

# Southern California Environmental Report Card 2006

UCLA INSTITUTE OF THE ENVIRONMENT

RC 2006

Institute of the Environment  
University of California, Los Angeles  
619 Charles E. Young Dr. East  
La Kretz Hall, Suite 300  
Los Angeles, CA 90095-1496  
Phone: 310-825-5008  
Fax: 310-825-9663  
Email: [ioe@ucla.edu](mailto:ioe@ucla.edu)  
Web site: <http://www.ioe.ucla.edu>



**This Report Card is printed on 100 percent post-consumer waste paper that is manufactured with windpower.**



**Natural resource savings from using recycled post-consumer waste fiber in lieu of virgin fiber for this publication:**  
*43 trees preserved for the future*  
*124 lbs. waterborne waste not created*  
*18,268 gallons wastewater flow saved*  
*2021 lbs. solid waste not generated*  
*3980 lbs. net greenhouse gases prevented*  
*30,464,000 BTUs energy not consumed*

**Savings from the use of emission-free wind-generated electricity:**  
*2068 lbs air emissions not generated*  
*4920 cubic feet natural gas unused*  
(savings are equivalent to planting 140 trees or not driving 2240 miles)

# Contents

RC 2006



**Urban Parks**



**Innovations in Environmental Monitoring**

2

**From the Director**

4

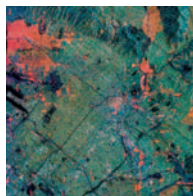
**Film and Television**



12

20

**Atmospheric Deposition**



30

38

**About the UCLA Institute of the Environment**



# From the Director



**Mary D. Nichols, J.D.**

Director

UCLA Institute of the Environment

Southern California is one of the world's most urbanized areas, and also one of its most biologically rich and diverse. The region is in many respects a tangle of contradictions. It boasts some of the world's best-known beaches, and some of the most challenging problems with urban runoff. The motion picture industry settled here to enjoy the year-round good weather and bright skies for filming, then beamed a noir vision of envi-

ronmental degradation and civic corruption around the globe. Having created and identified smog, the Los Angeles region designs and purchases more advanced-technology and alternate-fueled vehicles than any other metropolitan area. Given these contrasts, it should be no surprise that UCLA, the biggest university in the state housed on the smallest campus in the giant UC system, has pioneered in creating cross-cutting and interactive models for research, teaching and public service dedicated to solving the most challenging environmental problems facing humans and our planet.

Now almost a decade old, the Institute of the Environment has inspired and collaborated with innovators across the globe who are grappling with some of the same fundamental problems. The more we learn about the environment, the more we realize no field of knowledge can be overlooked in an effort to understand the dynamic relationship between people and the natural world. Art, politics, business and history must find ways to interact with science, medicine and technology—and more—as each of these

disciplines becomes more sophisticated and specialized.

Starting at the most basic unit of undergraduate education, this year the Institute launches the first Environmental Science degree to be offered at UCLA. This new degree is the result of an unprecedented collaboration between 17 departments, including courses offered by the School of Public Health and the School of Public Affairs. It builds on the recognition that environmental science is inherently multi-disciplinary: the Institute provides a year-long seminar involving community experts and visiting scholars as well as faculty from around the campus. Students will also learn some of the practical applications of environmental science through a capstone course that will engage them in real-world environmental problems.

As one of the premier research universities in the world, UCLA continues to foster collaborative environmental research projects involving faculty in the social sciences and policy studies, working with colleagues in physical sciences, engineering and life sciences to answer questions of pressing concern. The pub-

## **UCLA has pioneered in creating cross-cutting and interactive models for research, teaching and public service dedicated to solving the most challenging environmental problems facing humans and our planet.**

lication you now have in your hand—or on your computer screen—illustrates a small sample of the kinds of research underway.

The Southern California Environmental Report Card is one example of an innovative means of engaging the public and the university in an informed discussion. The 2006 Report Card is the ninth in a series of annual updates on the state of the region's environment. Both the UCLA Institute of the Environment and the topics we study have evolved rapidly over a relatively short time, but the Report Card retains its original form and function: a collection of brief essays on important environmental topics, presenting the researchers' findings in a context meant to be useful to both policy makers and the public. The faculty authors do their own grading and the grades are published as a familiar way of giving feedback on how various agencies and institutions are doing in maintaining and improving our natural environment.

Editors Ann Carlson, Professor of Law, and Arthur Winer, Professor of Environmental Health Sciences in the

School of Public Health, have selected four articles that demonstrate how our understanding of the environment and the ways in which we study it have changed. For the first time, a single industry—or in this case what Hollywood calls The Industry—is put under the microscope and examined for its environmental performance. Professors Charles Corbett and Richard Turco took on this intriguing assignment at the request of the California Integrated Waste Management Board, and their work has shown how complex and important it is to analyze our environment by economic sector.

This Report Card next looks at parks as an indicator of the health of a city and its people. We tend to think of Nature as something that exists on the outskirts of the urban area, along the coast, near the ocean, or in the mountains and deserts that surround us. But as recent surveys of the Los Angeles River show, small bits of open land can harbor biodiversity in the most densely developed areas. For humans, especially children, lack of access to open land is increasingly linked to the rise in obesity and diseases

related to a sedentary lifestyle, including diabetes and heart ailments. Professor Anastasia Loukaitou-Sideris reports increased focus on urban parks as integral parts of a healthy environment.

The third article offers a fresh perspective on issues the Report Card has addressed before. Air pollution and water pollution are both long-standing and serious problems that continue to undermine both human and ecosystem well being. Professor Keith Stolzenbach shows the role of gases and particles in the air as direct and indirect sources of water pollution within the Los Angeles basin. A more sophisticated understanding of the relationships between air and water in turn can lead to more effective efforts to control the sources.

In their collaborative essay on environmental monitoring, Professors Rundel, Estrin and Kaiser point out that rapid advances in sophisticated technology are helping to frame new scientific questions that in turn allow us to understand how natural systems respond to human activity, such as the buildup of

*continued on page 39*



# Film and Television

GRADES A to C

by Charles J. Corbett, Ph.D., Associate Professor of Operations and Environmental Management  
and Richard P. Turco, Ph.D., Professor, Department of Atmospheric and Oceanic Sciences

The motion picture (or film) industry holds a powerful and enduring sway over the imagination of people across the globe through images served up on the “big” screen. However, in watching film—or television—it is easy to overlook the sprawling industry that lies behind the scenes, bringing entertainment to life. Even less obvious are the environmental impacts of filmmaking, which involve energy consumption, waste generation, air pollution, greenhouse gas emissions and physical disruptions on location.

This article assesses the potential environmental effects associated with activities in the film and television industry (FTI) from several perspectives, keeping in mind that only limited data are available for such an assessment. Indeed, our analysis relies heavily on information collected during a recent two-year study carried out by UCLA’s Institute of the Environment under contract to the California Integrated Waste Management Board (CIWMB). The research is based in part on interviews with a cross section of individuals, but with limited access to proprietary infor-

mation. Hence, our findings are more illustrative than comprehensive regarding current environmental practices within the FTI.

In this overview, we first provide estimates of chemical emissions in specific categories (air pollutants and greenhouse gases) associated with FTI activities. Next, we highlight examples of beneficial practices adopted by the industry to manage environmental impacts. We then review the industry’s major trade publications to gauge the level of attention being paid to environmental issues. Finally, we offer a tentative grading of the FTI that reflects the achievements, and remaining obstacles, in reducing the environmental impacts of this complex enterprise.

### **ASSESSING ENVIRONMENTAL IMPACTS OF THE FTI**

To obtain a more fundamental understanding of the potential overall environmental impacts of the film and television industry, we employed a top-down approach based on the Economic Input-Output Life Cycle Assessment (EIO-LCA)

methodology.<sup>1</sup> We explain the complex assessment below but our bottom line conclusion is that the film and television industry is responsible for a significant amount of both air pollution and greenhouse gas emissions.

Under the EIO-LCA approach, an economic input-output analysis is first performed to determine the economic activity—both direct and indirect—in all sectors of the U.S. economy associated with \$1 of *final output* value in the film and television industry. The second step in the analysis yields the levels of pollutant emissions associated with each sector that supplies (directly or indirectly) to the FTI. It is these emissions, in turn, that are employed as a quantitative measure of environmental impact, even though actual outcomes—such as air quality or health consequences—are not explicitly derived. The sector-specific emissions reflect the pollution created by each sector activity, as explained below. These emissions are defined on a per-dollar basis of activity in each sector. Hence, the overall environmental impacts of the film and television industry—measured as



## Within metro Los Angeles, the FTI makes a larger contribution to conventional air pollution than four of the five other sectors we studied.

total pollutant emissions—can be obtained by multiplying the overall output value of the FTI times each sector's activity caused by \$1 of FTI output, times the appropriate sector emissions coefficient(s), and then summing over all affected sectors.<sup>2</sup>

The EIOLCA model divides the U.S. economy into 485 sectors, and determines economic links between each of these sectors. Firms in the film and television industry purchase goods and services from other firms within the industry, and from firms in the remaining 484 sectors. Each of these supplier firms, in turn, purchases goods and services from companies in other sectors, and so on. Thus, the input-output analysis yields the economic activity generated in *all* sectors directly or indirectly associated with the FTI; e.g., utilities, transportation, advertising, real estate, etc.

For each sector in the EIOLCA model, emission factors, or coefficients, are specified for key primary pollutants generated by the activities within that sector. Primary pollutants are those emitted directly into the atmosphere from identified sources, although there may be

secondary sources as well that are not counted (which is most relevant to “particulate matter,” or fine airborne particles). In the present analysis, we highlight the results for two specific categories of pollutants: “criteria” air pollutants and greenhouse gases (GHGs). The conventional primary criteria air pollutants include nitrogen dioxide (NO<sub>2</sub>), carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>) and particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>). The GHGs consist mainly of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). Using the EIOLCA methodology, releases can be determined in aggregate for all of the direct and indirect activities connected with FTI output. The total output is given on an annual basis in metric tons. Aggregate primary emissions provide a crude measure of the environmental impacts (on air quality or health), and offer a first-order metric for carrying out relative comparisons with other economic and industrial sectors. In the case of GHGs, which are related to global climate change, the total emissions have been converted into equivalent quantities of carbon dioxide (metric tons per year) that would yield the same

global warming potential as the actual GHG emission mix. For an analysis of California's contribution to greenhouse gas emissions more generally, refer to the article by R. Turco in RC 2001.

It should be noted that the emissions coefficients for each sector in the EIOLCA model are derived using a range of national databases, including the EPA's Toxics Release Inventory and National Emissions Inventory Database. Even so, emissions remain uncertain and variable and the derived aggregate values presented here should be taken as rough estimates. In focusing on the FTI, we use output data from the 1997 Economic Census for the purpose of estimating FTI activity in the Los Angeles metropolitan area (defined as Los Angeles, Orange, Riverside, San Bernardino and Ventura Counties), the entire state of California, and the United States. Five other industries were also selected for comparison: aerospace, petroleum refining, apparel, hotels, and semiconductor manufacturing. Transportation (in its various forms), though not included as a separate sector, is included as an input sector to the six sectors that our analysis focuses on.



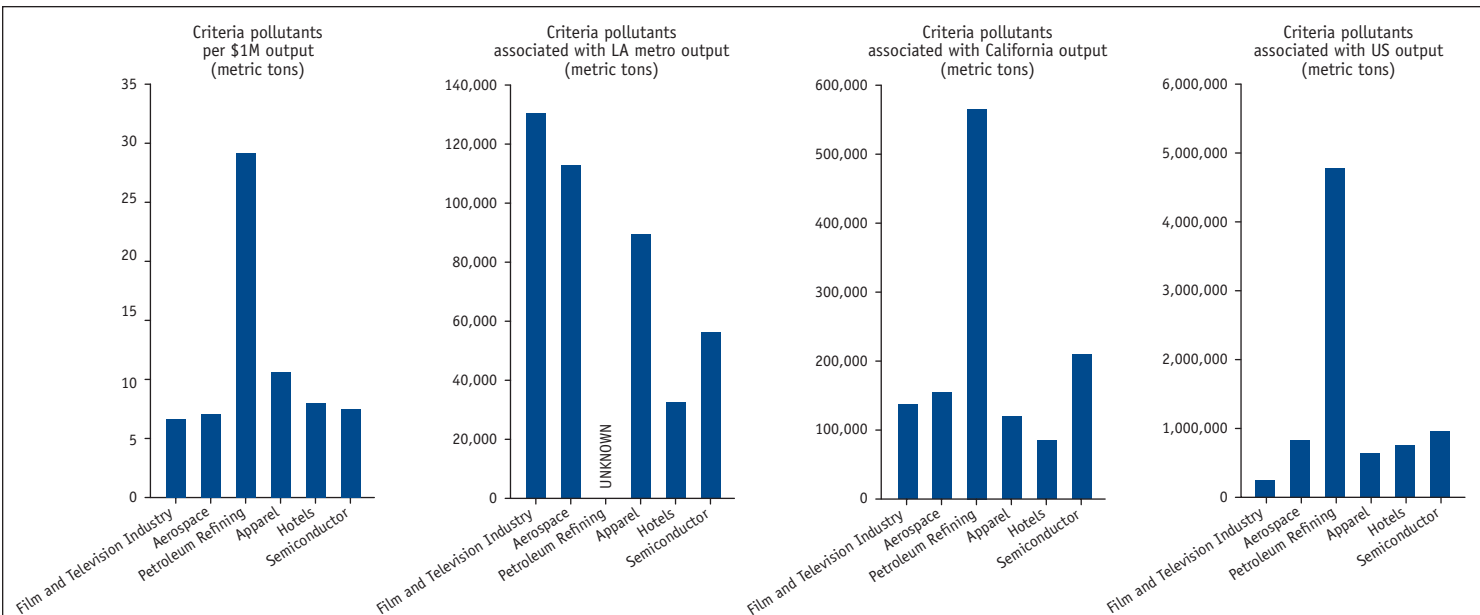


Figure 1. Criteria pollutant emissions (metric tons per year) for selected sectors within the geographical areas indicated.

