Toward the 21st Century:

Planning for the Protection of California's Environment

Final Report

Submitted to California Environmental Protection Agency by:
The California Comparative Risk Project

May 1994

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Pesticide and Environmental Toxicology Section
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Toward the 21st Century:

Planning for the Protection of California's Environment

Final Report

Submitted to:

James M. Strock
Secretary for Environmental Protection

Submitted by:

The California Comparative Risk Project

May 1994

Prepared by:
Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment

Toward the 21st Century: Planning for the Protection of California's Environment

PREFACE

California is among the nation's largest states in land area and is the largest in terms of population, government, and economy. We are often perceived as the leading state in promoting environmental issues. But California's unique blend of natural resources and beauty, industry, agriculture, and recreational potential, combined with its size, diversity, and social awareness makes our job of protecting public health and the environment especially challenging. As we look forward to the next century, we want to take the most effective and efficient measures to ensure a healthy environment for future generations.

Faced with similar challenges, the U.S. Environmental Protection Agency (U.S. EPA) recognized the possibility that its environmental protection efforts were not being effectively targeted. In particular, it was feared that focusing on environmental threats in isolation, rather than collectively, had resulted in a misdirection of scarce funds to less serious environmental problems. In 1986, U.S. EPA initiated a project aimed at setting priorities using a model that first quantifies then compares and ranks risks. Some states, following U.S. EPA's lead, also found the risk-ranking model useful for focusing on environmental issues of greatest concern. These projects have been generally referred to as "comparative risk projects."

To help identify environmental priorities for the future, the California Environmental Protection Agency (Cal/EPA) sponsored the California Comparative Risk Project with partial funding from U.S. EPA. As with other states before us, our project sought to incorporate the views of people with diverse backgrounds, cultures, and interests into a process that combines scientific analysis and judgment, with societal values and education. The results of the California Comparative Risk Project will be used to assist Cal/EPA in planning, evaluating, and organizing the activities of the Agency.

Participants in the California Comparative Risk Project were charged with identifying environmental threats of the greatest ecological, human health, and societal concern using the risk-ranking model. However, agreeing that risk is not the only factor that should be considered, our project also examined how economics, pollution prevention, environmental justice, education, and public participation contribute to environmental decision-making. The unique inclusion of this aspect in our project was in response to a growing debate nationally and in California about the limitations of a risk-ranking model for setting environmental priorities. I think you will find this innovative and ground-breaking discussion thought-provoking and helpful in understanding the multidimensional nature of environmental decision-making.

The findings and recommendations of the California Comparative Risk Project are presented in the following report. It is a compilation of two and one-half years of work involving nearly 300 volunteers representing a wide diversity of backgrounds including industry, agriculture, community groups, county and state government, universities, and environmental organizations. Our report includes a non-technical guide for the general reader, and several longer, more technical reports containing

recommendations prepared by our working committees. Recommendations to Cal/EPA from the Statewide Community Advisory Committee, the California Comparative Risk Project's primary citizens' advisory body, are also included in this report.

As the California Comparative Risk Project evolved, we had several objectives, including: 1) to assess and rank environmental threats to human health, ecological health, and social welfare; 2) to critique the risk-ranking model and explore other models for environmental protection and priority-setting, outlining their values and their implications; 3) to incorporate public input in the discussion of the diverse issues that contribute to environmental priority-setting; and 4) to seek consensus among the many perspectives and identify those issues for which there is a lack of consensus. I think these objectives were met, and I hope that you agree our project has charted a course for Cal/EPA through the maze of challenges on its way to planning for the healthy future of our State's environment and its inhabitants.

On behalf of all of the California Comparative Risk Project's participants, I am pleased to submit this report to James Strock, Secretary for Environmental Protection, for consideration in Cal/EPA's strategic planning, budgeting, and legislative processes. It is my sincere hope that other Californians will also find this report useful in making informed decisions on environmental priorities and learning about the environment in which we live.

I want to thank all of those who volunteered to be part of this project; it was a pleasure working with you. The primary lesson I learned as Project Director is that the end result is not as important as the means. I hope that this process invokes in all of us a desire to preserve our State's natural resources and to protect our health and welfare.

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Summary Report

INTRODUCTION

California Overview

From the time that humans first arrived in what we now call California, the dramatic landscapes -- ranging from ice-covered crags and barren deserts to lush forests, fertile valleys, and misty coastlines -- have inspired legions of explorers and residents. Today, California, which is the largest state in terms of population and economy, is still one of the most beautiful states in the country. Indeed, much of the State's wealth lies in the value of its landscapes and natural resources.

CALIFORNIA AT A GLANCE[1, 2]

Area: 155,973 square miles	*Deserts:* Mojave, Death Valley, Sonoran
Highest Elevation: Mt. Whitney (14,494 feet above sea level)	*Mountain Ranges:* Sierra Nevada
	Endangered/threatened animal species: 67
Lowest Elevation: Death Valley (282 feet below sea level)	*Endangered/threatened plant species:* 43
	Current Population: 30,380,000
Coastline: 1,264 miles	*Projected Population for 2010:* 38,096,000
Water Area: 7,734 sq mi	

Yet for thousands of years, the people living in this region have altered it, by fishing in its rivers, hunting in its forests, felling its trees, disposing of trash, and even making simple fires for warmth. In the last century, alterations of the environment have become much more severe and much less reversible. Free-flowing rivers have been dammed. Highways criss-cross the entire State, connecting densely settled residential and business areas. Habitats for fish, mammals, reptiles, and birds have been damaged. And many people live with an underlying fear that the pollution in our air, our water, and our land is hurting them, or will harm their children in the future.

Some environmental problems, like wildfires and background radiation, occur naturally. Others, like pollution and development, are clearly caused by humans and have been exacerbated by the State's rapidly expanding population, by resource extraction, and some believe by a lack of centralized planning.

Of course, the word "environment" means different things to different people. For many, it conjures visions of deserts, mountains, and streams, a wilderness that is separate from where we live and work. For others, "environment" refers to the built environment around them, the streets, parks, and buildings, for instance, that make up our cities and towns.

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[1] From World Resource Institute (1994). *The 1994 Information Please Environmental Almanac*, Washington, D.C.

[2] Department of Finance (1993). *Population Projections by Race/Ethnicity for California and Its Counties.*

But whether they live in rural, suburban, or urban areas, Californians have argued for decades about the best way to protect residents and ecosystems. The State has passed many laws and regulations; many of them have set standards for the rest of the country. Too often, the legislation has often focused on one environmental medium (water or air) or problem (pesticides) rather than using an inclusive approach. This has resulted in environmental protection that is either fragmented or overlapping. The need for environmental protection also has conflicted with the State's other priorities, including education, economic growth, transportation, crime prevention, and other social programs.

Rationale for Organizing This Project

How can policymakers and the public decide which resources to dedicate to which problems? One proposed way to prioritize environmental problems -- and develop viable solutions -- is through "comparative risk assessment." In this process, environmental problems are categorized, analyzed, and then ranked in terms of their relative severity. Such rankings help policymakers identify the environmental problems in their area, decide which ones pose the greatest relative risk, and structure the debate about priority-setting.

To help identify and structure environmental priorities, the California Environmental Protection Agency (Cal/EPA) sponsored the California Comparative Risk Project (CCRP). The end product of this two and a half-year process is a final report to Cal/EPA which, together with public comment, will be used to assist its planning. Equally important, the CCRP expands the methods of past comparative risk projects using innovative approaches.

This summary report provides an overview of the methods and findings of the committees of the CCRP. Full technical discussions of the committees' work are in the much larger technical report. Both of these reports are the products of the CCRP -- the content presented without substantive changes from Cal/EPA -- thus they are not Cal/EPA reports. Accordingly, the results and conclusions in all of the CCRP reports represent those of the CCRP participants and the committees and do not necessarily reflect the policies of Cal/EPA or the opinions of the members of the Statewide Community Advisory Committee. However, those who volunteered to work on the CCRP hope that Cal/EPA will use the results and apply the recommendations to improve planning for the protection of California's environment and its inhabitants.

WHERE CAN I FIND ...

Recommendations from the CCRP to Cal/EPA?

Recommendations can be found at the end of each section and in the final section of the summary report, as well as in the full technical report.

Risk-rankings of California's environmental threats?

The first three sections include rankings by individual committees. A summary of the three rankings of environmental health stressors can be found on page 32.

Discussion about environmental decision-making factors?

The California Comparative Risk Project considered factors other than risk that should be used in environmental decision-making. For a discussion on these topics, refer to the Education, Economic Perspectives, and Environmental Justice committees' reports.

An explanation of the CCRP process?

The introduction of this summary report provides an overview of the CCRP's work. The technical reports contains more detailed information of the project structure as a whole, as well as the full reports of the individual committees.

WHO PAID FOR THE CCRP?

The California Environmental Protection Agency and the U.S. EPA provided the only financial support to the project.

How many people took part?

More than 250 people from a wide range of backgrounds including universities, government agencies, businesses, and citizen and environmental activist groups volunteered in the CCRP.

How long did the CCRP take?

The project began in February 1992 and was concluded in May 1994.

What will the CCRP be used for?

The results of the CCRP, together with public comment on the project, will assist Cal/EPA in its ongoing planning, budget, and legislative processes. Other agencies and decisionmakers interested in environmental policy will find the systematic evaluation of central issues useful.

Why Analyze Risk?

The United States Environmental Protection Agency (U.S. EPA) initiated a comparative risk project for the country in 1986. At that time, analysts suspected that significant resources were being targeted towards problems that posed only moderate risks, while the Agency's mandate to focus on existing risks prevented it from addressing new or multifaceted problems (like indoor air pollution and global climate change). What was missing, Agency representatives thought, were comprehensive strategies for reducing current environmental risks in a cost effective manner and identifying those that might emerge in the future.

In 1987, the U.S. EPA published *Unfinished Business*, a ranking and analysis of 31 environmental problems facing the country at that time. The U.S. Environmental Protection Agency regional offices and several states (including Vermont, Louisiana, Colorado, and Washington) subsequently undertook similar projects. No two of these studies have been alike, but each has used a combination of science (for example, pollutant release data, computer modelling, and case studies) and the judgment of

scientists, citizens, and other community members to rank human-made environmental risks. Comparative risk projects historically have not addressed "natural" environmental risks_like earthquakes and floods.

In the context of environmental assessment, "risk" is the likelihood of harmful effects, including human disease or death, damage to ecosystems, property losses, and anxiety about the future. The *degree* of risk attributed to an environmental problem is based on both technical analysis and expert judgment, and it usually refers to current risk, or the risk that remains even with existing environmental programs in place. This gives policymakers a "snapshot" of *existing* threats, rather than those that would exist without public and private efforts or that are likely to exist in the future.

Typically, a risk becomes a "priority" when the public is concerned and policymakers decide to address it. This model of environmental priority-setting is a two-stage process. Analysts first have to understand the size and scope of various problems. Second, they have to decide which problems to address in light of feasibility, cost, equity, and other factors.

Some comparative risk projects have looked at risks *per se* (that is, *how severe is each problem?*). Others have developed priorities and recommendations (that is, *what problems should we address in the future?*). Still others have looked at a mix of risks and priorities.[3]

COMPARATIVE RISK GLOSSARY

Economic*s*. Study of how people make tradeoffs when faced with scarce resources.

Environment. The total surroundings on Earth, including the sum of living organisms, energy sources, and non-living natural and manufactured resources that affect the life, homeostasis, development, reproduction, and survival of all organisms.

Environmental justice. According to several studies, poor communities and communities of color bear a disproportionate burden of environmental hazards. The principles of environmental justice recognize this and other environmental disparities and maintain that everyone has an equal right to a clean, healthful environment in which to live, work, and play.

Exposure. The amount of a stressor that an organism contacts over a certain period of time.

Hazard. The measure of the stressor's potency or ability to cause health problems.

Pollution prevention. An environmental policy approach that seeks to reduce hazardous or toxic substances throughout their life cycle, from the extraction and processing of raw materials, through manufacturing, distribution, use, and disposal.

Public participation. The involvement of citizens in governmental decision-making processes. Participation ranges from being given notice of public hearings to being actively included in decisions that affect communities.

Risk. The probability or chance that a desired or unwanted action, circumstance, or event will result in loss or harm.

Stressor. A chemical, material, organism, radiation, temperature change, or activity that stresses human health, the environment, or quality of life.

The Traditional Risk-ranking Model

The first step in most comparative risk projects is to develop a list of environmental problems to analyze. The second step involves an analysis by project participants of the aspects of risk associated with those problems. Analysts then rank the severity of each problem area. Because the rankings are rarely the same among the categories of human health, ecological health, and social welfare, some

[3] Northeast Center for Comparative Risk (1993). *State Comparative Risk Projects: A Force for Change.* Vermont Law School, South Royalton, VT.

comparative risk projects create a list that integrates the three rankings into one. Others maintain separate lists.

Three categories of risk-ranking

Human health

Human health risks are the actual or estimated cases of human disease or injury caused by human-made environmental stressors. These include both cancer (for example, lung cancer caused by exposures to asbestos) and noncancer effects (for example, retarded mental development caused by ingesting lead in paint).

Ecological health

Ecological health risks are the estimated or anticipated damages to the structure and function of natural ecosystems. Examples include loss of fish and plant life due to water pollution, loss of wildlife habitat, changes in the physical landscape, and reduced growth rates in forests exposed to high levels of smog.

Social welfare

Social welfare risks reflect the degradation in the quality of life for an area's citizens. Some of this degradation_such as crop losses due to the invasion of non-native species_can be quantified. Other forms of degradation_such as anxiety about ozone depletion in the future_can be judged only qualitatively by surveying citizens and relying on expert judgment.

Concerns about the traditional risk-ranking model

Using the comparative risk model alone to set priorities has been widely criticized since U.S. EPA initiated the process in the mid-1980's.[4] The primary complaints have been that:

→ Risk alone should not predominate the decision-making process.

→ Focusing on the quantitative aspects of risk does not provide enough information on the qualitative aspects, such as anxiety about the future, involuntariness of exposure, and equity concerns.

→ Risk assessment and the comparative risk model are not solely "science-based" but incorporate judgments and values and are limited by a high degree of uncertainty.

→ Comparative risk projects often neglect the public participation and social values needed to make good decisions about environmental priorities.

Of course, whether decisions are about a personal purchase, a job, or a travel plan, we all make them based on a myriad of factors. Perhaps the most realistic way to view risk assessment is not as a science, but a procedure that provides information about the degrees of hazards associated with activities and exposures. The more information we have on relative risks, the better able we are to make good decisions.

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[4] Resources for the Future (1992). *Setting National Environmental Priorities: The EPA Risk-based Paradigm and Its Alternatives.* Conference Proceedings, November 15-19, 1992.

The California Project

The California Comparative Risk Project's original mission was to identify environmental threats of the greatest ecological, human health, and societal concern, using traditional risk-ranking methods. The national debates about risk assessment and comparative risk, however, figured very prominently in the evolution of the final CCRP's objectives, which were:

1) to assess and rank environmental threats to human health, ecological health, and social welfare;

2) to critique the risk-ranking model and explore other models for environmental protection and priority-setting, outlining their values and their implications;

3) to incorporate public input in the discussion of the diverse issues that contribute to environmental priority-setting; and

4) to seek consensus among the many perspectives and identify those issues for which there is a lack of consensus.

WHO TOOK PART IN CALIFORNIA'S COMPARATIVE RISK PROJECT?

The Executive Staff included a Project Director (a Senior Toxicologist from Cal/EPA's Office of Environmental Health Hazard Assessment), an Assistant Secretary of Cal/EPA, and the Director of the Office of Environmental Health Hazard Assessment.

Project Staff provided technical support and administered and provided documentation of the entire project.

Three Risk-ranking committees collected and analyzed data, and ranked risks to Human Health, Social Welfare, and Ecological Health.

The Education Committee analyzed the state of public environmental and occupational health education, developed criteria for curricula, and provided recommendations for public participation in the CCRP.

The Environmental Justice Committee critiqued the comparative risk process as it had previously been carried out by other states and the U.S. EPA and recommended ways to set environmental priorities that reflect an environmental justice and pollution prevention perspective.

The Economic Perspectives Committee examined the ways in which economic factors influence environmental decision-making.

The Interagency Management Cooperative, with representatives of over 30 State agencies, provided a forum for discussing CCRP issues and created case studies on how factors other than risk have influenced environmental protection strategies used in the past.

The Statewide Community Advisory Committee, the primary policy advisory committee, was made up of non-State-government members who were representatives of environmental and community organizations, local government, business, industry,

agriculture, and academia. Members of the Statewide Community Advisory Committee provided perspectives and advice on procedures and helped develop recommendations on priority-setting and decision-making.

The California public had an opportunity to participate through a series of roundtables on the State's environmental issues. The public will continue to have an opportunity to contribute during the public comment period which will follow the release of this report.

In order to achieve the CCRP's objectives, the original project structure and approaches were reevaluated and eventually revised. The final workplan of the CCRP presents several unique features.

The California Comparative Risk Project's content

Committees in the CCRP used quantitative approaches to identify and rank environmental topics where possible. But recognizing that factors other than *risk* are relevant to priority-setting, the CCRP devoted considerable time and resources to examining ways in which *economics, pollution prevention, environmental justice, education, and public participation* can be more fully included in risk-ranking and environmental decision-making process. *Sustainability* (improving the quality of life while preserving environmental potential for the future - or "living within the Earth's means"), was a sixth factor identified by the CCRP as important in environmental decision-making. However, due to limits in available expertise in this area, this factor was not considered to the same degree as the other five.

The California Comparative Risk Project's structure

Previous projects generally have a risk-ranking stage, and, more often than not, a risk-management stage (the development of plans to mitigate those risks). The original CCRP workplan called for a similar structure. However, as the debate about the risk-ranking model limitations advanced, the participants in the CCRP re-evaluated the direction of the State's project. What resulted was a unique three-component structure which incorporated the decision-making factors mentioned above. These three complementary components are described below.

Component 1: risk-ranking

The Human Health, Social Welfare, and Ecological Health committees assessed and reported on the environmental issues under their purview. During this process, analysts used existing methods and data to quantify, to the extent possible, the risks associated with environmental threats. This process used varying degrees of judgment and issues or values, depending on the availability and quality of the data. Some committees incorporated issues or criteria from Component 2 in their rankings. For example, the Social Welfare Committee included "equity" as a ranking criteria. The Human Health Committee considered "hot spots" and susceptible subpopulations in their approach. In their final reports, each committee provided information about the methods used, the results and conclusions, and recommendations to Cal/EPA.

> Environmental decision-making is a multi-dimensional process. Risk-based rankings of environmental topic areas are valuable and should be used for priority-setting in conjunction with other factors, including economics, public input, the potential for pollution prevention, the need to address the existence of disparate impacts on different populations, and the emergence of future risks.

Component 2: critiquing the risk-ranking model

While Component 1 committees analyzed risk, the Education, Economics, and Environmental Justice committees analyzed the extent to which other factors do or should influence risk-ranking, environmental decision-making, and management strategies. At the same time, the Interagency Management Cooperative (IMC) reviewed case studies of State agencies' environmental decision-making processes to get a sense of how other factors affect the management of environmental problems. In their final reports, each committee provided information about the committee's mission and process, the results of their deliberations, and recommendations to Cal/EPA.

Component 3: integration of components 1 and 2

Our integration involved broad discussion of factors and criteria from each Component. The Statewide Community Advisory Committee reviewed the work products of all the committees, as well as their recommendations. Members of the Statewide Community Advisory Committee developed their own recommendations to Cal/EPA about methods for future environmental decision-making and priorities. These are presented in this report, as are many of the technical committees' recommendations. The California Environmental Protection Agency and its boards and departments will also review the final reports and recommendations.

The environmental topic list

Most previous comparative risk projects have developed just one list of environmental problems for analysis. But comparing conceptually diverse categories of problems, such as pollutants (for example, toxic air contaminants or lead), sources (for example, waste sites and industry), and affected populations (for example, workers) resulted in considerable confusion and double-counting. To avoid these "apples with oranges" comparisons, the CCRP developed "environmental topic lists," which assessed environmental hazards from three distinct and relatively consistent subsets of environmental issues:

List I considered the traditional *statutory division* of environmental problems into the media (that is, air, water, land), that are impacted by the release of toxic substances from different sources (for example, factories and automobiles);

List II addressed major *environmental stressors* (for example, asbestos, environmental tobacco smoke, and ozone); and

List III considered overarching categories of *human activity* which impact the environment (for example, agricultural practices and energy systems). The California Comparative Risk Project decided early on that it would attempt to address these broad issues that account for impacts on the environment. Overpopulation, though potentially a major force behind the negative impact on the State's environment, was not analyzed.

ENVIRONMENTAL TOPIC AREAS

List I. Environmental Releases to Media By Sources

Water
Industrial releases to surface water
Municipal releases to surface water
Non-point source releases
Releases to groundwater

Land
Active hazardous waste generators
Inactive hazardous waste sites
Solid waste disposal sites
Storage tank releases
Treatment, storage, and disposal facilities

Air
Mobile sources
Residential and consumer product sources
Stationary and commercial area sources

List II. Environmental Health Stressors

Alteration of aquatic habitats
Alteration of terrestrial habitats
Asbestos
Carbon monoxide
Electromagnetic fields
Environmental tobacco smoke
Genetically engineered products or organisms
Greenhouse gases
Inorganics
Lead
Microbiological contamination
New chemicals
Non-native organisms
Oil/Petroleum
Persistent/bioaccumulative organochlorines
Ozone
Particulate matter
Pesticides - agricultural use
Pesticides - nonagricultural use
Radionuclides
Radon
SOx and NOx
Stratospheric ozone depletors
Substances that alter pH, salinity, and hardness
Thermal pollution
Total suspended solids, biological oxygen demand, and nutrients
Volatile organics

List III. Potential Threats to Environmental Integrity

Agricultural practices
Commercial/Industrial practices
Energy management practices
Municipal/Governmental practices
Natural resource practices
Recreational practices
Residential/Consumer practices
Transportation systems
Water management practices

Data and methods for risk-ranking

The committees in Component 1 examined the methods developed by previous comparative risk projects and then both developed new approaches and collected California-specific data to advance and refine the risk-ranking methods.

The Human Health Committee's quantitative analyses included a systematic procedure to identify environmental agents which could be used to best characterize environmental problems, and use of California monitoring data to identify average risks for California and some high-risk populations in the State. Members of the Human Health Committee relied primarily on actual human exposure data, rather than estimated exposures, to characterize many health risks.

The Ecological Health Committee relied on environmental data collected by regulatory agencies, industry groups, regional associations, and environmental groups. Unlike many other comparative risk projects, however, ecological effects were not fit into a category early in the analysis. Instead, the Ecological Health Committee developed cause and effect "pathways" to identify the most severe threats to California ecosystems. This allowed a more flexible approach to ranking.

Social welfare analyses in some previous projects have focused almost exclusively on economic impacts. Other projects have considered broader dimensions of social welfare, but have not developed systematic measures or databases. In order to consider a wide range of social welfare dimensions in a systematic manner, the Social Welfare Committee developed appropriate concepts and methods and used them to derive a ranking. Dimensions considered ranged from property value and income to peace of mind and equity.

Summary of the Technical Report

The remainder of this summary report focuses on the work of the individual technical and advisory committees. Condensing the text from the lengthy chapters of the full technical report to this smaller, less-technical summary, necessitated leaving out much detailed information. Please refer to the full technical document for a complete report of each working committee. As a reminder, the conclusions and recommendations presented in the following summary reflect the views of the individual committees and their members, and not necessarily those of Cal/EPA or the Statewide Community Advisory Committee. The report of the Statewide Community Advisory Committee is presented as a section in the summary report in its entirety.

WHAT ARE THE RELATIVE RISKS TO HUMAN HEALTH IN CALIFORNIA?

Introduction

In the context of human health, "risk" is the probability that adverse health effects_ranging from death to subtle biochemical changes_may occur due to exposure to a substance. These adverse effects can be divided into two categories: *carcinogenic* or cancer-causing effects, and *noncarcinogenic* effects, which range from immediate death (such as with carbon monoxide poisoning) to damage to the reproductive system to more subtle changes, like impaired breathing during heavy exercise.

PUTTING HEALTH RISKS INTO CONTEXT

Not all health problems come from environmental pollution. Many other factors also play a role, including: poverty and employment status, which affect nutrition and access to health care, violence, smoking, and drug use. In fact, scientists still do not know the exact degree to which human health problems can be attributed to pollution, and how much should be attributed to other environmental factors of lifestyle choices. The Human Health Committee suggested that given the scientific uncertainties involved in evaluating the impact of environmental stressors on human health, reducing or eliminating preventable exposures to hazardous substances, particularly in high-risk settings, is a sensible public health precaution.

Methods

Human health risk assessors use several different kinds of data, including *incidence data* (information on the actual occurrence of a disease) and *exposure monitoring* (information on the amount of emissions and other pollutants to which persons are exposed) to evaluate potential effects on human health.

To estimate the cancer-causing effects of an environmental topic, Human Health Committee analysts look at both human and animal studies linking exposure to a substance to cancer. The Human Health Committee assumed that any amount of exposure to carcinogens involves some risk for humans and that the risk increases as the dose increases.

Noncancer-causing toxic effects vary with the magnitude, frequency, and duration of exposure. Risk assessors generally assume that some level of exposure to non-carcinogenic substances will cause no adverse effect and evaluate risks by examining whether people are experiencing exposures that are above or below this apparent threshold.

Assessors estimate two types of risk for these threats: *individual risks* (one person's added risk of experiencing adverse effects) and *population risks* (the number of people in an exposed population who might experience adverse effects).

THE FIVE STEPS TO RANKING HUMAN HEALTH HAZARDS

In the course of a human health risk assessment, analysts ask a number of questions about each environmental problem. The first four steps comprise the steps of traditional risk assessment; the fifth step is the final step in a comparative risk process.

Hazard identification

Which substances in this topic area harm humans, and what kind of harm is it? Out of all the substances involved in this problem area (for example, air pollution) which substances will we look at in this analysis?

Dose-response assessment

What could happen to humans if they are exposed to different levels of these compounds? What are the cancer-causing effects? The noncancer-causing effects?

Exposure assessment

What are the sources and durations of exposures to this substance? How many people are exposed to the hazardous substance? What range of doses do they receive?

Risk characterization

Given all we have learned so far, what are the human health impacts of current exposures? What is the risk to an individual? What is the risk to an entire population? Are any subpopulations more impacted than others? How confident are we in the overall analysis?

Risk-ranking

How bad is this problem, relative to other environmental problems we have analyzed?

Ranking criteria

Using two criteria -– the severity of the impact and the number of people affected –- members of the Human Health Committee ranked the risks posed by the environmental topic areas as high, medium, low, or insufficient evidence to categorize. The definitions are as follows:

(H) Topic area either has severe impact on a large or small population or less severe but still significant impacts on a large population.

(M) Topic area has a significant impact on the California population, but the average population risk is lower than the "High" category, or fewer or smaller subpopulations experience high individual risks.

(L) Topic area has a detectable or potential health impact but with lower risks than topic areas ranked as medium.

(IN) Topic area lacks sufficient toxicological or exposure data to reach a scientifically supportable evaluation.

(NR) Not ranked.

(NP) Not a problem.

Human Health Rankings

Human health caveats

When reviewing the risk-rankings of the Human Health Committee, the following caveats must be considered:

→ The human health risks estimated by the Human Health Committee are only a portion of the total risk, because comprehensive quantitative data are not available for all the compounds released into the environment.

→ Risk assessments are presented as numerical results. This gives an appearance of accuracy which can be misleading. Due to methodological limitations (for example, the quantity and quality of data vary considerably between topic areas) results should be interpreted as order of magnitude indications of potential health impacts, not actual predictions of disease incidence.

→ Risk-ranking results are never determined by quantitative analyses alone. Selecting the data used, adopting risk assessment methods, and extrapolating from analyzed risks involves making major assumptions based on scientific judgment. The results of the Human Health Committee reflect the expertise and values of the scientists participating in the analysis. No single risk-ranking is based only on scientific data.

→ The technical approach of the Human Health Committee was not designed to evaluate emerging environmental problems. The focus on current risks, for example, cannot be used to identify problems that could be prevented by making proactive management decisions.

Risk-ranking environmental topic lists I and II

The Human Health Committee risk-rankings appear in full in the technical document. It is important to consider the specific populations at risk when interpreting these rankings. Some examples are given for each environmental topic, but because of space considerations, the complete information cannot be included in this report summary.

HUMAN HEALTH RISK-RANKINGS OF ENVIRONMENTAL RELEASES TO MEDIA BY SOURCES[1]

(Populations at disproportionate risk of high impact are given in parentheses)

High-ranked Risks

Mobile source releases to air
(children; people with respiratory or cardiac conditions; those living near transportation corridors)
Natural source releases to groundwater (those drinking from contaminated water supplies)
Residential and consumer product source releases to air
(children; smokers; those living in regions with high radon sources)
Stationary and commercial area source releases to air
(children; people with respiratory or cardiac conditions; those living near emission sources)

Medium-ranked Risks

Anthropogenic source releases to groundwater (infants; those drinking from contaminated water supplies)
Inactive hazardous waste sites (those near undiscovered or uncontrolled sites)
Non-point source releases to surface water (subsistence/sport fishers; those on private wells)

Low-ranked Risks

Industrial releases to surface water (subsistence/sport fishers)
Municipal releases to surface water (subsistence/sport fishers)
Treatment, Storage, and Disposal Facilities (those near uncontrolled releases)

Unable to Rank[2]

Active hazardous waste generators
Solid waste disposal sites
Storage tank releases

[1]Topics within each rank category are ordered alphabetically.

[2]Topic area lacks sufficient toxicological or exposure data to reach a scientifically supportable evaluation.

HUMAN HEALTH RISK-RANKINGS OF ENVIRONMENTAL HEALTH STRESSORS[1]

(Populations of disproportionate risk of high impact indicated in parentheses)

High-ranked Risks

Environmental tobacco smoke (children with parents who smoke)

Inorganics (subsistence fishers; those with contaminated drinking water supplies or living near near emission sources)

Persistent organochlorines (subsistence/sport fishers)

Ozone (people with respiratory conditions; or those who work or exercise outdoors)

Particulate matter (children; people with respiratory conditions)

Radionuclides (natural sources)

Radon (smokers; those living in areas with high radon concentrations or with highly contaminated groundwater)

Volatile organics (those with contaminated drinking water supplies or living near emission sources; users of certain consumer products)

Medium-ranked Risks

Carbon monoxide (pregnant women; unborn fetus; those with cardiac conditions or using unvented combustion equipment)

Lead (children living in contaminated older housing or urban areas)

Microbiological contamination (those with compromised immune system or drinking contaminated or untreated drinking water supplies)

Pesticides - agricultural use (pesticide applicators; some subpopulations with high dietary intakes)

Pesticides - nonagricultural (pesticide applicators; those living in frequently treated home or workplace)

Low-ranked Risks

Radionuclides (anthropogenic sources)

SOx and NOx (those with respiratory conditions, children in homes with unvented gas appliances)

Substances that alter pH, salinity, and hardness

Total suspended solids, biological oxygen demand, and nutrients (children drinking high-nitrate water)

Unable to Rank, Not Ranked, or No Problem [2]

Asbestos (IN)

Greenhouse gases (IN)

Alteration of aquatic habitats (IN)

Alteration of terrestrial habitats (IN)

Stratospheric ozone depletors (IN)

Electromagnetic fields (IN)

Genetically engineered products or organisms (IN)

New chemicals (IN)

Non-native organisms (IN)

Thermal pollution (NP)

Oil/Petroleum (NR)

[1] Topics within each rank are ordered alphabetically.

[2] Topic area lacks sufficient toxicological or exposure data to reach a scientifically supportable

evaluation.

Conclusions

Based on their work, the Human Health Committee developed three general conclusions about environmental health risks in California:

> *Several environmental stressors cause adverse health impacts that are more significant than others. In particular, the extent and severity of noncancer impacts determined some of the final risk rankings.*

This is the first comparative risk project in which some major noncancer impacts have specifically been quantified and included in the overall ranking process. Substances of greatest concern are *particulate matter*, and also *ozone, environmental tobacco smoke,* and *lead*. Respiratory disease (for example, asthma and bronchitis), aggravated cardiovascular disease, developmental or neurological toxicity, and premature mortality are the major related health effects.

Among cancer causing substances, the largest proportion of estimated cancer cases is associated with pollutants of natural origin (radon, natural background radiation, and arsenic). Exposures to these agents vary in the degree to which they can be controlled or reduced. Other contributors to estimated cancer cases include environmental tobacco smoke, diesel exhaust, dioxins, volatile organic chemicals, and pesticides, all of which have extensive population exposure due to their frequency as contaminants in ambient air, indoor air, or the food supply. Small populations also suffer high exposures to *persistent organochlorines* (substances, like DDT and PCBs, whose levels increase as they travel up the food chain) in edible organisms, like fish.

> *From the perspective of environmental releases to media, the highest estimated human health risks are associated with various sources of air pollution.*

Substantial portions of California's population are frequently exposed to air pollutants at levels that exceed regulatory standards. Exposure to *indoor air pollution* is of special concern, as people spend more time indoors than outdoors and they can be exposed to many different sources of pollution at once (including combustion appliances, consumer products, and emissions from domestic water use).

> *Most topic areas, including many ranked as "low" human health risks, can pose high risks to smaller populations.*

Some groups of people are particularly *susceptible* to some pollutants (for example, children to lead). Other groups suffer unusually high exposures because of their *activities* or *location* (some ethnic groups engage in subsistence fishing where fish are contaminated). Some groups also may be exposed to *multiple* contaminants by different exposures to contaminated media (for example, air, water, and food). This may increase their potential for adverse health effects. In other words, even if an environmental topic area is rated "medium" or "low" for the State as a whole, some exposed groups may be at "high" risk.

What are the greatest threats by environmental media?

All the major categories of *air releases* were evaluated as having high human health risks. Among noncancer risks, outdoor exposure to air pollutants from mobile, stationary, and residential sources are of concern due to widespread exposures. Among cancer risks, residential and consumer product sources in the indoor environment are of greatest concern, because people spend most of their time

inside, where they are exposed to multiple contaminants, including *radon* and *environmental tobacco smoke*.

Among *water release categories*, groundwater contamination represents the most significant source of health risk for average Californians, due primarily to exposure to natural contaminants like arsenic and radon. Other significant exposures involve cancer-risks (DBCP) and noncancer-risks (nitrate) from inadequately treated public water supplies Those relying on private wells in areas of contaminated aquifers are at highest risk.

The human health risks from *land releases* are generally low to medium, because exposures are not high. The highest risks are associated with exposures to uncontrolled inactive hazardous waste sites. The volume of hazardous waste generated annually (1.9 million tons) carries the potential for high human health risks to large populations, if regulatory oversight programs are not in place.

Who is most at risk?

One of the primary criticisms of past comparative risk projects has been that they do not identify the populations that are most affected by environmental stressors, either because of their susceptibility or their high exposures. Without this information, directing resources towards places and people at highest risk can be difficult. The Human Health Committee developed a list of populations that are potentially at greatest risk in the State, according to media. The full table can be found in the Human Health Committee chapter of the technical report. Some examples are provided here:

→ *Children* are at higher risk from exposure to environmental tobacco smoke, particulates, ozone, and nitrogen dioxide because these substances would aggravate asthma and lower respiratory infections.

→ *People of color* are at higher risk from exposure to lead, particulates, ozone, inorganics, and volatile and persistent organics. Preliminary analyses indicate that mass loadings of air toxicants from manufacturing facilities are greater in areas where the population is predominantly people of color.

→ People with preexisting medical conditions are at high risk from exposure to particulates, ozone, and carbon monoxide because these substances aggravate these conditions.

Other populations at higher risk noted by the Human Health Committee include smokers, workers, pregnant women and the developing fetus, private well users, the elderly, and subsistence and sport fishers.

Some geographical areas in California are also exposed to potentially more hazardous levels of toxicants. Inner city neighborhoods, for instance, may be near manufacturing facilities, hazardous waste sites, waste treatment plants, or freeways. The combined effect of the pollutants in these *"hot spots"* (or places with multiple sources of exposure) may be greater than the sum of the individual pollutants.

Data for a Statewide analysis of "hot spots" do not exist. The Human Health Committee did identify regions that may have disproportionately high exposures to pollutants (Table 4, Attachment B, Human Health Committee report), and some are listed here:

→ Regions with high geological radon (Santa Barbara, Ventura, Nevada, and Sierra counties).

→ Regions with contamination "hot spots" affecting aquatic biota (San Francisco Bay/Delta, Santa Monica and San Diego Bays, Lakes in northern and southern California).

→ Regions where water supplies are high in arsenic (San Joaquin Valley).

Other areas listed in the Human Health Committee technical report include: residential neighborhoods near air emission sources or uncontrolled hazardous waste sites, with older housing stock, in air basins regularly exceeding air quality standards; and regions affected by releases from Mexico, and where water supplies contain chemicals resulting from human activities.

The Human Health Committee also attempted to do an "environmental equity analysis," to see if there are any correlations between race, ethnicity, or income and exposure to air pollutants. The analysis is limited, due to incomplete data. Preliminary analyses indicate that:

→ Blacks and Hispanics live in areas that receive greater air pollutant emissions than whites, and

→ Variation in income level does not appear as correlated with proximity to air pollutant emissions as race is.

What kind of research is needed to improve our understanding of Human Health risks?

More research needs to be done to thoroughly understand the risks that environmental pollution poses to Californians, including:

→ Toxicity data are missing for many substances released in large quantities in this State. Monitoring data to describe actual human exposures to most pollutants are also not available.

→ Noncancer risk assessment methods need to be further developed

→ The California Environmental Protection Agency should devote more resources to characterizing population exposures to toxicants in California, including from micro-environments, from accidental releases, and among highly exposed groups.

Recommendations from the Human Health Committee

→ General topic area ranks can be used to guide agencies in setting environmental priorities. The Human Health Committee recommends that the priority-setting process also consider whether environmental health risks are equitably distributed. The priority-setting process should recognize that the identification of highly impacted populations may offer cost-effective opportunities for preventing environmental health impacts.

→ Levels of current risks are often relatively low because many topic areas have been the subject of controls on exposure. Any redirection of resources based on general rankings must consider the increased risks that might result if existing regulatory controls are reduced.

→ The Human Health Committee recommends that the risk-management process develop greater capacity to act to prevent predictable future impacts on public health.

→ The Human Health Committee recommends that comparative risk assessment should be integrated into regulatory agencies' planning processes and that rankings should be

reviewed regularly (perhaps every three to five years) in order to incorporate new scientific information into the priority setting process.

WHAT ARE THE RELATIVE RISKS TO CALIFORNIA'S ECOSYSTEMS?

Introduction

In California, human activities have had significant impacts on many types of ecosystems. Whether it is urban development reducing the habitats for endangered species, water diversions blocking Chinook salmon runs, or chemicals from irrigation run off damaging the reproductive systems of nesting birds, risks to California's ecosystems have created some of the most bitter debates in the State's history.

Methods

To determine the relative severity of these risks, the Ecological Health Committee examined the chains of influence that flow from human activities to wildlife and ecosystems. These chains are called "exposure pathways." It should be noted that the Ecological Health Committee did not start with the topic areas in the environmental topics list. Members eventually translated their findings into similar topic areas, however, as described at the end of this chapter.

The 1991 transportation spill of a pesticide in the Upper Sacramento River provides a good example of an exposure pathway. At the beginning of the chain, or pathway, is an *activity* (in this case, *transportation* of hazardous materials). This creates a specific *stressor* (metam sodium, widely used as a soil fumigant), which moves through a *medium* (this could be air, water, or land, but in this case it is water and air). The stressor comes in contact with a *receptor* (aquatic life), which may produce an *effect*. The effect of the metam sodium spill in the Sacramento River was that aquatic life for over forty miles was killed. The exposure pathway for this incident, then, can be written as follows:

Activity (Transportation) ∅ Stressor (Pesticide) ∅ Medium (Water) ∅ Receptor (Aquatic Life) ∅ Effect (Mortality)

Members of the Ecological Health Committee used a "bottom-up" approach to explore exposure pathways, starting from the effect on biological receptors and then moving back up to the stressor and activity. (In the metam sodium spill example, Ecological Health Committee members would begin with the death of aquatic life, and move back up the chain to transportation.)

The Ecological Health Committee ranked the magnitude and severity of the impact of approximately 100 effects as "high," "medium," or "low," by analyzing four factors of that risk: intensity, extent, reversibility, and probability/uncertainty. Then the Ecological Health Committee as a whole ranked all the effects investigated.

THE FOUR FACTORS OF ECOLOGICAL RISK

Intensity measures the ecological severity of the effect and ranges from non-lethal effects on organisms to complete destruction of ecosystems.

Extent measures the proportion of the ecosystem affected and ranges from less than one to 100 percent.

Reversibility measures the time required for the system to recover and ranges from less than one year to more than 70 years (which is "unrecoverable").

Uncertainty/probability measures the certainty that the effect will occur or the probability that the event producing the stressor will occur and ranges from no direct evidence to documented evidence it will occur.

The Ecological Health Committee then grouped the exposure pathways together based on the similar activities and stressors that cause negative effects in California's ecosystems. These groupings are called the "aggregate threats."

What Are the Greatest Threats to California's Ecosystems?

Ecological health caveats

When referring to the risk-rankings of the Ecological Health Committee, the following caveats must be considered:

→ The ranking of aggregate threats by the Ecological Health Committee incorporated evaluation of available data together with decisions based on scientific judgment. The aggregate threats and the rankings assigned were influenced by the experience and knowledge of Ecological Health Committee members.

→ The Ecological Health Committee believes the aggregate threats, as presented, reflect the major potential threats to California ecological systems and that there is a major difference in the magnitude of the threat between high, medium, and low groups.

→ The Ecological Health Committee was generally dissatisfied with the results of the translation from their "Aggregate Threat List" to the CCRP's general environmental topic lists. Although the translation to list II was adequate, the other translations would need substantial revision to conform with Ecological Health Committee members' perceptions of threats to California ecological systems.

→ Members of the Ecological Health Committee maintain that an aggregate threat ranking provides the best means to evaluate risks to ecological health in California.

Aggregate threats

The Ecological Health Committee presented its rankings of aggregate risks as the most pertinent means for evaluating environmental threats to California's ecosystems based on risk. These are presented in the following box.

RELATIVE RANKING OF AGGREGATE THREATS

High-ranked Risks

- Atmospheric oxidants
- Introduced species
- Mining waste and drainage
- Resource extraction from aquatic ecosystems
- Resource extraction from terrestrial ecosystems
- Urban runoff
- Urban sprawl
- Water diversion

Medium-ranked Risks

- Accidental releases of hazardous materials
- Agricultural practices
- Greenhouse gases
- Municipal wastewater
- Persistent toxicants
- Pesticides
- Petroleum, natural gas, or geothermal development
- Recreation

Low-ranked Risks

- Acid deposition
- Particulates
- Pathogenic microorganisms
- Road development
- Wild fires

The order of these topics within each category has no bearing on its severity.

Translation of aggregate risks to the environmental topic lists

Although a complete translation from aggregate threats to the environmental topic list developed by the CCRP was not possible, the Ecological Health Committee did translate its findings, as follows:

ECOLOGICAL HEALTH RISK-RANKING OF ENVIRONMENTAL HEALTH STRESSORS

High-ranked Risks

- Alteration of aquatic habitats
- Alteration of terrestrial habitats
- Inorganics
- Non-native organisms
- Ozone
- SOx and NOx (including acid deposition)

Medium-ranked Risks

- Greenhouse gases
- Lead
- Oil/Petroleum
- Persistent organochlorines
- Pesticides - agricultural use
- Pesticides - nonagricultural use
- Substances that alter pH, salinity, and hardness
- Total suspended solids, biological oxygen demand, and nutrients

Low-ranked Risks

- Microbiological Contamination
- Particulate Matter
- Volatile organics

Unable to Rank or Not Ranked

- Asbestos
- Carbon monoxide
- Electromagnetic fields
- Environmental tobacco smoke
- Genetically engineered products or organisms
- New chemicals
- Radionuclides
- Radon
- Stratospheric ozone depletors
- Thermal pollution and heat stress

The order of these topics within each category has no bearing on its severity.

What are the most sensitive ecosystems and species in the State?

In ranking aggregate environmental threats to California's ecosystems, the Ecological Health Committee identified biological receptors at highest risk. As an analogy, these more sensitive receptors are comparable to the more sensitive human subpopulations exposed to environmental contaminants. The biological receptors at highest risk should be placed in the context of the aggregate threat of concern. The full list of ecological receptors at the greatest risk for aggregate threats can be found in Table 3 of the Ecological Health Committee's report in the full technical document.

Some examples of the most sensitive ecological receptors for the highest ranked aggregate threats include:

→ Atmospheric oxidants: coniferous forests.

→ Introduced species: geographically restricted or specialized native species.

→ Mining waste and drainage: river communities; riparian communities.

→ Resource extraction from aquatic ecosystems: river communities; anadromous fish populations; marine invertebrate populations.

→ Resource extraction from terrestrial ecosystems: old-growth forest communities; hunted or collected species; forest communities.

→ Urban runoff: aquatic populations near large cities.

→ Urban sprawl: geographically restricted terrestrial populations near large cities.

→ Water diversion: aquatic and terrestrial estuarine communities; river communities.

Which ecological health threats need to be studied more?

Contaminants in non-point sources and sediments

Non-point sources (for example, runoff from land surfaces) are the major contributors to contaminants in surface waters. Sediment contaminants may contribute more to water column concentrations in enclosed bays than point source inputs (for example, heavy metals in sediments) to surface water.

Ecological systems impacted by multiple toxicants in multiple media

Salmon populations, biological communities in enclosed bays or estuaries, coniferous forest ecosystems near large population centers, and migratory waterfowl populations are all exposed to multiple threats.

Loss of diversity

Effort should be directed to determining the degree to which species diversity is reduced and ecosystem functions impaired in heavily impacted ecological systems. Non-native species may also be a significant threat, as they can crowd out native species and reduce diversity.

Recommendations From the Ecological Health Committee

→ Increased human population, coupled with the associated land-use changes present "overarching" impacts on California ecosystems. The size of the human population, the location of population centers and the development and operation of the infrastructure

necessary to support the human population pose the most serious current threat to California ecosystems. The potential for further degradation of ecological systems could be reduced by regional or Statewide land-use planning that incorporates consideration of ecological impacts.

→ Protection of groundwater resources is a serious problem which should be addressed. Groundwater resources should be protected to the same degree that surface waters are protected. Protection of groundwater resources should address potential contamination as well as excessive consumption rates.

WHAT ARE THE RELATIVE ENVIRONMENTAL RISKS TO CALIFORNIANS' SOCIAL WELFARE?

Introduction

A polluted river, an endangered species, or a sick human can be a symptom of an environmental problem, and methods often exist to measure the extent of their effect. But many environmental problems impact something far less tangible than an organism or ecosystem: the "social welfare" of an individual, family, or community.

"Social welfare" includes many dimensions, ranging from economic well-being to a sense of personal security and equitable distribution of impacts and benefits. Environmental problems, for instance, can diminish recreational opportunities; reduce property values or increase taxes; cause pain and suffering as a result of illness; create divisions and conflicts within communities; and undermine confidence in governing institutions. Environmental problems may also disproportionately impact subpopulations.

These dimensions are reflected in widespread concerns which cut across lines of education, income, age, and gender. In the more serious cases, these concerns reveal a depth of disruption of people's lives that is not captured in standard statistics of lost work days or frequencies of disease. To evaluate these kind of impacts, some comparative risk projects conduct a "quality of life" or social welfare analysis that focuses primarily on economic impacts (like property damage and lost work days), because these are easier to quantify. In the CCRP, the Social Welfare Committee also examined those social impacts which cannot really be quantified, such as peace of mind, aesthetics, equity, and future well-being.

Methods

What is optimal social welfare?

Although social ideals are highly subjective, the Social Welfare Committee developed the following definition of optimal social welfare as a standard for their analysis:

> *"People enjoy high levels of social welfare when they have good health and health care, personal security, meaningful employment, adequate income, a pleasing functional and diverse environment, a well-functioning infrastructure providing basic services, a range of satisfying recreational opportunities, good educational services, and a sense of community cohesiveness, participation, control, and trust with regard to governing institutions. There must also exist opportunities for personal choice, continuous self and community improvement, and an assurance that these benefits will be available to future generations."*

The subjective experience of ranking social welfare impacts

The Social Welfare Committee used a number of questions to help develop their ideas about social welfare impacts, including:

→ Is my health or the health of loved ones affected?

→ Will this threat affect my employment? The safety or value of my home?

→ Will I give birth to a deformed child?

→ Has my faith in human nature been damaged? Has my child's view of the world as a safe and nurturing place been damaged?

→ Was information withheld from me?

→ Can I still trust my government?

→ Did this happen to my community because of a lack of concern about minorities or poor people?

→ Will it polarize my communities and create scapegoats?

Social Welfare Committee ranking criteria

After developing a measure of optimal social welfare, Social Welfare Committee members developed criteria to determine whether a social welfare impact exists. Some of the criteria focus on objective impacts (like environmental or economic well-being). Others focused on more subjective perceptions (like peace of mind and community well-being).

Environmental and aesthetic well-being. Functioning natural ecosystems; pleasing urban, suburban, and rural communities.

Economic well-being. Meaningful employment; adequate income; well-functioning infrastructure; affordable housing.

Physical well-being. Good physical health; access to health care; and affordability of health care.

Peace of mind. Good mental health; trust of governing institutions; access to reliable information; personal security; and healthy personal relationships.

Future well-being. Assurance for the well-being of future generations; sustainability of economic practices; and sustainability of ecosystems.

Equity. Shared decision-making power; democratic control of government; and equitable distribution of impacts and benefits.

Community well-being. Cohesiveness; accountability of decisionmakers; resources and opportunity to participate in decision-making.

The Social Welfare Committee then developed eight measures to evaluate the extent of the impacts associated with each criteria. Those measures were: number of people exposed, number of people impacted, severity of impact, irreversibility (degree to which impact is reversible), involuntariness (degree to which people have a choice in being exposed), uneven distribution (degree to which

exposure falls disproportionately on a subpopulation), potential for catastrophic impact, and lack of detectability.

The Social Welfare Committee created matrices for each environmental topic area, so that each criteria could be measured as "high," "medium," or "low." After matrices had been developed, the Social Welfare Committee reviewed all of them together to determine their relative levels of concern.

Social Welfare Risk-ranking

Social welfare caveats

When referring to the risk-rankings of the Social Welfare Committee, the following caveats must be considered:

→ The nature of social welfare impacts precludes a systematic weighing and comparison of topic areas. However, in order to "rank," artificial separations and groupings occurred in terms of the topic areas and lists, the impacts on health, ecology, and social welfare, and the aspects of social welfare impacts themselves (in the form of criteria and measures). Currently, there is no effective way to validate whether such an approach can adequately capture the social welfare impacts present in the complex California system.

→ No well-established methodology or conceptual framework exists for assessing the social welfare impacts of environmental problems. Nor are there any systematic measures or databases available to use in these assessments.

→ The Social Welfare Committee was a group of diverse professionals, but did not comprise a representative cross-section of the State's population.

→ The rankings do not include a consideration of social welfare benefits, mitigation, or regulation costs.

→ The Social Welfare Committee was constrained by insufficient time, data, and resources.

→ Linking environmental problems to traditional social welfare impacts, like economics and aesthetics, is often tenuous, as any activity can have both beneficial and detrimental effects. Linking environmental problems to less traditional social welfare impacts, like anxiety or community fragmentation, can be even more difficult, as people's definitions of what is pleasing or desirable depend greatly on their background, circumstances, and personal taste.

Social Welfare Committee Rankings

The rankings of environmental topic area list II (Environmental Health Stressors) according to relative impact on social welfare are presented here.

SOCIAL WELFARE RANKING OF
ENVIRONMENTAL HEALTH STRESSORS

High-ranked Risks

- Alteration of aquatic habitats
- Alteration of terrestrial habitats
- Environmental tobacco smoke
- Greenhouse gases
- Lead
- Ozone
- Particulate matter
- Pesticides - agricultural use
- Pesticides - nonagricultural use
- Radionuclides
- Stratospheric ozone depletors
- Volatile organics

Medium-ranked Risks

- Asbestos
- Inorganics
- Microbiological contamination
- Non-native organisms
- Oil/Petroleum
- Persistent organochlorines
- Radon
- SOx and NOx

Low-ranked Risks

- Carbon Monoxide
- Substances that alter pH, salinity, and hardness
- Thermal pollution
- Total suspended solids, biological oxygen demand, and nutrients

Unable to Rank

- Electromagnetic fields
- Genetically engineered products or organisms
- New chemicals

The order of these topics within each category has no bearing on its severity.

Social welfare priorities

Based on the Social Welfare Committee's assessment, some of the environmental health stressors with the greatest overall social welfare impacts are *environmental tobacco smoke, ozone, particulate matter, alteration of aquatic habitats, alteration of terrestrial habitats,* and *radionuclides*.

All six ranked high in their impact on peace of mind. Environmental tobacco smoke, ozone, and particulate matter were judged to most significantly impact the environment and aesthetics, economics and/or health. The greatest impacts of habitat alteration were on the environment and communities, as well as on future well-being and equity. The impact of radionuclides is primarily on economics, the future, communities, and equity.

Recommendations From the Social Welfare Committee

- → Social welfare must be considered in any similar policy exercise or risk assessment.
- → Future study of social welfare impacts should be provided with resources necessary for full examination of appropriate data.
- → In any analysis of social welfare benefits, the relative distribution of these benefits should be determined. An analysis of "activities," rather than environmental topic areas, would facilitate an analysis of social welfare impacts.
- → In environmental policy processes, Cal/EPA must include community and public participation and input at every stage of the process. Impacted communities in particular should be involved. Appropriate models for such participation should be developed.
- → The California Environmental Protection Agency should continue to develop appropriate criteria, methods, and databases for addressing social welfare considerations. The most knowledgeable and experienced professionals in the State should be involved and the data collection, methodology, and analysis should undergo scientific peer review and community and public reviews at all stages of the process.

→ To enhance environmental decision-making, policymakers should obtain a full view of the issues and options by listening to the perspectives of persons from different sectors, as well as members of the public. Values are an important component in prioritizing risk or risk-reduction strategies, and should be made explicit where possible.

SUMMARY OF RISK-RANKINGS

The risk-rankings for Environmental Health Stressors (environmental topic list II) from the three Component 1 committees are provided together here for easy comparison. These rankings should be considered in the context of the other decision-making factors discussed in the summary report.

In using these rankings, the caveats must be considered and included in any reproductions or citation of these results. Furthermore, the additional information provided by the committees, for example the information about aggregate risks presented by the Ecological Health Committee, and the information on populations at risk presented by the Human Health Committee must also be referenced.

ENVIRONMENTAL HEALTH STRESSORS

(to be used only in conjunction with the caveats on pages 13, 20, and 27)

HUMAN HEALTH

HIGH

Environmental tobacco smoke
Inorganics
Persistent organochlorines
Ozone
Particulate matter
Radionuclides
(natural sources)
Radon
Volatile organics

MEDIUM

Carbon monoxide
Lead
Microbiological contaminants
Pesticides-agricultural use
Pesticides-non agricultural use

LOW

Alteration of acidity, salinity or hardness of water
Radionuclides (anthropogenic)
SO_X and NO_X
Total suspended solids, biological oxygen demand, or nutrients in water

SOCIAL WELFARE

HIGH

Alteration of aquatic habitats
Alteration of terrestrial habitats
Environmental tobacco smoke
Greenhouse gases
Lead
Ozone
Particulate matter
Pesticides-agricultural use
Pesticides-non agricultural use
Radionuclides
Stratospheric ozone depletors
Volatile organics

MEDIUM

Asbestos
Inorganics
Microbiological contaminants
Non-native organisms
Oil and petroleum products
Persistent organochlorines
Radon
SO_X and NO_X

LOW

Alteration of acidity, salinity or hardness of water
Carbon monoxide
Thermal pollution
Total suspended solids, biological oxygen demand, or nutrients in water

ECOLOGICAL HEALTH

HIGH

Alteration of aquatic and wetland habitats
Alteration of terrestrial habitats
Inorganics
Non-native organisms
Ozone
SO_X and NO_X

MEDIUM

Alteration of acidity, salinity, or hardness or water
Greenhouse gases
Lead
Persistent organochlorines
Oil and petroleum products
Pesticides-agricultural use
Pesticides-non agricultural use
Total suspended solids, biological oxygen demand, or nutrients in water

LOW

Microbiological contaminants
Particulate matter
Volatile organics

AN ENVIRONMENTAL JUSTICE PERSPECTIVE ON COMPARATIVE RISK

Introduction

> *Freedom from ecological destruction, freedom from environmental discrimination, and the need for democratic participation at every stage of policy-making should be central to just environmental policy.*
>
> *--Environmental Justice Committee*

On July 26th, 1993, a toxic cloud resulting from the accidental release of sulfuric acid at a local plant spread over Richmond, just northeast of San Francisco. A vital and diverse community, the most heavily exposed area of Richmond is home to primarily lower-income Black, Latino, and South East Asian residents. The town is the site of many large and small facilities that use or produce highly toxic substances, and that release contaminants into the environment every day.

Richmond residents are a high-risk population for environmental exposures. The fact that they are also poor and people of color is not unusual. Numerous studies have shown that poor communities and communities of color throughout the nation are subject to more pollution than wealthier and predominantly white communities.

Residents of such so-called "hot spots" may be more susceptible to health problems because of these exposures, and because they may not have ready access to adequate health care. National studies have indicated that environmental regulations also have been found to be less well enforced in such communities. [5]

These findings are among the basic tenets of what is called the "environmental justice movement." Environmental justice describes a policy approach that seeks to avoid putting disproportionate pollution burdens on any one community. But rather than try to "even-out" the pollution burden, environmental justice asserts the right of all communities to a healthful environment and strives to reduce pollution everywhere.

Mission

The mission of the Environmental Justice Committee was to provide the CCRP with a firm environmental justice framework. Rather than ranking the environmental topic areas, the Environmental Justice Committee commented on and provided alternatives for the comparative risk process itself. The findings and conclusions of the Environmental Justice Committee affected several aspects of the CCRP. The inclusion of the mission to examine and propose changes in environmental decision-making processes in the State; the Human Health and Social Welfare committees' work; and the Statewide Community Advisory Committee's recommendations for more public participation, for a multidimensional approach in considering risks, and for pollution prevention programs are just some examples of those effects.

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[5] For examples of studies on environmental justice, see Cole, L. (1993). Empowerment as the key to environmental poverty law. Ecology Law Quarterly. 19, 619-683.

To begin their work, members of the Environmental Justice Committee developed three fundamental principles for environmental justice:

1) The Environmental Justice Committee believes that *public participation* is inviolate and that full and meaningful public participation must be incorporated into agency activities and be a primary consideration in reviewing agency policies.

2) Environmental policies must *incorporate consideration of subpopulations* that bear disproportionate risks.

3) The principle of *pollution prevention* should guide all efforts at risk reduction and policy implementation.

Critique of the Risk-ranking Model

With the four principles in mind, the Environmental Justice Committee presented its critique of the traditional comparative risk process as follows:

> *The structure of decision-making procedures in comparative risk projects (and in environmental decision-making generally) has not adequately provided for full and meaningful community participation.*

Communities of color or with low income are often unable to participate on equal terms with industry and government. But people who live in a community are expert about what is happening there, and should have a strong voice in making decisions about its future.

> *Comparative risk exercises are grounded in a presumption that only limited resources are available for environmental protection.*

Government agencies often fail to pursue a range of good opportunities for increasing funding for environmental protection, including finding alternatives to hazardous processes and products, or levying pollution taxes. It might be more effective to spend money to develop and use alternatives to pesticides, for instance, than to first regulate them and then mitigate the problems they cause.

> *Comparative risk projects should distinguish between risks that would benefit from pollution prevention approaches (air pollution emissions) and those that would not (such as abandoned hazardous waste sites and lead paint in dwellings).*

Pollution prevention seeks to reduce or eliminate hazardous or toxic substances at all different stages of their use, from extraction of materials from the earth, through processing, manufacturing, distribution and use, to disposal.

Focusing on ways to prevent pollution in each of these steps (whether doing the stage differently or eliminating it altogether by changing the process or the end product) could result in cleaner workplaces, a cleaner environment, and less hazardous products for consumers and industry_rather than more health problems and pollution that has to be cleaned up after the fact.

> *Conventional risk assessment methods do not account for the disproportionate risk burdens borne by certain communities.*

Most comparative risk projects do not account for the impacts of cumulative and multiple exposures in toxic "hot spots" or to groups of people like farmworkers and their families. The Environmental

Justice Committee would like to see new methods developed to identify such high-risk groups and areas. Methods such as those used by the Human Health Committee to identify groups at risk to disproportionate health impacts should be expanded.

AN ENVIRONMENTAL JUSTICE SUCCESS STORY

Members of the Environmental Justice Committee prepared several historical case studies illustrating the concepts and actions of the environmental justice movement. All of these are included in the Environmental Justice Committee's report in the full technical CCRP document. Here is one example:

Kettleman City, a small, farmworker community in the Central Valley, is 95 percent Latino. The town already hosts the largest toxic waste landfill west of Louisiana. In 1988, plans were announced to build a hazardous waste incinerator there. The citizens began protesting, fearing that increased pollution from the incinerator would damage their crops and possibly their own health.

They also protested the fact that the environmental impact report (EIR), a document that the State requires for many new project that could affect the environment, was available only in English, although 70 percent of the residents of Kettleman City speak Spanish at home.

The residents' protests fell on deaf ears. With the help of a legal advocacy group, they educated themselves, in Spanish, about the project. The result was 120 letters, all in Spanish, protesting the incinerator. The residents ultimately won a lawsuit against the county's approval of the project. Among the judge's reasons for ruling for the residents was that the EIR was not available in their primary language.

The Kettleman City example shows that strategies can be designed that maximize public participation and lead to the inclusion of more voices in environmental decision-making.

Recommendations From the Environmental Justice Committee

The Environmental Justice Committee developed a number of recommendations to improve environmental decision-making, based its environmental justice principles:

Public participation

→ Greater and more meaningful participation should be promoted by providing sufficient technical resources to affected communities. The U.S. Environmental Protection Agency's Technical Assistance Grants, for example, offer community groups funds to hire their own experts.

→ The California Environmental Protection Agency should extend to all State environmental laws provisions for citizens' suits such as those in Proposition 65 (The Safe Drinking Water and Toxic Enforcement Act of 1986) and expand community right-to-know opportunities, as in New Jersey's *"Right-to-Know More" Act*.

→ The California Environmental Protection Agency should protect all provisions for public hearings on decisions that may affect a community's health or safety. The time and location of public hearings should be convenient. Access to public transit, childcare, and translation services, should be provided.

Consider subpopulations ("hot spots")

→ The California Environmental Protection Agency should ensure equitable and effective implementation and enforcement of all its regulations and activities.

→ To avoid the emergence of new "hot spots" across the State, Cal/EPA (and Cal/OSHA) should develop methods to identify potential "hot spots" in advance and start mitigating them. High-risk "hot spot" populations may include not only geographic areas but groups of people, like children and immigrant workers, who might suffer from language barriers and a lack of understanding about their rights.

Pollution prevention

→ Shortages of resources for environmental protection may be relieved by making manufacturers and users of hazardous materials prove that use and disposal of regulated chemicals is "safe." Currently, this burden is on the government or members of the public; too often, we learn of problems because of illness or accidents.

→ Pollution prevention plans that are now required should also require that methods of implementing them be included. The granting of operating permits should be contingent on such plans.

→ A Governor's Task Force on Pollution Prevention should be established to provide cross-agency coordination, review state environmental programs, many of which are not the control costs borne by some in Cal/EPA, and integrate prevention criteria directly into the evaluation of all their activities. Additionally, an Office of Pollution Prevention reporting to the Secretary of Cal/EPA might ensure that the pollution prevention principle permeates all the agency's activities.

ECONOMIC PERSPECTIVES ON ENVIRONMENTAL DECISION-MAKING

Introduction

Many of the aspects we most value about the environment have no agreed-upon price tag. It would be hard to work out the dollar value of having mountain lions in our wilderness areas, for instance, or knowing that Sierra lakes are pristine, or how the worth of a magnificent view or acres of fertile farmland, compare to the tax revenues provided by a shopping mall or a housing development. Obviously these aspects of the environment have value, even if we cannot say how much they are worth. Meanwhile, some control costs of running a business may continue to rise as environmental standards become more stringent.

In an era of diminished State and Federal budgets and increased attention to environmental problems, it can be difficult to decide how many resources should be applied to which problems. In fact, U.S. EPA's underlying reason for proposing a risk-ranking model to set priorities was the belief that it is increasingly important to address environmental problems in a more cost-effective manner. Currently, most decisionmakers account for economic factors in some way or another. But often it is *ad hoc*, or indirect. Only after priorities are set by the Legislature do decisionmakers make decisions about how best to spend State money.

By carefully studying the economic conditions that both cause and are created by particular environmental problems, policymakers can more fully understand the potential costs and benefits associated with managing them.

The Economic Perspectives Committee of the California Comparative Risk Project developed a guide that policymakers can use to better identify and balance environmental and societal needs. Although many other comparative risk projects have incorporated some sort of economic analysis into their projects (usually in the social welfare analysis), this is the first time a project has offered a "how-to" approach to addressing the economic aspects of environmental problems.

In the course of any economic analysis, the analyst has to ask, *what will we give up -- in terms of activities, money, or goods -- if we spend resources on this environmental problem?* From an economic standpoint, the ideal management option reduces the most amount of risk for a given amount of money (the "biggest bang for the buck"). Economic analyses should also identify who pays the costs and who reaps the benefits of environmental actions.

Economic Criteria for Decision-making

To set environmental priorities by economic criteria, an analyst would focus on estimating the costs and benefits of the proposed risk-reduction strategy. To provide a framework for this analysis, the Environmental Perspectives Committee developed four economic criteria to use as they evaluate risk-reduction measures. Those criteria are: "economic efficiency," "distributional impacts," "uncertainty," and "time considerations."

Each of the four criteria have a number of specific impacts and questions associated with them. Impacts that are qualitative are no less important than the quantitative ones. They do demand a different kind of consideration, however.

Economic efficiency

Economic efficiency refers to getting the most benefit for a given cost. The goal is to maximize benefits to the entire society, whether it is in the form of wealth, employment, improved human health, enhanced ecosystems, or greater social welfare. Analysts should also consider those environmental resources that have no real price or money value, like outdoor recreation; the idea that a resource exists, even if we do not use it (like a distant, pristine lake); and the idea that a resource will continue to exist for future generations.

What are the net wealth and income changes on the State's economy?

What is the ecological net benefit or resource value of the expected risk-reduction?

What is the net value of health benefits of expected risk-reduction?

Distributional impacts

Very efficient economic policies often create "winners" and "losers" in a situation. That is, some groups may get more jobs, more money, or more power than others. Some communities may become more or less desirable to residents or to businesses due to certain governmental decisions.

Which income or ethnic group is burdened and how much does each group benefit?

How does desirability of the community change for social and cultural reasons?

How do government revenues and spending change because of the risk reduction?

How does the desirability of doing business change in the affected area?

Uncertainty

The result of an environmental decision depends on many variables, including natural ecosystem cycles, the dependability of a new technology, changing policies and administrations, and fluctuating economies. Few of these variables can be predicted with precision. But identifying a range of possible outcomes can build in some margin of safety.

How great a factor is natural variation in the success of risk-reduction action?

What is the willingness to pay to reduce the uncertainty in technological development?

Will the risk-reduction action have sufficient political support?

How does the risk-reduction action affect the financial stability of the affected business?

Time considerations (time frame)

Should we act now? Should we wait until we know more? Often environmental decisionmakers have to weigh the costs of acting now against the benefits of holding off. Data and innovations that would make an action cheaper may become available in the future, for instance. But waiting can postpone the benefits of reducing risk or result in irreversible damage to an ecosystem or resource.

What are you willing to pay to collect additional information to decrease uncertainty?

To what degree does today's investment foreclose tomorrow's options?

Does reducing risk maintain resources for tomorrow's generations?

Economic Caveats

When considering economic factors and perspectives in decision-making, there are three caveats that need to be considered:

→ The relative importance of each of the economic criteria will change depending on the circumstance.

→ Not all of the questions can be answered with an identical degree of accuracy.

→ Comparing market and non-market value can be difficult. Because not all factors can be monetized, decisionmakers need to be aware of and sensitive to the more "qualitative" impacts of environmental actions.

Recommendations From the Economic Perspectives Committee

→ Economics is important to environmental decision-making. Policymakers should address economic considerations formally and completely.

→ Policymakers should recognize that reducing risk involves trade-offs and should be addressed explicitly.

→ The California Environmental Protection Agency should complete the economic analysis of the environmental topics using data and recommended methodologies after the project is completed.

→ Full understanding of the economic trade-offs of risk management is an integral part of environmental decision-making.

→ The California Environmental Protection Agency should implement programs in its own departments and boards and coordinate with other State agencies to track and collect data on actual expenditures by private and public entities to protect the environment. Such a knowledge base is fundamental to environmental decision-making and responsible resource allocation.

ASSESSMENT OF EDUCATION AND PUBLIC INVOLVEMENT IN ENVIRONMENTAL DECISION-MAKING

"Education is the cornerstone that enables individuals to feel stewardship for the environment around them - to understand its multi-dimensionality and interconnectedness, and to participate in decisions made about the environment. True public participation is not possible without education."

--Education Committee

Introduction

One of the stickiest problems in any comparative risk project is the question of the public's perception of risk. That is, even if scientists, policymakers, and advocates could create the most accurate scientific risk-ranking imaginable, citizens would still have their own perception of the severity of the environmental risks that surround them. Those perceptions are key to developing sound policies, effective education, and responsive government agencies.

Two important issues in any comparative risk project address the state of environmental education (that is, *How much do people know about environmental problems?* and *What are they being taught?*) and public participation (that is, *To what degree are citizens' views incorporated into the risk-ranking process and into environmental decision-making in general?*)

Such questions are difficult to answer. Several previous risk-ranking projects have tried to incorporate public opinion into their process. And other projects have recognized environmental education as important, and addressed it in their reports. The Education Committee decided early on that they wanted also to both assess the status of occupational health education and environmental education in California. The Education Committee also felt strongly that the California public should have a voice in the CCRP.

The Education Committee was very concerned with whether or not the programs effect empowerment within individuals and communities, and whether or not they are both targeted at and raise consciousness about multicultural issues. The group feels that these are urgent issues, given the rapidly changing demographic face of the state, and the changing perceptions of environmental problem. The Education Committee also recognized the need for integrating health issues into resource-based environmental education projects and curricula; creating well-coordinated programs; providing basic background in ethics in environmental decision-making; and teaching about the natural, built, and work environments.

EDUCATION COMMITTEE'S MISSION

1) To identify the status of occupational health and environmental education in the State of California and make recommendations.
2) To investigate the public participation process in the CCRP and make recommendations.
3) To facilitate communication among committees of the CCRP.
4) To educate ourselves as well as other committees about perceptions of risk.

History of environmental education

Nature study, conservation education, and outdoor education have played important roles in the classroom since the turn of the century. Many national and international events and trends have shaped that education, including the Dust Bowl crisis of the 1930's, the publication of Rachel Carson's *Silent Spring* in 1962, the civil rights and anti-Vietnam movements of the 1960', and the many environmental laws passed during the 1970's and 1980's.

