably than we have done in the past; and to ensure that negative environmental impacts of current and future resource use are mitigated or minimized. This will take imaginative policies, new technologies, innovative uses of existing technologies, and new institutional arrangements both locally and internationally. Specific questions addressed by ERG research include: What is the role of new energy sources, such as hydrogen, in our energy future? How can the more than one billion people without safe water and energy - most of whom live in the rural South - gain access to these life-sustaining resources? How can technologies and policies combine to protect human well-being as well as environmental health? What is the role of technology in the development of a resource-conserving society, and what is the role of society in the development and use of technologies?

What We Do: Research

Global Change Science

The overarching goal of ERG Global Change research is to understand the interdependence of human well-being and the health of ecosystems. ERG research focuses on the effects of human actions on, and the linkages among, biodiversity, ecosystem structure and function, and climate. This work spans a range of scales, from plot to landscape to global, and utilizes field manipulation experiments, the analysis of patterns in nature, and mathematical modeling. Specific current goals are to understand the extent to which ecosystem responses to climate change may result in feedbacks to climate that can either ameliorate or exacerbate global warming, and to develop, test, and apply to conservation issues, a general theory of the scaling properties of the distribution and abundance of species.

The primary site of field research is the Rocky Mountain Biological Laboratory in Colorado, with other work conducted on the Tibetan Plateau of China and the Marin Headlands and the Sierra foothills of California. A series of projects is also underway in Africa and Mexico to understand the impact of biomass use on global biogeochemical cycles. Current field projects include investigations of ecosystem response to manipulated climate change in a sub-alpine meadow, the effects of plant species richness on ecosystem functions, effects of invasive species and erosion episodes on soil carbon, and the relative role of climate and plant species composition on the carbon cycle along a forested climate gradient. Theoretical work is focused on the search for a unified understanding of the origin of, and the linkages among, power laws characterizing patterns in the distribution and abundance of species.

Governance Challenges

One of the major elements of ERG social science research for the new century will be exploring the challenges to governance that are emerging from the increased and complex linkages between and among problems and their consequences. At all levels from local to global, governments are faced with the need to anticipate indirect and long-term effects of their actions, ranging from the local health consequences of fuel choices to the global consequences of allowing or restricting emissions of greenhouse gases. ERG faculty and students are deeply engaged in the complex technical, economic, social, and political debates surrounding these and other issues such as deregulation and restructuring of electrical systems and protection of biological diversity. Particularly important research foci have been management options for public goods (such as communal water sources or forests) in the face of efforts to privatize resources; and the implications of increasing urbanization and resource inequities for our ability to govern the planet.

Potential new avenues of research are opening up at home and abroad, where energy and environmental studies involving ERG faculty, students, and affiliates in Africa, Latin America, North America, Europe and Asia are raising questions about both the reliability and range of the scientific-technical and socio-political bases for decision-making. This research has deepened our understanding of the processes by which technical knowledge informs decision-making. It is trite but true to say that we live in an increasingly connected world. What is not well understood are the indirect and long-term consequences of that connectivity. Many of us at ERG are working in one way or another on the central problem of whether and how societies can learn to adapt or transform historical patterns of governance to better address the range of irreversible, long-range, and cooperative decisions that need to be made.

What We Do: Research



Consumption, Resource Use and Equity

Anthropogenic environmental damage was once thought to come primarily from toxic substances that polluted the natural environment, and that such damage could be eliminated by technological innovation. We now know that problems are also caused by excessive flows of (otherwise benign) substances such as carbon or nitrogen, and by land conversions that reduce biodiversity. This new perspective would measure the mass and energy that humanity is moving about, and the land we are transforming for human use, in addition to analyzing traditionally-defined pollution. ERG has always been concerned with the human footprint on the natural world. Our new research illuminates the connections between consumption and the environment, by comparing societies with diverse patterns of energy and resource use, and by questioning the economic and social forces that drive particular consumption patterns.

