Chapter in: Paul R. Miller and Joseph R. McBride (Eds.) 1999
Oxidant air pollution in the montane forests of
Southern California: a case study of the San
Bernardino mountains. Ecological Studies Series,
Vol. 134. Springer-Verlag: New York, p. 373-393.

17. Human Aspects of Air Quality in the San Bernardino Mountains

P.L. Winter

Introduction

The preceding chapters of this book have provided information on the ecological characteristics of the San Bernardino Mountains, as well as the effects of ozone and other air pollutants on vegetation and soil in the San Bernardinos, and additional interactions with air pollution and forest health. This chapter focuses on the human aspects of air quality in the San Bernardino Mountains because of the desired connection between available scientific information, wider understanding and acceptance of that information, and movement toward policy and behavioral changes necessary to act on scientific knowledge. Much of the literature has drawn on results from studies conducted in locations other than the San Bernardino Mountains. The author makes the assumption that the majority of findings from differing, or larger geographical regions are applicable to the San Bernardinos, the focus of this book. Where applicability is tenuous, it is so noted. Examining human–environment interactions was referred to by Stern (1993) as a critical second environmental science, wherein the linkages between human activity and environmental protection can be explored. A connection to perceptions of air quality and recreation is explored in the light of the significant resource production represented by recreation in the San Bernardino National Forest (as demonstrated by the reporting of more than 6 million recreation visitor-days in 1995 alone for the forest; USDA Forest Service 1996). An early proposal to further examine social and economic issues related to the San Bernardino Mountains is found in Taylor (1973), wherein valuable historical background of the area is provided.

How much of a scientific concern is there regarding air quality and forests? There appears to be agreement among scientists studying air pollution in forests that ozone is the greatest threat to forest growth, with southern California conifer and Appalachian high-elevation spruce-fir ecosystems suffering the most (de Steiguer et al. 1990). Growth declines are expected to accelerate over the next 20 years, even if emissions remain constant. Threats of damage from ozone exposure extend into Class I wilderness areas, where air quality is of major protection concern. Based on their findings from New Hampshire and Vermont, Lefohn and Manning (1995) suggest that ozone presents a considerable risk to Class I areas nationally, necessitating continued monitoring efforts as well as continued research on cause-and-effect relationships between ozone and vegetative health and vigor.

A general discussion of the varied costs from air pollution damage to vegetation revealed economic losses (in terms of loss of crops and increased need to use pesticides when pollutants make the vegetation more susceptible to pests); losses to ecological structure and function, which can also have economic linkages, including impaired long-term sustainability of a system; loss or altering of genetic diversity of populations; and loss of cultural values based on the intrinsic worth of ecosystems (Tingey et al. 1990).

Agreement over degree of damage from air pollution and limits to growth in forests is not global, however. Kandler and Innes (1995) contend that much of the discussion of decline and peril of central European forests is based on poor information and that growth rates of trees and stands in central Europe are higher than at any other time of recorded growth. It is their assessment that improved forest management (e.g., regular thinning and forest pest management) may actually be more important than other environmental changes in examining forest growth. The main pollutants examined by these authors were sulfur dioxide, nitrogen dioxide, and ozone.

Such discussions make it difficult for laypersons to understand what scientists know thus far and how it affects them, if at all. These difficulties complicate any hopes of support for current or future policies designed to improve air quality and protect ecosystems. By focusing on the interactions between humans and the environment, however, there may be a natural linkage that the layperson can understand and more readily embrace.

Human Dimensions of Air Quality

The examination of the human dimensions of air quality reflects the varied impacts that air pollution has on quality of life.

Physical Impacts of Poor Air Quality

"A critical question in many urban environments is not whether the air is unhealthy, but, given that the air quality is poor, how severely is health affected?"

(Hall 1996, p. 743). "At low concentrations ozone causes coughing, nausea, irritation of the eyes, nose and throat, and headaches. At higher concentrations, 150–200 parts per billion, it damages lung function" (Godlee 1991, p. 1539). The damaged lung function is revealed through reduced forced vital capacity, forced expiratory volume, and peak expiratory flow rate. These findings are present for both individuals with asthma (considered at highest risk) as well as in healthy volunteers. Effects of ozone are worsened with exercise and prolonged exposure (Godlee 1991).

A comprehensive assessment of health effects of ozone and inhalable particulate exposure was conducted in the South Coast Air Basin of southern California. That assessment revealed nearly every resident being exposed to levels of ozone above federal air quality standards at least some time during the year. Thirty percent of San Bernardino County residents were exposed to ozone levels well above these standards (28 pphm), but only 7% of Orange County residents were exposed to such levels. School-aged children received higher exposures and dosages, as well as experiencing more health effects. Eye and throat irritation were the most frequent health effects identified from ozone exposure (Hall 1996). Similar findings are cited by Aunan (1996). A State of California Air Resources Board–sponsored study shows the 24-hour average ozone level in 1994 in the Lake Arrowhead community (in the San Bernardino Mountains) to be almost double the levels seen in 11 other comparison communities being monitored. This important study is examining the long-term exposure of air pollutants and its impact on children's health in southern California (1995).

An analysis of hospital emergency outpatient visits and admissions and measurements of air pollutants including smoke, carbon monoxide, and nitrogen dioxide were analyzed for the greater Athens, Greece, area during 1988 (Pantazopoulou et al. 1995). During the winter season, the effect of all air pollutants was statistically significantly related to both the increase in the number of cardiac admissions and emergency respiratory admissions. These were analyzed by using multiple linear regression and controlling for meteorological variables. An explanation for the lack of a significant relationship during summer months between air pollution and hospital emergency department visits was not offered. Ozone was not examined in this study because of its relatively low levels in Athens. The authors cite a study by Touloumi and others demonstrating statistically significant effects of air pollution on mortality in Athens using time series analysis of 1983–1991 data. Caution should be taken, however, in applying health effects results to other areas because of differences in pollution sources and levels, weather, time activity patterns, overall health status, age distribution of the population, and access to medical care (Aunan 1996; Lipfert 1997). Progress in studies of air quality and health linkages has been somewhat limited by scarce resources and few multidisciplinary studies (Dunn and Kingham 1996).

Fisher (1976) contends that the cost of air pollution to the urbanite is significant in terms of bronchitis, emphysema, other respiratory diseases, and even death from lung cancer. Structural damage to the lungs may result from chronic exposure to ozone (Godlee 1991). However, the offsetting benefit of greater access to medical treatment for urbanites is viewed as counteracting some of this cost (Fisher 1976), and there may be some physical, behavioral, and attitudinal adaptation to pollution exposure over time (Kates 1976; Evans and Jacobs 1982; Godlee 1991; Bell et al. 1996). Whether this adaptation should be viewed as positive or negative is addressed in the following section, examining some of the psychological and behavioral impacts of air pollution exposure.