### Air quality “criteria” pollutants

Based on the methodology described above, we determined the total emissions of criteria pollutants that contribute to air pollution, as shown in Figure 1. Criteria air pollutants are emitted from a wide range of sources. In general, emissions of these pollutants are strictly controlled by air quality regulations. Nevertheless, total emissions amount to millions of metric tons per year. Each panel in Fig. 1 contrasts the total annual output from the FTI to emissions from five other benchmark industrial sectors. The first panel (far left) shows U.S.-wide emissions per \$1 million of final output in each of the sectors analyzed. The remaining three panels give total annual emissions associated with the total economic activity of

each of the six sectors within the specific geographic areas indicated: the Los Angeles metropolitan area (middle left), California (middle right), and the U.S. (far right). Note that the data in Fig. 1 (and those that follow) include all of the emissions that occur nationwide as a result of economic activity, say, in the Los Angeles area or California. For example, firms in California use power that may be generated and therefore cause emissions out-of-state. Also note that the Census Bureau does not provide sufficient information to assess the impacts of petroleum refining in the Los Angeles region (hence the blank entry).

The results in Fig. 1 indicate that, wherever data are available, petroleum refining is the largest source of criteria

pollutants among the sectors studied. Nonetheless, the FTI in California accounts for an estimated 140,000 metric tons of criteria pollutants annually. Petroleum refining, by comparison, releases more than 550,000 tons. Emissions for the other four benchmark sectors amount to about 85,000 metric tons for hotels, 120,000 tons for the apparel industry, 155,000 tons related to the aerospace sector, and 210,000 tons from semiconductor manufacturing.

The film and television industry contributes to criteria emissions both directly and indirectly. For example, electricity consumption generates pollutant emissions at remote power stations. On the other hand, the use of vehicles for local transportation results in direct emissions

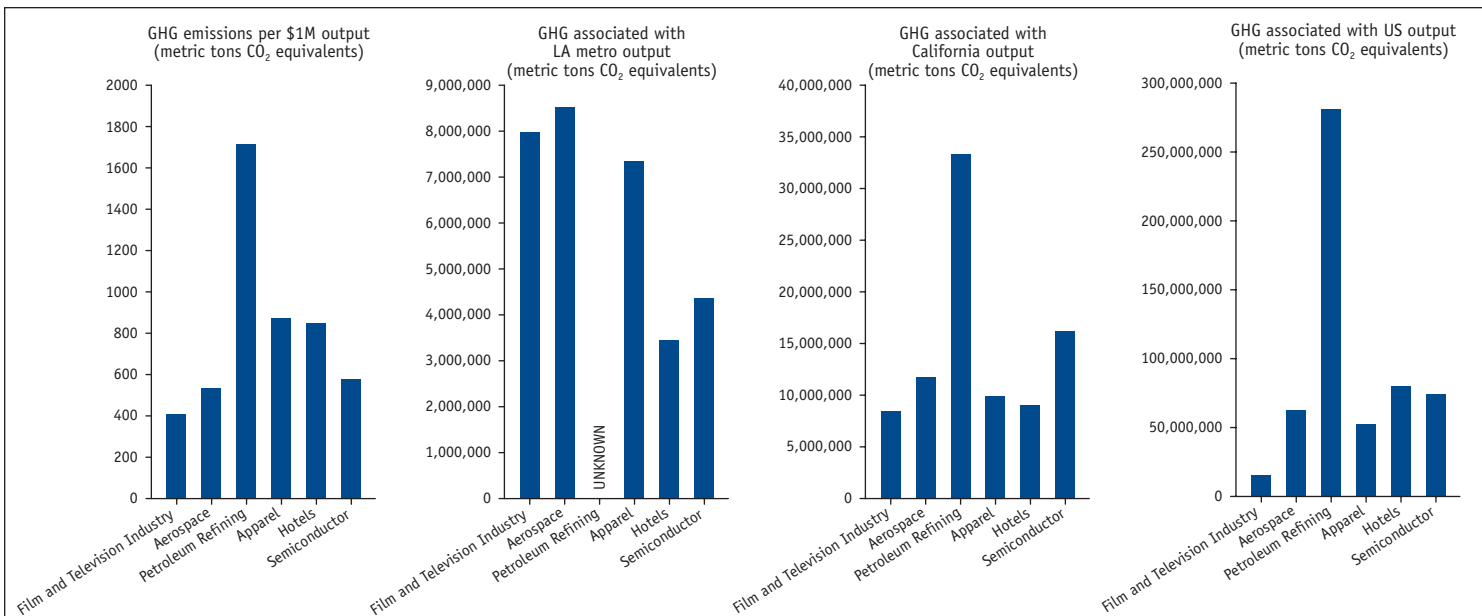


Figure 2. Greenhouse gas emissions (metric tons, CO<sub>2</sub> equivalent, annually) for selected sectors within the geographical areas indicated.

in the area of operations. Within metro Los Angeles, the FTI makes a larger contribution to conventional air pollution than four of the other sectors, although some of the differences are marginal given the accuracy attainable with the EIOLCA approach (petroleum refining is not included in the Los Angeles analysis, but would be a dominant source of criteria pollutants; similarly, transportation per se is not quantified as a “source” sector in this analysis).

**Greenhouse gas emissions** Figure 2 gives the results for greenhouse gas emissions from the same sector analysis as in Figure 1. The GHG burden is related mainly to fuel consumption; the total quantities shown are CO<sub>2</sub> equivalents.

The quantitative results are very similar to those for the criteria pollutants, and the analysis leads to similar conclusions. The greenhouse gas emissions associated with the film and television industry’s activity in California account for roughly 8,400,000 metric tons of CO<sub>2</sub> equivalents. This compares to about 9,000,000 metric tons for the hotel sector, 9,000,000 metric tons for apparel, 11,700,000 for aerospace, 16,200,000 for semiconductor manufacturing, and 33,400,000 for petroleum refining. While the film and television industry in California is the smallest of the six sectors studied, it may be surprising that the GHG emissions are even of the same order of magnitude as in the other sectors. This may be due to the heavy

reliance of the FTI on transportation and energy consumption in its normal operations, combined with the sheer size of the industry in Los Angeles and in California. With this rough assessment of the total impacts of the FTI, we now turn to some examples of best environmental practices we encountered.

## ENVIRONMENTAL BEST PRACTICES: INDUSTRY EXAMPLES

In order to begin to analyze the extent to which the industry is attempting to minimize its environmental impacts, we interviewed 43 individuals from a range of areas within the film and television industry. We noted that many useful initiatives are already in place: some stu-

## Our overall impression is that more could be done within the industry to foster environmentally friendly approaches.

dios have advanced recycling programs in offices and soundstages; several programs exist to recycle set materials on-site, or to donate them to other organizations; and energy efficiency and green building practices are being more widely adopted. Nevertheless, our overall impression is that these practices are the exception and not the rule, and that more could be done within the industry to foster environmentally friendly approaches.

A major challenge—one that differentiates the film and television industry from many others—is the degree to which work is controlled by short-lived production companies rather than by long-lived firms in stable supply chains, making it difficult to institutionalize best practices. Moreover, especially in filmmaking, the currently prevailing tendency within the industry is to operate in a “stop-and-go” mode. While very little happens for lengthy periods during a project’s early stages, activity switches into a fast mode once key agreements on finances or talent are arranged. Several of those interviewed indicated that more careful planning of the overall project and of actual shooting could ultimately

provide cognizant individuals more time to consider and implement environmental mitigation policies. Despite these obstacles, we found a number of innovative environmental practices, two of which we highlight below.

**Carbon-neutral production at *The Day After Tomorrow*** *The Day After Tomorrow* depicts an extreme outcome of abrupt climate and weather changes associated with global warming. Inspired by his personal commitment to environmental conservation, the film’s director and co-writer, Roland Emmerich, sought to ensure that the production of *The Day After Tomorrow* would not contribute to global warming. During the production of any motion picture, CO<sub>2</sub> is directly generated by vehicles, generators, trailers, and various machinery. Future Forests is one of several organizations that contracts to offset CO<sub>2</sub> emissions by planting trees or investing in climate-friendly technology. Future Forests estimated the carbon emissions and corresponding forest planting (or climate-friendly technology investment) necessary to offset the

impact of those emissions. Future Forests determined that this film would generate approximately 10,000 tons of CO<sub>2</sub>. Several industry sources confirmed that the cost of the corresponding carbon offsets was about \$200,000, which was paid by Emmerich and several of his associates.

An encouraging development is that another recent release, *Syriana*, was also made carbon neutral. For *Syriana*, Warner Brothers and Participant Productions together paid to offset the film’s CO<sub>2</sub> emissions through NativeEnergy, an organization with similar objectives although slightly different approaches than Future Forests.

**The ReUse People salvaging sets from *The Matrix 2* and *3*** The ReUse People (TRP) is a nonprofit organization that deconstructs buildings. The two sequels to *The Matrix*, known as *The Matrix Reloaded* or *The Matrix 2*, and *The Matrix Revolutions* or *The Matrix 3*, were both released in 2003 by Warner Brothers. Parts of both films were shot at three huge sets and on the streets of Oakland and Alameda Point. The “cave”



Professor Corbett's research and teaching focus on environmental issues in business, and revolve around examining links between good business practices and environmental protection. This has included studying the effects and global diffusion of ISO 9000 and ISO 14000 certification; and, most recently, the environmental footprint of a project-based industry such as the film and television industry.

Dr. Corbett has published in his field's top academic and business journals in several countries. He is a member of the editorial board of *Manufacturing and Service Operations Management*, an associate editor of *Operations Research*, past associate editor of *Management Science*, and guest editor of three special issues of *Production and Operations Management on Environmental Management & Operations*.

Before joining the faculty in 1996, Professor Corbett was a visiting scholar at the Owen Graduate School of Management at Vanderbilt University. He holds a PhD from INSEAD in Fontainebleau, France, and was an AT&T Faculty Fellow in Industrial Ecology during 1997-1999. He served as Associate Dean of the UCLA Anderson School's MBA Program from 2003-2006.

## Some aspects of the industry's environmental record deserve an A. However, policies to mitigate environmental impacts remain to be implemented more systematically.

set consisted of 90 tons of material, consisting mainly of wood and polystyrene blocks. The "tenement" set consisted of 300 tons of material, representing 8 building fronts. The "freeway" set consisted of more than 7,700 tons of concrete, 1,500 tons of structural steel and 1,500 tons of lumber. As a result of a joint project between Warner Brothers, the city of Alameda, the Alameda County Waste Management Authority, and The ReUse People, 97.5% of all the set material was ultimately recycled.

The ReUse People dismantled sets and handled processing and distribution of the salvaged materials. Thirty-seven truckloads of lumber were reused in housing for low-income families in Mexico, and all the steel was recycled. Even the k-rail from the freeway set was crushed and sold off as base rock. TRP's work force of 18 people worked 124 days to complete the project. According to the Alameda Waste Management Authority, the 11,000 tons diverted from the landfill represented 10% of the total annual solid waste stream for the city of Alameda.

We encountered several other similarly impressive practices in a variety of

productions. For example, the sitcom *According to Jim* has largely eliminated the use of paper in scriptwriting and editing by using Tablet PCs; the craftsman-style house featured in the 2001 New Line Cinema release *Life as a House* has been recycled into the Kenter Canyon Elementary School Library; Warner Brothers uses re-refined oil for their fleet by collecting and recycling used oil from existing vehicles; and Sony Pictures has received ISO 14001 certification for its environmental management system. The Environmental Media Association (EMA) and the Entertainment Industry Development Corporation (EIDC) both maintain online environmental production guidelines

### WHAT THE FILM AND TELEVISION INDUSTRY WRITES ABOUT

In addition to the economic sector analysis, and examples of environmental best practices, we also surveyed the coverage of environmental issues in the most important FTI trade publications, the *Hollywood Reporter* and *Variety*. Our



Environmental articles in The Hollywood Reporter and Variety, 1991-2004

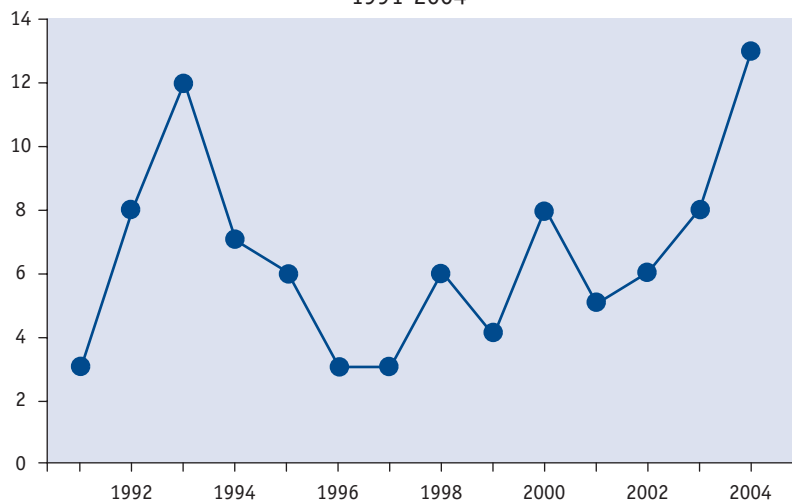


Figure 3. Selected articles with environmental themes in trade publications.

informal content analysis of these publications basically counted articles with genuine environmental focus that appeared from 1991-2004. The results are summarized in Figure 3. The analysis suggests that attention given to environmental issues peaked around 1993, but then tapered off during the mid-1990s. However, beginning around 1996/97, a trend toward an increasing frequency of environment-related themes developed. A significant acceleration, in fact, occurred during the most recent period (2002 through 2004). The majority of these stories focus on the environmental *content* of productions rather than environmental actions and policies. Until 2003, the EMA awards concentrated on films and shows that included environmental messages. In a positive development, the 2004 EMA

awards included, for the first time, a separate category for environmental “process” improvements based on EMA’s Green Seal checklist. This is likely to draw further attention to environmental practices during film development, production and distribution.