Understanding the culture of consumption leads naturally to questions of equity and inequity. Local and global inequities are a major impediment to healthy environments and sustainable economies. Globally, 86% of private goods are consumed by the richest 20% of the population while the poorest 20% consume only 1.3%. In the United States, poverty, minority status, and exposure to environmental hazards are strongly correlated. Yet alleviating inequalities simply by raising the consumption of the poor will dramatically exacerbate environmental stresses. Research at ERG is motivated by the understanding that, over time, less resource-intensive consumption and more equity in resource access are critical to progress in energy and environmental problem-solving.

Research that links consumption, resources and equity is driven by four underlying questions: What are effective, affordable, and fair responses to the threats of global climate change? How can environmental rights be defined and protected for future generations? What are the pathways that connect population, consumption and the environment? What are the practical and philosophical connections between resource use and healthy societies?

What We Do: Faculty Research

JOHN HARTE

published “Consider a Cylindrical Cow” [1], a more advanced sequel to his earlier “Consider a Spherical Cow”. His acceptance speech for the American Physical Society’s Leo Szilard Prize [2] posed the challenge of unifying the Darwinian and Newtonian approaches to global change science and has triggered several plans for symposia and workshops on the topic including one in Japan and one at the Aspen Center for Physics.

With his students, Harte developed a method for using annual growth rings of semi-arid land shrubs to determine how climate affects shrub growth, and applied the technique to characterize sagebrush range expansion in the subalpine Rockies under global warming [3]. With his students he also showed that observed soil organic matter loss under manipulated climate change in the Rockies was mediated by vegetation responses to climate change, not by direct effect of warming on soil decomposition [4] and that phenological responses to warming were predictable from environmental gradient analysis [5].

1. J. Harte, *Consider a Cylindrical Cow: Further Adventures in Environmental Problem Solving*. University Science Books, Sausalito, CA (2001) 211 pp.
2. J. Harte, “Toward a synthesis of the Newtonian and Darwinian worldviews”, *Physics Today*. October: 29-34 (2002).
3. T. Perfors, J. Harte, and S. Alter, “Enhanced growth of sagebrush (*Artemisia tridentata*) in response to manipulated ecosystem warming.” *Global Change Biology* 9 1-7 (2003).
4. S. Saleska, M. Shaw, M. Fischer, J. Dunne, M. Shaw, M. Holman, C. Still and J. Harte, “Carbon-cycle feedbacks to climate change in montane meadows: results from a warming experiment and a natural climate gradient”, *Global Biogeochemical Cycles* 16 2001gb001573 (2002).
5. J. Dunne, J. Harte, and K. Taylor, “Response of Subalpine Meadow Plant Reproductive Phenology to Manipulated Climate Change and Natural Climate Variability”, *Ecological monographs* 73 (1):69-86 (2002).

What We Do: Faculty Research



DANIEL KAMMEN

Professor Kammen's research projects are focused on clean energy technologies, and explorations of future energy systems for the U. S. and developing nations. He directs the Renewable and Appropriate Energy Laboratory (<http://socrates.berkeley.edu/~rael>) where many of these projects are based. ERG and RAEL were recently named by the U. S. Department Energy and the California Energy Commission as a regional 'applications' center for research and outreach on combined heat and power as well as distributed energy systems. Recent activities include:

- Published a series of papers on the health effects of indoor air pollution in developing nations, including the first ever analysis of the exposure-response relationship between smoke from biomass cooking and acute respiratory infection, a leading cause of illness worldwide.
- Conducted a series of research projects on the economic and environmental impact of an expanded focus on clean energy policies for the United States. These research papers and reports formed the basis for a series of testimonies that Kammen presented before U. S. House of Representatives and Senate Committees. A central goal of this work is to examine the potential for 'deep cuts' in greenhouse gas emissions while strengthening the economy.
- Worked with his students and colleagues in Kenya, Mexico and Sri Lanka to examine the growth, opportunities, and the obstacles, in clean energy markets in developing nations.
- Worked with Federal agencies to research and inform energy and environmental policy. Most recently, RAEL became the first university partner of the U. S. Environmental Protection Agency on the *Healthy Homes* initiative, and he served on the Nuclear Energy Research Advisory Committee (NERAC) for the U. S. Department of Energy's examination of the next generation of nuclear power options ('Generation IV').
- Conducted a series of studies of the economics of hydrogen production for use in fuel-cell power plants and vehicles. A key aspect of this work is to examine the opportunities for a dramatically new, *distributed energy* future. This work includes the potential for vehicles to serve as mobile power plants.