Psychological and Behavioral Impacts of Air Pollution

Examinations of the psychological and behavioral impacts of chronic air pollution exposure have been limited and are characterized by a primary focus on short-term exposure to pollutants or toxic odors in a laboratory setting (Evans 1994). There are, however, exceptions to this short-term exposure focus. The research conducted by Rotton and colleagues examines social data during high-ozone periods to identify linkages between pollutant exposure and psychological and behavioral indices. For example, Rotton (1993) studied incidences of reported sex crimes and found a statistically significant relationship between photochemical oxidant levels and obscene phone calls. The statistical relationship held, even after the effects of temperature were partialled out. A similarly disturbing crime trend was reported by Rotton and Frey (1985), wherein archival data spanning 2 years revealed a significant relationship between ozone and reports of family disturbances. Both of these studies are indicative of the negative social cost of ozone, most probably linked to increases in negative affect and irritability (characteristic of the larger line of research on environmental stressors). Such affective disturbances were also indicated by Rotton and Frey's 1984 article, revealing an increase in calls to police to handle psychiatric emergencies on days when photochemical oxidants were high.

Evans et al. (1982) examined instrumental and palliative coping strategies used in response to air pollution. Instrumental strategies included active forms of coping, such as gathering additional information about air pollution or changing behaviors by limiting time outside on smoggy days or using mass transit. Palliative strategies included more passive forms of coping, such as shifting one's perception of the air quality in one's immediate neighborhood. Length of residency was positively related to tendency to use palliative strategies such that individuals who had lived in a high-smog area longer were more likely to use these forms of coping to address air quality. Individuals living less time in a high-smog area were more likely to use instrumental strategies, including observing health advisories. These differences were indicated by long-term residents believing that smog had a less negative effect on them than did new residents, less of a belief that use of mass transit or car pooling would reduce smog, and a shifting of the amount of smog necessary in a visual scene before detection. Beliefs about the potential negative health effects of smog are important, as they have been found to be the best predictor of compliance with health advisories (Evans et al. 1988). In addition, beliefs about the ability to reduce smog are important in understanding compliance with health advisories (Evans et al. 1988). Viewing these studies in

combination raises a significant concern about the well-being of long-term residents in areas with high smog levels. If residents believe that their actions will not make a difference and that the personal risk is minimal, they will be unlikely to comply with health advisories or to take any advocacy role to address pollution (Evans 1994).

Economic Impacts of Air Pollution

Lee (1993) contends that "unless environmental problems are recognized as economic problems they will not be addressed sensibly, no matter how sophisticated our scientific knowledge" (p. 1980). Economic impacts of air pollution on health are viewed as well-established components of cost models using impact pathway approaches that capitalize on the best scientific data available (Holland 1995). Assessment is based on "willingness to pay for improvement" or "willingness to accept" further risk, rather than the absolute value of health or life. Pollution is also costly to organizations through employee illnesses (Fisher 1976). Economic costs have also been applied to the evidenced decrease in lifespan of buildings, materials, and cultural monuments (Kucera and Fritz 1995). Finally, air pollution controls have economic impacts in the form of pollution abatement, regulation, monitoring, and research and development (Vob and Schmid 1991; Linn et al. 1994). Although poor air quality has costs attached, improvements in air quality offer economic benefits. Analyses of economic impacts of air pollution and regulatory efforts should be offset by net increases due to spending changes and additional in-migration as air quality improves (Lieu and Treyz 1992), generally calculated in terms of wage-rate increase equivalents.

However, costs in terms of loss to natural resources is much less clear, as data are more limited (Vob and Schmid 1991; Holland 1995) and an agreed-on, systematic commodity structure for environmental resources is still lacking (Smith 1993). Nevertheless, it has been argued that applying economic values to public resources is possible, can be held constant across a variety of ideologies, and can be tied into intervention efforts when translated into individual economic consequences (Bell 1995).

In an attempt to counteract the varied costs of air pollution, several regulations have been enacted. The next section explores some of those regulatory responses and their effectiveness.

Regulatory Responses and Their Effectiveness

"Air pollution control in the United States and most other countries of the world has been a series of disjointed, uncoordinated efforts dealing with narrow issues and specific industries" (McIllvaine 1993). McIllvaine (1994) contends that older energy plants are not affected by the regulatory guidelines established in the United States (see also Schulze 1993), and some pollutants are heavily focused on through regulation whereas others are overlooked. Policies on air pollution and controls should be set on a global level (Vob and Schmid 1991; McIllvaine 1993) and focused on the variety of sources and industries causing pollution, instead of a select few (Anonymous 1993; McIllvaine 1993). Only marginal results can be expected out of national efforts without cooperation at the international level (Michel Mousel, President of Agence de l'environnement et de la maitrise de l'énergie in France, paraphrased in Rector 1992). "The design and enforcement of environmental regulations are based almost exclusively on prior scientific evidence concerning the links between particular environmental factors and health outcomes rather than on postintervention evaluation research" (Stokols 1992, p. 17).

Shortcomings in demand-side management practices for energy production have led to an increase in air pollution in some instances, rather than a decrease (Hall et al. 1995). In part, this is explained by the focus on installation of emission control technology, without consideration of actual emissions or air quality impacts when operating systems. The cleanest power plants are not necessarily the ones that are dispatched first (Hall et al. 1995). Air quality improvement measures addressed through the 1991 Air Quality Management Plan in the Los Angeles Basin were examined by Bae (1993). It is her assessment, based on 1991 data, that the program measures focused on reducing vehicle miles traveled have only a modest impact on air pollution reduction. The level of travel behavior changes that are assumed in the Air Quality Management Plan is not viewed as feasible, given the multiple determinants of travel behavior, including location of jobs some distances from households (Bae 1993). She argues that more transit use, ridesharing, and telecommuting are not needed to achieve clean air objectives, whereas technological solutions to the automobile emissions problem are of great importance.

Although some countries have been able to improve their air quality, developing countries are now considered to be at great risk because many lack the necessary monitoring and evaluation systems currently in place for major air pollutants in megacities such as Los Angeles and Tokyo (Mage et al. 1996). Tolley (1979, cited in Shukla and Parikh 1992) suggests that pollutant concentrations caused by industrial establishments, household fuels, and motor vehicles all increase with city size. However, sustainable development offers the opportunity to seek economic prosperity while guarding natural resources (Ramon John Hnatyshyn, paraphrased in Rector 1992). In fact, examinations of the ability to use pollution controls accompanied by economic growth and adoption of pollution abatement measures paint a more positive picture of the future as nations develop (Shulka and Parikh 1992). Such measures must be accompanied by a reduction in per capita consumption and a decrease in environmental throughput, especially in the more affluent nations (Vlek 1995).

Although several assessments have led to the conclusion that regulatory policies, have been ineffective, Rinquist's (1995) review of data from the Environmental Protection Agency spanning the mid-1970s to the late 1980s reveals that states with stronger regulatory programs have been effective in reducing atmospheric concentrations of nitrogen dioxide and sulfur dioxide. Therefore, although criticisms have been aimed at current regulatory policies, they are, in fact, demonstrating effectiveness.