### GRADES: A TO C

As might be expected for such a diverse industry, encompassing a wide range of organizations and individuals, it is impossible to assign a single grade for overall environmental performance. Some aspects of the industry’s environmental record deserve an A: e.g., the best practices highlighted earlier. In fact, because

*continued on page 40*



Richard Turco is the former Director of UCLA’s Institute of the Environment, Professor and past Chair of the Department of Atmospheric Sciences, and a member of the Institute of Geophysics and Planetary Physics. He received his Ph.D. in Electrical Engineering and Physics from the University of Illinois in 1971. Dr. Turco’s work includes research on the stratospheric ozone layer and the ozone “hole,” the causes of climate change on Earth, regional air pollution and airborne particulates, and global chemical cycles. In 1983, he jointly developed the theory of “nuclear winter.” Over the last decade, Dr. Turco has headed a research group building an advanced air quality model for the Los Angeles basin. The Surface Meteorology and Ozone Generation (SMOG) model was the first to explain the formation of dense elevated layers of pollution over Los Angeles. Dr. Turco’s 240 publications include a textbook on current environmental issues, “Earth Under Siege: From Air Pollution to Global Change”. He was honored with a MacArthur Fellowship in 1986, and the Leo Szilard Prize for Physics in the Public Interest.



A photograph of children playing in a park. A large tree trunk is the central focus. Several children are blurred in motion around it. One child in a bright green shirt is on the left, another in a light blue dress is in the foreground, and a child in an orange shirt is on the right. The ground is a mix of grass and a brick path. The overall scene is bright and active.

GRADES A to C+

# Urban Parks



by Anastasia Loukaitou-Sideris, Ph.D.

Professor and Chair, Department of Urban Planning

## INTRODUCTION

It seems incontestable that urban parks are a desirable asset for cities. But Southern California cities have found it increasingly difficult to provide the appropriate amount of park acreage with the right mix of park services. Indeed, “park wars” in Los Angeles have at times pitted developers against park advocates, environmentalists against soccer enthusiasts, and inner-city park users against suburban patrons. These “wars” have occurred despite the many benefits of parks. As valued physical settings parks offer visual and psychological relief in high-pace urban communities and contribute to the quality of life and overall sense of well being of urban dwellers. Parks are also important settings for involvement in sports and physical activity. Recently, and increasingly, evidence from the public health arena has linked park visits to health benefits for active users. Parks can also serve as a “substitute for nature” in cities, offering important environmental benefits. Their trees and vegetation reduce ambient heat levels and offer sequestration of air pollu-

tion, while their ‘softscape’ allows natural water filtration and absorbs runoff.

This article analyses the provision and politics of open space in Los Angeles by focusing on three different but inter-related aspects of park politics: 1) The increasing difficulty faced by municipalities and counties to provide and maintain green open spaces; 2) The inequitable distribution of parks and urban greenery throughout the Los Angeles urban terrain; and 3) The challenges of addressing different and competing open space needs for an increasingly heterogeneous public.

## INADEQUATE SUPPLY

In urban areas that are densely built, large depositories of land have all but vanished. Today, the dramatic fiscalization of land combined with decreasing tax revenues for cities have made the creation of new parks or the expansion and upgrading of existing ones a very expensive proposition for cities. California’s Proposition 13 and similar tax-cut measures in thirty-seven other states have seriously challenged municip-

pal budgets and reduced the size of city coffers. At the same time, parks and open spaces do not represent a profitable use of land in a monetary sense, as they do not produce property or sales tax revenue for cities. As a result, the supply of public parks has not kept pace with the growing urban population.

Indeed, the growth in urban park acreage is nowhere near proportional to the growth of urban areas, especially in the fast-growing cities of the West Coast. This is particularly true in the Los Angeles region. A comprehensive study of parks in the twenty-five largest metropolitan areas in the U.S. in 2000 found that the Los Angeles park system, which has only 10% of the total city land devoted to parks, lags all other large cities of the West Coast (see Table 1). Los Angeles ranks 17th among major U.S. cities, scoring below other large cities like New York and Philadelphia. And the Parks and Recreation Department’s per capita spending for parks in 2000 of \$35 per resident is well below the per capita spending of San Diego (\$83), San Francisco (\$95), Portland (\$108), and Seattle (\$153). Park acreage in Los

City	City Population (in 1996)	Population Density (persons/acre)	Park acreage per 1000 residents	Park space as % of city area	Park expenditures per resident
Los Angeles	3,554,000	11.8	8.5	10.0%	\$35 (in 1998-99)
San Diego	1,171,000	5.6	30.8	17.4%	\$83 (in 1998)
San Francisco	735,000	24.6	10.3	25.4%	\$95 (in 1998-99)
Seattle	525,000	9.8	11.8	11.5%	\$153 (in 1997-98)
Portland	481,000	6.0	26.2	15.8%	\$108 (in 1998-99)

Table 1: Comparison of Parks and Open Spaces among Major West Coast Cities.  
Source: Harnik P. (2000). *Inside City Parks*, Washington DC: Urban Land Institute.

Los Angeles is just 4.2 acres per 1000 residents, significantly lower than the national averages, which range from 6.25 to 10.5 acres per 1000 residents. The magnitude of the Los Angeles' population—triple that of San Diego and quintuple San Francisco's—makes the provision of adequate parkland and open space especially difficult.

Along with population size and density, limited local government revenue, particularly in the post-Proposition 13 era, also helps explain the relative dearth of parkland within Los Angeles. Between 1972 and 1998 the city of Los Angeles acquired less than 1,000 acres for parks, and in the immediate post-Proposition 13 years had to close 24 recreation centers and reduce the funds or cut down the operating hours for the remaining centers.

### UNEVEN ALLOCATION

The loss of revenue for park acquisition and operations has not affected neighborhoods equally. Parks in affluent suburban coastal and valley areas were able to harness the impact by imposing user fees for park services. Parks in low-income communities, however, saw a dramatic reduction of their staff, space and services. Similarly, the Quimby Act, a state law passed in 1975 that requires developers to pay a fee for park development or set aside land for parks in the immediate vicinity of their project, has favored newer suburban subdivisions and has done little to increase the park supply in built-up inner city areas.

A variety of options can be used to finance parks, ranging from property taxes, general obligation and revenue

**Between 1972 and 1998 the city of Los Angeles acquired less than 1,000 acres for parks.**

bonds, special assessment districts, impact fees, user fees, and real estate transfer taxes. But parks compete with other public goods and services, such as education, policing and public libraries, for limited public funds. Nevertheless, the strong economic climate and generosity of voters of the early 1990s brought substantial additional funding to Los Angeles parks. In 1992, Los Angeles County voters passed Proposition A, which assured \$550 million for parks, with \$126 million dedicated to parks in the city of Los Angeles. In 1996, voters approved Proposition K, a park bond assuring \$750 million in park improvements for Los Angeles County and \$25 million per year for 25 years for the city.

But a Los Angeles Times article reported that Proposition K projects are facing delays and cost overruns. Moreover researchers also found that the bond funding, which is allocated through a competitive process, does not reach all neighborhoods equally: "Communities of color [and] areas with the largest shares of young people received half as much Proposition K funding on a per youth basis than areas with the least concentra-



tion of children, and more privileged sub-areas with the highest rates of accessibility received as much if not more bond funds.” Instead of using the new revenue to close the open-space gap between wealthy and poor areas of the city and county, Proposition K seems to have exacerbated existing inequalities in the distribution of parkland. Thus, researchers have found that Latino neighborhoods on average have only 1.6 acres per 1,000 population, African-American neighborhoods enjoy on average 0.8 acres per 1,000 population, Asian-Pacific-Islander-dominated neighborhoods have 1.2 acres per 1000 residents, while white-dominated neighborhoods have on average 17.4 acres per 1000 residents, partly because they encompass the Santa Monica Mountains.

The dearth of parks in the city is more pronounced in some neighborhoods. Table 2 shows a rather dramatic picture of inequitable supply within the city of Los Angeles. Inner city council districts contain many fewer neighborhood parks per 1000 children than non-inner city districts. I recently authored a study focusing on the supply of parks in relation to

Council District	Park acreage	Children 0-17	% children 0-17	Total population	Park acreage/ 1000 children	Park acreage/ 1000 persons
1	179.78	67,779	29.6	228,686	2.65	0.79
2	346.83	57,880	24.5	236,537	6.00	1.47
3	327.12	50,714	21.8	232,829	6.45	1.40
4	175.30	37,970	16.0	236,973	4.62	0.74
5	268.25	33,512	14.2	236,414	8.00	1.13
6	218.82	38,797	16.8	231,516	5.64	0.95
7	141.66	68,905	29.8	231,545	2.06	0.61
8	91.74	67,056	29.0	230,289	1.37	0.40
9	77.26	78,903	34.3	229,853	0.98	0.34
10	70.48	57,832	25.6	226,142	1.22	0.31
11	411.34	41,927	17.7	236,846	9.81	1.74
12	532.44	53,432	22.6	236,497	9.96	2.25
13	88.81	58,714	25.4	231,588	1.51	0.38
14	192.38	60,568	26.8	225,852	3.18	0.85
15	264.17	72,487	31.1	233,157	3.64	1.13

■ Inner City District

Table 2: Neighborhood park acreage by council district in Los Angeles.

Source: City of Los Angeles, Commission on Children, Youth, and their Families, 1996.

population characteristics and needs, and found a persistent inequity between two different city areas (see Figure 1). The study created a ‘needs index’ for each neighborhood taking into account its median household income, percentage of households under poverty, density of children, and average number of people per household. It found that Los Angeles inner city neighborhoods had the highest need for parks yet had a much lower

acreage of neighborhood parks per capita than the more affluent neighborhoods of the San Fernando Valley.

Site visits also confirmed a differential quality among parks in these two regions. While the inner city parks were found to have more sport fields and indoor facilities, their levels of maintenance and cleanliness lagged far behind their counterparts in the San Fernando Valley. Moreover, surveys show parks are

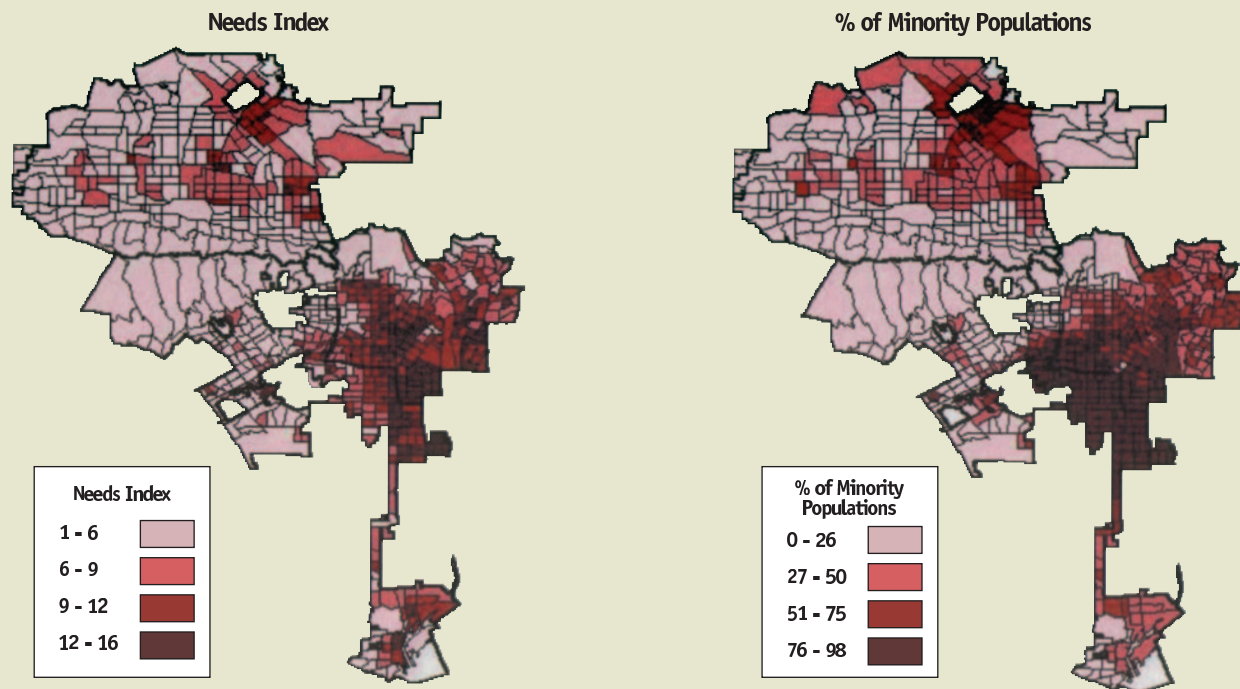


Figure 1: Needs Index and Percent of Minority Populations in the inner city and valley regions of Los Angeles.