Today, citizens learn about environmental problems through many different mediums, including news reports, newsletters from industries and activist groups, college courses, on-the-job training, and word of mouth. Rarely is this education enough. Indeed, lack of public understanding about environmental issues is consistently listed as a key problem in comparative risk projects. Several states have listed it as a "problem" in their ranking lists. The State of Michigan ranked it in their top six problems. The city of Jackson, Alabama ranked it as the number one problem.

Environmental education is a teaching method that makes connections among science, technology, economics, policy, people, and the environment. Such education is fundamentally different from nature and conservation education because it addresses the interactive interrelationships between humans and the environment. It differs from environmental *science* in that it addresses values and skills as well as empirical knowledge.

Evaluation of Education

To help assess the quality of environmental and occupational health education programs in California, the Education Committee developed:

1) a *vision statement* about ideal environmental and occupational health education,
2) a set of *criteria* against which materials and programs could be evaluated,
3) descriptions of *model curriculum*, and
4) *recommendations* for further environmental education in California.

Vision statement

The connection between workplace/occupational health issues and the environment should be emphasized.

→ Workplace production, handling, and disposal of chemicals directly impacts the environment.

→ Development of viable pollution prevention policies impact both the workplace and the community.

→ Communities most affected by occupational and environmental issues are often the same.

Environmental and occupational health education efforts need to be presented in a multicultural approach.

→ Educators should make sure that many different voices and values are heard and respected.

→ Infusing environmental and occupational health curricula and projects with a diversity of cultural understandings and approaches creates a reflection of the multiculturalism that exists in the real world.

→ Communities of color are often more heavily impacted by environmental and occupational health exposures than white communities. In a multicultural approach, educators and students would recognize that these injustices may have occurred.

Human health concerns need to be reflected in those curricula and projects that are currently focused primarily on natural resource-based issues (for example, recycling, water conservation).

→ There is an integral connection between the health of nature and the health of humans. A lack of a balance in one affects the other. This interrelationship needs to be made explicit.

→ Education about resource issues and human health issues should be joined during environmental decision-making processes.

California programs

In 1968, the California Legislature mandated conservation education in all elementary and secondary schools. This mandate was expanded throughout the 1970's and early 1980's to provide instruction in conservation and protection of natural resources.

Environmental and occupational health education in the State needs further improvement. The California Department of Education has only one full and one half-time staff people to coordinate all of the environmental education activities in the State. There is no central coordinating body for occupational health education. Although the California Environmental Education Interagency Network (CEEIN)[6] is working to provide interagency coordination and networking for environmental educators, and although many exciting and innovative projects exist at the grassroots level, environmental education in this State could benefit from centralized criteria and coordination.

Education and multiculturalism

Changing demographics occurring in California have made environmental educators focus anew on both *who* their programs reach and *how* students are served. For instance, the environment for urban schoolchildren is more likely to be concrete and city parks than lakes and mountains; all children need to learn about both environments. Issues of environmental justice -- that is, the fact that poor people and people of color tend to live in areas that are more heavily polluted -- should be addressed in the classroom. Reaching the diverse communities of California requires a coherent and organized outreach strategy.

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[6] A joint effort of Cal/EPA, the California Department of Education, and the Resources Agency.

The Three Circles Center for Multicultural Environmental Education in Sausalito, California lead the discussions and creations of innovative programs and curricula in multicultural environmental education. The Department of Education also recently published curricula that incorporates multicultural themes which will be made available to educators.

Model curricula and evaluation criteria

The Education Committee found a number of good model curricula that embodied its ideals for environmental and occupational health education. After reviewing a number of these curricula, it developed a set of *criteria* for educators to use in evaluating new and existing educational materials, including that:

→ Issues of literacy should be considered when matching the curricula and approach with the audience.

→ Mechanisms should be in place to enable education and action and provide opportunities for students to decide, plan, and implement action themselves.

→ The curricula should examine the processes that affect risk and should include a discussion of issues regarding risk assessment and risk-ranking. The curricula should present a discussion about the potential benefits of various production processes along with the risks arising from the processes.

→ The program should lead to empowerment of individuals and communities, that is, the power to analyze environmental situations and to take action the individual believes is relevant.

→ Pollution prevention, conservation, and sustainability should be emphasized.

→ Historical, ethical, cultural, geographic, economic, and sociopolitical relationships should be addressed.

Recommendations for environmental education in California

→ The assessment of environmental programs and materials initiated in the CCRP should be continued.

→ The State should formalize interagency partnerships dedicated to improving environmental education.

→ Environmental education should incorporate human health and occupational health concerns.

→ The State should encourage environmental educators to use multicultural and multilingual approaches and materials.

→ The State should acknowledge the connection between public participation and education.

→ The State should enhance existing legislation focused on environmental education.

Public Participation

Previous comparative risk projects have used a number of different methods to survey citizen perceptions of environmental problems in their region. Some projects have held community meetings

to discuss local environmental problems. Other projects have depended on mass distribution of surveys.

The Education Committee first contacted the League of Women Voters (LWV), which conducted public participation activities for the CCRP in San Mateo and in Los Angeles. (The LWV also provided ongoing support and advice for the development of the lists of environmental topic areas.) The California Comparative Risk Project then hired an outside consulting firm to conduct regional roundtables, in Hayward, Los Angeles, and Fresno, throughout the fall of 1993. The firm recruited participants from a number of different constituencies, including business, local government, universities, labor organizations, and environmental and ethnic groups.

What do Californians think are the most serious threats to California's environment?

Each roundtable had about 15 panelists who talked about what they saw as environmental priorities in California. Audience members were also invited to participate. A number of themes came clear after all three roundtables had been held, including that policymakers needed to pay more attention to environmental justice issues and to public participation. Panel members also suggested that traditional risk assessment methods can divide communities, and that too often, policymakers miss the context that affects a community's overall needs.

OBSERVATIONS FROM THE ROUNDTABLES

The Issues in Hayward

- Overpopulation
- Risk assessment methods
- Air pollution
- Pollution prevention
- Sustainability
- Environmental justice
- Pubic participation

The Issues in Fresno

- Water quality
- Regulations
- Unplanned growth
- Air quality
- Education
- Public participation

The Issues in Los Angeles

- Air pollution
- Environmental justice
- Corporate versus individual responsibility
- Public participation

Roundtable participants also proposed solutions to the State's environmental problems. Those solutions ran the gamut from the very general (for example, "rank solutions instead of risks") to the very specific (for example, "reverse car registration fees so that older, more polluting cars pay more"), and included requests for more planned growth, more public communication of risks, and more partnerships between industry and the public.

Recommendations on public participation in California

→ The public must be seen as a full and equal partner, not as an adversary.

→ Public participation occurs along a continuum. The way in which public participation is done should reflect a sincere attempt of establishing dialogue with the affected communities.

→ Public participation can be seen as a solution to some environmental problems in and of itself.

→ True public participation is not possible without education and an explanation of risks that incorporates an understanding of the culture and language of the affected community.

→ Project managers should decide in advance how public participation will be used; otherwise promises may be made which can not be kept. This will work against developing public trust.

→ Public participation should not be used as a way to buy off the community. It requires a genuine commitment to establishing, growing, and maintaining partnerships.

ENVIRONMENTAL DECISION-MAKING: A REVIEW OF THE INTERAGENCY MANAGEMENT COOPERATIVE CASE STUDIES

Introduction

Project Staff surveyed a number of California agencies, represented on the Interagency Management Cooperative (IMC) to see how five factors (risk, public participation, pollution prevention, economics, and environmental justice) affected the agencies' choices of past environmental decisions, priorities and solutions. Five agencies submitted nine case studies: the Department of Toxic Substances Control, the Department of Pesticide Regulation, the State Water Resources Control Board, the Air Resources Board, and the Department of Forestry and Fire Protection. The case studies are not intended to be representative of the agencies' decision-making process, only to offer examples for consideration by the CCRP.

Survey questions focused on the agency's mandate (that is, what is the agency required to do under Federal and State law); its decision-making processes (that is, how do they prioritize problems and solutions); the management options considered (that is, what solutions were available and which were chosen); and the ways in which risk and "non-risk" factors affected their analyses.

Observations

The analysis of the case studies by Project Staff provided several observations:

→ *Risks* are assessed very differently among the State agencies. All agencies attempted to make decisions based on sound scientific judgments. Most agencies also either considered themselves mandated to look at future or multiple risks or volunteered to do so.

→ *Pollution prevention*, which includes concepts of source reduction (controlling pollution before it occurs) and life cycle analysis (reviewing costs, benefits, and alternatives for each stage of the process under question) is not mandated as frequently. Even so, many agencies indicated that some form of lifecycle analysis was used on a discretionary basis. In contrast, *pollution abatement* (that is, reducing pollution after it has been released) is a dominant mandate.

→ Most of the agencies are mandated to provide public notice and formal hearings for pending decisions and provide access to published information. The full range of activities that might have engaged the public often was not used. None of the agencies, for example, had mandates to use public *education* programs or informal workshops on a significant basis, although some did so on their own. A few agencies required significant *community or public involvement* (typically in the form of co-sponsorships) in grant projects.

→ Formally or informally, most of the agencies interviewed consider some aspects of *environmental justice* in their decision-making processes. Most often, that factor is the identification of subpopulations who may be at more risk than the broader population.

→ Few agencies were mandated to include *economic factors* other than efficiency. Considerations generally took the form of evaluating impacts on businesses, for example, of toxic air emissions regulations on small businesses or of registration processes for new pesticides on agricultural enterprises.

Recommendations

These case studies *begin* an examination of how State agencies address the concerns of many people about public participation, distribution of risks among subpopulations, different economic perspectives, and pollution prevention. Project Staff suggest that the case studies support the need for Cal/EPA to:

→ better understand which models of public participation are appropriate for different decisions,

→ better understand how pollution prevention is interpreted and implemented among different agencies,

→ better understand how and when economic factors should be addressed in different situations, and

→ consider institutionalizing additional public participation activities, pollution prevention principles, and economic perspectives, where appropriate.

REPORT OF THE STATEWIDE COMMUNITY ADVISORY COMMITTEE

Preface

This Preface was prepared by Project Staff without the review of the Statewide Community Advisory Committee and does not necessarily represent the consensus of this committee.

The Statewide Community Advisory Committee (SCAC) served as the California Comparative Risk Project's (CCRP) primary policy advisory body. The mission of the Statewide Community Advisory Committee was to increase public input and integrate multiple and diverse perspectives into advice on the CCRP. The Statewide Community Advisory Committee was made up of 34 individuals who were non-State government representatives of environmental and social organizations, local government, business, industry, agriculture, and universities.

The Statewide Community Advisory Committee was charged with:

1) providing a public forum for the discussion of the issues raised during the CCRP that contribute to priority-setting for environmental protection;

2) providing advice and comments on the missions, goals, workplan, and implementation of the CCRP;

3) helping to identify alternative priority-setting models, in addition to the risk-ranking model;

4) participating in the integration of results from Components 1 and 2 and making recommendations to the California Environmental Protection Agency (Cal/EPA) on environmental protection priorities, the process for decision-making, and possible solutions; and,

5) contributing to a consensus-building process.

In over a little more than a one-year span, the Statewide Community Advisory Committee met for 10 regular meetings and a two-day Project Review Workshop. At the first meeting held in January 1993, the Statewide Community Advisory Committee expressed their concerns about the budget and timeline of the CCRP, and the limitations of the risk-based approach for environmental decision-making. The Statewide Community Advisory Committee therefore recommended early on that the CCRP workplan, timeline, and scope be revised to reflect these concerns.

During the course of the CCRP, the Statewide Community Advisory Committee was actively involved identifying other priority-setting models (in addition to the risk-based model), and providing feedback on the methodology and scope of work of the technical committees. For example, the Statewide Community Advisory Committee recommended that the Human Health Committee, with input from the Environmental Justice Committee, expand their scope of work to conduct an analysis to evaluate the risks of environmental stressors to highly impacted portions of the population and highly impacted geographical areas in the State.

The Statewide Community Advisory Committee also suggested ways for increasing public participation in the project and was instrumental in helping to organize three Regional Public

Roundtable meetings held in Los Angeles, Hayward, and Fresno for the purpose of obtaining information on the most important environmental issues as perceived by the public.

During the last stage of the CCRP (that is, Component 3), all of the CCRP committees generated final technical reports on their work which are incorporated in their entirety in the full technical CCRP report. During the two-day Statewide Community Advisory Committee Project Review Workshop in January 1994 and the last meeting of the Statewide Community Advisory Committee held in March 1994, the Statewide Community Advisory Committee was provided with the opportunity to review and comment on all aspects of the draft work products from the committees, make recommendations about the project, and provide recommendations on how Cal/EPA should establish priorities and allocate resources. It was during the workshop and the final meeting that the Statewide Community Advisory Committee developed the following report listing their recommendations to Cal/EPA.

The substance of this report includes principles for environmental decision-making, a commentary on the results from the technical committees, and recommendations for future action with regard to filling data gaps, conducting a pilot project for the identification of "hot spots" for human health and ecological risk in the State, preventing future risks, increasing public involvement and pollution prevention activities, and implementing the CCRP results.

The Statewide Community Advisory Committee successfully completed its charges and provided an important avenue for increasing public participation and providing multiple perspectives in the CCRP. The diverse opinions of Statewide Community Advisory Committee members always led to spirited debate, but in the end members would agree that barriers had been broken and communication channels opened for further dialogue on these issues.

Statewide Community Advisory Committee Report

Members of the Statewide Community Advisory Committee for the CCRP support the concepts presented in this report. The group worked to achieve consensus on major policy issues for comparative risk assessment and environmental decision-making. The precise wording of each finding and recommendation may not necessarily represent the verbatim wording that each member would prefer.

I. Principles for environmental decision-making

Environmental decision-making is a multi-dimensional process. Risk-based rankings of environmental topic areas are valuable and should be used for priority-setting in conjunction with other factors. Factors in addition to risk that need to be incorporated into decision-making include, but are not limited to, economics, public input, potential for pollution prevention, need to address the existence of disparate impacts on different populations, and emergence of future risks.

II. Commentary on reports from the Human Health, Ecological Health, and Social Welfare committees

The Statewide Community Advisory Committee endorses the process that the Human Health, Ecological Health, and Social Welfare committees used to prepare their reports and generate rankings of the environmental topic area list. The Statewide Community Advisory Committee recognizes that the technical work to generate the rankings was substantial and commends the efforts of the three committees.

The Statewide Community Advisory Committee believes that it is essential that the caveats developed by these committees on the use of the rankings be presented along with the rankings in all contexts where the rankings are presented so that the results are not taken out of context.

Acknowledging the limitations that have been identified, the Statewide Community Advisory Committee still finds that the assessments of the Human Health and Ecological Health committees are valuable and advises Cal/EPA to consider them in setting environmental priorities.

The Statewide Community Advisory Committee recognizes that there is considerable uncertainty in analyzing health and ecological risks. Further work should be done to identify the sources of uncertainty in the analyses. The California Environmental Protection Agency should continue to work on development of methods for comparative risk assessment that minimize uncertainty and emphasize scientific principles. The Statewide Community Advisory Committee recognizes that judgment is a necessary element of the ranking process that should be explicitly acknowledged.

Topic areas ranked low or not ranked should be evaluated to determine whether these rankings are a result of 1) low risk, 2) regulatory controls, or 3) lack of data. These limitations of the rankings should be recognized.

The criteria developed by the Social Welfare Committee are important considerations to take into account in priority-setting and decision-making. These criteria are: environmental and aesthetic well-being, economic well-being, physical well-being, peace of mind, future well-being, community well-being, and equity. The rankings of the Social Welfare Committee should be considered preliminary since their work did not allow for a full examination of existing data.

Future studies of social welfare impacts should encompass full examination of data not available to the Social Welfare Committee at the time of their analysis. The California Environmental Protection Agency should continue to develop appropriate methods for addressing social welfare.

III. Highly exposed populations and ecosystems

The Statewide Community Advisory Committee supports the evaluation of risks of environmental stressors to highly impacted portions of the population and specific ecosystems, in addition to the evaluation of risks on a statewide basis. The results of both analyses should be presented. Specifically, results for highly affected portions of the population and highly impacted geographical areas should be presented for human health, and results for highly threatened ecosystems, identified by use of the aggregate threat list, should be presented for ecological health.

Results of both the overall rankings and the highly impacted populations and ecosystems should be examined to identify areas for which additional research is needed. Further assessment of environmental exposures and epidemiology and ecological effects should be conducted where appropriate.

The California Environmental Protection Agency should give high priority to risk reduction actions in cases where important risks are confirmed after any appropriate further analysis.

Priority consideration should be given to high-risk environmental exposures to ecosystems and small populations.

The California Environmental Protection Agency should initiate pilot projects for "hot spots" for human health and/or ecological risks in geographical areas reflecting the diversity of the state, to develop strong empirical data for analysis of the issues of pollution prevention and environmental justice. In these pilot projects, data should be gathered to allow quantification of the releases of environmental contaminants and resulting exposures to humans or ecosystems, including collection of monitoring or exposure data where appropriate. Cumulative risks from all sources should be assessed as well as risks from individual sources. The California Environmental Protection Agency should identify opportunities for exposure reduction with an emphasis on pollution prevention as a first priority to mitigate risks in the selected areas. Appropriate and inclusive public participation models suited to the community should be developed and implemented.

IV. Data gaps

The Statewide Community Advisory Committee recommends that Cal/EPA take steps, within existing resources, to fill the data gaps identified by the technical committees.

V. Identification and prevention of future risks

Future potential impacts are important public health and environmental concerns. Greater capacity to identify and prevent future impacts on public health and the environment from emerging risks should be developed.

VI. Public involvement and education

The Statewide Community Advisory Committee finds that public involvement and education are essential to the multi-dimensional process inherent to environmental decision-making.

The California Environmental Protection Agency should develop and implement a plan to involve the public in its decision-making processes. This includes maximizing meaningful participation in the review of Cal/EPA's activities and progress in accomplishing its objectives of promoting long-term planning for sustaining a healthy environment and a higher quality of life.

The California Environmental Protection Agency's public participation groups and advisory committees should reflect the diversity of the State and its communities.

The Statewide Community Advisory Committee recommends that environmental education provide the information necessary for understanding of sound environmental decision-making by the public at all age levels.

VII. Social and economic analysis for risk management decisions

Analysis of social and economic factors should be addressed in priority-setting and decision-making. Economics has a function in environmental decision-making and should be addressed. The Statewide Community Advisory Committee recommends that analysis of economic trade-offs and benefits of risk management options should be an integral part of environmental decision-making. Current costs and benefits, as well as those that will accrue in the future, need to be considered. This analysis should consider the costs and benefits of taking action as well as failing to take action to address risks. The full array of societal

impacts should be considered, including economic well-being and positive effects of economic enterprises. Factors to consider in assessing economic well-being include employment, income classification, costs of changes in policy, and effects on business competitiveness.

Uncertainty should be recognized in the analysis, including uncertainties resulting from incomplete information, use of new technologies, political uncertainties, and effects of policy changes. When information is incomplete, benefits of action must be weighed against the costs of losing the ability to act on new information in the future. Scientific understanding often changes based on improved data, and these considerations should be incorporated into the analysis.

VIII. Environmental justice

The consideration of subpopulations that bear disproportionate risks (that is, "hot spots") must be incorporated into any new and/or existing environmental policies (for example, risk assessment, regulations.)

The California Environmental Protection Agency should ensure equitable and effective implementation and enforcement of all its regulations and activities.

IX. Pollution prevention

The Statewide Community Advisory Committee finds that pollution prevention can be an effective management tool for the reduction of risk and recommends reexamination of the results of other task forces' work for recommendations concerning pollution prevention. One alternative would be to consider a Governor's Task Force on Pollution Prevention. Such a task force would be responsible for reviewing all agency programs that have environmental responsibilities and for integrating multi-media pollution prevention criteria into the evaluation of these activities.

Regardless of the level of risk, priority should be given to identifying risk reduction measures that do not involve substantial tradeoffs (that is, win-win opportunities) and to implementing such measures as fully as possible.

X. Implementation

Comparative risk assessment processes should be integrated into regulatory agencies' planning processes. Rankings should be reviewed regularly (perhaps every three to five years) in order to determine if better data are available to provide firmer conclusions for risk management decisions. The Statewide Community Advisory Committee recommends that a group be established to oversee the implementation of the results of the comparative risk project.

Opportunities for cross-training of agency personnel, members of the interested public, and researchers on environmental issues should be encouraged. Forums for further development of methods for risk analysis and other elements of environmental decision-making are needed and should be encouraged by Cal/EPA.

The Statewide Community Advisory Committee finds that further work is needed to identify opportunities for merging of environmental and public health risks. For example, ocean water contamination impacts recreational users and also degrades the environment.

Introduction

Overview of the California Comparative Risk Project

History

The California Environmental Protection Agency (Cal/EPA) was created in 1991 to take a leading role in protecting California's environment and the health of its inhabitants. The formation of Cal/EPA offered an opportunity for Californians and policymakers to create a road map for effective and resourceful environmental protection strategies to carry us into the next century. To help chart its course, the Secretary for Environmental Protection James Strock initiated the California Comparative Risk Project (CCRP) in February 1992. Nearly 250 volunteer participants from a wide range of backgrounds and interests were involved in the research, analysis, and development of results contained in this final report, which marks the completion of this project.

The first comparative risk project was conducted by the U.S. Environmental Protection Agency (U.S. EPA) for the nation in 1986-87. This project was initiated because U.S. EPA, while realizing it had made great strides in abating the nation's most visible sources of pollution, considered that some of the nation's most serious or newly developing environmental problems may not be adequately addressed by its legislative and regulatory activities. In its report, *Unfinished Business: A Comparative Assessment of Environmental Problems*, U.S. EPA concluded that some environmental problems, including indoor radon; indoor air pollution; global warming and stratospheric ozone depletion; consumer products; discharges to estuaries, coastal waters, and oceans; and accidental releases ranked relatively high in terms of risk, but did not correspond with their current program priorities. The opposite was true for other environmental problems including RCRA and Superfund sites, underground storage tanks, and municipal wastes. Based on the results of this report, U.S. EPA's programs appeared to be more closely aligned with public and bureaucratic opinion than with the risks that were estimated by scientists and specialists.

Following the completion of the *Unfinished Business* report, U.S. EPA encouraged many of their regional offices to conduct similar projects for purposes of obtaining information on risks and identifying environmental management approaches that would be effective on a more local level. Since that time, several states and municipalities including Washington, Colorado, Vermont, Louisiana, Michigan, and Native American tribes in Wisconsin have also completed comparative risk projects and are in the process of implementing their results. These states and the U.S. EPA found the comparative risk process useful for focusing on risks of relatively greater threat to human health and the environment. These projects are still in the implementation stages and it is not clear how the results will impact legislation or new programs in those states. Presently, twenty-nine other comparative risk projects are being conducted or are in the planning stages in other states, cities, and regional areas.

Mission

The mission of the Cal/EPA-sponsored CCRP was to help the Agency direct its resources to mitigate environmental threats of the greatest ecological, human health, and societal concern.

To achieve its mission, the CCRP had four key objectives:

1) to assess and rank environmental threats to human health, ecological health, and social welfare;

2) to critique the risk-ranking model and to explore other models for environmental protection and priority-setting, outlining their values and their implications;

3) to incorporate public input in the discussion of the diverse issues that contribute to environmental priority-setting; and,

4) to seek consensus among the many perspectives and to identify those issues for which there is a lack of consensus.

Funding for the CCRP was largely contributed by State government and grant money from U.S. EPA. No money was received from private sources or special interest groups. All participants in the CCRP, with the exception of a small number of consultants and contractors, were unpaid volunteers, most of whom held full-time jobs.

Evolution of the California Comparative Risk Project

One of the objectives for the CCRP was to assess and rank environmental threats to California's environment and its inhabitants using consistent methodologies and existing data. To carry out this objective, the Human Health, Ecological Health, and Social Welfare committees were convened to identify environmental threats of the greatest concern using the risk-ranking model. Although they were able to access methods and results used by completed comparative risk projects, each committee developed its own methods and collected California-specific data in order to refine the risk-ranking approach for the State. These risk-ranking activities eventually became known as Component 1 of the CCRP.

Early on, the Project Director supported the formation of an Environmental Justice Workgroup of the Social Welfare Committee. No other comparative risk project had convened a formal working committee of environmental justice scholars and activists, and this working group was instrumental in providing a critique of the risk-ranking model and input on the evolution of the CCRP workplan. An Education Committee, also formed at the onset, was important in providing input on public participation, outreach, and internal communication among committees. Legislation, Planning, and Economics committees were also formed to provide management options to the greatest environmental threats. However, because it became clear that a useful discussion of management options could not occur until after the rankings had been completed, and because of time and resource constraints, these three committees were disbanded until follow-up work to the CCRP is initiated.

As the CCRP evolved, the scope of work was expanded beyond the traditional risk-ranking exercise for purposes of identifying and analyzing other factors besides risk that are important in environmental decision-making and priority-setting (e.g., pollution prevention, justice, economics, sustainability, and public participation and education). A major force that led to the expansion of the scope was the suggestions provided by CCRP's advisory and technical committees, and the growing national and Statewide debate (including U.S. EPA's own Scientific Advisory Board's review of the national project) about the limitations of the risk-ranking model for setting priorities. From this expansion, additional CCRP objectives were identified.

To accommodate the expanded scope of work, a second component for the CCRP was conceived for the purpose of addressing the non-risk factors that need to be considered in the environmental decision-

making and priority-setting process. Three committees made up Component 2 including the Education and Environmental Justice committees, and a newly formed Economic Perspectives Committee. Case studies examining how risk and non-risk factors might influence decision-making in State programs were added to complete the activities associated with Component 2.

Advisory Bodies

The Statewide Community Advisory Committee (SCAC) was convened to act as the CCRP's primary policy advisory body. All 34 members appointed to this committee were non-State government representatives of environmental and social organizations, local government, agriculture, business, industry, and universities.

Project Staff also created the Interagency Management Cooperative (IMC), which was comprised of over 30 senior representatives from various State departments and boards involved in environmental protection and resource management issues.

Other formal and informal advisory committees were formed throughout the course of the CCRP. Early on, a group of interested legislative staff followed the evolution of the CCRP and offered advice and comment. The Human Health Committee formally convened an advisory subcommittee to offer peer review. Three regional public roundtables were held around the State to seek input from the general public. In addition, on several occasions, Project Staff convened *ad hoc* advisory meetings inviting State experts and citizens to help steer the CCRP by providing input on specific implementation issues.

Final Report

The final CCRP report consists of two documents. The larger technical document includes the final and original reports, attachments, and appendices of all technical committees involved in the CCRP. The technical reports from Components 1 and 2, were prepared by the members of each working committee without substantive changes by Cal/EPA, Project Staff, or the SCAC. Therefore, the recommendations made in these chapters represent the consensus of those committees, and not necessarily Cal/EPA's or the SCAC's. The Statewide Community Advisory Committee's recommendations are also provided in the report, as well as a review of the IMC case studies.

The second, much shorter document, is intended for the general reader who wants a summary of the CCRP process, results, and recommendations. It is written in non-technical language and will receive wider public distribution than the full technical report. The contents of this summary report were prepared by Project Staff by referring to the full technical chapters and soliciting comments from the TRT Chairs. The summary report was not reviewed by the SCAC and does not necessarily represent the consensus of Cal/EPA or the SCAC.

Contact numbers are provided on the inside of the front cover of both documents providing information on how to obtain additional copies of the report.

Follow-up

The results of the CCRP will assist Cal/EPA in planning, evaluating, and organizing the activities of the Agency. As part of the CCRP recommendations, Cal/EPA may also consider follow-up activities related to the CCRP. The existing boards and departments within Cal/EPA, as well as other State and local agencies, will receive copies of the report. It is our hope that these State and local agencies and other organizations will find the process, results, and conclusions of this report useful in their decision-making and priority-setting processes. Californians may also find this report informative about the environment in which we live.

The Secretary for Environmental Protection is soliciting comments on the CCRP report to help guide the Agency in implementing the recommendations. Please submit comments to:

The California Comparative Risk Project
Cal/EPA
555 Capitol Mall, Suite 235
Sacramento, CA 95814

Workplan

INTRODUCTION

When the California Comparative Risk Project (CCRP) was conceived, a workplan was developed based, in part, on the comparative risk projects of other states and the U.S. Environmental Protection Agency (U.S. EPA). Following the release of the original workplan in February 1992, many good questions about the risk-based approach to priority-setting and the CCRP were posed. Drawing upon these comments, and what was learned during the CCRP, the original workplan was revised based on the assumptions that:

1) the California Environmental Protection Agency (Cal/EPA) desires to challenge the *status quo* of decision-making and current environmental protection priorities,

2) the questions raised in California and nationally concerning the current practice of comparative risk analysis should be addressed and evaluated,

3) the California Comparative Risk Project should involve the stakeholders by incorporating public input, and

4) educating ourselves and the public on environmental issues is necessary for effective environmental protection and therefore should be an integral part of the CCRP.

As the workplan evolved, we recognized that many additional activities and proposals might be worthy and useful for identifying environmental priorities. However, the two products developed within the time frame requested by the Secretary for Environmental Protection were a characterization and ranking of environmental threats and a critique of the various proposed priority-setting models, using a process that incorporates public input.

ORGANIZATIONAL STRUCTURE

The California Comparative Risk Project was sponsored by the Secretary for Environmental Protection, James Strock. The overall organization of the CCRP is shown in Figure 1.

Project Staff

The Project Director [a Senior Toxicologist in the California Office of Health Hazard Assessment (OEHHA)], the Assistant Secretary of Cal/EPA, and the Director of OEHHA (from December 1992 to March 1994) comprised the Executive Staff and directed the CCRP with input from the public, the advisory committees, and the Technical Research Team (TRT). They were supported by administrative and technical staff, which comprised the Project Staff. The Project and Executive Staff (herein referred to simply as the "Project Staff") remained neutral with regard to the research, analysis, conclusions, and recommendations conducted and produced by the TRT and the advisory committees.

The Project Staff was responsible for making administrative and management decisions regarding:

→ revising the workplan and the CCRP's mission and objectives;

→ implementing the workplan;

→ allocating resources received to fund the CCRP;

→ ensuring adequate communication among the advisory committees, the TRT, and the public;

→ convening advisory committees;

→ providing oversight to the TRT to ensure that the goals and objectives of the CCRP were achieved; and

→ guiding the preparation of the official CCRP report.

Statewide Community Advisory Committee

The Statewide Community Advisory Committee (SCAC) served as the CCRP's primary policy advisory body. The mission of the SCAC was to increase public input and provide multiple perspectives to the CCRP. Members were non-State government representatives of environmental and social organizations, local government, business, industry, agriculture, and universities. The Statewide Community Advisory Committee was charged with:

1) providing a public forum for the discussion of issues raised during the CCRP that contribute to priority-setting for environmental protection;

2) providing advice and comment on the missions, goals, workplan, and implementation of the CCRP;

3) helping to identify alternative priority-setting models, in addition to the risk-ranking model, to be evaluated as part of the CCRP;

4) participating in the integration of the results from the various components of the CCRP and making recommendations to Cal/EPA on environmental protection priorities, the process for decision-making, and possible solutions; and,

5) contributing to a consensus-building process.

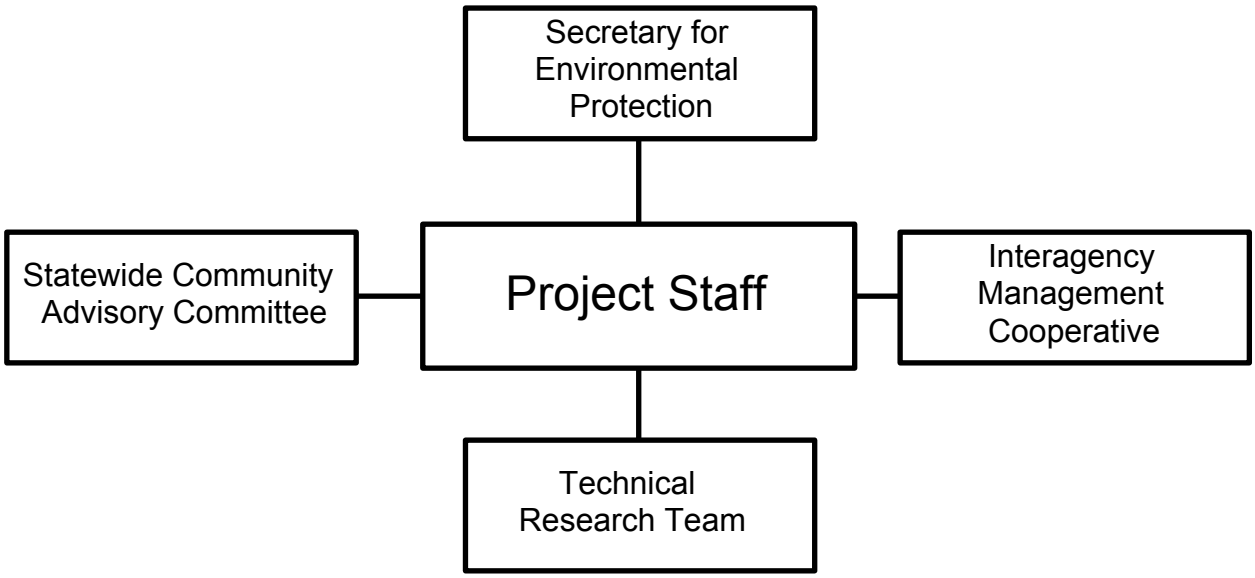

Figure 1.

Key Organizational Components of the California Comparative Risk Project.

Statewide Community Advisory Committee Membership List

Gerald Allen
Manager, Governmental Affairs
Eastman Chemical Company

June Andersen
Manager, Environmental Programs
IBM Corporation
Member, Santa Clara Manufacturing Group

Carl Anthony
President, Earth Island Institute

Sara Broadbent
Director, Environmental Services & Compliance
Waste Management of North America

Wendel Brunner
Assistant Health Services Director for Public Health
Contra Costa County

Patricia Buffler (Co-Chair)
Dean, School of Public Health
University of California, Berkeley

Robert Bullard
Center for African American Studies
University of California, Los Angeles

Patrick Burt
President, Acteron
Chairman, Waste Minimization and Pollution Prevention,

Chuck Center
Director, State Council of Laborers

Jan Chatten-Brown
Shute, Mihaly and Weinberger

Jack Chin
Steering Committee Member
Asian Pacific Environmental Network

Carl Cranor (Co-Chair)
Interim Dean of Humanities and Social Sciences
University of California, Riverside

William French
Executive Director
Rural Community Assistance Corporation

John Giovanetti
Director, Western Grower's Association

Mike Hertel
Manager, Environmental Affairs
Southern California Edison

John Hurst
Professor, Education Department
University of California, Berkeley

C. Richard Knowles
Manager of Environmental Remediation
Atlantic Richfield Company

Joseph LaDou
Director, International Center for Occupational Medicine
University of California, San Francisco

Melvin Lane
Director, Nature Conservancy;
Director, World Wildlife Fund;
Director, Pacific Gas and Electric;
Former Chairman, California Coastal Commission

Arthur Lawyer
Technology Sciences Group

Judy MacGregor
Consultant in Environmental Health and Toxicology

Esperanza G. Maya
Co-founder, People for Clean Air and Water

Gladys Meade
Director, Environmental Health
American Lung Association of California

Bob Merryman
California Conference of the Directors of Environmental Health

John Moore
President, Institute for Evaluating Health Risks

Lawrie Mott
Senior Scientist
Natural Resource Defense Council

Marina Ortega
California Indians for Cultural and Environmental Protection

Steven Pavich
Steven Pavich and Sons

David Roe
Senior Attorney
Environmental Defense Fund

Jim Ryerson
President
Ryerson, Master and Associates, Inc.

Robert Sawyer
Professor Emeritus
Department of Mechanical Engineering
University of California, Berkeley

Richard Sommerville
Air Pollution Control Officer
County of San Diego

Mike Traynor
Cooley Godward Castro Huddleson and Tatum

Ellen Widess

Statewide Community Advisory Committee Meeting Dates and Locations

Meeting date	Meeting Location
January 7, 1993 (Kickoff meeting)	San Francisco
March 24, 1993	San Francisco
May 20, 1993	San Francisco
June 23, 1993	Los Angeles
July 28, 1993	Los Angeles
September 13, 1993	San Francisco
October 13, 1993	Los Angeles
November 8, 1993	San Francisco
December 6, 1993	Los Angeles
January 12-13, 1994 (SCAC Project Review Workshop)	Pacific Grove
March 3, 1994 (Final meeting)	San Francisco

Interagency Management Cooperative

The Interagency Management Cooperative (IMC) provided a forum for communication about the CCRP among State agencies. Over 30 agencies were represented on this advisory committee. The Interagency Management Cooperative was charged with:

1) providing a forum for the discussion of issues raised during the CCRP that contribute to priority-setting for environmental protection;

2) identifying and sharing resources to aid the CCRP including staff, data, and funding if possible; and

3) describing case studies that illustrate how environmental protection strategies identified and critiqued in the CCRP have been applied in the past to reduce environmental threats.

Technical Research Team

The Technical Research Team (TRT) was responsible for conducting the activities related to identifying and ranking the major environmental threats in California and evaluating other "non-risk" factors important in environmental decision-making. As part of their activities, the TRT committees identified methods and criteria for evaluation, gathered and analyzed data, critiqued the risk-ranking model, made recommendations, and wrote the technical reports. Following the guidance of the Project Director, each TRT committee retained the freedom to develop its own membership, groundrules and methods, and to conduct its activities in order to achieve the objectives of the CCRP. The Technical

Research Team consisted of six committees assigned to specific research components of the CCRP (Figure 2).

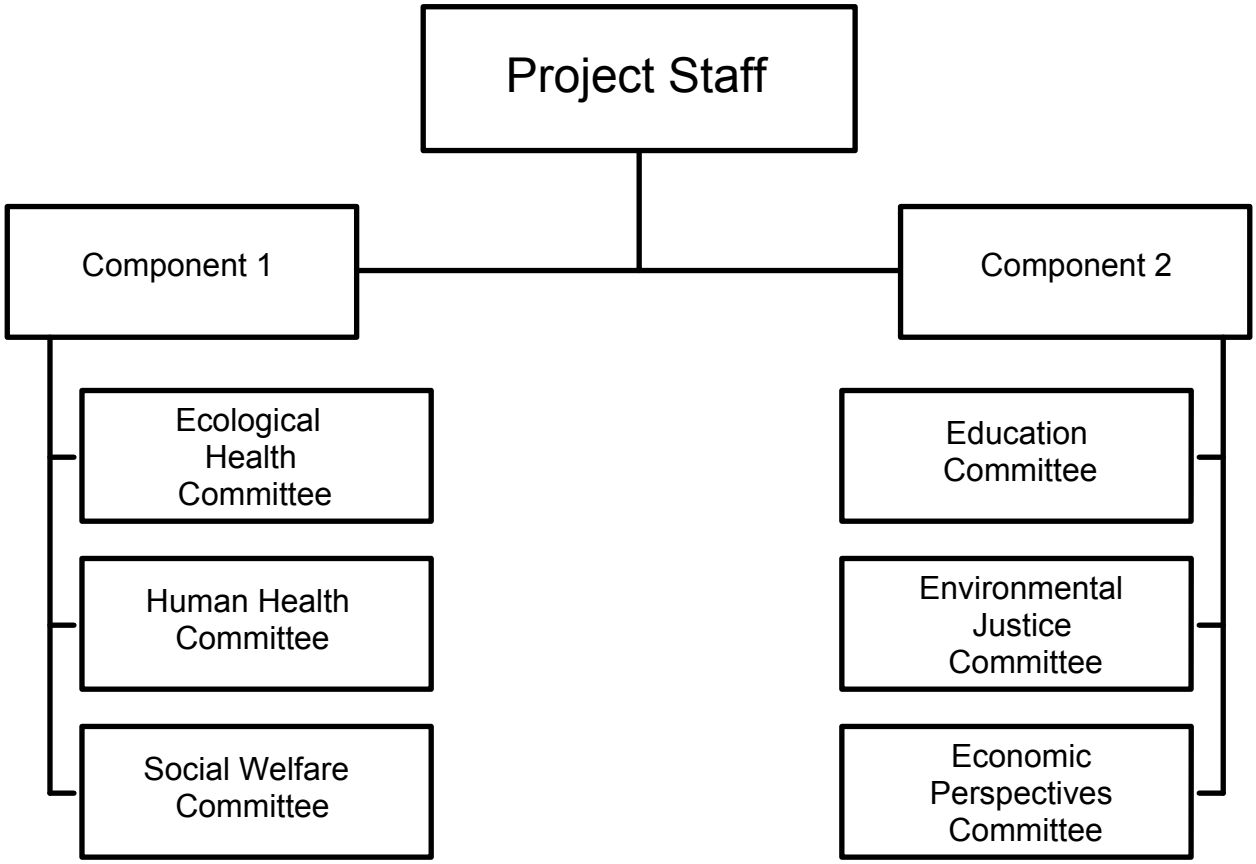

Figure 2.
Organization of the Technical Research Team.

Component 1 included the Human Health, Ecological Health, and Social Welfare committees. The Human Health Committee analyzed actual and estimated cases of human disease or injury caused by human-made environmental problems. The Ecological Health Committee analyzed actual and potential damages to California's natural ecosystems, such as loss of fish and plant life due to water pollution, loss of terrestrial wildlife habitats, and changes in physical landscape. The Social Welfare Committee examined the "quality of life" issues associated with environmental threats. Those issues include impacts on economic, community, aesthetic, and physical well-being, peace of mind, equity, and anxiety about the future.

Component 2 consisted of representatives from the five committees that were formed as part of the original workplan (Planning, Education, Environmental Justice, Legislative, and Economics committees). The Planning, Economics, and Legislative committees were disbanded until such a time that follow-up work to the CCRP is initiated.

Of the two remaining original committees in Component 2, the Education Committee developed a vision statement for environmental education, stating the current condition and what it should be in the future. Evaluation criteria were developed in order to provide a tool for assessing the quality of environmental and occupational health education in California.

The Environmental Justice Committee, as part of Component 2 activities, critiqued the comparative risk model and developed an alternative priority-setting model. The Environmental Justice Committee used case studies to illustrate how pollution prevention and environmental justice models could influence decision-making for setting environmental priorities.

One new committee was formed as part of Component 2. The Economic Perspectives Committee evaluated how taking economic factors into consideration when setting priorities influences the interpretation of a risk-based ranking and environmental decision-making in general. A case study approach was used to illustrate economic influences.

In addition to these six committees, a Case Study Review workgroup comprising representatives from the IMC, the TRT, and Project Staff was formed. This workgroup compiled and evaluated case studies provided by State agencies concerned with environmental protection and conservation issues that illustrate the role of risk and non-risk based factors used in making decisions about environmental protection.

Public Participation

The Education Committee was responsible for public outreach and participation in the CCRP. Some strategies used for this purpose, in addition to the SCAC, the public TRT meetings, and an extensive mailing list, included:

1) regional roundtable discussions to solicit the public's opinions on environmental priorities and the decision-making process,

2) a survey distributed to roundtable participants used concurrently with the results of the roundtable discussions, and

3) development of materials about comparative risk for use in outreach efforts.

Some of these tasks were performed by a consulting firm contracted by the CCRP, using supplemental U.S. Environmental Protection Agency funding.

PROJECT STRUCTURE

The final workplan was based on the following guidance from the California Secretary for Environmental Protection:

1) The California Environmental Protection Agency (Cal/EPA) seeks to obtain timely guidance on how the comparative risk model can help influence environmental priorities, and has asked for the results of a project that identifies and categorizes environmental threats according to their impact on ecological health, human health, and social welfare.

2) Management options can be developed either as a follow-up to the CCRP, or as part of other activities underway within Cal/EPA.

3) Region-specific priorities can be identified either as a follow-up to the CCRP, or as part of regional projects that may occur outside of Cal/EPA.

The California Comparative Risk Project contained three components:

Component 1.	Rank environmental threats.
Component 2.	Critique the risk-ranking model and evaluate other models.
Component 3.	Integrate the results of the Component 1 and Component 2 into recommendations to Cal/EPA.

Component 1:
Rank Environmental Threats

Task 1:	Created environmental topics area lists.
Task 2:	Identified methodology to rank environmental topic areas and discuss limitations of methods and data.
Task 3:	Quantified the impacts of threats or risks to the environment, human health, and social welfare, to the extent possible, using existing scientific data, criteria, and methods.
Task 4:	Ranked the environmental topics using comparative risk principles. To the extent possible, recommendations for incorporating methods or other approaches defined in Component 2 were considered in this task by some committees. A discussion of the assumptions and limits of the performed analysis were also part of this task.
Task 5:	Prepared committee reports documenting the process, methods, and results of Component 1.
Task 6:	Presented the risk-ranking results to the SCAC for use at the Project Review Workshop in January 1994.

As part of the Component 1 activities, the Ecological Health, Human Health, and Social Welfare committees collected and analyzed data to develop an initial ranking of environmental topic areas. The Statewide Community Advisory Committee was then asked to comment on these activities, and provide input in the integration of Components 1 and 2.

Component 2:
Critique the Risk-Ranking Model and Evaluate Other Models

A primary goal for Component 2 was to identify and characterize the factors, other than risk, that need to be considered in setting priorities and establishing policies associated with environmental threats. A critique and evaluation of several approaches for identifying and characterizing environmental protection priorities for California was then conducted using case studies. The broad areas that were defined as influencing priority-setting include risk, environmental justice, pollution prevention (e.g., source reduction), sustainable development[1] , economics, and public participation. Each Component 2 TRT committee generated questions, criteria, and recommendations based on their research and findings, which were used to help the SCAC identify environmental protection priorities at the SCAC Project Review Workshop. The Statewide Community Advisory Committee was also asked to comment on these criteria.

Task 1:	Identified models and decision-making factors that have been proposed for developing priorities to protect our environment.
Task 2:	Educated ourselves on the selected models, their origin, foundation, philosophy, and their contribution to environmental protection strategies. As part of this task, members of the IMC were asked to develop case studies that illustrate how risk and non-risk factors contribute to environmental decision-making in California.
Task 3:	Critiqued the risk-ranking model and other models identified in Task 1. Developed methodological approaches and principles based on the results of the analysis in Tasks 2 and 3 that aid in priority-setting, in assessing the adequacy of environmental and occupational health education, and for identifying environmental protection solutions.
Task 4:	Developed criteria and questions which can be used to help identify environmental protection priorities using the non-risk factors and models identified in Task 1.
Task 5:	Described the process and methods for arriving at Task 1 and Task 3. Prepared committee reports documenting the process, methods, and results of Component 2.
Task 6:	Presented the results of Component 2 activities to the SCAC for use at the Project Review Workshop in January 1994.

[1] Sustainable development was not addressed in the CCRP to the same extent as the other decision-making facto due to limitations in accessible information and expertise on this concept.

Component 3:
Integrate the Results of Components 1 and 2 Into Final Recommendations to Cal/EPA

In Component 3, the final CCRP report was prepared by each TRT committee and the Project Staff from the documentation developed in Components 1 and 2. The integration of Components 1 and 2 involved the development of a series of recommendations by the SCAC and the TRT committees. To facilitate this, a two-day SCAC Project Review Workshop was held in January 1994 to allow a free exchange of ideas about the results of the risk-based rankings, other environmental decision-making factors and processes, priorities for Cal/EPA's strategic planning, and recommendations for solutions. The workshop discussions led to a chapter in the CCRP summary report by the SCAC.

The final CCRP report includes the final reports from the TRT committees, the IMC case study review, and the SCAC. These documents were included in the final report without any substantiative changes to the text by Project Staff or Cal/EPA. Therefore, the recommendations made in these chapters represent the consensus of those committees, and not necessarily Cal/EPA's or the SCAC's. Public input from the regional roundtables was also factored into the final report.

The final summary report is a much shorter document, intended for the general reader who wants a non-technical summary of the CCRP process, results, and recommendations. The contents of this summary report were prepared by Project Staff by referring to the full technical chapters and soliciting comments from the TRT Chairs. The summary report was not reviewed by the SCAC and does not necessarily represent the consensus of Cal/EPA or the SCAC.

PRODUCTS AND MAJOR MILESTONES

The California Comparative Risk Project resulted in several products:

1) Environmental topic area lists that were used as a basis for identifying or portraying risk-based priorities.

2) A quantification, to the extent possible, of the impact of various environmental topic areas on ecological systems, human health, and social welfare, based on existing scientific data, using consistent methodologies and evaluation criteria within each committee.

3) Rankings according to risk of environmental threats to ecological systems, human health, and social welfare.

4) A critique of the risk-ranking model and an exploration of other models, including criteria that should be used to make environmental decisions and that might influence a risk-based ranking of environmental threats.

5) Statewide Community Advisory Committee recommendations on environmental priorities and decision-making, on process issues, and on possible solutions for incorporation into Cal/EPA's strategic planning.

6) A vision statement for environmental and occupational health education stating what it is now and what it should be in the future. Included in the discussion paper are criteria for evaluating the quality of environmental and occupational health education in California.

7) A summary of the diverse opinions about California's environmental priorities and the comparative risk model from the results of three regional public roundtables.

8) Recommendations on environmental priorities and follow-up activities from each TRT committee.

9) Observations from the review and analysis of nine case studies prepared by IMC representatives on how environmental decision-making factors have influenced State programs.

10) A final report documenting the process, methods, and results of the CCRP.

The Major CCRP Milestones

Event	**Date**
Project Initiated	February 1992
IMC Kickoff Meeting	March 31, 1992
Social Welfare Committee Kickoff Meeting	November 10, 1992
Ecological Health Committee Kickoff Meeting	November 19, 1992
Education Committee Kickoff Meeting	December 2, 1992
Environmental Justice Committee Kickoff Meeting	December 16, 1992
SCAC Kickoff Meeting in San Francisco	January 7, 1993
Human Health Committee Kickoff Meeting	February 18, 1993
Revised Workplan Released	March 11, 1993
IMC Case Study Presentations	August 10, 1993
Economic Perspectives Committee Kickoff Meeting	August 13, 1993
Regional Public Roundtable (Los Angeles)	October 30, 1993
Regional Public Roundtable (Hayward)	November 20, 1993
Regional Public Roundtable (Fresno)	December 4, 1993
SCAC Project Review Workshop	January 12 & 13, 1994
Final Report to Printer	May 10, 1994

Report of the Human Health Committee

Ranking Risks to Human Health

INTRODUCTION: RISK ASSESSMENT METHODS

Concern about the potential effects of toxic chemicals and agents on human health is a predominant motivation for social efforts to improve environmental quality. As a consequence, methods have been developed to quantify several types of human health risks, while many other impacts on environmental health can only be characterized qualitatively. This introduction explains the approach and methods used by the Human Health Committee (HHC) to evaluate and rank the human health impacts of different environmental topic areas. While comparative risk assessment attempts to base its conclusions on the best available scientific data and standard risk assessment methods, ranking results are never determined by quantitative analyses alone. The California Comparative Risk Project (CCRP) results reflect the expertise and values of the scientists participating in the HHC (see Attachment A for membership list). Selecting the data used, adopting risk assessment methods, and evaluating the risks of an entire topic area all involve substantial amounts of scientific judgment (NRC, 1994). Figure 1 (Attachment B) illustrates the major steps in the HHC's effort to rank human health risks.

The determination of whether or not a substance poses health risk to humans is based on clinical, epidemiological, or animal studies that demonstrate exposure to a substance is associated with the incidence of adverse effects. In the context of human health, "risk" is the probability that adverse health effects may occur. Adverse effects range widely in type and severity - from lethal effects to subtle biochemical effects. Exposure to environmental stressors like chemicals, pathogenic organisms, or radiation can cause cancer or various noncarcinogenic effects (ranging from very serious effects, including death, reproductive hazards, and brain damage, to physiologic changes, like reduced lung function). Health risks can be assessed for both individuals (i.e., one person's added risk of getting cancer) and entire populations (i.e., the number of exposed people in California expected to experience adverse effects). Several methods have been developed for describing these effects, including estimating numbers of expected cases or indicating whether current exposure levels exceed regulatory standards.

The Human Health Committee used three general approaches to evaluate human health risks:

1) When available, the HHC used incidence data - or data on the actual occurrence of a disease related to a specific environmental stressor. For example, data on the mortality associated with carbon monoxide poisoning in California formed the basis of the HHC's estimate of annual deaths due to this criteria air pollutant.

2) The Human Health Committee sometimes extrapolated from existing risk assessments to estimate the health impact of an environmental stressor in California. The U.S. Environmental Protection Agency's (U.S. EPA) analysis of health risks associated with environmental tobacco smoke, for example, was combined with California exposure data to characterize risks in California.

3) The Human Health Committee generally used quantitative risk assessment methods to evaluate topic areas. These methods estimate risks by combining information about exposures to toxic substances with data from animal or human studies on the relationship between different exposure levels and adverse impacts.

No matter how the health risks of a given environmental topic area are characterized, comparative risk projects always involve an additional level of risk analysis. Only a fraction of the potential health impact of a topic area can usually be analyzed with available data, so it is necessary to make judgments from limited risk assessment results about the health significance of entire topic areas. For example, the HHC developed risk estimates for only 20 pollutants out of hundreds of substances that are released into the air by different sources, assessing only a few of their potential adverse impacts on health. To provide a final evaluation of the human health risks posed by a topic area such as mobile sources, the HHC examined its analytical results on a limited set of indicator chemicals and used expert judgment to reach a final ranking.

The Human Health Committee's analysis was organized into four phases, following the risk assessment model used by most regulatory agencies:

During the hazard identification phase, the HHC evaluated available evidence to determine which substances are involved with an environmental topic area and what types of adverse human health effects they cause. In most cases, "indicator" chemicals (or agents) were selected to represent the major potential risks involved with a topic area (e.g., criteria air pollutants like ozone and carbon monoxide are indicator chemicals of the noncarcinogenic hazards posed by various sources of air pollution).

In the dose-response assessment phase, the relationship between different doses of a toxic substance and expected adverse effects was characterized. Typically, as the dose of a toxicant increases, adverse effects become more probable or more severe.

During the exposure assessment phase, the HHC estimated the magnitude, duration, and frequency of human exposure to selected pollutants and the number of people exposed via different pathways. For each indicator chemical, this resulted in an estimate of the range of doses to which people are currently exposed.

Finally, in the risk characterization phase, the HHC combined the information obtained from the hazard identification, dose-response assessment, and exposure assessment to estimate the risks associated with each topic area and to present information on uncertainties in the analysis.

THE FOUR STEPS OF HUMAN HEALTH RISK ASSESSMENT:

- Hazard identification asks "Which substances pose hazards to human health?"
- Dose-response assessment asks "What degree of adverse effects are associated with different levels of exposure to these substances?"
- Exposure assessment asks "How many people are exposed to the hazardous substance and what range of doses do they receive?"
- Risk characterization describes what adverse human health impacts we would expect based on current exposures and our confidence in the overall analysis.

THE FINAL STEP IN COMPARATIVE RISK ASSESSMENT:

- Risk-ranking asks "Just how bad is this problem relative to other topic areas?"

Hazard Identification

During this initial screening step, the HHC identified the key issues for a particular topic area. Possible sources of pollutants and exposure pathways were identified and those that are most relevant to estimating health risks were selected for further analysis. These steps are interrelated, but can be roughly broken out as follows:

Identification of indicator chemicals or sites

Many topic areas involve a large number of environmental stressors or a variety of pollution sources. Because of limitations on data availability and resources, analytical efforts must generally be focused on a limited number of chemicals that provide the best indication of potential risks. These "indicator chemicals" are selected to be representative of the major types of stressors associated with a given topic area. Criteria used to choose indicator chemicals include: potential for human exposure, inherent toxicity, availability of data, and whether a substance is typical of the range of adverse health effects and class of pollutants or sources associated with a topic area. This selection process focuses attention on the higher risk and better studied stressors associated with a topic area; it does not produce a "representative" sample of the complete range of stressors (both low and high-risk) associated with a topic area.

For some topic areas, particularly those involving hazardous material releases to land, it was not possible to select indicator chemicals. Land disposal sites vary tremendously in the chemicals they contain and in potential human exposure pathways. For these topic areas the HHC based its analysis on a selection of "indicator sites." Chosen from the universe of problem hazardous waste sites known to California regulators, sites were selected to provide examples of different types of land disposal activities (e.g., hazardous waste landfills or wood treatment plants.)

Identification of relevant exposure pathways

Exposure to environmental pollutants can occur via ingestion, inhalation, and dermal absorption. The Human Health Committee analyses typically focus on exposures from ingestion of contaminated drinking water or food or from inhalation of contaminated air. In some topic areas, ingestion of contaminated soil and house dust and dermal absorption from contact with contaminated media can be important exposure pathways. The Human Health Committee attempted to identify the most important pathways contributing to the population's total exposure to different toxicants.

Identification of health endpoints

Toxic chemicals and agents can have different adverse impacts on human health, varying in severity and organ system affected (e.g., a substance could be a moderate respiratory irritant at low doses and a serious reproductive hazard at higher doses). This aspect of hazard identification selects which adverse impacts on human health will be examined in the analysis and sorts substances into two broad categories: carcinogens and noncarcinogens.

Identification of the human health hazards posed by different toxic chemicals is a complex process involving evaluations of both human and animal data. While the strongest evidence of potential hazard derives from well-conducted clinical or epidemiological studies that link specific chemical exposures to adverse impacts in human populations, this type of information is unavailable for many substances of concern. It is generally difficult to identify human populations that have been exposed to specific toxicants at known doses and to characterize the health impacts of these exposures. In the absence of human data, scientists and regulators rely on toxicological data from animal experiments to identify

potential hazards. The necessity of extrapolating across species (from animals to humans) introduces significant uncertainties into the process of risk assessment.

The Human Health Committee has generally adopted hazard identifications made by regulatory agencies (such as U.S. EPA) or authoritative international scientific organizations (such as the International Agency for Research on Cancer). At present, only carcinogens are routinely identified by such organizations. Identification of potential human carcinogens was generally based on the weight-of-evidence approach used by U.S. EPA.[8] Noncarcinogens have not generally been authoritatively classified by their health endpoint (e.g., there are no lists of neurotoxicants or respiratory toxicants). Under Proposition 65, the State of California has established a process to identify substances that are reproductive or developmental toxicants. The Human Health Committee has based its identification of noncancer endpoints on the critical effects evident in human or animal studies that serve as the basis for regulatory standards or acceptable exposure guidelines.

Dose-Response Assessment

Understanding what dose of a toxic substance is needed to cause different toxic responses is essential for assessing health risks. "Dose-response relationships" define the potency of toxic substances, indicating how the degree of adverse effects changes with increasing dose. Regulatory agencies typically make two general assumptions about dose-response relationships for toxic substances:

→ For carcinogens, which may initiate the carcinogenic process by altering genetic material, it is generally assumed that effects can occur at very low doses and that there is no threshold for these adverse effects.

→ For most noncarcinogens, it is generally assumed that threshold levels exist, below which no adverse health effects will occur.

Because of this fundamental difference in the assumed dose-response relationships for carcinogens and noncarcinogens, the two are discussed separately below.

Carcinogens

Although the mechanisms of carcinogenesis are not well understood for most chemicals, available scientific evidence suggests that there is some probability of an adverse effect at any dose and that the probability of effect increases with increasing dose (U.S. EPA, 1986; CDHS, 1985). Because the probability is very low at low doses, it cannot be measured directly by either animal or epidemiological studies. Therefore, mathematical models have been developed to extrapolate from high to low doses. Extrapolation procedures typically used by regulatory agencies assume linearity at low doses and define an "upper bound" on risk (i.e., the risk is unlikely to be higher and could be lower). The United States

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[8] Based on human and animal evidence, supporting toxicological data, and the quality of evidence, U.S. EPA (1986) classifies substances into one of five major groups:
Group A: Known human carcinogen - sufficient human evidence.
Group B: Probable human carcinogen.
Group B1 indicates sufficient animal evidence and limited human evidence.
Group B2 indicates sufficient animal evidence and inadequate or no human evidence.
Group C: Possible human carcinogen - limited animal evidence and inadequate or no human evidence.
Group D: Not classifiable as to human carcinogenicity - inadequate human or animal evidence.
Group E: Evidence of non-carcinogenicity.
A similar classification system is used by the International Agency for Research on Cancer.

Environmental Protection Agency and the California Environmental Protection Agency (Cal/EPA) typically use a model called the linearized multi-stage model to estimate the relationship between the dose of a substance and the degree of carcinogenic response.

The Human Health Committee has adopted the conventional risk assessment assumptions and methods used by agencies to estimate cancer risks. These assumptions are detailed in Attachment C and are currently the subject of extensive review and debate. Some scientists argue that risk estimates substantially overstate actual human health risks because they are generated using multiple, worst-case assumptions (Nichols and Zeckhauser, 1988). Others maintain that conventional risk assessment practices ignore a number of important factors and are therefore unlikely to produce substantial overestimates of risk (Finkel, 1989). The Human Health Committee decided that consistent application of standard assumptions and methods would provide the best basis for comparing risks across topic areas, with the important caveat that resulting risk estimates should not be interpreted as predictions of actual disease incidence.

Based on modeled dose-response functions, regulatory agencies have developed "cancer potency factors" (CPFs) for many potential human carcinogens. [9] The Human Health Committee has used these potency estimates to assess the risks associated with exposures to carcinogens. Cancer potency factors express potency in terms of the risk per unit dose, assuming lifetime exposure. Cancer potency factors are sometimes referred to as "slope factors," as they are an upper bound estimate of the slope of the dose-response curve at low doses. To estimate risk using CPFs, the CPF is multiplied by the estimated dose.

Noncarcinogens

Noncarcinogenic toxic effects vary with the magnitude, frequency, and duration of exposure. Regulatory agencies generally assume that toxicological "thresholds" exist for biological effects other than cancer, meaning that there is some dose below which no adverse effect will occur. The probability and severity of an adverse effect occurring increases as the dose increases above the threshold level (U.S. EPA, 1990).

For some noncarcinogenic substances (e.g., criteria air pollutants like ozone), clinical or epidemiological data are available for characterizing dose-response relationships above the threshold. Dose-response functions relating health impacts to ambient levels of air pollution can be derived and used to estimate adverse impacts in different exposed populations. For example, the HHC used this approach to estimate the incidence of premature mortality among those who are exposed to ozone and particulate matter. Since this approach involves a number of uncertainties (in selecting the epidemiological studies used to generate dose-response functions and in applying these functions to different populations and exposure contexts), the HHC has also evaluated criteria air pollutant risks using the generic noncancer methods described below.

For most substances, dose-response relationships for noncancer effects are not well characterized. To describe potential health hazards in these cases, the HHC has relied on the comparison of estimated exposure levels to "acceptable" exposure levels derived by regulatory agencies. The "reference dose" (RfD) is typically the basis for these comparisons.[10] The reference dose is defined as "an estimate (with

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[9] The Human Health Committee obtained CPFs from the following sources, in order of priority: *Criteria for Carcinogens* (Cal/EPA, 1993); *Expedited Potencies for Proposition 65* (Cal/EPA, 1992); *Air Toxics "Hot Spots" Program Risk Assessment Guidelines* (CAPCOA, 1993); Integrated Risk Information System (U.S. EPA, 1993); *Health Effects Assessment Summary Tables* (U.S. EPA, 1992); *Health Assessment Guidance Manual* (ATSDR, 1990).

[10] Reference doeses have been obtained from the following sources, listed in order of priority: *health Effects Assessment Summary Tables* (U.S. EPA, 1992); *Office of Pesticide Program--Reference Dose Tracking Report* (U.S. EPA, 1993); *Health Assessment Guidance Manual* (ATSDR, 1990).

uncertainty spanning perhaps an order of magnitude) of daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (Barnes and Dourson, 1988).

A reference dose is developed by U.S. EPA by dividing a no-observed-adverse-effect level (NOAEL) [11] by uncertainty or "safety" factors. The factors are based on the type and quality of available data and account for various uncertainties, such as the need to extrapolate from animals to humans. [12] Reference doses are expressed in milligrams of substance per kilogram of body weight per day. Reference concentrations, or RfCs, are expressed in milligrams of a substance per cubic meter of air.

Some "acceptable" exposure levels used by the HHC to characterize noncancer risks were not developed using the NOAEL/uncertainty factor approach, but have instead been derived from existing regulatory standards or guidelines. California ambient air quality standards, for example, are used instead of RfDs to characterize the risks associated with exposures to criteria air pollutants. "Acceptable exposure levels" developed by Cal/EPA for the air toxics "hot spots" program are also used in some evaluations. These standards and exposure levels were used when RfDs were unavailable for specific substances but a toxicological guideline was needed to characterize risks. Caution must be exercised when comparing different noncancer risk characterizations because the quality of the data used in their derivation varies substantially and understanding about the residual risks when RfDs and standards are exceeded is limited.

Reference doses and regulatory standards generally represent conservative estimates of threshold levels and are typically compared with human exposures to indicate the likelihood of health impacts. As exposures exceed the RfD or applicable standard, the probability of adverse effects increases. The greater the exceedance, the more likely a potential human health hazard exists. However, it is important to emphasize that RfDs and noncancer regulatory standards (unlike cancer potency factors) cannot be used to estimate the probability of adverse effects at different doses. Because the dose-response relationship above a threshold level is different for different substances and because RfDs and standards incorporate different uncertainty factors, there is not a simple relationship between RfD exceedances and potential health risks.

Exposure Assessment

During the exposure assessment phase, the HHC evaluated the extent of exposure, the number of people exposed, and the intake of the substances to which people are exposed. These assessments made use of data from monitoring programs that describe pollutant levels in various environmental media (such as air or water), biota (such as edible fish), or data from exposure modeling.

When estimating the exposure to both carcinogens and noncarcinogens, the HHC took several steps which are outlined in the following text.

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[11] The NOAEL is the highest dose at which no adverse effect has been observed in toxicological experiments.

[12] Conventional uncertainty factors include a factor of 10 for extrapolations between humans and animals and a factor of 10 to account for variations in human susceptibility. If a NOAEL is not available for a particular substance, other measures such as the lowest-observed-adverse-effect level (LOAEL) are used and an extra uncertainty factor of 10 is applied. Modifying factors between 1 and 10 can also be used to account for variations in data quality, routes of exposure, and other areas of uncertainty (Barnes and Dourson, 1988). 1

Identifying significant exposure pathways

Most topic areas involve more than one exposure pathway. To confine the scope of analysis, exposure assessments generally focus on the exposure pathways posing the dominant risks. For some topic areas, this may be straightforward. The primary exposure route for indoor air pollutants, for example, is inhalation. For other topic areas, such as hazardous waste sites, it may not be possible to limit the analysis to one pathway, for exposure often can occur via drinking water, air, and direct contact as well. Where secondary pathways are significant contributors to total exposure, the HHC has tried to include these exposure routes.

A complicating factor in the identification of relevant exposure pathways is that the toxicity of some substances may vary for different exposure routes. For example, some nickel compounds are known to be carcinogenic if inhaled, but they have not been shown to be carcinogenic if ingested (NTP, 1989). In identifying relevant exposure pathways, it is important to consider the toxicities of target pollutants via the different exposure routes under consideration. In the absence of relevant data on the toxicity, metabolism, or absorption from different exposure routes, the HHC generally assumed that adverse effects known to occur with one exposure route are likely to occur with other routes as well.

Identifying sources and the location, timing, and quantity of pollutants released

For some environmental topic areas, the HHC was able to rely on inventories that are compiled by state and federal regulatory agencies to identify different sources of pollutant releases (such as landfills, manufacturing facilities, etc.).[13] For other topic areas, however, the sources are not well characterized or are too diffuse to be identified in inventories (such as the sources of organochlorine contamination in edible aquatic organisms).

A variety of factors, including the location and timing of pollutant releases as well as human activity patterns, influence whether significant human exposures to toxicants can occur. Past comparative risk projects have relied extensively on models to estimate exposures in a variety of situations. While models are useful for generating exposure estimates when data on actual pollutant concentrations in different media are unavailable, the HHC has emphasized the use of monitoring data in its risk assessments. The State of California possesses one of the most extensive exposure monitoring systems in the world (particularly in the areas of indoor and outdoor air pollution). Data about the distribution of toxicants in different media and regions of the State can be used to characterize the *total* human exposure accumulated from multiple pathways. This approach has enhanced the HHC's effort to characterize both average and high-end exposures in California and to identify highly impacted subpopulations, who frequently are ignored in analyses focusing on overall exposures. The total exposure method also has helped the HHC identify the principal sources and exposure scenarios contributing to health risks.

Estimating the number of people exposed to various concentrations via different pathways

A population's exposure to environmental stressors depends on the number and duration of activities involving contact with contaminated media. Using the exposure pathways defined for the analysis, this step identifies the numbers and types of people exposed and the range of exposures for each pathway. When exposure to an environmental stressor is virtually universal in California, risk estimates are based on an exposed population of 30 million. The Human Health Committee used census data to identify the size and composition of smaller exposed populations, such as the number of people over age 65 living in the Los Angeles air basin (Bureau of the Census, 1991).

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[13] The Human Health Committee relied on inventories presented in reports from State agencies (Cal/EPA, 1992) as well as electronic data bases, which are listed after the Reference Section of this report.

Calculating the total dose of indicator chemicals taken in by exposed populations

Exposure concentrations, or the level of pollutant in different environmental media (typically expressed in milligrams of pollutant per liter of drinking water, kilogram of soil or food, or cubic meter of air) must be converted into doses, or the amount of pollutant actually taken in by exposed humans (typically expressed in milligrams of pollutant per kilogram of body weight per day). This conversion requires making assumptions about different intake rates (e.g., how much air we breathe in a day) and body weights (which will obviously vary for children or adults, and males or females) and about the bioavailability of different toxicants. The following equation is used generally to calculate dose:

$$\text{Dose} = \frac{\text{Concentration x Intake}}{\text{Body Weight}}$$

Regulatory agencies typically employ a standard set of intake assumptions (U.S. EPA, 1989). For example, the average adult is assumed to ingest two liters of water per day and to inhale twenty cubic meters of air.

There is a great deal of variability in the doses of indicator chemicals different people receive in a population. Some groups in the population are exposed to greater contaminant concentrations than others, while intake rates vary across other groups. Factors such as age, gender, and activity patterns (where people spend time and what they do there) all affect exposures and dose. Most people spend much more time indoors than outdoors, for example. For some topic area analyses, the HHC relied on single-value default intake assumptions because of the lack of data. In other areas, however, the HHC was able to use distributional data to capture the variation in dose due to variations in pollutant concentration, inhalation and ingestion rates, activity patterns, and other factors. When available, the HHC used California-specific information about these parameters (such as the amount of time citizens spend indoors and outdoors or the amount of sport fish they consume). This has helped the HHC construct exposure scenarios more representative of the situations of various subpopulations in the State.

Some people also may be more sensitive to particular contaminants than others and may experience health effects at concentrations lower than those causing responses in the general public. In an effort to address potential impacts on susceptible populations, the HHC identified subgroups known to be at heightened risk due to specific toxic substances and collected exposure information on these groups whenever possible (e.g., on the number of asthmatic children exposed to criteria air pollutants). Data on population susceptibility were unavailable for most topic areas.

Risk Characterization

Risk characterization is the essential link between risk assessment and risk-ranking. This phase involves first integrating the information obtained from the hazard identification, dose-response, and exposure assessment phases and then presenting information on multiple contaminants and exposure pathways in a way that allows project participants to evaluate the relative risks posed by various topic areas. Risk characterization synthesizes the results of the risk assessment and provides the framework for communicating the results to those ranking topic areas and setting priorities based on their ranking.