Attitudinal Assessments and Behavioral Responses to Air Quality and Regulation Efforts

"Although the role of human behavior in air pollution is considerable, research has emphasized the technical, economic, and physical health aspects of the problem. Human behaviors such as energy use or choice of transportation mode directly affect the production of air pollution. Less directly, our attitudes and political and economic decisions about environmental protection also affect pollution levels" (Evans and Jacobs 1982, p. 105). The heavy focus on technology and emission standards (see, e.g., Zundel et al. 1995) directs our energies away from the potential gain that could be appreciated from examining human attitudes and behaviors that might also be addressed in pollution control. In fact, social scientists have much to offer in the way of pollution control (Vlek 1995).

Assessments examining awareness of pollution have pinpointed typical cues individuals used to detect the presence of air pollution, including dust, odor, discoloration and damage to property, respiratory irritation, eye irritation, and poor visibility (Evans and Jacobs 1982; Bell et al. 1996). Adaptation, perceived control, and other individual factors explain important differences in perceptions of air quality (Kates 1976; Evans and Jacobs 1982). Although laypersons tend to define or describe air pollution in terms of particular effects, experts are most likely to focus on causal factors and health effects. Even though individuals may be aware of air pollution, according to Evans and Jacobs (1982), there is little evidence that individuals significantly alter their outdoor activities in response to pollution, and very few actually lodge complaints to appropriate agencies about perceived poor air quality. A denial of personal adverse effects of air pollution and of the disadvantages of living in an area with poor air quality compound the pattern of nonresponsiveness to air quality issues (Liu 1996).

Possible Innovations in Intervention

The behavioral intervention literature offered by environmental and social psychologists offers an excellent reference point for potential innovations in pollution intervention, given the complexities of regulation in the face of attitudes, values, and behaviors (Oskamp 1991). However, much of the behavioral intervention literature has yet to be translated into efforts at the community or regional scale. Dwyer and colleagues' (1993) taxonomy of intervention strategies provides an organizing structure for the exploration of behavioral interventions. Intervention strategies may be targeted at the individual or group level, may be active or passive, and may involve antecedent or consequence conditions. The following discussion focuses on individuals or groups rather than organizations. Stern (1995) contends that "most pollution is caused by organizational behavior, not individual behavior." He also points out that the amount of pollution decrease that would result from changes in individual actions, assuming they could be changed by "simple acts of will" is marginal. Ozone should be noted as the exception to Stern's contention. Use of more environmentally sensitive technologies, educating the next generation, and taking collective action to promote technical and social changes are far more important initiatives (Stern 1995). Nevertheless, the individual can play an important role in collective action and changing direction, maintaining the merit of examining findings on individual and small group interventions. There is yet one more important caveat to address before moving forward, however. It is sometimes attractive among those holding knowledge about the environment and its protection to believe that to change individual behavior they need to share their knowledge with others, thereby affecting the others' knowledge base and consequently their values (Eden 1993). This presumably would then lead to a change in behavior, making the person more environmentally sensitive and responsible. Yet, there is no credible evidence that proenvironmental values are sufficient to guarantee environmental protection (Hutton and Ahtola 1991; Oskamp 1991; Stern 1995). In fact, although environmental concern is high among the general population, inaction remains the norm. Factors external to the individual seem to overwhelm many of the proenvironmental behaviors that might take place (Oskamp 1991; Stern 1995). The real interest will lie in long-term behavioral changes and commitments to environmentalism (Dwyer et al. 1993), accompanied by situations that allow individuals to act on their commitment (Stern 1995).

Individual-passive-antecedent strategies would involve things such as exposing an individual to written or oral information providing knowledge that would encourage a target behavior (Dwyer et al. 1993). Examples of brochures and signs that can be used in wilderness education (USDA 1989) serve as a tangible reminder of agency investment in these strategies. "This kind of strategy is based on the assumption that the relevant behavior is 'reasoned,' and that influencing the cognitive processes underlying behavior choices will also affect those choices themselves" (Vlek 1995, p. 15). These can be information- or morally based (Gardner and Stern 1996), although morality serves as less of an effective appeal than other bases (Eden 1993). Controlled studies of written prompts, in the forms of handbills or signs, have shown some effectiveness in increasing environmentally responsible behaviors (Dwyer et al. 1993). These written messages are usually simple, and ones that are worded positively appear to have more behavioral impact than those worded negatively. Modeling desired behaviors is another example of an individual-passive-antecedent strategy, wherein others are exposed to a video or first-hand viewing of environmentally responsible acts. Social demonstrations of desired behavior tend to work best under circumstances wherein the desired action is unclear (Cialdini 1988). Modeling assumes that the behavior and its underlying cognitive structure are strongly determined by social factors such as norms and customs, social comparison processes, privacy versus collectiveness, and public examples set by sometimes prominent members of society (Vlek 1995). It is important that models are detected by target observers, however, if one hopes for any behavioral impact. Modeling was used as part of a forest environmental education effort in dispersed recreation settings in hopes of encouraging responsible action. Although program educators were observed modeling during the majority of visitor contacts, recreationists who were interviewed rarely reported noticing their actions (Absher and Winter 1997).

Active-individual-antecedent strategies have also been applied for behavioral interventions. Of particular interest are the studies examining commitment, either written or oral, of individuals to behave in an environmentally responsible fashion. Written commitments appear to have longer-lasting effects than verbal ones under experimental conditions (Dwyer et al. 1993), and commitments made in public appear to strengthen people's personal, private commitment (Gardner and Stern 1996). Group strategies would be used in similar fashion to the individual ones described above, although team or competitive strategies can be brought into the intervention plan.

Individual-consequent strategies would involve methods such as direct feedback, indirect feedback, rewards, or penalties (Dwyer et al. 1993). An example of feedback is the monthly usage comparisons for current and past year appearing on gas and electric bills. Feedback, even on an intermittent basis, has been found to have some effect on energy consumption (Dwyer et al. 1993). I currently receive a rate-break on my electricity bill because I have permitted the utility to install a cycling device, wherein they can reduce my usage during peak periods. Penalties are found in the higher costs attached to usage above baseline levels. Such strategies can be effective; however, tax-based rewards and penalties tend to be more favorable to upper-income consumers (Howard 1993; Stern 1993). This would be especially true in circumstances wherein a desirable conservation behavior requires some significant up-front investment to be made, to enjoy the longer-term benefit of reduced consumption (Howard 1993). Group-consequent strategies would apply the same principles just described to a set of persons rather than being individually focused. Apartment dwellings are an example of one setting wherein group feedback and incentives have been used with some success (Dwyer et al. 1993). At the community level, caution must be exercised because not all communities distribute resources equally and not all members are necessarily happy. Concerns about individual freedom and procedural justice remain (Gardner and Stern 1996).