Source: Loukaitou-Sideris, A. and Stieglitz, O. (2002). "Children in Los Angeles Parks: A Study of Equity, Quality and Children's Satisfaction with Neighborhood Parks," *Town Planning Review*, 74(4): 467-488.

much more important in the lives of inner city children. For them the neighborhood park serves as an extension of their house, a viable alternative to the often absent back yard and private play space. Their visits to the park are frequent and casual. Using bikes, skates, or simply their feet, inner city children come to the park on weekdays and weekends to meet with their peers, and find space for play and sport activities. For suburban children the neighborhood park becomes important primarily on weekends as a

place for family picnics and sports events like soccer and baseball. Attachment to the neighborhood park is less strong, as the park is only one of many possible venues for recreation and play.

### CHALLENGES OF ACCESSIBILITY AND USE

Ironically, despite the scarcity of green open spaces in the region, many parks remain underutilized and devoid of social uses and activities. This paradox

often exists because some parks suffer from poor accessibility, perception of lack of safety, and lack of programs or facilities appealing to the needs and values of a diverse population. In general, however, inner city parks tend to be much more utilized than parks in the outlying suburban areas, because of higher densities, residential overcrowding, and relative lack of back yards and private open spaces.

Accessibility of parks remains challenging in California, where according to

## A comprehensive study of parks in the twenty-five largest metropolitan areas in the U.S. in 2000 found that the Los Angeles park system lags all other large cities of the West Coast.

the California Health Interview Survey conducted by the UCLA Center for Health Policy Research, more than a quarter of teenagers in the state reported having no access to a safe park, playground or open space. Parks and playgrounds were envisioned in the 1930s as important neighborhood assets that had to be in close proximity to residences. But in Los Angeles, only about a quarter of the city's population lives within a quarter-mile of a neighborhood playground or park facility.

Perceptions of lack of safety can also affect park visitation and use. A recent survey of park users by the City Controller's office reported that half of the respondents were reluctant to visit neighborhood parks out of concern for their personal safety. A 2006 study by the RAND Corporation found the most common user response for suggested improvements to neighborhood parks was safety.

A third challenge concerns the fit between desirable park uses and the design of parks and open spaces. The multiplicity of roles the urban park is now expected to play for a diverse public

may be difficult to address for park suppliers and may create conflict among competing user groups. What is the proper role or roles urban parks are expected to serve? Should they be designed as green oases for peaceful retreat, relaxation, and meditation? As facilities for active recreation and fervent group play? As social spaces for community involvement and cultural exchange?

The neighborhood park of the early 21st century is typically a few acres of land expected to serve myriad purposes and satisfy a multicultural clientele. Park suppliers try to satisfy these diverse and conflicting needs by following the norm of the "average user." They are responding to what they believe are universal needs, but this response may fail to address cultural patterns of park use. As a result, and as studies have shown, contemporary neighborhood parks do not always offer effective group settings that take into account the different use patterns of men, women, children, young adults, the elderly, or different ethnic groups. The typical neighborhood park design mixes elements from past park design models in order to create an easi-

ly reproducible, standardized milieu, one which seeks to be multiuse, but may also be insensitive to cultural and social specificities.

### RECOMMENDATIONS

While this article has stressed the challenges around the provision and allocation of parks in Los Angeles, developments in the last few years give us reasons for optimism. For one, voters have shown their support for urban parks by approving ballot measures and taxing themselves to provide future generations of Californians with more parkland. For the first time in the last fifty years the region has been able to identify and designate large pieces of land for park space. An important coalition of grassroots groups fighting for more parks and open spaces has slowly emerged. As a result of their efforts, the abandoned thirty-two acre rail yard near Chinatown will be converted into the Cornfield Park, while the El Toro Marine Corps Air Station, between Irvine and Lake Forest, will be transformed into Orange County's Great Park. In South Central



Los Angeles the Santa Monica Mountains Conservancy has converted a former cement pipe storage yard into the 8.5-acre Augustus F. Hawkins Natural Park. Other opportunities for park development exist in efforts to restore portions of the Los Angeles River and to create riverfront parks in different neighborhoods.

Park and Recreation departments should also not forget that small green spaces in the neighborhood (in contrast to more difficult to acquire large parks), can offer a host of recreational opportunities and environmental benefits. In cities like Los Angeles where land is scarce they should look for underutilized or empty lots in neighborhoods,

and along freeways, railway lines, riverfronts, and waterfronts. Mini-parks and adventure play grounds can be created in empty lots, and jogging and biking paths can be provided along transportation corridors. Parks should not be seen in isolation, but rather in connection to other land uses, such as housing and schools. Partnerships between Park and Recreation departments and school districts and shared uses should also be considered in the most dense and undersupplied neighborhoods of the region.

In addition to the traditional patterns of active and passive recreation we also need to consider less conventional uses in parks, if these are

deemed appropriate by the surrounding communities. Cultural events, after-school programs, urban gardening, even entrepreneurial activities and volunteerism can take place in some parks. At the same time, the educational and environmental potential of parks, presently quite unexplored and underdeveloped, can be cultivated to offer opportunities for youngsters to learn more about ecology and nature. Finally, the design of parks should be location-specific and respectful of the needs of the particular community.

In the late 19th century, American cities acted with great foresight by ensuring and converting land for recreational open spaces within their boundaries. This era gave future generations of urbanites the great gift of wonderful city parks. Today these parks are no longer sufficient to address the needs of a vastly expanded and heterogeneous public. We need more greenery and parks in our cities that can fulfill a host of different recreational, social, educational, and environmental benefits for the sake of current and future generations of citizens.



**Instead of using the new revenue to close the open-space gap between wealthy and poor areas of the city and county, Proposition K seems to have exacerbated existing inequalities in the distribution of parkland.**

## GRADES

Park Advocates: **Grade A.** Non-profit organizations such as the Trust for Public Land, The Center for Law in the Public Interest, the Friends of the Los Angeles River, NorthEast Trees, and many others have created a movement for urban parks in Los Angeles and have been instrumental in securing new land for urban parks in the Los Angeles region, and advocating for ballot measures for park funding.

Departments of Parks and Recreation: **Grade C+.** City bureaucracies have not displayed the necessary creativity to provide neighborhoods with open space opportunities and to match neighborhood needs with appropriate park design and programming. The level of maintenance of different parks within the same park district often varies, with parks in under-privileged neighborhoods of the city showing the greatest wear and tear.

## SOURCES

City of Los Angeles, City Controller's Office (January 2006). *Analysis of the Maintenance Activities of the Department of Recreation and Parks.*

Harnik, P. (2000). *Inside City Parks.* Washington DC: The Urban Land Institute.

Loukaitou-Sideris, A. (1995). "Urban Form and Social Context: Cultural Differentiation in the Uses of Urban Parks," *Journal of Education and Planning Research*, 14:89-102

Loukaitou-Sideris, A. and Stieglitz, O. (2002). "Children in Los Angeles Parks: A Study of Equity, Quality and Children's Satisfaction with Neighborhood Parks," *Town Planning Review*, 74(4): 467-488.

RAND Corporation (2005) *The Role of Parks in Physical Activity and Health.*

Wolch, J. Wilson, JP, and Feherenbach, J. (2005). "Park and Park Funding in Los Angeles: An Equity-Mapping Analysis," *Urban Geography*, 26(1):4-35.

Yanez, E. and Muzzy, W. (2005) "Healthy Parks, Healthy Communities: Addressing Health Disparities through Public Financing of Parks, Playgrounds, and Other Physical Activity Settings," Policy Brief, Los Angeles; The Trust for Public Land.



Professor Loukaitou-Sideris' research focuses on the public environment of the city and her work seeks to integrate social and physical issues in urban planning and architecture. Her research includes analysis of changes that have occurred in the public realm; cultural determinants of design and planning and their implications for public policy; quality-of-life issues for urban residents; and transit security. She has served as a consultant to the Transportation Research Board, Federal Highway Administration, Southern California Association of Governments, South Bay Cities Council of Government, Los Angeles Neighborhood Initiative, the Greek Government, and many municipal governments on issues of urban design, open space development, land use and transportation. She is the author of numerous articles, the co-author of the book *Urban Design Downtown: Poetics and Politics of Form* (University of California Press, 1998), the co-editor of the book *Jobs and Economic Development in Minority Communities* (Temple University Press, 2006), and is currently working on a book about the social uses of sidewalks to be published by the MIT Press.



# Atmospheric Deposition



GRADES B+ to C-



by Keith D. Stolzenbach, Ph.D.

## Professor, Department of Civil and Environmental Engineering

Many of the substances in the atmosphere are completely natural, such as the oxygen we breathe or dust particles that have been resuspended by wind from the Earth's crust. However, human activities have resulted in the presence of other substances that we consider pollutants because they are potentially harmful to human or ecosystem health. Air pollutants posing a risk to human health include gases such as ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide; particle-associated components of combustion exhaust including carcinogenic polycyclic aromatic hydrocarbons; heavy metals; and particles smaller than 2.5 microns (PM<sub>2.5</sub>). Previous Southern California Report Card articles have dealt with the human health aspects of regional air quality (RC 1998 and 2003), particulates (RC 2001), and personal exposure (RC 2005). In this article, we discuss atmospheric deposition—the transfer of substances from the air to the many surfaces that make up the world we live in, such as soil, vegetation, water, pavement, vehicles, and buildings—with an emphasis on particle deposition. We do so because to date, atmospheric dep-

osition has largely been neglected in considering the effects of air pollutants on human health.

### ATMOSPHERIC DEPOSITION

Anyone who has dusted a room or washed a car has encountered the effects of atmospheric deposition. Pollutants in the atmosphere can deposit on all of the solid surfaces of a watershed and then be washed off by rain, becoming part of the storm water runoff that reaches rivers, lakes, and coastal waters. Pollutants may also be deposited directly from the atmosphere onto the surface of a water body. A secondary, but important, reason to be concerned about atmospheric deposition is that pollutants that are not washed off may accumulate on surfaces such as soil, forming a reservoir of toxic substances that may later be resuspended back into the air, causing a threat to human and ecosystem health even after the original sources of the pollutant have been removed.

Substances exist in the atmosphere either as molecules of gases or as solid or liquid particles, called *aerosols*, that

range in size from 0.001 to 100 microns (it takes a thousand microns to make a millimeter). Both gases and particles are deposited on surfaces by one of two general mechanisms (Figure 1). *Wet deposition* occurs when raindrops drag molecules of gases and particles down with them as they fall. *Dry deposition* results from the combination of molecular diffusion, impaction, and gravitational settling. Wet deposition is the most important deposition mode in regions with appreciable annual rainfall, but in semi-arid regions such as Southern California atmospheric deposition is likely to be dominated by dry deposition processes. The most rapid dry deposition rate is the gravitational settling of particles in the 10 to 100 micron size range. As noted earlier, because the wet and dry deposition rates for most gases and for very small particles are slow, atmospheric deposition has largely been neglected in considering the effect of air pollutants on human health. Yet atmospheric deposition can be a major environmental problem: acid rain is the most well known problem of atmospheric deposition and some of the country's most important

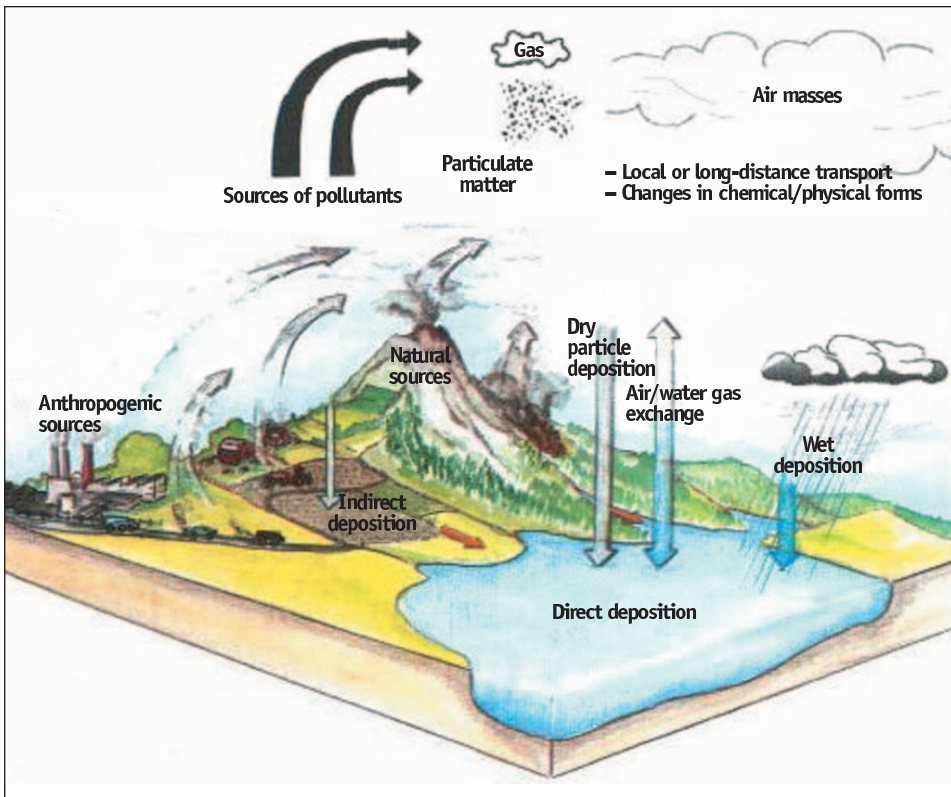


Figure 1: Atmospheric deposition processes.

water bodies, including Lakes Erie and Tahoe, have faced significant pollution from deposits from the atmosphere.