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What We Do: Faculty Research

CATHERINE KOSHLAND

Catherine Koshland and two Berkeley students published one of the first critical reviews (1) of the literatures and concepts in the emerging field of industrial ecology. The paper has had an ongoing impact on the field, and its key ideas were recently reconsidered in a retrospective review.

With ERG student Pam Franklin, and Berkeley colleagues, Catherine Koshland played a key role in the assessment of the impacts associated with the use of MTBE (methyl tertiary butyl ether) as a major component of reformulated gasoline. This work ranged from basic combustion science contributions about the by-products of MTBE (2) to an assessment of the dynamics of the regulatory policy process (3). As part of a University of California team addressing the MTBE issue, this work played a key role in the state's decision to phase out the use of MTBE.

Catherine Koshland continues to work at the intersection of health, energy and air quality (4), pursuing fundamental studies of the characteristics of combustion generated nanoparticles as well as PM 2.5. Of particular interest is the impact of technological innovation and intervention (5) on exposures to air pollution, reflected in current studies in China on shifting fuel sources and appliances for cooking and heating (9), as well as studies on diesel particles (6). Other recent work has focused on the production and impacts of nano-particles (7,8), particularly those produced in combustion systems.

1. O'Rourke, D., Connelly, L. and Koshland, C. P. (1996) "Industrial Ecology: A Critical Review," *International Journal of Environment Pollution (IJEP)*, Vol.6, Nos2/3, pp.89-112.
2. Franklin, PM, CP Koshland, D Lucas, RF Sawyer. (2001) "Evaluation of combustion byproducts of MTBE as a component of reformulated gasoline," *Chemosphere* Vol. 42, No. 5-7, pp 859-870.
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4. Koshland, C. P. (1996) "Impacts and Control of Air Toxics," *The Twenty-sixth Symposium (International) on Combustion*. The Combustion Institute.
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8. Choi, J. H., Stipe, C.B., Koshland, C. P., Sawyer, R.F., and Lucas D. (2005) "NaCl Particle Interaction with 193 nm Light: Ultraviolet Photofragmentation and Nanoparticle Production," *Journal of Applied Physics*.

What We Do: Faculty Research



RICHARD B. NORGAARD

currently serves on the Independent Science Board of CALFED (California Bay-Delta Authority) and as Treasurer on the Board of Directors of the American Institute of Biological Sciences. He is the most recent recipient of the Kenneth E. Boulding Award presented at the 9th biennial meeting of the International Society for Ecological Economics in Delhi, December 2006.

Norgaard is studying how scientists from multiple disciplines can work together to understand complex systems. The scientific assessments of the Intergovernmental Panel on Climate Change (with Paul Baer, ERG PhD 2005) and the Millennium Ecosystem Assessment are his case materials though he is also looking at the scientific aspects of conflict resolution in California water controversies.

He recently completed work in the area of trade, environment and governance with Xuemei Liu (Agricultural and Resource Economics, PhD, 2001) and with ERG graduate student Ling Jin. In addition, he is once again pursuing coevolutionary explanations of social and ecological change with postdoctoral scholars Georgos Kallis and Lee Worden.

1. Norgaard, Richard B. and Xuemei Liu. forthcoming. "Market Governance Failure," *Ecological Economics*.
2. Sneddon, Christopher, Richard B. Howarth, and Richard B. Norgaard. (2006) "Sustainable Development in a Post-Bruntland World," *Ecological Economics* 57(2):253-68.
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What We Do: Faculty Research

GENE ROCHLIN, *Emeritus*

continues to play a leading role in the global conference series on large technical systems, which has produced, inter alia, six volumes to date. He continues his research into the political, organizational and institutional problems that arise from our increasing dependence upon various forms of information technology (IT) for performing a variety of tasks ranging from personal communication to international banking [1,2]. He has also extended his research into highly reliable organizations to the study of the role of IT in the creation, mitigation, and management of uncertainties, crises, and risks [3,4].