Human behavior and environmentally destructive or harmful actions need to be analyzed in terms of limiting factors such as technology, attitudes, knowledge, money, convenience, attention, and trust, as all are needed for behavior change (Stern 1993; Gardner and Stern 1996). It is clear that interventions must have multiple features, and because limiting factors vary by individuals and can change over time, they must be dynamic and flexible (Stern 1993; Gardner and Stern 1996). The ability for interventions to maintain behavioral changes over the long term has been underexplored. There is a distinction between changing behavior and maintaining that behavior change. For example, antecedents and consequences that were removed after an experiment was over took the behavioral changes with them (Dwyer et al. 1993). It is important that other contingencies, such as social approval or acceptance, fill in once the initial intervention effort subsides. In many cases, environmentally responsible actors are still made to feel that they are "on the fringe," despite the high level of environmental concern expressed (Eden 1993). An increased sense of competence, as well as the motivators of frugality and participation, can be intrinsically satisfying and may, in fact, serve to sustain environmentally responsible acts when external contingencies are not relied on (De Young 1996). At an individual level, it is important to recognize that behaving in an ecologically responsible fashion represents a wise personal investment, whereas behaving irresponsibly becomes even more costly on a daily basis (Howard 1993). Environmental behaviors must be viewed as personal responsibilities, as efficacious, and as possible (Eden 1993). "A good argument can be made that air pollution reduction may be society's most difficult environmental issue. . . . For air pollution reduction, effects cannot be measured on an individual level, and benefits may not accrue at all if others do not participate" (Hutton and Ahtola 1991, p. 253). The complexity of intervention is compounded by attitudinal and behavioral strategies used to cope with chronic exposure to air pollution (Evans 1994).

This chapter now turns to the discussion of the linkage between recreationists and air quality. Recreationists represent a large constituency, and there is some evidence that avid recreationists are more likely to be environmentally responsible (Winter 1996a), although the explanation for this difference is not yet fully understood.

Perceived Air Quality and Recreation

Amendments to the Clean Air Act in 1977 provide for the protection of visibility in national parks and wilderness areas (Class I areas) (Bell et al. 1985). The amendments came about in part because of the increased concern that scenic views in national parks were deteriorating and that existing clean air provisions were not protecting visual air quality in parks and rural areas (Borie 1988). Inclusion of references to "humanly detectable" reductions in visibility in sections of the Clean Air Act amendments draw attention to the importance of human perception (Daniel 1990). Haze is one of the most heavily relied predictors in human estimates of air quality (Malm et al. 1981; Molenar et al. 1994; Bell et al. 1996), and ratings of visual air quality appear to be reliable and valid (Latimer et al. 1981; Malm et al. 1981). Part of the management difficulty with reduced visibility from regional haze is that it is very complex. The atmospheric processes involved, along with the transport of haze over hundreds of miles from the source, explain just part of the complexity (Borie 1988). One example of the long-distance transport was provided by Borie (1988), who stated that one-third of the sulfates in the Grand Canyon were found to originate in urban southern California. There are additional values to natural resources running far beyond how they might be enjoyed first-hand through recreation. Wilderness affords therapeutic opportunities not available in other settings (Kale 1995). "Many of us receive satisfaction simply from knowing wild lands exist" (Dickensen 1981, p. 3), and the reported importance of aesthetic appreciation and ecological protection are demonstrative of those values (Manning and Valliere 1996). There are a multitude of values attached to wilderness, and recreation may be declining in importance among those values (McCloskey 1990). Nevertheless, recreation remains a significant commodity offered by forests.

Recreationists' Perspectives on Air Quality

Air quality and the more general scenic quality of an area are important considerations in the recreational experience. Visibility and visual quality are an important component of scenic beauty measures (Daniel 1990), and vistas are highly preferred among choices of outdoor scenes (Nelson and Loewen 1993). Of 11 potential values of wilderness presented to respondents in a survey of visitors to the Breadloaf Wilderness in Vermont, "Wilderness is a place to enjoy the beauty of nature" received the highest overall rating (mean of 5.55, scale was 1 = not at all important to 6 = extremely important) (Manning and Valliere 1996). Visitors to the Indian Peaks backcountry area were surveyed regarding general trip characteristics, sociodemographics, and physical resource attributes affecting trip satisfaction. For the 286 respondents, the most important attribute contributing to their backcountry visit was "clean fresh air" (average rating of 1.124 based on a scale from 1 to 9, 1 = most strongly adds to satisfaction and 9 = most strongly detracts from satisfaction). Overall, the most positively rated items were those dealing with a pollution-free environment and scenic beauty (Brown et al. 1977). Respondents to a survey examining recreation in Bryce Canyon (USDI 1980) revealed the high importance assigned to scenic views (rated as important, very important, or extremely important by approximately 99% of respondents) and to clean air (rated as important, very important, or extremely important by approximately 94% of respondents).

Physical Costs of Recreating in Pollution

An additional significant adverse impact of poor air quality on recreation, especially that which involves physical exertion, is well documented. Brunekreef and others (1994) studied young, healthy males participating in a series of amateur cycling training sessions and competitive races. Low concentrations of ozone were significantly associated with declines in lung function, as well as shortness of breath and wheeze. Eye irritation and cough were not significant. Even when the highest ozone concentration days were excluded from analysis, the significant relationship between ozone exposure and decreased lung function during exercise remained. Concentrations of other pollutants were low during the life of the study, and adjustments for humidity and air temperature did not eliminate the significant findings. Brunekreef and colleagues note that the exercise their subjects were engaged in was vigorous and that such significant relationships between low ozone levels and decreased lung function were not found in less strenuous exercise situations.

A 10% reduction in aerobic capacity of subjects breathing ozone comparable with peak levels in smog-prone cities has been demonstrated. Long-term exposure has also been shown to have a cost, through obstruction in respiratory bronchioles, for example (Stamford 1990).

Gong and Krishnareddy (1995) summarize the effects of pollutants on exercise as well. High ozone levels are known to cause restrictive lung dysfunction, leading to coughing, chest tightness, and shortness of breath; high carbon monoxide levels can impair oxygen delivery; sulfur dioxide worsens nasal symptoms in people with allergies and causes bronchospasms in asthmatics; and airway irritation from fine particulates can lead to bronchospasms. Each of these is contrary to the positive goal of outdoor exercise, which is to increase and maintain physical health.

Recreationists are counseled to avoid the adverse effects of poor air quality. Castleman (1991) advises readers to jog in the early morning hours when air pollutants, especially auto-related ones, are at their lowest. He states that warm months are the worst time for ozone, a key component of smog. Ozone effects on the jogger can include tickling in the throat, raspiness, coughing, shortness of breath, tightness in the chest, and possibly headache and nausea. Castleman recommends avoiding physical exertion during those periods when air quality is the worst; Stamford (1990) provides similar advice for city dwellers interested in exercise. Health advisories, however, are typically ignored among adult urban dwellers, as previously discussed (Evans et al. 1982).