Water pollutants of concern that may deposit from the atmosphere include compounds that increase the acidity of rainfall or fog, nutrients that may cause excess algal growth (eutrophication), and toxic organic and inorganic (metals) compounds. Acid rain, primarily caused by the emission of nitrogen and sulfur from motor vehicles, industries and power plants, harms vegetation

(Figure 2) and impairs water quality. Acid rain has been one of the longest standing issues involving atmospheric deposition in the United States and has been addressed at the federal level by the National Atmospheric Deposition Program (NADP). Eutrophication of water bodies by excess nutrients results in lowered, often zero, dissolved oxygen levels and consequent death of fish and other organisms in addition to dramatic changes in taste and odor of the water (Figure 3). Eutrophication of major

water bodies in the United States, notably Lake Erie, was one of the driving forces behind the federal Clean Water Act of 1972 and is still of concern in many regions. In California, nutrient additions by atmospheric deposition are thought to be a primary cause of the decrease in the clarity of Lake Tahoe (Figure 4).

Among the organic compounds of interest in aquatic systems are pesticides such as DDT, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenols (PCBs), all of which are internationally recognized as important persistent organic pollutants (POPs). Metals identified as important water pollutants are copper, cadmium, chromium, lead, mercury, nickel, and zinc. These organic compounds and metals are present in the sediments of many water bodies and are of concern because of their effects on aquatic organisms, and, in the case of lead and mercury, on human health. Mercury currently receives special attention from the NADP because of its ability to travel long distances as a gas before entering water bodies by atmospheric deposition.





Figure 2: A forest devastated by acid rain.



Figure 3: An eutrophic lake choked by an algae bloom.

Although many of the inputs of water pollutants from treatment plants and other facilities (*point sources*) have been reduced by successful treatment and source reduction efforts, it is now recognized that *non-point sources* originating from urban and agricultural activities in a watershed are sufficiently large that water quality improvement objectives have not been met in many locations. Regulatory efforts to improve and protect water quality, particularly by establishing Total Maximum Daily Loads (TMDL) (see articles on storm water quality and regulation in RC 2004 and

2005, respectively), must consider the contribution of atmospheric deposition relative to other point and non-point sources in the watershed.

This article, using the findings of studies conducted over the last ten years at UCLA, in collaboration with the Southern California Coastal Water Research Project (SCCWRP), summarizes the current state of understanding of atmospheric deposition as a contributor to water quality problems. The article focuses on the Los Angeles region as a model for urbanized areas, particularly those in relatively dry climates where dry

deposition is the dominant mode of deposition. The discussion deals mainly with the metals identified as water pollutants, but many of the conclusions presented here apply to acidic rain, nutrients, and organic compounds. Deposition of atmospheric mercury is not discussed here, largely because of the absence of upwind sources of mercury on the U.S. West Coast. The article identifies the important sources of metals in Los Angeles, the resulting patterns of deposition, and the relative importance of atmospheric deposition of metals, followed by a discussion of what scientific and institution-

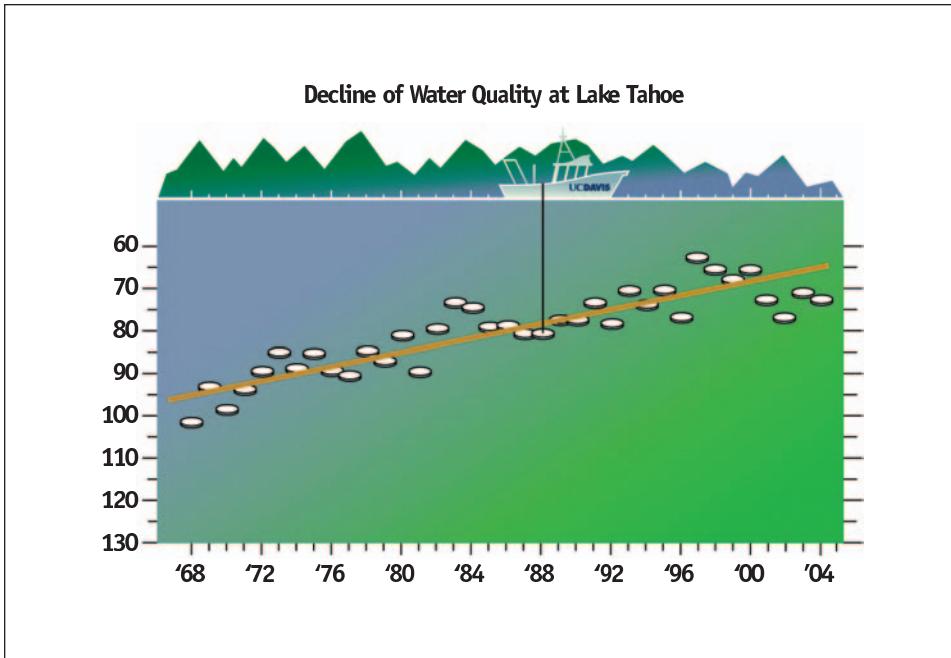


Figure 4: The clarity of Lake Tahoe, as measured by the depth to which a standard secchi disk can be seen, has decreased over the last three decades.

al steps can be taken to deal with atmospheric deposition. The article concludes by awarding grades for past regulation and monitoring efforts and for forward-looking attempts to understand and deal with this important problem.

## SOURCES OF METALS TO THE ATMOSPHERE

Estimates of pollutant emissions to the atmosphere have been developed by the combined efforts of the U.S. Environmental Protection Agency (EPA), the California Department of Environmental Protection (CALEPA), and the South

Coast Air Quality Management District (SCAQMD) for three categories of sources. *Point sources* are fixed sources associated with specific large industrial facilities; *mobile sources* are moving vehicles; and *area sources* include construction vehicles, distributed smaller industrial sources, and resuspended dust.

The most significant source of metals to the atmosphere, in Los Angeles and elsewhere, is resuspension of dust, often called “fugitive” dust, from roads by moving vehicles and from other paved and unpaved surfaces by wind (Figure 5). Chemical studies of the dust indicate it is

**The most significant source of metals to the atmosphere is resuspension of dust from roads by moving vehicles and from other paved and unpaved surfaces by wind.**

primarily composed of natural material typical of the earth’s crust but also contains significant amounts of the metals we are concerned with here with regard to water pollution. These metals have become intimately mixed with the crustal material, making identification of their “real” sources difficult.

Recent measurements indicate wild fires can also be a significant source of metal laden dust. It is not clear whether the high level of metals in the atmosphere following a fire are the result of resuspension of metal laden soil by the strong updrafts associated with wildfires, or if the metals are taken up from the soil by the vegetation and released by the burning.

It is now known that resuspended dust can be transported between continents and that dust from China often reaches the U.S. West Coast. Thus it is likely that contaminants associated with dust could be transported between regions in California, although we do not have any measurements with which to estimate how important this mode of transport is for the Los Angeles region, either as a source or sink.

**Atmospheric deposition has largely been neglected in considering the effect of air pollutants on human health yet can be a major environmental problem.**

Studies focusing on lead in the Los Angeles region have shown the current levels of lead present in resuspended dust far exceed the supply from contemporary sources now that the main historical source of lead to the environment, leaded gasoline, has been reduced to near zero levels. Lead levels in the atmosphere and in newly deposited material appear to be supplied by resuspension of “old” lead present in soils and other surfaces. This phenomenon is likely to be important for other pollutants subject to atmospheric deposition.

Regulatory programs designed to protect human health have successfully reduced emissions of many substances from point and mobile sources. However, tire wear remains a significant source of zinc and brake pad wear is a significant source of copper from mobile sources. The heaviest and largest of the particles containing copper and zinc may deposit directly on the road or surrounding area, but a large fraction is dispersed into the atmosphere. Some researchers have suggested that weights used to balance tires are a significant source of lead.

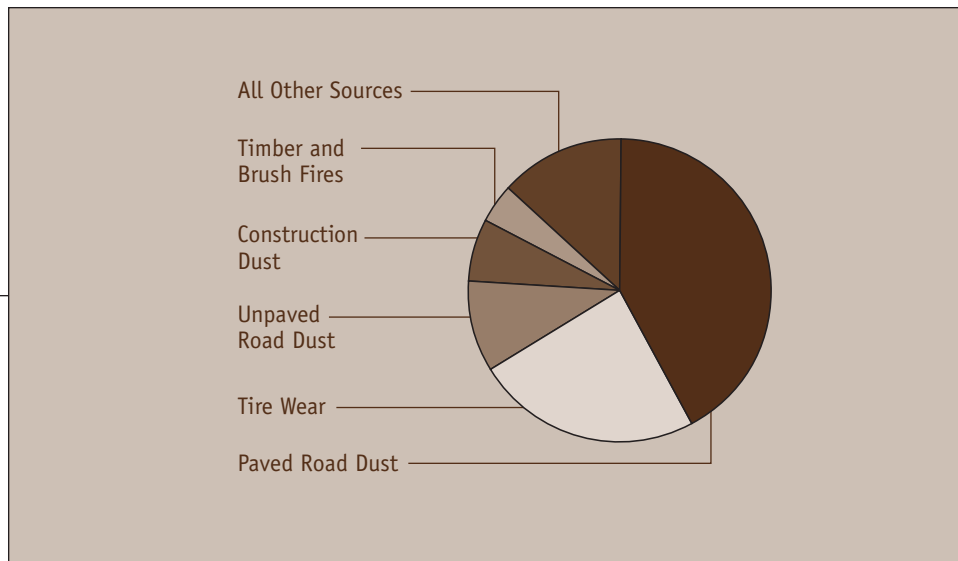


Figure 5: The major sources of atmospheric emission of zinc in the Los Angeles region.

### **PATTERNS OF ATMOSPHERIC DEPOSITION**

Scientists from UCLA and elsewhere have used air quality computer models to determine the transport and fate of metals in the Los Angeles region using as inputs the estimates of sources described above. The models indicate about a fourth to a third of the material emitted into the atmosphere is deposited within the region and the rest is carried away by the wind (Figure 6). Most of the deposited material falls on land or urban surfaces rather than directly on a water surface, but there is some deposition on coastal waters because of night-time breezes from the land and because of persistent Santa Ana winds. Because of the relatively small total rainfall in

Southern California, dry deposition is much more important than wet deposition. The UCLA measurement program also documented for the first time the presence of significant amounts of particles between 10 microns and 100 microns in size in the air above Los Angeles. Although there are substantial amounts of metals on particles smaller than 10 microns, it is the largest particles that are responsible for most of the atmospheric deposition of metals.

The pattern of dust and metal concentrations in the atmosphere and the associated deposition on land is relatively uniform spatially in the Los Angeles urban region, although deposition near major sources, such as freeways, is higher than the regional background rate within about 100

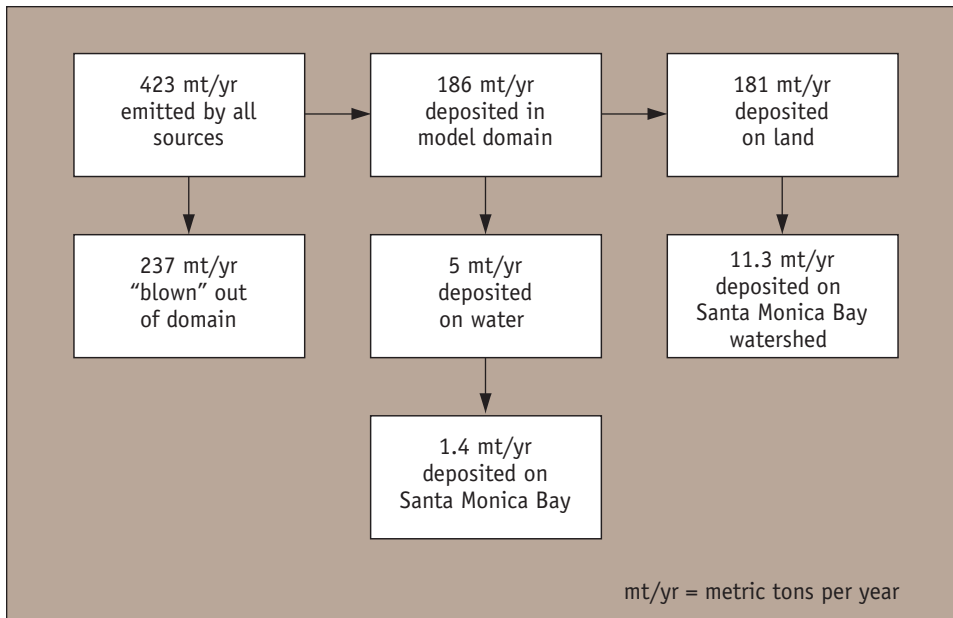


Figure 6: Computed “budget” of zinc emitted in the Los Angeles region.

meters of the road. In the urban areas, daytime concentration and deposition of metals is greater than nighttime because of the influence of traffic on resuspension. These patterns have been documented by direct measurements of deposition using specially designed deposition surfaces.