Drawing on his work on crisis management and organizational reliability, Rochlin has been working with colleagues at Berkeley and elsewhere on the design of a research program on political and institutional responses to the problems of international security in an era of global networking, terrorism and nontraditional warfare, where an opponent's capabilities, scope, location, and even identity may be difficult to ascertain. In this capacity, he has been active in organizing the first and (upcoming) second conferences on information technology and national security, in cooperation with the Office of Homeland Security, the National Science Foundation, the National Institute of Justice, and the Tucson Police [5].

Prof. Rochlin is also working in collaboration with colleagues from the Departments of History and Nuclear Engineering on a study of the social, institutional, and organizational elements of U.S. nuclear waste policy, from its origins in the 1950s through the present.

1. Rochlin, G. I. (1997) *Trapped in the Net: The Unanticipated Consequences of Computerization*. Princeton: Princeton University Press, 1997. (also translated into Chinese, Portuguese, and Romanian).
2. Rochlin, G. I. (2001) "Networks and the Subversion of Choice: An Institutional Manifesto." *Journal of Urban Technology* 8 (3) (2001): 65-96.
3. Rochlin, G. I. (2001) "Les Organisations «Hautement Fiabiles»: Bilan et Perspectives de Recherche." In Mathilde Bourrier, ed., *Organiser la Fiabilité*, Coll. Risques collectifs et situations de crise. Paris, l'Harmattan: 24-58.
4. Rochlin, G. I. (2002) "Safety as a social construct: the problem(atique) of agency." In J. Summerton and B. Berner, eds., *Constructing Risk and Safety in Technological Practice*. London, Routledge: 123-139.
5. Rochlin, G.I. (2003) "Mind the Gap! Advanced Networked Informatics and the Limitations of Organizational Adaptability." Invited paper at the joint NSF/NIJ symposium on informatics and national security, Tucson Arizona, June 2003 (to be published).

What We Do: Faculty Research



ISHA RAY

conducts research on productivity and equity in the use of water in developing countries -- with a particular focus on access to water for small farmers and poor consumers. Her analyses have challenged the conventional wisdom in agricultural economics that raising farm water prices will lead to higher levels of water conservation [1, 4]. Her research in western India [2] and Turkey has elucidated the agricultural and political economies of farmer-level cooperation over water. Such cooperation is essential for sustainable and equitable water management in semi-arid agriculture. Ray has worked with colleagues from Berkeley and the Middle East to show that creative environmental diplomacy among Jordanians, Palestinians and Israelis, over e.g. food trade, agricultural pest management and wastewater re-use, has great potential to foster cooperation at “track-two” levels [3].

Isha Ray’s ongoing research projects include a study of the health and economic outcomes of community-based drinking water systems in rural Mexico, and of the social impact of very low-cost information technology applications in rural India. In addition, she is co-editing a book comparing and contrasting the approaches taken by economists and anthropologists to the study of common property resources such as water, forests and common lands.

1. Ray, Isha (2003) “Get the prices right: water prices and irrigation efficiency in India,” Forthcoming in F. Molle, J. Berkoff and R. Barker (eds.) *Irrigation Water Pricing in Context: Exploring the Gap Between Theory and Practice*.
2. Ray, Isha and Jeffrey Williams (2002) “Locational asymmetry and the potential for cooperation on a canal,” *Journal of Development Economics*, 67: 129 - 155.
3. Ray, Isha, Gershon Baskin, Zakaria al-Qaq and W. Michael Hanemann (2001) “Environmental diplomacy in the Jordan Basin,” *Institute of Global Conflict and Cooperation Policy Paper* 42.
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