Diminished Enjoyment of the Recreational Experience

Scenery is very important in the appreciation and enjoyment of natural resource settings (Daniel 1990; Taylor and Winter 1995), especially viewing it through clean, fresh air (USDA 1990). Given this importance of scenery, and the potential physical effects that can detract from a visit to natural resource areas, it is clear that air quality plays an important role in preservation and existence of natural resource areas. Wilderness offers an opportunity to escape from the everyday environment of buildings and streets and from urban ugliness and environmental concerns (Kaplan and Talbot 1983). Especially true for urbanites, wilderness offers a reprieve from the intense daily filtering of our environment, which leads to inattention of details in a setting (Milgram 1976). Air quality is a component of the overall scenery, and "pleasant scenery is often the key to the quality of an outdoor recreation activity" (Cordell et al. 1990, p. 87). Evidence of pollution can clearly detract from the nature experience. A survey of Coloradoans revealed "viewing the scenery" as the most important experience in a wilderness visit out of 20 possible experiences presented (Walsh et al. 1981). The wilderness experience is supposed to offer contact with "unadulterated expressions of nature" (McCloskey 1990, p. 17). However, the degree to which the relationship between atmospheric pollutants and wilderness experiences goes beyond valuing clean air and good visibility is not well known (Watson and Williams 1995). Concerns about air quality affecting recreation extend into the San Bernardino Mountains specifically, as demonstrated in the following sections.

San Gorgonio Wilderness Case Study

The San Gorgonio Wilderness, located in the San Bernardino National Forest in southern California, encompasses 56,722 acres (Hendee et al. 1990). It was among the 54 wildernesses specifically designated in the Wilderness Act of 1964, Public Law 88-577; and its original acreage of 33,898 was increased to the present size with the California Wilderness Act of 1984, Public Law 98-425 (Browning et al. 1988). Originally proposed as a downhill ski resort, hiking enthusiasts banded together as "Defenders of the San Gorgonio Wilderness" and successfully fought for wilderness designation (Wondelleck and Yaffee 1994). According to comparisons using recreation visits per acre from 1986, the San Gorgonio ranks as the second most-visited wilderness in California and falls within the top 12 in the nation (Hendee et al. 1990). The high use is managed through a mandatory permit system for both day and overnight use year-round. A volunteer association of approximately 120 members contributes thousands of person-hours annually (Wondelleck and Yaffee 1994), adding to the Forest Service's efforts for wilderness patrols, trail maintenance, and visitor education.

Visitors to the San Gorgonio Wilderness

Located within an hour's drive of more than 7.5 million people (Wondelleck and Yaffee 1994), the vast majority (98%) of San Gorgonio Wilderness visitors come from the five-county Los Angeles metropolitan area (Winter and Tocco 1995). The reported pattern of geographically proximate wilderness visitation is in keeping with wildernesses near other large urban centers (Hendee et al. 1990).

Fall Visitors' Air Quality Experiences

A wilderness recreation survey was conducted in Fall 1994 on the San Gorgonio Wilderness (Winter 1996b). Recreationists were contacted at a trailhead and asked to complete a mini-survey. Those expressing a willingness to participate in a longer mailed survey were queried regarding trip characteristics, reactions to potential wilderness management strategies, wilderness knowledge, and sociodemographics. Of the 65 Fall respondents to the mailed survey, approximately 75% were on a repeat San Gorgonio Wilderness visit in 1994. The average years reported for San Gorgonio Wilderness repeat visitors was 11 years.

Respondents were asked a series of questions regarding perceived air quality in the San Gorgonio Wilderness. Items queried are typical indicators reported in judgments of environmental quality (Evans and Jacobs 1982), and perceptions of areas are valuable in assessing the conditions of environments (Craik and Zube 1976). Almost 37% of San Gorgonio visitors reported an impaired view of the landscape due to poor air quality, whereas only 8% reported experiencing difficulty breathing and 2% reported "burning eyes due to air pollution." Only a few (6%) reported a lack of discomfort or impaired view. Therefore, the majority listed at least some adverse experience due to poor air quality. These questions were responded to based on recollections of the experience, through the mailed survey completed within 1–3 months maximum after the wilderness visit. Recalled experiences were of interest because of their longer-term potential role in wilderness attitudes and opinions. There may be some very distinct differences between what would have been reported in situ and what was recalled for the mailed survey (Stewart and Hull 1994). Assessments of impaired view would have been interesting to contrast, when made on site, with data from the IMPROVE program as presented in Copeland (this volume).

Wilderness Volunteers' Perceptions of San Gorgonio Air Quality

In 1995, the San Gorgonio Volunteer Association members were contacted by the author and invited to participate in survey querying their wilderness volunteer experiences. They were asked to provide information on their degree of volunteerism, perceived uses of the wilderness, perceptions of visitors, perceptions of wilderness quality, opinions regarding potential management interventions, benefits and drawback to wilderness volunteerism, and sociodemographics.

The 90 volunteer respondents averaged 3.5 years (median) of volunteer work on the San Gorgonio Wilderness. A significant monthly contribution of person-hours was reported, with 31 hours as the median. Because of their familiarity with the wilderness and its attributes, the San Gorgonio Volunteer Association was viewed as an ideal information source regarding air quality. Respondents were asked to indicate what wilderness visitors should expect to experience on their visits to the San Gorgonio. Almost half (49.5%) indicated that impaired view of the landscape due to air pollution should be expected, whereas 11% indicated that burning eyes due to air pollution should be expected, and about 9% reported that visitors should expect some difficulty breathing. Slightly less than half (46.2%) indicated that none of those effects should be expected, that the air quality during their wilderness visits had been fine. Again, querying recollections of air quality and its impact on the recreational visit to the San Gorgonio may have yielded very different results than responses in situ may have provided. However, it is clear from these data that approximately half the responding volunteers perceived some air quality problem within the San Gorgonio Wilderness that would affect recreation.

Recreationists' Willingness to Ensure Improved Air Quality

When a problem with air quality is perceived, as it was in the San Gorgonio Wilderness case study previously described, how willing are individuals to make some investment to change their experiences? Results from other geographical areas provide information useful toward solutions for the San Gorgonio.

Trade-Offs for Visibility in the Grand Canyon

An experiment by Bell and others (1985) demonstrates the willingness of individuals to make trade-offs to increase visibility of vistas in recreational settings. Experimental subjects were presented with three scenic vistas of the Grand Canyon with varying degrees of visibility (low, moderate, high), information on driving time, and information on waiting time to see an archeological site. Based on a visit/choice scenario, experimental subjects showed a clear preference for good visibility and short waiting and driving times. In fact, the average person was

willing to spend almost an extra hour in driving time (55.8 minutes) for one incremental improvement in visibility of the San Francisco Peaks and about half an hour in waiting time (30.4 minutes). Other potential factors in the decision-making process were not considered such as sociodemographics, entrance fees, or crowds. Bell and colleagues contend that "one way of documenting how people value visibility is through their willingness to increase effort and time commitment (costs) for an increase in visibility (reward). Visibility should be considered a natural resource that contributes positive or reward outcomes to a recreation setting" (Bell et al. 1985, p. 473).