The modeled and observed patterns of atmospheric concentrations and deposition of heavy metals, combined with the measured properties of regional dust, has led scientists to hypothesize that dust-associated substances—including metals—deposit relatively close to the original source of the material but then are resuspended and redeposited numerous times before being carried out of the

region by winds, sequestered on the land surface, or washed off by rainfall (Figure 7). Thus deposition from the atmosphere is only one component of a complex system of pollutant transport operating at the land-air boundary.

### IMPORTANCE OF ATMOSPHERIC DEPOSITION

The relationship between atmospheric deposition of metals and water quality has been documented by a combination of model simulations and water sampling in the Los Angeles region. The findings are that nearly all the metals deposited on impervious urban surfaces wash off with the next rainfall, but that on more

## Atmospheric deposition is a potentially significant source of metals to water bodies.

natural land surfaces between 20% and 30% of the metals are sequestered from immediate runoff, (although the data on lead indicate sequestered pollutants may be available for resuspension by wind over longer time periods).

Comparison of the mass of metals reaching the land surface by atmospheric deposition with the mass found in runoff and with known mass inputs from other sources clearly shows atmospheric deposition is a potentially significant source of metals to water bodies (Figure 8). The contribution of atmospheric deposition can be as high as 99% in the case of lead, for which other contemporary sources are negligible.

### MITIGATION

Important scientific and institutional steps can be taken to deal with the effects of atmospheric deposition on water quality. It is important to refine current estimates of original sources and of resuspended dust sources of pollutants. Many emissions estimates are based on outdated information. Current estimates of these sources leave many



## Resuspended dust can be transported between continents, and dust from China often reaches the U.S. West Coast.

questions unanswered about the relative importance of vehicles and wind as mechanisms for resuspension in urban regions. In addition, it is vital to assess the relative magnitude of local and distant sources of potential pollutants, including intraregional sources.

Our understanding of key processes is incomplete. In particular, we need to know more about the spatial and temporal variability of resuspension, sequestration and wash-off so we can assess the importance of older sources and design and evaluate remediation and control schemes.

The most important institutional step is to modify air quality regulations to allow greater consideration of water quality impacts. Current regulations lump water quality concerns in a general category of “welfare effects” and do not enable regulators to consider cross-media issues fully. It is important for air and water agencies to work together in ways they have not done previously and to take a multidisciplinary approach. This change is long overdue and is key to progress in dealing with atmospheric deposition. Fortunately, agencies such as

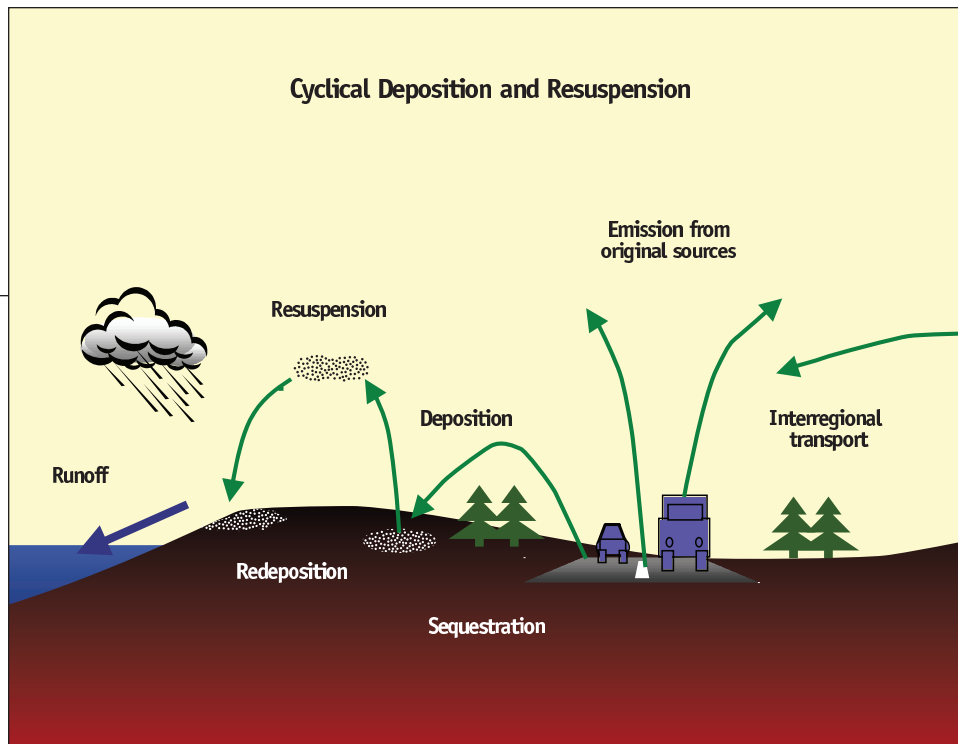


Figure 7: Hypothesized processes affecting coarse particle transport.

the California Air Resources Board and SCCWRP are beginning to interact for the first time in an interdisciplinary manner to address this issue.

Regulators should continue to reduce known sources of water pollutants. Efforts are already underway in the San Francisco Bay area, for example, to examine the potential benefits of reducing copper in brake pads, and similar studies should be undertaken for zinc in tires.

Land use regulations can take advantage of what we already know about patterns of deposition near roads and

freeways by minimizing use of these hot zones for sensitive uses such as residences and schools. In some cases it may be possible to provide vegetative buffer zones that reduce the size of the high deposition region near sources.

Finally, regulators should authorize and fund the extension of routine air quality monitoring to include particles larger than 10 microns and identified water pollutants such as metals, as well as conduct direct measurement of deposition rates. These measurements would inform future scientific studies of atmospheric deposition.

Annual Loadings to Santa Monica Bay (metric tons/year) from Different Sources				
	Aerial Deposition	Sewage Treatment Plants	Industrial	Power Plants
		Non-Aerial Sources		
Chromium	0.5	0.60	0.02	0.14
Copper	2.8	16.0	0.03	0.01
Lead	2.3	<0.01	0.02	<0.01
Nickel	0.45	5.10	0.13	0.01
Zinc	12.1	21.0	0.16	2.40

Figure 8: Relative importance of atmospheric deposition of metals in Santa Monica Bay.

## CONCLUSION

It is clear that achieving air and water quality objectives requires a consideration of atmospheric deposition of pollutants as a significant point source of pollutants. The effects of atmospheric deposition are linked to a system of dust transport at the air-land interface. Inferences about, and control of, the effects of human sources to this system are made difficult by the presence of nat-

ural material and by the complexity of the transport processes. Progress in understanding and dealing with atmospheric deposition as a non-point source will require continued acquisition of scientific information and the evolution of cross-media and multi-disciplinary regulatory and monitoring approaches.

**Current lead levels in the atmosphere and in newly deposited material appear to be supplied by resuspension of “old” lead present in soils and other surfaces.**

## GRADES

Past regulation and monitoring of atmospheric deposition: **Grade C-**. Past and current regulations and monitoring priorities have not addressed adequately the cross-media nature of atmospheric deposition.

Recognizing and acting on the problem of atmospheric deposition: **Grade B+**. Water agencies have recently supported studies of atmospheric deposition and the State air and water boards have begun the process of working together on this problem. However these efforts are largely voluntary and virtually no legal apparatus exists to compel agency action.

**It is important for air and water agencies to work together in ways they have not done previously and to take a multidisciplinary approach. This change is long overdue and is key to progress in dealing with atmospheric deposition.**

## **ACKNOWLEDGEMENTS**

This article could not have been written without the collaboration of Ken Schiff and others at the Southern California Coastal Water Research Project (SCCWRP). The author also acknowledges the contributions of his colleagues Professors Sheldon Friedlander, Richard Turco, and Arthur Winer. Reports and papers describing the results of atmospheric deposition studies in the Los Angeles region can be found on the SCCWRP web site ([www.sccwrp.org](http://www.sccwrp.org)).



Keith D. Stolzenbach is a Professor in the Department of Civil and Environmental Engineering. His research deals with environmental fluid mechanics and transport, particularly the fate and transformation of natural and anthropogenic substances in natural water bodies and the interactions between physical, chemical, and biological processes. He has been involved with the scientific and policy issues of coastal water quality in Boston and Southern California. His research during the last eight years has involved measurements and modeling of atmospheric deposition in the Los Angeles regions. Professor Stolzenbach received his Ph.D. from MIT in 1971 after which he worked for the Tennessee Valley Authority for three years and then as a faculty member at MIT for eighteen years before moving to UCLA in 1992.



An aerial photograph of a city, likely New York City, with a vibrant color overlay. The colors are primarily shades of green, blue, and orange, creating a textured, almost abstract appearance. The overlay seems to represent different data layers or environmental zones. The overall effect is a high-tech, data-driven visualization of an urban landscape.

GRADE A-

# Innovations in Environmental Monitoring



by Philip W. Rundel, Ph.D., Professor, Department of Ecology and Evolutionary Biology;  
Deborah Estrin, Ph.D., Professor, Department of Computer Science and Director, Center for Embedded  
Networked Sensing (CENS); and William Kaiser, Ph.D., Professor, Department of Electrical Engineering

Southern California faces many challenges in managing our environment, as do other regions of the country. How do our human activities affect, and in turn are affected by, changes in ecosystem structure, regional climate, and land use? How will future changes in land use and predicted changes in climate in Southern California influence fundamental ecosystem processes and critical services on which we depend so strongly? What will be the spatial and temporal scales of such changes and will responses be gradual or abrupt? At their roots, these questions reflect not just a curiosity about our future, but a desire for proactive management to mitigate undesirable outcomes. We would like to know the magnitude, pace, and geography of ecological changes, and to understand the implications of such changes for our environment and the provision of ecosystem services to humans. Answers to these questions will require new technologies in environmental monitoring and remote sensing.

In past years, articles in the Southern California Environmental

Report Card have dealt with a variety of regional issues, for example air pollution, groundwater pollution, biodiversity, and invasive species. While it is appropriate to address these important issues with focused attention, we also need to understand the complexity of our environment and the interaction between individual drivers of change. Human populations are initiators of ecosystem change as well as responders to such changes. Growing human population drives increases in urbanization and suburbanization in Southern California, and our needs for housing, commerce, food, and recreation have consequences for the structure and function of both natural ecosystems and our human environment. Changes in land use and land cover give rise to fundamental changes in ecological structures and processes, and thus to the ecosystem services that feed back to us. We all benefit from, and indeed depend on, a relatively high level of sustainability in water resources, soil fertility, climate conditions, and biodiversity.

Resource managers and policy administrators in the past have generally perceived ecosystems, and the organisms

they contain, as passive responders to climate variation and climate change, with no reciprocal effect on weather and climate. We now know, however, that ecological processes in one part of a region may have impacts on distant areas through the atmosphere and its circulation, and through flows of water through drainage networks. The realization that land use and ecosystem structure have important feedbacks to weather and climate has been a transforming paradigm for sustainable management of our environment.

Appropriately addressing all of these aspects of environmental impacts and interdependencies will require an entirely new generation of technology innovations. Fortunately, three important areas of technology advancement are occurring at the present time: new technologies for sensors and sensor platforms, remote sensing technologies, and technologies for efficient data transmission and analysis. This article describes these important new technological developments, and highlights examples of their applications to key environmental problems.

**Sensor networks have the potential to revolutionize science and influence major economic, agricultural, environmental, social and health issues.**

## SENSORS AND SENSOR PLATFORMS

The rapid development and miniaturization of technologies used in digital cameras, cell phones, and wireless computers are allowing scientists to develop networks of small sensors that will lead to a new era of monitoring the health and stability of our environment. Wireless devices half the size of a cell phone now exist with sensors to measure light, wind speed, rainfall, temperature, humidity, and barometric pressure. Moreover, these devices store collected data, process desired data averages or transformations, and then transmit requested data by radio frequency along a series of wireless hops to an Internet node.