Cancer risk estimates

For most topic areas, potential carcinogenic effects are characterized by presenting estimates of an individual's added lifetime cancer risks and estimates of population incidence, or the number of extra cancer cases expected in exposed populations. Cancer risk estimates are generated using a variety of assumptions that are described in Attachment C. Since these assumptions are frequently conservative,

cancer risk estimates should generally be interpreted as "upper bound" estimates (i.e., risks are unlikely to be higher, but could be substantially lower). Estimates should not be interpreted as predictions of actual disease incidence but as a general indicator of the relative magnitude of potential impacts.

Individual cancer risk

An individual's excess lifetime cancer risk due to an environmental exposure is estimated based on information provided by the dose-response and exposure assessment phases. It is typically calculated by multiplying the carcinogenic potency of the substance in question by the lifetime average daily dose to the exposed individual:

$$\text{Individual Excess Lifetime Cancer Risk} = \text{Cancer Potency} \times \text{Dose}$$

Risk estimates can be calculated for individuals in various subpopulations, based on the distribution of exposures. When such data were available, the HHC presented estimates of cancer risks for individuals exposed at average concentration levels. In addition, risk estimates for individuals receiving the highest exposures are provided. The Human Health Committee has also attempted to quantify the number of Californians at different risk levels (e.g., the number experiencing added cancer risks which are greater than one in ten thousand). When data on the distribution of exposures were unavailable, conventional default assumptions are used to characterize risks to exposed individuals. These assumptions are listed by media in Attachment C.

Population cancer burden

The estimated incidence of cancer cases in the population, sometimes referred to as the theoretical cancer burden, is also determined based on information provided by the dose-response assessment and the exposure assessment. It can be calculated by multiplying the individual cancer risk by the number of people exposed:

$$\text{Cancer Cases} = \text{Average Cancer Risk} \times \text{Exposed Population}$$

This calculation can be made for individual subpopulations at different risk levels and then summed to estimate the number of cancer cases predicted for the total population. Theoretical cancer burdens for the State are calculated assuming that Californians continue to be exposed to toxicants at current levels for a lifetime. To facilitate comparisons across topic areas, HHC summary tables generally provide annualized estimates of the number of additional cancer in exposed populations. These are obtained by dividing the total estimated cancer burden by 70 (the number of years a person is assumed to live).

Noncancer risk estimates

Comparative risk analyses typically characterize noncancer risks using three factors: the severity of the health effects, the ratio of estimated doses to some measure of acceptable or "safe" dose, and the number of people potentially exposed. Information on these three factors is generated in the first three phases of the risk assessment process: hazard identification, dose-response evaluation, and exposure assessment. The risk characterization phase involves summarizing and integrating this information into an evaluation of the potential adverse health effects associated with specific topic areas.

Severity of health effects

The hazard assessment phase of the human health risk analysis identifies the pollutants of concern for each topic area and the likely health effects associated with exposure to those substances. In many cases, one substance may cause more than one health effect. For example, lead can cause subtle neurological impacts at low doses, cardiovascular impacts at higher doses, and infertility at even higher doses. Rather than consider multiple endpoints for each pollutant, analyses typically focus on the endpoint that drives regulatory concern. In the case of noncarcinogens, this is usually the adverse effect

that occurs at the lowest dose and is the critical endpoint on which the RfD or other measure of acceptable exposure is based.

Characterizing the severity of the health effects is often controversial. Although numerical severity scales have been developed (U.S. EPA, 1993), they are highly subjective and have not been adopted for use by the HHC. Instead, severity was taken into account qualitatively when the HHC ranked different topic areas. Important factors considered in evaluating severity include the nature of the illness in terms of impact on quality of life, reversibility, functional impairment, etc. In each case involving noncancer risks, the HHC identified the principal adverse health effects.

Ratio of exposure to acceptable dose

Information developed in the dose-response and exposure assessment phases of the risk analysis is used to characterize the potential hazard posed by exposure to different concentrations of toxicants. For many noncarcinogens, the HHC provides a "hazard index" (HI) by calculating the ratio of pollutant dose to an acceptable dose, usually a regulatorily defined RfD:

$$HI = \text{Dose from Exposure}/\text{Reference Dose}$$

The hazard index indicates the degree to which the dose of a hazardous substance exceeds acceptable levels, but it provides only a rough indication of the potential for adverse effects in exposed populations. The higher the index, the greater the dose is relative to the RfD and the greater the cause for concern that the exposed population could experience adverse health effects.

Caution must be exercised when using HIs to compare the noncancer risks associated with different chemicals. Such comparisons implicitly assume that the dose-response function for all substances is the same, but this clearly is not the case. Moreover, RfDs and acceptable exposure guidelines like air quality standards are derived from health effects of varying severity and incorporate different uncertainty factors. If exposures exceed the RfD for different substances by the same magnitude, it does not mean that similar risks of adverse effects are involved. One substance with an HI of 2 could have a high probability of a severe adverse effect at existing exposure levels, while another with the same HI could pose negligible health risks.

Size of exposed population

Analysis of Statewide monitoring results provides information on the distribution of pollutant exposures and the types and sizes of exposed populations. In general, existing monitoring systems are not designed to provide data for assessing acute noncancer health risks. Except for a small number of criteria air pollutants, these systems focus on characterizing average, long-term exposures rather than on identifying peak exposures that are more relevant to many acute noncancer endpoints. Where available, the HHC has attempted to use sources of short-term exposure data (e.g., facility-specific data produced by the air toxics "hot spots" program) to identify peak concentrations and the size of exposed populations. In a few cases, data were available to describe not only the number of people exposed above acceptable levels but also the expected incidence of noncancer adverse effects in exposed populations. The risk assessment results for criteria air pollutants, for example, indicate both the number of people exposed above regulatory standards and the number of estimated cases of different types of respiratory illness that exposed populations could experience.

Uncertainties

Both cancer and noncancer risk characterizations are accompanied by an evaluation of the level of confidence the HHC had in the results. Levels of confidence vary because risk assessment methods rely on different assumptions and the quality of available information differs substantially across topic areas. Data on exposure concentration, duration and timing of exposure, intake and bioavailability factors, nature and size of the population affected, and ultimately the doses to exposed populations were not

consistently available for all selected indicator chemicals. Similarly, the quality of dose-response data for both carcinogens and noncarcinogens varies widely. In many instances, the information available to assess these factors are very limited and time and resource constraints may not allow for the extensive analysis required to accurately evaluate them. The critical assumptions used by the HHC to construct exposure profiles and intake estimates and to estimate risks at low doses are presented in Attachment C. The Caveats and Uncertainty Section discusses the important caveats that the HHC has placed on its analytical results.

In all cases, risk assessments produce numerical results that present the appearance of accuracy, but it is inappropriate to treat results as actual predictions of health risks. Due to methodological limitations, results should generally be interpreted as order of magnitude indications of potential health impacts.

HUMAN HEALTH RANKING RESULTS

Ranking Criteria: Defining High, Medium, and Low

The Human Health Committee agreed that it was not possible to define absolute, quantitative health risk measures that clearly delineate high, medium, and low-risk topic areas, so explicit numerical thresholds (e.g., greater than 1,000 estimated deaths per year or individual cancer risks greater than one in one hundred) were not used to define different risk categories. Health impacts were evaluated primarily on the basis of two factors: the severity of the adverse health effect and the size of the population exposed. The highest risk impacts could involve either significant adverse impacts on human health for a large proportion of the population, or serious adverse impacts on smaller populations. The Human Health Committee's approach assumed that there is a spectrum of severity, ranging from effects with relatively little impact on health status (such as skin irritation), through significant effects (such as increased risks of cancer or reproductive toxicity) to serious effects (such as premature mortality).

The Human Health Committee used the following relative guidelines to define its high, medium, and low-risk categories:

High (H): Topic area has a substantial health impact on the California population. Substantial impacts are either observable in epidemiological data or estimable with a good degree of confidence using risk assessment methods. The concept of substantial impact incorporates consideration of both the severity of expected adverse human health effects and the size of the population expected to experience these effects. Effects are considered severe if there is a high probability of adverse outcome and a serious impact on human health. For both cancer and noncancer endpoints, severity judgments are influenced by the degree of structural or functional impairment, the condition's reversibility, and its impact on quality of life. The Human Health Committee did not define any relative equivalency between cancer and noncancer impacts; these adverse impacts are weighed separately in topic area evaluations.

Medium (M): Topic area does not have as substantial a health impact on the California population as those in the high-risk category, but the impact is significant relative to comparison topic areas. Average population risks are lower than the highest risk category, or fewer/smaller subpopulations experience relatively high individual risks.

Low (L): Topic area has a detectable or estimable potential health impact on the California population that is less significant relative to comparison topic areas, but not negligible.

Insufficient Evidence to Categorize (IN): Topic area lacks sufficient toxicological or exposure data to reach a scientifically supportable evaluation of its impact on human health. Information indicating why these topic areas might pose reasons for concern about potential impacts on public health is provided. Some topic areas placed in this category were judged by the HHC to be high priorities for further research.

Not a Problem (NP): Topic area was judged not to present risks to human health.

Not Ranked (NR): Topic area was not ranked because it was covered under other topic areas.

Ranking Process

Rankings are based on the results of the risk characterizations produced by the HHC, which combine both qualitative hazard identification and quantitative risk assessment information. The Human Health Committee used a two-phase, bottom-up approach to ranking topic areas. In the first phase, quantitative estimates of a topic area's impact on human health were examined, such as expected cancer incidence or number of individuals exposed above acceptable levels. The Human Health Committee began its ranking process by asking whether the evidence justifies placing it in a low-risk category. If not, the topic area was located in or between the medium or high-risk categories on the basis of the severity and extent of estimated health impacts. Phase one ranking resulted in a preliminary ranking of the topic area on the risk spectrum.

In the second phase, the HHC focused on the relative importance of a topic area's impact compared to other topic area impacts. Preliminary ranks were readjusted on the basis of these risk comparisons, and the HHC attempted to sort topic areas into a fairly even distribution among the high, medium, and low-risk categories. Final ranks should not be interpreted as the consensus opinion of all participants in the HHC, but as the results of a process of debate in which opinions sometimes ranged from high to low on a given issue and reflected substantial disagreements about assessment methods or results. Contested ranking evaluations were resolved by majority vote.

Ranking Results

Table 1 (Attachment B) provides an overview of the ranking results, indicating the overall rank assigned to each topic area and identifying specific populations that could experience high human health risks within a topic area. More detailed information about the human health rankings for each environmental topic area are displayed in Table 2 (Attachment B). The detailed ranking templates include descriptions of the cancer and noncancer concerns identified by the HHC for each topic area, a comment field explaining the basic rationale underlying assigned ranks, and a summary indication of the HHC's level of confidence in its analysis. For each ranked topic area, the HHC developed a summary sheet, outlining cancer and noncancer quantitative risk assessment results, describing the overall strength of evidence supporting the evaluation, and flagging significant environmental equity or susceptible population impacts. These summary sheets are included in the Human Health Committee Appendix of this CCRP report.

Use of the ranking results

The general topic area ranks can be used to guide agencies in setting environmental priorities. Since most topic areas (including many ranked as low human health risks overall) can pose high risks to smaller populations, the HHC recommends that the priority-setting process consider whether environmental health risks are equitably distributed. Moreover, the priority-setting process should recognize that the identification of highly impacted populations may offer cost-effective opportunities for preventing environmental health impacts.

Both Table 1 and Table 2 include important caveats about the use and interpretation of the HHC's results. Rankings are based on available data about current risks, with existing regulatory controls in place. Rankings of some topic areas would be substantially different if regulatory controls were removed. The risk estimates presented have widely varying degrees of uncertainty and are often provided only for several indicator chemicals associated with a topic area. Estimates should not be interpreted as actual predictions of disease incidence or as indicating the total human health impact of different topic areas. These limitations are discussed in more detail in the sections on limitations and caveats below.

Principal findings

Three general conclusions about environmental health risks can be drawn from reviewing the HHC ranking results:

> *From the perspective of environmental stressors, the HHC found that exposures to toxic chemicals and agents have a significant impact on human health.*

Among noncarcinogens, the largest proportion of estimated premature mortality is associated with exposure to particulate matter. The largest contributors to respiratory morbidity are ozone, particulate matter, and environmental tobacco smoke. Carbon monoxide and environmental tobacco smoke aggravate the health status of individuals with cardiovascular conditions. Neurotoxicity is also a concern, because several tens of thousands of California children have elevated blood lead levels that are neurotoxic and may contribute to learning difficulties and declines in IQ. Many of the HHC's final topic area rankings were driven by the extent and severity of noncancer impacts. The relative importance of noncancer impacts suggests that comparative risk projects must be cautious about rankings based on assessment methods that only provide quantitative risk estimates for carcinogens and that the development and validation of noncancer risk assessment methods should be a higher priority.

Among carcinogens, the largest proportion of estimated cancer cases is associated with pollutants of natural origin (radon, natural background radiation, and arsenic). Exposures to these agents vary in the degree to which they can be controlled or reduced. Other contributors to estimated cancer cases include environmental tobacco smoke, diesel exhaust, dioxins, volatile organic chemicals, and pesticides, all of which have extensive population exposure due to their frequency as contaminants in ambient air, indoor air, or the food supply. From the perspective of added individual cancer risks, persistent and bioaccumulative organochlorines are important, because small groups are exposed to very high concentrations in edible organisms.

> *From the perspective of environmental releases to media, the highest estimated human health risks are associated with various sources of air pollution.*

The total health impact associated with air topic areas is substantial, despite extensive regulatory controls aimed at reducing outdoor exposures to air pollutants from mobile and stationary sources. Substantial portions of California's population are frequently exposed to criteria air pollutants at levels that exceed regulatory standards. Hundreds of thousands of cases of exacerbated respiratory diseases and about one thousand cases of premature death annually are estimated to be associated with exposures to criteria air pollutants. Exposures to potentially carcinogenic air pollutants may be associated with several thousand cancer cases annually, predominantly due to exposures to radon, diesel exhaust, and environmental tobacco smoke. Because of limited data and the indicator chemical methodology adopted by the HHC, this assessment of total impacts is likely to have covered only a portion of actual

impacts on human health. Risks associated with several potentially important additional pollutants could not be estimated, and not all adverse health effects of assessed pollutants were addressed.

The opportunities for extensive human exposures to hazardous substances is much greater as a result of air releases than releases to either water or land. This occurs because pollutants are frequently released into air sheds where large populations reside and because there are more high exposure scenarios involving air pollution. This is particularly true for exposures occurring in indoor environments, where people spend most of their time and where a number of pollution sources can contribute to concentrations that are frequently substantially higher than outdoor ambient levels. Sources of indoor air pollution often involve multiple topic areas, including residential heating practices and consumer product use, infiltration from outdoor stationary and mobile sources, and use of contaminated groundwater.

Most topic areas, including many ranked as generally low human health risks, can pose high risks to smaller populations.

Higher risks to smaller populations may occur because these groups are particularly susceptible to adverse impacts (such as people with compromised immune systems exposed to microbiological contaminants) or because group activity patterns or location result in unusually high exposures (such as ethnic groups engaged in subsistence fishing in contaminated aquatic environments). Examples of topic areas with high impacts on small populations are provided in Table 3 (Attachment B) and discussed below in the section on identifying high-risk groups.

Many of these disparate impact problems are not targeted by current regulatory programs, although risks could be reduced by intervention. This finding complicates any effort to simply reorganize regulatory priorities on the basis of overall health risk-rankings, because significant health benefits could be associated with interventions that prevent avoidable impacts in these high-risk subpopulations. In addition, the existence of such subpopulations in most topic areas raises concerns about environmental equity. Data were generally insufficient to identify whether the same subgroups were frequent receptors of high-risk exposures from multiple topic areas, which would raise concerns about potential cumulative or synergistic impacts. Some examples of such multiple impacts were identified, particularly for susceptible subpopulations like asthmatics, who are affected by several respiratory tract toxicants released by a variety of source categories.

Ranking water, land, and air releases

Several other preliminary observations can be drawn about the human health impacts of different categories of releases to environmental media.

Among "water release" categories, groundwater contamination represents the most significant source of health risk for average Californians, because of exposures occurring as a result of this resource's use for domestic water supplies. The highest risk contaminants (arsenic and radon) have natural sources, but groundwater can also be the predominant source of exposure to some organic chemicals with high estimated cancer risks (DBCP) as well as to substances posing noncancer hazards (nitrate). For volatile toxicants in drinking water, significant exposures result from ingestion, dermal exposure while bathing, and inhalation of volatilized contaminants in the indoor environment. At present, contamination is extensive but regulatory controls restrict human exposures among those served by large public water systems. Impacted aquifers are not used for drinking water or the contaminants are reduced to allowable levels. Those relying on water from private wells in areas of contaminated aquifers or from inadequately treated public water supplies are at highest risk.

Among "land releases," human health risks were judged to be generally low to medium because of limited opportunities for extensive human exposure. The highest risks are associated with exposures to uncontrolled inactive hazardous waste sites (either before site discovery or because of a failure to limit

human contact), but the number of such situations that currently exist in California could not be determined and is probably small. Among sites being managed under state and federal regulations, current health risks are generally highest at sites in urban areas with opportunities for direct residential contact (e.g., town gas sites). Much more extensive population exposures to stressors from these sites could occur in the future if the groundwater resources they have contaminated are needed for drinking water supplies. Risks associated with currently permitted treatment, storage, and disposal facilities were ranked generally low because releases are controlled to *de minimis* levels. The volume of hazardous waste generated annually (1.9 million tons) carries the potential for high human health risks to large populations if regulatory oversight programs are not in place. Additional efforts are necessary to evaluate the potential health threats posed by accidental sudden releases of hazardous materials into the environment. Serious data gaps made it impossible to evaluate the human health impact of several important waste management activities (solid waste landfills and hazardous materials storage tanks) that are known to contaminate groundwater.

All the major categories of "air releases" were evaluated as having high human health risks, with a variety of stressors from stationary, mobile, and residential sources contributing to substantial numbers of adverse health outcomes. Examining noncancer risks, outdoor exposures to criteria air pollutants from mobile, stationary, and residential sources are associated with extensive population impacts on respiratory health. Examining cancer risks, residential and consumer product sources in the indoor environment were predominantly responsible for estimated impacts. There are several reasons for this. People spend most of their time breathing indoors rather than outdoors, so this exposure setting contributes substantially to the total dose of toxicants received. The indoor environment is also contaminated with multiple pollutants. Two known human carcinogens (radon and environmental tobacco smoke) occur indoors at elevated concentrations. Many other toxic pollutants (such as formaldehyde and para-dichlorobenzene) also occur at much higher levels indoors than outdoors.

Evaluating environmental topic list III

The Human Health Committee found that the level of aggregation represented by the topic areas in list III was too broad to meaningfully assign overall ranks. To facilitate comparisons with ecological and social welfare ranks, the HHC indicated which of our ranked topic areas fit within the broad categories of list III (Table 2, list III, Attachment B).

Interpreting the Human Health Rankings

Evaluating the relative significance of estimated health impacts

Environmental pollution is one of a multitude of factors contributing to human morbidity and mortality. Risk-rankings based on estimated cases of illness (e.g., asthma) or death (e.g., due to lung cancer) should be considered within a larger public health context. If resources are limited and choices must be made between competing approaches to improving public health, a number of additional important factors must be considered in evaluating whether and where to intervene to prevent environmental health problems. Both urban violence and automobile accidents, for example, are responsible for substantial numbers of deaths annually in California. Poverty and unemployment play very substantial roles as factors in the illness experience of Californians because of their impact on nutritional status and access to health care. Smoking and drug and alcohol abuse, health problems more directly related to personal choice, are the largest identifiable chemical contributors to human morbidity and mortality. All of these public health problems are subject to social intervention and may be competing with pollution control activities for social resources. General public health problems like violence or personal smoking are outside the scope of Cal/EPA regulatory responsibilities and a policy

decision was made early in the CCRP to focus HHC efforts on ranking environmental health problems associated with human exposures to toxic chemicals and agents.

The proportion of human health risks that can be attributed to environmental stressors is unknown for most types of adverse effects. Information identifying important causal factors is generally unavailable for most types of human diseases, although it is clear that multiple genetic and environmental factors are generally involved. Causal factors are unknown, for example, in about 70 percent of cases of developmental defects like congenital malformation (Wilson, 1977). Environmental exposures appear to play a significant role in exacerbating respiratory diseases, but no estimates of their proportional contribution are available. Scientists have devoted the most attention to studying cancer. Some have estimated that between 5 and 15 percent of all cancer deaths may be associated with chemical and radiation exposures occurring in workplaces and the ambient environment. To place this in perspective, some estimate that 35 to 50 percent of cancers involve dietary factors and 20 to 30 percent involve tobacco (OTA, 1981). Cancer is known to be a multistage disease involving multiple causal factors, so it is difficult to separate the contribution of different environmental factors.

Evaluating qualitative differences between types of risks to human health

While general public health problems provide a context for evaluating the magnitude of health problems posed by environmental contaminants, it is important to note that they often involve qualitatively different types of risks. Decisions to drive automobiles and face the risk of accidental death, for example, are made voluntarily after consideration of the benefits of this activity. In contrast, many environmental health risks involve involuntary exposure to toxicants generated by activities that do not directly benefit those who bear the added health risks. There are ethical (has the risk been imposed or chosen voluntarily?) and political (are risks and benefits equitably distributed?) considerations that are clearly important factors in reaching judgments about the acceptability of different environmental health risks.

General public health problems also differ in the extent to which information is available to guide risk reduction efforts, as well as in the cost and potential effectiveness of potential interventions. While diet is a substantial contributor to cancer incidence, for example, the relationship between specific dietary components and cancer risk are not well enough established to identify and prevent the most harmful exposures (NAS, 1989). Other substantial contributors to cancer incidence like personal smoking may be difficult to control with socially acceptable regulation compared to more easily preventable exposures.

Understanding limitations of available risk assessment methods

Environmental topic areas were ranked using available data on toxicology and current exposures in California. Many topic areas that ranked low or medium are known sources of impacts on human health, but were not ranked higher because regulatory controls currently in place substantially reduce potential risks. This clearly complicates any effort to evaluate regulatory priorities by comparing health ranks with regulatory costs. If overall risks are low because of regulatory expenditures, reallocation of resources should not occur without evaluating the potential for increasing risks by removing exposure controls. In general, data are insufficient to estimate what the health impact of these areas would be in the absence of existing controls on exposure and risk.

Numerical estimates are useful primarily in indicating the relative scale and severity of different environmental exposures, and should not be interpreted as actual "body counts." Risk estimates are based on data of varying quality and methods that incorporate different assumptions and degrees of conservatism. The Human Health Committee was only able to evaluate a few indicator chemicals out of the many toxicants currently being released into California's environment and was generally unable to assess the impacts of cumulative exposures. Due to methodological limitations, results should

generally be interpreted as order of magnitude indications of potential health impacts. These estimates should *not* be interpreted as indicating the *total* health impact of different topic areas.

Numerical estimates of estimated cancer cases per year, average added individual cancer risks, or estimates of the incidence of noncancer effects must be interpreted cautiously. For carcinogens, it should be noted that risk assessment methods involve substantial uncertainties (e.g., because of the need to extrapolate from animals to humans or from high-dose to low-dose exposures), that both individual risks and population burden estimates are based on theoretical models, and that the levels of risk predicted are generally too small to be observed using epidemiological methods. For noncarcinogens, there are substantial uncertainties involved in the quantitative estimation of the health impacts of exposure to ozone and particulate matter. For both carcinogens and noncarcinogens, it should also be noted that the indicator chemical approach and limits on available exposure data prevented quantitative assessment of a number of potentially hazardous agents (e.g., polycyclic aromatic hydrocarbons, mercury).

Complementary Approaches to Ranking Human Health Risks

Critics of the comparative risk process rightly point out that ranking arbitrarily defined topic areas does not provide sufficient information to set environmental priorities, because opportunities for targeting intervention to those at highest risk often are lost in aggregate rankings. Throughout the course of its analyses, the HHC attempted to use methods and collect exposure data that can provide complementary perspectives on its conventional ranking results. The Human Health Committee's "distributional" approach to risk assessment facilitates describing how risk levels vary across individuals in a population (either because of exposure patterns or increased susceptibility to pollutant effects). This approach can illuminate some important aspects of environmental problems that are not captured by the general rank assigned to topic areas. The following sections present summaries of our effort to identify the population groups at highest health risk and the major settings in which people are exposed to environmental stressors.

Identifying high-risk groups

The distributional approach to characterizing human health risks can be used to identify population subgroups that may be experiencing unusually high adverse health impacts, either because of high pollutant concentrations, high intake, or inherent susceptibility. Table 3 (Attachment B) lists the receptor groups that could potentially be subjected to disproportionate human health impacts in California. This table summarizes information on highly exposed or susceptible populations that the HHC developed during its evaluation of environmental topic areas. Information on the size of the populations at risk is derived from a variety of sources. [14]

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[14] General information about the age, race, and sex distribution of the California population are based on 1990 census data (Bureau of the Census, 1991). Estimates of the prevalence of different respiratory conditions are generated for states and counties by the American Lung Association (ALA, 1994). Estimates of the prevalence of cardiovascular conditions have been derived from national estimates generated by the American Heart Association (AHA, 1993). The prevalence of HIV infection was estimated by the Office of AIDS, California Department of Health Services (Personal communication from J. Singleton). The number of pregnant women in California has been estimated from birth data provided by the Health Data and Statistics Branch, California Department of Health Services. The number of children exposed to lead has been estimated by the California Department of Health Services (Personal communication from A. Bradman). The number of workers exposed to lead has been estimated based on a survey of lead industries (Sharp, 1991). The number of Californians exposed to unvented combustion appliances was estimated by the California Air Resources Board (Personal

In a number of topic areas, the HHC found that available data indicated that potentially hazardous exposures to some toxicants are concentrated in certain geographic areas of California. Residents of these areas may therefore experience high risks because of their potential for unusually high exposures. Table 4 (Attachment B) lists these areas and describes the size of potentially affected populations, the health effects of concern, and the list I and list II topic areas contributing to the environmental health problem.

Context for evaluating the high-risk groups identified by the CCRP

Workers are probably the population group that is most regularly at risk of experiencing the highest exposures to environmental stressors. Due to a lack of data, these exposures were characterized for very few topic areas (only pesticides and lead). Because information on occupational risks was not available consistently across topic areas, none of the general rankings took occupational impacts into account. However, it should be emphasized that occupational exposures are of major public health significance. Worker exposures can be orders of magnitude greater than indoor residential exposures that have been ranked high by the HHC. Working in lead industries or in activities involving pesticide use can involve high exposures that result in lead or pesticide poisonings that are detectable by illness surveillance systems.

High exposures of public health concern are also possible as a result of accidental releases. Facility process upsets, chemical spills, and transportation accidents can result in sudden acute exposures to hazardous materials, occasionally involving substantial numbers of people. Although reporting of such incidents recently became mandatory in California, there are few data available to characterize their general impact on human health. The risks of accidental releases were also not taken into account in general topic area ranks.

High-risk groups by topic area

Among "water release" categories, several relatively small groups can be identified that experience disproportionately high exposures to toxicants. Sports or subsistence anglers who consume aquatic organisms from ecosystems with contamination "hot spots" can experience very high added individual cancer risks (from organochlorines released by industries and municipal treatment and storm drain systems) and potentially hazardous exposures to developmental toxicants like mercury (from non-point releases, abandoned mines, and industrial wastes discharged into municipal treatment systems). Private well users may experience high cancer and noncancer health risks because they are exposed to natural and anthropogenic groundwater contaminants without the regulatory controls that limit the general public's exposures through municipal drinking water systems. Californians living in proximity to contaminants released in Mexico may also experience increased risks of exposure to microbiological contaminants, inorganics, and persistent organochlorines.

"Land release" categories do not generally make a significant contribution to the average Californian's total exposure to toxicants. However, small groups in the immediate proximity of some site categories can experience substantial exposures, particularly before sites are discovered or if sites are inadequately regulated. High exposures are most probable among those using unmonitored private wells or having direct contact with contaminated soils. An additional source of disproportionate health risks may occur if small populations experience multiple exposures because of the clustering of waste sites and treatment, storage, and disposal activities in some urban areas.

Among "air release" categories, there are a variety of groups that could experience disproportionate health impacts. Residents in air basins that regularly exceed air quality standards experience increased

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communication from P. Jenkins). The number of smokers in California has been estimated based on the prevalence of smoking (20%) in adults over 18 years of age (Pierce *et al.,* 1992).

risks of mortality and morbidity, particularly if they have preexisting respiratory or cardiovascular conditions. Residents of regions with high geologic radon experience increased lung cancer risks, particularly if they live in certain types of homes or obtain water from private wells. Available exposure data indicate that Californians living in buildings with strong pollutant sources and limited air exchange can also experience relatively high health risks. Sources responsible for added cancer risks include a variety of building materials and consumer products and infiltration of outdoor pollutants. Sources responsible for noncancer risks include smoking (ETS) and misused or malfunctioning combustion appliances. Data on exposures occurring near stationary sources of air releases indicate there are also occasional "hot spots" produced by facility emissions, but information was inadequate to characterize the size of exposed populations or the potential for cumulative exposures from multiple facilities.

There are highly exposed populations to virtually all the "*environmental stressors*" in the environmental topic area list II. The following discussion provides more detailed examples of receptor groups that may be at high risk because of their proximity to emissions sources or their increased susceptibility to pollutant effects.

Proximity to emissions sources

Certain geographic areas and communities in California are the recipients of relatively high loadings of environmental stressors, from a variety of sources. Inner city neighborhoods, for example, are frequently adjacent to major roadways that are sources of vehicular pollution and the site of manufacturing facilities that emit substantial quantities of air pollutants. There is considerable public concern about the potential health impacts of cumulative (and possibly synergistic) exposures to all these pollutants from all these sources. The topic area approach of conventional comparative risk projects fails to assess this cumulative impact or to identify population subgroups which are subjected to multiple stresses from different topic areas.

Unfortunately, the data needed to examine the extent of cumulative exposures from multiple sources are generally unavailable. Exposures to relatively few pollutants are regularly monitored in California, and it is often impossible to identify responsible sources for observed concentrations. Data on the release of toxicants from various source categories are also generally unavailable. The best data available for examining how the loading of environmental stressors is geographically distributed cover only one source category: manufacturing facilities. Toxic release inventory (TRI) data were used to identify the California communities receiving the largest emissions of reportable air pollutants. The top 25 zip code areas receiving emissions are listed in Table 5 (Attachment B).

There are a number of important limitations to using TRI data to identify areas and populations that may be experiencing high pollutant exposures and resulting health risks. [15] The location of emissions may not correlate with exposures because numerous factors influence the dispersion of pollutants in an airshed (e.g., wind direction, stack height, the atmospheric fate of released pollutants). Pollutant loading analyses also treat all pollutants equally in spite of the tremendous variation in the toxicity of different substances (e.g., the release of a pound of ammonia will have substantially less impact on human health than a pound of lead). Even acknowledging these limitations, however, a number of interesting hypotheses about the distribution of environmental health risks can be examined.

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[15] Toxic release inventory (TRI) data is also limited by the scope of its reporting requirements, which apply only to manufacturing facilities in specific SIC codes that use more than a threshold volume of listed chemicals. Sources such as utilities, treatment, storage, and disposal facilities, municipal sewage treatment plants, and federal facilities have not been required to report emissions. Some of these source categories will be covered by an expansion of TRI reporting requirements to be implemented in 1995. Toxic release inventory reporting requirements also cover only approximately 300 chemicals at present; 314 additional substances are being considered for inclusion in the program in 1994.

The Statewide Community Advisory Committee (SCAC) requested that the HHC examine whether the environmental loading of pollutants is unevenly distributed across racial, ethnic, or economic groups. A working group within the HHC conducted a statistical analysis of statewide TRI air emissions to characterize the average per capita air pollutant loading for different racial and economic groups in California. The analysis is limited because data are only available on emissions from selected manufacturing sources, while it is clear that emissions from mobile sources are also likely to be inequitably distributed. The working group used a measure developed by U.S. EPA called the population emissions index (PEI) to illustrate how per capita air pollutant loadings vary across different population groups, defined in terms of their race or economic class. [16] It is important to emphasize that the PEI is only a surrogate measure for examining whether pollutant exposures or pollution-related health risks vary across population groups. [17]

If things are fair (equitable), all groups would have the same PEI. Figure 2 (Attachment B) displays the results of the PEI analysis conducted on total TRI releases to air. Blacks and Hispanics experience higher loadings of TRI air pollutants than whites. [18] (Hispanics constitute 98 percent of the "other" category in Figure 2 due to the coding practices of the Census Bureau.) In contrast with race or ethnicity, groups with different income levels do not appear to experience substantially different pollutant loadings. This analysis provides initial support for the hypothesis that people of color live in areas that receive a disproportionate share of pollutant releases from manufacturing facilities.

To provide a graphic illustration of the relationship between releases and community composition, maps have been prepared that display how manufacturing emissions of toxic substances vary by zip code areas with different racial and income characteristics. Figure 3 (Attachment B) illustrates the results of this mapping for Los Angeles County, plotting TRI air emissions by zip codes within the county.

Highly susceptible groups

Because relevant data are lacking for most indicator chemicals, the HHC could not explicitly account for differences in susceptibility to most assessed health endpoints. Such differences can be associated with a variety of factors, such as genetic make-up, life style activities, or access to health care. The Human Health Committee focused on two more easily identifiable attributes of susceptible populations: health status (some conditions increase an individual's susceptibility to pollutant effects) and exposure considerations (some activities enhance an individual's likelihood of receiving high doses of toxicants).

Table 3 (Attachment B) identifies several susceptible populations that are subject to exposures that can significantly exacerbate their health status. From the perspective of health status, individuals with preexisting medical conditions are at increased risk of adverse effects from a variety of topic areas and

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[16] The methodology and complete results of this analysis are found in Bois *et al*. (1994). This analysis was conducted at the census tract level rather than the zip code level in order to obtain better geographic definition of pollutant loading.

[17] To interpret the PEI as a measure of potential health risk, it is necessary to make several simplifying assumptions: 1) concentrations that people are exposed to are directly proportional to the amount of toxics reported released in their proximity, and 2) all individuals in a given area will be exposed to the same concentration of an emitted toxic substance, independent of the number of exposed individuals in an area or any possible differences in their activity patterns, breathing rates, etc. Both of these assumptions can be challenged, but until air pollutant monitoring systems can provide spatially-refined ambient concentration data, equity analyses will be forced to rely on pollutant loading data.

[18] Due to the way PEIs are estimated from population and emissions data (the uncertainty in both types of data is unknown), it is not possible to ascertain the statistical significance of differences in PEI measures directly. A detailed statistical analysis of these results will be presented in Bois *et al*. (1994).

environmental stressors. The largest groups affected are those with preexisting respiratory conditions like asthma, emphysema, and chronic bronchitis (which are exacerbated by particulate matter, ozone, and environmental tobacco smoke) and those with cardiovascular conditions like coronary heart disease (angina can be aggravated by carbon monoxide). Many elderly members of the population have one or several of these conditions, and may suffer premature mortality as a result of exposure to criteria air pollutants. Pregnant women are another major group whose health status may make them particularly susceptible to adverse impacts from pollutant exposure. Individuals with compromised immune systems (such as the very young or the elderly) may have very serious reactions to microbiological contaminants that cause only minor gastroenteritis in the general population. Smokers are more susceptible to radon, asbestos, and other respiratory tract carcinogens.

From the perspective of exposure considerations, a susceptible population of particular concern is children, who may be heavily exposed because of their behavior patterns (crawling on contaminated surfaces, hand-to-mouth activity) or dietary preferences (intake of large quantities of relatively few foods). In the case of both lead and pesticides, childhood doses (on a body weight basis) can be substantially greater than adult doses, resulting in exposures exceeding allowable levels. Other populations at increased risk due to activities that increase exposures above normal include athletes who exercise heavily in air basins with poor air quality.

Identifying exposure settings that are major contributors to health risks

From the perspective of risk prevention, it is valuable to identify the major exposure pathways contributing to estimated adverse human health impacts. This information is useful for designing effective interventions: control strategies, for example, should be focused on limiting the most significant sources of exposure if we want to reduce overall health risks.

As an example of this total human exposure perspective, the results from analyses of several different topic areas involving pollutant releases to water and air can be combined to identify the principal exposure pathways involved in cancer risks due to volatile organic chemicals. California residents are exposed to these pollutants through three important pathways: tap water, indoor air, and outdoor air. Table 6 (Attachment B) presents the estimated cancer risks associated with the total human exposure to three compounds in terms of individual and population risks and identifies the risks associated with different media.

Table 6 (Attachment B) illustrates that for several volatile organic chemicals that are carcinogens (formaldehyde and tetrachloroethylene in this example), substantial exposures mainly occur through inhalation of indoor air. Current regulatory management efforts targeting these chemicals, however, focus either on limiting contaminant levels in drinking water or limiting organic releases to outdoor air. While water use and outdoor infiltration are sources for these contaminants in the indoor environment, consumer products and building materials are much more important contributors to the highest levels of human exposure. Benzene provides an example of an organic chemical with strong outdoor sources (predominantly automobiles) that are subject to regulatory controls but still pose relatively significant cancer risks. Indoor sources of benzene exposures include environmental tobacco smoke and consumer products, which have not been subject to regulatory controls.

Table 6 (Attachment B) also raises the policy issues involved in attempting to rank environmental stressors by their estimated illness burden (cancer cases, in this example). Chloroform exposures, which result from use of chlorine disinfectants to control microbiological contaminants in the water supply, are estimated to cause high individual cancer risks and a relatively significant number of annual cancer cases. Water consumers are exposed to relatively high risks (there is human evidence of an association between bladder cancer and exposure to chlorinated water supplies [NTP, 1989]), but also benefit from chlorine's reduction of microbial disease risks. Other organics in Table 6 (Attachment B) are associated with comparable cancer risks but little or no benefit to the exposed.

Identifying Emerging Hazards and Prioritizing Future Research Needs

While evaluating and comparing the different environmental topic areas covered by the CCRP, the HHC identified several important research needs. In general, we have recommendations affecting the generation of toxicity and exposure data and the development of comparative risk methods. More specifically, there are some topic areas where the HHC concluded data were insufficient to support a risk-ranking, but that the area should be prioritized for research because of its potential impact on human health. The Human Health Committee was unable to devote time to identifying and ranking emerging public health problems, so additional analysis will be required to establish a complete research agenda.

Priorities for developing exposure and toxicity information

During the indicator chemical selection process, the HHC identified a number of high volume releases where we lack either the toxicological or exposure data to assess potential risks. The Human Health Committee also noted that there are ongoing exposures to complex mixtures of contaminants in California that cannot currently be assessed because of missing toxicological or exposure data. Ranking health risks in the absence of information to characterize the potential impacts of these exposures requires extended leaps of faith – that agencies have already identified, tested, and monitored for the major stressors, that interactions between toxicants are not likely to alter risk estimates substantially, and that analysts have a plausible basis to reach general judgments about topic area impacts from analyses of relatively few indicator chemicals or sites. This problem affects virtually every topic area: we are unable to assess the hazards of pollutants formed in urban airsheds (e.g., nitro-polycyclic aromatic hydrocarbons); over 95 percent of the carbon compounds present in domestic wastewater or landfill leachate are uncharacterized by current monitoring methods.

To address some of these critical data gaps, the HHC recommends that greater resources be devoted to exposure monitoring and that some toxicity testing requirements be improved. Monitoring data to describe actual human exposures is currently available for less than half of the indicator chemicals selected by the HHC and less than five percent of the substances reported under TRI as released to environmental media. The Human Health Committee recommends that Cal/EPA devote substantially more resources to characterizing population exposures to toxicants in California, particularly in micro-environments known to contribute substantially to human exposures (like workplaces, residences, vehicles) and among groups with activity patterns that result in large exposures (like subsistence fishers or children). Information to characterize the frequency, type, and extent of population exposures associated with accidental releases is also needed. Private organizations possessing exposure data (like manufacturing firms or companies that have assessed products for compliance with Proposition 65) could make such information available to the public for review in future comparative risk analyses.

The California Environmental Protection Agency should establish a screening procedure for identifying potentially high exposure substances lacking adequate toxicology data and nominate these chemicals for thorough testing by the Federal Interagency Testing Committee. Toxicity data needed to assess the health consequences of shorter-term exposures should also be a higher priority. At present, evaluations of acute dietary exposures to pesticides, for example, generally rely on comparisons with acceptable doses developed for chronic exposure scenarios. Noncancer risk assessment methods deserve greater attention and development, because the hazard index approach is not amenable to consistent comparisons across compounds. Current noncancer risk assessment methods have been most developed for criteria air pollutant impacts, and their capacity to produce quantitative estimates of mortality and morbidity have clearly influenced the ranks given to air release topic areas. Non-respiratory system adverse impacts, such as neurotoxicity or reproductive toxicity, which are important

public concerns, are generally not quantifiable at present, although some groups are exposed to high levels of lead and mercury, for example.

Priorities for research into emerging hazards

Available data were insufficient to rank a number of different topic areas. In its discussions of these topic areas, the HHC identified several that deserved further research because of their potential for adverse impacts on human health. The Human Health Committee recommends that Cal/EPA establish a process for identifying priorities for future research into emerging public health problems because the committee was unable to review and prioritize all potential candidates.

In environmental topic area list I, the HHC recommends that solid waste disposal sites be the subject of research activities because of significant gaps in the data available to assess potential human exposures. These sites can be located near residential areas, have unassessed but potentially significant routes of exposure (soil gas migration to nearby residences), and represent a major source of future groundwater contamination. Information is also needed about other waste management facilities (like recycling and materials reprocessing facilities) that are located in or near residential areas. Additional information should also be obtained about whether storage tank releases are associated with significant exposures and whether any remaining on-site waste disposal activities are being conducted by manufacturing firms.

In environmental topic area list II, the HHC recommends that electromagnetic fields (EMF) be the subject of research activities. While available epidemiological evidence about a connection between EMF exposure and childhood and adult cancers was insufficient to support a health risk-ranking, the severity of potential outcomes and virtually universal exposure opportunities makes further investigation critical. Epidemiological, toxicological, and exposure studies are all required. Lower priorities include obtaining current exposure information for asbestos and evaluating the potential impacts of global climate change and habitat alteration on human health. In regard to the general category of novel products and organisms, the HHC recommends using available pre-market screening mechanisms whenever possible to prevent the introduction of chemicals or products with hazardous characteristics.

CAVEATS AND UNCERTAINTIES

General

While comparative risk assessment attempts to base its conclusions on the best available scientific data and generally accepted methods, ranking results are never determined by quantitative analyses alone. The Human Health Committee had access to more information than has been available to other comparative risk projects, but data gaps and scientific uncertainties limit our ability to characterize the adverse impacts of environmental stressors on human health. Selecting the data used, adopting risk assessment methods, and extrapolating from analyzed risks to evaluate the risks of an entire topic area all involve substantial amounts of scientific judgment. The California Comparative Risk Project's results reflect the expertise and values of the scientists participating in its technical committees; procedures adopted by the HHC have shaped its ranking results. The rankings provided are not scientific determinations of actual health impact, but expert judgments about the relative importance of different topic areas reached by a process of analysis and debate.

Through the risk analysis and ranking process, the HHC found that comparing health impacts across a wide variety of topic areas is a difficult task because of limitations on available toxicological and exposure data and risk assessment methods and because of the difficulties involved in developing consistent measures for comparing impacts. In many respects, the value of the exercise involved identifying how much we do not know about the health impacts of different topic areas and identifying opportunities for targeting interventions at high risk groups. While we hope that our report provides a useful contribution to debates over how to set environmental priorities, we recognize that our technical approach involves significant limitations that are inherent in broad scale comparative risk projects.

The Human Health Committee has based its risk estimates on contemporary population exposure patterns, so its rankings presume the existence of current regulatory controls. This assumption raises several concerns. First, levels of current risks are often relatively low because many topic areas have been the subject of controls on exposure. High risks are most likely if controls have been poorly implemented or enforced, or not extended to all sources of potential exposure. Any redirection of resources based on general topic area rankings must consider the increased risks that might result if existing regulatory controls are reduced. Second, future potential impacts are obviously an important public health concern, even if no contemporary impact from a topic area has been observed (e.g., ozone depletion). The Human Health Committee's focus on current risks cannot be used to identify emerging environmental health problems that might be prevented by making proactive decisions. It is critical that the environmental management process develop a greater capacity to act to prevent predictable future impacts on public health, rather than wait until evidence demonstrates we have an unaddressed high hazard problem.

The Human Health Committee's general ranking of topic area risks should not be interpreted as the members' recommendations about which environmental problems should be the highest priorities for regulatory or legislative action. The Human Health Committee has called attention to a number of additional aspects of health risk that must be considered when setting environmental priorities. These include whether there are small populations experiencing high risks due to their exposure patterns or susceptibility and whether intervention efforts are focused on the principal sources of human exposures to environmental stressors. Given the scientific uncertainties involved in evaluating the impact of environmental stressors on human health, reducing or eliminating preventable exposures to hazardous substances, particularly in high-risk settings, is a sensible public health precaution.

The Human Health Committee recommends that comparative risk assessment should be integrated into regulatory agencies' planning processes. Rankings should be reviewed regularly (perhaps every three to five years) in order to incorporate new scientific information into the priority-setting process. Prior to institutionalizing a regular comparative ranking process, agency use of this report (to modify regulatory priorities, target regulatory interventions and communicate risks to the public) should be evaluated.

Specific Caveats for Risk Assessment Methods

Risk assessment methods employed by the HHC are subject to a number of limitations, which can result in either over- or under-estimation of potential adverse impacts on human health. Models used for extrapolating from animal studies to human risks or from high to low dose exposures have substantial uncertainties. Assessing health risks utilizes information about the potency of a substance, the expected range and duration of human exposures and the susceptibility of target populations. When available, many of these data are obtained from experiments conducted under artificial conditions on genetically homogeneous animals using higher doses than humans will experience. This raises questions about their extrapolation to humans. Quantitative risk assessment methods can produce

substantially different results depending on the choice of models and assumptions. The Human Health Committee generally adopted the risk assessment approach of state and federal regulatory agencies.

Many aspects of the health impacts of different topic areas could not be examined in this report because of constraints on available data and methods, resources, and time. The indicator chemical approach adopted by the HHC means that only a portion of the hazards associated with a topic area are assessed, ignoring the impacts of exposures to many substances for which we have little or no toxicology or exposure data. Some potentially significant effects are not addressed in conventional risk assessments. For instance, synergistic or cumulative effects –- interactions among and between chemicals that create a greater health risk than caused by a single exposure -- are generally not evaluated. Similarly, information about human variability in susceptibility to toxic hazards is usually unavailable, so the extent of variability in risk across the population is not known.

Risk assessment estimates have been generated using expedited methods by a variety of participants and it has not always been possible to thoroughly review all assumptions and calculations made. Results presented have not undergone thorough external scientific review. In summary sheets, numerical risk estimates are often presented to several significant figures, lending an illusory appearance of accuracy. It has not been possible to impose a consistent convention on the way results have been presented by participants, but it is inappropriate to treat results as actual predictions of health risks. Due to methodological limitations, results should generally be interpreted as order of magnitude indications of potential health impacts. It is inappropriate to abstract quantitative results generated within the CCRP and use them as evidence of high or low risks in policy arenas that have different standards of scientific evidence.

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Computer Data Bases Used by The Human Health Committee

California Department of Health Services:

Public Drinking Water System: Source Contamination Sampling Data Base (1984-1992)

Cal/EPA - Air Resources Board:

Ambient Air Toxics Data Base (1987-1992)

AB 2588 Air Toxics Source Inventory Data Base (1993)

California Indoor Exposure Studies Data Base (1993)

Cal/EPA - Department of Pesticide Regulation:

Pesticide Use Report Data Base (1990)

Tolerance Assessment System Data Base (1993)

Cal/EPA - Department of Toxic Substances Control:

CalSites Data Base

California Comparative Risk Project Data Base (1994)

Cal/EPA - Office of Environmental Health Hazard Assessment:

Chemical List of Lists (1993)

AB 2588 "Hot Spots" Health Risk Assessment Data Base (1993)

Toxics Release Inventory (1987-1992)

ACKNOWLEDGMENTS

The Human Health Committee Report was written by William Pease, Co-chair, Lauren Zeise, Chair, and Sara Hoover, Human Health Committee member, with the assistance of one of the CCRP's Research Writers, Susan Davis. This report reflects the extensive review of the HHC and discussions of report content in several HHC meetings. Substantial portions of the introductory sections on risk assessment methods are based on text from the U.S. EPA (1993) *Guidebook to Comparing Risks and Setting Environmental Priorities* .

This human health risk-ranking project could not have been conducted without the voluntary contributions of the members of the HHC, who attended frequent meetings, provided data and analyses for review, drafted narrative summaries of each topic area analysis, engaged in ranking debates, and reviewed and commented on all materials generated during the project. Members of the HHC are identified Attachment A. Their organizational affiliations are provided for information purposes only: members participated as individuals and the HHC's results have not been endorsed by specific organizations. While the HHC's overall ranks generally reflected group consensus, individual members sometimes disagreed over specific risk assessment methods or results. Members who regularly participated in HHC activities are highlighted in bold.

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ATTACHMENT A:

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ATTACHMENT B:

TABLES AND FIGURES

Figures 1-3

Tables 1-6

Figure 1.
Flow Chart Illustrating Steps Taken by the
Human Health Committee To Rank Human Health Risks.

insert Table 1

insert Table 1

insert Table 2

insert Table 2 (cont).

insert Table 2 (cont).

insert Table 2 (cont).

insert Table 2 (cont.)

insert Table 2 (cont).

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insert Table 2 (cont).

insert Table 2 (concluded)

insert Table 3 (cont)

insert Table 3 (cont)

insert Table 3 (concluded)

insert Table 4

insert Table 4 (cont).

Table 5.

Geographic Areas Receiving Largest Emissions

of Reportable Air Pollutants (Manufacturing Sources Only).

Total Reported TRI Releases to Air (1991) (Pounds)	ZIP Code of Receiving Area	Location of Receiving Area
2,770,513	92665	ORANGE
2,198,091	90503	TORRANCE
1,617,516	94509	ANTIOCH
1,422,580	90846	LONG BEACH
1,305,764	94510	BENICIA
1,291,675	90023	COMMERCE LOS ANGELES VERNON
1,134,108	92621	BREA
1,033,820	95501	EUREKA
991,799	92504	RIVERSIDE
987,280	90250	HAWTHORNE
977,911	90224	COMPTON RANCHO DOMINGUEZ
952,814	94538	FREMONT
941,255	93562	TRONA
823,398	91730	CUCAMONGA RANCHO CUCAMONGA
785,754	90245	EL SEGUNDO
731,249	91406	VAN NUYS
724,375	92069	SAN MARCOS
709,411	95330	LATHROP
704,914	92631	FULLERTON
702,531	90745	CARSON
702,039	90670	SANTA FE SPRINGS
671,002	94533	FAIRFIELD
655,828	92806	ANAHEIM
650,501	90749	CARSON COMPTON
636,585	95765	ROCKLIN SUNSET WHITNEY RANCH

insert Figure 2

insert Figure 3

insert Table 6

ATTACHMENT C:

ASSUMPTIONS

Exposure and Cancer Risk Assessment Assumptions

The conventional approach to assessing cancer risk is to multiply an estimate of the dose received by the cancer potency to derive a risk estimate:

$$\text{Cancer risk} = \text{Cancer potency} \times \text{Dose}$$

This risk estimate is typically assumed to hold for each person in the population. Because exposures and susceptibilities vary from individual to individual, this estimate can overstate the risks to some, and significantly understate the risks to others.

In comparing risks across environmental topic areas, the HHC wanted to be able to distinguish cases where small groups of individuals might experience high risks from those cases in which the risks across the population are relatively uniform. To do this, a variation on the conventional approach was applied. Instead of assigning a single value, the doses took on multiple values, representing different exposures in different individuals. The Human Health Committee decided not to vary cancer potency unless the data were sufficient to explicitly estimate the differences in susceptibility (e.g., the potency of radon in active smokers was assigned a different value from past- and never- smokers). Assumptions made in estimating dose and potency are described below.

Cancer Potency Assumptions

The Human Health Committee decided to use the cancer potency estimates published by regulatory agencies. If multiple cancer potency estimates were available, values developed by Cal/EPA were selected over other published values. If the California Environmental Protection Agency had not derived potencies, those of U.S. EPA were selected as the second choice.

Assumptions commonly made by U.S. EPA and Cal/EPA are the following:

→ In the absence of human data, carcinogenic effects observed in valid, well-conducted, and relevant studies in laboratory animals are indicative of carcinogenicity in humans.

→ Cancer potency in animals can be extrapolated to humans by use of an interspecies scaling factor.

→ Cancer incidence seen at a given dose by one route of exposure (e.g., inhalation, ingestion) will be the same if the same dose is given by a different route, unless available data indicate otherwise.

→ Dose-response models can be used to estimate low dose risks based on experimental observations at higher doses.

→ No threshold for carcinogenesis exists.

For some chemicals, metabolic and physiologic data have enabled regulatory agencies to perform a more complicated analysis to account for the differences in the carcinogenic activity by different routes of exposure, and at high and low doses (e.g., vinyl chloride, methylene chloride). Cancer potency values generally do not account for the potential increased susceptibility of the fetus and newborn, and for situations where significant exposures occur early in life, risks may be understated.

Exposure Assumptions

Depending on data availability, doses for environmental stressors (identified in environmental topic area list II) were usually estimated for exposures from breathing ambient and indoor air, and consuming tap water. An example of an application of the analysis is given in Table 6 (Attachment B), which presents risk estimates for four volatile organics (topic area II-12) measured in drinking water, and ambient and indoor air monitoring studies. In the HHC's calculations, continuous exposure to current levels was assumed. Given population migration and developing regulatory controls on toxicants, this assumption could result in an overstatement of risk. It could also result in an understatement of risk where large future exposures may occur (e.g., plume of groundwater contamination moving toward well head). Further assumptions made in deriving exposure estimates are discussed below.

Tap water

→ Tap water exposures to volatile organics were assumed to occur through ingesting the water, inhaling volatiles as they are released from the water (primarily during and just after showering), and absorption through the skin.

→ Variability in exposures among Californians by the three routes were assumed to be described by a statistical distribution.[19]

→ Water at the tap was assumed to have the same concentration as water entering the distribution system (where monitored).

→ Exposures to water from contaminated wells were assumed to occur to those living nearest to the well, with the number of people served calculated by dividing the number of people in the system receiving well water by the number of active wells in the system.

→ Concentrations were assumed to be those in the California Department of Health Services (CDHS) computerized data base of monitoring results submitted by water purveyors. In characterizing the distribution of exposure across the population, exposure was assumed to occur only if detected through sampling of a water source and included in the CDHS data base. Since the data base does not include all monitoring results, and concentrations associated with significant risks for many compounds may fall below the detection limit, this procedure may substantially understate exposures of concern.

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[19] Water consumption intakes are assumed to be log normally distributed. The parameters of the distribution were derived from "best" and "upper confidence" values provided by Thomas McKone of Lawrence Livermore National Laboratory and colleagues in risk assessment reports submitted to the California Department of Health Services and Cal/EPA.

→ The concentration in water from an individual well was assumed to be the average of measurements taken. Non-active wells were excluded from the analysis.

→ Radon was treated as an exception. The California Department of Health Services data base contained information on few wells. The county-by-county radon averages reported in a document developed for use by the water utilities [20] were assumed to be representative of radon exposures across the State.

→ Known plumes of groundwater pollution which are not reported in well head measurements are not considered in health risk estimates, because it is assumed that humans currently are not exposed.

Air

The California Air Resources Board (ARB) developed the data used in estimating inhalation exposures in ambient and indoor environments. The following assumptions were made by the HHC in estimating exposures:

→ Indoor air concentrations across the State can be described by statistical distributions, such as the "log normal" distribution.

→ Representative statewide indoor air concentrations can be derived from monitoring surveys of residences in Woodland, Los Angeles, Riverside, Placerville, and other California locations.

→ A distribution of values of the amount of air that different population subgroups breathe indoors and outdoors can be estimated from California activity pattern data and pulmonary ventilation data.

→ Exposure assessments developed by ARB through their monitoring network provide an estimate of ambient air concentrations experienced by individuals in the population. The monitoring network was designed to characterize exposures of the general population, and provides only limited information on the variability of concentrations experienced by individuals, including those experiencing elevated concentrations near emitting facilities and heavily traveled transportation corridors.

Report of the Ecological Health Committee

Ranking Risks to Ecological Health

PREFACE

The results and recommendations of the Ecological Health Committee speak for continued and innovative environmental protection. California's diverse ecological systems are under increasing pressure from an array of stressors produced by human activities. It is my opinion, that the situation

[20] Kennedy/Jenks Consultants (1991). Impact Analysis of the Proposed Radon Drinking Water Regulation on California Water Utilities. Final Report for the Association of California Water Agencies. Kennedy/Jenks, San Francisco, October.

can only worsen unless preservation of ecological resources is factored into the land-use conversions required by California's increasing human population. Hopefully, the results and recommendations of this report will be useful in that effort.

One of the major goals I had for the Ecological Health Committee was to identify, develop, and utilize a methodology which would enable future comparative risk teams to fill the identified data gaps, incorporate new information, and perform subsequent comparative risk rankings more easily and more rapidly. I believe we have accomplished that goal.

The Ecological Health Committee of the California Comparative Risk Project benefited from a diverse base of membership. Several members gave extensively of their time, expertise, and energy in completing this report. I would like to personally thank Jim Bennett, Ed Fendick, Will Gala, Mary Ellen Harris, Bob Rollins, Bobbye Smith, and Brent Takemoto for their special efforts.

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INTRODUCTION

Articles describing dramatic changes in animal and plant populations and ecosystems appear regularly in newspapers and popular literature. There is little doubt that human activities are having significant negative impacts on California's natural resources. These negative impacts are caused by direct action, such as clearing the land, or the production of some type of chemical or physical stressor which acts on ecological systems. For example:

> *Urban development has decreased the historic habitat of the Stephens' Kangaroo Rat in Riverside and San Diego County from 308,000 acres to 21,000 acres in 1990. That species is now in danger of extinction and has been placed on both the State and Federal Endangered Species lists.*
>
> *The winter run of Chinook salmon in the Sacramento River system, estimated by returns to the Red Bluff diversion dam, has fallen from nearly 120,000 in 1968 to approximately 100 in 1991, due mainly to impacts associated with water diversion.*
>
> *Agricultural drain water enriched with selenium caused documented reproductive failure in aquatic birds nesting at Kesterson Wildlife Refuge from 1983 through 1985. That threat has been reduced considerably in recent years. But aquatic birds using agricultural evaporation ponds at other locations in the Central Valley currently demonstrate similar, though less severe, reproductive effects.*

The Ecological Health Committee (EHC) of the California Comparative Risk Project (CCRP) sought to define and rank those activities or stressors having the greatest negative impact on ecological systems within California (see Attachment A for the membership list).

Methodology

A flow diagram illustrating the major decision points in the committee's deliberations can be found at the end of this chapter (Figure 1).

The Ecological Health Committee began development of a threat list before the Human Health and Social Welfare committees. The Ecological Health Committee's initial step was to develop a comprehensive list of potential threats to California's ecosystems. Three approaches were considered in developing that list:

1) ***Existing lists.*** Compile the lists of threats addressed by other federal and state comparative risk projects. This list could be developed relatively quickly, leaving more time to consider a relative ranking of threats in California;

2) ***Media-specific lists.*** Develop a list of potential threats based on release to specific environmental media. This approach would distinguish releases to air from releases to land and water; and

3) ***Organization-based lists.*** Develop a list of potential threats based on the current regulatory organization of the California Environmental Protection Agency (Cal/EPA). This approach would provide information immediately useful to Cal/EPA managers in the areas of air, water, and toxics.

The Ecological Health Committee decided, after review of a draft list of threats used by other comparative risk projects, that a compilation of existing lists would be too general and contain too many levels of threats to be easily used in ranking ecological threats in California.

The media-specific approach was judged unacceptable because impacts on ecological systems are frequently the result of stressors in all environmental media. For example, the benthic community of San Francisco Bay is impacted by polycyclic aromatic hydrocarbons deposited from air and delivered to San Francisco Bay by water.

The Ecological Health Committee found the Cal/EPA organization-based approach to be insufficient because the organizational structure does not currently address all of the environmental threats the EHC had identified. For example, logging and its associated impacts are regulated by the California Department of Forestry and Fire Protection, while stream-bed alteration (which can be associated with logging) is regulated by the California Department of Fish and Game.

The Ecological Health Committee, therefore, decided to use an entirely different approach, which would allow consideration of both numerous stressors applied to a single ecological unit and a single stressor which affects numerous ecological systems. Such a method, referred to as the "exposure pathway" approach, would not be constrained by previous compilations of threats or an existing organizational structure.

The Ecological Health Committee and the two other California Comparative Risk Project risk-ranking committees were also asked to use a common environmental topic list template to present a ranking of common environmental threats. The common environmental topic list is divided into three areas. Topic list III, "Potential Threats to Environmental Integrity," was based on the highest organizational level of the EHC's "exposure pathway" model. All three of the topic list sections were developed prior to completion of the EHC's ranking. The listings for the EHC in the topic lists are, therefore, translations of the final ecological rankings to these topic lists.

Pathway Effect Model

To develop a list of potential threats to ecological systems in California, the EHC used a model which draws from exposure analysis. This model can be presented as the complete "exposure pathway" from an "activity" which produces a "stressor" (e.g., a pesticide) moving through an environmental "medium" (e.g., air or water), to impact a biological "receptor." Any change in the biological receptor which can be measured is the "effect" produced by that "stressor." This exposure pathway can be presented as:

Activity ∅ Stressor ∅ Medium ∅ Receptor ∅ Effect

The model can be applied to many different ecological processes. For instance, fish kills in the upper Sacramento River due to the spill of metam sodium near the town of Dunsmuir in 1991 would be presented as:

Transportation ∅ Pesticides ∅Water ∅ Fish Populations ∅ Mortality

The model is, however, limited in several ways. First, and most significantly, stressors which do not reach a biological receptor cannot produce an effect and therefore were excluded from the analysis.

Chemical stressors released to groundwater, for example, would not be considered in this type of analysis unless the contaminated groundwater is pumped to the surface, or the groundwater surfaces naturally, where it can contact a biological receptor.

Second, stressors present in the environment, but below the level needed to produce an effect, were also excluded. Ecological systems can withstand some level of most stressors without displaying measurable negative effects. Not all releases of stressors, therefore, create a negative impact on ecological systems. Only those activities or stressors producing fairly significant effects were included for ranking. Aquatic sediments which are contaminated with heavy metals above "normal" levels, for example, would not be included unless there is an observable effect due to that level of heavy metal concentration.

These constraints were not believed to be serious limitations, as the purpose of this risk-ranking exercise is to identify and rank the most significant threats, with the goal of applying regulatory resources to reduce or eliminate them.

The Ecological Health Committee formed study teams based on experience or interest to develop the list of potential threats based on nine general topics:

1) ***Commercial/Industrial Practices.*** Activities usually taking place on an industrial or commercial property, including production or manufacturing, which generate materials leaving the property boundary in air, water, or soil.

2) ***Municipal/Governmental Practices.*** All activities conducted under the direction of a governmental body of any size for support of infrastructure, including corporation yards, municipal utilities, public works, landfills, road maintenance practices, housing development, infrastructure activities at Federal facilities, and county activities.

3) ***Residential/Commercial Practices.*** All activities in and around personal residences, including releases from personal residences, such as wood burning, painting, fertilizer application, stormwater runoff, consumer product use, and other household practices.

4) ***Natural Resource Practices.*** Collection of mineral, animal or plant resources from natural, non-managed settings, including any extraction from systems which are not managed for replacement such as fishing or timber harvest of old growth forests.

5) ***Electrical Energy Management Practices.*** Generation and transmission of electrical energy for industrial, municipal, or residential uses.

6) ***Transportation Systems.*** Activities related to the construction, maintenance, and use of facilities for transport of goods, people or materials, including building and operation of airports and seaports, transportation by pipelines, releases or spills during transport, and introduction of non-native species by transportation activities.

7) ***Agricultural Practices.*** Production of plants or animals for food, fiber, or ornamental purposes, including aquaculture and silvicultural practices.

8) ***Water Management Practices.*** Extraction, diversion, conveyance, and storage of groundwater and surface waters.

9) ***Recreational Activities.*** Direct impacts associated with recreational facilities, including land-use planning impacts and releases related to leisure activities.

Impacts associated with race tracks, tennis courts, hot air balloons, golf courses, dog and cat breeding, fish hatcheries, lead from shotgun pellets, river rafting, and ski areas are included.

After several attempts to develop a list of threats to ecological systems using a "top-down" approach, the EHC decided to use a "bottom-up" approach, starting from the "effect" on biological "receptors" up the exposure pathway to the "stressor" and "activity." The Ecological Health Committee believed that grouping all the exposure pathways developed in this manner would produce a reasonable and supportable list of threats to ecological systems.

Approximately 100 exposure pathways were developed by the study teams. Most study teams concentrated on those "effects" which were the most significant based on the available literature and best scientific judgment.

Ranking Effect Pathways

Each study team developed a complete exposure pathway associated with the biological effect being investigated. Then, four ranking criteria were developed and applied to each exposure pathway. These ranking criteria were: Intensity, Extent, Reversibility, and Probability/Uncertainty. Each ranking metric ranged from 1 (low) to 5 (high).

Intensity - a measure of the ecological severity of the effect

1 - Non-lethal effects on individual organisms only

2 - Loss of individual organisms

3 - Non-lethal effects on whole populations

4 - Loss or exclusion of populations

5 - Complete destruction of an ecosystem

Extent - a measure of the proportion of the ecosystem type affected

1 - Less than one percent of the ecosystem affected

2 - One to five percent of the ecosystem affected

3 - 5 to 10 percent of the ecosystem affected

4 - 10 to 50 percent of the ecosystem affected

5 - 50 to 100 percent of the ecosystem affected

Reversibility - a measure of the time required for the system to recover

1 - Less than one year

2 - One to five years

3 - 5 to 20 years

4 - 20 to 70 years

5 - Unrecoverable (greater than 70 years)

Uncertainty/Probability - a measure of the certainty that the effect will occur or the probability that the event producing the stressor will occur

1 - No direct evidence that effect will be produced

2 - Effect is possible based on understood biological principles

3 - Effect is probable based on experience with similar situations

4 - Some effects have been measured

5 - Effect documented to occur

These ranking metrics were applied to all exposure pathways by the study teams. Each study team then summed the scores, which could range from 5 to 20 for each exposure pathway. All the exposure pathways were then ranked as "high," "medium," and "low" within each study area based on the summed score.

The next step was to determine the appropriate ranking for the effects in comparison with all the effects investigated. The Ecological Health Committee considered all effects ranked "high" by the study teams and evaluated whether each should be ranked "high" across all study areas, given the significance of the effect in ecological systems throughout California. Each study team presented their evidence in support of ranking the effects "high" and the EHC voted.

Effects which did not get majority support to be considered "high" were ranked "medium." Several effects which failed to get a majority vote as originally described were combined and voted upon again. Effects which were ranked "medium" and "low" within the study team area were given the same "medium" or "low" rank across all study areas. The "medium" and "low" ranked effects were also evaluated to determine whether a combination of several medium-ranked effects would elevate the combined effects into the next higher category. No "medium" or "low" ranked effects were elevated to a higher rank.

Aggregating Effect Pathways

Approximately 75 exposure pathways remained after the initial ranking across all nine study areas. The original pathway numbering system was retained during revision and consolidation to prevent confusion. These 75 exposure pathways spanned a broad range of "activities," "stressors," and "effects." A workgroup of EHC members considered several methods of aggregating these effects into a manageable number. It became obvious that there was insufficient data to partition the relative contribution of each environmental topic list III component (e.g., industrial, municipal, or residential practices) to the same effect. As mentioned above, ecological systems can bear some level of most stressors without displaying measurable negative effects. Release of stressors to the environment, therefore, does not equate to a predictable level of negative impact on ecological systems.

The workgroup decided to attempt an aggregation based on: 1) single stressors, or groupings of stressors, which are the cause of different types of effects; and 2) activities which produce many kinds of stressors.

First, the workgroup examined the list of exposure pathways ranked "high" across all study areas. Exposure pathways which contained a similar "activity" or "stressor" portion of the exposure pathway were then grouped and ranked as "high." For example, the "atmospheric oxidants" aggregate threat was developed from four exposure pathways including those from the Industrial Practices, Transportation, Electrical Energy Management, and Residential Practices workgroups, each of which had been ranked "high" individually. These groups were termed "aggregate threats" because many exposure pathways were grouped, or aggregated, by a common "activity" or "stressor."

Second, "medium" and "low" ranked exposure pathways which matched the "high" ranked aggregate threat under "activity" or "stressor" were included in the matching aggregate threat. To continue the "atmospheric oxidants" example from the previous paragraph, five medium-ranked exposure pathways were added to the "atmospheric oxidants" aggregate threat: two from the Recreational Practices workgroup, one from the Transportation Systems workgroup, one from the Residential Practices workgroup, and one from the Agricultural Practices workgroup.

The aggregation workgroup reasoned that release of an additional amount of the stressor or similar activities in different settings are more likely to increase the effects attributed a "high" ranked aggregate threat than produce a completely different effect. The remaining medium-ranked exposure pathways were grouped by stressor or activity and ranked as "medium" aggregate threats. The remaining low-ranked exposure pathways were grouped and ranked as "low" aggregate threats.

The rankings of the aggregate threats were reviewed by the EHC and changes in rank were made by majority vote. This grouping of exposure pathways into aggregate threats provided the following benefits:

1) Because the general public has already heard of many of these aggregate threat groups, communicating the groupings and rankings to the public will be easier.

2) The groupings provide some flexibility to risk-reduction strategies. Each of the activities grouped into an aggregate threat can be examined to determine which would be most amenable to regulatory action and which would provide the greatest reduction in threat.

AGGREGATE THREAT RANKINGS

The Ecological Health Committee's ranking of aggregate threats is shown below. No significance should be attached to the order in which individual entries appear within the "high," "medium," or "low" groupings. Placement refers only to the order in which the working group performed the aggregations.

High-ranked aggregate threats

a. Resource extraction from terrestrial ecosystems

b. Resource extraction from aquatic ecosystems

c. Mining waste and drainage

d. Water diversion

e. Introduced species

f. Atmospheric oxidants

g. Urban runoff

h. Urban sprawl

Medium-ranked aggregate threats

a. Accidental releases of hazardous materials

b. Municipal wastewater

c. Persistent toxicants

d. Greenhouse gases

e. Petroleum, natural gas, or geothermal development

f. Recreation

g. Pesticides

h. Crop irrigation and grazing practices

Low-ranked aggregate threats

a. Wild fires

b. Acid deposition

c. Pathogenic microorganisms

d. Particulates

e. Road development

The complete list of exposure pathways (Table 1, Attachment B) and a summary list outlining the ecosystems impacted by each exposure pathway is attached (Table 2, Attachment B). An additional

listing of sensitive ecological receptors for each aggregate threat is also provided (Table 3, Attachment B).