Willingness to Pay for Improved Air Quality Among Recreationists

Persons who had registered for races or had purchased sporting goods at a community sporting goods store were contacted in a questionnaire mailing in Louisiana (Farber and Rambaldi 1993). The researchers contend that outdoor exercise enthusiasts should be better informed about the relationships between air quality and health, due to their generally higher education levels. Respondents ($n = 790$, with a 61.8% response rate) were informed that the local area had 14 days of unhealthful air quality in the prior year. They were asked to select a range of money that represented what they would be willing to pay annually in taxes or product costs to guarantee that the local air was always in the healthful range. The median response fell in the \$91–\$100 interval, for annual willingness to pay, with a daily median of \$6.79 per person per day. Of greatest interest in this study is the indicated willingness to make a financial commitment to improved air quality, in keeping with other studies cited by Farber and Rambaldi (1993). Exact ranges of willingness to pay for cleaner air in the San Bernardinos are not known.

Maintaining Air Quality in Natural Areas Extends Beyond Recreational Concerns

Valuing natural areas' relationships to air quality was revealed by wilderness users and nonusers alike in a survey examining potential purposes of wilderness. Virden (1990) reported that 80.1% of wilderness users and 80.9% of wilderness nonusers listed the protection of air quality among the top five purposes of wilderness. Coloradoans were asked which, among 13 reasons provided, were the most important reasons for valuing existing or potential wilderness areas. Protecting air quality was the third highest reason provided for wilderness, with 77.2% indicating that is was either "very" or "extremely important" (Haas et al. 1986). Significant differences in these responses were not found between wilderness visitors and those who had not visited Colorado wildernesses. The clean air found in wilderness areas can also help protect the scenic integrity of areas adjacent to them (Cordell et al. 1990). However, as Lackey (1996) points out, although there is public support of the environment and an appreciation of it, publics vary in their views and intensities of opinions. The decisions made in environmental management occur in a larger political context rarely addressed in public opinion polls.

Implications for the San Bernardino National Forest

It has been argued that the value of wilderness to the present generation will be dwarfed by the values accrued to future generations (Haas et al. 1986). Several strategies are already available for relaying information to visitors at natural resource areas (USDA Forest Service 1989). Unfortunately, talks specifically focused on air quality in the San Bernardinos appear to be of little interest to recreationists (Chavez and Mainieri 1995). However, information about the natural resources in the area is of interest. The innovative interventions described earlier in this chapter may offer additional intervention methods, which when paired with those already in place, can serve as an effective mechanism in creating the awareness, agreement, and behavioral commitments necessary to improve air quality. More than 6 million recreation visitor-days were reported by the San Bernardino National Forest in 1995 (USDA Forest Service 1996). These visitor-days represent a critical constituency base for improving the understanding of air quality concerns in the San Bernardino Mountains and hopes for support for policy-based changes. In addition, residents of the Los Angeles Basin may have definite interests in the health and sustainability of the flora and fauna of the San Bernardinos, which go beyond recreation-related concerns. Residents in the San Bernardino mountain range, both year-round and seasonal, have a vested interest as well.

Conclusions

"Clean air cannot be achieved through study and research. Clean air can only be achieved through an appropriate amount of study followed by a major commitment to a plan of action" (Schulze 1993, p. 21). Better approaches to presenting options in environmental management and their implications need to be developed (Lackey 1996). We desperately need to present scientific findings in an informative and interesting manner to build public support (Wiggins 1997). Although knowledge about the San Bernardino Mountains and degree of damage to the forests is fairly well advanced, translations into understandable information for the layperson will very much depend on personally relevant and important information being relayed. Poor air quality affects the ecosystem and humans within it through reduced environmental experiential quality and health risks. Being made aware of these conditions is not enough (Hutton and Ahtola 1991). Air quality scientists also need to translate these conditions into personal impacts, as well as offering practical and possible solutions to reduce impacts (Hutton and Ahtola 1991; Eden 1993; Vlek 1995). They also have to ensure that the information provided is specific to the area, relaying and understanding of local conditions and their related hazards (Peltu 1991). Scientists must work hard at relaying the balances of varying environmental risks to publics whose perceptions of the greatest hazards may not match technical experts' assessments. Priorities and legislative agendas are more likely to be driven by public perceptions than by

scientists' perceptions, increasing the importance of effective and credible communication of scientific knowledge (Slovic 1997). Although recreationists were this chapter's main focus for such intervention efforts, more broadly focused interventions also need to be explored.

References

Absher, J.; Winter, P.L. Evaluation of the 1995 eco-team program. Riverside, CA: USDA Forest Service, Pacific Southwest Research Station; 1997.

Anonymous. Seeing the parkland through the haze. Sci. News 143:95; 1993.

Aunan, K. Exposure-response functions for health effects of air pollutants based on epidemiological findings. Risk Anal. 16:693–709; 1996.

Bae, C.C. Air quality and travel behavior: untying the knot. J. Amer. Planning Assoc. 59:65–74; 1993.

Bell, P.A. It's the economy psychologist! Paper presented at the American Psychological Association Convention, August, New York. Ft. Collins, CO: Colorado State University; 1995.

Bell, P.A.; Greene, T.E.; Fisher, J.D.; Baum, A. Environmental psychology, 4th ed. Fort Worth, TX: Holt, Rinehart & Winston, Inc.; 1996.

Bell, P.A.; Malm, W.; Loomis, R.J.; McGlothin, G.E. Impact of impaired visibility on visitor enjoyment of the Grand Canyon: a test of an Ordered Logit Utility Model. Environ. Behav. 17:459–474; 1985.

Borie, L. A tale of sites unseen. Sierra 73:30–31, 33–36; 1988.

Brown, P.J.; Haas, G.E.; Manfredo, M.J. Identifying resource attributes providing opportunities for dispersed recreation. Final report. Ft. Collins, CO: College of Forestry and Natural Resources, Colorado State Univ.; 1977.

Browning, J.A.; Hendee, J.C.; Roggenbuck, J.W. 103 Wilderness laws: milestones and management direction in wilderness legislation, 1964–1987. Bull. 51. Moscow, ID: University of Idaho, College of Forestry, Wildlife and Range Sciences; 1988.

Brunekreef, B.; Hoek, G.; Breugelmans, O.; Leentvaar, M. Respiratory effects of low-level photochemical air pollution in amateur cyclists. Am. J. Respir. Crit. Care. Med. 150:962–966; 1994.

Castleman, M. A jog in the smog. Sierra 76:20; 1991.

Chavez, D.J.; Mainieri, T. Recreation day use series report 1: San Bernardino National Forest. Report submitted to the San Bernardino National Forest. Riverside, CA: USDA Forest Service, Southwest Pacific Research Station; 1995.

Cialdini, R.B. Influence: science and practice, 2nd ed. Glenview, IL: Scott Foresman/Little, Brown College Div.; 1988.