Deploying arrays of hundreds of these sensor devices will allow us to fill a gap between local-scale ecological observations and environmental data from scattered regional weather stations. Such micrometeorological measurements at fine spatial and temporal scales will help scientists understand the relationship of broad-scale changes in global climate and local microclimate that control

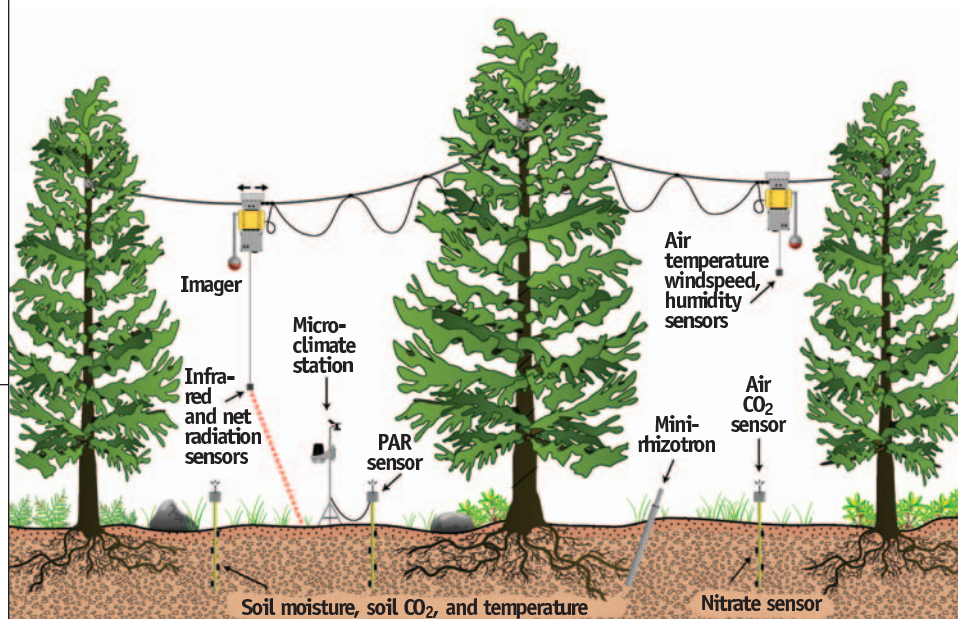


Figure 1. Cable-mounted mobile instrumentation platforms can communicate with fixed environmental sensors on the ground.

many ecosystem and physiological processes. These sensor networks have the potential to revolutionize science and to influence major economic, agricultural, environmental, social, and health issues, as well as to enhance opportunities for new educational programs.

Beyond fixed arrays of meteorological sensors, new types of sensors and improved sensor platforms are also being developed to provide environmental scientists with significant tools for understanding fundamental ecosystem processes in a manner not previously possible. Multi-spectral video imagers, acoustic sensors, gas analyzers, and other high-performance instruments are now being added to remote, unattended network deployments (Figures 1 and 2). These technologies greatly expand our

ability to monitor the environment to understand patterns of global change and changes in levels of water and air pollution. The use of such instruments is possible with new platforms that combine multiple processor and wireless network modules. These platforms have energy control systems to allow the nodes themselves, and their sensor devices, to operate only on demand, thus conserving energy for long-life operations.

Sensors mounted on trams or other mobile platforms are allowing an innovative approach to the flexible and efficient deployment of environmental sensors. In what is termed *actuated sensing*, fixed sensors can communicate the local presence of an unusual dynamic condition (e.g. a frost or dew point condition or a rare bird call) to a mobile system, tasking

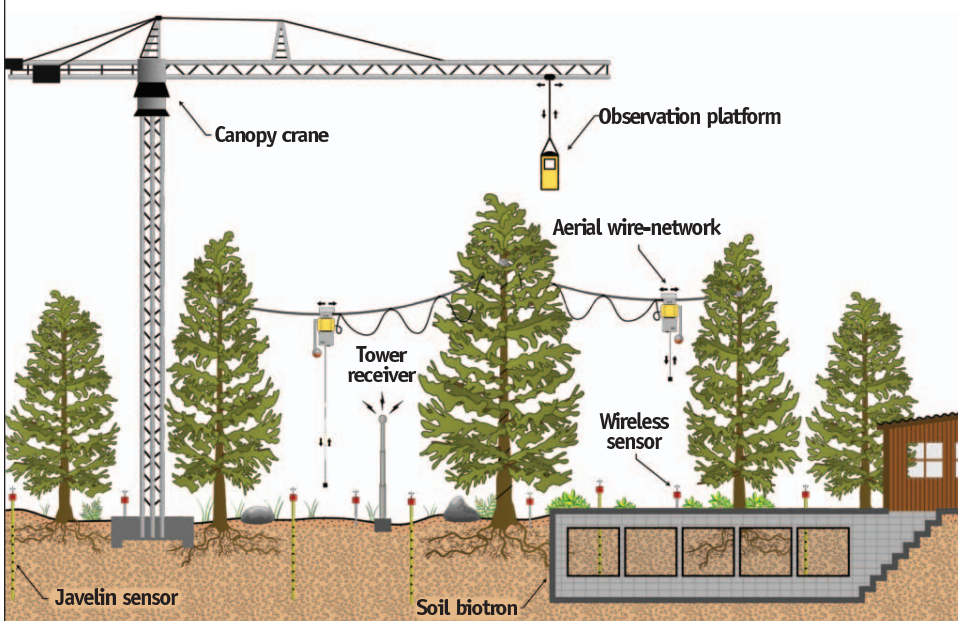


Figure 2. Proposed structure for a new generation of Biological Observatories with networked arrays of environmental sensors.

it to move to scan the area to better understand the spatial and temporal scales of the phenomenon or animal presence.

Beyond sensors and sensor platforms themselves, however, other critical components of these new technologies consist of the means for coordination of sensor modalities across multiple spatial and temporal scales, the infrastructure to link sensors to a broadly accessible wireless network, and of course the reliability for long-term deployment with appropriate maintenance and calibration of sensors. Key to the success of these systems are appropriate tools for the storage and management of large data sets so that users can rapidly and efficiently access multiple configurations of data sets in real-time.

## REMOTE SENSING

Remote sensing of ecological patterns and processes is a key element of the new technologies being applied to environmental monitoring and ecosystem model development. Resulting data are being collected by a combination of satellite sensors in earth orbit and instrumentation mounted in small aircraft. These sensors provide measurements of structural, spectral, and thermal characteristics of the land surface at a scale broader than that measured by fixed sensor arrays. Examples of such sensing instruments are multi-spectral imaging by the Moderate Resolution Imaging Spectroradiometer (MODIS), and radar interferometry, in satellites; and light detection and ranging LiDAR

**New technologies greatly expand our ability to monitor the environment to understand patterns of global change and changes in levels of water and air pollution.**

(laser altimetry), and thermal imagers, in aircraft.

MODIS is a key instrument aboard two NASA satellite systems. These satellites view the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths. The multi-spectral sensing capability of MODIS allows it to quantify surface characteristics of the earth such as land cover type, snow cover, surface temperature, foliage cover of vegetation, and fire occurrence. These data also allow analysis of leaf area, leaf duration and net primary productivity at a landscape scale, and thus provide important inputs to parameterize or validate models of ecosystem sustainability. Data from satellite-based instruments such as MODIS are allowing scientists to improve our understanding of global dynamics and processes, and further to develop models to predict spatial and temporal scales of global change across the landscape. MODIS has also been used for other regional analyses in Southern California. For example, UCLA researchers have recently used satellite images from MODIS of the 2003 Southern California wildfires to assess the expo-

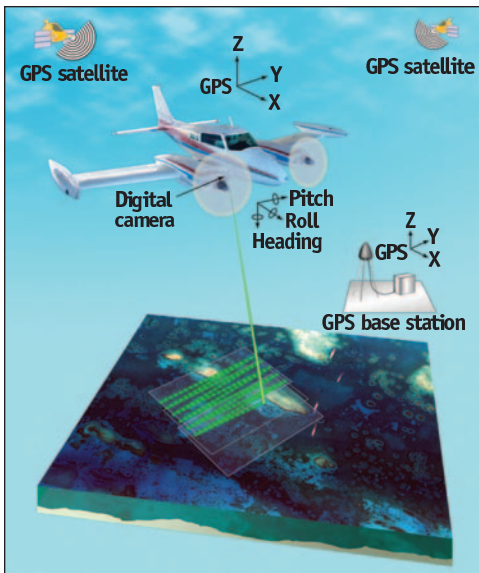


Figure 3. Applications of LiDAR technology (see text).

tures of residents of the region to fine and coarse particles generated by the fires.

Synthetic aperture radar (SAR) interferometry is another satellite-carried instrument developed to detect subtle changes in the earth's surface over periods of days to years with an unprecedented scale (global), accuracy (millimeter-level), and reliability (round-the-clock, all-weather). Over longer time scales of several years or more, high-resolution topographic data collected with SAR can also be used for large-scale change detection by comparing elevations at different times. This technique allows measurement of catastrophic changes in topography due to earthquakes, landslides, major floods, volcanic activity, and glacial melting. For

## SAR interferometry can detect subtle changes in the earth's surface over periods of days to years with an unprecedented scale, accuracy and reliability.

example, SAR data has been effectively used to measure seismic displacement associated with earthquakes in California.

LiDAR instrumentation mounted in small aircraft provides the capacity for three-dimensional characterization of vegetation structure, and thus the structural complexity of forest stands (Figure 3). Unlike video sensors, lidar directly measures the distribution of vegetation structure along a vertical axis, and can provide measures of canopy height, stand basal area, biomass and total cover to a remarkable level of precision. Such data have wide application in forest and agricultural management. Key to this technology is the joint use of high-speed laser rangefinders, precise inertial navigation systems to measure the three-dimensional movement of the host aircraft, and paired GPS systems on the aircraft and a ground station for precise positioning.

### DATA TRANSMISSION AND ANALYSIS

As new technologies allow us to collect massive sets of data across broad geo-

graphical areas in a manner not previously possible, a critical challenge lies with how researchers and resource managers will manage and utilize such large masses of data. The goal, of course is to allow researchers to access these data streams in real time, to quickly analyze them, and to utilize models to apply complex data streams to help mitigate environmental problems. Many of the most significant questions related to the complexities of our environment lie at interfaces: the interface of atmosphere with soil systems, soil with freshwater aquatic systems, and freshwater with marine ecosystems. Understanding these complex interactions requires real-time linkages between data streams from sensor arrays operating in the air, in plant canopies, in the soil, and in adjacent waters.

Rapid progress in technologies for commercial wireless networking, now widely available to the general public, has provided an important advancement for networked sensors both in local area systems covering a few km<sup>2</sup>, as well as for regional systems extending over distances of 10-100 km. These WiFi technologies allow inexpensive, energy effi-



cient and broadband connectivity through microservers to the Internet. Since the WiFi infrastructure is low cost and self-configuring, its deployment in natural and urban environments is convenient and rapid, accommodating wireless sensor arrays over a communication range of 100-200 m.

Commercial wireless technology also allows for long-range broadband links that may connect observation systems over large regions. One exciting example of new technologies for data access and transmission can be seen with HPWREN (High Performance Wireless Research and Education Network), a joint effort of the San Diego Supercomputer Center (SDSC) and the Scripps Institution of Oceanography. This exploratory project has created a high-performance, wide-area wireless network that spans much of San Diego County and adjacent counties. It includes backbone nodes on the UC San Diego and San Diego State University campuses, as well as a number of remote areas in San Diego County, including mountain peaks with hundreds of square miles of line-of-sight coverage. The HPWREN data communications infrastructure provides

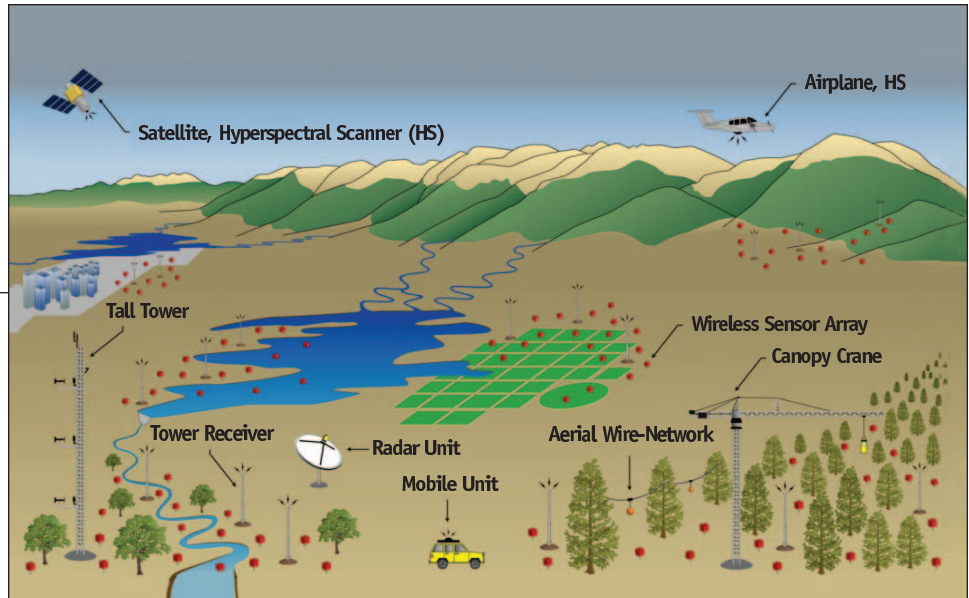


Figure 4. Regional distribution of sensor arrays and nodes in the proposed NEON program.

wireless high-speed Internet access for emergency data communications by local government agencies and first responders, for field researchers from many disciplines (geophysicists, seismologists, astronomers, oceanographers, and ecologists), and for rural Native American learning centers and schools. In using the high-speed HPWREN network, with a capacity to transmit 45 million data bits per second, emergency workers in mountain and desert locations and field researchers at remote sites can wirelessly transmit large amounts of data in real time. Because of the network's high speed, images from high-resolution cameras can be instantly transferred over the network without interfering with other traffic.

## NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)

The National Science Foundation (NSF) is in advanced planning stages for a major environmental program called the National Ecological Observatory Network (NEON). The mission of NEON (Figure 4) is to increase our understanding of how U.S. ecosystems and organisms respond to variations in climate and changes in land use at regional and continental scales. Understanding the significance of land use changes on our environment, and doing this in a manner relevant for urban planners and decision makers, provides a core component of the



Deborah Estrin is a Professor of Computer Science at UCLA, holds the Jon Postel Chair in Computer Networks, and is Director of the NSF-funded Center for Embedded Networked Sensing (CENS). Estrin received her Ph.D. (1985) in Computer Science from the Massachusetts Institute of Technology, her M.S. (1982) from M.I.T. and her B.S. (1980) from U.C. Berkeley. Professor Estrin chairs the Sensors and Sensor Networks subcommittee of the National Ecological Observatory Network (NEON) Network Design Committee, has been a co-PI on many NSF and Defense Advanced Research Projects Agency (DARPA) funded projects and has served on panels and committees for many networking related conferences.

William Kaiser is a Professor of Electrical Engineering at UCLA. In 1994, he initiated the first wireless networked sensor research with a vision of linking the Internet to the physical world through distributed monitoring. This research thrust continues with development of new robotic wireless sensor systems for environmental monitoring. Kaiser received his Ph.D. from Wayne State University in 1984.

## A critical challenge lies with how researchers and resource managers will manage and utilize the large masses of data we can now collect.

program. Land use changes that affect ecosystems and organisms include the conversion of land from wild to managed or urban land cover, and from agricultural uses to urban environments. The program will use new technologies, as described above, to measure important feedbacks between the biosphere and the atmosphere that are associated with alterations in land use, land cover, and vegetation. NEON will also investigate interrelationships between climate dynamics, biodiversity, invasive alien species, and emerging diseases such as west Nile virus. Thus, NEON programs will greatly advance our regional efforts toward environmental sustainability for Southern California by allowing us to better understand the environmental implications of land use policies, and by helping to mitigate unwanted effects of global change.

### THE FUTURE

As the influence of human activities continues to change the state of our environment and natural ecosystems, resource management efforts have

responded by becoming far more interdisciplinary, integrative, and collaborative. Efforts to address the environmental “grand challenges,” such as the effects of climate change and land use on our Southern California ecosystems, are promoting the coordination of standard measurement protocols and data management infrastructure across our region.

The key goal driving the development of new technologies for environmental monitoring continues to be an improved understanding of the complex behavior of ecological systems in a world with dynamic climate variation, and a means of predicting future environmental sustainability. These complexities of our ecological systems in Southern California arise not only from the dynamic nature of our physical and chemical environment, but also from our diverse biological systems and most especially our human societies. Effective predictive models for understanding ecological complexities and their reciprocal implications for human activities will depend on the collection of high-quality data, new approaches to synthesizing and visu-

**NEON programs will greatly advance our regional efforts toward environmental sustainability for Southern California by allowing us to better understand the environmental implications of land use policies, and by helping to mitigate unwanted effects of global change.**

alizing these data across multiple spatial and temporal scales, and knowledge transfer to allow resource managers and land use planners to take advantage of these advances in a real-time collaborative manner.

#### **GRADE A-**

Engineers, information technologists, statisticians, and ecologists are all working together effectively today in collaborative programs to advance the applications of new technologies for environmental monitoring and to improve our understanding of how variations in land use and climate influence ecosystem structure and function, as well as the consequences of these variations for society. The Center for Embedded Networked Sensing (CENS) at UCLA has been a focus of this research, with active participation of scientists and engineers from USC, UC Merced, UC Riverside, and Caltech. More information on this program is available at <http://research.cens.ucla.edu>.



Philip Rundel is Professor of Biology in the Department of Ecology and Evolutionary Biology at UCLA, and a senior investigator in the Center for Embedded Networked Sensing (CENS). He joined the faculty of UCLA in 1983 after 13 years on the faculty of UC Irvine. He is a plant ecophysiologicalist who has worked for many years on a variety of aspects of the ecology of mediterranean ecosystems of California and similar areas in the world. His work with CENS involves the development and application of new technologies in embedded networked sensing systems, mobile sensing platforms, and wireless communication systems that can be physically embedded in an environment and act to reveal events and processes that are invisible to more traditional observational technology. He teaches courses on California Ecosystems and Conservation Biology.



# About the UCLA Institute of the Environment

The Institute of the Environment formed in 1997 to bring together a community of scholars focused on finding sustainable solutions to major environmental problems. Our members and constituents represent a broad array of academic disciplines, research interests, policy concerns and outreach avenues. Los Angeles is our home, and it provides a rich mixture of urban environmental health challenges and opportunities for enhanced resource management. But our interests span the globe, from tropical ecosystems to innovative energy technologies.

## WHAT DO WE DO?

- We create partnerships for new research that cross the traditional boundaries of natural science, social science, humanities, law, business, public health and public policy, to name a few.
  - We develop new policy solutions that affect the global, regional and local environments, and work with non-governmental organizations,
- including businesses and environmental organizations, as well as government agencies to maintain a lively debate.
- We develop educational programs to meet the needs of today's students, whether they are environmental professionals or citizens of the world.

## OUR NEW ACADEMIC PROGRAM

As an interdisciplinary center, we also continue to focus on cross-disciplinary methods of education to train our future leaders to tackle our most pressing environmental problems. This Fall, we are inaugurating our new interdisciplinary Environmental Science degree program. This new major is an innovative dual-component program that offers students disciplinary breadth through the Environmental Science major and focused, disciplinary depth through a minor or concentration in one of eight environmental science areas: Atmospheric and Oceanic Sciences,

Environmental Biology, Environmental Engineering, Environmental Health, Environmental Systems and Society, Geography/Environmental Studies, Geology, and Geophysics and Planetary Physics. The new program includes 17 different departments.

## THE 'GREENING' OF UCLA

In June 2005, the IoE moved into the first LEED (Leadership in Energy and Environmental Design) certified "green" building on the UCLA campus. La Kretz Hall will be the first of many "green" certified buildings on campus since the University of California adopted a policy on Green Building Design, Clean Energy Standards and Sustainable Transportation Practices—articulating a commitment to alternative transportation planning, green power purchasing and conservation measures and incorporating the principles of energy efficiency and sustainability in the planning, design and construction of new buildings, and the renovation of existing structures.

**The Report Card is a collection of essays on important environmental topics, presenting researchers' findings in a context meant to be useful to both policy makers and the public.**

## From the Director

*continued from page 3*

greenhouse gases. As it becomes increasingly obvious that current levels of emissions to the atmosphere are causing measurable effects, understanding the potential for mitigation and adaptation takes on a larger importance, even as society looks for ways to slow or halt the buildup. "Sound science" is a term of art, sometimes used by policy makers urging delay in taking action, but in the case of global warming the need for science that can inform local and regional decisions about urban greening, water infrastructure, agricultural and forest policies is growing more urgent every day.

Each of the articles approaches the question, "So, how are we doing?" using a different set of analytical tools. But taken together, they present a remarkable picture of a region that is making progress towards sustainability in the face of enormous challenges. Perhaps this reflects some bias on the part of the editors, but I think it more likely that this approach—a willingness to wade into messy current issues while keeping one's head above water—is characteristic of the research that is being produced by the outstanding faculty who give their

time and talent to the work of this Institute.

A final new campus effort worth sharing with you is UCLA's Committee on Sustainability of which I have been appointed Co-chair. Working with students, administrators, campus operations managers and all interested members of the campus community, we have embarked on an ambitious effort to incorporate sustainability into all aspects of life at UCLA. Though "sustainability" is a fuzzy term, most of us have a sense that it means preventing and cleaning up waste and pollution, using finite resources efficiently and substituting renewable resources wherever feasible, so as to leave enough for future generations. Here is one of the most widely accepted definitions:

Sustainability refers to the physical development and institutional operating practices that meet the needs of present users without compromising the ability of future generations to meet their own needs, particularly with regard to use and waste of natural resources. Sustainable practices support ecological, human, and

economic health and vitality. Sustainability presumes that resources are finite, and should be used conservatively and wisely with a view to long-term priorities and consequences of the ways in which resources are used.

UCLA is looking at itself as well as others when it rates environmental performance. We are evaluating how to operate in a sustainable environment, looking at all aspects of the campus. From energy used in buildings to the food served in dining halls, from the courses we offer to the long term plans for campus growth, UCLA is taking the idea of sustainability seriously. By the time the 2007 Report Card is released, I hope to be able to report on the progress of this effort, which is housed at La Kretz Hall and incorporated into the IoE.

As always, we welcome your comments.

## The lack of obvious industry-wide rules and standards suggests that the FTI as a whole has yet to devise effective approaches for implementing progressive environmental practices.

### Film and Television

*continued from page 11*

there are a growing number of people in the industry working to achieve higher levels of environmental performance, it is probably inappropriate to assign low grades to lagging elements during this period of rapid transition. Nevertheless, the lack of obvious industry-wide rules and standards suggests that the FTI as a whole has yet to devise effective approaches for implementing progressive environmental practices. It is possible that more is being done than we are aware of. In fact, on the basis of confidentiality, we have been made aware of additional environmentally proactive behavior within the industry that is not reported here. While green production guides such as those issued by the EIDC and the EMA have value, the limited publicly-available information on environmental performance, and the lack of third-party verification mechanisms, do not favor a conclusion that the FTI is doing all it can. As an enterprise, the industry obviously recognizes that its environmental messages—both on the screen and off—represent a powerful tool for public education. However, policies to mitigate environmental impacts within the

industry remain to be implemented in a more systematic and transparent manner.

Environmental best practices: **Grade A.**  
Industry-wide actions: **Grade C.**

#### REFERENCES

The report, “Sustainability in the Motion Picture Industry,” on which this article is based, was produced under contract to the California Integrated Waste Management Board (CIWMB) by Charles J. Corbett and Richard P. Turco, April 13, 2006. Detailed references and sources can be found in that report.

#### ACKNOWLEDGEMENTS

We thank our UCLA student team, especially Joanna Hankamer, Shannon Clements and Jeannie Olander. Other students who contributed are Fatma Cakir, Patricia Greenwood, Penny Naud, Kimberly Pargoff, Michael Rabinovitch, Linh Goc and Todd Steiner. Professor David Rigby collaborated to estimate the environmental impacts of the film and television industry. Professors Barbara

Boyle, Mary Nichols and Gigi Johnson shared contacts and insights. Many individuals generously provided time for this project. Finally, the UCLA team received exceptional support from the contract managers at CIWMB (Judith Friedman, Brenda Smyth, and Kristy Chew).

#### NOTES

1. Carnegie Mellon University Green Design Institute (2005); the Economic Input-Output Life Cycle Assessment (EIO-LCA) model is available at: <http://www.eiolca.net>. After the analysis in this report was carried out, the EIO-LCA input-output data and sector definitions were updated, and we are currently reanalyzing the estimates presented here.
2. A correction is made to account for the difference between the definitions of “final output” and “size” of a sector; refer to the full report for more details.

**Editors**

Ann E. Carlson, J.D.  
Arthur M. Winer, Ph.D.

**Managing Editor**

Bonnie Barclay

**Authors**

Charles J. Corbett, Ph.D.  
Deborah Estrin, Ph.D.  
William Kaiser, Ph.D.  
Anastasia Loukaitou-Sideris, Ph.D.  
Philip Rundel, Ph.D.  
Keith D. Stolzenbach, Ph.D.  
Richard P. Turco, Ph.D.

**Design**

Vita Associates

**Printing**

Pace Lithographers, Inc.

**Photographs**

Bonnie Barclay (10, 19)  
CORBIS (cover, 4, 12, 20, 30)  
Robert Reed Hutchinson, UCLA  
Photographic Services (11)  
William Kaiser (36)  
Scott Quintard, ASUCLA  
Photography (37)  
Ernesto Rodriguez (2)  
Orit Stieglitz, Ph.D. (18)  
UCLA Photographic Services (29)  
Xuan-Mai Vo (36)

**Figures/Diagrams**

Charles J. Corbett, Ph.D. and  
Richard P. Turco, Ph.D. (7, 8, 11)  
City of Los Angeles, Commission on  
Children, Youth, and their Families (15)  
Jason C. Fisher, National Ecological  
Observatory Network (32, 33, 35)  
Peter Harnik, Urban Land Institute (14)  
Orit Stieglitz, Ph.D. (16)  
Keith Stolzenbach, Ph.D. (25, 26, 27, 28)  
The UC Davis Tahoe Environmental  
Research Center (24)  
U.S. E.P.A. (22)

---

**Acting Chancellor, UCLA**

Norman Abrams

**Director, IoE**

Mary D. Nichols, J.D.



**Institute of the Environment  
University of California, Los Angeles  
619 Charles E. Young Dr. East  
La Kretz Hall, Suite 300  
Los Angeles, CA 90095-1496  
Phone: 310-825-5008  
Fax: 310-825-9663  
Email: [ioe@ucla.edu](mailto:ioe@ucla.edu)  
Web site: <http://www.ioe.ucla.edu>**