DISCUSSION OF AGGREGATE THREATS

The Ecological Health Committee believed there was a significant difference in threat when crossing from the "high" ranked group to the "medium" ranked group and from the "medium" ranked group to the "low" ranked group. Several activities which might be considered significant threats to ecological systems in California, based on the results of other state and federal comparative risk projects, either do not appear in the ranking or are ranked relatively low. The aggregate threat summary and the detail sheets for each exposure pathway should be consulted for full documentation of the effects used to rank each aggregate threat.

Resource Extraction From Terrestrial Ecosystems

Definition

Physical alterations and resource extraction resulting from activities associated with the harvesting of natural resources (e.g., timber, biota, soil) from terrestrial ecosystems such as forests, including alterations to native habitats caused by performing removal processes (e.g., clear cuts, loss of spotted owl habitat, loss of old growth forests), site preparation (leveling the land, erecting temporary structures), gaining access to the site (building roads) or post-harvest maintenance (burning wood residues, removing snags). This aggregate also includes impacts on soil condition (e.g., compaction, erosion, chemical inputs) and adverse effects on species biodiversity and sustainability of harvest (CCRP Ecological Health Committee).

History

Sacramento Valley riparian woodlands were logged rapidly after the Gold Rush for fuel, fencing, and other uses. The Gold Rush also induced logging of the Sierra pine forests for mining timbers. Riparian redwood and spruce riparian forests were the first forests logged on the North Coast. North Coast logging continued until World War II and accelerated after the war due to population growth. (Summarized from California State Lands Commission, 1993.)

Current condition

Once trees are felled and cleared of limbs, the logs must be moved to the nearest transportation access. Most log moving in California is performed by large tractors. Removal by helicopter or cable system is more expensive and reserved for steeper slopes. Construction of logging roads and landing areas for log accumulation have the greatest impact on rivers. Limbs and remaining organic material (slash) is usually burned. Logging near rivers can contribute substantial amounts of logging waste to rivers. Logging riparian stands can cause significant increases in river temperatures. (Summarized from California State Lands Commission, 1993.)

Resource Extraction From Aquatic Ecosystems

Resource extraction from aquatic ecosystems includes both the intentional and unintentional taking of organisms from aquatic ecosystems. For example, California salmon populations are intentionally harvested by commercial and recreational fishing while some estimates of unintentional take of juvenile

fish are as high as 10 million per year killed through unscreened water diversions in the Sacramento River system.

Definition

Decreases in plant, invertebrate and fish populations, and alterations in biological communities resulting from activities associated with the commercial and recreational fishing in freshwater and marine ecosystems, including physical alterations to native habitats caused by performing removal processes, gaining access to the site (trampling river banks) or post-harvest practices (dumping fishing wastes overboard). Also includes impacts on water quality (e.g., chemical inputs, increased turbidity, sedimentation) and adverse effects on species biodiversity and sustainability (CCRP Ecological Health Committee).

History

Several aquatic populations have supported a significant fishery prior to population decline. California salmon and the sea urchin are cited as examples of dramatic population declines attributable, in part, to harvest activities.

California ocean salmon harvest has averaged over seven million pounds per year over the last 30 years (California State Lands Commission, 1993). Northern California urchin fishery was first permitted by California Fish and Game in 1985. The northern California urchin fishery supported a catch in excess of 30 million pounds as recently as 1988 (Pete Kalvass, Department of Fish and Game, personal communication).

Current condition

Salmon landings during the decade of the 1990s were one-quarter to one-half of the recent average catch. Ocean commercial fishing was banned in 1992 to protect the Klamath River run salmon. Ocean and recreational fishing were limited in central California to protect the winter-run Chinook salmon on the Sacramento and fall-run Chinook on the Klamath River. Water diversions which are screened to protect aquatic organisms are frequently not protective of eggs, larvae, and juveniles. Unscreened individual diversions in Central Valley rivers are responsible for a loss of an estimated 10 million juvenile salmonids. (Summarized from California State Lands Commission, 1993.)

The northern sea urchin harvest, in pounds landed, has fallen every year since 1988. The estimated harvest for 1993 is approximately six million pounds, a decrease from more than 30 million pounds landed in 1988. The southern sea urchin fishery has declined from approximately 27 million pounds landed in 1990 to an estimated 16 million pounds landed in 1993 (Pete Kalvass, Department Fish and Game, personal communication).

Mining Waste and Drainage

Mining waste and drainage is ranked as a "high" threat due to the input of heavy metals to aquatic systems from closed mines. For example, approximately one ton of heavy metals enter the Sacramento River system each day from Iron Mountain mine.

Definition

Adverse environmental effects caused by pollutants released from mines or mining waste including acid mine drainage or physical alterations to terrestrial ecosystems resulting from activities associated with mining, including alterations to native habitats caused by performing removal processes

(excavating sites, releases of particulates), site preparation, gaining access to the site, or post-mining practices (CCRP Ecological Health Committee).

Current condition

The largest mining industry in California is aggregate mining. River channels and flood plains are the primary source of mined aggregate. An estimated 128 million tons of aggregate were mined in 1986. Terrace mining adjacent to the river channel can cause significant habitat changes should the river "capture" the mining pit. (Summarized from California State Lands Commission, 1993.)

"Ninety percent of the copper, zinc, and cadmium measured in the Sacramento River originate from inactive mines. Iron Mountain Mine near Keswick and Shasta dams discharges more metals to rivers and streams than any other source in the nation. Approximately one ton of copper and zinc are released daily. This is equal to one-fourth of the discharge from all industrial and municipal treatment plants in the country."

Dredging activities were not necessary in the Sacramento San Joaquin River Delta prior to hydraulic mining activities in the Sierra. Sediment from hydraulic mining raised the river channel bottoms so that dredging was required for continued use of the river for transport.

Penn Mine is a closed copper and zinc mine located on the Mokelumne River between Pardee and Camanche dams. More than 55,000 feet of mine shaft exist at the mine. Introduction of rainwater to the sulfide ore body results in production of sulfuric acid. The sulfuric acid solution dissolves heavy metals such as copper and zinc. A flushing of some mine shafts in 1937 produced a 60 mile long fish-kill. Camanche dam, completed in 1964, stores the heavy metals which can become remobilized by strong river flows, especially when the water level behind Camanche dam is low.

Water Diversion

Definition

Losses of selected aquatic habitats (sites with distinctive ecological characteristics or properties essential to the sustainability of rare or endangered aquatic wildlife) and physical alterations resulting from activities associated with maintaining adequate supplies of clean drinking water (CCRP Ecological Health Committee).

History

The first irrigation ditches were built in 1858 to convey Kern River water (California State Lands Commission, 1993). By 1880 the 100 mile long San Joaquin and Kings River Canal was the single largest irrigation system in California. These water projects were supported by private water companies. The large Federal Central Valley Project began in the 1930s and the State Water Project completed the current system of water storage and conveyance.

Current condition

Water management practices as an environmental threat

Water management practices as a "threat" or "agent" of stress on California ecosystems includes both existing "management" aspects, (e.g., how water is captures, diverted, extracted) and future "development" aspects (e.g., the construction of new facilities). Herein, the existing water delivery system (e.g., dams, reservoirs, State Water Project, Central Valley Project, groundwater wells) were considered as a baseline, or the present state of the environment. Consequently, no judgments were made regarding the ecological significance of the mere presence of the existing infrastructure.

However, environmental alterations resulting from the operations of such facilities are considered (i.e., river habitat losses as a result of impounding flows in dams was not addressed. However, subsequent and continual stream channelization or surface water salinization was considered). While the threats attributable to the future development of water supply systems were not quantified, it appears reasonable to assign a level of risk which is equal to or greater than that assigned to threats associated with the operations of existing facilities.

To provide a common point of reference, the following conditions and assumptions are acknowledged:

→ Water is a limited resource in California.

→ Demands for water continue to increase, often distant from where water supplies originate.

→ Water supply infrastructure disrupts habitat.

→ The majority of the land in the State is and was desert or drought-tolerant habitat.

→ The majority of managed land-use is agriculture.

→ Agriculture is a managed ecosystem.

→ Both surface water and groundwater effect the environment.

→ The "management" of water includes both operation of present facilities and future development of groundwater and surface water resources.

→ The environmental "window" considered by this analysis is 100 years.

Sources and uses of water in California

California receives a total of about 199 million acre feet (MAF) of water per year, from precipitation (193 MAF) and surface water inflow from adjacent states (6 MAF). Approximately 58 percent of this total is used by native vegetation and unirrigated lands, about 25 percent flows to the Pacific Ocean, to salt sinks, and to neighboring states, about 14 percent is diverted for use and about three percent recharges groundwater basins (California State Water Resources Control Board, 1991a).

Managed water uses in California

Annually, surface waters contribute about 60 percent and groundwaters contribute about 40 percent of the total volume of water distributed for use in the State. Of this water, approximately 85 percent is used for agriculture and 15 percent is used for municipal (industrial/commercial/ domestic) purposes. Demographers predict increasing demands on water supplies from both the municipal and industrial sectors. Trends in agricultural demands are uncertain. Financial incentives attendant with "water transfers" from agricultural uses to municipal uses may decrease agricultural demands, it may have no effects, or it may increase agriculture's reliance on groundwater supplies. As evidenced by groundwater overdrafts, agricultural demands in areas such as the San Joaquin Valley and the Salinas Valley have exceeded sustainable supplies (California State Water Resources Control Board, 1991b).

Surface water resources

There are approximately 1,400 Federal, State, and private dams in California (California State Lands Commission, 1993). Threats to surface water resources and their attendant habitats attributable to water management practices are most pronounced within the combined watersheds of the Sacramento River and the San Joaquin River (San Francisco Bay/Delta watershed ecosystem). These watersheds,

draining through the San Francisco Bay/Delta, comprise approximately 40 percent of the land mass of the State and generate an annual surface water runoff of approximately 30 MAF. Over 50 percent of the runoff water from this watershed is diverted for managed uses. Approximately two-thirds of all water consumed in the State comes from this watershed (including groundwater), and about 40 percent of the State's drinking water originates from this source. In addition to these eater supply features, the Bay/Delta Estuary system provides critical habitat for approximately 80 percent of the State's commercial fishing, and it contains Suisun Marsh, the largest contiguous brackish marsh in the United States (providing 30 percent of California's wintering habitat for flyway birds).

The vital water supply and critical ecological characteristics associated with the Bay/Delta watershed substantiate the use of this watershed as the illustrative and premier water management practices example upon which to make related risk comparisons for the entire State.

Groundwater resources

Approximately 40 percent of all water used in California is groundwater, and in times of drought, extractions account for nearly 60 percent of all water used (Water Education Foundation, 1991). Of the 450 groundwater basins/aquifers that underlay about 40 percent of the land area, approximately 250 MAF of water can be economically reached. This is about six times the volume of water that can be held in all existing surface water reservoirs (43 MAF). Agricultural uses account for about 70 percent of total groundwater use and municipal and industrial uses account for the remaining 30 percent.

Relationship between groundwater resources and surface water ecosystems

There are several threats to surface water ecosystems which result from the extraction of groundwater resources. Over-drafting (over pumping) can cause land subsidence which increases soil erosion potential, root zone desiccation affecting shallow-rooted native plants, and submergence of surface flows in river systems (i.e., dry river beds). Additionally, overdrafts cause aquifer compaction and sea water intrusion which result in a (practically irreversible) loss of water supply storage capacity. The loss of storage capacity in groundwater aquifers places increased stress on surface water supplies and their ecosystems.

In this report, groundwater aquifers are not considered "ecosystems" because there are no readily definable suites of organisms associated with them (the possibility that there are unique microorganism assemblages has not been investigated).

Non-indigenous Species

Definition

The condition of a species being beyond its natural range or natural zone of potential dispersal. All domesticated and feral species and all hybrids except for naturally-occurring crosses between indigenous species (U.S. Congress, Office Technology Assessment, 1993).

Current condition

An estimated 4,500 non-indigenous species have established free-living populations in the United States. Twenty of 23 non-indigenous insect species that have become established in California since 1980 arrived on imported plants. San Francisco Bay is now home to 96 species of non-indigenous species such as sponges, worms, and crustaceans. Approximately 300 plant species in California originally escaped from ornamental horticulture. The oleander (*Nerium oleander*) and the edible fig (*Ficus carica*) have established populations in the Central Valley riparian habitat along the Sacramento River. Populations of stickleback (*Gasterosteus aculeatus*) in southern California, outside the natural

distribution boundaries, may be due to accidental transport with intentionally-stocked sport fish. The non-indigenous population of Asian clam (*Potamocorbula amerensis*) in San Francisco Bay grew explosively after a recent flood reduced populations of other San Francisco molluscs more susceptible to lowered salinity. (Summarized from U.S. Congress, Office of Technology Assessment, 1993.)

Effects include reductions in the populations of native species (primarily fish, but also vegetation and mammals) and demographic shifts in species composition resulting from planned and accidental releases of exotic species, including the planned stocking of surface waters with non-native sportfish, and accidental releases of exotic species from airplanes and cargo vessels that transport goods from foreign countries.

The endemic fish fauna of the Great Basin rivers and lakes has been severely impacted by non-indigenous species. The Lahontan Cutthroat trout was abundant enough to support a commercial fishery. Introduction of other trout in combination with water diversion combined to reduce the Lahontan Cutthroat trout sufficiently for it to be listed as a federal threatened species. At least 48 species on non-indigenous fish have become established in California. (Summarized from California State Lands Commission, 1993.)

At least 150 intentionally or accidentally-introduced species of plants or animals currently reside in San Francisco Bay. The first introduction occurred during the Gold Rush when wooden ships were scuttled in the bay after the crews deserted for the gold fields. The Asian clam (*Potamocorbula amurensis*) became the most numerous mollusc in northern San Francisco Bay less than a year after introduction. Twenty years after introduction of 432 striped bass over a million pounds per year were caught. (Summarized from Andrew Neal Cohen, Sacramento Bee, Forum Section, November 28, 1993.)

Yellow starthistle was apparently introduced into California during the 1840s. It has increased from 1.2 million acres in 1958 to 7.9 million acres in 1985. Acreage has increased since 1985, but the recent increase has not been well documented. (Summarized from Maddox *et al.*, 1986.)

Atmospheric Oxidants

Definition

Adverse effects on coniferous trees, and potentially other plants, resulting from gaseous emissions (SO_2, NO_2) and secondary pollutants (O_3) with oxidizing properties. Oxidants are emitted or produced from emissions originating from a wide variety of recreational, industrial, transportation, and residential sources associated with the combustion of fossil fuels (CCRP Ecological Health Committee).

Levels not to be exceeded

Ozone (O_3)

California Ambient Air Quality Standards (AAQS): one-hour average concentration of 0.09 ppm (180 ug/m^3). This was the first oxidant standard when established in 1959 by the Department of Public Health at 0.15 ppm. The ozone standard was revised in 1969 by the newly-created California Air Resources Board (ARB) to 0.10 ppm in consideration of effects on human and animal health, vegetation, materials, and visibility. The ozone standard was last revised in September, 1987 (Stromberg *et al.*, 1987).

National AAQS: one-hour average concentration of 0.12 ppm (235 ug/m^3) (Stromberg *et al.*, 1987).

Sulfur dioxide (SO_2)

California AAQS (short-term): one-hour average concentration of 0.25 ppm (655 ug/m^3). First established by California ARB at 0.50 ppm in 1969, and revised in 1970, 1974, 1975, and 1977 based on bronchoconstriction in asthmatics. The sulfur dioxide standard is designed to protect against adverse effects from short exposures to SO_2 (e.g., 5 to 10 minutes). Last revised in September, 1983 (California Air Resources Board, 1991a).

California AAQS (longer-term): 24-hour average concentration of 0.04 ppm (105 ug/ m^3) based on protecting populations from increased incidence of respiratory disease and excess mortality. Last revised in August, 1991 (California Air Resources Board, 1991a).

National AAQS (short-term): 24-hour average concentration of 0.14 ppm (365 ug/m^3) (California Air Resources Board, 1991a).

National AAQS (short-term): annual average concentration of 0.03 ppm (80 ug/m^3) (California Air Resources Board, 1991a).

Nitrogen dioxide (NO_2)

California AAQS: one hour average concentration of 0.25 ppm (470 ug/m^3). The standard was first established by ARB in September, 1969 based on protecting sensitive individuals from bronchial irritation, biochemical alterations in normal and sensitive populations, and prevent atmospheric discoloration. Last revised in December, 1992 (California Air Resources Board, 1992b; Brisby *et al.*, 1992)

National AAQS: annual average concentration of 0.053 ppm (100 ug/m^3) (California Air Resources Board, 1992b; Brisby *et al.*, 1992).

Current condition (air quality)

Ozone

Thirteen of 14 air basins in the state are either unclassified or nonattainment areas for ozone; the only air basin designated as an attainment area is the North Coast (Nystrom *et al.*, 1993).

Sulfur dioxide

No area in California has violated any ambient air quality standard for SO_2, as recently as the period from 1987 to 1989.

Nitrogen dioxide

The California AAQS was exceeded only in the South Coast Air Basin during the period from 1988 to 1991.

Extent of effects and major concerns

Collectively, the above atmospheric oxidants have been shown to cause damage to a wide variety of plants in California. For the most part, at levels commonly measured in California, plant damage from SO_2 or NO_2 alone, is expected to be minor. In comparison, studies in the southern part of the State, especially in the San Bernardino mountains, have found significant amounts of tree injury on ponderosa and Jeffrey pine from O_3. In recent years, damage has also been reported on pine trees in the Sierra Nevada, suggesting that O_3 levels are present at levels that can cause damage after several successive years of exposure.

Urban Runoff

Definition

Adverse effects on aquatic ecosystems resulting from chemical residues (toxic metals and organics, excess nutrients) in non-point source pollution. These residues originate from a wide variety of municipal and residential practices (CCRP Ecological Health Committee).

Current condition

"The primary cause of water quality degradation in impaired water bodies in California is non-point source pollution. Non-point sources include agricultural, forestry, and urban runoff. Urban, agricultural, and wildland runoff contribute much more significantly to river pollution than point sources such as municipal and industrial discharges." Metals such as cadmium, copper, lead, and zinc are transported to rivers from urban landscape. Gasoline and oil deposited on paved surfaces are a significant source of polycyclic aromatic hydrocarbons (PAHs) for rivers. Pesticides, herbicides, and fertilizers used in residential settings contribute to the stress on aquatic systems. Between 50 and 80 percent of impairment of water bodies is attributable to non-point source discharges. (Summarized from California State Lands Commission, 1993.)

Substantial increases in loadings (kg/year) of heavy metals, nutrients, biochemical oxygen demand, and total suspended solids to the San Francisco Bay Estuary are expected from urban runoff. Urban runoff is the single largest contributor to the volume of pollutants entering the Estuary. (Summarized from San Francisco Estuary Project, 1992.)

"When it rains, silt and other suspended solids wash off plowed fields, construction and logging sites, urban areas, and mined land. Sedimentation can smother benthic communities and alter habitat. Salmonids, which need clean gravel for successful spawning and early rearing, are particularly vulnerable to impacts from sedimentation. Sediments constitute nearly half of the materials introduced into rivers from non-point sources." (Summarized from California State Lands Commission, 1993.)

Urban Sprawl

Definition

Loss of terrestrial and aquatic habitats from the physical alterations resulting from establishment of urban environments (CCRP Ecological Health Committee).

Current condition

"Urban land-use is often traumatic to entire watersheds not only because of the construction of dams and flood control projects, but also because of massive landform changes which alter runoff patterns and drainage networks." Approximately 80 to 90 percent of the riparian habitat in most western states has been eliminated. Urbanization presents the greatest threat to the remaining riparian habitat. Levee construction, to protect development in the flood plain, is an additional threat to the remaining riparian habitat. Infiltration in upper watershed reaches is reduced by extensive artificial cover typical of urban environments. This causes downstream areas to receive higher river flows over shorter periods. Sediment loading peaks during construction and decreases below normal levels afterward. Least Bell's Vireo, presently represented by approximately 300 pairs, is dependent on riparian willow community for nesting sites. Southern California river systems contain most of the few remaining sites. It is a state and federally-listed species. Nest predation by Brown-headed Cowbird is a contributing factor to the decline of the Least Bell's Vireo. Southern California streams, which currently support a remnant

anadromous fish population, supported steelhead populations numbering from 5,000 to 20,000 prior to extensive urbanization. (Summarized from California State Lands Commission, 1993.)

The population of the San Francisco Bay area increased 14 percent during the 1980s making the Bay Area the fourth most populated area in the country. The population of the San Francisco Estuary region is expected to increase an additional 13 percent (San Francisco Estuary Project, 1992).

Accidental Releases of Hazardous Materials

Definition

Local and global environmental effects associated with the release of liquid or gaseous hazardous materials (e.g., toxic hydrocarbons, CFCs, crude oil), accidental releases include large-scale chemical spills from oil tankers and locomotives, unquantified releases from toxic waste impoundments, and gas leaks from waste disposal sites (CCRP Ecological Health Committee).

History

Accidental releases of hazardous substances increased with population growth and the transport of chemicals and hazardous materials required to maintain the industrial and commercial practices and support of the infrastructure associated with a growing California population and manufacturing base.

Current condition

Accidental releases of substances harmful to ecological systems is not an uncommon event. Perhaps the most widely-publicized recent event was the rupture of a tank car containing 19,000 gallons of metam sodium, a soil fumigant, after derailment of a Southern Pacific train near the town of Dunsmuir in July 1991. The alga, fungi, invertebrate, and fish populations were essentially eliminated along 42 miles of the upper Sacramento River. The former wild trout fishery remains closed to protect the surviving wild trout and allow them to repopulate the river. Monitoring of recovery continues under direction of the California Department of Fish and Game.

Municipal Wastewater

The regulatory program in place to lower the threat to ecological systems from municipal wastewater contributed to ranking municipal wastewater as a "medium" threat while urban runoff (non-point source runoff) is ranked "high" because no program is currently in place and control will be difficult.

Definition

Permitted releases from Publicly-Owned Treatment Works (POTWs) (CCRP Ecological Health Committee).

Current condition

Permitted releases from POTWs are approximately three billion gallons per day. Permitted releases from industrial facilities, for comparison, are approximately 600 million gallons per day. The concentration of pollutants in municipal wastewater discharged to surface waters is regulated by

National Pollutant Discharge Elimination System (NPDES) permits for each facility. The regional guidelines for discharge limits are set by each Regional Water Quality Control Board (RWQCB) in the Basin Plan specific for each geographic region.

Persistent Toxicants

Industrial wastewater does not appear as a separate threat because regulated industrial discharges to water are approximately 20 percent of the total permitted discharges to water and the majority of ecological effects seem associated with persistent toxicants from past activities.

Definition

Those materials which, when released to the environment, degrade at a rate slow enough to allow accumulation in environmental media. Adverse effects to aquatic habitats and sensitive species are caused by persistent toxicants released from the commercial processes (industrial practices) or from practices that use the product (residential activities) (CCRP Ecological Health Committee).

History

Metals are a common contaminant which may be distributed by all types of human activity and because they do not degrade, they are persistent in the environment. Mercury was the first anthropogenic persistent pollutant to enter California waters. Approximately 3,500 tons of mercury were used in gold mining activities between 1853 and 1884. Metallic mercury, presumably released during the mining activities of this period, can still be found in California rivers draining the Sierra Nevada. (Summarized from California State Lands Commission, 1993.)

Current condition

Water concentrations of heavy metals in San Francisco Bay and San Diego Bay are determined by sediment concentrations of those metals rather than the water-borne inputs of the metals. Metals built up in sediment are more important determiners of surface water concentrations in these bays than the pollution control efforts directed to permitted discharges (Flegal and Sanudo-Wilhelmy, 1993).

Greenhouse Gases

While some of the ecological effects predicted for greenhouse gases are certainly severe, some greenhouse gas modeling predicts little or no change in temperature. The Ecological Health Committee believed the uncertainty in the range of potential warming predictions and the uncertainty in time period until effects are observed were reason to rank greenhouse gases a "medium" threat.

Definition

Shifts in ecological zones caused by climatic changes associated with the release of gaseous compounds that prevent the re-radiation of long wave infrared radiation. Greenhouse gases (e.g., CO_2, N_2O, CH_4) are produced from a wide variety of fuel use (recreational, industrial, transportation, residential practices) and agricultural practices (animal maintenance, use of fertilizers) (CCRP Ecological Health Committee).

History

Ambient Air Quality Standards. There are no California or National Access for CO_2, N_2O, or CH_4.

Current condition

Air quality

As an example of what kinds of changes could occur over the next 50 to 100 years, the California Energy Commission (1991) assumed that emissions of greenhouse gases could lead an effective doubling of ambient CO_2 between the years of 2030 to 2050 (i.e., to about 700 ppm). One to two decades after the effective doubling of CO_2, air temperatures would increase about 3ÁC (California Energy Commission, 1991).

Extent of effects and major concerns

If projections of global climate models are correct, the natural ecosystems of California may undergo major changes during the next century. Potential major changes include: economic losses in timber, fisheries, and recreation; changes in parks and preserve areas; losses of endangered species; and losses of existing habitat areas. More specific projections are of little value given the uncertainties in model performance and input data (Botkin *et al.*, 1991).

Petroleum, Natural Gas, or Geothermal Development

The Ecological Health Committee believed that the *California Environmental Quality Act* (CEQA) Ecological Impact Report (EIR) process required for any petroleum, natural gas, or geothermal development would protect ecological systems and ranked that threat "medium."

Definition

Activities related to exploring and extracting petroleum, natural gas, or geothermal energy, construction of on-site storage facilities, and on-site use of petroleum, natural gas, or geothermal resources (CCRP Ecological Health Committee).

Recreation

Definition

The loss of native habitat and wildlife due to recreational practices and products disposed in recreational areas, other than those pollutants or practices associated with fossil fuel use or combustion activities (CCRP Ecological Health Committee).

Current condition

Recreational activities which appear to have minimal impact associated with the activity can produce significant potential threat when the activity is continuous. A single gun club contributed an estimated 322 tons of lead, as lead shot, to San Francisco Bay mudflats during 30 years of operation (Sacramento Bee, November 23, 1993, page B3).

"Marina construction; marina and boat operation, repair, and maintenance; and dredging and dredge disposal are the three source categories of marina and boating operations that may cause non-point pollution" (California State Lands Commission, 1993).

Pesticides

Definition

Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any plant or animal pest, for regulating plant growth, or for use as a spray adjuvant in any agricultural or non-agricultural environment (CCRP Ecological Health Committee).

Current condition

California uses about 600,000 pounds of agricultural and non-agricultural pesticide chemicals each year. The three basic sources of information on pesticide sales and use are the *Economic Poison Sales Report*, the *California Pesticide Use Report* (PUR), and national surveys produced by the U.S. EPA Office of Pesticide Programs.

For 1990, the national survey shows about 2.2 billion pounds used of pesticides as active ingredients. About 1.1 billion pounds were "conventional pesticides not including sulfur, wood preservatives, and disinfectants." Approximately 77 percent (or 834 million pounds) of these were used in agriculture.

For 1990, the *Economic Poison Sales Report* totals 578,593,296 pounds of active ingredient sold in California. This totals all pesticides including disinfectants, home use, swimming pool chemicals, spray adjuvants, as well as agricultural and structural pest control. Of this 227,918,275 pounds (39 percent) was chlorine gas, primarily for water treatment.

The *Pesticide Use Report* for 1990 totals 181,899,749 pounds of active ingredient covering most agricultural and structural pest control. It does not include home or disinfectant use. After subtracting sulfur (55.5 million pounds) and structural pest control (9.5 million pounds), the remainder (116.9 million pounds) can be roughly compared to the U.S. EPA figure of 834 million pounds. This means that California uses about 14 percent of the national agricultural pesticide use. (California produces about 16.5 percent of the national crop production.)

On the other hand, these same figures would indicate that California may use about 234 million/ 1.1 billion pounds or 21 percent of the national usage of non-agricultural pesticides with about 9.5 percent of the national population. These usage figures are largely dominated by home and commercial disinfectants and swimming pool chemicals. This does not include chlorine gas for water treatment since U.S. EPA does not include it in any of their figures. Agricultural and non-agricultural pesticide use in California has resulted in incidents of soil and water contamination as well as losses of vertebrate and invertebrate animals.

Crop Irrigation and Grazing Practices

Crop irrigation and grazing practices are ranked as a "medium" threat because this aggregate threat includes effects associated with application of irrigation water, runoff of nutrients, fertilizer application, and burning of post-harvest biomass. Effects associated with agricultural pesticide use are included in the pesticide aggregate threat with municipal and residential pesticide use. Effects associated with diversion of water for agricultural use are included in the water diversion aggregate threat which is ranked as a "high" threat.

Definition

The loss of selected ecosystems resulting from pollutants, excess nutrients in fertilizer, ammonia emissions, or land-use practices converting unmanaged lands into crop growing areas to improve agricultural productivity, other than those pollutants or practices associated with fossil fuel use or combustion activities (CCRP Ecological Health Committee).

History

Spanish and Mexican colonists introduced sheep and cattle grazing to California in the late 1700s. Overgrazing, drought, and introduction of non-indigenous grasses and weeds lead to a dramatic loss of native grasslands. Foothills and forests were used for grazing when grasslands became overutilized (California State Lands Commission, 1993).

Current condition

"The most extensive source of water pollution impairing and threatening the state's rivers and streams is agriculture, primarily from excess nutrients, pesticides, herbicides, sediments, and habitat modification." California agriculture uses approximately 85 percent of the developed water supply on over 8.5 million irrigated acres and river flows are timed to meet agricultural demand. "The SWRCB identified agriculture as contributing to over five percent of the pollution statewide to California's rivers." Agricultural drainage water is one-third the flow of the Sacramento River during peak rice irrigation in early summer.

"Farming and ranching occupy 30.6 percent of the state's land. Livestock grazing by sheep and cattle occurs on half of all the undeveloped land in California, but is mainly concentrated in the Central Coast region, the San Joaquin Valley, and the foothills." (Summarized from California State Lands Commission, 1993.)

"Of the original approximately 545,000 acres of tidal marsh in the Estuary, approximately 509,000 (93 percent) have been diked or filled and converted to other uses -- primarily agriculture -- and salt pond and urban use" (San Francisco Estuary Project, 1992).

Wild Fires

Definition

Accidental ignition of standing plant communities frequently causing destruction of large areas (CCRP Ecological Health Committee).

Current condition

In the California Department of Forestry direct protection area, the number of wildfires per year during the 10-year period from 1984 through 1993 ranged from 6,238 in 1991 to 8,130 in 1988. The number of acres burned in wildfires over the same period ranged from 23,154 in 1991 to 223,282 in 1985. The average number of acres burned per wildfire is weighted by the large number of small fires. Some fires, such as the Malibu fire, the Altadena fire, and the Laguna Canyon fire of 1993, destroy thousands of acres of grassland, brush, or forest, leaving the ground bare and susceptible to severe erosion during rain events.

Acid Deposition

Effects associated with acid deposition are ranked "low" because the principal ecosystems at risk from acid deposition are alpine lakes at elevations of 8,000 feet. The well documented atmospheric impacts on coniferous forests are included in atmospheric oxidants which is ranked as a "high" threat.

Definition(s)

The total loading of hydrogen ions, nitrogen, and sulfur to a given location over a specified period of time from the transfer of acidic air pollutants in precipitation, gases, particles, and fog/cloudwater (CCRP Ecological Health Committee).

"Acid deposition" means the wet or dry deposition of acid chemical compounds from the atmosphere (Health and Safety Code Section 39010.5).

"Acid deposition precursor" means an air contaminant which may be transformed to an acid gas or particle in the atmosphere (Health and Safety Code Section 39010.6).

The transfer of acidity, nitrogen-derived and sulfur-derived compounds from the atmosphere by wet, dry, and fog/cloud deposition processes (paraphrased from many sources).

History

Ambient air quality standards

California does not have an ambient air quality standard for acidic air pollutants. One of the requirements of the Atmospheric Acidity Protection Program is to consider the need for a standard in California. The U.S. Environmental Protection Agency has not established a national standard for acidic air pollutants, but the Federal Clean Air Act Amendments of 1990 call for U.S. EPA to examine the ecological basis for a critical loading standard for acidic deposition.

Enabling legislation in California

In 1982, the Governor of California and the California Legislature adopted the Kapiloff Acid Deposition Program, establishing a research and monitoring program in California to study the environmental effects of acidic deposition. The major findings from the Kapiloff program were summarized in five annual reports and a technical summary in 1989. Later that year, the Governor and

Legislature approved the Atmospheric Acidity Protection Program to address the recommendations of the Kapiloff program and to consider the need for ambient air quality standards for acidic air pollutants (Takemoto *et al.*, 1992).

Current condition

Air quality

The Air Resources Board operates the California Acid Deposition Monitoring Program (CADMP) to measure levels of atmospheric inputs from wet and dry deposition. At selected sites, the 25-station wet deposition network has been in operation since 1983, and the 10-station dry deposition network has been in operation since 1988. The range of annual average pH levels in the wet deposition network through June 1990 was 4.79 to 5.54, considerably less acidic than rain in the eastern United States. On a regional basis, the average acidity of wet deposition is highest in southern California. From July 1989 to June 1990, daytime 12-hour average concentrations of nitric acid vapor ranged from less than 0.1 to 5.7 ug/m^3.

Extent of effects and major concerns

While effects on manufactured materials are projected to be minor, the long-term impacts of acidic air pollutants alone, or in combination with atmospheric oxidants, on ecological resources and human health are highly uncertain. Mid-elevation mixed conifer forests are exposed to high levels of oxidants and nitrogen deposition in mountains surrounding the South Coast Air Basin, and the acid-neutralizing capacity of soils in high-elevation watersheds in the Sierra Nevada is limited, creating the potential for long-term ecological damage (Takemoto *et al.*, 1991).

Pathogenic Microorganisms

Definition

Microorganisms which cause some adverse environmental effect due to resource over utilization, pathenogenicity, or toxins (CCRP Ecological Health Committee).

Current condition

Wild birds and mammals are susceptible to viral and bacterial infection from domesticated animals (David Jessup D.V.M., California Department of Fish and Game, personal communication). Viral infection can cause catastrophic mortality in wild populations. Waterfowl can be infected by a herpes virus causing a disease called "duck plague." The potential for adverse effects on bird populations is evident in the current "duck plague" outbreak in the finger lakes region of New York State where "approximately 14,000 waterfowl have died to date." There have been no massive die-offs of this magnitude yet in California. Several minor outbreaks of "duck plague" have occurred in California, most recently in the Venice Beach area of Los Angeles in 1993. California Fish and Game controls outbreaks of "duck plague" by removing infected and potentially infected waterfowl. Avian influenza and Newcastle disease are two other viral diseases which can be transmitted to wild bird populations. Desert big-horn sheep populations can be devastated by infections of *Pasteurella sp.* pneumonia transmitted from domestic sheep. There are two documented cases of die-offs of entire herds of a state-listed subspecies of desert big-horn sheep due to infection from domestic sheep. Deer mortalities in the thousands are attributed to infection by three viral diseases, among them the virus causing "bluetongue" (Jessup *et al.*, 1984; Jessup, 1985; Jessup *et al.*, 1990).

Particulates

Definition

Atmospherically distributed particles (with diameters equal to or smaller than 10 micrometers) (CCRP Ecological Health Committee).

Levels not to be exceeded

Suspended particulate matter

California AAQS (short-term): 24-hour average concentration of 50 ug/m^3 modified after the total suspended particulate standard adopted in 1969. Suspended particulate matter (PM10) standard adopted by the California Air Resources Board (ARB) in 1982 based on recommendations by the California Department of Health Services based on studies that people with serious respiratory illness suffer increased death rates when exposed to elevated levels of PM10. Particulate matter from diesel exhaust is classified as a probable human carcinogen by the World Health Organization.

California AAQS (longer-term): annual geometric mean of 30 ug/m^3 based on the effects of long-term exposure studies and the lifetime risk posed by carcinogens in PM10.

National AAQS (short-term): 24-hour average concentration of 150 ug/m^3 based on a lung function responses in children living in Steubenville, Ohio.

National AAQS (longer-term): annual arithmetic mean of 50 ug/m^3 based on respiratory effects in children and adults.

One observation, visibility-reducing particle

California AAQS: in sufficient amount to reduce prevailing visibility to less than 10 miles when relative humidity is less than 70 percent (except for the Lake Tahoe Air Basin, where the visual range is 30 miles).

Enabling legislation in California

The California Clean Air Act of 1988 identified PM10 as a tier II air pollutant and directed the ARB to conduct a comprehensive examination of the causes and effects of PM10. In its report to the Legislature, the ARB would address: 1) the extent of the nonattainment problem, 2) the significance of natural and windblown emissions, 3) the effectiveness of control measures, 4) attainment plans, 5) monitoring and modeling information needs, and 6) the earliest practical attainment date (Spears *et al.*, 1991).

Current condition

Air quality

The 24-hour California AAQS is exceeded in 13 of 14 air basins designated in the state, while the annual average California AAQS is exceeded in 11 air basins. There are also problems with meeting the State's visibility standard; only the Lake County Air Basin is in attainment with the standard for visibility-reducing particles.

Extent of effects and major concerns

While there are major concerns regarding the effects of PM10 on human health, effects on visibility are of concern for ecological resources in the State.

Road Development

Definition

Reductions in large mammal populations (e.g., cougars) and other vertebrates due to the establishment of roadways in migration paths (CCRP Ecological Health Committee).

Current condition

Road development and use of roadways in relatively undeveloped areas is known to have an impact, in terms of direct mortality due to vehicle collisions, on slow-moving vertebrates such as desert tortoises (EnviroPlus, 1993). Underpasses to allow passage below roadbeds have been constructed in the desert for tortoises and in northern California for amphibians. Migratory large mammals such as deer suffer mortalities due to vehicle collision. Large predatory mammals, such as mountain lions, may have the size of their seasonal home ranges restricted resulting in decreased carrying capacity.

RECOMMENDATIONS OF ECOLOGICAL HEALTH COMMITTEE

Recommendations Based on Ranking

The ranking of each aggregate threat should not be interpreted as a prioritization for legislative or regulatory action. The ranking of aggregate threats by the EHC incorporated evaluation of available data together with decisions based on best scientific judgment. The aggregate threats and the rankings assigned were influenced by the experience and knowledge of the committee members. The Ecological Health Committee believes the aggregate threats, as presented, reflect the major potential threats to California ecological systems and that there is a major difference in the magnitude of the threat between the high, medium, and low groups.

The protection afforded by in-place regulatory programs is factored into the ranking. Ecological systems in California have suffered significant alteration in the period since the large human influx during the Gold Rush in the mid-1800s, but these changes are not addressed in the EHC's ranking. The baseline for ranking the aggregate threats is the condition of California ecological systems between approximately 1990 and 1994. The protection afforded by in-place regulatory practices is, therefore, factored into the rankings and reduction of these in-place regulatory programs would cause associated threats to become more significant.

Increased human population coupled with the associated land-use changes present "overarching" impacts on California ecosystems. The size of the human population, the location of population centers, and the development and operation of the infrastructure necessary to support the human population pose the most serious current threat to California ecosystems. The potential for further degradation of ecological systems could be reduced by regional or Statewide land-use planning, which incorporates consideration of ecological impacts. This regional or Statewide land-use planning could provide input for local land-use decisions.

Protection of groundwater resources is a serious problem which should be addressed. Contamination of groundwater which does not come in contact with a biological receptor via natural discharge to the surface or active extraction by humans was not ranked by the EHC because of the exposure model used in the study. However, the EHC believes that groundwater resources should be protected to the same degree that surface waters are protected. Protection of groundwater resources should address potential contamination as well as excessive consumption rates.

Recommendations for Further Research

The threat associated with contaminants in non-point sources and contaminated sediments should be addressed. Industrial and municipal point source discharges are currently regulated. There is information indicating a majority of the current contaminant input to rivers, bays, and coastal areas is associated with non-point residential, municipal, and agricultural sources. Recent studies indicate that contaminants already in sediment may contribute more to water column concentrations in enclosed bays than surface water inputs. Continued input of contaminants from former mining operations seriously impact water quality in parts of California.

Ecological systems impacted by multiple toxicants in multiple media should be studied more fully. Some ecological systems are at greater risk, just as certain human populations are at greater risk, due to multiple exposures. These ecological systems should be studied more fully because potentially severe impacts will first appear in these systems. Salmon populations, biological communities in enclosed bays or estuaries, coniferous forest ecosystems near large population centers, and migratory waterfowl populations are examples of ecological systems exposed to multiple threats. The impact of introduced species on ecological systems already under stress should be included in the investigations.

Loss of diversity is a significant threat which should be assessed. Decreases in species diversity pose a threat to California ecological systems. This is more difficult to assess than acute mortality or elimination or geographic restriction of habitat. More effort should be directed to determining the degree that species diversity is reduced, and the degree that ecosystem functions are impaired in the most heavily impacted ecological systems of California. Introduction of non-indigenous species may be a significant threat to California ecosystems, with reduced species diversity due to other impacts.

Recommendations Relating to Comparative Risk

Incorporate comparative risk in programmatic decisions. The results of the risk-ranking component of comparative risk studies provide ranked threats which can be evaluated, based on criteria such as degree of threat reduction and ease of implementation, for inclusion in programmatic planning. The results of the EHC ranking represent the current threats to ecological systems. The Ecological Health Committee was hampered by the difficulty involved in locating information on impacts to ecological systems. Resources should be directed to locate and characterize the wealth of ecological information already collected by regulatory agencies. Once the information is characterized and made available, the comparative risk rankings should be regularly reviewed and updated as necessary.

TRANSLATION TO THE ENVIRONMENTAL TOPICS LIST

The Ecological Health Committee translated the aggregate threat rankings to each group of the environmental topics list.

Translation to List I

Translation to list I of the environmental topics (Table 4, Attachment B) produced a ranking with one "high" topic ("non-point source releases") and one "low" topic ("residential and consumer product sources") with the remaining topics ranked as a "medium" threat. As a group, "releases to water" probably produce the most significant immediate effects in ecological systems. "Releases to land," however, can serve as a cause for long-term ecological effects depending on containment.

Translation to List II

Some environmental topics of list II were not addressed by the EHC. For example, significant ecological effects were not attributable to "carbon monoxide" (topic II-2) and "environmental tobacco smoke" (topic II-3). List II topics not evaluated by the EHC are indicated by a "U" (Table 5, Attachment B).

Other aggregate threats translated easily to the environmental topics on list II. For example, the aggregate threat "greenhouse gases" translated directly to the equivalent "green house gases" (topic II-5) and "persistent toxicants" translated directly to the equivalent "persistent/bioaccumulative organochlorines" (topic II-13).

Still other aggregate threats are covered by more than one environmental topic in list II. For example, "ozone" (topic II-15) and "SOx and NOx (including acid deposition)" (topic II-25) are both included in the "atmospheric oxidants" aggregate threat. Both list II topics were given the rank of the "high" which "atmospheric oxidants" received.

Finally, there are some environmental topics in list II which would include multiple aggregate threats. For example, "inorganics (topic II-6)" would include "mining waste and drainage," "urban runoff," "municipal wastewater," and "persistent toxicants." In this case, the list II topic was given the rank of the highest-ranked aggregate threat.

Translation to List III

Translation to the environmental topics in list III proved least satisfying. This reflects the EHC's inability to collect data defining the individual contributions of the list III topics and was the reason the EHC developed aggregate threat groupings. Two separate methods of ranking the list III topics were applied.

The first method was to assign the same rank as the highest ranked exposure pathway for each aggregate threat in the nine list III topics (Table 6, Attachment B). This produced a set of list III topics which had only "high" and a set of list III topics with mixed "high," "medium," and "low." The list III topics with only "high" exposure pathways were "commercial/industrial practices," "natural resource

practices," and "water management practices." A group indicated by "H" had mostly "high" exposure pathways with some "medium" exposure pathways. A third group, indicated by "M" had mostly "medium" exposure pathways.

While some of these rankings conform with information reviewed by the EHC, the inability to factor out the specific inputs from each list III topic makes interpretation difficult.

The second method assigned a numeric value of 3 for "high," 2 for "medium," and 1 for "low." The numeric total of the exposure pathways for each aggregate threat in the nine list III topics (Table 7, Attachment B). The ranking by this method is greatly influenced by the number of exposure pathways developed by the study groups for each list III topic. "Recreational practices" ranked second, while "water management practices" ranked last. This method of ranking does not work in cases where the list III workgroups developed vastly differing numbers of exposure pathways. The data reviewed by the EHC does not support the results of this second ranking method.

Success of Translation

The Ecological Health Committee was generally dissatisfied with the results of the translation. The most satisfactory translation was to the environmental topics list II. The results of the translation to environmental topics list I and environmental topics list III would require substantial subjective revision to conform with the EHC member's perception of threats to California ecological systems. The Ecological Health Committee believes the ranking of aggregate threats provides the best means to evaluate and utilize the ranking of threats to ecological systems.

UNFINISHED BUSINESS

Some of the tasks initially considered by the EHC were not completed due to lack of time. Additionally, several difficulties were encountered in the ranking process which should be addressed prior to any future ecological comparative risk efforts. The incomplete work and ranking difficulties are each discussed individually.

The Activity by Stressor Matrix

The Ecological Health Committee adopted an exposure pathway model to assess impacts to ecological systems:

Activity ∅ Stressor ∅ Medium ∅ Receptor ∅ Effect

Definitions were developed for all the activities and stressors (Attachment C). The potential interactions of activities and stressors where then evaluated using a matrix approach. Activities were shown as column headings and stressors as row headings. The transfer medium was indicated in the matrix cell where the appropriate activity column and stressor row intercepted in the table (Table 8, Attachment B). The transfer medium is an environmental medium that transports pollutants or stressors, such as air, water, soil, or biological tissue.

The Ecological Health Committee was unable to complete the analysis of this matrix of potential interactions of activities and stressors. The intent was to keep the data describing observed ecological "effects" and the data describing "loading" of stressors to specific media, such as tons of nitrogen oxide released to air, separate. The observed ecological "effects" would be traced back to the appropriate stressor in the activity by stressor matrix. The "loading" data would then be evaluated to determine whether the "loading" of stressors to a medium could be assigned to the potential activity-stressor interactions not associated with ecological "effects." The potential activity-stressor interactions associated with the "loading" data should represent either:

1) Loading of stressors to media which are currently regulated and therefore produce little if any observable ecological effect because the more toxic components are removed, or

2) Potential threats to ecological systems which were not identified in the initial collection of ecological "effect" data and need further evaluation.

The Ecological Health Committee did not make the comparison of the collected ecological "effects" data with the matrix of potential stressors produced by specific activities due to a lack of time and resources. This comparison of potentially significant stressors and observable ecological "effects" could be a task for subsequent comparative risk projects.

Intensity and Extent Aspects of Ranking

There was a great deal of discussion during development of the system used to rank exposure pathways. One of the EHC members considered the "Intensity" ranking component in detail. The

suggestions for changing the "Intensity" ranking component were not submitted in time to be employed in the ranking of the EHC.

The "Intensity" ranking component, as employed, attempts to express the magnitude of the effect on organisms and the sensitivity of the biological species, community, or ecosystem as a single value. In addition, complete destruction of an ecosystem, which scores the highest, is a major leap from the organism or population level effects which score lower. Scoring "intensity" in this manner is somewhat simplistic and implies a linear progression from toxicological effects to ecological effects. One method of addressing these simplifications would be to consider "intensity" based both on the ecological system affected and the magnitude of the effect. The "intensity" score would be the arithmetic product of the score given to an ecological system component and a separate magnitude of effect component. The proposed ecological system component and magnitude effect component with scoring from lowest (1) to highest (5) is:

Ecological System Component Score:

1	2	3	4	5
Individual Organism	Single Population	Multiple Population	Biological Community	Ecosystem

Magnitude of Effect Score:

1	2	3	4	5
< 1 percent	5-10 percent	20 percent	35 percent	50 percent

Laboratory data indicating that a species of phytoplankton (Ecological System Component Score = 1) is killed (Magnitude of Effect Score = 5) by a component of crude oil would receive an "intensity" score of 5. The highest "intensity" score using this system would be 25. Evidence that a phytoplankton population (Ecological System Component Score = 2) decreases by 20 percent (Magnitude of Effect Score = 3) would receive an "intensity" score of 6, while information that both phytoplankton and zooplankton (Ecological System Component Score = 4) decreases by 20 percent (Magnitude of Effect Score = 3) would receive an "intensity" score of 12.

Impacts on populations or habitats which have restricted distributions within California presented a special problem. The consensus of the EHC was that consideration of the relative impact was important when ranking threats. There was general agreement that loss of 10 percent of the habitat of the desert pupfish, and therefore 10 percent of the desert pupfish populations, could be as significant as loss of 10 percent of the Sierra Nevada pine population even though the Sierra Nevada pine population loss would encompass a much larger geographical area. The Ecological Health Committee attempted to include relative impact in the "Extent" aspect. However, the problem of how to normalize scoring for ecological systems which vary greatly in distribution and uniqueness requires further development.

Recreation Impacts

The Ecological Health Committee had difficulty in combining the threats associated with recreational activities with threats associated with other human activities. Threats associated with recreation frequently involve changes in habitat type. Damming a river or stream to produce a lake or pond destroys the aquatic community associated with flowing water, replacing it with a different

community associated with warmer, quieter water. Some recreational impacts involve physical taking of organisms in hunting, fishing, or collection of wildflowers. Physical "trampling" during visits to recreational areas can significantly alter the habitat and exclude certain types of organisms. Organisms raised at propagation facilities, such as fish hatcheries, can become the population majority effectively eliminating the "wild type" genome. Development of an approach to more fully assess recreational impacts could be a task for future comparative risk projects.

Further Data Needs

Many of the "detail sheets" which describe the reasoning and references used to develop the ranking scores for each exposure pathway contain suggestions for further data collection which would improve the information base used to rank each particular exposure pathway (see EHC Appendix). California regulatory agencies currently collect a large amount of environmental data which could address the majority of the identified data needs. Unfortunately, the environmental data are contained only in individual documents, which are difficult to access. If the California Environmental Protection Agency intends to make comparative risk an integral part of the policy-setting procedure, the environmental information currently collected which addresses the data needs identified in the EHC report should be located, collected, and synthesized prior to the next comparative risk effort.

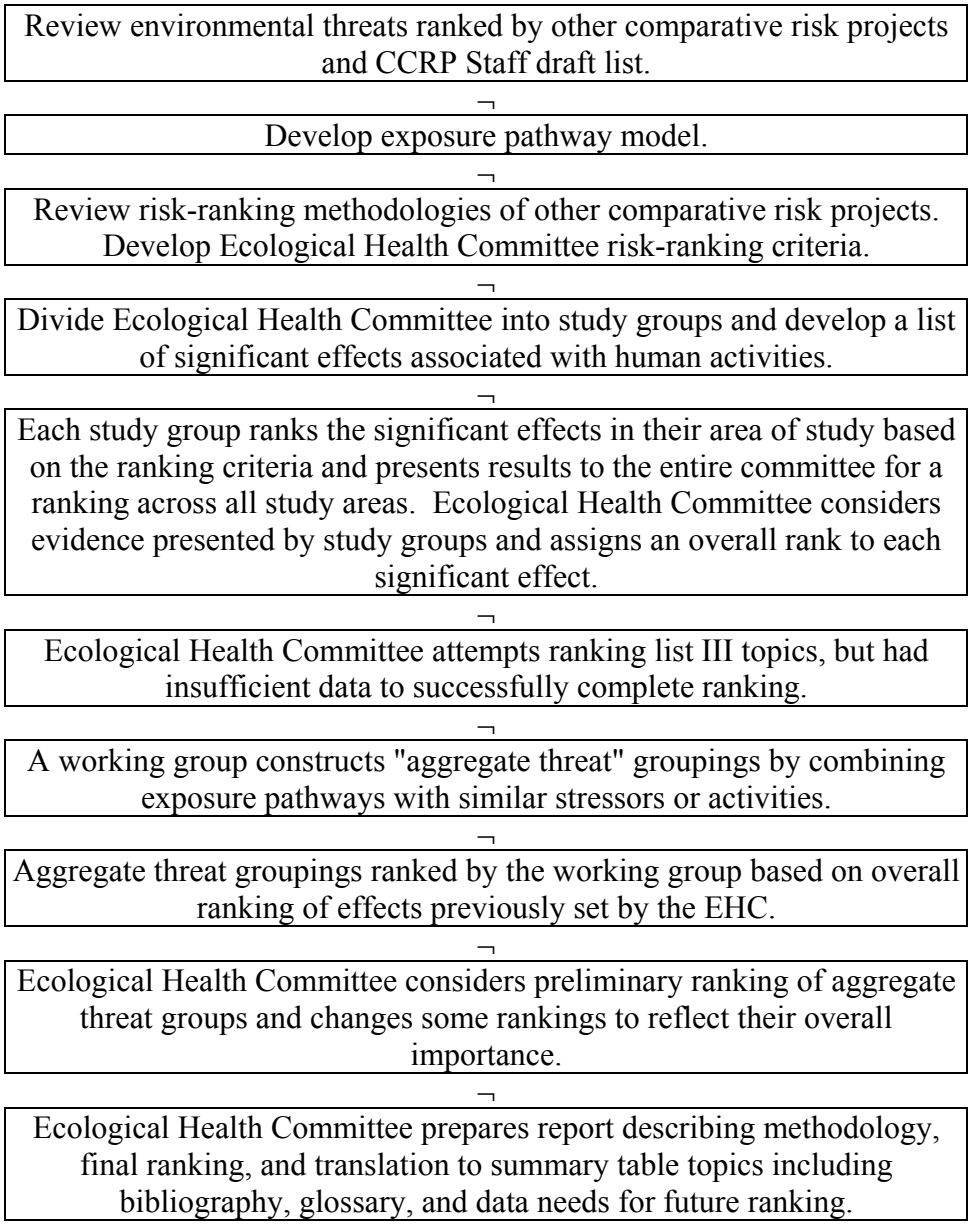

Figure 1.

Diagram of Ecological Health

Committee Major Decision Points.

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ATTACHMENT A:

ECOLOGICAL HEALTH COMMITTEE MEMBERSHIP LIST

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ATTACHMENT B:

TABLES

Tables 1 to 8

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ATTACHMENT C:

AGENT AND STRESSOR DEFINITIONS

Accidental releases. An Agent. Sudden, unplanned release of toxic or hazardous substances.

Acid deposition. A stressor. Acidic deposition-the deposition of acidic and acidifying substances from the atmosphere.[1]

Acid Mine drainage. A stressor. Runoff from mines and mine tailings that contains dissolved heavy metals and strong mineral acid(s), usually from the microbial oxidation of ore.

Animal maintenance. An Agent. Grazing activities associated with raising livestock for commercial purposes as well as maintenance of animals for recreational activities.

Atmospheric oxidant. A stressor. Oxidizing gaseous constituent of the atmosphere such as sulfur oxides, nitrogen oxides, and tropospheric ozone, usually originating from human activities or formed by chemical reactions involving air pollutants and sunlight.

Channelization of surface streams. A stressor. Artificial straightening of river and stream beds associated with changes in riparian biological communities.

Clear cutting and deforestation. A stressor. Harvesting of standing timber in large, contiguous areas usually with little revegetation or preservation of wildlife corridors.

Construction and demolition waste. A stressor. Used or waste materials originating waste from the construction, repair, remodeling, and demolition of structures and roadways.

Contained burning. An Agent. Combustion within some type of enclosure as compared with open combustion. Combustion within boilers, furnaces, incinerators, and wood stoves would be included. Physical containment is the restraining component, not whether emission controls are a component of the combustion system.

Crop management. An Agent. Agricultural practices associated with crop selection such as selecting the appropriate crop for soil type, topography, and water requirements. Also included are management practices such as crop rotation, selection of irrigation method, and mechanical control of weeds.

Crude oil. A stressor. Unprocessed liquid petroleum product from natural sources.

Dams and reservoirs. A stressor. Structures designed to impound and store water for later delivery, often located in stream and river beds.

Dams, reservoirs and flood control structures. An Agent. Water management facilities used to store, convey, and divert water. Dams, reservoirs, levees, channels, and canals would be included here.

Dissolved oxygen depletion. A stressor. Reduction of the oxygen content of water brought about by the decomposition of biodegradable materials.

Electromagnetic radiation. A stressor. Ionizing and non-ionizing electromagnetic radiation.

Erosion. A stressor. Removal and transport of surface soils from their native location by water or wind.

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[1] In: The Acidic Deposition Phenomenon and its Effects, Critical Assessment Review Papers, Vol 1, Definitions, EPA-600/8-83-016AF.

Fertilizer application. An Agent. Application of fertilizer to agricultural lands.

Greenhouse gases. A stressor. Atmospheric gases, such as carbon dioxide and methane, which allow short wavelength infrared to penetrate to the surface but reflect the re-radiation of longer wavelength infra-red back to the earth's surface.

Groundwater overdrafts. A stressor. A lowering of the groundwater table through excessive pumping which may result in subsidence, a loss of storage capacity and water quality impacts.

Habitat alteration or land-use conversion. An Agent. Physical alteration of habitat to allow development for other purposes. Filling woodland for municipal or private development, controlling floods to convert flood plains to agricultural, or residential use would be included here.

Harvesting. An Agent. Collection of living natural resources. Harvest of managed as well as non-managed resources are included here.

Hazardous materials or toxic materials. A stressor. Materials which by their intrinsic physical or toxicological properties present a danger of explosion, corrosion, ignition, or poisoning.[2]

Hydrocarbon fuels. A stressor. Processed liquid petroleum products.

Incidental chlorination byproducts. A stressor. Toxic or bioaccumulative materials usually formed by the chlorination of organic material in waste water and drinking water treatment.

Introduced species. A stressor. Deliberately or accidentally introduced non-native or bioengineered species including feral and hatchery-raised animals.

Irrigation, leaching or drainage. A stressor. Dissolution and transport of materials in runoff or seepage from agricultural land.

Irrigation. An Agent. Practices included in application of water to land. Residential lawn watering, agricultural irrigation, and irrigation of recreational facilities are included here.

Land disposal. An Agent. Activities related to the disposal of waste materials on land. Construction and operation of municipal or industrial landfills are included as well as placement of material on private land by individuals.

Light pollution. A stressor. Light emitted from urban areas, including back scatter.

Livestock. A stressor. Animals produced for meat, hide, or ornamentation.

Manufacturing processes. An Agent. Practices involved in the production of goods for sale or distribution. Electrical generation would be included here.

Mining activities. An Agent. Removal of minerals from the original location with potential processing prior to use in manufacturing. Generation of mining tailings would also be included here.

Mining waste and drainage. A stressor. Tailings and removed overburden from mining sites including runoff.

Mobile sources. An Agent. Releases from energy sources which are not fixed to one location.

Noise pollution. A stressor. Loud, unmusical, or disagreeable sound.

Non-waste material stockpiles. A stressor. Accumulation of material intended for future use or sale which is available to outdoor weathering.

Nutrients. A stressor. Organic or inorganic substances which, in excess amounts, promote eutrophication.

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[2] Sec. 25501, CAL H&SC as applied in Chapter 6.95, Div. 20, California Health and Safety Coce.

Open burning. An Agent. Combustion in the open atmosphere. Industrial gas flares, camp fires, forest fires, agricultural burns, and home barbecues would be included here.

Particulate/PM10. A stressor. Atmospherically distributed particles of 10 microns or less.

Pathogenic microorganisms. A stressor. Microorganisms which cause an adverse environmental effect due to resource over utilization, pathenogenicity, or toxins.

Persistent Toxicants. A stressor. Materials which tend to persist in the environment producing toxic effects.

Pest management. An Agent. Practices of controlling or exterminating unwanted species associated with agricultural, industrial, or residential settings.

Pesticides. A stressor. Any produced chemical used for killing or otherwise controlling animals or plants.

Petroleum, natural gas or geothermal development. An Agent. Activities related to exploring, extracting, and construction of on-site storage facilities, and on-site use of petroleum, natural gas, or geothermal resources.

Physical alteration and destruction. A stressor. Habitat alteration by purely physical forces or means, such as channelization, canopy removal, filling, or draining.

Physical collection of organisms. A stressor. Planned catching, hunting, or gathering organisms.

Polycyclic aromatic hydrocarbons. A stressor. Organic chemicals containing only carbon and hydrogen and forming molecules consisting of co-joined benzene rings.

Pre-existing contamination or condition. An Agent. Activities which are no longer going on, but resulted in accumulations of waste materials which now pose a threat, or naturally occurring soil conditions which pose a threat when specific land-use is allowed.

Radioactive materials. A stressor. Materials which emit alpha or beta particles or electromagnetic radiation due to radioactive decay.

Road development. A stressor. All activities associated with the construction or maintenance of surface roads, including clearing, grading, and surfacing.

Runoff. A stressor. Surface water originating from rainfall, snow melt, and rising groundwater.

Salinity. A stressor. Increases in salt content of soils, surface or groundwater from seawater intrusions, leaching, evaporation, or waste discharges.

Sea level rise. A stressor. Increase in ocean mean level resulting in flooding of coastal land.

Septic systems. A stressor. Subsurface disposal of household wastewater through a septic tank.

Silt. A stressor. Sediment suspended or transported in water that often accumulates in on the bottom of rivers or lakes, especially with particles smaller than sand but larger than clay.

Sludge. A stressor. Liquid or solid residue with a solids content of two percent or more, rich in organic material and produced by settling or sedimentation, particularly from waste water.

Solid waste. A stressor. Waste materials which are not liquid or gaseous.

Stationary sources. An Agent. Releases from energy use of facilities which are temporarily or permanently in one location.

Storage tanks. An Agent. Activities related to storing materials which have some future planned use in enclosed, usually large, containers.

Stratospheric ozone depletion. A stressor. Lowering of ozone concentration in the earth's upper atmosphere caused by reactions involving certain synthetic chemicals.

Surface water depletion. A stressor. A reduction in surface water flow or volume caused by excessive diversions.

Thermal pollution. A stressor. Discharge of heated water which locally and significantly raises the temperature of a receiving water body.

Toxic metals and metal compounds. A stressor. Materials that contain heavy metals such as copper, cadmium, chromium, nickel, and zinc and produce toxic effects.

Toxic organic compounds. A stressor. Carbon-based chemicals that may exert toxic effects.

Tropospheric ozone. A stressor. Ozone in the lower atmosphere above ambient levels, produced by the action of sunlight on other air pollutants.

Urbanization. A stressor. Conversion of land from rural to urban use.

Volatile organic compounds. A stressor. Carbon-based compounds, usually solvents, with vapor pressures high enough for significant volume loss to the atmosphere at ambient temperatures.

Waste Impoundments. An Agent. Storage of materials which have no further planned use.

Waste vegetation including slash. A stressor. Plant material harvested or removed from land as waste material and not intended for commerce.

Wastewater. An Agent. Treatment and discharge of wastewater from residential or industrial treatment facilities.

Water allocation and Use. An Agent. Practices associated with distribution of available water resources and the final use of that water. Physical alteration of stream bed would be included here.

Water treatment. An Agent. Practices used to treat "raw" water and the waste products produced.

Wild fires. A stressor. Ignition of standing plant communities occasionally burning massive areas of forest and brush.

Report of the Social Welfare Committee

Ranking Risks to Social Welfare

INTRODUCTION

A polluted river, an endangered species, or a sick human can be a symptom of an environmental problem, and resources often exist to measure the extent to which they are caused by that problem. But many environmental problems impact something far less tangible than an organism or ecosystem, that is, the "social welfare" of an individual, family, or community.

Social welfare includes many dimensions, ranging from economic well-being to a sense of personal security and equitable distribution of impacts and benefits. For instance, environmental problems can diminish recreational opportunities, reduce property values or increase taxes, cause pain and suffering as a result of illness, create divisions and conflicts within communities, and undermine confidence in governing institutions. These dimensions are reflected in widespread concerns which cut across lines of education, income, age, and gender. In the more serious cases, these concerns reveal a depth of disruption of people's lives that is not captured in standard statistics of lost work days or frequencies of disease. In addition, environmental problems may disproportionately impact subpopulations. And further, problems which may seem minor today could have major social welfare implications if, in the future, they are found to affect health or the long-term sustainability of ecosystems.

Recognizing the significance of social welfare impacts to any comprehensive evaluation of environmental problems, the California Comparative Risk Project (CCRP) convened the Social Welfare Committee (SWC) (See Attachment A for membership list). The Social Welfare Committee's charge was to assess and rank adverse social welfare impacts of diverse environmental problems in California within the context of the CCRP. In undertaking this task, the SWC faced a number of challenges. One major challenge confronting the SWC was the absence of a well-established methodology and conceptual framework. Some U.S. Environmental Protection Agency (U.S. EPA) sponsored comparative risk projects have focused exclusively on economic impacts, considering only such quantitative impacts as property damage and lost work days. Other projects have considered broader dimensions of social welfare, but have not developed systematic measures or databases. Therefore, in order to carry out its charge, the SWC had to develop appropriate concepts and methods, as well as use them to derive a ranking. Even with more obvious social welfare dimensions such as economic and aesthetic impacts, this task was daunting given the time and resources available to the SWC. With less obvious dimensions such as anxiety and community fragmentation, it was formidable.

Several members of the SWC felt constrained by the fact that the SWC's charge excluded the consideration of possible benefits from the activities causing the environmental impacts (see Reflections on the Comparative Risk Approach). Economically or socially motivated activities (e.g., transportation systems, energy use) certainly produce beneficial as well as adverse social welfare impacts. Similarly, some members felt that the effects of possible mitigation measures should be considered, as these might have larger social welfare impacts (e.g., economic costs) than the environmental impact itself. The Social Welfare Committee's narrow charge precluded the consideration of the larger picture of benefits, adverse impacts, and mitigation measures.

Another major challenge constraining the SWC was insufficient time and resources, which limited the collection of data that may have been useful (see Data Sources and Caveats). Some members of the SWC felt that the data base on how environmental impacts were actually experienced by individuals was

not adequately available to the SWC and, therefore, that the criteria, measures, and rankings produced should be viewed as preliminary. In addition, the project structure in which all of the committees worked independently and simultaneously made it necessary for the SWC to attempt to collect data (e.g., on human health and ecological health impacts) which preferably would have been provided by the committees addressing these areas (see Caveats).

Recognizing the importance of evaluating social welfare impacts, the SWC pursued its task in spite of these challenges. Identifying seven dimensions, or criteria, of social welfare impacts and developing ways to measure environmental impacts on each dimension, the SWC assessed and ranked social welfare impacts of the environmental topic areas developed by the CCRP. Throughout the process the SWC questioned and critically evaluated its purposes and procedures. Methods and procedures are described in the first section of this report. Findings and rankings are reported in the following section, and in the final section the SWC reflects upon the analysis of social welfare impacts and provides a series of recommendations.

METHODOLOGY

A flow diagram illustrating the major decision points in the SWC's deliberations can be found in Figure 1.

The concept and measure of "social welfare" are not as well defined as concepts of human or ecological health. The Social Welfare Committee's initial focus was to explore what social welfare is and what the impacts on social welfare related to environmental problems might be.

The Social Welfare Committee unanimously adopted the following definition of optimal social welfare:

> *"People enjoy high levels of social welfare when they have good health and health care, personal security, meaningful employment, adequate income, a pleasing functional and diverse environment, a well-functioning infrastructure providing basic services, a range of satisfying recreational opportunities, good educational services, and a sense of community cohesiveness, participation, control, and trust with regard to governing institutions. There must also exist opportunities for personal choice, continuous self and community improvement, and an assurance that these benefits will be available to future generations."*

Many categories of social welfare such as health care, adequate income, well-functioning infrastructure, and educational services are significantly influenced by net income on an individual or community basis. Net income can be influenced by the presence or absence of activities and the benefits and adverse impacts that result. Other categories of social welfare such as community cohesiveness and trust with regard to governing institutions are highly influenced by how the community or the government deals with real or perceived inequities in the distribution of impacts and benefits. However, as directed, the SWC addressed only adverse social welfare impacts resulting from environmental topic areas.

Initial process: the Social Welfare Committee explored social welfare as it relates to environmental problems.

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The Social Welfare Committee developed definition of optimal social welfare.

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The Social Welfare Committee developed list of questions, criteria, and measures.

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Criteria and measures brought together in an impact assessment matrix.

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List II ranking: SWC collected data and filled out matrices for all list II topic areas.

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The Social Welfare Committee reviewed and discussed all matrices.

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The Social Welfare Committee evaluated criteria summary rankings for consistency and reasonableness.

¬

Final list II ranking.

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List III ranking: a subcommittee of SWC developed approach for ranking list III; this included identification of list II topic areas contributing to list III threats.

¬

The Social Welfare Committee reviewed and approved approach; SWC modified list II topic areas considered and listed additional concerns under list III threats.

¬

The Social Welfare Committee developed an initial draft ranking.

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Between meetings, individual members developed relative rankings and prepared rationales for list III ranks.

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The Social Welfare Committee discussed rationales and agreed on ranking distribution.

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Final list III ranking.

Figure 1.
Social Welfare Committee
Risk-Ranking Methodology.

Criteria Development

The Social Welfare Committee brainstormed to develop criteria for evaluating the impact on social welfare posed by the environmental topic areas. One outcome of the brainstorming was a list of questions that could help in understanding those social welfare impacts from an environmental problem that are very difficult to quantify. Such questions relate to the very personal, individual experience of an environmental problem in which a person's fundamental security and trust may be undermined, and include:

→ Is my health or the health of my loved ones being affected?

→ Will this threat affect my employment?, the safety of my home?, the value of my home?

→ Will I give birth to a deformed child?

→ Has my faith in human nature been damaged?, my sense of the home as a place of safety and security?, my children's view of the world as a safe and nurturing place?

→ Was information withheld because of corporate or governmental concerns about liability, or profits, or the costs of prevention?

→ Was the particular hazard the result of some activity that I consider worthwhile, or was it the result of the profit motives of industry or political expediency of government agencies or other institutions?

→ Did this happen to my community because of lack of concern about an area populated by racial/ethnic minorities?, by poor people?

→ Will it polarize my community and create scapegoats?

→ Can I still have trust in government?

A second outcome of the brainstorming was a draft list of criteria (tools for determining whether any social welfare impact existed) and measures (tools for determining the magnitude of the impact). Keeping questions such as the above in mind, the SWC listed seven broad criteria that incorporate most of the dimensions of the definition of social welfare. As an alternative approach, one SWC member suggested that there should be only four main criteria: environmental well-being, human health well-being, economic well-being, and community well-being. The rationale was that these four criteria would create a framework allowing impacts on community well-being components such as equity, peace of mind, and future to be placed on a more equal footing with benefits from economic well-being components such as job creation, income improvement, and public revenue enhancement in any future consideration of both benefits and impacts.

However, the SWC decided to move ahead with the list of seven criteria and agreed to test their usefulness in a trial experiment in ranking the list of environmental topic areas. The criteria are: environmental and aesthetic well-being, economic well-being, physical well-being, peace of mind, future well-being, equity, and community well-being. Some of these focus on more objective conditions or impacts (e.g., environmental and aesthetic well-being, economic well-being), while other criteria (e.g., peace of mind, community well-being) focus more on subjective perceptions and anxieties. The Social Welfare Committee developed operational definitions and illustrative examples of these (see

Attachment B). Though initiated as a trial, the trial ranking became the final ranking due to time constraints.

Measures Development

The Social Welfare Committee developed eight measures to evaluate the extent of the impacts associated with each criterion, again keeping the questions above in mind. The measures are: number of people exposed, number of people impacted, severity, irreversibility, involuntariness, uneven distribution, potential for catastrophic impact, and lack of detectability. As with the criteria, these measures were to be experimental tools, but they became the final tools due to time constraints. The Social Welfare Committee also developed definitions for high, medium, and low concern (see Attachment B).