Cordell, H.K.; Bergstrom, J.C.; Hartmann, L.A.; English, B.K. An analysis of the outdoor recreation and wilderness situation in the United States: 1989–2040. A technical document supporting the 1989 USDA Forest Service RPA assessment. Gen. tech. rep. RM-189. Ft. Collins, CO: USDA Forest Service; 1990.

Craik, K.H.; Zube, E.H. Perceiving environmental quality, research and applications. New York: Plenum Press; 1976.

Daniel, T.C. Measuring the quality of the natural environment: a psychophysical approach. Am. Psychol. 45:633–637; 1990.

deSteiguer, J.E.; Pye, J.M.; Love, C.S. Air pollution damage to U.S. forests: a survey of perceptions and estimates by scientists. J. For. 88(8):17–22; 1990.

De Young, R. Some psychological aspects of reduced consumption behavior: the role of intrinsic satisfaction and competence motivation. Environ. Behav. 28:358–409; 1996.

Dickenson, R.E. Wilderness values in the national parks. Wilderness Resource Distinguished Lectureship. Moscow, ID: University of Idaho Wilderness Research Center; 1981.

Dunn, C.; Kingham, S. Establishing links between air quality and health: searching for the impossible? Soc. Sci. Med. 42:831–841; 1996.
Dwyer, W.O.; Leeming, F.C.; Cobern, M.K.; Porter, B.E.; Jackson, J.M. Critical review of behavioral interventions to preserve the environment: research since 1980. Environ. Behav. 25:275–321; 1993.
Eden, S.E. Individual environmental responsibility and its role in public environmentalism. Environ. Planning 25:1743–1758; 1993.
Evans, G.W. The psychological costs of chronic exposure to ambient air pollution. In: Isaacson, R.L.; Jensen, K.F., eds. The vulnerable brain and environmental risks. vol. 3. Toxins in air and water. New York: Plenum Press; 1994:167–182.
Evans, G.W.; Jacobs, S.V. Air pollution and human behavior. In: Evans, G.W., ed. Environmental stress. Cambridge: Cambridge University Press; 1982:105–132.
Evans, G.W.; Jacobs, S.V.; Frager, N.B. Behavioral responses to air pollution. In: Baum, A.; Singer, J.E., eds. Advances in environmental psychology. vol. 4. Environment and health. New York: Lawrence Erlbaum Associates; 1982:237–269.
Evans, G.W.; Colome, S.D.; Shearer, D.F. Psychological reactions to air pollution. Environ. Res. 45:1–15; 1988.
Farber, S.; Rambaldi, A. Willingness to pay for air quality: the case of outdoor exercise. Contemp. Policy Issues 11:19–30; 1993.
Fisher, C.S. The urban experience. New York: Harcourt Brace Jovanovich; 1976.
Gardner, G.T.; Stern, P.C. Environmental problems and human behavior. Needham Heights, MA: Allyn & Bacon; 1996.
Godlee, F. Air pollution: II-road traffic and modern industry. BMJ. 303:1539–1543; 1991.
Gong, H., Jr.; Krishnareddy, S. How pollution and airborne allergens affect exercise. Physician Sportsmed. 23:35–38, 39–42; 1995.
Haas, G.E.; Hermann, E.; Walsh, R. Wilderness values. Natural Areas J. 6:37–43; 1986.
Hall, D.C.; Win, M.S.; Hall, J.V. Air pollution impacts from demand-side management. Energy 20:27–35; 1995.
Hall, J.V. Assessing health effects of air pollution. Atmos. Environ. 30:743–746; 1996.
Hendee, J.C.; Stankey, G.H.; Lucas, R.C. Wilderness management. Golden CO: International Wilderness Leadership Foundation; 1990.
Holland, M.R. Assessment of the economic costs of damage caused by air-pollution. Water Air Soil Pollut. 85:2583–2588; 1995.
Howard, G.S. Thoughts on saving our planet: political, economic, cultural and bureaucratic impediments to ecological activism. Counseling Psychol. 21:597–617; 1993.
Hutton, R.B.; Ahtola, O.T. Consumer response to a five-year campaign to combat air pollution. J. Public Policy Marketing 10:242–256; 1991.
Kale, M. Wilderness and the human spirit. Am. For. 101:39–43; 1995.
Kandler, O.; Innes, J.L. Air pollution and forest decline in central Europe. Environ. Pollut. 90:171–180; 1995.
Kaplan, S.; Talbot, J.F. Psychological benefits of a wilderness experience. In: Altman, I.; Wohlwill, J.F., eds. Behavior and the natural environment. New York: Plenum Press; 1983:163–203.
Kates, R.W. Experiencing the environment as hazard. In: Proshansky, H.M.; Ittelson, W.H.; Rivlin, L.G., eds. Environmental psychology, 2nd ed. New York: Holt, Rinehart & Winston; 1976:401–418.
Kucera, V.; Fritz, S. Direct and indirect effects on materials including cultural monuments. Water Air Soil Pollut. 85:153–165; 1995
Lackey, R.T. Ecological risk assessment. In: Molak, V., ed. Fundamentals of risk analysis and risk management. New York: CRC Press/Lewis Publishers; 1996.
Latimer, D.A.; Hogo, H.; Daniel, T.C. The effects of atmospheric optical conditions on perceived scenic beauty. Atmos. Environ. 15:1865–1874; 1981.
Lee, D.R. An economist's perspective on air pollution. Environ. Sci. Technol. 27:1980–1982; 1993.

Lefohn, A.S.; Manning, W.J. Ozone exposures near class I wilderness areas in New Hampshire and Vermont. Atmos. Environ. 29:601–606; 1995.
Lieu, S.; Treyz, G.I. Estimating the economic and demographic effects of an air quality management plan: the case of southern California. Environ. Planning 24:1799–1811; 1992.
Linn, X.; Polenske, K.R.; Robinson, K. Economic impact analyses in U.S. state and local air pollution control agencies: a survey. J. Air Waste Manage. Assoc 44:134–140; 1994.
Lipfert, F.W. Air pollution and human health: perspectives for the '90s and beyond. Risk Analysis 17:137–146; 1997.
Liu, F. Urban ozone plumes and population distribution by income and race: a case study of New York and Philadelphia. J. Air Waste Manage. Assoc. 46:207–215; 1996.
Mage, D.; Ozolins, G.; Peterson, P.; Webster, A.; Orthofer, R.; Vandeweerd, V.; Gwynne, M. Urban air pollution in megacities of the world. Atmos. Environ. 30:681–686; 1996.
Malm, W.; Kelley, K.; Molenar, J.; Daniel, T. Human perception of visual air quality (uniform haze). Atmos. Environ. 15:1875–1890; 1981.
Manning, R.E.; Valliere, W.A. Environmental values, environmental ethics, and wilderness management. Int. J. Wilderness 2:27–32; 1996.
McCloskey, M. Evolving perspectives on wilderness values: putting wilderness values in order. In: Preparing to manage wilderness in the 21st century: proceedings of the conference, State Botanical Gardens, April 4–6. Gen. tech. rep. SE-66. Athens, GA: USDA, Southeastern Experiment Station; 1990.
McIllvaine, R.W. Air pollution control and waste management in a new world. J. Air Waste Manage. Assoc. 43:293–297; 1993.
McIllvaine, R.W. Air pollution challenges and forecasts. J. Air Waste Manage. Assoc. 44:248–252; 1994.
Milgram, S. The experience of living in cities. In: Proshansky, H.M.; Ittelson, W.H.; Rivlin, L.G., eds. Environmental Psychology, 2nd ed.: people and their physical settings. New York: Holt, Rinehart and Winston; 1976:494–507.
Molenar, J.V.; Malm, W.C.; Johnson, C.E. Visual air quality simulation techniques. Atmos. Environ. 28:1055–1063; 1994
Nelson, T.M.; Loewen, L.J. Factors affecting perception of outdoor public environments. Perceptual Motor Skills 76:139–146; 1993.
Oskamp, S. Attitudes and opinions, 2nd ed. Englewood Cliffs, NJ: Prentice Hall; 1991.
Pantazopoulou, A.; Katsouyanni, K.; Kourea-Kremastinou, J.; Trichopoulos, D. Short-term effects of air pollution on hospital emergency outpatient visits and admissions in the greater Athens, Greece, area. Environ. Res. 69:31–36; 1995.
Peltu, M. Risk perception and the real world. N. Scientist 1782:4; 1991.
Rector, A.B. Towards the year 2000: critical issues in the global environment. J. Air Waste Manage. Assoc. 42:1573–1576; 1992.
Ringquist, E.J. Is "effective regulation" always oxymoronic?: the states and ambient air quality. Soc. Sci. Q. 76:69–87; 1995.
Rotton, J. (1993) Atmospheric and temporal correlates of sex crimes: endogenous factors do not explain seasonal differences in rape. Environ. Behav. 25:625–642; 1993.
Rotton, J.; Frey, J. Psychological costs of air pollution: atmospheric conditions, seasonal trends, and psychiatric emergencies. Pop. Environ. 7:3–16; 1984.
Rotton, J.; Frey, J. Air pollution, weather, and violent crimes: concomitant time-series analysis of archival data. J. Personality Soc. Psychol. 49:1207–1220; 1985.
Schulze, R.H. The 20-year history of the evolution of air pollution control legislation in the USA. Atmos. Environ. 27B:15–22; 1993.
Shukla, V.; Parikh, K. The environmental consequences of urban growth: cross-national perspectives on economic development, air pollution, and city size. Urban Geogr. 13:422–449; 1992.
Slovic, P. Public perception of risk. Environ. Health 59:22–23, 54; 1997.

Smith, V.K. Nonmarket valuation of environmental resources: an interpretive appraisal. Land Econ. 69:1–26; 1993.
Stamford, B. Exercise and air pollution. Physician Sportsmed. 18:153–154; 1990.
Stern, P.C. A second environmental science: human–environment interactions. Science 260:1897–1899; 1993.
Stern, P.C. Understanding and overcoming barriers to pollution prevention. Paper presented at the American Psychological Association Convention, August, New York. Washington, DC: National Research Council; 1995.
Stewart, W.P.; Hull, R.B. Capturing the present moments of leisure: concerns of in situ research. Paper presented at the NRPA leisure research symposium, October 12–16, Minneapolis, MN. College Station, TX: Texas A&M University, and Blacksburg, VA: Virginia Polytechnic Institute and State University; 1995.
Stokols, D. Establishing and maintaining healthy environments: toward a social ecology of health promotion. Am. Psychol. 47:6–22; 1992.
Taylor, D.; Winter, P. Environmental values, ethics and depreciative behavior. In: Chavez, D.J., tech. coord. Proceedings of the second symposium on social aspects and recreation research. Gen. tech. rep. PSW-156. Albany, CA: USDA, Pacific Southwest Research Station; 1995:59–66.
Taylor, O.C. Oxidant air pollutant effects on a western coniferous forest ecosystem: historical background and proposed systems study of the San Bernardino Mountain area. Riverside, CA: Statewide Air Pollution Research Center, University of California; 1973.
Tingey, D.T.; Hodsett, W.E.; Henderson, S. Definition of adverse effects for the purpose of establishing secondary national ambient air quality standards. J. Environ. Qual. 19:635–639; 1990.
USDA, Forest Service. Rocky Mountain region annual report. Ft. Collins: USDA; 1990.
USDA, Forest Service. San Bernardino National Forest recreation use report, 1995. San Bernardino, CA: USDA; 1996.
USDA, Forest Service Recreation Staff. Ideas for wilderness information and education. Washington, DC: USDA; 1989.
USDI. Descriptive analysis of the data from the Bryce Canyon National Park visitor survey. Washington, DC: Economic Staff, Office of Policy Analysis; 1980.
Virden, R.J. A comparison study of wilderness users and nonusers: implications for managers and policymakers. J. Park Recreation Admin. 8:13–24; 1990.
Vlek, C.A. Technical versus socio-behavioral solutions to environmental problems: psychology's unexploited potential. Paper presented at the American Psychological Association Convention, August, New York. The Netherlands: University of Groningen; 1995.
Vob, A.; Schmid, G. Cost-effectiveness of air-pollution control measures. Energy 16:1215–1224; 1991.
Walsh, R.G.; Gillman, R.A.; Loomis, J.B. Wilderness resource economics: recreation use and preservation values. Ft. Collins, CO: Department of Economics, Colorado State University; 1981.
Watson, A.E.; Williams, D.R. Priorities for human experience research in wilderness. Trends 32:14–18; 1995.
Wiggins, R.C. Scientists must clarify the societal relevance of research. Scientist 8(3):10; 1997.
Winter, P.L. Environmental concern and environmental action: how do recreationists fare? The sixth international symposium on society and resource management: social behavior, natural resources, and the environment, May 18–23, University Park, PA. University Park, PA: Pennsylvania State University; 1996a.
Winter, P.L. San Gorgonio Wilderness visitor survey. Technical report. Riverside, CA: USDA, Pacific Southwest Station; 1996b.
Winter, P.L.; Tocco, L. Capturing urban wilderness visitation on the San Gorgonio. Paper presented at the 4th international outdoor recreation and tourism trends symposium, St. Paul, MN, May 14–17. Riverside, CA: USDA, Pacific Southwest Station; 1995.

Wondelleck, J.M.; Yaffee, S.L. Building bridges across agency boundaries: in search of excellence in the United States Forest Service. Ann Arbor, MI: School of Natural Resources and the Environment, The University of Michigan; 1994.
Zundel, T.; Rentz, O.; Dorn, R.; Jattke, A.; Wietschel, M. Control techniques and strategies for regional air pollution control from energy and industrial sectors. Water Air Soil Pollut. 85:213–224; 1995.