Data Sources

Social Welfare Committee members reviewed the topic areas to identify the major issues involved in each and to provide data to be used in assessing (preferably quantitatively, but at least qualitatively) the types and magnitude of social welfare impacts involved. This research varied, depending both on the data available and on the resources and expertise of the SWC member. Time constraints precluded review of case studies, testimony by affected individuals, and interview data that would have provided direct information on how environmental risks are experienced by the public.

For each topic area, members developed a description of the area and the available data, then major issues were discussed in the SWC. In some cases, other members provided additional data or perspectives, or identified data gaps. The Social Welfare Committee then discussed these gaps, and decided to correct them (as much as time and resources allowed), dismiss them (if they had an insignificant impact on the assessment), or treat them as an uncertainty.

Approach to List II Ranking - Matrix Development

A matrix was developed with the criteria on the horizontal axis and the measures on the vertical axis, and a summary line for each of the criteria. The objective of the matrix was to bring together all the criteria and measures in as efficient and useful a way as possible. A space was also provided for an overall social welfare rank (i.e., a single, subjectively-weighted summary of all seven criteria combined).

The areas on environmental topic list II (Environmental Health Stressors) were split up among the SWC members who agreed to collect data and write brief summaries describing each topic area and the data available. Using available data and best judgment, members then assessed the social welfare impact of each of their assigned topic areas, using the matrix to suggest low, medium, or high levels of concern within each box in the matrix and an overall level of concern. See Attachment C for a sample matrix for the list II topic area "lead."

The Social Welfare Committee next reviewed the impact assessment matrices together, discussing available data and differences in opinion among members as to the appropriate levels of concern or impact. We attempted to reach either consensus or tolerable compromise on all matrices. This was a time-intensive process, but it provided insights into different ways of thinking about social welfare concerns and topic areas.

Approach to List III Ranking

The ranking of environmental topic list III (Threats to Environmental Integrity) was handled in a somewhat different way from environmental topic list II. Because of time constraints, a subcommittee of the SWC met several times and developed an approach to use in ranking list III threats which utilized the work done for ranking list II.

For each list III threat (e.g., water management practices), topic areas from list II judged to be associated with the threat (e.g., volatile organics, pesticides - non-agricultural use) were specified. The full SWC reviewed this approach and agreed to use it as a starting point, adding "Additional Concerns" as well as modifying the list II topic areas specified under each list III threat.

The rankings of the list II topic areas also were specified, as well as our estimation of the relative contribution (major/moderate/minor) of the list II topic area to the list III threat. The list III threat, "water management practices," is detailed in Attachment D as an example of the process.

The Social Welfare Committee ranked list III using a consensus approach. An initial list of high, medium, and low ranks was created by the SWC at one meeting. Between meetings, SWC members developed their own relative rankings of the list III threats and recorded the weighting they had used.

To rank list III, we considered:

→ the list II topic areas specified, especially those of high rank which were major or moderate contributors, and medium-ranked topic areas which were major contributors;

→ the extent of ecological disruption including the area covered, reversibility, and fear of the ecological damage associated with the list III threat;

→ an intuitive or "gut" sense of the relative burdens posed;

→ an estimation of where the responsibility for critical decision-making lies;

→ the scope of the threat (e.g., as a practice, its share of the California economy);

→ the scope of the list II topic area(s) specified as a major contributor (e.g., "Alteration of Terrestrial Habitats" covers a larger number of impacts than "Asbestos"); and

→ the number of people contributing to the problem (e.g., lifestyle choice).

The final rank assigned to each list III threat was a result of discussions of the relative ranks of the items, and the SWC's judgment as to appropriate groupings of the threats into high, medium, and low ranks.

Environmental topic list I was not ranked due to time constraints.

RANKING

Caveats

The Social Welfare Committee's rankings must be viewed with the following qualifications in mind related to time, SWC composition, data, and methodology.

Time

The constraints of time affected the SWC's work in terms of the collection and review of data, evaluation and revision of the methodology, and the number of topic area list rankings possible. The available time was insufficient to do the comprehensive job we would have liked to do.

Social Welfare Committee composition

The Social Welfare Committee was a group of diverse professionals who tried to provide a balanced perspective on social welfare concerns. The Social Welfare Committee did not comprise a representative cross-section of the state's population. It was composed of representatives from State and local governmental agencies, faculty from universities, representatives from major corporations, and private environmental consultants. If an objective of the CCRP was to independently assess the State's environmental priorities, then the involvement of State agencies may call into question the independence of this effort. Despite broader recruitment efforts, there was no representation from small business, labor, agriculture, people in disproportionately impacted subpopulation communities, environmental groups, or social welfare agencies providing services to affected populations.

The composition of the SWC is an important issue because social welfare impact assessment necessarily requires value judgments, not simply scientific measurements of impacts, and it matters whose values are used in making those judgments. Value judgments were necessary at several points in the SWC's process:

1) selecting criteria and measures of social welfare (because this is a new and fluid area of scientific inquiry;
2) weighting the diverse measures (e.g., number of people exposed, irreversibility, involuntariness) to obtain a summary ranking of each criterion (e.g., physical well-being, aesthetics);
3) selecting and evaluating data; and
4) weighting the different criteria to obtain a single overall summary ranking of a topic area/stressor.

Data

Due to lack of time and resources, the SWC was unable to develop a fully appropriate database for assessing social welfare impacts (e.g., via surveys, focus groups, database analyses), or to obtain and review all the data that do exist related to social welfare impacts. Existing data are not systematically compiled but must be culled from a large number of case studies and other sources with varying methodologies, including surveys of public opinion on the environment and/or hazardous technologies, public hearing testimony, and accounts by groups of survivors, making the data difficult to use in a comparative ranking. The paucity of data, concepts, and theoretical frameworks for social welfare impacts available to the SWC frequently meant that only readily available data were interpreted to

derive the social welfare impacts presented here. In addition, the organization of the CCRP (i.e., committees working in parallel) precluded the use of the technical data and human and ecological health impact analyses developed by other committees.

Methodology

Although the methodology is an earnest effort to capture and represent the full dimensions of social welfare impacts due to the environmental topic areas, it is inherently limited for several reasons. First, California is a complex system, with synergism and overlap existing among the environmental problems and issues; these should have been considered in an integrated manner. However, in order to approach the task of ranking as set up under the comparative risk model, a number of artificial "separations" and "aggregations" occurred to enable a systematic approach:

→ separation/aggregation of environmental problems into separate entities (environmental topic areas and lists);

→ separation/aggregation of the impacts of the various environmental topic areas in terms of human health, ecological health, and social welfare;

→ and the subsequent separation/aggregation of the aspects of social welfare impacts themselves in the form of criteria and measures.

The first two of these separations/aggregations were imposed by the CCRP to facilitate comparisons of the human health, ecological health, and social welfare rankings. With such categorizations already defined, and a lack of time for review of data to validate the separations/aggregations provided, the SWC could not determine whether these particular categories reflect the way that impacts are actually experienced by individuals. The result is that a number of important elements of California's complex system may not be addressed in the ranking.

Second, social welfare conditions other than those directly related to the environmental topic areas influence the overall impact of the considered topic areas on people. For example, the availability of health care (e.g., to farmworkers exposed to pesticides) may influence the impact of the exposure on the exposed individual.

Third, the SWC developed the criteria and measures used for the ranking, as well as the rankings themselves, without input from the broader population of the State and was unable to check these against actual facts and perceptions, due both to time and financial constraints and to the complexity of the task; hence, the rankings can only represent the SWC members' best judgment. This judgment reflects the SWC composition, described earlier (See Social Welfare Committee Composition), that did not have representation from all concerned groups.

Fourth, since the SWC's charge was to address only the adverse impacts of the activity or substance under consideration, there was no attempt to balance social welfare benefits and adverse impacts. It is also important to note that neither mitigation nor regulation costs were included in the evaluation of economic impact.

RESULTS

The Social Welfare Committee succeeded in developing a ranking of environmental topic list II by collecting available data concerning social welfare impacts of environmental problems and using the criteria and measures to evaluate the data. Due to limitations on time and resources, these rankings are limited and partial and should be seen primarily as a methodological trial. However, the SWC's rankings represent a substantial first step toward understanding social welfare issues and can be used to inform further evaluations of California's environmental problems. With strong reservations about its work, expressed above as caveats, the SWC presents the results of its adverse impact assessments and rankings of list II topic areas/stressors in Table 1. Overall rankings (summaries across all criteria for each topic area) are provided in Attachment E.

Table 1.
Ranking of List II --- Environmental Health Stressors.

Line Code	Topic Area	Env/aesthetic Well-being	Economic Well-being	Physical Well-being	Peace of Mind	Future Well-being	Equity	Community Well-being
II-1	Asbestos	L	M	H	M	M	M	M
II-2	Carbon Monoxide	L	L	M	L	L	M	L
II-3	ETSmoke	M	H	H	H	M	H	M
II-4	Ozone depletors	H	H					
II-5	Green house gases	L	L	L	H	H	L	L
II-6	Inorganics	M	M	M	M	M	H	M
II-7	Lead	L	H	H	M	M	H	M
II-8	Microbio. Contam.	M	M	M	M	L	M	L
II-9	New chemicals	U	U	U	L	U	U	L
II-10	Gen. eng. prod/org.	L	L	L	M	U	L	L
II-11	Non-native organisms	M	H	L	L	H	L	M
II-12	Volatile organics	M	M	H	M	M	H	M
II-13	Organochlorines	M	M	H	M	M	H	M
II-14	Oil/petroleum	H	M	L	M	M	M	M
II-15	Ozone	H	H	H	H	L	M	L
II-16	Particulate matter	H	M	H	H	L	H	M
II-17	Pesticides - agri. use	L	M	M	H	M	H	M
II-18	Pesticides - nonagri.	L	L	L	H	M	H	H
II-19	Alter. aquatic habitats	H	M	L	H	M	H	H
II-20	Alter. terres. habitats	H	M	L	H	H	M	H
II-21	Thermal pollution	L	L	L	L	L	L	L
II-22	Radon	L	M	H	L	M	L	L
II-23	Electromag. Fields	L	L	U	H	U	M	M
II-24	Radionuclides	L	H	M	H	H	H	H
II-25	SOx and NOx	M	H	M	M	L	M	M
II-26	Subs/alter pH, sal.	L	L	L	L	M	L	M
II-27	TSS, BOD, nutrients	M	L	L	M	L	L	L

NOTE: Overall rankings (H = high, M = medium, and L = low) summarize the committee's criteria assessments as a summation of measures.
U = unable to estimate, as a summary ranking, indicates where there are no data or data are not possible to obtain at present time.

For each of the list II topic areas, SWC members summarized what impacts were assessed in ranking each criteria, and the SWC reviewed and modified these summaries (see Social Welfare Appendix for summaries). While limited data were used in assessing the social welfare impacts of list II topic areas, the ideas captured in the summaries provide a sense of what the SWC weighed in ranking. For example, the summary for "particulate matter" notes that the SWC's "high" ranking for the criterion impact on "environmental and aesthetic well-being" reflected"... its impact on visibility, which is a serious problem in many urban air basins in California, [such that] the aesthetic impact of particulate matter was judged to be of high concern." In the summary for "non-agricultural use of pesticides," the SWC's considerations in ranking the criterion "peace of mind" as "high" are reflected in a quote from an environmental impact report for an eradication program (aerial spraying for the Mediterranean fruit fly): "Public apprehension and anxiety are recognized adverse impacts of pest eradication projects. ... In addition to anxiety and apprehension, some members of the public are angered and upset over what is characterized as 'involuntary exposure'."

The rankings of environmental topic list III threats are presented in Attachment F.

REFLECTIONS AND RECOMMENDATIONS

Reflections on the Comparative Risk Approach

As a result of the efforts to assess social welfare impacts in the context of a comparative risk project, the following issues have been identified:

1) methods for evaluating social welfare need further development;
2) useful data on social welfare impacts may not be amenable to ranking, but may need to be considered to adequately assess social welfare;
3) failure to review the social welfare benefits associated with the activities creating the adverse impacts may lead to a false impression of the overall net social welfare effect; and
4) what should be done about social welfare may be as important a question as which impacts are ranked high, medium, or low.

Methods development

Environmental problems can have serious consequences on human well-being beyond direct impacts on health and ecosystems; these social welfare impacts should be considered in any evaluation of a problem. The efforts of the SWC made a first step in the development of a method for assessing these impacts. However, further development of the methodology is needed for use in future assessment of environmental problems.

Significance of case study data

Two SWC members emphasized the critical importance of case study material and public testimony. Case studies of individuals and communities that have been victims of known or suspected exposure to serious environmental risks have been done. These members believe that even the most cursory review of these studies reveals a depth of disruption of people's lives that is difficult to capture in summations of lost days of school or work, or frequencies of reported tumors or genetic deformities. Rather, these studies reflect underlying fears about the contamination of one's surroundings, the immediate and long-term dangers posed by such contamination, and the sometimes invisible, frequently uncontrollable, nature of the threat. For some, this has damaged a basic security in one's ability to secure the health and safety of one's family. For many, the fact that both exposure and protection from exposure, may have come as products of human decisions made by corporate or governmental agencies, without prior informed consent, has led to a deep suspicion of the major institutions of society.

Often studies of comparative risk have focused only upon the impacts of separate contaminants on those highly specific health outcomes which have been well documented. Such studies have missed the depth and the breadth of human concerns about fouling of air and waterways, jeopardizing future generations, concealing information regarding the extent of danger, and official refusal to hear the human welfare concerns or to encourage community participation in their resolution. Public concern over dangers that have not yet been clearly documented are mistakenly viewed as public hysteria rather than as evidence for a more fundamental concern over potential dangers and resentments over exposure without prior informed consent. It is for this reason that these two members place the greatest emphasis upon conveying to Cal/EPA, the need for a public and community risk assessment process that could assess, document, and convey the actual social welfare impacts in ways not available to the SWC.

Consideration of benefits

Several SWC members were concerned that the CCRP did not address the benefits associated with the activities contributing to the listed environmental topic areas, only the adverse impacts. Although virtually every economic or social activity (e.g., manufacturing, transportation modes, water management) results in some type of adverse environmental impact, these members felt that these activities are undertaken in the first place because a determination is made that a net economic and/or social benefit will be derived. In many cases, the determination may not consider all adverse impacts and benefits or their distribution. These members felt that the greatest adverse social welfare impacts on a community may come from the same activity that causes the greatest benefit to that community.

Several members of the SWC believe that placing emphasis on adverse impacts alone exaggerates the negative side of the equation related to environmental impacts and contributes to trends such as increasing "not in my backyard" sentiment and an increasing unwillingness to accept any impact from existing activities. These members contend that the real issue may be the adequacy or equity of the compensating benefits and that consideration of these requires that both benefits and impacts be assessed. Therefore, they felt it would be more appropriate to review the beneficial impacts in conjunction with the adverse impacts, and derive a net benefit/adverse impact for use in the ranking. These members believe that this is especially critical for social welfare analysis which is necessarily broader than human health or ecological health analysis.

Other SWC members indicated that an adequate assessment of adverse impacts and benefits would require information on their distribution (i.e., who receives what benefits and who bears what adverse impacts). Some members believe that activities causing adverse social welfare impacts are initiated for purely economic benefit for some, without due consideration for public benefit or safety for others.

Some members felt that considering benefits fundamentally changes the nature of a social welfare analysis (e.g., the definition of "affected community" expands to include those who gain an economic advantage from the activities).

Other members of the SWC felt that the consideration of benefits should enter later in the picture, that is, that the ranking should reflect only the assessment of adverse impacts, and that the derivation of net effect should be left to the risk management or policy-making step. Some SWC members felt that the assessment of benefits along with adverse impacts was too complex a task to be addressed by a single committee. For example, in the current exercise with only adverse impacts considered, the SWC was able to accomplish only a trial evaluation. Additional development of criteria and evaluation of databases relevant to benefits would expand the scope of work even further. Moreover, the assessment of benefits from activities generally requires somewhat different expertise than assessment of their adverse impacts. Therefore, these members thought that if benefits were to be addressed, that task should be performed by a separate group, whose protocols and assumptions could be made consistent with those of the committees assessing adverse impacts. The benefit assess-ment could thereby be available to policymakers together with the assessments of adverse impacts.

Some SWC members felt that the need for evaluation of the bigger picture of benefits along with adverse impacts also exists for human health and ecological health assessments, because in these realms as well, the actions that result in the adverse impacts can frequently be found to be associated with an initial perceived or real benefit to human health, ecological health, and or social welfare, as well as possible existing benefits (e.g., the use of x-rays for human health, and the building of a dam for ecological health).

State response to adverse environmental impacts

Several SWC members felt that questions like: "Should the response to adverse environmental impacts be regulation, research, or education?" "Should the State undertake that response?" and "How

might social welfare benefits be impacted by different response approaches?" are as important as "Which areas have the biggest impacts?"

RECOMMENDATIONS

Recommendations for Organizing a Social Welfare Analysis

Mission statement

At the beginning of any process to analyze social welfare impacts (whether a ranking is to be achieved or not), a mission statement should be developed to specify the exact nature and scope of the work to be done and the major components of the project to be developed.

List of topic areas

In order to appropriately determine the project scope, the list of topics to be analyzed must be developed, each topic thoroughly defined, and the list and definitions finalized before the analysis begins. The topics and definitions should be structured to facilitate the analysis defined in the mission statement. For example, if benefits were to be included in the analysis, then specific activities, rather than the "stressors" used in environmental topic list II ranked above, might be a more useful framework for the work to be done.

Protocol

After the scope has been defined, a protocol should be developed with input from people with expertise in social welfare analysis and other applicable fields, to address how best to:

1) compose and retain a SWC that will most effectively represent the various interests of Californians;
2) identify and collect appropriate existing data on social welfare (e.g., case studies, public testimony, transcripts of public testimony present in other forums, interviews with people, organizations, and leaders from affected communities, economic and income databases and tax fee/records);
3) fill data gaps (e.g., survey tools, focus groups, interviews with people);
4) assess social welfare impacts of health effects that are not adequately assessed by standard health methods of epidemiology and toxicology (e.g., widespread, but subtle immunological effects);
5) evaluate relative "valuing" of social welfare impacts ("benefits" and "adverse impacts");
6) develop methodology to assess social welfare impacts, as well as their distribution;
7) develop methodology for assessing impacts on both a general and a "hot spot" (where impacts are most severe) basis; and
8) if a ranking is to be done, develop an appropriate methodology.

Time and resources

Before work is begun, a workplan, based on the above protocol, should be developed and the time and resources necessary to complete the project estimated. If insufficient resources and/or time are available, a revised workplan must be developed and, if necessary, the mission statement revised to reflect the reduced project scope.

Recommendations to Cal/EPA

→ Social welfare must be considered in any similar policy exercise or assessment of risk.

→ Future study of social welfare impacts should be provided with resources necessary for full examination of appropriate data, including case studies and testimonies of individuals and communities who have experienced the impacts most directly.

→ In any analysis of social welfare benefits, the relative distribution of those benefits should be determined. The analysis of "activities" rather than environmental topic areas would facilitate the analysis of social welfare benefits.

→ In any environmental policy process, Cal/EPA must include community and public participation and input at every stage of the process, and in particular, impacted communities must be involved. Appropriate models for such participation should be developed.

→ Social welfare analysis should be integrated into regulatory decision-making.

→ The California Environmental Protection Agency should continue to develop appropriate criteria, methods, and databases for addressing social welfare considerations. Data compilation and analysis should address both adverse impacts and benefits, as well as differences in the relative value different segments of California's population place on those impacts and benefits. The most knowledgeable and experienced professionals (e.g., social science, environmental science, health, and economics) in the State should be involved and the data collection, methodology, and analysis should undergo scientific peer review and community and public reviews at all stages of the process, including policy-making.

→ Both to enhance environmental decision-making and to appreciate the nature of social welfare impacts, policymakers should obtain a full view of the issues and options by listening to the perspectives of persons from different sectors, as well as representing members of the general public. This will help to determine how differences in the values different portions of the population place upon social welfare impacts should be handled. The California Environmental Protection Agency should give due consideration to the sometimes amorphous beliefs, fears, hopes, and perceptions of the public. Values are an important component in prioritizing risk or risk-reduction strategies, and should be made explicit where possible.

ATTACHMENT A:

SOCIAL WELFARE COMMITTEE MEMBERS

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ATTACHMENT B:

SOCIAL CRITERIA AND MEASURES

Environmental and Aesthetic Well-being

Includes: functioning natural ecosystems; pleasing urban, suburban, and rural communities and neighborhoods; a range of satisfying recreational and cultural opportunities.

Negative impacts include: reduced visibility; noise, odors, dust, and other unpleasant sensations (e.g., water weeds or turbidity in a lake, grime on buildings); visual impact from degradation of natural, urban, suburban, or agricultural landscapes; loss of access to recreation lands (public or private); and degraded quality or recreation experience (e.g., spoiled wilderness, fished-out streams, dammed whitewater).

Economic Well-being

Includes: meaningful employment and adequate income, well-functioning infrastructure, affordable housing, opportunities for self improvement, access to adequate education, mobility.

Negative impacts include: higher out-of-pocket expenses to fix, replace or buy items or services (e.g., higher waste disposal fees, costs of well replacement, higher housing costs); property value losses; lower income; higher taxes; lost jobs; health care costs and lost productivity; commercial harvest losses (e.g., damage to agriculture, forestry, and fishing); costs incurred trying to avoid an illness; and degradation of infrastructure (e.g., materials damage to physical structures including soiling, peeling, cracking, erosion, and discoloration).

Physical Well-being

Includes: good physical health, access to health care, affordability of health care, potential for mitigation of health impacts.

Negative impacts include: pain and suffering, cancer, disability and limited functioning, disease.

Peace of Mind

Includes: good mental health, trust of governing institutions, access to reliable information, personal security, healthy and stable personal relationships.

Negative impacts include: anxiety, fear, loss of trust in governing institutions, loss of sense of personal security, and fragmenting of families.

Future Well-Being

Includes: assurance for the well-being of future generations, sustainability of economic practices, sustainability of ecosystems.

Negative impacts include: lack of assurance of the well-being of future generations; unsustainable practices (e.g., economic, environmental, agricultural); shifting of costs (e.g., economic, health impacts, environmental damage) of today's activities to future generations, including today's children, as well as people not yet born.

Equity

Includes: shared decision-making power, democratic control of government, equitable distribution of impacts and benefits.

Negative impacts include: inequitable distribution of impacts and benefits (e.g., health, economic, aesthetic), and greater and more adverse impacts than average due to greater vulnerability of the subpopulation.

Community Well-being

Includes: cohesiveness, accountability of decisionmakers, resources and opportunity to participate in decision-making.

Negative impacts include: loss of sense of connection to community, changes in the appearance and feel of a town or community, breakdown in community cohesiveness, individual liberty exercised at the expense of the common good, community authority exercised at the expense of the individual, disruption of community, loss of control, division and conflict within communities and/or between communities (e.g., urban-rural conflicts).

Measures

Number of people exposed

H = > one million people

M = 10,000 to 1 million people

L = < 10,000 people

Number of people impacted

H = > one million people

M = 10,000 to 1 million people

L = < 10,000 people

Severity (degree of impact to individual, community, or future generations)

H = causes significant change (e.g., physically, culturally, emotionally, or economically)

M = causes moderate change

L = causes little or no change

Irreversibility (degree to which impact is irreversible over a short period of time).

H = irreversible

M = might be reversible after 10 years

L = reversible within 10 years

Involuntariness (degree to which people have a choice in being exposed). This measure assumes awareness of the impact and impact

H= not voluntary (includes no alternative, economic or otherwise)

M= can be avoided, but takes significant effort (e.g., moving, financial constraints)

L= easily avoidable and accessible alternatives are available to all

Uneven distribution (degree to which exposure falls disproportionately on a subpopulation)

H= significant impact on subpopulation

M= moderate impact

L= low impact

Potential for catastrophic impact (degree to which a catastrophic impact upon a group of people is likely)

H= high likelihood/high magnitude, if it occurs

M = less likelihood/less magnitude, if it occurs

L = low likelihood/low magnitude, if it occurs

Lack of detectability (degree to which exposure or impact [(whichever applies) can be detected.)]

H= very difficult to detect presence; special equipment and expertise needed and even those may be non-definitive

M= can be detected without special equipment but only if people are alerted

L= highly detectable; people easily "know" when they're being impacted or exposed

ATTACHMENT C:
SAMPLE MATRIX OF CRITERIA AND MEASURES ASSESSMENT FOR TOPIC AREA LEAD

CRITERIA	Environ/ Aesthetic Well-Being	Economic Well-Being	Physical Well-Being	Peace of Mind	Future Well-Being	Equity of Impacts	Community Well-Being
MEASURES							
No. of people impacted	L	M	M	M	M	H	L
No. of people exposed	L	H	H	M	H	H	L
Severity of impact	L	H	H	L	H	H	M
Irreversibility	L	H	H	M	H	M	M
Involuntariness	L	M	M	M	M	M	M
Potential for catastrophe	L	L	L	L	L	L	L
Lack of detectability	L	H	H	L	H	L	L
Summary	L	H	H	M	H	H	M

For further clarification of the matrix as a tool, note the following cells and explanation: The cell at the intersection of the criteria "peace of mind" (containing an "M") and the measure "involuntariness" reflects the moderate level of anxiety of people living in old homes and unable to move who wonder if their children are exposed to lead poisoning; the cell at the intersection of the criteria "equity" and the measure "severity" (containing an "H") reflects the severe impacts on predominantly low-income people and minorities.

ATTACHMENT D:

EXAMPLE OF ENVIRONMENTAL TOPICS LIST III RANKING METHOD FOR WATER MANAGEMENT PRACTICES

Environmental topic list II areas with their rankings, categorized by proportional contribution

Major

Physical stressors - Alteration of aquatic/wetland habitats (high)

Physical stressors - Alteration of terrestrial habitats (high)

Substances which alter pH, salinity, hardness (low)

Moderate

Volatile organics (high)

Total suspended solids, biological oxygen demand, nutrients (low)

Inorganics (high)

Minor

Pesticides - non-agricultural use (high)

Social Welfare Committee Additional Concerns

Recreation issues

Water allocation issues:

south/north conflicts

urban/agricultural conflicts

agricultural/environmental conflicts

Bottled water

ATTACHMENT E:

RANKING OF LIST II --- ENVIRONMENTAL HEALTH STRESSORS

Line Code	Topic Area	Overall
II-1	Asbestos	M
II-2	Carbon Monoxide	L
II-3	ETSmoke	H
II-4	Ozone depletors	H
II-5	Green house gases	H
II-6	Inorganics	M
II-7	Lead	H
II-8	Microbiological Contaminants	M
II-9	New chemicals	U
II-10	Genetically engineered products/organisms	U
II-11	Non-native organisms	M
II-12	Volatile organics	H
II-13	Organochlorines	M
II-14	Oil/petroleum	M
II-15	Ozone	H
II-16	Particulate matter	H
II-17	Pesticides - agricultural use	H
II-18	Pesticides - nonagriculural use	H
II-19	Alteration of aquatic habitats	H
II-20	Alteration of terrestrial habitats	H
II-21	Thermal pollution	L
II-22	Radon	M
II-23	Electromagnetic Fields	U
II-24	Radionuclides	H
II-25	SOx and NOx	M
II-26	Substances which alter pH, salinity, hardness	L
II-27	TSS, BOD, nutrients	L

NOTE: Overall rankings (H = high, M = medium, and L = low) summarize the SWC's criteria assessments as a summation of measures. U = unable to estimate, as a summary ranking, indicates where there are no data or data are not possible to obtain at present time.

ATTACHMENT F:

RANKING OF ENVIRONMENTAL TOPIC LIST III

High

Industrial/Commercial Practices

Transportation Systems

Municipal/Governmental Practices

Agricultural Practices

Medium

Water Management Practices

Residential/Consumer Practices

Natural Resource Extraction

Electrical Energy Management Practices

Low

Recreational Practices

Report of The Environmental Justice Committee

Environmental Justice and Comparative Risk

PREFACE

When the Environmental Justice Committee of the California Comparative Risk Project (CCRP) was formed, the project was already underway. Due to both this timing and the nature of comparative risk projects, Environmental Justice Committee members were concerned about the CCRP's outcome and skeptical that we would be able to exert any impact on it. In addition, some people following the development of the CCRP and some members of the Statewide Community Advisory Committee (SCAC), when it was later formed, viewed the Environmental Justice Committee as a threat to the CCRP (though many SCAC members were supportive from the outset). Those who were critical indicated that they thought our committee would be anti-science and adversarial.

As the CCRP proceeded we presented our views and recommendations to the SCAC through presentations and our draft report. The discussions at SCAC meetings were congenial and SCAC members expressed considerable interest in our overall approach. It has become clear that the Environmental Justice Committee has had a significant and positive impact on the CCRP, helping to shift the terms of the discussion and expand the dialogue. A number of our key recommendations were adopted by the SCAC, as reflected in their report (see SCAC Recommendations in the Summary). The Human Health Committee undertook some of the analyses we suggested, demonstrating their feasibility and usefulness to policymakers. On the other hand, we continue to be concerned that the language of comparative risk and risk-based rankings allow agencies to make decisions about environmental resource allocation that ignore environmental justice, pollution prevention, and democratic participation, as we have described them in our report.

Our report provides a brief review of the Environmental Justice Committee's history, our perspective on the traditional comparative risk model, and our recommendations for environmental decision-making in California. We have included throughout the report case studies that illustrate several of our points. We hope that the report will be helpful not only to the CCRP, but to other comparative risk projects as well.

While we believe that our specific recommendations may be of use in other projects, we do not intend them to be adopted as a substitute for the engaged participation of the environmental justice community. We encourage other comparative risk projects to use our recommendations as a framework, but note that such projects require for their success the inclusion of all stakeholders. Meaningful public participation is key for the Environmental Justice Committee, and our recommendations are only a beginning.

INTRODUCTION

The Environmental Justice Movement

> On July 26, 1993, a toxic cloud resulting from an accidental release of sulfuric acid at the General Chemical Company spread through an already heavily polluted neighborhood of Richmond, California. This area of Richmond, which is located in western Contra Costa County northeast of San Francisco, is the home for primarily lower income Black, Latino, and South East Asian residents. Richmond is the site of a large number of oil refineries, chemical plants, and other facilities that use or produce highly toxic substances, facilities which also release toxic contaminants into the environment on a daily basis. Though some authorities claimed at the time that the sulfuric acid spill did not pose a significant long-term environmental risk and that most pollutant releases in the area occur within single media regulatory limits, it is nevertheless clear that Richmond residents are a high-risk population. This situation results from the cumulative risks to which Richmond residents are subject, the inability of government agencies to fully evaluate and target such risks, and the inadequacy of environmental regulation to confront these issues in a comprehensive and proactive manner. The fact that Richmond residents are poor and people of color is representative of such high-risk population groups that are located throughout the country. This basic factor -- that poor communities and communities of color are frequently and disproportionately subject to multiple hazards and inadequate environmental protection and review -- has become a basic tenet of what has been called the "environmental justice movement."

In California, as across the country, environmental justice issues and groups are numerous. The environmental justice movement is united in understanding that freedom from ecological destruction, freedom from environmental discrimination, and the need for democratic participation at every stage of policy-making are central to an environmental justice perspective and the need to reorient environmental policy. The governing metaphor of "justice" situates the environmental justice movement and perspective within larger considerations of social justice and places environmental policy within the goals and objectives of social justice policy. The Environmental Justice Committee defined its mission as placing the challenge of the CCRP firmly in an environmental justice framework. Our report provides viable alternative strategies for targeting environmental hazards and establishing the need for an environmental justice, democratic participation, and pollution prevention framework for policy-making.

The term "environmental justice" is used throughout the report to describe a growing social movement as well as a particular set of environmental policy issues. Though a relatively new concept, "environmental justice" refers to a rich tradition of urban and rural environmental activism that dates back to the beginning of the century. The environmental and occupational hazards experienced by the most vulnerable groups in society -- the poor, recent immigrants, women, people of color, children and communities subject to multiple forms of pollution -- have long been concerns of community activists, social reformers, and public interest scientists.

CASE STUDY

PEOPLE UNITED FOR A BETTER OAKLAND: PUEBLO FIGHTS LEAD POISONING

Francis Calpotura and Renku Sen, organizers in the PUEBLO campaign to eradicate lead poisoning in Oakland, describe lead poisoning as "one of the most pervasive environmental hazards affecting low-income, inner-city children in America, ... especially dangerous because its effects are difficult to diagnose without a special blood test. Moreover, its effects are largely irreversible." People United for a Better Oakland (PUEBLO) attracted residents into the campaign who had direct experience with lead poisoning. Residents like Ramon Zamone, a worker in a metals factory, had to bear all the costs of his children's medical treatment and getting the lead out of his home. Though his youngest daughter had loss of coordination, nose bleeds, and hair loss, his doctor failed to recognize these classic symptoms of lead poisoning.

PUEBLO brought together African American, Asian, and Latino immigrant communities, and fought for three specific demands:

1) Environmental screening: immediate testing of homes built before 1950 and all public spaces, including parks, schools, and adult workplaces;
2) Access to health care: self-certification for California Health and Disability Prevention Program (CHDPP) services for all facilities meeting the eligibility requirements, and immediate blood tests for low-income children, paid for by CHDPP; and
3) Abatement: adoption of a county-wide Lead Abatement Plan, including public education, referral for blood lead screening and medical treatment, subsidies to fund the abatement of lead in residential properties, and professional education for contractors and medical workers.

PUEBLO'S campaign has been difficult and challenging for its members. Opponents ranged from some city officials to the real estate lobby. On the issue of blood testing of low-income children, the campaign filed a law suit that resulted in a Statewide program that tests hundreds of thousands of young children for lead in their blood.

The campaign also won Oakland residents the most comprehensive Lead Abatement Plan on the West Coast. Though work needs to continue, duplication of models such as PUEBLO's will go a long way towards winning the battle to prevent lead poisoning.

In recent years, the concept of environmental justice has been used by community movements that formed in response to the multiple environmental hazards and disproportionate risks that communities like Richmond experience (Cole, 1993). Environmental problems are woven into the social fabric of residents' lives, and so communities are recognizing the need for broader social solutions beyond the mitigation of a particular risk or environmental hazard. Contaminated water, dirty air, and exposure to hazardous materials are becoming seen as part of the larger context of problems any single community may face, including inadequate access to quality health care and education, poor job opportunities, and lack of affordable housing.

Environmental justice advocates argue forcefully against the redistribution of environmental risks to other communities and propose instead that risks be reduced or eliminated at their source. Demanding structural solutions and preventive approaches, an environmental justice framework incorporates such concepts as source reduction and pollution prevention. As early as 1971, the Council on Environmental Quality (CEQ) issued warnings about the disproportionate environmental burdens experienced by the poor and people of color, and urged that governmental policies take into account such inequities (CEQ, 1971). Yet, instead of seeking to define an "environmental justice" perspective with respect to such activities as rulemaking, permitting, and enforcement, environmental policies have actually reinforced disparities. The result has been the frequent setting of waste disposal facilities in powerless communities, the elimination of "green space" in inner city areas, and the differential implementation and enforcement of regulations, to list a few examples.

Environmental Justice Committee members share core environmental justice principles, articulated at the 1991 People of Color Environmental Summit, which include "the right to be free from ecological destruction" and that "public policy be based on mutual respect and justice for all peoples, free from any form of discrimination or bias." Environmental justice is also centrally about the right of people to participate "as equal partners at every level of [environmental] decision-making, including needs assessment, planning, implementation, enforcement and evaluation" (People of Color Environmental Leadership Summit, 1991). The Environmental Justice Committee's critique of the CCRP is framed by these principles and highlights the necessity for environmental agencies to meet the needs of our State's diverse population by emphasizing democratic public participation and giving priority to preventing and eliminating environmental hazards and restoring the air, water, and land we all depend on.

The California Comparative Risk Project

In 1992, the California Environmental Protection Agency (Cal/EPA) established the CCRP with support from the U.S. Environmental Protection Agency (U.S. EPA). This project, similar to projects organized in other cities and states across the country, was intended to undertake two simultaneous tasks:

→ develop a ranking of risks aimed at "identifying, and ranking major environmental problems in the state," and,

→ establish a "strategic plan to mitigate those risks."

According to Cal/EPA Secretary James M. Strock, the ranking of risks would be accomplished by bringing "good scientific minds together to help establish the 'best science'." (CCRP, 1992). The second task, developing a plan to address environmental risks, would involve combining the "objective" ranking with a subjective evaluation of social concerns.

The California Comparative Risk Project is an outgrowth of a process first initiated with the publication of the U.S. EPA's 1987 report Unfinished Business: A Comparative Assessment of Environmental Problems, and followed in 1990 with the U.S. EPA's Science Advisory Board's report *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* (U.S. EPA, 1987; 1990). Both documents adopted the use of quantitative risk assessment for ranking environmental hazards as a means to prioritize risks. Since the U.S. EPA's 1987 report, there has been much discussion both within and outside of the scientific community about three issues in particular:

→ whether current quantitative risk assessment techniques, by themselves, lead to the most desirable, just, and fair public policies;

→ whether quantitative risk assessments are value-free and lead to "objective" priority-setting; and,

→ whether the current risk assessment approach, which focuses on a narrow set of considerations, is comprehensive enough to identify and redress the scope of environmental risks for the most vulnerable groups in society, and to emphasize a prevention (as opposed to remediation) framework.

The Environmental Justice Committee

The Environmental Justice Committee was established by the CCRP Director as one way to elaborate upon social concerns within the comparative risk process. In organizing the CCRP, however,

Cal/EPA officials stated that the primary objective of the CCRP was the risk-ranking exercise itself, and that social concerns, including environmental justice, were somewhat tangential (Ault, 1992). Environmental justice concerns were neither clearly defined nor specifically related to the process of "scientific" ranking that was to be the centerpiece of the project outcome.

The segregation of the "science" of the risk-rankings from the weighing of social considerations in the development of management options was formalized during the course of the CCRP when two components were defined. Component 1 (composed of the Human Health, Ecological Health, and Social Welfare committees) was to perform risk-ranking, while Component 2 (composed of the Environmental Justice, Economic Perspectives, and Education committees) was created to evaluate other factors considered in environmental decision-making, and to critique the risk-ranking model.

The Environmental Justice Committee believed that, in essence, the two "components" were set up in opposition to one another: one to rank and the other to criticize. Late in the process, cooperation was initiated between participants of various committees in both Components 1 and 2. Time constraints, however, limited rethinking of the "ranking" paradigm within the CCRP as a whole.

Despite the barriers we encountered in attempting to incorporate environmental justice perspectives into the CCRP, it is important to note that, as of this writing, no other comparative risk project in the United States has included such a committee. The fifteen-member Environmental Justice Committee is composed roughly equally of northern and southern Californians, and of activists and academicians broadly representative of the concerns of the environmental justice movement, including occupational health, people's relationship to the land, urban and rural environmental quality, and environmental health (see Attachment A). More than half of the members of the Environmental Justice Committee are people of color, and over half are women.

A CRITIQUE OF COMPARATIVE RISK AS RISK-RANKING

During meetings of our Environmental Justice Committee, we reviewed and critiqued traditional comparative risk assessment methodologies and put forth alternative approaches to priority-setting other than ranking risks. We identified significant limits to the comparative risk process as it has been described in U.S. EPA documents, in federal legislation to mandate the comparative risk approach in U.S. EPA, and in the CCRP's original workplan. This section presents our critique with respect to four issues:

1) The structure of decision-making procedures in comparative risk projects (and in environmental decision-making generally) has not adequately provided for full and meaningful community participation. The projects, therefore, can not account sufficiently for many legitimate social policy concerns, and fail to consider data not usually recognized as important by regulatory agencies.

2) Comparative risk exercises are grounded in a presumption that only limited resources are available for environmental protection, forcing choices to be made between risks to be managed or mitigated without first exhausting all strategies for increasing the total resources available or recognizing that pollution prevention may increase resources by reducing the need for governmental regulation.

3) When determining the list of risks to rank, the lack of distinction between risks amenable to pollution prevention approaches and those that are not (such as abandoned hazardous waste sites, lead paint in dwellings, and radon) precludes opportunities for encouraging pollution prevention.

4) The use of conventional quantitative risk assessment methods and unidimensional measures of risk do not enable decisionmakers to recognize the disproportionate risk burdens borne by certain communities.

Underlying each of these issues is the environmental justice-based concern that specific communities, most often those composed of lower income individuals and/or people of color, bear disproportionately greater risks. As U.S. EPA acknowledged in its report, Environmental Equity: Reducing Risk For All Communities, differential risk burdens result from exposures to multiple hazards, and from increased susceptibility to adverse effects due to compounded exposures and lower health status generally (U.S. EPA, 1992). It is this concern which must be accounted for in any priority-setting process that might influence the future distribution of resources for environmental management and protection.

The Necessity for Public Participation

Public participation is now widely accepted in diverse policy fields, and relies on industry, community, and government collaboration. Regarding the environment, it encourages communities to address selected environmental risks locally through public hearings and other forums.

In theory, the growth in emphasis on public participation has been a welcome change but, in truth, communities of color and low-income communities are often unable to participate on equal terms with industry and government. Greater efforts by policymakers are required to engage these populations in effective and fair public decision-making.

CASE STUDY
CALIFORNIA FARMWORKERS

In her article Individual and Cultural Differences in Adaptation to Environmental Risks, Environmental Justice Committee member Elaine Vaughan states that public participation efforts are effective and successful only when diverse groups are able to be engaged in the risk management process (Vaughan, 1993). Vaughan studied farmworkers from several counties in California, and found that attitudes and behavioral responses toward environmental risks can vary significantly among different sociodemographic groups. Her sample included 282 male participants who shared many characteristics with the larger farmworker population in California. "The vast majority had an educational level less than grade school, more than 90 percent were born in Mexico, and most had worked in the fields for more than 10 years," Vaughan writes. "Among these individuals, knowledge of pesticide exposure and accompanying risks was high, but actual responses to exposure varied." The impact of environmental pollutants on human health depends upon social, economic, and cultural conditions. In this study of immigrant farm laborers, those in the most economically vulnerable situation also experienced the greatest levels of exposure and were the least informed about pesticides.

Vaughan notes that economic instability and feelings of powerlessness hold back the workers' participation in activities that could protect their health and help manage their risk. She concludes that policymakers need to recognize and address specific socioeconomic, cultural, and psychological influences if participatory strategies are to be effective in reducing and preventing environmental risks across diverse communities.

An environmental justice approach seeks participation in the decision-making process by communities called upon to bear the risks under review, and strives to create the conditions in which policymakers and risk analysts become sensitive to and incorporate into their evaluations the communities' information and knowledge. This public participation approach is based on the idea that people who live in a community are experts in their own right about what is happening there and, further, should be the ones who decide what will happen to the community in the future. Such public participation, or the concept of "we speak for ourselves," is a central tenet of the environmental justice movement and reflects the American democratic tradition.

A major part of the mission of the CCRP's Education Committee was to investigate and make recommendations concerning the CCRP's public participation process, and we endorse and refer the reader to that committee's report beginning on page 255 of this CCRP report. We agree with the Education Committee that the CCRP's public participation efforts were valuable but insufficient.

Comparative risk projects present a considerable public participation challenge in a state as large and diverse as California. California environmental justice groups have made recommendations for improving public participation in site-specific and regulation-setting decisions that apply equally well to comparative risk projects: among these are the provision of translation services; project materials in the reader's primary language; convenient and culturally appropriate forums for participation, including transportation and childcare considerations; and increased expert community assistance funded by the state, such as the "Community Technical Assistant Contract Grant" program that once existed in the California Department of Toxic Substances Control, or the similar program provided for by the Superfund Amendments and Reauthorization Act of 1986.

The Presumption of Limited Resources and Choosing Between Risks

Comparative risk inherently implies that choices must be made regarding which risks to mitigate and which to ignore. This is based on a presumption that given limited resources, ranking enables policymakers to allocate funds for environmental management more "efficiently." But, as Mary O'Brien

of the University of Montana has argued, governmental agencies have failed to pursue a range of politically viable opportunities for increasing funding for environmental protection (for example, "pollution taxes"). Secondly, O'Brien argues that decisionmakers need to identify alternative processes and products (e.g., a toxics use reduction strategy), rather than simply comparing and choosing between risks to mitigate. For example, rather than rank the risks of different pesticides or compare the risk of pesticides to other toxic substances or hazards, both risk analysis and risk reduction activity should be focused on alternative methods of pest control. By eliminating the use of these chemicals, the need for extensive government monitoring and regulation also is reduced, maximizing the resources available for environmental management (NAS, 1983).

CASE STUDY
KETTLEMAN CITY:
TAKING CULTURAL FACTORS INTO ACCOUNT

A dispute over the siting of a toxic waste incinerator in Kettleman City highlights the responsibility of policymakers to address obstacles that limit communities from full participation. Kettleman City, a small, farmworker community in California's Central Valley, is 95 percent Latino and 70 percent of its 1,100 residents speak Spanish in the home. Most residents work in the agricultural fields. The town also hosts the largest toxic waste dump west of Louisiana.

In 1988, Chemical Waste Management (CWM) proposed to build a new toxic waste incinerator at the dump. Despite local government's view that Kettleman City residents would have no opinion regarding this project, local residents formed a protest organization, People for Clean Air and Water. They soon found that democratic participation in the County planning process was going to be a challenge.

Specifically, a 1,000 page environmental impact report (EIR) on the proposed incinerator was available, but only in English. The County staunchly refused to translate it into Spanish, citing the absence of any legal responsibility to do so. The residents were not dissuaded; they held house meetings and educated themselves on the contents of the EIR with the help and support of California Rural Legal Assistance. These meetings were conducted in Spanish. The results proved to be remarkable. Seventy-five percent of all the public comments on the EIR -- 120 letters -- were in Spanish, from the people of Kettleman City. This outpouring of public comment demonstrated that Kettleman residents both cared about the project and wanted to be included in the environmental review process.

Kings County did not value this input, however, and a lawsuit by the community was required to overturn the County's approval of the incinerator. Among the reasons the judge cited for overturning the County's decision was the lack of meaningful participation by the residents because the documents were not in Spanish.

In this situation, a lawsuit resulted because a local government agency refused to allow community input into the environmental review and decision making process. A strategy that sought to maximize, rather than stifle, public participation would lead to the inclusion of more voices in environmental policy-making.

Pollution Prevention

An environmental justice approach to risk ranking is fundamentally related to issues of pollution prevention. Pollution prevention can be defined as an approach which seeks to reduce or eliminate hazardous or toxic substances throughout their entire lifecycle: from the extraction and processing of raw materials, through multiple manufacturing steps, distribution, and use, to their eventual disposal. Ranking risks, on the other hand, establishes a process of evaluating and prioritizing risks for purposes of policy intervention only after such risks have been created. If pollution prevention were to take precedence over and frame any evaluation of risks, we would be better able to address why and how risks are created in the first place.

CASE STUDY
SAN DIEGO SCHOOLS: PESTICIDE USE REDUCTION

In 1991, the San Diego Unified School District adopted an integrated pest management (IPM) policy that resulted in several environmental benefits. It reduced reliance on toxic pesticides by mandating the use of poisons only as a last resort; it reduced exposure to children, teachers, and school personnel; and it reduced the amount of toxic wastes disposed of by the schools. Initiated by the 2,000 member Environmental Health Coalition, the IPM program won support from the San Diego Teachers Association, California Teachers Association, National Parent-Teachers Association and environmental groups. Over 3,000 concerned residents signed a petition in support of the program.

The integrated pest management procedures for the first year included the following: a new flea monitoring schedule that resulted in a reduced need for flea spraying; the ant spray Safrotin, an organophosphate, was removed; and a cockroach control plan for school busses required all food to be cleaned out before spraying would proceed. A new cockroach monitoring and record keeping method along with alternative methods for eliminating cockroaches was instituted at several school sites. While these methods are good first steps, the district still uses weed-killers such as Roundup, and insecticides at school sites. Alternative methods are being explored with the goal of eliminating the use of these toxics in the schools.

Presently, the County of San Diego is considering adopting a similar IPM to reduce the use of toxic pesticides in all county buildings and on county properties. This proposal is expected to save the county money as well as provide a more effective means of controlling pests. Currently as much as $130,000 to $200,000 is spent on pesticide products. The proposal was developed by a county task force that includes representatives from environment, agriculture, and pest control organizations.

CASE STUDY
SANTA MONICA:
LOCAL GOVERNMENT AND CITY EMPLOYEES
WORKING TOGETHER TO REDUCE TOXICS

Custodial, janitorial, and residential housecleaning can be hazardous. Workers, many of whom are people of color, are potentially exposed to such toxic substances as toluene, trichloroethylene, formaldehyde, perchloroethylene, and xylene. Despite the growing focus on pollution prevention as a strategy to address toxic releases, the focus has been on wastes and relatively little has been developed with respect to product use.

In July 1993, the City of Santa Monica launched a pilot program to use non-toxic cleaning alternatives. The program grew out of recommendations proposed in a U.C. Los Angeles study of the use of toxics in city departments. The city's Environmental Program Division staff met with custodians and together they agreed that hazardous cleaners were a problem. They decided to hire S.A.F.E. Inc., a cleaning service that promotes non-toxic cleaning materials, to do an evaluation and develop a list of possible alternative products.

A series of meetings brought together S.A.F.E consultants and city custodial staff to discuss questions about the hazardous nature of existing products and the effectiveness of various alternative cleaning products. The City's custodial staff, 90 percent of whom are workers of color, shared stories about their exposures to cleaning materials and were enthusiastic about the alternatives.

The willingness of the workers to participate in the pilot program combined with the City's commitment to make toxics use reduction a policy framework promises significant change in the use of toxics in Santa Monica. Businesses have expressed interest in the program, which is likely to become a model for pollution prevention action for both government and industry.

It is increasingly clear that the prevention of environmental hazards is far preferable to the management and control of hazards once they have been created. Today, the costs of controlling and managing environmental hazards have become astronomical for industry, government, and communities. Handling hazardous materials and disposing of wastes is expensive, and imposes risks and liabilities for all parties involved. Since pollution prevention addresses the generation of risks at the

front end of a production system, it can establish cleaner workplaces, a cleaner environment, and fewer hazardous products for both consumers and industry. In fact, there is little disagreement today that pollution prevention should be the highest priority for policymakers and industry.

CASE STUDY
THE CHEVRON CORPORATION:
TOXIC USE REDUCTION IN RICHMOND

According to Greg Karras in his article "Pollution prevention: the Chevron story," (Karras, 1989) the Chevron USA petroleum refinery in Richmond, California, is the largest of six major refineries operating near San Francisco Bay. In 1986, Chevron was responsible for 35 percent of the chromium and more than 50 percent of the nickel discharged into the north end of the Bay. Lab results linked the disappearance of 12 species of aquatic life to Chevron's metal discharge. In 1986, Citizens for a Better Environment (CBE) and United Anglers of California appealed to the Regional Water Quality Control Board when Chevron requested renewal of its discharge permit. After reviewing the evidence, the Board required Chevron to examine its in-plant operating procedures and to develop methods to reduce or eliminate metal discharges. This decision also authorized CBE to review Chevron's pollution audits and to be involved in evaluation of Chevron's pollution prevention proposals.

Chevron ultimately selected toxic use reduction (TUR) methods which would reduce the need for producing, transporting, and handling toxics. Toxic use reduction methods include substituting alternative chemicals, reformulating products, and changing operational procedures. This represents a pollution prevention approach to the problem. Traditional waste treatment methods, on the other hand, assume that use of toxics will continue.

Chevron agreed that only when TUR methods were not feasible would waste treatment measures be considered as a temporary, short-term expedient. By 1988, this new approach led to a 70 percent to 90 percent decrease in the company's toxic metal discharges into the Bay.

While it is still unclear whether other industries will voluntarily embrace pollution prevention and TUR, the affected communities must move forward and participate in shaping new pollution prevention strategies. U.S. Environmental Protection Agency programs like "Technical Assistance Grants" (TAGs) should be expanded to help educate communities on pollution prevention and TUR, and to help facilitate ways for communities to negotiate, review, and evaluate industry pollution prevention plans effectively.

Previous risk rankings have missed opportunities for identifying pollution prevention activities because they have not distinguished between risks that are amenable to pollution prevention and those that are not. Risks that could be reduced by a pollution prevention approach include, for example, occupational exposures and emissions from industrial facilities; a variety of risks arising from our dependence on the automobile; and occupational exposures, drift, runoff, and residues from agricultural chemicals. Risks that are not amenable to a pollution prevention approach (though they may be mitigated in other ways) include abandoned hazardous waste sites, lead paint in housing, and radon, among others.

Failure to make this distinction perpetuates a risk management approach that always addresses problems after the fact. Instead, all new policies for managing risks should be scrutinized through a pollution prevention lens, and new sources of industrial hazards should not be deemed "acceptable" until all or "preventive" measures have been taken.

In many cases, a pollution prevention approach may require shifting the burden of avoiding risks. Management and mitigation measures should be identified in a manner that provides for a fair distribution of costs and benefits. Generators of risks amenable to prevention should bear the true costs of their activities, and public resources should be used for health or ecological problems that pollution prevention cannot ameliorate.

Quantitative Risk Assessment and Comparative Risk

Quantitative risk assessment has been a foundation of risk-ranking. Both as a "science" and in relation to the traditional methods it has employed, it has a detailed literature advocating its use. However, risk assessors themselves have noted its limitations (Gough and Wilson, 1993), and there is a growing literature describing its limits and the underlying values associated with its use. The criticism of traditional risk assessment has focused largely on the vast uncertainties inherent in quantifying risks. Additional criticism has been leveled at the risk-ranking process in regard to the methods of comparison (e.g., comparing global warming to lead exposures, or wetlands destruction to nuclear power plant safety).

An environmental justice perspective elaborates upon these critiques by pointing out the limits to and biases of determining risks averaged over entire populations. The use of aggregate statistics and population risk measures ignores the significance of toxic "hot spots," locations where multiple risks occur. Moreover, risk assessment usually does not account for exposures to multiple hazards over time, differences in individual susceptibilities to toxics, and potentially synergistic exposures.

Since 1983, when Risk Assessment in the Federal Government was published by the National Academy of Sciences (NAS), the U.S. EPA's official position has been that environmental decisions should be more "scientific" and that the "science" of risk assessment must be separated from the policy or value-laden decisions in risk management (O'Brien, 1992). The National Academy of Sciences proposed this two-step model of risk assessment and management as a means to insulate the "science" of risk assessment from value-laden management decisions. It has been criticized for being unrealistic by both scientists and philosophers of science who argue that no practice of science is purely objective, and social scientists who claim that risk assessors cannot be immune to the political factors of the institutions within which they operate. "Value" choices in the risk evaluation process need to be made explicit.

The two-step model has also been criticized as unproductive, failing to provide useful guidance. Some authors argue that the context within which the "science" of risk assessment is performed should shape how scientific information is used and interpreted, and that there should be feedback among the social, political, economic, and scientific aspects of risk assessment and management in the ways in which we define the questions we ask, collect and analyze data, and translate scientific findings into public policies (Hadden, 1984).

CASE STUDY
BARRIO LOGAN, SAN DIEGO
SMALL POPULATION, LARGE RISKS

Barrio Logan, located south and east of downtown San Diego, is another prime example of a "hot spot" community. Ninety-nine percent of the residents of Barrio Logan are Latino. These residents live in a neighborhood where many of the schools, stores, and homes are in close proximity to various types of industries. One hundred and twenty-seven industries in Barrio Logan store potentially dangerous chemicals. In addition, Barrio Logan industries generate 23 million pounds of hazardous waste.

Residents in Barrio Logan have worked actively to eliminate the risks imposed on them by the high number of dangerous industries in their neighborhood. They have sought and won the relocation of a large hazardous waste treatment and disposal plant located across the street from the Barrio Youth Station, a community service center.

Population versus individual risk measures

Previous comparative risk exercises, from the 1987 Unfinished Business to recently completed state projects, have ranked environmental health hazards using measures of population risks; that is, measures of the additional incidence of some adverse impact in the affected population. These exercises have

been grounded in an assumption that risks ought to be ranked unidimensionally in a way that reflects only the magnitude of their impacts on society as a whole. We view diverting resources toward the most highly ranked risks, then, as setting priorities only in accordance with a goal of overall risk reduction.

The problem with using only total population as a measure of risk is that it ignores how high individual risks might be, and how they are distributed. For example, if arsenic were to leach from an abandoned toxic waste site into a nearby waterway, it could present huge individual risks. The statewide population risk associated with this situation, however, might be very small if just a small number of people depended on that water supply. Ranking the site using population risks alone would not identify it as a priority. Most often these cases are in poor communities and communities of color.

A circular construct emerges: waste sites and industrial facilities are located in poor communities and then are not subject to stringent intervention or remedial action because the population risks (as opposed to individual risks of those exposed) are seen as minimal. By using population risk as the yardstick, risk assessors and policymakers justify not taking action on the basis of the lesser benefits of mitigation to the overall population. Using average population risk for ranking without also looking at maximum individual risk is simply a policy choice, not a "scientific" decision.

Hot spots of multiple, cumulative, and synergistic risks

Geographic areas where residents experience greater environmental risks are commonly called "hot spots." These communities contain a multitude of polluting industries and waste sites. Hazel Johnson, an activist from South Chicago, Illinois, which is ringed by such facilities, describes her situation as "living in the heart of a toxic donut."

"Hot spots" in the United States are disproportionately in communities of color. They are often characterized by old housing stock contaminated by lead or asbestos. In many such areas, landfills or discharges from industry pollute the air, land, and water, including rivers and other places where people fish for subsistence. Freeways often cut through these communities, causing smog as well as toxic risks from the transport of chemicals. Multiple toxic exposures, including those in the workplace, combine with other factors such as poverty, lack of adequate medical care, and poor nutrition, to further harm the community's health and welfare. Our case studies of Richmond, PUEBLO in Oakland, and Barrio Logan on previous pages are all examples of "hot spots."

RECOMMENDATIONS: ALTERNATIVES TO RISK-RANKING

We have argued in this report that the exercise of risk-ranking is fraught with danger because of the historically small role played by the public, the reliance on traditional quantitative risk assessment, and a policy focus on "end-of-pipe" strategies to contend with existing risks. The Environmental Justice Committee has approached the issue of risk evaluation and the implicit management strategies associated with it from a different perspective, one based on several core, related values: public participation, environmental justice, and pollution prevention. We also recognize that environmental goals should not be divorced from other community and social needs (such as health care for all, food security, and jobs and a secure income) that comprise the community's right to a secure future.

The following recommendations are an alternative to ranking-risks categorized by environmental medium (e.g., air toxics vs. wetlands loss), by chemical (arsenic vs. trichloroethylene), or by source or activities (refineries vs. farming). Instead, we propose that comparative risk projects view these sorts of indicators -- when risks are considered significant enough to warrant attention by environmental agencies -- not as the primary problem to address, but as symptoms of shortcomings in the ways in which environmental decisions are made. In other words, our critique suggests that the risk evaluation priorities should be comprised of changes to the decision-making process itself, rather than comprised of a ranking that addresses symptoms.

We put forth three fundamental proposals. These are:

1) that public participation is inviolate, and provisions for maximizing full and meaningful participation must be primary to reviews of all environmental agency activities (for example, permit streamlining, if implemented, must not sacrifice public participation);

2) that the consideration of subpopulations that bear the disproportionate risks (i.e., "hot spots") must be incorporated into any new and/or existing environmental policies (i.e., risk assessment, permitting, enforcement); and

3) that all policies must have as their primary objective the prevention or reduction of risks that may harm human health and/or the environment. This principle of pollution prevention should guide all efforts at risk evaluation and policy implementation.

Below are some examples of how these proposals could be operationalized.

Hot spots

→ Consideration of communities that bear disparate risk burdens can, in part, be accomplished in a number of ways. First and foremost, however, Cal/EPA must ensure equitable and effective implementation and enforcement of all its regulations and activities.

→ Beyond implementation and enforcement, Cal/EPA must reconsider the methods by which environmental hazards are evaluated. Individual risks (in addition to population risks) must be assessed as a means to identify people or communities that bear high risks but are lost in statistics aggregated statewide. Within such assessments, Cal/EPA must recognize that disproportionate risks occur in both

settings of place (e.g., home, neighborhood, schools, community, region) and social activities or experiences (e.g., jobs and health status).

→ For the purpose of reallocating resources, Cal/EPA should include and give prominence to geographical considerations in establishing its priorities, rather than relying on other measures such as environmental media, chemicals, source or industrial activities. This would enable decisionmakers to direct resources toward communities that suffer multiple risks and that have long been overlooked. Further, models of equitable risk-sharing should be employed in decisions regarding the setting of new sources.

→ To avoid the establishment of new "hot spots" across the State, Cal/EPA (and the California Occupational Safety and Health Administration, Cal/OSHA) should develop methods of proactive hazard identification and mitigation, with particular attention to high-risk populations. These populations may include children, communities subject to a multitude of environmental assaults, and immigrant workers who might unduly suffer from language barriers and a lack of understanding of their rights to a safe workplace. Other communities that are disproportionately impacted by environmental hazards could be identified by utilizing geographical data bases of chemical use, storage, and release, such as the "Toxic Release Inventory" (TRI), the Air "Hot Spots" Act, community right-to-know information, and the myriad other data held by Cal/EPA.

Public participation

→ An open decision-making process relies upon Cal/EPA's support for full participation of California residents in all environmental programs. This includes residents' input at the problem definition, planning, and implementation stages of Cal/EPA projects (from comparative risk exercises to the development of new rules and regulations), and oversight of enforcement activities. To guarantee this right, Cal/EPA should expand provisions for citizens' suits in response to violations for state environmental laws. Such a proposal could be realized by extending citizen lawsuit provisions such as those in California's Proposition 65 (The Safe Drinking Water and Toxic Enforcement Act of 1986) to all the State's environmental laws and other state and federal environmental legislation, and by expanding community right-to-know opportunities as was done under New Jersey's "Right-to-Know More" Act.

→ The California Environmental Protection Agency must protect all provisions for public hearings on decisions that may affect a community's health or safety. Current Cal/EPA efforts to streamline regulatory and siting procedures, for example, should not be accomplished at the expense of shutting off opportunities for public participation. Adjudicatory hearings might be provided for the most significant decisions, such as the setting of toxics-generating facilities and hazardous waste sites. Time and location of hearings and public meetings should be convenient, with access to public transit and provision of childcare, translation services, and sufficient notice.

→ Fuller and more meaningful participation should be promoted by providing sufficient technical resources to affected communities. Technical assistance grants programs should be established and well-funded. It is imperative that technical resources

include translation services and the provision of materials in residents' and workers' primary language(s).

→ Our Environmental Justice Committee members also endorse the Education Committee's recommendations concerning public participation.

CASE STUDY
THE FIRST INTERTRIBAL PARK
USING TECHNICAL ASSISTANCE TO FOSTER PUBLIC PARTICIPATION

The InterTribal Sinkyone Wilderness Council is a consortium of 10 federally-recognized California Indian Tribes. The Council has developed a land-use management and restoration plan to protect, preserve, and manage 3,800 acres adjacent to Sinkyone Wilderness State Park in Mendocino County. The plan includes restoration of rainforests, coastal stream corridors, and marine areas.

The area is already being used to educate both visitors and Native people and to help preserve the Indian traditions. It will also become a learning ground for developing an ecological relationship with the land based on Native culture. The California Department of Forestry and Fire Protection, the California Coastal Conservancy, and the Department of Parks and Recreation have provided funding for the Council's planning effort that includes funding for technical assistance; the Council has drawn on students and faculty from several California campuses. The State is also funding the Council to conduct a forest inventory and carry out stream restoration, thus providing new skills and jobs. Negotiations are underway between the Council and the Coastal Conservancy to transfer title of the land to the Council.

This case study highlights the successful use of technical assistance funding to foster meaningful public participation in ecological management, while recognizing and preserving Native American culture.

Pollution prevention

→ The overriding objective of pollution prevention should guide all Cal/EPA decisions whenever possible. Both new and existing sources of environmental discharges should be required to evaluate and implement all feasible pollution prevention strategies before operating permits are issued, and all reallocation of Cal/EPA resources should be undertaken only after all such opportunities are exhausted.

→ Shortages of resources for environmental protection may be relieved by shifting to manufacturers and users of hazardous materials the responsibility for demonstrating that the use and disposal of regulated chemicals is "safe." Such a change is consistent with, and can be supported by, a "whole facility approach" for permitting and enforcement. This would aid the establishment of industry-specific technical assistance and review programs for pollution prevention across Cal/EPA departments and boards, as developed in U.S. EPA's "Source Reduction Review Project."

→ Extend current requirements for a pollution prevention audit to include methods of implementation, as a permitting condition for any facility that reports toxic releases under TRI provisions. A formal process for evaluation of pollution prevention efforts could be based on pollution prevention plans established annually and reported through the TRI, or on the source reduction plans required under the California Hazardous Waste, Source Reduction, and Management Review Act.

→ Institutionally, some identifiable entities must be responsible for ensuring that the pollution prevention principle permeates all Cal/EPA programs and activities. This might be accomplished with the establishment of an Agency-wide Office of Pollution

Prevention in Cal/EPA, reporting directly to the Secretary. Cross-agency coordination also is imperative and could be achieved by a Governor's Task Force on Pollution Prevention. Such a task force would be responsible for reviewing all agencies' programs that have environmental responsibilities, and for integrating prevention criteria directly into the evaluation of all their activities.

We offer these three proposals and the examples of recommendations derived from them as a starting point in establishing an environmental justice framework for risk evaluation and policy implementation. We are pleased that rather than limiting itself to risk-ranking, the CCRP has incorporated our recommendation that changes in the environmental decision-making process be a key part of the project's proposals to policymakers. We note in particular that the SCAC has included among its recommendations a call for public participation and for a multidimensional approach in considering risks, including activities that would address "hot spots" and expand the potential for pollution prevention. We encourage a continuation of this dialogue while remaining firm in our belief that without these and other aspects of environmental justice, comparative risk will remain an exercise that exacerbates rather than addresses these core concerns.

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ATTACHMENT A:

ENVIRONMENTAL JUSTICE COMMITTEE MEMBERS

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Report of the Education Committee

Assessment of Education and Public Participating in Environmental Decision-Making

EXECUTIVE SUMMARY

The Education Committee, which was composed of members from state government, education, industry, and environmental and community activist organizations, adopted the following mission:

1) To identify the status of occupational and environmental education in the State of California and make recommendations.
2) To investigate the public participation process in the California Comparative Risk Project (CCRP) and make recommendations.
3) To facilitate communication among CCRP committees.
4) To educate ourselves as well as other committees about perceptions of risk.

The work products of the Education Committee include a vision statement on education programs, criteria for assessing education programs, a brief history of environmental and occupational health education, a listing and review of innovative curricula, and a set of recommendations on future education programs. In addition, the Education Committee developed the framework for, and a series of observations regarding, public participation in comparative risk projects. There is also a summary of the results of the regional public roundtables written by PS Enterprises in this report of the Education Committee.

One of the goals of the Education Committee was to assess the quality of both occupational health and environmental education programs in California. The sheer number of formal and informal programs and materials, however, rendered this assessment impossible. As an alternative, the group developed a set of criteria, against which materials and programs should be evaluated in the future. These criteria can be found on in this Education Committee report.

The Education Committee was very concerned with whether or not the programs effect empowerment within individuals and communities, and whether or not they are both targeted at and raise consciousness about multicultural issues. The group feels that these are urgent issues, given the rapidly changing demographic face of the state, and the changing perceptions of environmental problems. The Education Committee also recognized the need for integration of health issues into resource based environmental education projects and curricula.

The Education Committee developed a vision statement addressing ideal occupational health and environmental education programs. While the Education Committee is aware that the field of environmental education is broad and diverse, members decided to develop a vision statement on environmental education that will be inclusive of multiple concerns. The vision statement, supporting principles, and other materials are found in this chapter.

The following is an executive summary of findings from the Education Committee addressing public participation and environmental and occupational health education. It also summarizes the concerns voiced by the public at the roundtable forums and from previous experiences of the Education Committee members.

Education

The Education Committee recognized immediately the need to assess environmental and occupational health education in California. We found an overwhelming number of formal and informal ways that environmental and occupational health education is being conducted. There are many curricula and supplemental materials with few agreed-upon criteria or evaluation mechanisms. And despite the number of projects and curricula, there is still a large gap between the numbers of programs and curricula in existence and the extent to which any segment of the population in California is properly educated regarding environmental issues, risk communication or occupational health issues. This applies to children, high school and college students, and adults as well.

A lack of public understanding regarding environmental issues is consistently listed as a key problem in comparative risk projects. Several states have listed it as one of their "problems" in their ranking lists. The State of Michigan ranked it in their top six and the city of Jackson, Alabama ranked it as their number one problem.

Key findings

For a more detailed discussion of the findings of the education assessment, see the full report of the Education Committee.

→ All environmental programs should have an education and risk communication component that includes information about the interrelationship of occupational health and environmental health concerns.

→ Education efforts need to be multicultural in approach and be targeted to appropriate languages and literacy levels.

→ Environmental education, occupational health education, and risk communication are under-funded and lack the administrative support needed to achieve a well educated and empowered citizenry. This informed citizenry is the cornerstone to development, adoption, and implementation of sound public policy.

Public Participation

Public participation must be an integral part of the environmental decision-making processes and should start from the very beginning of any project. The public must be seen as a full and equal partner, not as an adversary. The process should be one where each party truly incorporates each other's ideas, concerns, and knowledge into their own way of thinking about the problems they are facing.

Key findings

→ Public participation occurs along a continuum. The way in which public participation is done should reflect a sincere attempt to establishing dialogue with the affected communities.

→ Public participation is necessary and not negotiable, and should influence the decision-making process in an explicit manner.

→ Public participation can be seen as a solution to some environmental problems in and of itself.

→ True public participation is not possible without education and an explanation of risks that incorporates an understanding of the culture and language of the affected community.

→ In order for the public to participate, meetings must be held at convenient locations and times. There should be vigorous outreach into the affected communities and translators provided as needed.

→ There is a need to decide in advance how public participation will be used; otherwise promises may be made which cannot be kept. This will work against developing public trust.

→ Public participation should not be used as a way to try to buy off the community. It requires a genuine commitment to establishing, growing, and maintaining partnerships.

Risk Assessment and Comparative Risk

Comparative risk projects that use only risk assessment for priority-setting are not utilizing all the information necessary for comprehensive environmental priority-setting.

Key findings

→ Risk assessment cannot be used by itself. It is a tool that has many uncertainties and assumptions inherent in it. It should be utilized with an understanding of its limitations.

→ The technical process of risk assessment should be improved to incorporate concerns of environmental justice and public participation (e.g., hot spots, cumulative risks, worker risks, individual risk and vulnerable populations). The process is evolutionary.

→ One of the most important products from the risk-ranking committees of the CCRP would be the documentation of their processes and findings to make clear to policymakers the issues inherent in risk-ranking (especially uncertainties in methodological, economic feasibility, and data issues) -- not just the results. There was no consensus among Education Committee members on whether risk-ranking should be used to set priorities. If ranking is used to set priorities, the Education

Committee thinks that the public and workers should be involved in the ranking process.

Environmental Justice

Environmental justice concerns must be addressed. At each roundtable, environmental justice concerns were voiced and the issues of multiculturalism in education were also expressed by the Education Committee members. The Education Committee also supports the concerns voiced by the Environmental Justice Committee.

INTRODUCTION

One of the stickiest problems in any comparative risk project is the question of the public perception of risk. That is, even if scientists, policymakers, and advocates could create the most accurate scientific risk-ranking imaginable, citizens would still have their own perception of the severity of the environmental risks that surround them. In addition, other factors besides scientific risk-rankings may influence any individual citizen's opinion about what environmental problem is most important. Those factors are essential to developing sound policies, effective education, and responsive government agencies.

Some very important questions for a comparative risk project, then, address education, that is, *How much do people know about environmental problems?* and *What are they being taught?* and public participation, that is, *To what degree are citizens' views incorporated into the risk-ranking process and into environmental decision-making in general?*

Such questions are very difficult to answer. Several previous risk-ranking projects have attempted to incorporate public opinion into their process. Other projects have recognized environmental education as important and addressed it in their reports. But no other project has attempted to assess or develop criteria, or make recommendations about occupational health and environmental education.

The California Comparative Risk Project's (CCRP's) Education Committee decided early on that they did not just want to only assess how much citizens know. They also wanted to assess the status of both occupational health education and environmental education in the State of California.

Indeed, the mission adopted early on by the Education Committee was as follows:

1) To identify the status of occupational and environmental education in the State of California and make recommendations.
2) To investigate the public participation process in the CCRP and make recommendations.
3) To facilitate communication among CCRP committees.
4) To educate ourselves as well as the other committees about perceptions of risk.

This final report of the Education Committee is divided into three major sections. The first section is the Education Assessment which includes a vision statement on environmental and occupational health education, criteria regarding environmental and occupational health education in California, a detailed description of deliberations of the Education Committee, a brief history of environmental and occupational health education, a description of model curricula, recommendations regarding education efforts in California, and a resource section. The second section is on public participation and includes a report on the roundtables and public participation effort in the CCRP as well as a critique of that effort. The third section evaluates the process and activities of the Education Committee.

The Education Committee began as one of the largest committees in the CCRP, with almost 40 active members, including educators, environmental and community activists, occupational health educators, industry representatives, California Environmental Protection Agency (Cal/EPA) employees, and representatives from other State agencies, including the Resources Agency, the Department of Health Services, and the Department of Education (see Attachment A for membership list). Invitations were extended to labor representatives, and teachers in kindergarten through eighth grade (K-8), but for various reasons, these groups were not able to actively participate on the Education Committee.

At the end of the CCRP, 22 members maintained active participation with about 10 members provide peer review upon request. The Education Committee divided itself into two sub-groups, one

devoted to the task of education assessment, and the other devoted to the task of developing a structure for public participation.

STATUS OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH EDUCATION

Citizens learn about the environment through many different media. Many citizens have learned about the environment and environmental problems by reading reports in newspapers, magazines, and newsletters published by industries and environmental groups. Other citizens may have formal training in environmental science or environmental policy. Some may have learned through health and safety classes provided on the job. Most citizens fall somewhere in the middle; they learned some things about the environment in their formal education and then picked up more information from media reports, on-the-job training, and word of mouth.

But who knows how much and how well it is being taught? One of the goals of the Education Committee was to assess the quality of both occupational health and environmental education programs. After an initial database search, however, Education Committee members realized that the sheer number of formal and informal programs and materials would make such an assessment very difficult. For instance, even a partial list of potential materials would include all environmental education curricula developed by public and private schools and colleges, state parks, and all the occupational health materials developed by private industry, trade schools, colleges, and adult education programs throughout California. In addition, there are materials from local, State, and Federal agencies. An initial database search on "environmental education" brought up 16,000 citations and 203 journals or magazines.

In addition, research into the current and historical definitions and trends in the environmental education showed that there were various philosophical approaches resulting in different "kinds" of environmental education programs and approaches.

As an alternative to assessing materials, curricula, and programs, the Education Committee decided to develop a vision statement and a set of criteria against which materials and programs could be examined. The criteria are intended to be general enough that they may be applied to most categories of environmental and occupational health education. They reflect a view of the Education Committee regarding both the presentation and contents.

Vision Statement for Environmental and Occupational Health Education

Two prominent concerns within the Education Committee were whether or not the educational approach affects empowerment within individual workers and communities, and whether or not they are both targeted at and raise consciousness about multicultural issues. Two other important concerns were whether or not the connection between occupational health concerns and environmental concerns was explicit and whether health concerns were reflected in those curricula and projects that are currently more exclusively focused on natural resource-based issues (e.g., water conservation, recycling). The Education Committee felt that all these are urgent issues, given the rapidly changing demographic face of the State, and the changing perceptions of environmental problems.

The Education Committee developed a vision statement addressing ideal occupational health and environmental education programs. The Education Committee was aware, however, that the field of environmental and occupational health education is broad and diverse, and that opinions about what constitutes the "environment" are changing. Also, issues of multiculturalism and environmental justice

are becoming a part of the debate. The Education Committee hopes the vision statement on environmental and occupational health education is inclusive of multiple concerns. The supporting principles for this vision statement are also included.

Vision statement

As we look at new models of education about the environment, we want to expand our thinking to include the following:

The connection between workplace/occupational health issues and the environment should be emphasized.

Workplace production, handling and disposal of chemicals directly impacts the environment, that is, what goes on in the plant impacts the surrounding community.

Development of viable pollution prevention policies impacts both the workplace and the community. Toxic use reduction, product substitution and changing technologies all affect workers, jobs, the environment, and the community.

Communities most affected by occupational and environmental issues are often the same. For instance, studies show that three out of five hazardous waste sites are located in communities of color. Statistics also document that workers of color are twice as likely to suffer a disabling injury or illness in the workplace that white workers (Robinson, 1991). (For more information on the occupational/environmental connection, see Attachment B.)

Environmental and occupational health education efforts need to be presented in a multicultural approach. A multicultural approach to education in this context means the following:

A cornerstone in educational principles is to begin teaching at a level that the "learner" understands. From a multicultural perspective, this means recognizing the culture, language, and customs of the learner and addressing them with that understanding. Doing this can create an atmosphere of acceptance, critical thinking, and knowledge acquisition leading to action.

Infusing environmental and occupational health curricula and projects with a diversity of cultural understandings and approaches creates a reflection of the multiculturalism (diversity) that exists in the real world. If done well, this will engage those who otherwise might be left out of the process and lead to a more comprehensive understanding of the issues and to better problem solving.

Communities of color – those often left out of more "traditional" environmental education approaches – are those communities that are more heavily impacted by environmental and occupational health exposures. A multicultural approach in education will identify that environmental injustices may have occurred and that these communities have a stake in obtaining the knowledge and being involved in problem solving. (For more information on multicultural environmental education, see Attachment C)

We believe that human health concerns need to be reflected in those curricula and projects that are currently focused primarily

on natural resource based issues (e.g., recycling, water conservation).

Much of the current environmental education approach focuses on natural resources. There is an integral connection between the health of nature and the health of humans. A lack of balance in nature can affect human well-being and *vice versa*. This interrelationship needs to be explicit.

Risk communication is the discipline within environmental health that encompasses communication about human health concerns from exposures to chemicals in the environment. The definition of risk communication with individuals and communities assumes dialogue and public participation in the environmental decision-making process. It is important that education about resource issues and human health issues are joined in the discussion and in the decision-making process.

Supporting principles of vision statement

Public participation and education are inextricably linked.

Education is the cornerstone that enables individuals to be stewards of the environment around them; to understand its multidimensionality an interconnectedness, and to participate in decisions made about the environment.

Environmental education should be grounded in the principles of pollution prevention, conservation, and sustainability.

Environmental education is effective only if it is interactive, contextual, and on-going.

Environmental education should teach people about the need to consider ethical issues as they relate to the environment.

Informed decision-making depends on an understanding of the multitude of perspectives and ethics that people have about the envionment.

Environmental and occupational health education efforts need to be grounded and presented in a multicultural and multilingual approach.

Environmental education must include information about both ecosystem health and human health.

Environmental education must include information about the natural, the built, and the work environment.

The "environment" for most school children in cities is not lakes, fields, and mountains, but streets, buildings, and urban parks. Environmental education for them should include information on this urbanscape, including its ecosystems, its pollutants, and proposed solutions to its problems, while also failiarizing them with environments found outside the urban boundary.

Environmental education programs, projects, and materials should be well coordinated and broadly distributed.

Regulatory guidelines regarding education and notification should be consistent in environmental and occupational arenas.

The goal of environmental and occupational health education should be empowerment and/or action.

Empowerment is the belief that one has the authority to act and that one's actions will matter. It involves the ability to think critically about issues, find solutions for problems, and enact the solutions in the private or ublic sphere.

A discussion of scientific principles underlying environmental issues should be included.

Education Committee Process

As the Education Committee debated how to best incorporate an assessment of environmental and occupational health education in the CCRP, we faced a series of decision points. We decided to chronicle these in order to explain our process and to possibly provide guidance to others should they venture down a similar path.

At each discussion point, we used a process of dialogue among the Education Committee members and each idea was carefully evaluated and discussed. This approach allowed free expression of diverse perspectives which enhanced the deliberations and decision-making.

Our initial idea was to provide a useful list of environmental education curricula and projects that could be referenced by teachers or anyone interested in the materials. Additional curricula and references were obtained from reference sections of other criteria and suggestions from various individuals. We did a literature search on ERIC using the key words "environmental education" which resulted in 15,608 citations. We did a secondary one limiting the search to the key words "environmental education" and "California." This resulted in 136 citations. We also did a search on the magazine and journal articles database, 1988 to present "environmental education." This resulted in 203 citations.

Additionally, we obtained a draft copy of a project undertaken by the California Department of Health Services, that had tried to do a similar project by listing curricula, lesson plans, activities for community education, books, pamphlets, fact sheets, and agencies and organizations from which to obtain information on environmental hazards, problems, and education. The Education Committee looked at this information and struggled with how to organize it and what the goal of organization would be. We decided to attempt fitting the educational materials into the format of the environmental topics list being used by the technical committees for risk-ranking. In this way, we were attempting to link our activities more directly with those of the technical committees and find a way that we might be able to comment on the quantity and quality of education materials available on the problems after they were ranked according to risk.

The problems with this approach very quickly became apparent. There was too much material to be able to collect and to reference in any useful way. Even if we were able to list all curricula and materials, the listing would not be very useful without some form of evaluation to guide individuals through the listing. Anyone using such a list would have an overwhelming amount of information and

no way of assessing its usefulness. We did not have the time or expertise to evaluate all the curricula and there was already underway a project headed up by the California Department of Education using educators to develop criteria and evaluate curricula. In addition, this approach left out our concerns about occupational health, multiculturalism, and links with human health. We decided to reference the California Department of Education's curricula and compendium project and decide how we could structure our work to fit our vision and time table.

One suggestion focused on limiting our search and discussion to issues of risk communication rather than all environmental education and to make links with occupational health and multiculturalism from that perspective. We debated the idea recognizing that this was a comparative risk project and therefore might most appropriately focus on risk communication. One member developed a proposal on this idea for the Education Committee to debate. This proposal included a model for risk communication that targeted points of intervention, topics, and target audiences in a multidimensional "risk cube." While the Education Committee felt that this approach was innovative, they felt it was more narrow than was desirable and so discussion continued.

There was some discussion of compiling a list of organizational sources to go to for information on environmental education instead of listing all curricula and materials. However, this was deemed impractical and it was decided we did not want to create a directory and that this type of listing would run into the same problems as listing of materials. We finally decided to create a vision statement and then choose several sample curricula that reflected different approaches and some of the issues highlighted in the vision statement. We also decided to develop criteria that could be applied when evaluating curricula and approaches. These criteria are listed in the next section. Community and grass roots education on environmental and occupational health concerns was also very important to the members of the Education Committee, but a decision was made to focus on curricula in order to narrow the project. Still, the Education Committee believes the concepts in the vision statement and criteria can be applied when thinking about community education.

Education Criteria

The following criteria were merged from two sources: the deliberations of the Education Committee, and the criteria used by the California Department of Education in the curricula and compendium project. They are not presented in any order of importance.

EDUCATION CRITERIA

The audience should be clearly determined.

The content should be factual and concepts presented in a format and at a level appropriate to the audience.

Issues of literacy including not only the kinds of words that are used but also the educational approach should be considered when matching the curricula with the audience.

Mechanisms should be in place to enable education and action and provide opportunities for students to decide, plan, and implement action themselves.

The curricula should examine the processes that affect risk and should include a discussion of issues regarding risk assessment and risk-ranking.

The curricula should present a discussion about the potential benefits of various production processes along with the risks arising from the processes.

The program should lead to empowerment of individuals and communities, that is, the power to analyze environmental situations, understand the positive and negative impact on their own community or themselves and others, and then to take action the individual believes is responsible.

Environmental and occupational health education should include diverse and multicultural perspectives and should include the visions and voices of varying ethics and values.

Pollution prevention, conservation, and sustainability should be emphasized.

Environmental and occupational health education should foster an awareness of, and a sense of respect for people and stewardship for the environment.

Barriers to taking actions and achieving success should be analyzed.

Historical, ethical, cultural, geographic, economic, and sociopolitical relationships should be addressed.

The relationship between occupational health concerns and environmental concerns should be explicit. For example, the way in which workers are trained in the handling of chemicals can have an impact on the community as well.

History and Current Issues Regarding Environmental and Occupational Health Education

The Education Committee recognized that there are already some models and attempts at linking the specific issues we outlined in our vision statement and criteria. Some of the curricula and programs that are involved in these efforts are referenced later in this report. However, research revealed that despite attempts, the field of occupational health and environmental education is still struggling with incorporating the factors outlined in our vision statement and considered important by the Education Committee and by others historically. A short description of the history of environmental education and its predecessors can shed some light on the discussion.

Nature study, conservation education and outdoor education -- the antecedents of today's environmental education -- first appeared in school curricula early in this century. All continue to exist today, in multiple forms and guises. Nature study was first brought to formal education in the early 1900's and was the forerunner of science teaching in elementary schools, and remains one of its key elements.

The Dust Bowl of the 1930's gave rise to conservation education. This focus on environmental problems was initiated by federal, state, and local resource management agencies. Many of these agencies continue to see education as a tool for accomplishing their missions.

Traditionally, outdoor education is an approach, and does not necessarily have a set of materials. Its sole specification is its venue, that is the outdoors. Its popularity grew in the 1950's with the advent of the school camping movement.

Calls for education dealing with the environment became more widespread after the 1962 publication of *Silent Spring* by Rachel Carson, commonly identified as the event which triggered the environmental movement of the 1960's and the 1970's. Frustrations over environmental catastrophes also fueled events. The civil rights marches and anti-Vietnam War demonstrations represented the beginning of a change in the way citizens viewed the rights and responsibilities of citizenship. The 1970 Earth Day celebration was a landmark expression of public advocacy for a realignment of environmental values. During this period of environmental activism, numerous federal and state laws aimed at promoting goals for environmental quality were enacted, prominent among them the 1969 *National Environmental Policy Act* and the 1970 *National Environmental Education Act*. The recent 1990 *National Environmental Education Act* reaffirms the purpose of the earlier act and focuses on schools as the place for effective environmental education (Disinger and Monroe, 1993).

In occupational health, similar events occurred. The passing of the *Occupational Safety and Health Act* in 1970 and subsequent "right-to-know" laws provided an arena where workers were given the right to education regarding health and safety in the workplace.

Since the 1970's, environmental education has been characterized as a way of teaching which makes connections among science, technology, economics, policy, people, and the environment. An increasing concern has been for the quality of the human environment. Environmental education is fundamentally different from nature and conservation education because it addresses the interactive interrelationships between humans and the environment. It is also different from environmental science -- the scientific study of those interrelationships because environmental education is concerned with values and skills as well as knowledge.

In 1977, official delegates from 65 member nations attended a United Nations Educational, Scientific and Cultural Organization (UNESCO) conference at Tbilisi, Georgia (formerly part of the U.S.S.R.) and agreed upon 12 guiding principles to define and guide the development of environmental education. These principles stated that environmental education should emphasize skills and strategies and develop critical thinking, should reflect an understanding of social, cultural and political factors, should consider the environment in its totality, including the workplace and should reach beyond kindergarten to 12th grade (K-12), to an audience that includes citizens, adults, and environmental professionals.

Individuals returning from this conference to the United States created a strategy for implementation of principles. From 1978 to 1988 environmental education received increasing attention at the state level and within colleges and universities. Many non-profit organizations, nature centers, museums, and other non-formal institutions assumed leading roles in environmental education. The passage of the 1990 *National Environmental Education Act* created a National Environmental Education Advisory Council and focused additional attention on the need for state and federal leadership in environmental education efforts. Several states have enacted legislation requiring environmental education be taught in K-12.

In the 1993 first report of the National Advisory Council on Environmental Education (NACEE, 1993), "environmental education" was defined in the following manner:

> *"Environmental Education is the interdisciplinary process of developing a citizenry that is knowledgeable about the total environment including both its natural and built aspects - that has the capacity to engage in inquiry, problem solving, decision-making and action that will assure environmental quality."*

Even though the interconnections between the workplace and the environment were emphasized in the Tbilisi statement which had provided some of the impetus for furthering environmental education in the United States, they were not specifically reflected in this definition.

California

In 1968, the California Legislature required conservation education in all elementary and secondary schools. Additional education code sections relating to conservation education were added in 1970 and 1977 and required all elementary and secondary schools to provide instruction in conservation and protection of natural resources (Disinger and Monroe, 1993). In the late 1980's, the California Department of Education developed a "point of view" statement on environmental education emphasizing that environmental education should be integrated in thematic instruction throughout curricula and it should be interdisciplinary (see Attachment D for the entire Point of View Statement).

The California Department of Education currently employs only one full-time and one half-time staff persons to coordinate all of their activities in environmental education including:

1) coordination of the Environmental Education Grant Program,
2) assist in development of the curricula and compendium projects,
3) assist in development of the Model Curriculum Projects; and
4) assist in implementing legislated activities (a complete description of the Department of Education's activities is in the Education Committee Appendix).

The situation for occupational health education is of even greater concern with no central coordinating body and no mandates to provide health and safety education except a recent requirement that cosmetology students get 20 hours of training in potential impacts from working in their field. Other attempts to teach health and safety in kindergarten through eighth grade (K-8) or in vocational education classes in high schools have been spotty and under-funded.

The California Environmental Education Interagency Network (CEEIN) is an effort between Cal/EPA, the California Department of Education and the California Resources Agency to provide interagency coordination and networking of environmental educators in the various agencies.

The mission of CEEIN is to foster an environmentally literate citizenry who understands the impact of their actions on the natural and built environments. The California Environmental Education Interagency Network advocates that education is essential to developing a thorough understanding of and respect for the environment, leading to ecologically and economically sound decisions and actions that sustain the earth. Through a partnership of agencies and organizations, CEEIN will work to develop and enhance environmental education efforts throughout California by providing a forum to share its members' resources, programs and products. The education efforts and resources will focus on California schools, serving all students from kindergarten through grade sixteen (CEEIN, 1994).

This creative approach is relatively new but has already had benefits for all involved. However, the agencies involved do not include occupational health nor regular health groups. The group might consider expanding its membership.

In addition to the California Department of Education environmental education efforts, many exciting and innovative projects exist at the grassroots level within the resource-based environmental education community and various State agencies have personnel providing environmental education in various ways. Community groups, environmental advocacy groups, non-formal environmental education centers, parks, extension services, and university centers also provide environmental and, in some cases, occupational health education as well.

Multicultural environmental education

The changing demographics occurring in California have made environmental educators focus on who their programs reach and how students are served. The central questions are how to serve the diversity of the California population and how to do it in a way that is culturally inclusive; how can effective outreach efforts be designed and implemented to respond to the needs of communities of color for culturally based environmental education. These questions have led environmental educators to reevaluate their approaches and experiment with new curricula and programs.

Such efforts are underway in various places, one of the most prominent being the Three Circles Center for Multicultural Environmental Education (see Attachment C). Three Circles Center was founded by a multicultural and multiracial group of educators, activists, and youth workers operating on

the understanding that to expand the definition of environmental education required diverse cultures to be in leadership positions and in positions to create alliances with various communities.

The California Department of Education has recently published a curricula that incorporates multicultural themes and this will be available to educators in California and across the country for use in the classroom.

Central to the question of how to incorporate a multicultural approach in environmental education is the recognition of environmental justice concerns. Environmental justice refers to the necessity and effort to correct inequities in the distribution of environmental and occupational hazards and also those which occur in the process of environmental policy-making. The racial implications of such inequalities have been documented and are increasingly noted in the academic and popular media (University of Colorado Law Review, 1992). The correction of these environmental inequities is often pursued by communities of color using the traditional means of social activism from the civil rights movement.

The environmental justice movement is just at the beginning of incorporating ideas on the need for multicultural environmental education but the process has begun. The environmental education profession is also just beginning to recognize and incorporate environmental justice ideas.

"Model" Curricula

The following curricula were chosen because they represented some concern raised by the Education Committee or because they were representative of a particular approach to environmental or occupational health education. They are listed by the age group they are intended for. Short descriptions of each curricula with some highlights regarding why they were chosen are included. Contacts for further information are also included.

We did not intend to claim that these represent all the innovative and exciting curricula available in California or in the nation. We limited our discussion to these due to time and resource constraints. Still, we felt that these examples are very interesting and represent a range of approaches as well as some possibly less well known approaches.

Listing of any curricula does not reflect endorsement by the Education Committee. Descriptions provided in some cases are those provided by the creators of the curricula.

Pre-kindergarten through eighth grade (PreK-8)

CHEM

The Chemicals, Health, Environment and Me (CHEM) project is a program of the Chemical Education for Public Understanding Program (CEPUP) at the Lawrence Hall of Science at Berkeley. Chemicals, Health, Environment and Me is a series of 10 units designed to provide experiences for fifth and sixth graders that help them understand:

→ the nature of chemicals and how they interact with people and the environment;

→ how to collect, process, and analyze information;

→ how to use scientific evidence as a basis for lifestyle oriented decisions; and

→ how studying science and mathematics can be a productive and relevant part of their lives.

The 10 units are titled:

Everyday Chemicals

The Inside Story

My Sweet Tooth

What is a Threshold

Smoking and My Health

Mystery Spill

The Hazardous Home

Trash or Cash

Carbon Dioxide and Me

CHEM Chronicle

Each unit overviews science concepts and processes as well as some societal issues. The focus is on science and includes experiments and activities to demonstrate scientific principles. There are some connections made between occupational concerns and environmental concerns and some connections with health concerns but the overall approach is to use scientific evidence as the basis for decision-making.

→ Chemicals, Health, Environment and Me operates with the cooperation of the National Science Teachers Association (NSTA). The project is made possible with support from the Exxon Education Foundation and the Exxon Chemical Company and other foundation support.

CEPUP (SEPUP)
Lawrence Hall of Science
University of California
Berkeley, CA 94720
(510) 642-8718

Household Toxics

The "Household Toxics" curriculum presents practical information on the safe use, storage, and disposal of household toxics, and on the use of alternatives. It is a 4th, 5th, and 6th grade curriculum in support of the California Department of Education Framework in Health and Science.

In the fourth grade, students develop an awareness of which household products are toxic, how they are identified on the labels, how they enter the body, and the most common hazards. The fifth graders learn rules for safer storage and the sixth grade focuses to a community awareness of the effects of household toxics. The occupational and environmental health connection is alluded to as is the effect of toxics on the urban environment.

In the lessons, the students learn about the properties of household toxics in a way that reinforces basic chemical concepts. They learn about acute and chronic health effects of exposures in a way that reinforces human biological concepts. And they learn about alternatives and effects on community health in a way that reinforces ethical concerns.

Included in the curricula for each grade level is an 11-minute video *Outta Sight, Outta Mind*, two 60-minute lesson plans, exercises for the students, and a teachers' guide to the exercise and reference materials.

Environmental Health Coalition
1844 Third Avenue
San Diego, CA 92101
(619) 235-0281

Household Hazardous Materials: Pollution Solutions Start at Home

This curriculum is an interdisciplinary curriculum for middle school and junior high school students with three units. Each unit has three related lessons that are designed to tie into the State frameworks in history/social science, science, and English/language arts. Each lesson includes a variety of skill and learning processes and also includes a possible student action.

These are designed to develop critical thinking and lead to empowerment of the student. Historical connections to current environmental problems and issues provides a rich contextual framework and develops a broad sense of the environment. The actions involve expanding the realm of learning activities to include fellow students, family, government agencies, manufacturers, and the community. This curriculum also includes a video: *Hazardous Waste: Whose Problem Is It Anyway?*

Environmental Health Coalition
1844 Third Avenue
San Diego, CA 92101
(619) 235-0281

CEPUP modules

Twelve modules are developed for use in junior high school. Each module contains between five and eight activities that includes science concepts, process skills, and societal issues. Teachers' manual provides information on how to conduct the activities, review of concepts for the students, discussion for the class room, and master student sheets for each activity. As with the CEPUP curriculum, the basis for discussion is grounded in scientific principles and the rise of science as basis for decision-making.

The Modules include:

Chemical Survey and Solutions and Pollution

Risk Comparison

Determining Threshold Limits

Investigating Groundwater: the Fruitvale Story

Toxic Waste: A Tracking Simulation

Plastics In Our Lives

Investigating Chemical Processes: Your Island Factory

Chemicals in Foods: Additives

The Waste Hierarchy: Where is "Away"

Investigating Hazardous Materials

Household Chemicals

Refrigeration

CEPUP
Lawrence Hall of Science
University of California
Berkeley, CA 94720
(510) 642-8718

Curricula and Compendia (C&C) Projects

While not curricula in themselves, the C&C projects reviewed many curricula and evaluated them using a list of criteria created by the California Department of Education and teachers expert in environmental education. The compendia are easy to use resource guides for educators who want to incorporate environmental education concepts into their lessons. Each compendia contains a conceptual matrix which is aligned with the California Department of Education Unifying Concepts of Environmental Education and is specific to the topic area. There are seven topic areas targeted:

Air Quality

Aquatic and Terrestrial Habitats

Energy Resources

Human Communities

Integrated Waste Management

Plant and Animal Communities

Water Resources

Several of these are finished as of March 1994 and others are in process. They are translated from English to French and Spanish. This is an enormous evaluative effort that focuses on pedagogy, teaching and learning qualities, presentation, and organization as well as content. The conceptual matrix addresses moving the student from fostering awareness of and respect for the environment to understanding basic concepts and arriving at sustaining responsible actions towards the environment.

The criteria used to evaluate the curricula are both content and process based and correspond to the California Department of Education framework. There is not a focus on occupational or work related issues. Multiculturalism is included in one of the criteria.

California Department of Education
Science and Environmental Education
721 Capitol Mall
Sacramento, CA 94244
(916) 657-5374

A Child's Place in the Environment

This is an elementary school curriculum that utilizes an activity-based approach to develop an interdisciplinary, thematic environmental education program. The California Department of Education funded the development of six grade level units of approximately 20 sequential lessons that are correlated to four state frameworks in science, visual and performing arts, history/social science, and English/language arts. The lessons are linked by a conceptual storyline, guiding students through understanding, value analysis, thinking, and problem solving and action projects. There is a strong multicultural awareness embedded in the curriculum with discussion regarding the meaning of different

issues to different cultures, emphasizing the gains from joint problem solving, and recognizing the possibility of differential impacts on different communities.

Konochti Unified School District
c/o Olga Clymire
Lake County Office of Education
1152 South Main Street
Lakeport, CA 95453
(707) 263-7249

California State Environmental Education Guide

This curriculum for kindergarten through sixth grade (K-6) consists of eight instructional units and six action projects. Each unit is organized around a theme and is based on concepts from the California Department of Education frameworks. All units integrate content areas and are activity based. The action projects are designed to take students from awareness to action. There is also a section that addresses topics such as how to manage outdoor groups and learning style considerations.

Alameda County Office of Education
Media Sales
313 West Winton Avenue
Hayward, CA 94544

Toxics: Taking Charge

Designed to address fourth through sixth grade, this is the first of a series of instructional units that deals with controversial environmental issues in the classroom setting. The unit consists of nine classroom activities and an action project. Students learn by collecting information on household toxics, looking at their own and other people's attitudes about toxics, and working toward making responsible choices about toxics in their home.

Alameda County Office of Education
Media Sales
313 West Winton Avenue
Hayward, CA 94544

California Class Project

This is a middle school curriculum that addresses contemporary, real-life issues. Originally developed by the National Wildlife Federation, the materials were customized for California by rewriting the lessons based on input from 200 field takers and experts from colleges, universities, and government agencies. The 33 classroom ready lessons are presented in six thematic units that correspond to the science framework and utilizes hands on approaches that promote high-level thinking processes.

Los Angeles County Office of Education
(310) 922-6334

Project Wild

Project Wild is an interdisciplinary, supplementary, environmental conservation education program emphasizing wildlife.

Project Wild has developed extensive instructional materials for use in kindergarten through twelfth grade that are designed for easy integration into school subject and skill areas -- especially science, social studies, language arts, mathematics and art -- so that classroom teachers may use the materials as a means by which to teach required concepts and skills. At the same time, these materials teach about people, wildlife, and the environment. Educators in no-school settings, such as scout leaders, outdoor camp personnel, park naturalists, and others may find the materials of use. Activities are organized into seven major sections, corresponding to a conceptual framework moving from awareness and appreciation and responsible human actions.

The sections are:

Awareness and Appreciation

Diversity of Wildlife Values

Ecological Principles

Management and Conservation

People, Culture, and Wildlife

Funds, Issues, and Consequences

Responsible Human Actions

Each activity includes a statement of objectives, a description of the instructional method, background information, a list of materials, step-by-step instructions, examples of ways to evaluate, and other key factors.

There are two guides, one organized by the previously mentioned sections and one with activities designated by its applicability to language arts, science, social studies, and mathematics.

These activities are well described and delve into the issues in ways that develop higher order analysis and problem solving. The approach is conservation-based. Multiculturalism is not mentioned but there is discussion of different values that might come into decision-making. Several connections to human health concerns are made.

Project Wild
Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814
(916) 653-3857

Environmental Education Activity Guide

This curriculum developed by the California Department of Forestry and Fire Protection's Project Learning Tree is designed for students PreK-8. It is a comprehensive curriculum used in all 50 states and was just recently evaluated and redesigned. There are 96 separate activities that can be used in classroom settings as well as non-formal settings. The conceptual framework moves from understanding to action, and the activities match with the needs of science, language arts, social studies, reading, arithmetic, music, and special education. Each activity relates to a storyline that develops content understanding as well as fostering a values discussion and suggested actions. Human communities and the interaction with the environment is included. The storylines include diversity, interrelationships, systems, structure and scale, and patterns of change. Multiculturalism is explored

and a section in the appendix describes the relationship between multicultural education and environmental education, and urges merging of two.

Project Learning Tree
Department of Forestry and Fire Protection
1416 Ninth Street
P.O. Box 944246
Sacramento, CA 94244
(916) 653-7958

Community Connections: An Interdisciplinary Urban Environment Education Curriculum

This curriculum is designed for middle school and can be adapted to relate to the science, social studies, language arts, and math frameworks for the California Department of Education. It is a curriculum that focuses on the connections and similarities between natural and human environments. It is based on the following principles:

→ every community has niches to be filled, and organisms capable of fulfilling them;

→ every community is a complex web of interdependent relationships;

→ every community needs diversity and the greater the diversity, the healthier (i.e., more sustainable) the community.

The curriculum is creatively designed to work with students addressing the developmental issues of adolescence and focuses on the community. It is therefore multicultural in that it invites students to talk about their own cultural background and community.

Education Department
Oakland Museum
1000 Oak Street
Oakland, CA 94667
(510) 238-3818

High school and vocational schools

Curricula and Compendia (C&C) Projects

See description under PreK-8.

Project Wild

See description under PreK-8.

Toxics on the Job, Protecting Your Health

This curriculum focuses on the dual risks of tobacco smoke and other toxic chemicals at work. It is designed for use in vocational education classes but can be used in other settings as well. The goal of the curriculum is for students to use the information to become problem solvers on the job. A cooperative learning approach is employed that encourages students to take an active role in the class. Participation in classroom activities gives students practice in planning strategies to improve health and safety on the job. The curriculum is divided into four interrelated units. It is available in English and Spanish.

The units are:

Threats to Your Health on the Job

Investigating Chemical Hazards at Work

How to Make the Job Safer

An Action Plan

There are trade-specific handbooks that tailor general curriculum for use with collision repair workers, construction workers, welders, and machinists. Throughout these, workers are encouraged to view tobacco smoke as an occupational hazard and are encouraged toward creating smoke-free workplaces.

The instructors manual provides instructions and activity sheets for activities.

This curriculum provides an innovative approach to linking the dual (and multiplicative) hazards of smoking with chemical exposures. It also delivers a stop smoking message to blue collar workers -- nearly half of whom still smoke in the United States.

Workplace Hazard and Tobacco Education Project (WHATEP)
Labor Occupational Health Program
2515 Channing Way
Berkeley, CA 94720

Health Occupations: Future Workers Education Project

This project has four separate curricula designed for use at high schools, vocational/technical schools, and training institutions and community colleges. The curricula are trade-specific for auto body and repair, health occupations, cosmetology, and welding. They are designed to help train future workers in proper health and safety measures and to increase their awareness of occupational health issues.

These are the basic health messages provided throughout:

→ Most occupational illness and injuries are preventable.

→ Workers can take steps to prevent occupational illness and injury.

→ Employers are required to provide a safe healthful workplace free from recognized hazards.

→ Employers and employees can work together and solve potential health problems at work.

The training packet includes a teacher's guide, curriculum handouts, worksheets, transparencies, respiratory system poster, and a glossary. The transparencies and poster are visual depictions that are discussed in the curricula.

This is an innovative and easy to use curriculum for high school and vocational education schools on occupational health issues.

American Lung Association
562 Mission Street, Suite 203
San Francisco, CA 94105

(415) 543-4410

Designing a Bottom-up Walking Tour: An Empowerment Curriculum for Inner City Youth

This curriculum is designed as a guide for teachers when creating a walking tour of a neighborhood with students at the high school level. In this curriculum, the learners select a site (or neighborhood) around which to design a tour because of its cultural, emotional, political, and historical meaning to them. The environment is the total of all of these findings plus a study of the actual physical environment. The point of examining all these factors is recognizing the interrelationships of history, culture, politics, and the environment and thinking critically on this, reflecting on and identifying problems and solutions. The process designed by the curriculum leads the learners through research and observation and encourages them to act and develop a strategy for change.

In addition to students, the teachers become learners in this process, and the environment is viewed as the total of a variety of factors. The focus is wherever the learners decide on, and it is a process that is easily used in the urban setting and that includes researching the culture of the past and current human inhabitants, thereby linking multiculturalism to the study of the environmental issues.

Urban Habitat Program
Earth Island Institute
300 Broadway, Suite 28
San Francisco, CA 94133

Professionals/workers

Kids and the Environment: Toxic Hazards
A Course on Pediatric Environmental Health

This course connects occupational health and environmental health issues and utilizes pediatricians as a respected source of information for families. It is first at providing information to clinicians on environmental and occupational health issues.

This is not strictly a curriculum but a course on environmental health issues that covers toxicology and epidemiology, taking an environmental history, pesticides and children, working children and occupational exposures, and legal issues.

This course was developed by the Environmental Epidemiology Training Project in the California Department of Health Services and supported by a grant from the Agency for Toxic Substances and Disease Registry.

California Department of Health Services
Environmental Epidemiology Training Project
5900 Hollis Street, Suite E
Emeryville, CA 94608
(510) 540-3657

Protecting Children from Environmental Health Hazards
Environmental Health Training for Nurses

This course is a series of three workshops for public health nurses on environmental hazards. It is innovative in that it provides professional education for environmental and occupational health issues to

practitioners that provide front line services to clients and are excellent sources of information for those clients.

The workshop service was developed by the Children's Environmental Health Network, a project of the California Department of Health Services.

Children's Environmental Health Network
5900 Hollis Street, Suite E
Emeryville, CA 94608
(510) 540-3657

The Right to Understand: Linking Literacy to Health and Safety Training

This publication is a manual/curriculum that includes guidelines and practical tips for developing materials and programs with literacy in mind. It is directed at trainers or those who provide occupational health education to workers. This 200-page manual includes illustrations and chapters on literacy, on getting to know your audience, developing easy to read materials, evaluating materials, participatory training activities, and alternative testing methods.

The emphasis in this manual is that education is ineffective if it is not geared to the understanding of the recipient. Without understanding there can be no empowerment.

Labor Occupational Health Program
2515 Channing Way
Berkeley, CA 94720
(510) 642-5507

Emergency Response and Prevention Workbook

This workbook written and produced by the Labor Institute for the Oil, Chemical and Atomic Workers Union is designed as a training manual for two levels of workers; those who are likely to be the first ones to witness or discover a hazardous material release and those who are expected to respond to chemical emergencies from a safe distance. This training concept came from mandates within SARA (Superfund Reauthorization and Amendment Act) that directed the Occupational Safety and Health Administration to develop safety standards and required training of workers who might be involved in hazardous emergency situations involving toxic substances. This covers a wide range of workers.

The workbook is a series of activities using the Small Group and Activity Methods as the training procedure. This is a participatory method that puts the learner in the center of the workshop activities solving practical problems and building their own skills and experiences. It is a structured experience leading to problem solving and based on empowerment of workers.

The 19 activities include specific information on toxicology, reading MSDS (material data safety sheets), legal requirements, worker rights, and protective equipment. The workplace/environment connection is alluded to:

The Labor Institute
853 Broadway, Room 2014
New York, New York 10003
(212) 674-3322

OCAW

255 Union Blvd.
Lakewood. Colorado 80228
(303) 987-2229

Jobs and the Environment

This curriculum is designed to create an understanding of the jobs/environment debate between workers and environmentalists. The training methodology utilizes Small Group and Activity Methods and is designed to elicit critical thinking and participation of all attendees. Participants are divided into small groups of six individuals and then each group works on the six activities in the curriculum, including:

Environmentalism, Job Fear and the Public

Trends in the Labor Market

Environmental Trends

The Scope of the Toxics - Related Economy

Perspectives on the Jobs/Environment Conflict

Building a Common Agenda

Each activity has fact sheets with information for the group to read and discussion questions to answer. There is feedback from all the groups at the end.

This curriculum approaches the occupational health/environment question by discussing the issues in small groups of workers and environmentalists.

Public Health Institute
853 Broadway, Room 2014
New York, New York 10003

Other education approaches

Colleges and higher education

All of the previously referenced curricula are designed for kindergarten through 12th grade (K-12) or at the vocational school level. There are also many environmental education curricula and classes taught at the college level. The Education Committee recognized these but felt that we were unable to expand the scope of this current project to adequately review the many curricula, textbooks, and classroom approaches that exist. However, the Education Committee did want to underscore the importance of providing environmental science and environmental education programs to all undergraduates. This could be an interdisciplinary approach or as an environmental track. Graduate students also need to be informed about the importance of environmental issues, their intellectual challenge, their scope, and significance. Environmental messages need to be brought into the educational framework of the professional programs of law, business, public health, engineering, for example.

Recruitment of individuals from diverse cultural and racial backgrounds to environmental science professions is crucial to creating a problem-solving workforce that reflects the needs and concerns of diverse communities. This recruitment should be a high priority. The Education Committee recognizes the relationships between providing environmental and occupational health education that is culturally sensitive in K-12 thereby encouraging culturally diverse children to be interested in issues of the environment, and creating a pool of individuals interested in pursuing environmental sciences and environmental education of the college level.

Extension services

Extension services connected to universities provide many continuing education courses and certification courses in various environmental and occupational health areas.

Community education

Community groups play an important role regarding education on many environmental and some occupational health issues.

People United for a Better Oakland provided extensive community education about lead poisoning. A similar group in San Francisco, Coalition to Prevent Lead Poisoning, conducted education in Hunters Point, an area with lead contamination problems and a primarily African-American population. Other community-based groups across California have conducted similar education campaigns creating fact sheets and written materials as well as information sessions at community centers on a variety of environmental issues. These community based approaches often address the whole environment of the community more effectively as they are not as likely to divide the problem into a media or regulatory approach.

Recommendations

Research conducted by the Education Committee on the state of environmental and occupational health education revealed that there is a multitude of curricula and approaches but a lack of overall coordination and evaluation mechanism. With the exception of efforts by the California Department of Education (which is currently examining K-12 curricula), these educational efforts lack coherence in criteria and strategy.

Many exciting and innovative projects exist at the grassroots level within the resource-based environmental education community and various State agencies have personnel providing environmental education in various ways

Environmental education guidelines were added to the California Education Code in 1976 (Disinger and Monroe, 1993). Those guidelines required all elementary and secondary schools to provide instruction in conservation and protection of natural resources. But currently only one and one-half full time employees at the Department of Education coordinates all the efforts, including the awarding of grants which foster innovative projects across the State.

The situation for occupational health education is of even greater concern in K-12. Some attempts have been made to teach health and safety concerns in vocational education in the high school. Those attempts, however, are spotty and under-funded. There are no mandates with the exception of a recent requirement that cosmetology students get 20 hours of training in potential health impacts from working in their field.

These concerns prompted the Education Committee to make the following specific recommendations:

RECOMMENDATIONS

The assessment of environmental education, occupational health education, and risk communication programs and materials initiated in the CCRP should be continued. A process should be established and funded so that a thorough, formal and continual assessment can be conducted.

Funding for education must be an integral part of all environmental and occupational health programs.

The State should formalize interagency partnerships dedicated to improving environmental and occupational health education.

The California Environmental Education Interagency Network is a first step in this direction. This network involves Cal/EPA, the Resources Agency, and the California Department of Education in a cooperative process of networking and resources sharing. Other agencies responsible for worker and health issues should be encouraged to participate.

Environmental education should incorporate human health and occupational health concerns.

The State should encourage environmental and occupational health educators to use multicultural and multilingual approaches and materials and to recognize cultural and philosophical diversity in their approaches.

The State must acknowledge the connection between public participation and education and foster public participation as part of its mission. This public participation should be institutionalized, be proactive and be culturally sensitive. It should include input from all stakeholders.

The State must enhance existing legislation focused on environmental and occupational health education.

A model curriculum should be developed that is inclusive of occupational health, environmental health, and resource-based environmental issues, and that addresses multicultural concerns.

Resources

In the process of researching information and curricula for the education assessment, the Education Committee came across a variety of books, work books, organizations, and materials that were helpful to us in our process or that we felt might be interesting to others. Some have already been referenced in the body of our report but most have not. This list is not meant to be all inclusive of such resources and we would be interested in additions.

Books

Race and the Incidence of Environmental Hazards: A Time for Discourse (1992).

Edited by Bunyan Bryant and Paul Mohai.

This is a collection of articles on environmental justice presented at a conference held in 1990 in Ann Arbor, Michigan. This conference was the first of its kind focusing on environmental justice and with presenters being scholars from communities of color affected by inequitable environmental exposures.

Forcing the Spring: The Transformation of the American Environment Movement (1993).
Robert Gottlieb.

This book chronicles the range of 20th century social movements that developed in response to urban and industrial forces over the past 100 years and places the environmental movement within the larger context of American social history.

Environmental Protection in the United States Industry Agencies Environmentalists (1987).
Joseph M. Petulla.

This book examines contemporary groups and institutions in industry, agencies and environmental groups to chronicle what is being done for environmental protection. Through survey research, political, and ethical issues are revealed and discussed.

Toxic Wastes and Race in the United States (1989).
Commission for Racial Justice. United Church of Christ.

Workbooks

Teaching About Job Hazards: A Guide for Workers and Their Health Providers (1993).
Nina Wallerstein and Harriet Rubenstein.

This manual guides health care providers in the design, implementation, and evaluation of worker health and safety education.

Toxic Free Neighborhoods: Community Planning Guide. Environmental Health Coalition (1993).

This guide helps communities of color in their efforts to decrease toxics in their neighborhoods by providing information and specific strategies.

Improving Dialogue with Communities: A Risk Communication Manual for Government (1989).
Hance, Chess, and Sandman.

Center for Environmental Communication
Rutgers University
Cook College
P.O. Box 231
New Brunswick, NJ 08903

This program has many risk communication resources which are available at reasonable cost. They will send a materials list upon request.

Reports

Status and Opportunities for Environmental Education in the Bay Area (March 1993).
A report prepared for the San Francisco Foundation by Running Grass and Steve Christiano.

This report covers findings related to the following four key items: cultural diversity, partnerships and collaborations, educating for a new environmental ethic, and career development.

A Vision for the Nineties: Strategies for Improving and Implementing Environmental Education Curricula (1992).
Conference Synopsis, May 28-29, 1992. Sponsored by California Department of Education.

United Nations Conference on Environment and Development. United States of America National Report (1992).
Chapter 9 of this report focuses on Environmental Education with an overview of the Environmental Education Act of 1990 and an overview of the many different ways environmental education is done. This chapter ends with an issues section.

National Report of Environmental Education. Prepared by National Advisory Council on Environmental Education (July 1992).
Covers states of environmental education in the United States and makes recommendations.

Defining Environmental Education (1993).
The Environmental Education Toolbox.

National Consortium for Environmental
Education and Training
School of Natural Resources and Training
University of Michigan
Ann Arbor, Michigan 48109-1115
(313) 763-1312

Environmental Literacy: Its Roots, Evolution and Directions in the 1990's (1992).
Charles E. Roth.
Available from Clearinghouse for Science, Mathematics, and Environmental Education, The Ohio State University, 1929 Kenny Road, Columbus, Ohio 43210-1080.

Grant Funding for Your Environmental Education Program: Strategies and Options.
Prepared by North American Association for Environmental Education in cooperation with U.S. Environmental Protection Agency's Office of Environmental Education.

North American Association of Environmental Education
Publications and Memberships
P.O. Box 400
Troy, Ohio 45373

Model Environmental Education Act (1992).
Drafted by Environmental Education Subcommittee of the National Environmental Task Force.

The Council of State Governments
Iron Works Pike
P.O. Box 11910
Terington, Kentucky 40578

Directories

The Harbinger File.

A directory of citizen groups, government agencies and environmental education programs concerned with California environmental issues. Available in the public library.

Coastal Marine Educational Resources Directory (1990).

This directory is an alphabetical listing of 100 organizations that responded to a survey on Marine and Coastal Education Resources. Information includes a description of locations, addresses, contact persons, services, available speakers and education programs.

California Coastal Commission
631 Howard Street, 4th Floor
San Francisco, CA 94105
(415) 543-8555

People of Color Environmental Groups Directory (1992).

Listing of over 200 people of color grassroots environmental groups from across the United States.

Department of Sociology
University of California
Riverside, CA 92521-0419

Organizations and Agencies

Descriptions of those organizations that developed various curricula reviewed in this Education Committee report are mostly included in the curriculum section. The following list represents other organizations that are involved in environmental, occupational health, or multicultural education. The list is not meant to be all inclusive.

National Association of Professional Environmental Educators
101 The Embarcadero, Suite 210
San Francisco, CA 94103

National Environmental Education Advisory Council.

This council was formed by the United States Environmental Protection Agency (U.S. EPA) in November 1991 as mandated by the National Education Act to advise the administrator of U.S. EPA on implementation of the Environmental Education Act and to serve as liaison between the Federal government and environmental educators across the country. There are also regional environmental education councils.

Kathleen MacKinnon
U.S. EPA
Office of Environmental Education
401 M Street, S.W. (A-107)

Washington, D.C. 20460

North American Association for Environmental Education.

This is an association of environmental education professionals. The organization serves as a networking and support agent and as a source of expertise for efforts in policy, standards, and materials development.

NAAEE
P.O. Box 400
Troy, Ohio 45373
(513) 676-2514

Films for Educators: Environmental Awareness Series (1992).

This catalogue lists videos that address multidimensional needs of communities and cities that are focusing on solving environmental problems.

Films for Educators, Inc.
420 East 55th Street, Suite 6V
New York, NY 10022
(212) 486-6577

National Consortium for Environmental Education and Training (NCEET).

This consortium works to support, enhance, and extend effective environmental education in grades K-12. They developed the environmental education toolbox consisting of manuals, videos, instruction plans, classroom activities, and resource guides. They also publish articles and network with agencies and groups involved in environmental education.

NCEET
School of Natural Resources and Environment
University of Michigan
Ann Arbor, Michigan 48109-1115
(313) 763-1312

National University of Continuing Education Association (NUCEA).

This association represents professionals and institutions that offer credit and non-credit higher education programs. The U.S. Environmental Protection Agency has selected a section of NUCEA to coordinate the development of a network of regional training centers to provide training to workers involved in lead abatement. They offer a catalogue of courses on occupational and environmental health provided by NUCEA institutions.

Judy L. Jarrell
Dept. of Environmental Health
University of Cincinnati
3223 Eden Avenue, ML-056
Cincinnati, OH 45267-0056

Natural Resource Conservation Education Program.

The mission of this organization is to provide support for the implementation of conservation education programs that meet the needs of states diverse human and natural communities. Objectives include (among others) assisting in development of conservation education partnerships with federal, state, local, private, and non-profit organizations and educators; and to develop and promote multicultural environmental education programs.

California Environmental Education Interagency Network.

Network of environmental educators in California government including Cal/EPA, Resources Agency and Department of Education. The mission statement for CEEIN is included in page 268 of this chapter.

Commencement 2000 - United States Department of Agriculture's Forest Service.

This is a long-term strategy to achieve a skilled and diverse workforce. This program works with feeder schools from K-12 that have environmental and natural science curricula and provide opportunities for day, overnight, and week-long environmental studies and career awareness trips. The project is committed to developing collaborative relationships with institutions and organizations who have identified work force diversity as an achievable goal and support multicultural involvement in environmental and natural resource education.

USDA Forest Service
Pacific Southwest Region
630 Sansome Street
San Francisco, CA 94111
(415) 705-2604

Pesticide Education Center.

The Pesticide Education Center (PEC) was founded in 1988 to educate the public about the hazards and health effects of pesticides. The Pesticide Education Center works with community groups, workers, individuals, and others concerned about risks to their health from exposures to pesticides used in agriculture, the home and garden, and other environmental and industrial uses. The Pesticide Education Center provides information, consultation, and has materials on pesticides. They have produced two videos and accompanying training manuals in English and Spanish. One, for farmworkers, has farmworkers themselves telling stories of pesticide-related health problems. The video also describes how a pesticide enters the body, the symptoms of poisoning, and ways to minimize exposure. The training manual uses a question and answer format to expand upon health issues.

The other video is for mixers, loaders, and applicators and describes pesticide-related health concerns and personal protective equipment. The training manual expands on the subjects covered in the video and provides reference sources.

PEC
P.O. Box 420870
San Francisco, CA 94142

Coalition to Prevent Lead Poisoning.

This group created a unique educational campaign (including written materials and a video) on lead poisoning for an inner city multiethnic community.

Coalition to Prevent Lead Poisoning
116 New Montgomery Street, Suite 233
San Francisco, CA 94105
(415) 777-9648

Earth Island Institute/Urban Habitat.

The Earth Island Institute was founded to develop innovative projects working for the preservation and restoration of the global environment. One of the missions is to forge a link between traditional environmental concerns, peace concerns, and social justice. They publish a newsletter "Race, Poverty and the Environment" that provides education and information consistent with this vision.

Urban Habitat is one of the programs at the Earth Island Institute that hopes to educate a new generation of multicultural urban environmentalists. There is an environmental education program that developed one of the curricula reviewed by this project.

Earth Island Institute
300 Broadway, Suite 28
San Francisco, CA 94133
(415) 788-3666

Labor Occupational Health Program.

The Labor Occupational Health Program (LOHP) provides training sessions, publications, films, slide shows, and technical assistance on occupational health and safety issues. They have been a major source of such education to the worker community for about 15 years. They allow use of their extensive library with information on hazard identification, toxicology, industrial hygiene, and standards and regulations.

LOHP
2515 Channing Way
Berkeley, CA 94720
(510) 642-5507

Three Circles Center for Multicultural Environmental Education.

The Three Circles Center serves to introduce, encourage, and cultivate multicultural perspectives and values in environmental and outdoor education, recreation, and interpretation. The Three Circles Center develops training sessions, workshops, and materials; gives presentations, and provides consultation and is active in elementary school environmental education in the public schools. They have a quarterly newsletter.

Three Circles Center for
Multicultural Environmental Education
P.O. Box 1946
Sausalito, CA 94965

(415) 331-4540

PUBLIC PARTICIPATION

From the beginning, the Public Participation workgroup of the Education Committee felt strongly, as did the Project Director, that the public should have a voice in the CCRP. Including all the citizens of California was economically and logistically impossible. Finding a way to include even representative or sample voices proved to be a challenge.

In June, 1993, the League of Women Voters (LWV) conducted public participation activities regarding the CCRP in San Mateo at the biannual convention, and in Los Angeles with their Southern California Environmental Action Committee. The League of Women Voters continued to be involved with the public participation process by consulting on regional participation for the three roundtables. One of the members of the Education Committee was the Natural Resources Director for the State LWV. She was instrumental in providing entry to the State convention of LWV as well as in raising the issue of public participation within the CCRP. Members of LWV provided input on the problem list that was created by technical committees and on the process of environmental decision-making as it was being contemplated by the CCRP. The League of Women Voters are public participation advocates and had major concerns that there was not adequate attention or resources being directed toward providing public input in the CCRP. The Education Committee concurred in this opinion and made recommendations to the CCRP Executive Staff.

In August, 1993, with a supplemental grant from the U.S. EPA, the CCRP hired a consulting firm, PS Enterprises, to help develop a feasible structure for public participation in the CCRP. The plan chosen included holding three "regional roundtables" -- in Hayward, Fresno, and Los Angeles -- in October, November, and December of 1993. A formal report by PS Enterprises summarizing all issues presented at the roundtables is included as Attachment E.

The roundtable formats were consistent. Each began with a staff introduction to the CCRP, continued with discussion by local opinion leaders (e.g., representatives from various constituencies including businesses, local government environmentalists, ethnic communities, grassroots coordinators), and followed with opportunities for participants to voice their views.

A variety of methods were employed to gather information and opinions from participants at the roundtables, including a survey, comment cards, evaluation forms, and transcripts by a court reporter. A summary of the survey results and the survey instrument is included in the Education Committee Appendix .

The Education Committee decided to critique the public participation process to fulfill its mission of making recommendations regarding public participation in the CCRP.

The specific activities conducted by LWV and the roundtables organized by PS Enterprises were regarded highly by the Education Committee. Specifically, the roundtables were seen as a model of ways to include diverse points of view on the issues of environmental decision-making and priority-setting. The approach consisted of focusing primarily on discussion by roundtable participants with facilitated input from the audience. The audience listened to the discussion and provided input via cards collected by circulating staff and by voting on topics that they desired the roundtable presenters to cover. There was also an opportunity for participants to ask questions and to make comments in an open microphone session at each event.

At each of the roundtables, the level of discussion was engaging and achieved a high level of thinking about the complexities of the issue and the many different approaches. During these roundtable discussions, some very specific recommendations were made about problem solving and many philosophical differences were aired. The success of these roundtables was due in large part to the creative approach designed by the consulting firm in conjunction with CCRP Staff and the

Education Committee, and the diversity of opinion represented on the roundtables and in the audience. None of these were easy achievements and each took great effort.

The audience was able to direct the roundtable conversation via the cards and also had the benefit of hearing different perspectives on particular issues from individuals who were experts on the topic because of the constituency they represented or because of some particular technical or professional expertise. Therefore, the audience was educated about the issues and provided input to decision-making; the roundtable presenters were educated by each other and the audience as well. Feedback from some participants indicated that regional repetition of these roundtables could provide a basis for the decision-making and environmental problem solving necessary to move forward.

Criticisms of this process for increasing public participation were that there was not enough outreach for the public roundtables and the turnout was therefore not as high as desirable. Also, this model, while highly effective at engaging the kind of individuals that attended the event, is not an effective model for grassroots community participation or worker participation. Either of these would have required considerably more outreach to specific community leaders in specific neighborhoods and workplaces. A more extensive public participation project would also have included translators or native speakers presenting the information and asking for input from non-English speaking communities.

The Education Committee also had concerns about the considerable resources and time required for outreach projects. We felt that the public participation component of the overall CCRP was under-funded (even with receiving an additional grant to proceed, halfway through the CCRP). Because funding was not available in the beginning, public participation was not as well-developed and representative of California as it could have been, and therefore not an integral component of the overall CCRP until later in the process.

The original CCRP workplan of 1992 described some mechanisms of public involvement that were intended to be incorporated into the overall process at the beginning. One of these, the Statewide Community Advisory Committee (SCAC) was to be made up of members of the broad ethnic and cultural California public, representing diverse perspectives on environmental protection. There was a delay of over six months in forming and convening the SCAC, primarily the result of the difficulty Cal/EPA had in selecting its members. In the end, the SCAC did not represent the ethnic diversity of the California population and this was an issue the SCAC addressed at their first meeting. One SCAC recommendation, that "Cal/EPA's public participation groups and advisory committees should reflect the diversity of the State and its communities" was developed in part because of the lack of diversity on the SCAC.

Other features of the original workplan that increased public participation were eliminated early on because of severe shortfalls in the budget. For example, the original workplan called for regional advisory committees to parallel the work of the SCAC. These regional advisory committees would have been addressing problems of local concern, and could have better represented the local ethnic, cultural, and political diversity of that locale. Community outreach (e.g., mailing lists, public advertisement and notices, brochures, education materials) were similarly eliminated or greatly reduced early on due to budget deficiencies. Finally, holding a Statewide symposium was considered up to the last few months of the CCRP when budget and time limitations precluded the organization of a major workshop on environmental decision-making.

The Education Committee recommends integrating public participation at the inception of projects like a comparative risk project and providing for continual feedback to the overall project on an ongoing basis. Models such as we used in the CCRP are only one way of providing input into the process. In addition, there should be considerable effort to include more grassroots community input in future projects such as a comparative risk project. Public participation that is meaningful is expensive and takes a lot of time, and this needs to be recognized and planned for. It is conceptually challenging

to design good public participation projects and requires individuals who know how to design them and who are respected by the community members you are trying to reach. Public participation needs to be organized and carried out not just to satisfy the minimum mandated requirements, but to be truly inclusive and to provide information that will affect decision-making. Lastly, public participation is not a luxury -- it is essential to the development of sound public policy.

EDUCATION COMMITTEE MISSION AND CAVEATS

The Education Committee is satisfied with having completed substantial pieces of work relative to each to its missions.

Education Assessment (Mission 1)

The task of assessing education materials and projects was challenging due to the sheer volume of materials currently in circulation and the plethora of potential target audiences. Nonetheless, the Education Committee was able to develop a vision statement, research historical and current perceptions of environmental and occupational health education, and multicultural issues, develop criteria, collect and review various curricula from diverse perspectives, create a resource list, and make specific recommendations regarding environmental and occupational health education.

Public Participation (Mission 2)

Accounting for the many different perceptions and opinions of the public is not an easy process. The Education Committee made many recommendations regarding public participation on an ongoing basis and kept the issue in the forefront during the entire length of the CCRP. We developed and implemented a model with the assistance of the consulting firm and were successful in having public input be recognized as one of the six factors necessary for decision-making by the CCRP and the SCAC.

Inter-project Communication (Mission 3)

The California Comparative Risk Project dedicated itself early on to facilitating communication among the different working committees. Committee members accomplished this goal primarily by making recommendations about the structure of the CCRP and the committees. The Education Committee has also made periodic suggestions about the ways to structure and integrate Components 1 and 2.

Public Perception (Mission 4)

Developing a sense of the public's perception of environmental problems has been addressed by the members of the Education Committee and by using the LWV and PS Enterprises to interact with citizens. The Education Committee has also sought to educate itself about the *process* of public perception by reading materials on environmental ethics and risk communication, and having speakers address the Education Committee about multicultural issues, traditional environmental and occupational health education, and the ethical issues involved in environmental priority setting. The Education Committee resource base was greatly enhanced by having various perspectives presented and discussed as they have deliberated on the entire comparative risk process.

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ATTACHMENT A:
EDUCATION SUBCOMMITTEE MEMBERSHIP LIST

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Clark Brink
Air Resources Board

Tricia Broddrick
Integrated Waste Management Board

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Todd Miller, Research Associate for committee support.

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The League of Women Voters and, especially, Gloria Anderson for consultation and focus on public participation.

ATTACHMENT B:

Environmental/Occupational Health Connection

written by
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January 1994

Status of Occupational Health

Traditionally, most occupational and environmental health issues have not been linked together. The two areas are regulated by different agencies, assess exposure risk differently, have significantly different abilities to assess penalties for violations of the law and different levels of funding. For example:

The Occupational Safety and Health Administration (OSHA), the agency that regulates workplace health and safety, has set the standard for cancer risk of one in 1,000. The United States Environmental Protection Agency (U.S. EPA) standards have a goal of limiting cancer risk to one death in one million people exposed (Smith *et al.*, 1993).

The U.S. Environmental Protection Agency's standards for ambient air quality are generally stricter than OSHA's standards for the workplace. In the case of lead, U.S. EPA's standard (1.5 micrograms per cubic meter of air) is 33 times stricter than OSHA's lead exposure standard for the workplace (50 micrograms per cubic meter of air) (AFL-CIO, 1993).

The maximum criminal penalty for employees that willfully violate OSHA standard resulting in the death of a worker is six months in jail. In contrast, U.S. EPA regulations allow violators of environmental laws to be sentenced to a maximum of 15 years in prison (AFL-CIO, 1993).

The Occupational Safety and Health Administration is seriously underbudgeted and understaffed. While U.S. EPA currently receives six billion dollars each year ($24 per citizen), OSHA's annual budget is $285 million ($1.14 per citizen). At their current staffing level, Federal OSHA can only inspect each workplace every 79 years! The situation for California's program, Cal/OSHA, is not much better. Their inspectors can only visit the workplace once every 66 years!

These comparisons show how workers are often exposed to chemicals at a higher level to the workplace. They also point to the need to strengthen occupational health regulations and funding. This will help ensure that both environmental and occupational regulations and policy can protect people from exposure to chemicals and other hazards at the workplace and in the community.

Linking Environmental and Occupational Health Education

As we look at new models of how to do education in the area of the environment, we have an opportunity to learn from the limitations of how occupational health risks have been regulated and funded in the past. We can also create curriculum that emphasizes connections between workplace/occupational health issues and the environment, including these issues:

Workplace production, handling, and disposal of chemicals directly impacts the environment, that is, what goes on in the plant impacts the surrounding community.

Development of viable pollution prevention policies impact both the workplace and the community. Toxic use reduction, product substitution, and changing technologies all affect workers, jobs, the environment, and the community.

Communities most affected by occupational and environmental issues are often the same. For instance, studies show that three out of five hazardous waste sites are located in communities of color. Statistics also document that workers of color are twice as likely to suffer a disabling injury or illness in the workplace than white workers (Robinson, 1991).

Discussion and Analysis

Unless these connections between occupational and environmental health are made, future efforts in the areas of pollution prevention and toxic use reduction will lack the comprehensive approach needed to create safe and healthy places to live and work. As Philip Landrigan, Chairman of the Department of Community Medicine at Mount Sinai School of Medicine has stated,

> *"The tragedy of environmental diseases is that they are highly preventable. Toxic environmental diseases arise as a direct consequence of human activity and can therefore, in theory, be prevented through modification of that activity. Such containment is demonstrably achievable through legislation, regulation and other well-understood mechanisms of communal action. Children must be protected from exposure to lead. ... Dangerous chemicals in the work environment must be replaced with safe substitutes; and workers and consumers must be provided with knowledge, training, and protective equipment."* (Rachel's Hazardous Waste News, 1993).

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ATTACHMENT C:

Towards a Multicultural Environmental Education

Three Circles Center for Multicultural Environmental Education

Volume 1, Issue 3

Winter 1994

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insert Education Attachment C Page 3

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ATTACHMENT D:

Point of View on Environmental Education

from the

California Department of Education

Spring 1990

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EDUCATION COMMITTEE

ATTACHMENT E:

Cal/EPA Comparative Risk Project

Regional Roundtables Report

prepared and submitted by

PS Enterprises

Environmental Decision-making: Review of the Interagency Management Cooperative Case Studies

INTRODUCTION

Governmental agencies continually make a myriad of decisions about identifying and rectifying environmental problems. The types of decisions they make range widely, from priority-setting and program development, to ongoing regulation and management of natural resources, to mitigation of already contaminated areas. Any one decision typically involves complex judgments about many different elements.

This report, developed by the California Comparative Risk Project (CCRP) Staff, examines selected aspects of a sample of decisions that State agencies have made about environmental problems. It summarizes background information on nine case studies submitted to the CCRP by the Interagency Management Cooperative (IMC), which is composed of representatives of various State agencies.

The case studies were solicited by the CCRP as a means of gathering preliminary information on how factors such as risk, public participation, pollution prevention, economics, and environmental justice influence environmental decision-making at the State agency level. The selected focus on these factors reflects interests expressed by many members of the CCRP's Statewide Community Advisory Committee and of several CCRP working committees. The case studies presented herein are not intended to be representative of the agencies' decision-making processes.

The California Comparative Risk Project

In February 1992, the California Environmental Protection Agency (Cal/EPA) initiated the CCRP as one means of assessing priorities for environmental management in California. During the course of the CCRP, two components were established. Component 1 aims to identify scientific methodologies to rank human health, ecological, and social welfare threats, and to gather available data and develop such rankings. This work was conducted through the CCRP's Human Health, Ecological Health, and Social Welfare committees. Component 2 aims to identify and characterize what factors, other than risk, need to be considered in setting priorities and establishing policies for environmental protection. This work was conducted through the Education, Environmental Justice, and Economic Perspectives committees, along with the IMC case study effort.

The Interagency Management Cooperative Case Study Process

The Interagency Management Cooperative was organized to provide a forum for communications about the CCRP among participating State agencies. Over 30 agencies are represented on this advisory committee (see Attachment A for list of IMC members).

Project Staff met with IMC representatives on July 20, 1993, to discuss the concept of case studies, solicit comments from the representatives about relevant topics regarding dissemination of case study information, and solicit tentative ideas for specific case studies.

Subsequent to this meeting, Project Staff drafted a set of questions to be used as a template for the case studies. The questions focused on the following general areas (see Attachment B for detailed list of questions):

1) relevant Federal and State statutory authority (including provisions regarding flexibility and discretionary activities),

2) decision-making process (including weighting or prioritization schemes),

3) management options considered and chosen, and

4) the influence of non-risk and risk factors in the decision-making process.

Within the fourth area identified above, Project Staff initially asked IMC representatives to identify whether or not the following factors were of concern in their case study decisions:

→ risk

→ pollution prevention

→ public participation

→ environmental justice and equity

→ economics

→ sustainability

→ others (e.g., public perception, ease of implementation, time to implement).

All of these -- but particularly economics, pollution prevention, public participation, and environmental justice -- emerged during the CCRP as issues of general concern to many interest groups. The Component 2 committees of the CCRP -- Environmental Justice, Education, and Economic Perspectives -- also identified these factors as critical to sound environmental decision-making.

Project Staff then met with IMC representatives on August 10, 1993, to discuss the draft questions and solicit final IMC commitments for case studies. The nine case studies submitted are listed in Table 1 and summarized in Attachment C. The full case studies submitted by IMC members are available upon request from the CCRP.

Project Staff met with IMC representatives on December 21, 1993, to discuss a first draft report summarizing the case studies. That draft contained a matrix that attempted to condense and compare the case studies in terms of the influence of the factors listed above. Interagency Management Cooperative representatives expressed concerns that these factors represent very general issues that may overlap and are subject to a broad range of interpretations.

Table 1. Submitted Case Studies.

	AGENCY	DESCRIPTION
CASE 1	Department of Toxic Substances Control	Remediation of Hazardous Waste Site
CASE 2	Department of Toxic Substances Control	Permit Renewal for Hazardous Waste Recycling Facility
CASE 3	Department of Pesticide Regulation	Registration of New Pesticide
CASE 4	Department of Pesticide Regulation	Development of Minimal Exposure Pesticide List
CASE 5	State Water Resources Control Board	Assessment of Liability from a Sewage Spill
CASE 6	State Water Resources Control Board	Awarding Loans for Municipal Sewage Works Projects
CASE 7	Department of Water Resources	Awarding Grants for Urban Streams Restoration Projects
CASE 8	Air Resources Board	Identifying and Managing Toxic Air Emissions
CASE 9	California Department of Forestry	Modifications to the Timber Harvest Plan

In response to these concerns, and to better understand the range of meanings and uses within each factor, Project Staff refined the broad factors into more detailed subcategories; these are discussed in the next section. To provide greater consistency with the Component 2 committees, the subcategories were derived largely from the work of the Environmental Justice, Economic Perspectives, and Education committees.

Each case study then was assessed by the original respondents in terms of whether or not these subcategories were reported to play a part in that particular decision. In some cases, these assessments were clarified via telephone interviews with the relevant case study respondents. The scoring notation used in the matrices was designed to identify those subcategories that entered into the decision-making process, to distinguish subcategories that were of major importance versus minor or tangential importance, and to identify whether inclusion of a subcategory in the decision-making process was mandatory or discretionary. The scoring notation used in the matrices is as follows:

M = mandatory and of major importance

D = discretionary and of major importance

m = mandatory and of minor importance

d = discretionary and of minor importance

0 = did not enter decision-making process.

Finally, a draft report on the case studies, dated January 27, 1994, was sent to IMC members for review. On March 17, 1994, the IMC met to review written comments on the draft and to offer additional suggestions for revising the report.

Factors and Subcategories

As mentioned above, each factor was divided into subcategories for further evaluation. Ultimately, five factors were evaluated in the case study analysis.[7]

Risk

Risk is a measure of the extent of potential harm posed by environmental stressors to human health, the natural environment, or the quality of human life. Risk assessment and risk management often lie at the heart of environmental decisions. Risk assessment is the process by which the form, dimension, and characteristics of that risk are estimated. Risk management is the process by which options to reduce or mitigate risks are analyzed, chosen, and implemented. Risk can be evaluated in a variety of ways, which in turn influence the assessment and management of those risks. In the case study analysis, risk as a factor in environmental decisionmaking was categorized as follows:

> ***Existing risks*** occur in situations in which humans or ecological resources (e.g., species, habitats) are currently exposed to and suffer some degree of risk from environmental stressors. These situations include, for example, abandoned hazardous waste sites that have contaminated groundwater supplies and exposed people to toxic substances. Many existing risks are already regulated to some degree.
>
> ***Future risks*** represent potential situations in which humans or resources might -- at some unknown time in the future -- be exposed to and suffer some degree of risk. An example is the contamination of a groundwater aquifer that may be utilized for drinking water at some unspecified time in the future.
>
> ***Individual or subpopulation risks*** are risks that disproportionately impact smaller groups of people than the general population. Risk assessments that calculate average risks to the general population, for example, may conceal greater risks to workers, low-income communities, communities of color, or small children.
>
> Multiple or Cumulative Risks, also known as "hot spots," are risks that are compounded because of the proximity of other environmental hazards.

Pollution abatement and prevention

Pollution prevention is a term of increasing popularity and recognized importance, although its definition is highly variable and the subject of national debate. It can be defined as a multi-media approach which seeks to reduce or eliminate hazardous or toxic substances throughout their entire lifecycle (i.e., from the extraction and processing of raw materials, through multiple manufacturing steps, distribution and use, to their eventual disposal) without inter-media tradeoffs between air, land, and water. It differs from traditional regulatory approaches which focus on controlling pollution from the "end of the pipe" (i.e., pollution control to reduce releases, or abatement for actual cleanup of releases), because it seeks to reduce future risks by reducing emissions or other environmentally degrading activities at their source.

Activities such as treatment or pollution control would not generally be considered pollution prevention. However, they are included here -- under the umbrella of pollution abatement – to

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[7] Based on discussion among CCRP Staff and IMC members at the December 21, 1993, IMC meeting, sustainability was deleted from further analysis; it was the most ambiguous factor, with interpretations ranging from "the depletion of natural resources" to "sustaining timber harvest levels."

demonstrate the range of activities that some decision-makers have considered as pollution prevention, particularly in the context of already existing risks (e.g., such as from existing leaking underground storage tanks).

> ***Treatment*** refers to methods designed to manage existing hazards after the release of toxic substances or other stressors to the ambient environment. An example is the pumping of contaminated groundwater.[8]
>
> ***Pollution control*** is an end-of-pipe approach that seeks to reduce pollution after it has been generated but prior to its actual release to the environment. An example is the use of particulate scrubbers to contain air emissions.
>
> ***Source reduction*** includes a range of activities -- for example, substitution of alternative materials, equipment and process modifications, and housekeeping measures -- such that actual generation of pollutants is reduced, regardless of the subsequent application of treatment or pollution control technologies.[9]
>
> ***Lifecycle analysis*** can be viewed in at least two ways. It can mean assessing the impacts of alternatives that directly substitute one material or process for another. It also can be interpreted more broadly as analyzing the costs and benefits of all activities associated with the manufacturing of products, including costs and benefits from the extraction of raw materials and the disposal of waste residuals.

Public Participation

The Education Committee concluded that "true public participation is not possible without education and an explanation of risks that incorporates an understanding of the culture and language of the affected communities." In practice, definitions of who constitutes the public and what is considered public participation range widely.

> Notice only on request is a minimum level of public outreach, requiring the public to formally request information about pending decisions before such information is provided.
>
> ***Standard notice and formal hearing*** involves the mandatory publication of a public notice about the holding of a hearing at which public comments on a pending decision are solicited.
>
> ***Published information available*** represents the provision of information to the public in the form of brochures, reports, videotapes, and other forms of communication.

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[8] The differences between treatment, abatement, and pollution control are not clear-cut. For example, not all treatment occurs after release to the ambient environment; under the impending land ban for certain hazardous wastes, disposal can only be used for those residues that cannot be reclaimed and that are stabilized through prior treatment (i.e., before release for disposal). Some observers may consider this more a form of pollution control.

[9] Congress specifically excluded recycling from the definition of "source reduction" in the Pollution Prevention Act of 1990.

Informal agency-sponsored workshops (such as seminars, question/answer sessions, and conferences) are usually held at the discretion of an agency as a way to educate the public or solicit comments on potential management options.

Community co-sponsorship occurs when the formal participation of a community-based entity (e.g., local government, non-profit organization) is required in order for a project to receive approval and/or funding. It is based on the idea that people who live in a community are an integral part of the decision-making process.

Environmental justice

Environmental justice deals with the concern that specific communities, most often those composed of lower income individuals and/or people of color, bear disproportionately greater risks than the population at large. As addressed by the Environmental Justice Committee, it encompasses at least three broad goals: public participation, accountability for the assessment of individual and cumulative risks, and pollution prevention. Each of these goals can be evaluated independently, as described in the previous sections, and as part of a general environmental justice factor.

Pollution prevention is significantly embedded in an environmental justice approach because it seeks to eliminate future risks which would affect, for example, the most vulnerable groups in society.

Risk, in the context of environmental justice, includes the assessment of risks to individuals or subpopulations (i.e., "environmental equity") and the assessment of multiple or cumulative risks (i.e., "hot spots").

Public participation is also central because environmental justice is inherently process-oriented, based on the premise that a fair process will generate fair outcomes.

Economics

Economic considerations have come to the foreground in environmental decision-making, particularly in the context of how trade-offs are made in the face of scarce resources. The Economic Perspectives Committee concluded that at least four broad categories of economic factors should be evaluated when determining environmental priorities:

Economic efficiency is assessed in terms of net benefits as measured by economic impacts on consumers and producers. This can include direct and indirect costs and savings, such as avoided costs and impacts on non-market valued human health and environmental amenities.

Distributional impacts include impacts on, for example, employment sectors, ethnic groups, local community amenities, government revenues, overall business competitiveness, and future generations.

Uncertainty may lie in a number of areas, including technology and engineering, politics and governance, financing, and/or the predictability of environmental responses to management activities.

Time frame considers, for example, the value of information obtainable in the future and the irreversibility of investments in mitigation and other technologies.

FINDINGS AND OBSERVATIONS

Summary of Factors as Reported

Risk

The risk matrix (Table 2) indicates that risks were assessed very differently across the case studies. Most case studies reported mandates to evaluate existing risks and multiple or cumulative risks. With respect to multiple or cumulative risks, however, subsequent telephone interviews determined that this assessment was not made in any consistent way. Roughly one-half of the respondents reported mandates to consider future risks and individual or subpopulation risks.

Agencies may not necessarily have the same definitions in mind with respect to certain terms. For example, in Case 5 (see Table 2), odors at an overloaded publicly owned treatment works (POTW) would affect nearby residents only, not the general public, so any decision about this situation would focus by necessity on risks to the local subpopulation. In filling out the "individual or subpopulation risks" category for Case 5, however, the State Water Resources Control Board (SWRCB) considered that it had no choice in how to treat the issue and therefore entered "O" (did not enter the decision-making process). Other agencies encountering a similar situation could interpret their actions in this category as being either mandatory or discretionary.

Pollution abatement and prevention

The pollution abatement and prevention matrix (Table 3) shows quite clearly that the use of pollution control (i.e., abatement) is the dominant mandate, while source reduction and lifecycle analysis lag in terms of mandates. Even so, a number of respondents, even in cases not concerned with toxics, indicated that some form of lifecycle analysis was used on a discretionary basis. The California Air Resources Board, for example, performed a lifecycle analysis when it considered the issue of reformulating fuels to burn more cleanly. The analysis considered additional emissions from increased refining as well as tanker emissions from an increase in imported fuels.

The lifecycle approach is consistent with the Environmental Defense Fund (EDF) and Metropolitan Water District study on halogenated solvents (see Attachment D) and, in general, with national debates on this issue. Environmental Defense Fund representatives presented this case study at an early meeting of the Statewide Community Advisory Committee; it is an example of how pollution prevention can be examined from lifecycle and cost/benefit analytical perspectives. The study estimated that the use of halogenated solvents could be reduced by roughly one-half or more, using currently available methods under present operational constraints.

Table 2. Risk Matrix.

	Existing Risks Only	Future Risks	Individual or Subpopulation Risks	Multiple or Cumulative Risks
1. Remediation of Hazardous Waste Site	M	M	M	M
2. Permit Renewal for Hazardous Waste Recycling Facility	D[2]	M[1]	M[1]	M[1]
3. Registration of New Pesticide	O[3]	M	M	M
4. Development of Minimal Exposure Pesticide List	M	M	M	M
5. Assessment of Liability from Sewage Spill	M	D	O	M
6. Awarding Loans for Municipal Sewage Works Projects	M	D	O	M
7. Awarding Grants for Urban Stream Restoration Projects	M	m	m	m
8. Identifying and Managing Toxic Air Emissions	M	M	M	M
9. Modifications to Timber Harvest Plan	M	M	M	M

[1] "Required under CEQA."

[2] "Existing risk often aids in evaluation of mandatory assessment of future risk."

[3] "A pesticide cannot be used until it is registered; therefore, the term "existing risks" is not applicable."

M = mandatory and of major importance
m = mandatory and of minor importance
D = discretionary and of major importance
d = discretionary and of minor importance
O = did not enter decision-making process

Table 3. Pollution Prevention Matrix.

	Treatment	Pollution Control	Source Reduction	Lifecycle Analysis
1. Remediation of Hazardous Waste Site	M	M	O	O
2. Permit Renewal for Hazardous Waste Recycling Facility	M	M	M	M
3. Registration of New Pesticide	O	M	M	M
4. Development of Minimal Exposure Pesticide List	O	d	d	M
5. Assessment of Liability from Sewage Spill	M	M	O	O
6. Awarding Loans for Municipal Sewage Works Projects	O	M	O	O/M
7. Awarding Grants for Urban Stream Restoration Projects	D	d	d	d
8. Identifying and Managing Toxic Air Emissions	M	M	M	D
9. Modifications to Timber Harvest Plan	O	O	M	M

Treatment: For example, pumping of contaminated groundwater.
Pollution Control: for example, use of particulate scrubbers to contain generated air emissions.
Source Reduction: any practice that reduces amount of a pollutant *entering* a waste stream, as opposed to treatment *after* entering a wastestream.
Lifecycle Analysis: includes consideration of risks, benefits, and costs associated with *entire* lifecycle of given activity (as opposed to only those associated with manufacturing portion of lifecycle), from initial extraction of materials, through manufacturing, commercial distribution, use and reuse, and waste disposal.

M = mandatory and of major importance
m = mandatory and of minor importance
D = discretionary and of major importance
d = discretionary and of minor importance
O = did not enter decision-making process

Public participation

The public participation matrix (Table 4) indicates that participation ranged from providing information on request to community co-sponsorship. The majority of mandates involved "standard notice and formal hearing" (i.e., via *Administrative Procedures Act* activities) and making "published information available." The full range of activities that might engage the public often were not used; only a few agencies, for example, used public information programs on a significant basis. However, this study did not evaluate whether or not it would have been appropriate to bring into play additional public participation activities in these particular situations.

Table 4. Public Participation Matrix.

	Published Information Available	Public Education Programs	Informal Agency-Sponsored Workshops	Community Co-Sponsor Required	Notice Only on Request	Standard Notice and Formal Hearing
1. Remediation of Hazardous Waste Site	M	d	d	d	O	M
2. Permit Renewal for Hazardous Waste Recycling Facility	M	d	d	d	O	M
3. Registration of New Pesticide	m	O	O	O	m	O
4. Development of Minimal Exposure Pesticide List	M	d	O	O	O	M
5. Assessment of Liability from Sewage Spill	O	O	O	O	O	M
6. Awarding Loans for Municipal Sewage Works Projects	M	O	D	M[1]	O	M
7. Awarding Grants for Urban Stream Restoration Projects	D	d	d	M	m	M
8. Identifying and Managing Toxic Air Emissions	M	D	D	M	n/a (already do notice and hearing)	M
9. Modifications to Timber Harvest Plan	M	D	d	O	O	M

[1] Local air district.

M = mandatory and of major importance
m = mandatory and of minor importance
D = discretionary and of major importance
d = discretionary and of minor importance
O = did not enter decision-making process

Environmental justice

Several respondents reported that environmental justice was not a factor in the decision-making process (Table 5). Indirectly, however, many of them did consider some of the goals that correspond to environmental justice, most frequently via identification of subpopulations in risk assessment.

Table 5. Environmental Justice Matrix.

	Pollution Prevention	Individual or Sub-population Risks	Multiple or Cumulative Risks	Future Risks	Public Participation
1. Remediation of Hazardous Waste Site[2]	M[1]	M[1]	M[1]	M[1]	M[1]
2. Permit Renewal for Hazardous Waste Recycling Facility	D	M[2]	M[2]	M[2]	M[2]
3. Registration of New Pesticide	M	M	M	M	m
4. Development of Minimal Exposure Pesticide List	O	M	M	M	m
5. Assessment of Liability from Sewage Spill	M	O	M	D	M
6. Awarding Loans for Municipal Sewage Works Projects	M	O	M	D	M
7. Awarding Grants for Urban Stream Restoration Project	d	m	m	m	M
8. Identifying and Managing Toxic Air Emissions	M	M	M	M	M
9. Modifications to Timber Harvest Plan	M	D	M	M	M

Pollution Prevention broadly defined to include all activities listed in pollution prevention matrix (see Table 5).
Public Participation broadly defined to include all activities listed in public participation matrix (see Table 4).
[1] "Required for all actions under State and Federal regulations for hazardous waste sites."
[2] "Required under CEQA."

M = mandatory and of major importance
m = mandatory and of minor importance
D = discretionary and of major importance
d = discretionary and of minor importance
O = did not enter decision-making process

In addition, public participation is generally considered a key component of environmental justice activities. Table 5 indicates that public participation usually is mandated; as noted above, though, the more detailed public participation matrix (Table 4) indicates that many forms of public participation were not used in these situations.

Economic considerations

Economic considerations usually took the form of evaluating impacts to small business (Case 8) and agriculture (Cases 3 and 4). These efforts generally would fall under the categories of economic efficiency or perhaps distributional impacts. Few agencies were mandated to consider factors other than economic efficiency (Table 6). Although many considered the other economic factors on a discretionary basis, these factors rarely were reported as being significant in the decision-making process.

Table 6. Economics Matrix.

	Economic Efficiency	Distributional Impacts	Uncertainty	Time Frame
1. Remediation of Hazardous Waste Site	D	d	M	D
2. Permit Renewal for Hazardous Waste Recycling Facility	D	d	M	M
3. Registration of New Pesticide	m	d	d	O
4. Development of Minimal Exposure Pesticide List	d	d	D	O
5. Assessment of Liability from Sewage Spill	M	d	d	M
6. Awarding Loans for Municipal Sewage Works Projects	M	d	d	D
7. Awarding Grants for Urban Stream Restoration Projects	D	d	D	D
8. Identifying and Managing Toxic Air Emissions	M	M	D	D
9. Modifications to Timber Harvest Plan	M	M	M	O

Economic Efficiency: for example, assessed in terms of net benefits as measured by economic impacts on consumers and producers, or/and non-market valued human health and environmental amenities.
Distributional Impacts: for example, on jobs, ethnic groups, local community amenities, government revenues, overall business competitiveness, future generations.
Uncertainty: for example, in technology and engineering, politics and governance, financing, and/or predictable environmental response.
Time Frame: for example, value of information obtainable in future, irreversibility of investment.
M = mandatory and of major importance
m = mandatory and of minor importance
D = discretionary and of major importance
d = discretionary and of minor importance
O = did not enter decision-making process

Observations

The following discussion reflects the Project Staff's interpretation of the case studies, including revisions in response to comments made by IMC members (either in writing on earlier drafts, or verbally at the last two IMC meetings). It does not necessarily reflect the views of any participating agency.

At the outset, it is important to note that environmental decision-making, whether in the specific situations represented by these case studies or at broader policy levels, requires a complex mix of many professional disciplines and judgments. For each situation, and at different times, any one factor -- be it the need for better risk assessment or greater public participation -- is likely to be considered differently. In part this is because changes can occur over time in value systems, knowledge, and environmental conditions themselves. In many cases weightings are of necessity made on the basis of professional judgments, tempered by inputs from public participation processes, that change over time. Clearly, the diverse array of factors involved in decision-making cannot be characterized in a static manner or by any one decision-making model.

In this exercise, additional problems make it difficult to directly compare the influence of different factors and to draw definitive conclusions about the exact extent to which agencies consider these factors in their overall decision-making. For example, some case studies represent enforcement actions, while others represent planning exercises. Some decisions are about site-specific activities, while others are about the overall development of regulatory programs. The case studies also do not contain detailed information on broader historical and political factors -- both external and internal -- that may have shaped agency decision-making processes.

Definitional problems also persist. Even with the refinements represented by the subcategories, no standardized definitions exist for most of the factors examined here. As a result, agencies could -- and seemingly did -- vary in how they interpreted and used terms such as "individual or subpopulation risks," "pollution prevention," "pollution control," and "source reduction." Much depends on context; pollution prevention means very different things, for example, to the California Department of Forestry and the Department of Toxic Substances Control.

Despite these caveats, the information in the case studies warrants some general observations. The agencies generally attempted to make decisions based on sound scientific judgments about risks, although they sometimes differed in how they interpreted some terms in the risk category. Most focused on only a small portion of the range of economic factors, namely economic efficiency.

Most agencies reported mandates to consider "public participation" and "pollution prevention," although not all forms of either were used. Whether additional forms should or could have been used in these situations, however, was not examined in this exercise. Reviewers noted several reasons, for example, why an agency might not use any additional types of public participation; these included mandates with little discretion in procedure, insufficient time for education, lack of public interest, and lack of resources for discretionary actions.

Given the above discussion, the case studies *begin* an examination of how State agencies address the concerns of many people about public participation, distribution of risks among subpopulations, different economic perspectives, pollution prevention, etc. Project Staff suggest that the case studies support the need for Cal/EPA to:

1) better understand which models of public participation are appropriate for and effective in different situations;

2) better understand how "pollution prevention" is interpreted and implemented including determining what attention is given to avoiding future risks and to documenting cost savings that are associated with specific efforts;

3) better understand how and when additional economic factors should be addressed in different situations; and,

4) if appropriate, consider means of institutionalizing additional public participation activities, pollution prevention principles, and economic perspectives.

ATTACHMENT A: IMC MEMBERS OR DESIGNEES

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James Behrmann
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ATTACHMENT B:

INITIAL CASE STUDY QUESTIONS

Goal of case studies

To provide information on how scientific, sociopolitical, economic, and other factors influence:

a) the setting of relative environmental priorities (i.e., which problems are "more" important), and

b) how agencies choose among available management options to reduce or mitigate a particular environmental problem.

Questions

1) Problem area

Briefly describe the environmental problem area (note: the area should correspond to one on the CCRP environmental topics list), including geographic scale, demographics of affected populations, etc.

2) Relevant Federal and State statutory authority

a) List relevant Federal and State statutory authorities.

b) Summarize what factors, issues, and parameters the statutes:

i) allow your agency to consider,

ii) mandate your agency to consider,

iii) prohibit your agency from considering, and

iv) do not mention.

c) Without a direct mandate to consider this problem, would the agency have addressed it on a discretionary basis?

3) Decision-making process

a) Parameters, criteria, or considerations used:

i) provide definitions or descriptions,

ii) how were the definitions/descriptions determined (e.g., statutorily, regulatorily, administratively)?

b) Describe sources and types of data used.

c) Describe any weighting or prioritization scheme (e.g., matrix, decision-tree) used on input data and parameters.

d) Describe decision flow and decision points:

i) include description of the extent and timing of public participation (public hearings or meetings),

ii) include description of the extent and timing of involvement by specific interest groups.

e) How long did the process take?

f) What other State agencies were or should have been involved?

4) Management options

a) Describe the array of options identified for solving or reducing the problem.

b) Describe the agency's choice (including rationale) of a preferred option.

c) What other reduction or mitigation measures for other environmental problems were foregone by this decision?

d) In terms of relative importance (high, medium, low), where does this particular problem rank in the array of problems your agency must address? How did the agency decide this?

5) Influence of Component 2 non-risk factors

a) For each of the following influencing factors, please indicate how it was factored into the decision-making process (i.e., qualitatively or quantitatively; if the latter, any weighting factor?):

i) risk (protection of public health, environment, or welfare);

ii) public participation (hearings, meetings);

iii) environmental justice, environmental equity;

iv) pollution prevention;

v) economics (including, marginal costs, full-cost accounting of externalities, etc.);

vi) sustainability; and

vii) others (public opinion, public perception, public acceptance, ease of implementation, degree of controversy, time to implement).

b) Rank the relative importance of these factors.

c) Do the relevant statutes provide any flexibility in how these factors can be weighed or assessed?

6) If I could do it again...

In hindsight, please describe whether and how your agency would have handled this situation and decision-making process differently.

7) How to restructure environmental decision-making

Please describe any ideas you have on how the State and its decision-making bodies might restructure decision-making about environmental priorities. (These will not be considered as recommendations or endorsements.)

ATTACHMENT C:

CASE STUDY SUMMARIES

Case 1: McColl Hazardous Waste Site Department of Toxic Substances Control

Overview

McColl is an inactive hazardous waste disposal facility that lays adjacent to residential housing, a golf course, and a regional park. Contaminants at the site included heavy metals and hydrocarbons. In 1982, the site was placed on the U.S. Environmental Protection Agency's (U.S. EPA's) National Priorities List (NPL), making it eligible for Comprehensive Response, Compensation, and Liability Act (CERCLA, commonly referred to as Superfund) funding for cleanup. The Department of Toxic Substances Control (DTSC) is authorized by the State of California to regulate hazardous waste and substances. The Department of Toxic Substances Control worked with the U.S. EPA (who is currently the lead agency) in designating a mitigation strategy. "Soft Material Solidification" is the most recent strategy chosen for this site.

Decision-making process

The Department of Toxic Substances Control followed the criteria delineated in the NPL to be considered in remedy decision-making, with two modifications. Those modifications were: 1) the State's acceptance of the proposed remedy, and 2) consideration of the community's preference for a remedy.

Management options

Numerous cleanup alternatives have been evaluated for McColl in the last decade. A total of nine alternatives were evaluated.

Significant Component 2 factors

Risk

The risk receptors were considered to be the human population immediately surrounding the site (estimated at 16,000) including children residents, adult residents, and country club workers. The pathways identified were through inhalation of volatile organic compounds and fugitive dusts, ingestion of homegrown vegetables, incidental ingestion of soil, and dermal contact with contaminated soil.

Risks to on-site workers and other communities (who could be affected by off-site re-disposal or treatment) were considered in the evaluation of alternatives.

Public participation

Public participation was a required element of the NPL and public acceptance was critical. Community participation was enhanced by high-profile media attention focused on the site by Lois Gibbs and the Campaign for Economic Democracy. Public hearings were held

throughout the process with participation by organized community groups. However, DTSC reported that participation was lacking from both on-site workers and other affected communities that would have been recipients of waste in off-site disposal or treatment option.

Economics

The capital, operation, and maintenance costs of all alternatives were considered.

Case 2: Hazardous Waste Recycling Facility Department of Toxic Substances Control

Overview

The Department of Toxic Substances Control is responsible for permitting activities of hazardous waste facilities. An active solvent recycling facility located in a small city surrounded by agriculture came up for permit renewal. The facility had leaking underground storage tanks which had contaminated the groundwater. The Department of Toxic Substances Control renewed the facility's permit and is in the process of specifying remediation measures.

Decision-making process

The permitting process starts with an application from the facility and DTSC considers all of the following areas before a decision is reached: waste receiving, storage, treatment, recycling, facility operation (including worker training), and future closure of the facility. Public hearings are held if public comments are received on the draft permit.

Significant Component 2 factors

Risk

Risk was reported as the number one factor in the decision-making process. Human exposure risks are related to groundwater contamination from the leaky storage tanks and air emissions. The city's 20,000 residents rely on groundwater from wells.

Public participation

No public comments were received, therefore, no public hearing was held.

Pollution Abatement and Prevention

Pollution prevention was reported as the second most important factor in the renewal of the permit. Since "the facility recovers valuable chemicals, there is less demand to produce new chemicals thus reducing potential environmental problems that might result from the manufacturing operations."

Economics

The negative impact on solvent waste generating facilities was a consideration in not denying or withholding the permit.

Case 3: New Active Ingredient Pesticide Product Registration Department of Pesticide Regulation

Overview

The Department of Pesticide Regulation (DPR) is vested with the authority to regulate the sale and use of pesticides to protect human health and safety and the environment. The registration of a pesticide product (Capture 2 EC) containing a new active ingredient (bifenthrin) was delayed for use on cotton in California until the agency gathered additional information on the exposure risks.

Decision-making process

Pesticide products containing new active ingredients are evaluated by all relevant scientific disciplines based on Federal and State data requirements. Full consensus must be met in order to win approval. Members of the public are notified and public comment is considered prior to final approval.

Management options

Registration of Capture 2 EC was delayed until concerns raised by scientific evaluators regarding worker reentry intervals and dermal absorption were addressed and resolved.

Significant Component 2 factors

Risk

Risk was identified as the primary factor in delaying approval. Toxicity studies indicated the potential for adverse effects to cotton workers.

Pollution abatement and prevention

Once a pesticide is registered, the DPR's regulatory program provides an on-going pollution prevention process, including encouraging the development of pest management systems.

Economics

The Department of Pesticide Regulation is mandated to consider the economic benefit to pesticide use, which include factors in the implementation of mitigation measures to reduce hazards.

Case 4: Defining Minimal Exposure Pesticide List Department of Pesticide Regulation

Overview

Federal law establishes uniform label requirements for pesticide products and prohibits states from requiring label changes. In order to restrict pesticides with a potential for chronic, reproductive, or developmental health problems, the State of California established additional State worker safety regulations. In accordance with these regulations, DPR developed a Minimal Exposure Pesticide (MEP) list to restrict pesticides that require strict handling procedures because of their potential to result in chronic health problems.

Decision-making process

The creation and placement of the first active ingredients in the MEP list was conducted as a normal regulatory action. The process included public hearings held throughout the State, a 45-day public comment period and a final notification where decisions were posted for public view.

Management options

Options identified to reduce worker exposure to a pesticide active ingredient were: 1) to cancel the registration, or 2) to minimize exposure with use of additional personal protective equipment or of additional administrative and engineering controls (such as required in the MEP).

Significant Component 2 factors

Risk

The protection of human health, specifically of farm workers and pesticide handlers, was the driving factor to reduce risk.

Public participation

Hearings were held throughout the State with participation from both farm labor groups and affected industries.

Economics

Economics was ranked as the second most important factor in deciding not to cancel the registration of a pesticide active ingredient.

Case 5: Assessment of Civil Liability from a Sewage Pump Station
State Water Resources Control Board

Overview

Administrative Civil Liability (ACL) is one of several enforcement measures available to the State and regional water boards. Repeated spills totaling 30,300 gallons of raw sewage into a small drainage channel occurred from a municipal pump station. The Regional Water Resources Control Board (RWRCB) assessed a monetary penalty on the city.

Decision-making process

Once it was determined that the sequence of violations was significant enough to warrant an ACL, the amount of the penalty was determined. By law, nine factors must be weighed in determining the liability. These factors include the nature and gravity of the violation, ability to abate problem, voluntary actions taken, ability to pay, history of violations, degree of culpability, economic savings, and other matters as justice may require (such as penalties assessed for similar situations).

Management options

Management options ranged from a phone call to referral to the attorney general.

Significant Component 2 factors

Risk

Concern for public health drove the decision to apply ACL. Concerns had also been expressed by the California Department of Fish and Game as to the volume and toxicity of the disinfectants that were used in mitigation.

Economics

In assessing monetary penalties, the RWRCB considered staff costs, other penalties imposed for similar situations, compensation for damage to waters of the State, and what reasonable amount will cause the violator to avoid future incident.

Culpability

While the spills were accidental, some negligence was involved. The City had repeated pump failures and overflows. By failing to inform the RWRCB they obstructed mitigation efforts.

Case 6: State Revolving Loan Fund State Water Resources Control Board

Overview

The State Water Resources Control Board (SWRCB) operates the State Revolving Loan Fund (SRF), a multi-billion dollar program to provide low interest loans for:

1) construction of public owned waste water treatment works,
2) water reclamation,
3) implementation of nonpoint source and storm drain pollution control management programs, and
4) development of estuary conservation and management programs. The State Revolving Loan Fund program implements the Federal Clean Water Act and various State laws including the Porter-Cologne Water Quality Control Act.

Decision-making process

Each Regional Water Resources Control Board conducts a public hearing, adopts a priority list, and sends it to the SWRCB. The State Water Resources Control Board adopts a Statewide priority list in a similar manner. Decision-making in the SRF Program involves many qualitative judgments.

Significant Component 2 factors

Risk

The highest priority for funding is given to protect public health, followed by other water quality concerns such as violations of standards.

Public participation

All priority lists and authorizations to award loans are adopted at public meetings. Associations of dischargers have played a strong role in advising the SWRCB on loan/grant policies.

Others

An important factor in prioritizing funding is a qualitative assessment of readiness to proceed.

Case 7: Urban Streams Restoration Process Department of Water Resources

Overview

The Department of Water Resources (DWR) is responsible for addressing urban runoff and protecting critical riparian and wetland habitats. The Department of Water Resources developed a system to set priorities for providing both funding and technical assistance to support local government agencies and citizens in solving their urban runoff and flooding problems.

Decision-making process

Based on previous grant projects, DWR concluded that partnership projects developed jointly by citizen groups and local governmental agencies accomplished the most with the least need for micro-management. Applicants submit the required form with a project description, with goals and educational benefits identified. The regulations then specify a multi-disciplinary review team with representatives from DWR and the Department of Fish and Game to select projects for funding.

Significant Component 2 factors

Risk

The primary risk is identified as flood and erosion damage to private property, public safety, and ecological values. Urban runoff threatens to destroy the riparian and wetland habitats which are critical for a significant percentage of California's rare, threatened and endangered species.

Public participation

Public participation is integral to making decisions on funding. The Department of Water Resources only funds projects where community groups are co-sponsors with local government agencies.

Others

Other factors include degree of innovation, educational value, breadth of support, accomplishment of multiple objectives, continuity with prior projects, youth employment or career development, urgency, and whether the funding is likely to trigger other sources.

Case 8: Risk Management for Air Toxics
Air Resources Board

Overview

The Air Resources Board (ARB) is legislatively mandated to control the emissions of air toxics to prevent harm to human health. The Air Resources Board targets emissions using a two-phase process of risk assessment and risk management.

Decision-making process

For the risk assessment phase, the law directs ARB to utilize scientific criteria in assessing the risks to human health. Potentially toxic substances are selected and prioritized in terms of which ones pose the greatest public health risk.

In the risk management phase of the decision-making process, the law requires ARB to prepare a report which assesses the sources and the need and appropriate degree of control of a toxic air contaminant, in consultation with local districts, affected industry, and the public. The control options are evaluated and prioritized based on technical feasibility and considering present and future emissions, risk, atmospheric stability, numbers of sources, cost, availability of substitutes, and other pollution prevention considerations.

Management options

By law, the ARB must reduce emissions of toxic air contaminants, for which there is no threshold exposure level, to the lowest level achievable through the application of best available control technology, considering the factors listed above.

Significant Component 2 factors

Risk

This program was developed specifically to manage human health risks.

Public participation

Public participation is an important element in the process of identifying and, when appropriate, regulating a toxic air contaminant. Public workshops are held early in the process. Reports are available for multiple comment periods and are reviewed by an independent scientific review panel. When risk management is determined to be appropriate, ARB establishes a working committee of local districts and holds additional public workshops and individual meetings with industry representatives and other interested members of the public.

Economics

Cost is one of the most critical issues considered in risk management, with special consideration made for small businesses.

Pollution abatement and prevention

Control options considered include substitution, process modifications, and improved training, in addition to simply controlling emissions.

Case 9: Modified Timber Harvest Plan Department of Forestry and Fire Protection

Overview

The *Forest Practice Act* authorizes the State Board of Forestry (SBF) to adopt forest practice rules and regulations. The Act enables the Board to take action to implement forest practice rules. In 1992, SBF determined it was necessary to find a way to relieve some of the regulatory burden on small landowners for which compliance costs may preclude continued timberland management. The State Board of Forestry therefore adopted the "Modified Timber Harvest Plan" (MTHP) to provide non-industrial landowners an opportunity to conduct timber operation in accordance with the mandates of the *Forest Practice Act* with reduced costs for preparing permit applications.

Decision-making process

Legal and procedural criteria as specified in the *Forest Practices Act*, *California Environmental Quality Act*, and the *Administrative Procedures Act* were met before ultimate approval and implementation of these rules. The data used in decision-making came from public testimony and from a series of relevant studies and reports derived from staff and from the public workshops. This included a cost study based on survey results from non-industrial landowners.

Management options

The State Forestry Board considered an array of different regulatory options including exempting non-industrial landowners of 3 to 10 acres from portions of the regulations which apply to permit applications. In the case of the MTHP rules, SBF circulated four notices with different options and alternatives for language. These were evaluated by SBF and one was adopted.

Significant Component 2 factors

Sustainability, economics and risk

The *Act* requires the SBF "to promote maximum sustained production of high quality timber products while giving consideration to other values including environmental impacts and economics." Therefore, sustainability of harvest must be balanced against both economic considerations and environmental protection.

ATTACHMENT D:

EXECUTIVE SUMMARY FROM ENVIRONMENTAL DEFENSE FUND AND METROPOLITAN WATER DISTRICT'S REPORT TITLED *THE POTENTIAL FOR SOURCE REDUCTION AND RECYCLING OF HALOGENATED SOLVENTS*.

This five-year, in-depth study of businesses and industries in southern California concludes that up to 44 percent of halogenated solvent use in the United States could be eliminated within five years, up to 58 percent within 10 years, and up to 65 percent longer term, using presently practical means within present operational constraints. These estimates of reduction potential are based on currently realistic and available techniques that would not have unacceptably negative impacts of their own. Starting from the 1988 baseline, the estimates also assume constant production levels in each of the 10 industry categories studies. The 10 categories, each of which is covered in a separate Technical Support Document, together account for 92 percent of baseline demand for virgin halogenated solvents in the United States. Total 1988 usage of these solvents in the United States in all forms was approximately 802,600 metric tons.

The approach of the study yields conservative -- arguably, much too conservative -- results in terms of the reduction potentials reported. Estimates based solely on technical availability of reduction measures would be much higher. However, the sponsors' goal was to provide a bedrock estimate of what is presently practical within present constraints, using as much detailed, industry-by-industry and process-by-process data as possible. Chemical industry data on reduced demand from 1988 to 1991 is consistent with the study's reported results, although direct comparison is not appropriate.

The Source Reduction Research Partnership (SRRP) was formed in a joint effort by the Metropolitan Water District of Southern California (a water-distributing agency serving 15 million customers) and the Environmental Defense Fund (a public-interest organization with 200,000 members) which together sponsored and arranged funding for this research. Halogenated solvents were chosen as the project's focus because of their extensive use by a wide spectrum of industries large and small, their history of contaminating important groundwater supplies, and their status as ozone depletors and/or carcinogens.

In addition to providing information on well over 100 various reduction and recycling techniques and their potentials for lowering the demand for halogenated solvents in specific industrial applications, the study also includes a lifecycle inventory and tradeoff analysis, which explores the issues involved in comparing the impacts of halogenated solvent use with the impacts of some major alternatives. This experimental analysis shows that impact comparisons made at the local (e.g., factory) level may not be valid at the global level, and that some comparative results can be counter-intuitive.

Human Health Committee Appendix

Summary Sheets by Environmental Topic Area

GENERAL CAVEAT

Summary sheets have been prepared for the SCAC to provide an overview of the results of analyses conducted by the Human Health Committee (HHC) in order to assign ranks to different topic areas. These sheets are necessarily abbreviated versions of more thorough analyses and emphasize the quantitative and qualitative considerations that were most relevant to the HHC's ranking process.

Numerical estimates of cancer cases per year, average added individual cancer risks, or the incidence of non-cancer effects like respiratory illnesses in children must be interpreted cautiously. Quantitative risk estimates vary widely in degrees of uncertainty but for simplicity single values are reported in summary tables. These estimates should be interpreted as rough indications of the potential health impacts of toxic exposures, rather than actual predictions of disease incidence. Because HHC analyses of most topic areas relied on evaluating a few indicator chemicals out of the many toxicants currently being released into California's environment, these estimates should not be interpreted as indicating the *total* health impact of different topic areas.

Risk estimates must be interpreted cautiously because they are based on data of varying quality and methods that incorporate different assumptions and degrees of conservatism. Numerical estimates are useful for indicating the relative scale and severity of different environmental exposures and should not be interpreted as actual "body counts" by participants in environmental policy debates.

Summary sheets have been prepared for all topic areas that were ranked "High" or "Medium" Due to time and resource constraints, it was not possible to provide summary sheets for topic areas that were ranked either "Low" or "Insuffient Evidence to Categorize."

INDUSTRIAL RELEASES TO SURFACE WATER

Line Code I-1

I. Definition

Topic area I-1 includes industrial "point sources" of pollution which directly discharge effluents into surface waters through discrete conveyances such as pipes or outfalls. The Toxic Release Inventory (TRI) indicates that 66 facilities directly discharged about 10 million pounds of wastes to surface waters in California in 1991.

II. Human Health Risk Assessment Results for Indicator Chemicals

Data are available only to assess the cancer and noncancer health risks from emissions of TCDD or dioxin, an indicator chemical that is predominantly attributable to industrial point sources. Data on TCDD and congener concentrations in sport fish were collected near two pulp mills on the Sacramento River in 1989. Current risks are likely to be lower because of substantial reductions in TCDD emissions over the last several years. The size of the exposed population is not known, but is unlikely to be larger than 1,000. Available data on monocyclic aromatic hydrocarbons (MAHs), a class of indicator chemicals that are discharged by industries to surface waters, indicate no significant health risks.

A. Summary of Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Comments
TCDD (dioxin)	B2	5 in 1,000	Average individual risk for a sport fisherman consuming 23 g per day of contaminated trout fillet.
TCDD (dioxin)	B2	2 in 1,000	Average individual risk for a sport fisherman consuming 23 g per day of contaminated Squawfish fillet.

B. Summary of Noncancer Risks

Indicator Chemical	Health Effect	Hazard Index	Comments
TCDD (dioxin)	Immunological and reproductive effects	7.4	Hazard index for a sport fisherman consuming 23 g per day of contaminated trout fillet.
TCDD (dioxin)	Immunological and reproductive effects	3.6	Hazard index for a sport fisherman consuming 23 g per day of contaminated trout fillet.

C. Summary of Risk Characterization

Areas where aquatic resources have been contaminated to such an extent that sports or subsistence fisher people could experience adverse health impacts include the Bay/Delta watershed (including the Sacramento and San Joaquin Rivers), major bay and riverine systems in southern California, and mined areas in northern California. The cancer and noncancer risks associated with industrial releases to surface water can be quantified to a limited extent only for TCDD. Industrial point sources (refineries) are associated with elevated concentrations of selenium in San Francisco Bay area ducks, which are currently the subject of a health advisory based on reproductive toxicity. Data on industrial point source discharges to surface waters that result in the contamination of drinking water indicate that few health risks are generally involved. Some metals releases contribute to generally low levels of trace elements in surface water dependent drinking water systems, but little evidence indicates organic chemical contamination of surface water supplies.

III. Estimated Percent of Topic Area Analyzed

_____ High __X__ Medium _____ Low

Although exposure data exists for very few stressors directly released to surface waters by industrial point sources, a substantial proportion of the topic area's impact has probably been covered. Releases from point sources are reportable under the Toxic Release Inventory and are dominated by non-persistent pollutants that are not chronic toxicants (methanol and ammonia). Fish tissue monitoring indicates that compounds of greatest concern have large bioaccumulation factors and long half-lives in sediment, characteristics typical of now-banned industrial chemicals like organochlorine pesticides or PCBs.

IV. Level of Confidence

_____ High __X__ Medium _____ Low

There are substantial data gaps in the information needed to describe the extent of aquatic resource contamination in California and the exposure potential of certain population groups at high risk (e.g., subsistence fishers), as well as to apportion responsibility between source categories. In spite of these limitations, overall confidence in the assigned rank is medium because opportunities for extensive human exposure to contaminants released into surface water are relatively limited. Drinking water exposures are generally unlikely, due to regulatory controls on the quality of water used in public drinking water systems. Edible organism exposure is limited by the relatively small proportion of the California population that fishes or hunts frequently, particularly in hotspot areas of known contamination which are posted with health advisories.

Considerable uncertainties do surround our capacity to completely characterize the exposures of those who do regularly consume aquatic organisms. Monitoring efforts have historically been focused on a small subset of chemicals (about 25 "priority pollutants") discharged into aquatic environments. Available data are inadequate to characterize exposures to most of the substances known to be discharged. In addition, data on the size of population subgroups consuming edible organisms from different contaminated water bodies and on general population exposures are unavailable.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

None identified.

B. Highly exposed subpopulations

Individuals relying on caught fish for a regular part of their diet are highly exposed to contaminated fish. Sport anglers are more likely to be exposed than the general population.

VI. Comparative Rank

A. General Population

_____ **High** _____ **Medium** __X__ **Low**

Risks to the general population are likely to be low, as there are limited opportunities for extensive human exposure to released contaminants through consumption of either drinking water or edible aquatic organisms.

B. Highly Exposed Subpopulations

__X__ **High** _____ **Medium** _____ **Low**

Groups that regularly consume large quantities of edible organisms from contaminated water segments are likely to experience significant health risks.

MUNICIPAL RELEASES TO SURFACE WATER

Line Code I-2

I. Definition

Topic Area I-2 includes discharges from the outfalls of publicly owned treatment facilities, encompassing both municipal sewage treatment and industrial discharges that flow through publicly operated treatment works (POTWs). The combined volume of industrial waste and municipal sewage represent the largest quantity of permitted discharges in the state.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary of Theoretical Cancer Risks

The only data available to assess cancer risks associated with municipal releases involve exposures to several persistent organohalides that bioaccumulate in edible aquatic organisms. The following table summarizes cancer risks associated with exposures to DDT, PCBs, and chlordane in fish caught off the coast of southern California near Los Angeles. This contamination is a consequence of historic industrial discharges of these pollutants through POTWs into the offshore marine environment.

Indicator Chemical	Weight of Evidence	Average Individual Risk	Comments
DDT (total), PCBs, chlordane	B2	1 in 1,000	Average individual risk for typical consumer of white croaker as a result of cumulative exposure to the indicator chemicals listed.

B. Summary of Noncancer Risks

No quantitative data are available to assess noncancer risks associated with municipal releases to surface water. In some parts of California, POTWs contribute to heavy metal loading into aquatic environments that can result in potentially hazardous tissue concentrations of pollutants like mercury and selenium. The major noncancer health impact of POTW releases are probably associated with discharge of microbiological agents to surface waters, although problems arise only when such systems malfunction and untreated sewage comes into contact with people as a result of either recreational or drinking water exposures.

C. Summary of Risk Characterization

Areas where aquatic resources have been contaminated to such an extent that sports or subsistence fisher people could experience adverse health impacts include the Bay/Delta watershed (including the Sacramento and San Joaquin Rivers), major bay and riverine systems in southern California, and mined areas in northern California. The cancer risks associated with municipal releases to surface water can be

estimated only for cumulative exposure to DDT, PCBs, and chlordane. Limited data on noncancer risks suggests the principal concern is exposure to waterborne pathogens when treatment systems fail.

III. Estimated Percent of Topic Area Analyzed

_____ **High** _____ **Medium** **X** **Low**

Exposure data exist for very few stressors released to surface waters through municipal point sources, although POTWs are recipients of substantial loads of toxic pollutants from industrial point sources and a variety of urban non-point sources. The extent to which POTW treatment systems remove hazardous pollutants before effluent is discharged to surface waters is poorly characterized for many compounds. Some pollutants collected by POTW systems are persistent in aquatic environments (e.g., trace metals, PAHs) and are detectable in edible aquatic organisms within the zone of influence of treatment plant outfalls. As with industrial releases, fish tissue monitoring indicates that compounds of greatest concern have large bioaccumulation factors and long half-lives in sediment. Many such substances are no longer in industrial use, but POTWs serve as a collection point for them as they runoff contaminated urban areas.

IV. Level of Confidence

_____ **High** **X** **Medium** _____ **Low**

There are substantial data gaps in the information needed to describe the extent of aquatic resource contamination in California and the exposure potential of certain population groups at high risk (e.g., subsistence fishers), as well as to apportion responsibility between source categories. In spite of these limitations, overall confidence in the assigned rank is medium because opportunities for extensive human exposure to contaminants released into surface water are relatively limited. Drinking water exposures are generally unlikely, due to regulatory controls on the quality of water used in public drinking water systems. Edible organism exposure is limited by the relatively small proportion of the California population that fishes or hunts frequently, particularly in hotspot areas of known contamination which are posted with health advisories.

Considerable uncertainties do surround our capacity to completely characterize the exposures of those who do regularly consume aquatic organisms. Monitoring efforts have historically been focused on a small subset of chemicals (about 25 "priority pollutants") discharged into aquatic environments. Available data are inadequate to characterize exposures to most of the substances known to be discharged. In addition, data on the size of population subgroups consuming edible organisms from different contaminated water bodies and on general population exposures are unavailable.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

None identified.

B. Highly Exposed Subpopulations

Individuals relying on caught fish for a regular part of their diet are highly exposed to contaminated fish. Sport fisher people are more likely to be exposed than the general population.

VI. Comparative Rank

A. General Population

_____ **High** _____ **Medium** **X** **Low**

Risks to the general population are likely to be low, as there are limited opportunities for extensive human exposure to released contaminants through consumption of either drinking water or edible aquatic organisms. This topic area involves greater risks than direct industrial releases because a substantial volume of pollutants, including organochlorines, microbiological contaminants, and nitrates, are discharged to aquatic environments through POTWs.

B. Highly Exposed Subpopulations

X **High** _____ **Medium** _____ **Low**

Groups that regularly consume large quantities of edible organisms from contaminated water segments are likely to experience significant health risks. These groups include several populations of immigrants from Asian countries that utilize contaminated estuaries as a major source of food.

NON-POINT SOURCE RELEASES

Line Code I-3

I. Definition

Topic Area I-3 includes "non-point" source releases, pollutants that reach surface waters through sources other than discrete conveyances for effluents. This includes runoff from urban, industrial, agricultural, silvicultural, or undisturbed land.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary of Cancer Risks

Cancer risks cannot be quantitatively assessed for this topic area. Insufficient exposure data are available to assess the cancer health risks from polycyclic aromatic hydrocarbons (PAHs), a class of indicator compounds that is predominantly attributable to non-point urban runoff. Cancer risk estimates calculated for both industrial and municipal point source releases also involve a component that can be attributed to non-point releases, because contaminated sediment in the aquatic environment serves as a continuous source of exposure to TCDD, DDT, and PCBs for biota.

B. Summary of Noncancer Risks

Two major sources of noncancer risk are associated with non-point sources. First, leaking septic systems and other inadequate animal waste disposal systems (e.g., manure piles and feed lots) are a major source of microbiological agents contaminating surface water and occasionally causing outbreaks of gastroenteritis. (Most exposure to these agents occurs through non-point contamination of ground water by these same sources.) Second, runoff from abandoned mines is the principal source of mercury contamination in edible aquatic organisms in California. Consumption of fish contaminated with mercury poses reproductive and neurological risks, particularly to pregnant women. Health advisories recommending reduced fish consumption apply to a number of lakes in California, as well as to the entire Bay/Delta estuary.

III. Estimated Percent of Topic Area Analyzed

_____ **High** _____ **Medium** ___X___ **Low**

Relatively little is known about non-point source contributions to surface water and biotic contamination, although it is clear that such sources contribute substantially to ongoing exposures to persistent organohalides, trace elements, and microbiological agents.

IV. Level of Confidence

_____ **High** ___X___ **Medium** _____ **Low**

There are substantial data gaps in the information needed to describe the extent of aquatic resource contamination in California and the exposure potential of certain population groups at high risk (e.g., subsistence fishers), as well as to apportion responsibility between source categories. In spite of these limitations, overall confidence in the assigned rank is medium because opportunities for extensive human exposure to contaminants released into surface water are relatively limited. Drinking water exposures are generally unlikely, due to regulatory controls on the quality of water used in public drinking water systems. Edible organism exposure is limited by the relatively small proportion of the California population that fishes or hunts frequently, particularly in hotspot areas of known contamination which are posted with health advisories. Considerable uncertainties do surround our capacity to completely characterize the exposures of those who do regularly consume aquatic organisms. Monitoring efforts have historically been focused on a small subset of chemicals (about 25 "priority pollutants") discharged into aquatic environments. Available data are inadequate to characterize exposures to many of the substances found in urban and agricultural runoff. In addition, data on the size of population subgroups consuming edible organisms from different contaminated water bodies and on general population exposures are unavailable.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

None identified.

B. Highly Exposed Subpopulations

Individuals relying on caught fish for a regular part of their diet are highly exposed to contaminated fish. Sport fishers are more likely to be exposed than the general population. Individuals relying on surface water or wells for drinking water in rural areas with private septic systems may experience high exposures to pathogenic microbiological agents.

VI. Comparative Rank

A. General Population

_____ **High** ___X___ **Medium** _____ **Low**

Risks to the general population are medium, because non-point sources are generally the major contributors to potential exposures to trace elements (from inactive mines), persistent organochlorines (from urban runoff in storm drains or contaminated sediment), microbiological contaminants (from leaking septic systems), and nitrates (from agricultural fertilizer use). There are limited opportunities for extensive human exposure to released contaminants through consumption of either drinking water or edible aquatic organisms. The most substantial risks involve exposure to mercury through fishing activities, but affected populations are small.

B. Highly Exposed Subpopulations

___X___ **High** _____ **Medium** _____ **Low**

Groups that regularly consume large quantities of edible organisms from contaminated water segments are likely to experience significant health risks.

RELEASES TO GROUNDWATER

Line Code I-4

I. Definition

This topic area covers natural and anthropogenic sources of groundwater contamination. Radon and arsenic are major geochemical contaminants in California groundwaters. With regard to anthropogenic sources, significant levels of groundwater contaminants have resulted from the use of agricultural chemicals and storage and land disposal of chemicals used in manufacturing. All forms of groundwater pollution which occur as a result of land disposal of wastes (i.e., Topic Areas I-5, I-6, I-7, I-8, I-9) are included in this topic area, as well as additional sources such as underground injection, fertilizer leaching, septic systems, road salt, nonwaste material stockpiles, pipelines, and irrigation practices. While this area involves double counting with various land topic areas, it is included as a separate "special" topic area to provide a summary perspective on the overall risks associated with groundwater sources.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary Table: Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individ. Risk	Size of Exposed Population	Estimated Annual Cancer Cases	Risk Distrib. # > 10^{-4} (per life)	Comments
Natural Sources						
Arsenic	A	> 10^{-2} > 10^{-3} > 10^{-4}	30,000 - 200,000? 100,000-1 million? 1 - 10 million?	200 - 2,000?	1 - 10 million	[a]Exposure to contaminated groundwater widespread but poorly characterized
Radon	A	0.0013	roughly 20 million	570	6 million	[a]Risks due to radon released during showering
Anthropogenic Sources						
Carbon Tetrachloride	B2	4 x 10^{-5}	> 191,000	< 1	> 15,100	a
1,2-Dibromo-3-chloropropane	B2	1 x 10^{-4}	> 236,000	< 1	> 63,400	a
Tetrachloroethylene	B2/C	2 x 10^{-5}	> 773,000	< 1	> 21,500	a
Trichloroethylene	B2	6 x 10^{-6}	> 519,000	< 1	> 1,140	a
Total anthropogenic				1		

[a] Cancer potency estimates derived from animal bioassay data are used in all risk calculations, with the exception of those for radon and arsenic, which are based on human data. Risk estimates for environmental exposures are inherently uncertain. For a discussion see the caveat/uncertainty section of this report.

B. Summary Table: Noncancer Risks

Indicator Chemical	Health Effect	Hazard Index	Size of Population at Risk	Cases per year or Exposures above Acceptable Level	Comments
Arsenic	hyperpigmentation, keratosis and possible vascular complications	> 1	> 50,000	Extent of exposure to those on private systems or wells unknown.	Only some of the more highly exposed populations accounted for here.
Carbon Tetrachloride	liver lesions	È 1	5,000 - 30,000	Unknown. Probably negligible	1,000-fold adjustment factor used in calculating RfD
1,2-Dibromo-3-Chloropropane	male infertility	È 1	?	Unknown	Theoretical values of decrease in male fertility available for high end exposure levels
Diuron	abnormal blood pigment	< 0.02	--	--	--
Nitrate	methemoglobinemia	È 1	Uncertain È 1 million?	Fatal cases believed unlikely. Non-fatal cases not known.	Information on nitrate concentrations private water sources limited.
Simizine	weight gain; hematologic effects	< 0.4	--	--	--
Tetrachloroethylene	hepatotoxicity in mice; weight gain in rats	< 0.6	--	--	--
Trichloroethylene	--	<.6	--	--	--
Natural uranium	kidney toxicity	È 1	Uncertain	Unknown	--

III. Estimated Percent of Topic Area Analyzed

_____ **High** **X** **Medium** _____ **Low**

A limited number of indicator chemicals were selected and evaluated, and concentration measurements were available for a relatively small fraction of drinking water wells. In particular, data to assess the extent to which arsenic exposure occurs are currently not available. Potentially high exposures in private systems and individual private wells could not be quantitatively assessed due to lack of data.

IV. Level of Confidence

X **High** _____ **Medium** _____ **Low**

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Infants and dialysis patients are susceptible to methemoglobinemia from nitrate exposures. Current and past smokers are at higher lung cancer risk from radon than those who do not now and never did smoke.

B. Highly Exposed Subpopulations

Radon and arsenic levels vary significantly across the State, with large levels occuring in certain areas.

VI. Comparative Rank

A. Natural Sources

__X__ High **_____ Medium** **_____ Low**

High theoretical cancer risks calculated for some segments of the population for radon and arsenic. Relatively high risks to radon are borne by a substantial fraction of the population.

B. Anthropogenic Sources

_____ High **__X__ Medium** **_____ Low**

The extensive regulatory controls applied to protect the public's drinking water have minimized the exposure to the anthropogenic groundwater contaminants. However, some exposure is difficult to limit due to pervasive groundwater contamination in certain locations. Consequently some individuals are exposed to relatively high cancer risks from certain groundwater contaminants, such as 1,2-dibromo-3-chloropropane (DBCP), and there is essentially no margin of safety with regard to nitrate exposures in numerous locations. Private systems are largely unregulated and significant exposures to nitrates and carcinogens may occur.

INACTIVE HAZARDOUS WASTE SITES

Line Code I-7

I. Definition

This topic area includes inactive hazardous waste sites that are regulated under the Resource Conservation and Recovery Act (RCRA) or under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The topic area includes two broad categories of sites: the 90 sites that are on the Superfund National Priority List (NPL) and a much larger number of approximately 400 "state-lead" sites. Assessed sites have been categorized according to the major types of contaminants: volatile organic chemicals and solvents (including closed military bases), pesticides, wood treatment chemicals, landfills, toxic metals (including abandoned mines), fuels and petroleum wastes, polychlorinated biphenyls, asbestos, and former manufactured gas plants (town gas sites). These sites can contaminate soil or ground or surface water, pollute the air, or directly expose humans. They frequently involve complex mixtures of pollutants. Evaluation of this topic area has been based on a selection of indicator sites that are representative of the major types of inactive sites and that have been the subject of relatively recent risk assessments.

II. Human Health Risk Assessment Results for Indicator Sites

A. Summary of Theoretical Cancer Risks

Indicator Site Type	Major Impacted Media	Average Individual Risk Range for Current Conditions	Size of Potentially Exposed Population
Dioxins	Soil	2 in 10,000 to 2 in 100,000	~ 100
Pesticide	Soil, Water	8 in 10,000 to de minimis	~ 10 - ~ 100,000
Petroleum products	Soil, Air, Water	1 in 10,000 to de minimis	~ 100 - ~ 100,000
Town Gas	Soil	3 in 10,000 to 4 in 100,000	~ 1,000
Toxic metals	Soil	1 in 10,000 to de minimis	~ 100
Wood treatment	Soil, Water	2 in 1,000 to 2 in 1,000,000	~ 100 - ~ 100,000
VOCs and solvents	Water	6 in 10,000 to de minimis	~ 100 - ~ 1,000,000

Estimated cancer risks from sites with significant soil contamination is greatest at town gas sites, wood treatment sites, and sites with PCB contamination. Relatively small populations are exposed because many of these contaminants are not mobile in the environment. Risk scenarios and potential population exposures differ across these sites. of greatest concern are town gas sites, because they are

numerous (approximately 400 identified in California), often found in urban areas, and involve the greatest potential for direct human exposure. Prior to the realization that gas manufacturing wastes were hazardous, parks, residential housing, and commercial/industrial facilities were constructed in direct contact with soil contamination. Wood treatment facilities are less numerous, often located in sparsely populated rural areas and have high levels of arsenical and dioxin contamination that are generally restricted within facility boundaries. PCB sites are also less numerous, usually located in manufacturing areas, with little opportunity for general population exposure.

Estimated cancer risks from groundwater contamination are highest for petroleum product, wood treatment, and VOC sites. Exposures and risks are generally greatest in hypothetical "future" scenarios, in which currently unused contaminated aquifers are tapped for domestic purposes (without any safe drinking water controls on allowable concentrations). The current availability of alternative drinking water supplies precludes full population exposure to contaminants in the San Gabriel Valley aquifer, for example. A notable exception involving current exposures to Superfund Site contaminants in drinking water involves the Newmark Wellfield, a large water supply for the city of San Bernardino. Wellhead treatment is used to reduce contaminants to allowable levels for an impacted population of over 250,000.

Estimated cancer risks associated with air emissions is greatest for near neighbors exposed to sites contaminated with petroleum products.

B. Summary of Noncancer Risks

Noncancer health risks presented by hazardous waste sites have not generally been quantified, because acutely hazardous concentrations of chemicals with significant release potential are usually managed during the emergency response phase of site identification. Some site types do pose potential noncancer risks with chronic exposure, notably battery and metals facilities (which have hazard indices for exposure in a residential setting to lead-contaminated soils of between 25 and 50) and many VOC-contaminated sites (which frequently have hazard indices exceeding one for future exposures through domestic use of contaminated ground water).

III. Estimated Percent of Topic Area Analyzed

_____ **High** _____ **Medium** __X__ **Low**

Only a small percent of the hazardous waste sites in California were directly addressed by this analysis, although an effort was made to select representative sites and the best data tends to be available on sites with the largest potential for exposure or adverse health impacts. Evaluated sites were selected because they were well-studied examples of broad categories of existing inactive hazardous waste sites. The analysis could not estimate either the total California population potentially exposed to all known sites or the cumulative impact on certain communities of multiple sites.

The analysis has not addressed potential human health risks posed by accidental sudden releases of hazardous substances into the environment. It has also not characterized acute health threats, physical threats from sites or explosives and fire hazards. At many sites, state agencies have taken action after preliminary evaluations to reduce such risks immediately, including preventing access to sites, controlling physical threats (e.g., subsidence of landfilled areas) or eliminating explosive or fire hazards (e.g., drum stabilization).

IV. Level of Confidence

_____ **High** _____ **Medium** __X__ **Low**

Level of confidence is low because of uncertainties affecting the extent of current population exposures to hazardous waste sites and estimation of the health consequences of exposures to complex mixtures or multiple sites. The extent of uncertainty about exposure varies widely with contamination type. Where risk information is based on concentrations of non-leachable contaminants in surface or near-surface soils, the calculation of risk for off-site receptors is associated with a large degree of uncertainty. off-site exposure estimates are derived by coupling a number of conservative models, and exposures will be restricted to the present and potentially future populations residing within site boundaries. Population exposure estimates for contaminants that are dispersing in ground water require estimation of both current and potential future consumers of contaminated drinking water as well as assumptions about the ongoing adequacy of regulatory controls on drinking water exposures. Air emissions from waste sites (including subsurface migration of landfill gas, off-site dust transport, and vapor emissions) are generally uncharacterized and the subject of current research efforts.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

None specifically identified.

B. Highly Exposed Subpopulations

The most highly exposed groups are those residing on abandoned contamination sites, a scenario that occurs most frequently with town gas sites. Other high exposures may occur among those living in close proximity to sites with uncontrolled dust or vapor emissions, or those drinking from private water supplies that tap contaminated aquifers. Given the large number of sites in some urban areas, there is also a potential for high cumulative exposures.

VI. Comparative Rank

_____ **High** __X__ **Medium** _____ **Low**

Medium because inactive hazardous waste sites are generally subject to a variety of regulatory controls limiting potential human exposures and risks (e.g., limits on direct site access, restrictions of consumption of contaminated drinking water). **High** at some sites before discovery and mitigation of acute hazards or due to failures to control exposures. Soil contamination which occurs in areas where direct public contact exists or is probable is associated with relatively high risks. The largest potential population exposures are associated with sites that contaminate groundwater, but impacted aquifers are not currently used for public drinking water supplies or are treated before use.

STATIONARY AND COMMERCIAL AREA SOURCES

Line Code I-10

I. Definition

Stationary and commercial area sources are defined as all non-residential sources of emissions, including large point sources (e.g., refineries) and smaller sources (e.g., chrome plate shops, dry cleaners). The environmental health stressors (topic list II) particularly relevant to topic area I-11 are: carbon monoxide (II-2), inorganics (II-6), volatile organics (II-12), persistent organochlorines (II-13), ozone (II-15), particulate matter (II-16), and SOx and NOx.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary Table: Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Annual Cancer Cases	Risk Distrib. # > 10^{-4}	Comment
acetaldehyde	B2	7×10^{-6}	30 million	3	a	b
benzene	A	2×10^{-5}	30 million	8		
benzo(a)pyrene	B2	6×10^{-7}	30 million	<1		
1,3-butadiene	B2	6×10^{-6}	30 million	2		
cadmium	B1	5×10^{-6}	30 million	2		
chloroform	B2	$<8 \times 10^{-7}$	30 million	<4		
chromium	A	4×10^{-5}	30 million	18		
formaldehyde	B1	2×10^{-5}	30 million	7		
methylene chloride	B2	6×10^{-6}	30 million	2		
nickel	A	2×10^{-6}	30 million	<1		
styrene	c	4×10^{-7}	30 million	<1		
tetrachloroethylene	B2/C	2×10^{-5}	30 million	6		
trichloroethylene	B2	2×10^{-6}	30 million	1		
Total indicator chemical risk		1×10^{-4}	30 million	È 50		

a Emitting facilities have been identified where theoretical lifetime risks estimated for the maximally exposed individual exceed 1×10^{-4}/life for asbestos, benzene, chloroform, chromium (hexavalent), methylene chloride, and tetrachloroethylene. There was insufficient information for extrapolating estimates to other facilities in California.

b The estimates indicate risks associated with this Topic Area, so total airborne risks for a given pollutant may be considerably higher (due for example to exposures from mobile sources). The estimates do not take into account elevated exposures that might occur near emitting facilities. Twenty-four hour exposure at ambient concentrations is assumed. Cancer potency estimates derived from animal bioassay data are used in all risk calculations, with the exception of those for benzene, cadmium, and chromium (hexavalent), which are based on human data. Risk estimates for environmental exposures are inherently uncertain. For a discussion, see the caveat/uncertainty section of this report.

c U.S. EPA classification not available. Classified by the International Agency for Research on Cancer as a 2B carcinogen.

B. Summary Table: Noncancer Risks

Indicator Chemical[a]	Health Effect	Hazard Index	Size of Population at Risk	Estimated Impact: # of Cases or Exposures above Acceptable Level	Comments
Ozone: Analysis 1[b]	Cough, headache, decreased lung function	> 1	26 million exposed above NOEL at least once per year	> 4 million residing in areas with >150 hrs/yr above standard	Number of individuals experiencing most serious effects difficult to quantitate. ARB estimates stationary and commercial area sources contribute 37% to total urban ozone.
Ozone Analysis 2[b]	Death	--	Individuals with preexisting conditions	0-100	Results from regression analysis. In calculating cases it was assumed that 37% of ambient ozone is due to emissions from stationary and commercial area sources.
	Asthma attacks	--	asthmatics	67,000-330,000	
	Respiratory hospital admissions	--	" "	150 - 500/yr	
	Minor restricted activity days	--	30 million	200,000 - 780,000 days	
Particulate Matter (PM10): Analysis 1[b]	Exacerbation of several respiratory diseases; bronchitis; decreased lung function	> 1	30 million	31 million exposed to concentrations above air quality standard	Number of individuals experiencing serious effects difficult to quantitate. Mobile sources are a significant contributor to PM10.
Particulate Matter (PM10): Analysis 2[b]	Death	--	individuals with preexisting medical conditions	500 - 1,100	Results from regression analysis. In calculating cases it was assumed that 52% of PM10 is due to emissions from stationary or commercial area sources.
	Hospital admissions	--	" "	590-1,500	
	Significantly restricted activity days	--	" "	3-8 million days	
	Lower respiratory illness in children	--		38,000-112,000 occurrences	
	Asthma attacks	--	asthmatics	62,000-680,000 occurrences	
	Emergency room visits	--	" "	16,000-48,000 occurrences	
	Chronic bronchitis		--	4,100-12,500	

[a] The health contributions of indicator chemicals carbon monoxide and nitrogen dioxide are minimal for the Stationary and Commercial Source Topic Area and so are not indicated in the table.

[b] The Human Health Committee did not reach consensus on the degree to which health effects for ozone and particulate matter could be quantified. The Human Health Committee developed two analyses to inform and provide a context for its deliberations. The results of those analyses are presented here.

III. Estimated Percent of Topic Area Analyzed

_____ **High** ___X___ **Medium** _____ **Low**

Ambient air measurements from the Air Resources Board monitoring stations were used to assess exposures. The monitoring network is not designed for characterizing the elevated concentrations that potentially occur near emitting facilities. Therefore, the exposures and associated risks experienced by those living near the numerous industrial facilities in California have not been well characterized. Risk assessments developed by affected industries which attempt to evaluate the exposure to those residing near industrial facilities have been submitted to the Office of Environmental Health Hazard Assessment Air Toxicology and Epidemiology Section. Reviewed assessments were available for only 301 facilities, and although informative, provide limited information on the size of the population that might be exposed and the magnitude of the exposure and risks.

IV. Level of Confidence

___X___ **High** _____ **Medium** _____ **Low**

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Individuals with preexisting respiratory conditions, such as asthma and emphysema, are at considerable risk from ozone and particulate matter exposures above the ambient standards.

B. Highly Exposed Subpopulations

Those residing near emitting facilities are the most highly exposed.

VI. Comparative Rank

___X___ **High** _____ **Medium** _____ **Low**

The topic area was assigned a rank of high due to the contribution by stationary and commercial sources to exposures to ozone and particulate matter. Although the HHC did not reach consensus on the degree to which health impact could be quantified, there was consensus that the health impact was high. Cancer risks contributed to the high level of concern. However, the HHC noted the level of uncertainty associated with the presented cancer risk estimates is moderately high, and exposures of those living near emitting facilities is poorly characterized.

MOBILE SOURCES

Line Code I-11

I. Definition

Mobile sources include automobiles, trucks, buses, trains, planes, and a variety of off-road vehicles and commercial machinery. The environmental health stressors (Topic List II) particularly relevant to Topic Area I-11 are: carbon monoxide (II-2), green house gases (II-5), inorganics (II-6), volatile organics (II-12), oil and petroleum products (II-14), ozone (II-15), particulate matter (II-16), and SOx and NOx.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary Table: Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Annual Cancer Cases	Risk Distrib. # > 10^{-4}	Comment
acetaldehyde	B2	2×10^{-6}	30 million	1	Very Small	a
benzene	A	2×10^{-4}	30 million	95	21.5 million	
benzo(a)pyrene	B2	2×10^{-7}	30 million	<1	Negligible	
1,3-butadiene	B2	1×10^{-4}	30 million	58	Large	
diesel	b	2×10^{-3}	30 million	170-1,000	Large	
formaldehyde	B1	1×10^{-5}	30 million	7	Unknown	
styrene	b	6×10^{-7}	30 million	<1	Negligible	
Total indicator chemical risk	--	2×10^{-3}	30 million		È 30 million	

a The risk estimates do not take into account elevated exposures that might occur near highly traveled transportation corridors. The estimates assume 24 hour exposure at ambient concentrations. Cancer potency estimates derived from animal bioassay data are used in all risk calculations, with the exception of those for diesel and benzene, which are based on human data. Risk estimates for environmental exposures are inherently uncertain. For a discussion, see the caveat/uncertainty section of this report.

b U.S. EPA classification not available. The International Agency for Research on Cancer classified diesel engine exhaust as a 2A carcinogen and styrene as a 2B carcinogen.

B. Summary Table: Noncancer Risks

Indicator Chemical	Health Effect	Hazard Index	Size of Population at Risk	Estimated Impact: # of Cases or Exposures above Acceptable Level	Comments
Carbon monoxide	Death	--	30 million	15 cases	Unintentional poisonings (e.g., from operating motor vehicles with leaky exhaust systems)
	Aggrevation of angina	--	Small	Small number of cases. Difficult to quantitate.	8-hour standard exceeded periodically in 6 different California air districts
Nitrogen dioxide	Decrease in pulmonary function	> 1 infre-quently	4 million	Small number of cases. Difficult to quantitate.	Air standard exceeded in LA Basin locations 1-4 times/yr 1990-1992
Ozone: Analysis 1[a]	Cough, headache, decreased lung function	> 1	26 million exposed above NOEL at least once per year	> 4 million residing in areas with >150 hrs/yr above standard	Number of individuals experiencing most serious effects difficult to quantitate. Mobile sources the most significant contributor to urban ozone.
Ozone Analysis 2[a]	Death	--	Individuals with preexisting conditions	0-170	Results from regression analysis. In calculating cases it was assumed that 63% of urban ozone is due to mobile sources
	Asthma attacks	--	asthmatics	110,000-560,000	
	Respiratory hospital admissions	--	" "	1,000 - 3,000/yr	
	Minor restricted activity days	--	30 million	0.5 - 2.1 million	
Particulate Matter (PM10): Analysis 1[a]	Exacerbation of several respiratory diseases; bronchitis; decreased lung function	> 1	30 million	31 million exposed to concentrations above air quality standard	Number of individuals experiencing serious effects difficult to quantitate. Mobile sources are a significant contributor to PM10.
Particulate Matter (PM10): Analysis 2[a]	Death	--	individuals with preexisting medical conditions	440 - 1,000	Results from regression analysis. In calculating cases it was assumed that 48% of PM10 is due to mobile sources
	Hospital admissions	--	" "	550-1,500	
	Significantly restricted activity days	--	" "	3-8 million days	
	Lower respiratory illness in children	--		36,000-108,000 occurrences	
	Asthma attacks	--	asthmatics	60,000-650,000 occurrences	
	Emergency room visits	--	" "	15,000-45,000 occurrences	
	Chronic bronchitis		--	4,000-12,000	

[a] The Human Health Committee did not reach consensus on the degree to which health effects for ozone and particulate matter could be quantified. The Human Health Committee developed two analyses to inform and provide a context for its deliberations. The results of those analyses are presented here.

III. Estimated Percent of Topic Area Analyzed

X High _____ **Medium** _____ **Low**

IV. Level of Confidence

X High _____ **Medium** _____ **Low**

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Individuals with preexisting respiratory conditions, such as asthma and emphysema, are at considerable risk from ozone and particulate matter exposures above the ambient standards. Regarding carbon monoxide exposures, the most susceptible populations are individuals with coronary artery disease, anemics, and fetuses and infants of smoking mothers.

B. Highly Exposed Subpopulations

Those residing near busy thoroughfares are the most highly exposed.

VI. Comparative Rank

X High _____ **Medium** _____ **Low**

The topic area assigned a rank of high primarily due to the contribution by mobile sources to exposures to ozone and particulate matter. Although the HHC did not reach consensus on the degree to which health impact could be quantified, there was consensus that the health impact was high. Cancer risks, particularly those due to diesel emissions, contributed to the high level of concern. However, the HHC noted the level of uncertainty associated with the cancer risk estimates for diesel and other carcinogens is moderately high.

RESIDENTIAL AND CONSUMER PRODUCT SOURCES

Line Code I-12

I. Definition

This topic area covers contributions to airborne risks, indoors and outdoors, from residential use of consumer products, other residential activities, and emissions from building materials and furnishings. Exposures experienced while in office buildings are also covered. Consumer product contributions to indoor air include, for example, emissions from moth balls, room deodorants, paint solvents, cosmetics, and furniture. Emissions to ambient air for this topic area include those from wood stoves, combustion of garden wastes, and painting. Topic list II (Environmental Health Stressors) areas particularly relevant to the evaluation of this topic area are: Carbon monoxide (II-2), environmental tobacco smoke (ETS) (II-3), volatile organics (II-12), and particulate matter (II-16).

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary Table: Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Annual Cancer Cases[a]	Risk Distrib. # > 10^{-4}	Comments
asbestos	A	??	??	?	??	Indoor levels not well measured
benzene	A	4×10^{-5}	30 million	17	5.6 million	b
benzo(a)pyrene	B2	8×10^{-7}	30 million	<1	È 0	b
1,3-butadiene	B2	3×10^{-6}	30 million	13	3.2 million	b
chloroform	B2	3×10^{-7}	30 million	1	350,000	b
p-dichlorobenzene	B2/C	3×10^{-4}	30 million	106	12 million	b
diethylhexylphthlate	B2	2×10^{-7}	30 million	<1	3.2 million	b
environmental tobacco smoke	A	2×10^{-5}	9 million	200	--	b
formaldehyde	B1	3×10^{-4}	30 million	124	26 million	b
radon	A	3×10^{-3}	30 million	2,000	Large number	Ave. risks in 9 Cal regions ea >10^{-4}
styrene	c	7×10^{-7}	30 million	<1	È 0	b
tetrachloroethylene	B2	9×10^{-6}	30 million	4	110,000	b
trichloroethylene	B2	8×10^{-7}	30 million	<1	È 0	b
Total indicator chemical risk		2×10^{-3}	30 million	È2,000 radon È 470 non-radon		

a Cancer risk burden attributed to this topic area. This number was obtained by multiplying the number of people at 10^{-4} or greater risk from indoor exposure to the compound by the fraction that consumer or residential sources of the compound contribute to indoor levels.

b The risk estimates indicate risks associated with this topic area; total airborne risks for a given pollutant may be considerably higher. Cancer potency estimates derived from animal bioassay data are used in all risk calculations, with the exception of those for benzene, radon and environmental tobacco smoke, which are based

on human data. Risk estimates for environmental exposures are inherently uncertain. For a discussion, see the caveat/uncertainty section of this report.
c U.S. EPA classification not available. IARC classifies styrene as a 2B carcinogen.

B. Summary Table: Noncancer Risks

Indicator Chemical	Health Effect	Hazard Index	Size of Population at Risk	Estimated Impact: Annual # of Cases or Exposures above Acceptable Level	Comments
Carbon monoxide	Death	--	1.5 million Californians may use unvented appliances	33 deaths (annual average)	Unintentional poisonings primarily from using unvented combustion appliances or misuse of gas stoves and kerosene heaters
	Headache, nausea, lethargy	--	15 million	Unknown but potentially significant	" "
	Aggravation of angina and other heart disease	--	Small	Small number of cases. Difficult to quantitate.	" " Plus motor vehicle traffic
Nitrogen dioxide	Decrease in pulmonary function, aggravation of condition of asth-matics and bronchitics	--	asthmatics	Difficult to quantitate	The presence of a gas stove in a home increases risk of respiratory illness in children by approximately 20%.
Environmental Tobacco Smoke (ETS)	Aggravation of asthmatic conditions in children	--	250,000 - 650,000 asthmatic children	50,000 - 130,000 asthmatic children exposed to ETS	Large exposures can occur in the home environment.
	Lower respiratory infections (LRI)	--	675,000 children under age 18 months	10,000 - 18,000 cases	ETS exposure associated with 20 - 30% incidence of LRI
Particulate Matter (PM10)	Exacerbation of respiratory diseases; aggravation of asthma	NQ	NQ	NQ	Components of PM10 generated from indoor sources different from outdoor sources. Indoor exposure levels similar to outdoor. Morbidity and mortality from indoor sources not currently quantified.
Formaldehyde and other VOCs	mucous membrane irritation, headaches	--	Potentially large	Potentially large	Occurrences of high exposures reported in the literature. VOCs may contribute to sick building syndrome.

III. Estimated Percent of Topic Area Analyzed

X High _____ **Medium** _____ **Low**

IV. Level of Confidence

X High _____ **Medium** _____ **Low**

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Young children, children with asthma, and people with preexisting chronic respiratory disease are at higher risk from the respiratory effects of ETS. Those exposed to known causes of lung cancer (e.g., asbestos and radon) may be at higher cancer risk from ETS. Radon lung cancer risks are highest among smokers. Subgroups potentially susceptible to nitrogen dioxide include those with other preexisting respiratory diseases, with compromised immune function, or both (e.g., infants and young children, people with cystic fibrosis, the elderly). People with preexisting heart disease are most sensitive to carbon monoxide.

B. Highly Exposed Subpopulations

Children whose parents smoke heavily are highly exposed to ETS. The highest levels of radon occur in mountainous areas of the State. Those living in homes with combustion appliances are most exposed to nitrogen dioxide and carbon monoxide. Approximately 1.5 million Californians are exposed to unvented combustion appliances, such as gas stoves and kerosene heaters used for residential heating, and are thus at greater risk from carbon monoxide. African-Americans died from accidential carbon monoxide poisoning at twice the rate as whites on a per capita basis from 1977 to 1988, the last year for which data were analyzed. People who live in mobile homes and new conventional homes are more exposed to formaldehyde. New buildings can have very high levels of volatile compounds.

VI. Comparative Rank

X High _____ **Medium** _____ **Low**

The topic area was given a rank of high. The health effects associated with exposures to radon and environmental tobacco smoke are highest. The health effects and exposures due to other indoor pollutants, especially VOCs, are significant. Theoretical cancer risks estimated for agents demonstrated to be carcinogenic in laboratory studies contributed to the high level of concern. However, the HHC noted that the level of uncertainty associated with the cancer risk estimates is moderately high. Noncancer effects from indoor exposures to particulates, ETS and VOCs can also be significant.

CARBON MONOXIDE

Line Code II-2

I. Definition

Carbon monoxide (CO) is an odorless, colorless, tasteless, nonirritating chemical asphyxiant gas that arises from both mobile, stationary, and residential combustion sources. Acute exposure to a sufficiently high concentration can result in death or permanent injury. Carbon monoxide is the most common cause of death from poisoning in the United States.

II. Human Health Risk Assessment Results

A. Summary of Cancer Risks

No cancer risk is associated with exposure to CO.

B. Summary of Noncancer risks

Indicator Chemical	Health Effect	Size of Population at Risk	Estimated Impact: # of Cases or Exposures above Acceptable Level	Comments
CO	Death by asphyxiation (unintentional)	> 1.5 million	~ 50 deaths/year	Most associated with stationary motor vehicles and heating or cooking appliances
CO	Myocardial ischemia	~ 800,000	~ 300,000	Aggravates preexisting condition, particularly during exercise
CO	Potential reduction in oxygen transport by blood at exposures above air quality standards	30 million	Annually: 16.1 million people experience at least one exceedance of 8-hr CAAQS of 9 ppm; 5.7 million person-hours of exceedance of 1-hr CAAQS of 20 ppm	Ambient monitoring provides incomplete picture of exposures, since it does not indicate potentially higher exposures in cars and homes

III. Estimated Percent of Topic Area Analyzed

X High _____ **Medium** _____ **Low**

IV. Level of Confidence

X High _____ **Medium** _____ **Low**

Risk for the most sensitive populations are well-defined. Morbidity and mortality following acute CO exposures are well-documented and uncertainties are low. The incidence of these adverse effects, however, may be significantly under-reported. Health impact of frequent but minor excursions above air quality standards on healthier segments of population requires further investigation. Substantial variations in carboxyhemoglobin concentrations among individuals complicate assessments of population response to elevated CO levels.

V. POPULATIONS OF CONCERN

A. Identifiable Susceptible/Sensitive Populations

Fetuses (especially those with smoking mothers) and young infants; pregnant women; the elderly; and individuals with: coronary artery disease or congestive heart failure, peripheral vascular or cerebrovascular disease, hematological diseases that affect oxygen-carrying capacity or transport in the blood, and genetically unusual forms of hemoglobin associated with reduced oxygen-carrying capacity. Individuals exposed to other toxicants (e.g., alcohol) and individuals who have not adapted to high altitude are also susceptible.

B. Highly Exposed Subpopulations

Individuals operating motor vehicles with leaky exhaust systems, living in homes with unvented gas appliances for heating and cooking, or inhaling products of combustion from smoke (e.g., in house fires) are highly exposed. Individuals working in occupations exposed to high CO concentrations, including but not limited to those associated with transportation (e.g., auto mechanics, road work repair crews, parking garage and gas station attendants, and police) and industrial processes (e.g., steel production and petroleum refining) have high exposures.

VI. Comparative Rank

_____ **High** **X** **Medium** _____ **Low**

Medium because CO is the single environmental stressor associated with greatest number of observed unintentional deaths, CO contributes to the loss of thousands of days of normal activity annually, and CO can seriously aggravate adverse health effects in individuals with angina or cardiovascular disease. Higher mortality risks are associated with indoor exposures. Lower health risks associated with outdoor exposures because impact of lower ambient CO concentrations is generally less severe.

ENVIRONMENTAL TOBACCO SMOKE

Line Code II-3

I. Definition

Environmental tobacco smoke (ETS) is a mixture of several thousand substances, many of which are carcinogenic or otherwise toxic in humans. Environmental tobacco smoke is a frequent contaminant of indoor air in residences and many public settings. The similarities between ETS and tobacco smoke exposures experienced by active smokers suggests that the recognized health problems experienced by smokers can be shared by non-smokers who are exposed to ETS. Current epidemiological studies support this for many, but not all, active smoking-related health effects.

II. Human Health Risk Assessment Results

A. Summary of Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population.	Estimated Annual Cancer Cases
ETS	A	2 in 100,000	9 million	200/year

B. Summary of Noncancer Risks

Indicator Chemical	Health Effect	Size of Population at Risk	Estimated Impact: # of cases or exposures above threshold	Comments
ETS	Exacerbated asthma in children Lower respiratory infections (LRI)	250,000-650,000 asthmatic children 675,000 children under age 18 months	50,000-130,000 asthmatic children exposed to ETS 10,000-18,000 LRIs in children exposed to smoking parents	ETS exposure exacerbates asthma in 20 percent of affected children ETS exposure associated with 20-30 percent of incidence of LRI

III. Estimated Percent of Topic Area Analyzed

_____ High **_X_ Medium** **_____ Low**

Environmental tobacco smoke exposure may have potential impacts on several significant health effects that have not been quantitatively addressed in this analysis. These include potential contributions to cardiovascular disease and various types of respiratory illness in adults.

IV. Level of Confidence

X High _____ **Medium** _____ **Low**

Similarities between ETS and tobacco smoke received by active smokers would suggest that nonsmokers would be subject to the same health problems as active smokers, although with a lower prevalence due to smaller exposures. Relatively conclusive epidemiological evidence for some major impacts on health (lung cancer and childhood respiratory illness), but not for other health effects. The causal association between ETS and cardiovascular disease is not conclusive. Similarly, there is limited evidence that ETS can be associated with nonrespiratory cancers. If the lack of conclusiveness is a result of the insensitivity of epidemiological studies to detect subtle defects in study populations, the "true" impact of ETS on an exposed population would be underestimated, since this risk characterization is based only on health endpoints which have been clearly linked to ETS exposures.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Young children, children with asthma, developing fetuses, people with preexisting chronic respiratory disease, and those exposed to known causes of lung cancer (e.g., asbestos or radon).

B. Highly Exposed Subpopulations

Children of heavy smoking parents.

VI. Comparative Rank

X High _____ **Medium** _____ **Low**

High because about 200 lung cancer deaths per year can be attributed to ETS exposure and coincident exposures to children may be associated with tens of thousands of additional cases of lower respiratory illness. Possible contributions to other adverse health impacts also significant.

OZONE DEPLETORS

Line Code II-4

I. Definition

The stratospheric "ozone layer" prevents potentially harmful ultraviolet radiation (UV-B) from reaching the earth's surface. A number of chemicals released during industrial processes and from consumer products accumulate in the stratosphere and contribute to the catalytic destruction of ozone. Such chemicals are termed "ozone depletors." Stratospheric ozone at the latitude of the United States has already declined significantly, by about five percent in the winter and spring months and by about two percent in summer (Stolarski *et al*., 1992). As stratospheric ozone concentrations decrease, the amount of harmful UV-B radiation reaching the earth's surface increases. For every one percent decrease in stratospheric ozone, biologically effective ultraviolet radiation could increase by one and one-half to three percent (Urbach, 1987). UV-B radiation damages genetic material and increasing exposures could have significant impacts on human, plant, and animal health.

II. Human Health Risk Assessment Results

No methods are currently available for quantitatively estimating the human health impacts of ozone depletion on California, primarily because regional estimates of increased UV-B radiation are unavailable for our latitude (32Á to 42Á N). Dose-response data are available to estimate potential increases in non-melanoma and melanoma skin cancer incidence and mortality, but results depend completely upon assumptions made about how much ground level UV-B radiation will increase. The following discussion of potential health impacts in California is based on general studies of the impact of ozone depletion on the United States and the world.

A. Summary of Cancer Risks

The U.S. Environmental Protection Agency has developed a range of estimates of future cancer incidence for the American population alive today as well as for generations born before 2074. Among the population alive today, U.S. EPA estimates that between 1985 and 2074 there will be about one million additional non-melanoma skin cancer cases attributable to stratospheric ozone depletion (resulting in 16,500 deaths) and about 12,000 additional malignant melanoma cases (resulting in about 4,000 deaths). Apportioning these cases to California on the basis of the state's percentage of national population (15 percent), stratospheric ozone depletion may be associated with 150,000 additional non-melanoma skin cancer cases (resulting in about 2,500 deaths) and around 1,800 additional malignant melanoma cases (resulting in about 600 deaths) between 1985 and 2074. This is equivalent to about 2,000 additional non-melanoma skin cancer cases and about 50 additional deaths per year.

B. Summary of Noncancer Risks

The U.S. Environmental Protection Agency has also estimated the number of additional cataract cases that could occur with different degrees of ozone depletion. Among the population alive today, U.S. EPA estimates that between 100,000 and 3,200,000 additional cases of senile cataract could occur, depending on whether stratospheric ozone is reduced by as little as one percent or as much as 50

percent. California's share of these cases could range between 15,000 and 480,000 among people alive today.

A significant indirect consequence of ozone depletion may involve increased human exposure to criteria air pollutants in urban areas of California. Since decreasing stratospheric ozone allows UV radiation to penetrate deeper into the earth's atmosphere, ground level concentrations of pollutants formed by interaction with UV radiation will increase. To the extent that tropospheric air pollution increases, there will be increased incidence of the adverse respiratory and circulatory system impacts associated with smog.

C. Summary of Risk Characterization

Stratospheric ozone depletion may result in increased ultraviolet radiation exposure in California, which would have a substantial impact on both benign and malignant skin cancer rates in California by the middle of the next century. Incidence and mortality rates for these cancers, which have risen substantially over the past two decades due to a variety of factors, could increase by an additional 5 to 35 percent. Additional adverse impacts on the eye, such as increased incidence of cataracts and retinal degeneration, are also expected to accompany increased UV radiation exposure. At present, however, the extent of UV radiation increases at California latitudes is impossible to predict with any confidence. Significant human health impacts are much more likely at higher latitudes of the Southern Hemisphere, where observed total ozone depletions have been large.

III. Estimated Percent of Topic Area Analyzed

_X_ High **_____ Medium** **_____ Low**

IV. Level of Confidence

_____ High **_____ Medium** **_X_ Low**

Considerable uncertainty surrounds any quantitative estimates of the impact of ozone depletion on the California population, due primarily to the lack of region-specific data on the increase in UV-B radiation occurring as a result of ozone depletion. There are also large quantitative uncertainties about the future emissions of CFCs and other trace gases. Additional uncertainties involve the dose-response relationships between increased UV-B exposure and skin cancer, particularly for malignant melanoma.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Individuals with lightly pigmented skin are likely to be more susceptible to increases in damaging UV radiation.

B. Highly Exposed Subpopulations

Individuals who spend considerable time outdoors during work or recreation.

VI. Comparative Rank

Insufficient Evidence to Categorize

Known role of enhanced UV radiation in causing skin cancers and cataracts is grounds for concern about public health impact, but future impacts in California are speculative at present because extent and timing of increases in UV flux at state latitudes are impossible to predict. Medium priority for future research to characterize possible increases in UV exposure.

GREENHOUSE GASES

Line Code II-5

I. Definition

Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxides (NO_2), and chlorofluorocarbons (CFCs). Increases in the anthropogenic emissions of these gases have been linked to a projected increase in global temperatures. The primary greenhouse gas is CO_2. The California Energy Commission has estimated that average temperatures in this state could increase by as much as 5.4ÁF. Such an increase could directly and indirectly affect human health in California (CEC, 1991). Increased temperatures could affect water supplies, flooding patterns, and wetlands, electricity demand and supply, agricultural practices and supplies, forest growth patterns and susceptibility to natural environmental hazards, endangered species habitats, outdoor recreation, air quality, and human health. The likely rise in sea level could have a substantial impact in California, because of the concentrated populations at the coast.

II. Human Health Risk Assessment Results

Significant human health impacts may be associated with global warming, due to the direct impacts of temperature on human morbidity and mortality, the indirect impacts of temperature on air pollution levels, and the indirect impacts of climate change on disease vectors.

A. Summary of Cancer Risks

None identified.

B. Summary of Noncancer Risks

There is a well-documented association between weather and mortality, with evidence suggesting that individuals with compromised circulatory (Kalkstein, 1991) or respiratory (Longstreth, 1991) systems are at high risk of premature death. Individuals with coronary heart disease and cerebrovascular disease (stroke) are particularly susceptible to heat stress, and would be the most severely affected by the increasing temperatures associated with global warming. One study has estimated that the number of excess deaths in California could exceed 2,000 per year statewide among those at greatest risk.

Global climate change may adversely affect regional air pollution levels because of higher temperatures, increased ultraviolet radiation (due to stratospheric ozone depletion), and possible changes in precipitation and wind patterns. The magnitude of these effects on current criteria air pollutant levels in California cities is not known.

Global warming may also affect the transmission of vector-borne diseases (Shope, 1991). At present, such diseases are not a major public health problem in the United States or in California. This is due to effective vector control programs and adequate hygienic practices. Global warming could result in conditions more favorable to the spread of vectors.

C. Summary of Risk Characterization

The health risks associated with global warming are largely speculative at present because of the absence of information about how regional temperatures or precipitation might change. All California

residents will be exposed to increased temperatures, but the extent of adverse health impacts from this change is currently unknown. There could be a significant increase in premature mortality due to the impact of heat stress on those with compromised circulatory or respiratory systems. Some populations will also be exposed to various secondary effects of global warming, including increased exposures to allergens and disease vectors, increased levels of smog, and forced migrations due to sea level rise.

III. Estimated Percent of Topic Area Analyzed

_____ **High** __X__ **Medium** _____ **Low**

IV. Level of Confidence

_____ **High** _____ **Medium** __X__ **Low**

While there is scientific consensus that global mean temperatures will increase as a consequence of increasing atmospheric concentrations of greenhouse gases, substantial uncertainties surround any effort to predict regional impacts on ground level temperatures and weather patterns. At present, information about changes in the climatic parameters associated with global warming (temperature, precipitation) is generated by computer models, which cannot provide useful regional predictions. The grids used for computer models are usually several hundred kilometers square, far too large to estimate changes in micro climates within California. Finally, little data exists on the human health impacts of global warming.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

B. Highly Exposed Subpopulations

VI. Comparative Rank

Insufficient Evidence to Categorize

No current health impacts attributable to global climate change. Anticipated impacts are largely secondary, through interaction of temperature with atmospheric pollution formation and disease vector ranges. The most severe impacts will probably be associated with aggravation of heat stress induced premature mortality, particularly among the sick and elderly. The extent to which this will occur in California is currently unknown.

INORGANICS

Line Code II-6

I. Definition

Inorganic chemicals not covered as items on the environmental stressors list are addressed in this topic area.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary Table: Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Annual Cancer Cases	Risk Distrib. # > 10^{-4}	Comments
Arsenic Groundwater	A	> 10^{-2} > 10^{-3} > 10^{-4}	30,000 - 200,000? 100,000-1 million? 1 - 10 million?	200 - 2,000?	1 - 10 million	Exposure to contaminated groundwater widespread but poorly characterized
Cadmium Ambient air	B1	5 x 10^{-6}	30 million	2	a	See write-up for Topic Area I-10
Chromium (hexavalent) Ambient air	A	4 x 10^{-5}	30 million	18	a	See write-up for Topic Area I-10

[a] Emitting facilities have been identified where theoretical lifetime risks estimated for the maximally exposed individual exceed 1 x 10^{-4}/life for hexavalent chromium. There was insufficient information for extrapolating estimates to other facilities in California, or for determining whether risks to some populations near cadmium emitting facilities exceed 10^{-4}/life.

B. Summary Table: Noncancer Risks

Indicator Chemical	Health Effect	Hazard Index	Size of Population	Cases per year or Exposures above Acceptable Level	Comments

Arsenic	hyperpigmentation, keratosis and possible vascular complications	> 1	> 50,000	Extent of exposure to those on private systems or wells unknown.	Only some of the more highly exposed populations accounted for here.

III. Estimated Percent of Topic Area Analyzed

_____High **_____Medium** **_____X____Low**

IV. Level of Confidence

_____X____High **_____Medium** **_____Low**

V. Populations of Concern

Highly Exposed Subpopulations

Those living in living in areas with high arsenic levels in tap water (primarily due to geochemical contamination of groundwater).

VI. Comparative Rank

_____X____High **_____Medium** **_____Low**

LEAD

Line Code II-7

I. Definition

Lead is an ubiquitous and persistent metal, found in virtually all media that people directly contact, including air, water, soil, dust, and food. During the last century, over one billion pounds of lead have been dispersed into the California environment. It has been widely used in industrial products, including paint and gasoline, resulting in contamination in many residential and occupational settings. Lead exposure in children occurs largely as a result of ingestion of lead-contaminated soil and house dust, and poses neurological risks. Lead exposure in adults currently occurs primarily in occupational environments, and poses cardiovascular, renal, neurological, and reproductive risks.

II. Human Health Risk Assessment Results

A. Summary of Cancer Risks

Lead compounds are considered probable human carcinogens. Cancer risks due to ambient air exposures to lead were not estimated because of the substantial declines in outdoor lead concentrations that have occurred since use of lead in gasoline was phased out.

B. Summary of Noncancer risks

Indicator Chemical	Health Effect	Size of Population at Risk	Estimated Impact: # of Cases or Exposures above Acceptable Level
Lead	At high exposures (>25 µg/dL): Neurotoxicity, cardiovascular toxicity, reproductive toxicity, nephrotoxicity	~ 200,000 adults in lead industries ~ 450,000 children in pre-1950 homes with lead paint	~ 1,000 cases of high adult blood lead reported annually (likely underestimate) ~ 500 cases of high child blood lead reported annually (likely underestimate)
Lead	At lower exposures (10-25 µg/dL): Children - neurotoxicity, reduced IQ, low birthweight No apparent threshold: subclinical effects likely below 10 µg/dL Adults - increased blood pressure, exacerbates cardiovascular diseases	2.7 million children under age of six; some older children in high exposure settings	Several hundred thousand children under 6 may have blood lead levels exceeding 10 µg/dL. ~ 20-60,000 of these may have blood levels exceeding 20 µg/dL

III. Estimated Percent of Topic Area Analyzed

X High _____ **Medium** _____ **Low**

IV. Level of Confidence

_____ **High** **X Medium** _____ **Low**

Adverse health effects of high dose lead exposures are well-documented with extensive toxicological and epidemiological data. Impact of moderate blood lead levels in children on neurological development and intelligence supported by numerous epidemiological studies. Recent studies indicate that there is no apparent threshold for lead's adverse neurological effects, although the severity of effects at low doses (< 10 µg/dL) remain the subject of debate. Moderate level of confidence in exposure estimation, because lead is only stressor for which there is extensive monitoring in the population. Extrapolating results from studied populations to the entire California population of children is complicated by bias in existing sampling programs towards high-risk groups.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

All individuals are susceptible to adverse effects of lead. Preschool-age children, fetuses, pregnant and lactating women are particularly sensitive to neurotoxic and developmental effects of low level lead exposure. Children with inadequate nutrition (particularly for calcium, iron, and other minerals) are particularly sensitive due to increased lead absorption and retention.

B. Highly Exposed Subpopulations

Highest exposures in general population occur among children in low-income families, particularly if living in older housing stock near major transportation corridors. Children with pica (habit of eating dirt or dust) can experience very high exposures. Adults can be exposed to lead at very high levels occupationally, particularly in lead industries with poor exposure controls.

VI. Comparative Rank

_____ **High** **X Medium** _____ **Low**

Medium impact in the general population, because toxicological significance of very low blood lead levels is uncertain. Considerable debate in the HHC about general rank for lead, with a minority maintaining that general impact was high. **High** impact on poor children in older housing stock or in lead-contaminated inner city areas. Several tens of thousands of children under 6 have blood lead levels that are likely to exceed 20 µg/dL. **High** impact occupationally, as several thousand adults are identified annually as lead poisoned due to workplace exposures.

MICROBIOLOGICAL CONTAMINANTS

Line Code II-8

I. Definition

This topic area covers a variety of microorganisms that can cause human disease (e.g., cyst-forming protozoans that cause giardiasis and cryptosporidiosis). Due to resource limitations, we have addressed only waterborne microbiological contaminants, excluding airborne agents (such as tuberculosis) or agents transmitted through contact with contaminated blood (such as HIV). Human exposure to microbial agents in water may result from contamination of drinking water with human waste, body contact with contaminated water, and consumption of contaminated shell fish or irrigated agricultural crops. There is a wide taxonomic range of agents that can pose health risks, including viruses, bacteria, protozoa, and helminths. Some of these agents cause gastroenteritis, others are associated with meningitis, upper respiratory tract infections, and encephalitis.

II. Human Health Risk Assessment Results

A. Summary of Cancer Risks

Waterborne enteric agents in California have not been shown to be directly or indirectly associated with cancer.

B. Summary of Noncancer Risks

It is not possible to quantitatively characterize the extent of illness associated with most exposures to microbiological agents in California, although there is sufficient evidence to indicate that they contribute to a low level endemic incidence of gastroenteritis in the general population. The annual risk of enteric illness has been estimated at between 1 per 1,000 to 1 per 100 people (with a significant percentage of these illnesses to waterborne exposures). The greatest risk is experienced by the elderly population, which is more susceptible to mortality associated with diarrhea. Illness surveillance data are available for relatively few diseases. Approximately 40,000 cases of disease associated with fecal transmitted agents are reported annually in California, but very few are attributed to waterborne transmission (most are due to food handlers or close personal contact with an infected person). No waterborne enteric pathogen outbreaks have been reported in communities relying on large public water systems in California in recent years, although there have been smaller outbreaks (<100 cases of diarrhea) in rural communities with contaminated surface water supplies. The most serious water-related microbiological disease in California is Legionnaire's disease, which results from inhalation of aerosolized bacteria that grow in contaminated cooling system water. Approximately 50 to 100 cases are reported in California annually, with the most severe outcomes occurring in individuals with compromised immune systems.

Most microbiological agents of concern have pathogenic and non-pathogenic strains, with different minimum infecting doses, tolerances for environmental conditions, and susceptibilities to water or sewage treatment processes. Acceptable doses or dose-response information are generally unavailable for use in evaluating the significance of observed concentrations of microbiological agents in drinking water supplies. Sampling of surface water supplies used by the Metropolitan Water District and the State Water Project indicate regular contamination by low levels of *Giardia*, *Cryptosporidium* , and enteric viruses, although concentrations are generally substantially lower than in other parts of the

United States. Such agents are also regularly detected in finished drinking water, although at still lower concentrations.

Estimates of the risk of acquiring a disease through water contact recreation are controversial because of the lack of dose-response and exposure data. A study of Santa Monica Bay estimated the risk of contracting acute gastroenteritis from swimming in contaminated coastal waters as between 0 and 12 cases per 1,000 persons exposed. The extent of this problem along the California coast is difficult to determine, because sewage spills from treatment works were not required to be reported to a central agency until 1993.

III. Estimated Percent of Topic Area Analyzed

_____ **High** __X__ **Medium** _____ **Low**

Most significant waterborne pathogenic agents have been identified and most of the serious fecally transmitted diseases are reportable in California, indicating that a substantial portion of health problems associated with waterborne agents can be evaluated. The significance of low level drinking water exposures to the incidence of endemic gastroenteritis is difficult to determine, but the social costs of these so-called "mild illnesses" can be substantial.

IV. Level of Confidence

_____ **High** __X__ **Medium** _____ **Low**

While concentration and dose-response data are unavailable for most microbiological agents, confidence is medium because both treatment systems and illness surveillance systems limit the probability that there is a serious, widespread illness burden associated with exposures to contaminated water. The few common source outbreaks of gastrointestinal disease associated with drinking water contamination or reported sewage spills have been detected relatively quickly and sources identified (usually a failure of mechanical treatment systems). However, presence of low levels of numerous microbiological agents in finished water supplies and the difficulties of estimating gastroenteritis cases and identifying their causes indicate a need for further research in this area.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Certain individuals have lower thresholds of tolerance for enteric viruses, and can be at increased risk of recurring illnesses when exposed to contaminated drinking water. Individuals with compromised immune systems (due to diseases like HIV or immunosuppressive therapy) may also be more susceptible to opportunistic pathogens contracted through the water supply. The two common infections that are most often fatal to AIDS patients, however, are pneumocystosis and toxoplasmosis, neither of which is waterborne.

B. Highly Exposed Subpopulations

Highest exposures occur through less regulated small water systems or private wells which have been contaminated by improper sewage disposal (generally leaking septic systems) or natural or agricultural wastes. High exposures can also result from regular consumption of contaminated shell fish.

VI. Comparative Rank

_____ High **_X_ Medium** **_____ Low**

Medium because of extensive population exposure to low levels of waterborne agents that may contribute to the incidence of endemic gastroenteritis.

VOLATILE ORGANICS

Line Code II-12

I. Definition

A number of volatile organic substances have been evaluated as indicator chemicals for Water (I-1 to I-4) and Air (I-10 to I-12) topic areas on the list I. In addition, exposure to volatile organics occurs at several of the indicator sites used in characterizing inactive and active hazardous waste facilities (topic areas I-6 and I-7). Exposure to volatile by-products resulting from chlorinating drinking water are also considered.

II. Human Health Risk Assessment Results for Indicator Chemicals And Indicator Sites

A. Summary Table: Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Cancer Cases (per year)	Risk Distribution # > 10^{-4}	Comments
Acetaldehyde: Ambient Air	B2	9.2×10^{-6}	30 million	4		b
Benzene:	A					b
Ambient Air		2.4×10^{-4}	30 million	100	large[a]	
Indoor Air		1.6×10^{-4}	30 million	68	large	
Tap Water		8×10^{-6}	30 million	<1		
1,3-Butadiene:	B2					b
Ambient Air		1.4×10^{-4}	30 million	60	large	
Indoor Air		1.2×10^{-4}	30 million	51	13 million	
Carbon tetrachloride: Groundwater	B2	4×10^{-5}	> 191,000	<1	>15,000	b
Chloroform:	B2					b
Ambient Air		8×10^{-7}	È 0	<1	È 0[a]	
Indoor Air		6.1×10^{-6}	30 million	3	640,000	
Tap Water		1.1×10^{-4}	20 - 30 million	30 - 50	7 - 9 million	
1,2-Dibromo-3-chloropropane: Groundwater	B2	1×10^{-4}	> 236,000	< 1	>63,000	b

a Emitting facilities have been identified where theoretical lifetime risks estimated for the maximally exposed individual exceed 1×10^{-4}/life for benzene, chloroform, methylene chloride, and tetrachloroethylene. This information was not included in the analysis used to produce this table. There was insufficient information for extrapolating estimates to other facilities in California.

b Cancer potency and risk estimates are inherently uncertain. For a discussion, see the caveat/uncertainty section of the report.

A. Summary Table: Theoretical Cancer Risks (continued)

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Cancer Cases (per year)	Risk Distri-bution # > 10^{-4}	Comments
p-Dichlorobenzene: Indoor Air	B2/C	3.1×10^{-4}	30 million	133	15 million	b
Formaldehyde: Ambient Air	B1	3.2×10^{-5}	30 million	14	large	b
Indoor Air		3.1×10^{-4}	30 million	124	29 million	
Methylene chloride	B2	5.6×10^{-6}	30 million	2	small[a]	b
Styrene: Ambient Air	c	9.6×10^{-7}	30 million	<1	negligible	b
Indoor Air		8.8×10^{-7}	30 million	<1	negligible	
Tetrachloroethylene Groundwater	B2/C	1.9×10^{-5}	> 773,000	<1	>21,500	b
Ambient Air		1.5×10^{-5}	30 million	6	negligible[a]	
Indoor Air		1.6×10^{-5}	30 million	7	183,000	
Trichloroethylene: Ambient Air	B2	2.3×10^{-6}	30 million	<1	negligible	b
Indoor Air		1.4×10^{-6}	30 million	<1	negligible	
Volatile Organics at Hazardous Waste Facilities (I-6; I-7)		6×10^{-4} to 6×10^{-8}	0 - 3 million	0 - 26	uncertain	b

[c] U.S. EPA classification not available. Classified by the International Agency for Research on Cancer as a 2B carcinogen.

III. Estimated Percent of Topic Area Analyzed

_____High ____X___Medium _____Low

IV. Summary Evaluation of Evidence

_____High ____X___Medium _____Low

V. Populations of Concern

Highly Exposed Subpopulations

Those drinking highly contaminted drinking water, living near hazardous waste sites, and using consumer products emitting substantial levels of volatile organics (e.g., moth balls).

VI. Comparative Rank

__X_High **_____Medium** **_____Low**

PERSISTENT/BIOACCUMULATIVE ORGANICS

Line Code II-13

I. Definition

This topic area covers persistent organic compounds not assessed in other items (e.g., particulate matter) on the environmental stressor list.

II. Human Health Risk Assessment Results for Indicator Chemicals

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Annual Cancer Cases	Risk Distrib. # > 10^{-4}	Comments
DDT	B2	1/1,000	10,000	<1	10,000	High exposures from ingesting contaminated fish
PCBs	B2	1/1,000	10,000	<1	10,000	High exposures from ingesting contaminated fish
Dioxin Equivalents	B2	10^{-4} - 10^{-5}	30 million	200-2,000	30 million	

III. Estimated Percent of Topic Area Analyzed

_____**High** __X__**Medium** _____**Low**

IV. Level of Confidence

_____**High** __X__**Medium** _____**Low**

V. Populations of Concern

A. Highly Exposed Subpopulations

B. Subsistence and sport fishers.

VI. Comparative Rank

__X__**High** _____**Medium** _____**Low**

OZONE

Line Code II-15

I. Definition

Ozone is a colorless gas which occurs naturally in the upper atmosphere and at trace quantities in the lower atmosphere at ground level. Ozone forms as a result of photochemical reactions involving volatile organic compounds and nitrogen oxides, reaching elevated levels in many urban areas where there are major mobile and stationary sources of these precursors. As ozone concentrations increase above acceptable levels, people experience increasingly severe respiratory symptoms.

II. Human Health Risk Assessment Results

A. Summary of Cancer Risks

Ozone has not been identified as an animal or human carcinogen by any authoritative scientific body, although under some test conditions ozone exposure has caused tumors in laboratory animals. Potential cancer risks could not be assessed.

B. Summary of Noncancer risks

Indicator Chemical	Health Effect	Estimated Impact: # of Cases or Exposures above Acceptable Level	Comments
Ozone	Potential respiratory symptoms at exposures above air quality standards	26 million people experience one or more days/year above CAAQS of 0.09 ppm; 4 million experience more than 150 hours per year above NAAQS of 0.12 ppm	
Ozone	Exacerbation of asthma	180-880,000 added attacks/year	Debate over methods predicting adverse impacts at different ozone levels
Ozone	Premature mortality in individuals with respiratory illness	~ 100 premature deaths/year	Occurring in susceptible population only

III. Estimated Percent of Topic Area Analyzed

X High _____ **Medium** _____ **Low**

IV. Level of Confidence

X High _____ **Medium** _____ **Low**

Confidence in data indicating health impacts are high due to the number of controlled clinical studies on human subjects and observed patterns of respiratory symptoms and illnesses during ozone episodes. Confidence in methods used to produce quantitative estimates of illness burdens as a result of California exposures above air quality standards is medium, as there remains extensive debate about appropriate dose-response models and the interpretation of results. Considerable uncertainties surround presumption that no major chronic health impacts (e.g., depletion of lung function with age, or cancer) are associated with current levels of exposure.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Individuals with a preexisting reduced pulmonary function, such as bronchitis or emphysema.

B. Highly Exposed Subpopulations

Individuals working or exercising in areas with high ozone concentrations.

VI. Comparative Rank

X High _____ **Medium** _____ **Low**

High because there are extensive population exposures to ozone in California, associated with a wide variety of health impacts that range from minor decrements in lung function or respiratory irritation to serious aggravation of asthma or other respiratory illnesses. The most serious illness burden occurs in those with already compromised respiratory systems.

PARTICULATE MATTER

Line Code II-16

I. Definition

Particulate matter comprises a broad range of materials, including solids and aerosols of natural and anthropogenic origin. Particulates with an aerodynamic diameter of less than 10 microns (referred to as PM10) are the principal public health concern, because larger particles are not considered respirable in humans. PM10 is composed of materials which elicit toxicity through chemical interactions with cellular components and materials which are chemically inert but result in an adverse health response.

Natural sources of PM10 include wind-blown soil, pollen, and combustion products from naturally occurring forest fires. Anthropogenic sources of outdoor PM10 include mobile source exhaust, fugitive dust from roadways, construction or agricultural activities, wood smoke and chemical particles such SO4.

II. Human Health Risk Assessment Results

A. Summary of Cancer Risks

Components of some types of PM10 may be carcinogenic (e.g., diesel exhaust), but PM10 as a complex mixture is not generally considered carcinogenic. Any cancer risk associated with exposures to PM10 is not currently quantifiable. Cancer risks associated with diesel exhaust and polycyclic aromatic compounds are assessed separately in topic areas I- 10-12.

B. Summary of Noncancer risks

Indicator Chemical	Health Effect	Size of Population at Risk	Estimated Impact: # of Cases or Exposures above Acceptable Level	Comments
PM10	Exacerbation of respiratory diseases and decrements in lung function at exposures above air quality standard	30 million	28 percent of potential person-days of exposure annually exceed CAAQS of 50 µg/m3	
PM10	Increased incidence of lower respiratory illness in children		~ 70-200,000 additional illness incidents	Debate over methods predicting adverse impacts at different PM 10 levels
PM10	Premature mortality in individuals with respiratory illnesses		~ 1,000 premature deaths/year	Occurring in susceptible populations only

III. Estimated Percent of Topic Area Analyzed

_____ **High** ___X___ **Medium** _____ **Low**

IV. Level of Confidence

_____ **High** ___X___ **Medium** _____ **Low**

The level of confidence that exposure to PM10 can result in human health impairment is high. Confidence in the quantitative dose response estimates of mortality and morbidity associated with increases in PM10 is low to moderate. It is not known whether the mortality and morbidity associated with PM10 exposure in the cited studies is a general property of all particulate components or is associated with one or more constituents which may be present to varying degrees in different locations. Epidemiology studies of the health effects of PM10 to date have focused on urban areas where the composition of particulate matter may be very different than in predominantly agricultural areas or areas where the particulates are primarily wood smoke or dry lake dust. Mortality estimates relate only to acute exposures; level of confidence in coverage and assessment of chronic effects of PM10 exposure is low.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Individuals with either undeveloped (infants) or compromised respiratory function (older adults, individuals with preexisting conditions like asthma, emphysema, or chronic obstructive pulmonary disease).

B. Highly Exposed Subpopulations

Populations exposed to fugitive dust in agricultural regions (e.g., Sacramento Valley and San Joaquin Valley air basins); to wood smoke (e.g., the Lake Tahoe and Mammoth Lakes), and in urban areas (e.g., the South Coast and San Francisco Bay Area air basins). Homes with malfunctioning heating systems or cigarette smokers generally have higher than average PM10 levels.

VI. Comparative Rank

___X___ **High** _____ **Medium** _____ **Low**

High because of substantial percentage of total population's potential exposure time that exceeds air quality standard. Although there are significant uncertainties about the size of sensitive populations and estimated morbidity and mortality impacts, potential impacts are larger and more severe than any other assessed stressor.

AGRICULTURAL USE OF PESTICIDES

Line Code II-17

I. Definition

Topic area II-17 includes the health risks associated with chemical exposures via agricultural pesticide application, including run-off and drift, and pesticide residues in foods. Health impacts include occupational illnesses among farm workers, risks to the general public from exposure to pesticide drift in ambient air or consumption of contaminated drinking water, and risks to consumers from dietary residue exposure. Over 150 million pounds of pesticides are used annually in California for agricultural purposes.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Summary of Theoretical Cancer Risks

The following tables summarize theoretical cancer risks greater than 1 in 100,000 due to dietary or occupational exposures to pesticides considered probable (B2) human carcinogens.

General Public -- Dietary Exposures

Indicator Chemical	Weight of Evidence	Size of Exposed Population	Estimated Annual Cancer Cases	Average Individual Risk	Comments
DDT	B2	30 million	2	4 in 1,000,000	Adult female diet
Mancozeb	B2	30 million	133	3 in 10,000 7 in 10,000	Average adult diet Average child's diet
Maneb	B2	30 million	21	5 in 100,000 1 in 10,000	Average adult's diet Average child's diet
Propargite	B2	30 million	7	2 in 100,000	Average adult's diet

Farm Workers -- Occupational Exposures

Indicator Chemical	Weight of Evidence	Average Individual Risk	Comments
Captan	B2	4 in 10,000 8 in 100,000	Mixer/loader/applicator Field worker
Chlorothalonil	B2	1 in 1,000 2 in 10,000 2 in 10,000	Mixer/loader/applicator Field worker Flagger
Mancozeb	B2	6 in 10,000 3 in 10,000	Mixer/loader/applicator Field worker

For the average consumer, estimated dietary intakes of several indicator pesticides pose added cancer risks greater than one in one hundred thousand. Occupational risks can be substantially higher.

Assuming the entire California population is exposed to pesticides through the food supply, the theoretical annual cancer burden associated with average adult dietary intakes of seven indicator pesticides is approximately 200 added cases per year. It is not possible to estimate incidence due to occupational exposures because the size of the population at risk is unknown.

B. Selected Noncancer Risks

General Public -- Dietary Exposures

Indicator Chemical	Health Effect	Hazard Index	Comments
Diazinon	Inhibition of cholinesterase	46	Average child's diet for a day (acute exposure)
Mancozeb	Decreased weight gain	2	Average child's diet over time (chronic exposure)

Examples selected are highest hazard indices estimated for average dietary exposures to indicator pesticides. Acute exposures to several other indicator pesticides occasionally exceed acceptable intake levels among high-end consumers of treated foods; chronic exposures exceeding reference doses are less frequent. The risks associated with cumulative exposures to pesticides affecting similar health endpoints have only been assessed for five organophosphates that inhibit cholinesterase. Slightly over one percent of all children experience a cumulative exposure exceeding acceptable intakes on any given day, although the clinical significance of these exposures remains uncertain.

Farm Workers -- Occupational Exposures

Approximately half of the illnesses reported annually to California's Pesticide Illness Surveillance Program (PISP) involve agricultural use of pesticides. There are 800 to 1,000 acute illnesses reported annually among agricultural workers, although this is probably an underestimate of the actual number.

C. Summary of Risk Characterization

Observed illness related to agricultural pesticide use occur predominantly among workers, including both mixer/loader/applicators and field workers. Exposure data indicate that a small proportion of the population (high-end consumers like children) can experience acute exposures that exceed acceptable levels, but the clinical significance of these exposures is not known. Chronic exposures to indicator pesticide residues in the diet could be associated with 200 added cancer cases annually across the California population, and may be associated with some noncancer impacts. Significant acute and chronic health risks can be associated with non-dietary exposures to agricultural pesticides as a result of drift or groundwater contamination, although these relatively high risks are experienced by much smaller populations that those associated with dietary exposure.

III. Estimated Percent of Topic Area Analyzed

_____ **High** _____ **Medium** **X** **Low**

Selected indicator pesticides represent only a small percentage of total pesticide exposure. Theoretical cancer burden estimates, for example, are based on exposures to seven potentially carcinogenic pesticides, while U.S. EPA has identified over 60 agricultural pesticides that are potentially carcinogenic.

IV. Level of Confidence

_____ **High** _____ **Medium** __X__ **Low**

While observed risks to workers are significant and reflected in annual illness reports, it is more difficult to characterize the magnitude or extent of risks to the general public with much confidence. Exposure estimates are based on monitoring data when possible, but many assumptions are often necessary to estimate doses. Adequate toxicology data for many pesticides is often lacking, particularly to characterize acute risks among the most highly exposed. The cumulative contribution of total intake of carcinogenic pesticides to lifetime cancer risks is also poorly characterized. The potential health impacts of multiple, synergistic, or cumulative exposures are not well-characterized, but such exposures occur frequently and may pose a significant health risk. Exposures in rural communities as a result of agricultural applications are largely uncharacterized.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Children may be particularly susceptible to effects from exposures to agricultural pesticides because of their high consumption of particular foods, and their specific vulnerability to certain health effects.

B. Highly Exposed Subpopulations

Farm workers are highly exposed to agricultural pesticides. Certain segments of the general population may be exposed to locally high concentrations of pesticides due to drift or groundwater contamination.

VI. Comparative Rank

A. General Public Exposures

_____ **High** __X__ **Medium** _____ **Low**

A rank of medium is assigned to general public exposures because of extensive population exposure to relatively low levels of pesticides, which may increase cancer risks as a result of chronic exposure and pose noncancer risks of neurotoxicity or reproductive toxicity. Higher potential risks occur among some subpopulations with high intakes (e.g., children or consumers of contaminated groundwater). Rank is not higher because cancer risk estimates are theoretical and the toxicological significance of high hazard indices among high-end consumers remains uncertain.

B. Pesticide Applicators

__X__ **High** _____ **Medium** _____ **Low**

Significant health risks for farm workers are expected based on the annual observed acute illness burden, and relatively high estimates of added lifetime cancer risk.

NONAGRICULTURAL USE OF PESTICIDES

Line Code II-18

I. Definition

Topic area II-18 includes the health risks associated with structural pest control, landscape and right-of-way maintenance, regulatory and public health applications, and home and garden use in institutions and residences. Several hundred million pounds of pesticides are used per year in California for nonagricultural purposes.

II. Human Health Risk Assessment Results for Indicator Chemicals

A. Selected Theoretical Cancer Risks Due to Nonoccupational Exposures

Nonagricultural use of pesticides poses a potentially significant added cancer risk, particularly to applicators and possibly to children.

Indicator Chemical	Weight of Evidence	Average Individual Risk	Comments
Captan	B2	7 in 100,000	Home and garden applicators
Ethylene thiourea (carcinogenic metabolite of mancozeb)	B2	6 in 10,000	Home gardener using compressed air backpack

B. Selected Noncancer Risks Due to Nonoccupational Exposures

A significant number of poisoning incidents are observed annually, particularly among children. Estimated exposures can substantially exceed acceptable doses for noncancer effects.

Indicator Chemical	Health Effect	Hazard Index for Acute Exposures	Comments
Chlorpyrifos	Cholinesterase inhibition	53	Infant exposure 24 hours after use of aerosol fogger in non-ventilated home
Diazinon	Cholinesterase inhibition	199	Coincident exposure after spraying in office building
Triadimefon	Decreased red blood cell count and hemoglobin	100	Coincident exposure to child after turf application

C. Summary of Risk Characterization

Observed illnesses related to most types of nonagricultural pesticide use occur predominantly among applicators. However, available data indicate that residents of treated homes and bystanders in treated public buildings are also at risk for potentially hazardous exposures. Individuals with activity patterns that maximize exposures will be at the highest risks, particularly children.

About 900 cases of acute illness are reported annually in California as associated with nonagricultural use of pesticides. About 70 percent of those cases are due to occupational exposures. That implies that at lease 300 cases of acute pesticide poisoning are occurring annually in California as a result of nonoccupational exposures. This illness burden is probably a substantial underestimate because the State's surveillance system is biased towards identifying occupational illnesses.

III. Estimated Percent of Topic Area Analyzed

_____ **High** _____ **Medium** __X__ **Low**

IV. Level of Confidence

_____ **High** _____ **Medium** __X__ **Low**

While risks to workers appear to be significant, no data are available to characterize the magnitude or extent of risks to the general public with much confidence. We currently lack both exposure and toxicology data for most of the individual pesticides used for nonagricultural purposes, and have virtually no capacity to assess the potential health impacts of multiple, synergistic, or cumulative exposures.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

B. Highly Exposed Subpopulations

Examples of high-risk subpopulations due to high exposures include young children exposed to recently treated surfaces and individuals who spend most of their time indoors in homes subjected to frequent pest control treatment.

VI. Comparative Rank

A. General Public Exposures

_____ **High** __X__ **Medium** _____ **Low**

A rank of medium is assigned to general public exposures because of high risks to children and frequent users, as well as evidence of a regular pattern of illnesses associated with coincident exposures to residential and commercial building pest control.

B. Pesticide Applicators

__X__ **High** _____ **Medium** _____ **Low**

Higher exposures and therefore higher risks are expected for pesticide applicators, particularly untrained workers using pesticides in building maintenance.

RADON

Line Code II-22

I. Definition

Radon[222] is a gas produced by the radioactive decay of radium that occurs naturally in most soils and rock. Although it is found universally in the environment, concentrations in soils vary widely in different parts of California because of geological variation. The products of the radioactive decay of radon, often referred to as "radon daughters," are inhaled and thought to be the principal cause of lung cancer attributed to radon itself. The majority of human risk associated with radon is due to breathing radon daughters which have accumulated in enclosed buildings. Radon emissions from soil and rock generally infiltrate buildings through cracks in the slab foundation, leakage around pipe entryways into the home, and cracks under floorings. Building materials sometimes also act as sources of radon indoors. In addition, exposure can occur directly from tap water when the water source is ground water. In this case, risk is due primarily to inhalation of radon released from water during showering.

II. Human Health Risk Assessment Results

A. Summary of Theoretical Cancer Risks

Indicator Chemical	Weight of Evidence	Average Individual Risk	Size of Exposed Population	Estimated Annual Cancer Cases
Radon	A	3 in 10,000	Nearly all Californians are exposed via soil and rock emissions, at widely varying concentrations 2/3 of population may be exposed to radon via groundwater	1,100 40 - 600

B. Summary of Noncancer Risks

There are no known noncancer effects on humans from low level exposures.

III. Estimated Percent of Topic Area Analyzed

X High _____ **Medium** _____ **Low**

IV. Level of Confidence

X High _____ **Medium** _____ **Low**

Radon has been classified as a known human carcinogen based on extensive data from epidemiological studies evaluating the incidence of lung cancer in miners. Dose-response estimates derived from these studies are complicated by coincident exposures to other carcinogenic substances in the workplace and substantial differences in exposure levels between mines and most homes. Lung

cancer risk estimates due to rock and soil emissions into homes may be marginally overstated because they are based on the national prevalence of smoking, while California's prevalence is lower (in 1990, 22 percent of Californians and 28 percent of the United States population smoked). Risk estimates for tap water exposure accounted for smoking prevalence in California. Medium confidence in California exposure data, which was derived from Statewide surveys of roughly 0.1 percent of the population. Surveys of radon in groundwater drinking sources have evaluated 20 percent of state public systems.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

The population at greatest risk to radon associated lung cancer are smokers (and former smokers, to a lesser extent). This is attributable to the synergistic interaction between smoking and radon in causing lung cancer.

B. Highly Exposed Subpopulations

High exposures are most likely in regions with geologically high radon content, including Santa Barbara, Ventura, and Sierra Nevada foothill counties. Additional contributions to high end exposures come from drinking water sources such as private wells in regions with high radon content.

VI. Comparative Rank

X High _____ **Medium** _____ **Low**

High because of large estimated contribution to annual lung cancer mortality. Individual added cancer risks vary widely across the State and are determined by local geology, housing type, and smoking behavior.

RADIONUCLIDES

Line Code II-24

I. Definition

Radionuclides are important as a source of ionizing radiation. Ionizing radiation possesses sufficient energy to ionize atoms and can damage molecular structures critical to life. The most common forms of radiation (alpha, beta, gamma, and "x") are produced in the radioactive decay of certain atomic nuclei. Ionizing radiation has both anthropogenic and natural sources. Medical x-ray usage is the major source of anthropogenic radiation, but has been excluded from this analysis because evaluating therapeutic and diagnostic procedures is beyond the scope of the CCRP. Radon, the single most important natural source of ionizing radiation exposure, is analyzed separately in topic area II-22. This analysis distinguishes between natural sources of radiation exposure (i.e., from terrestrial and cosmic sources, as well as from radionuclides internal to the human body) and anthropogenic exposures, because they involve significantly different health impacts and vary in their avoidability or controllability. Anthropogenic sources of radiation exposure include emissions of radionuclides during fuel combustion and exposures associated with a variety of consumer products.

II. Human Health Risk Assessment Results

A. Summary of Theoretical Cancer Risks

Ionizing radiation has a direct biologic effect by fragmenting biologically important molecules such as DNA, and an indirect biologic effect by fragmenting molecules such as water, which forms reactive ions or free radicals that can later affect important molecules and tissues. These effects can be somatic (directly affecting the individual) or genetic (heritable alterations). This capacity to damage DNA underlies radiation's ability to induce human cancers. Estimates for excess annual cancer mortality in California due to exposure to natural and anthropogenic sources of ionizing radiation are listed in the table below.

Ionizing Radiation Source		**Size of Exposed Population**	**Estimated Excess Annual Cancer Mortality**
Natural Sources:			
	Cosmic	30 million	647
	Terrestrial	30 million	672
	Internal	30 million	935
Anthropogenic Sources:			
	Combustion emissions, radon emissions from domestic water use, building materials, and consumer products	30 million	240

B. Summary of Noncancer Risks

No data are available to assess noncancer risks associated with radiation exposure. The most serious impact involves the induction of heritable genetic defects, which could result in either increased

incidence of spontaneous abortions or congenital malformations. These effects are not expected at low-level background exposures typical for the general population in California

C. Summary of Risk Characterization

Approximately 2,000 cancer deaths per year are expected as a result of exposure to natural radiation sources, which are largely unavoidable. Only cosmic radiation exposures are within human control to some extent, because substantial fractions of total exposure are accumulated while flying in airplanes. Less than 200 cancer deaths per year are expected as a result of exposure to radionuclides emitted during fuel combustion and to radiation from consumer products (such as building materials), mining, and agricultural products. (A significant percentage of the 240 cases reported in Table A are attributable to radon emissions from domestic water supply, which are ranked separately under topic area II-22.)

III. Estimated Percent of Topic Area Analyzed

X High _____ **Medium** _____ **Low**

Radiation exposures have been relatively thoroughly characterized by the Committee on the Biological Effects of Ionizing Radiation (BEIR), whose work serves as the basis for the risk estimates presented in this analysis.

IV. Level of Confidence

_____ **High** **X Medium** _____ **Low**

Confidence is medium because there are a number of uncertainties that surround the dose-response and exposure data used to estimated cancer incidence. Numerous factors contribute to these uncertainties, including 1) not all tissue targets of radiation are known, 2) biological consequences of a given dose of radiation vary with the linear energy transfer of the radiation, 3) dose and dose rate are important parameters but are seldom measured, and 4) it is difficult to estimate accurately the size of various populations potentially exposed. Significant uncertainty affects characterization of radiation exposure attributable to anthropogenic sources, particularly in exposures due to transport and disposal of radioactive waste materials and exposures associated with the BEIR Committee's "consumer products" category. The contribution of radiation exposures to inherited defects or other adverse health endpoints has not been assessed due to lack of sufficient data.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

None identified.

B. Highly Exposed Subpopulations

Individuals exposed via their occupation are likely to be the most highly exposed. Medical technicians, miners, oil workers, power plant workers, and laboratory workers are all at risk for significant exposures.

VI. Comparative Rank

A. Natural Sources

X High _____ **Medium** _____ **Low**

Approximately 2,000 cancer deaths are predicted to occur annually in California from exposures to natural sources of radiation. These sources are uncontrollable, but some exposures (~ 25 percent associated with cosmic rays) could be minimized.

B. Anthropogenic Sources

_____ **High** _____ **Medium** **X Low**

Less than 200 cancer deaths are predicted to occur annually in California from exposures to anthropogenic sources of radiation, and there are significant uncertainties affecting whether the national data upon which this estimate is based is applicable to California. Radioactive residuals from fuel combustion, for example, are largely associated with coal-fired power plants, which are not prevalent in California.

SO_X AND NO_X

Line Code II-25

I. Definition

Sulfur oxides (SO_x) and nitrogen oxides (NO_x) are produced by combustion processes and are associated with a wide variety of primary and secondary effects on health and the ecosystem. This analysis focuses on the health impacts of nitrogen dioxide exposures in California, because exposures to sulfates are relatively insignificant relative to other parts of the United States where coal is an important fuel for industrial or utility energy production. Nitrogen dioxide is a pollutant commonly present in both indoor and outdoor air. The analysis also focuses on primary effects on health associated with nitrogen dioxide exposures, rather than secondary effects associated with the role of NO_x in the formation of urban smog or acid deposition. The health impacts of ozone are evaluated separately in topic area II-15. Acid deposition alters the chemistry of affected aquatic and terrestrial ecosystems, and can have indirect effects on human health by mobilizing toxic metals into water supplies. These indirect effects are not significant in California because acid deposition problems are geographically restricted to areas in the Sierra or San Bernardino mountains that are not major sources of trace elements for drinking water supplies.

II. Human Health Risk Assessment Results

A. Summary of Cancer Risks

Nitrogen dioxide is not a carcinogen, although NO_x compounds participate in atmospheric reactions in contaminated air sheds to produce a wide variety of nitrogen compounds, some of which are mutagenic and under evaluation to ascertain their carcinogenicity.

B. Summary of Noncancer Risks

Indicator Chemical	Health Effect	Size of Population at Risk	Estimated Impact: # of Cases or Exposures above Acceptable Level
NO_x	Exacerbation of asthma, increased respiratory illness in children at exposures above air quality standards	~ 15 million, including those in urban airsheds with occasional exceedances of CAAQS and those in residences with unvented combustion appliances	~ 6.5 million people annually experience at least one day annually when hourly outdoor concentrations exceed the CAAQS of 0.25 ppm 25-50 percent of all California homes may have indoor concentrations exceeding CAAQS at some time during year

Outdoor concentrations of nitrogen dioxide rarely exceed California's air quality standard, reducing the likelihood of adverse health impacts. Indoor concentrations, however, can reach levels of one ppm in homes where there are unvented combustion appliances, such as gas stoves or space heaters, or malfunctioning appliances such as furnaces. Such low level NO_2 exposures can have adverse impacts on sensitive subpopulations, such as children and asthmatics. Epidemiological studies have indicated an association between indoor exposure to NO_2 and the incidence of respiratory infections in children, but

data are insufficient to estimate a dose-response relationship for observed concentrations in California. Presence of a gas stove in the home appears to increase the risk of respiratory illness in children by approximately 20 percent. Dose-response data are also unavailable to characterize the impact of NO_2 exposures on asthmatics, although it is known that such exposures result in increased bronchial reactivity and decreased lung function.

III. Estimated Percent of Topic Area Analyzed

_____ **High** __X__ **Medium** _____ **Low**

Potential exposures of health impacts of outdoor exposures are relatively well covered, but extent of indoor exposures and possible health consequences for susceptible individuals are the subject of current research.

IV. Level of Confidence

_____ **High** _____ **Medium** __X__ **Low**

Low because of lack of data needed to characterize contribution of NO_2 exposures to incidence of respiratory illness in children and aggravation of respiratory illnesses in adults. Animal and human data indicate that NO_2 can adversely affect respiratory defenses, with potential consequences for immune system controls over infection and cancer metastases. More research is needed to characterize these potentially significant health impacts, given extensive, if occasional, population exposures in indoor environments.

V. Populations of Concern

A. Identifiable Susceptible/Sensitive Populations

Asthmatics and individuals with chronic bronchitis appear to be particularly susceptible to NO_2 impacts, as well as others with preexisting respiratory disease or compromised immune function. Examples of such groups would include infants and young children, people with cystic fibrosis, patients undergoing chemotherapy, people with immune deficiencies, and the elderly. Potentially susceptible subpopulations comprise a significant fraction of the general population.

B. Highly Exposed Subpopulations

Highest exposures occur in homes with unvented or malfunctioning combustion appliances, notably unvented kerosene heaters. Roughly 15 percent of California households are estimated to have gas appliances that produce elevated NO_2 levels.

VI. Comparative Rank

_____ **High** _____ **Medium** __X__ **Low**

Medium risks for some indoor exposures, because of potentially significant contribution to respiratory infections in children and the exacerbation of illnesses in others with preexisting respiratory

diseases. Such exposures occur occasionally in homes relying on frequent use of unvented combustion appliances. **Low** for outdoor exposures, because opportunities for chronic exposures to significant concentrations are unlikely as a result of regulatory controls on emissions. NO_2 remains an important pollutant in the outdoor environment because it is a precursor to ozone, which has a high impact on human health due to ambient exposures.

Ecological Health Committee Appendix

Detail Sheets for Exposure Pathways

GENERAL NOTE

For consistency, exposure pathway numbers are the sequential number originally assigned. Non-sequential numbers indicate exposure pathways which were combined or dropped from the analysis.

Completed detail sheets were not furnished by several workgroups. Draft detail sheets outlining the exposure pathway elements and ranking criteria scoring are included for the unfinished detail sheets.

Complete references for citations are listed in the References.

EXPOSURE PATHWAY #3

Habitat alteration and impacts to vegetation, wildlife, and other organism populations due to resource extraction from forests.

A. Pathway Elements

Agent(s):	Harvest
Stressor:	Physical Alteration and Destruction
Medium:	Biological
Receptor:	Extant old-growth (virgin) forests
Effect:	Destruction of old-growth characteristics

B. Ranking Score (Total Score = 20)

Intensity:	5	Ecosystem level effects - remaining virgin forests of the Coast Range and Sierra Nevada mountains
Extent:	5	50 to 100 percent of the extant old-growth forests
Reversibility:	5	Irreversible within a human life span
Probability:	5	Loss of old-growth characteristics are certain under any resource extraction method

C. References

D. Remaining Data Needs

Analysis of effects of habitat fragmentation and subsequent effects on biodiversity.

Enhanced public awareness of the unique character and value of the old-growth ecosystem to allow informed societal choices between resource preservation and resource utilization.

EXPOSURE PATHWAY #4

Physical alteration and loss of habitat at mineral extraction sites such as mine sites, gravel mining locations, and petroleum, natural gas, or geothermal facilities.

A. Pathway Elements

Agent(s):	Mining Activities; Petroleum, Natural Gas, or Geothermal Development
Stressor:	Physical Alteration and Destruction
Medium:	Land, Water
Receptor:	Extraction Site
Effect:	Removal or alteration of extant ecosystem

B. Ranking Score (Total Score = 12)

Intensity:	3	Effects on populations at the extraction site: pit mines, gravel mining operations, and energy-extraction sites remove or displace vegetation, wildlife, and other fauna
Extent:	1	Less than one percent of the California ecosystem is likely to be used for mineral or energy resource extraction
Reversibility:	3	Revegetation of extraction sites can result in almost immediate reversibility (or at least initial restoration), while gravel extraction from river corridors can irreversibly alter the riparian corridor; score is median for the range
Probability:	5	Effects are confirmed: gravel mining along the Russian River has lowered the stream bed; development of geothermal steam fields has altered habitats

C. References

D. Remaining Data Needs

Overall extent within California is low, but local impacts can be high. The best example is Russian River corridor. Are these alterations fully understood by, and acceptable to, society?

EXPOSURE PATHWAY #5

Increased sedimentation and turbidity in estuaries and freshwater corridors caused by mining or by erosion from timber harvest sites alters the aquatic habitat of those waterways.

A. Pathway Elements

Agent(s):	Harvest and Mining Activities
Stressor:	Physical Alteration
Medium:	Water
Receptor:	Aquatic Ecosystems
Effect:	Increased turbidity decreases water quality and, when combined with increased sedimentation, produces alterations in the habitat suitability of the waterways for aquatic species

B. Ranking Score (Total Score = 14)

Intensity:	3	Population effects: increased sedimentation reduces spawning habitat for salmon and trout
Extent:	4	The collective extent of potentially affected ecosystems includes north coastal rivers as well as the San Francisco Bay estuarine system
Reversibility:	2	If adequate flushing flows in affected stream reaches are present, effects are essentially immediately reversible; a more likely scenario is only occasional scouring
Probability:	5	Effects are confirmed: San Francisco Bay continues to receive sediment originating as erosion and runoff, and Sierra Nevada and Coast Range trout and salmon streams are similar recipients of erosion and runoff

C. References

D. Remaining Data Needs

Better-managed (or implemented) erosion control for timber harvest sites. Better-defined source attribution for sediment loading to San Francisco Bay.

EXPOSURE PATHWAY #7

Toxicity to aquatic organisms in waters receiving drainage from mine sites due to acidity or elevated metal content.

A. Pathway Elements

Agent(s):	Mining Activities or Pre-existing Contamination or Condition
Stressor:	Acid Mine Drainage, Mining Waste
Medium:	Water
Receptor:	Aquatic Ecosystems
Effect:	Overt or covert toxicity to aquatic species

B. Ranking Score (Total Score = 12)

Intensity:	3	Population effects: declining striped bass fishery in Sacramento River might be linked, at least in part, to drainage from Iron Mountain Mine
Extent:	3	Water bodies receiving mine drainage (e.g., San Francisco Bay ecosystem) are a large portion of California aquatic resources
Reversibility:	1	Effects would be reversible if isolation of mine drainage were complete
Probability:	5	Effects confirmed: toxicity to aquatic species resulting from exposure to mine drainage has been demonstrated

C. References

D. Remaining Data Needs

Better defined source attribution: can effects to aquatic species arising from exposure to drainage from Iron Mountain Mine, for example, be partitioned out from other chemical or physical stressors in the affected waterways?

EXPOSURE PATHWAY #9

Clear cutting and deforestation and other physical alteration of upland terrestrial habitats by natural resource extraction practices convert habitat to earlier successional stages or barren land, with subsequent effects on animal populations residing therein.

A. Pathway Elements

Agent(s):	Harvest
Stressor:	Clear cutting and Deforestation; Physical Alteration
Medium:	Land, Biological
Receptor:	Terrestrial Ecosystems
Effect:	Erosion and topsoil loss as contributors in conversion to barren land; disrupted terrestrial communities

B. Ranking Score (Total Score = 10)

Intensity:	3	Population effects: timber harvests remove portions of the resident vegetation populations, thereby altering the habitat suitability for resident animal species
Extent:	1	The extent of un-regulated clear cutting and deforestation is small
Reversibility:	1	Revegetation practices initiate restoration of harvested areas
Probability:	5	While effects of clear cutting are confirmed, this ranking may overstate the threat due to the limited extent of un-regulated clear cutting and deforestation

C. References

D. Remaining Data Needs

Evaluation of habitat fragmentation caused by the aggregate activities of public, commercial, and private-citizen landholders.

EXPOSURE PATHWAY #13

Over-harvest of species contributes to population reductions or age-class shifts in population structure for those species.

A. Pathway Elements

Agent(s):	Harvest
Stressor:	Physical collection of organisms
Medium:	Biological
Receptor:	Native and/or introduced aquatic or terrestrial species, including: marine or anadromous sportfish (e.g., salmon); freshwater sportfish (e.g., trout and bass); shellfish (e.g., clams, oysters, mussels, and abalone); echinoderms (e.g., sea urchin); game animals (e.g., deer, fur bearers, fowl, and waterfowl)
Effect:	Species may become locally extirpated

B. Ranking Score (Total Score = 12)

Intensity:	4	Over-harvest causes loss of local populations
Extent:	1	These few species represent a small portion of the overall California ecosystem, yet these species typically are "high-profile" with considerable public awareness
Reversibility:	2	Removal of the harvest pressure should precipitate initial population recovery within the next breeding cycle, which could be up to three or four years later for salmon
Probability:	5	Effects of over-harvest are known

C. References

D. Remaining Data Needs

Continued monitoring of species receiving harvest pressures; continued monitoring of harvest amounts.

EXPOSURE PATHWAY #14

Searches for extractable natural resources intrude further into formerly unoccupied or undeveloped regions, increasing habitat fragmentation and limiting "wilderness." Road development and increased access to wild and remote areas enhances the potential for future "development" in these areas.

A. Pathway Elements

Agent(s):	Harvest; Mining Activities
Stressor:	Road Development
Medium:	Land
Receptor:	Wild or remote "wilderness" (unofficial designation)
Effect:	Increased intrusion fragments habitat and reduces the wilderness value; access increases the likelihood for future intrusion into these areas

B. Ranking Score (Total Score = 8)

Intensity:	1	The initial forays into remote or wild areas has only small localized effects, but subsequent follow-up activities, such as resource extraction practices, foreshadow further more-intensive effects
Extent:	2	The extent of (unofficial) wilderness suitable for resource extraction activities in California is likely small
Reversibility:	3	Once access to remote areas is made available for mechanized travel, the "wilderness" character is effectively lost; however, the limited extent of wilderness areas suitable for resource extraction suggests that there is a degree of reversibility. Ranking is the median of the range
Probability:	2	Effects are possible: once permanent roads are constructed, development is possible

C. References

D. Remaining Data Needs

Identification and quantification of potentially-suitable (for harvest) forested land; identification and quantification of potential mineral resource areas.

EXPOSURE PATHWAY #27

Habitat conversion, relocation of the tidal prism, increased spawning mortality, reduced contaminant assimilation capacity, and soil salinization from surface water diversion, especially in the San Francisco Estuary/Delta system.

A. Pathway Elements

Agent(s):	Surface Water Diversion
Stressor(s):	Surface water depletion, tidal prism movement, thermal pollution, physical alteration of habitat, salinization of surface waters, and dams acting together
Medium:	Surface water
Receptor(s):	Estuarine and riverine fish, wildlife, and habitats, especially wetlands
Effect(s):	Habitat alteration and loss, destruction of fish spawning areas, accentuation of the effects of droughts and pollutant spills, and increased groundwater extraction effects

B. Ranking Score (Total Score = 17).

Intensity:	4	Population loss, (freshwater to brackish water) marsh conversions, elevations of agricultural soil salinity, changes in tidal prism location effecting prey availability, flow alterations effect fish migration and spawning areas.
Extent:	4	10 to 50 percent of Delta ecosystem, primarily in the Suisun Marsh
Reversibility:	4	(10 to 30 years); based on development of alternative water supplies, including development of additional groundwater aquifers and desalination plants, "re-plumbing" existing waterways, implementing large scale management plans, and reestablishing affected species
Probability:	5	Stresses on surface water resources from surface water diversion of the San Francisco Bay Delta are widely documented

C. References

California State Water Resources Control Board (1991)

Nehlsen *et al*. (1991)

San Francisco Estuary Project (1991)

San Francisco Estuary Project (1992)

D. Remaining Data Needs

Relative contribution of pollutant load from purposive (e.g., application of pesticides, herbicides, fertilizers) versus collateral (e.g., heavy metal leaching from fertilizers) agricultural practices.

EXPOSURE PATHWAY #28

Decline in aquatic resources, particularly anadromous fisheries, from physical destruction via entrainment in pumps and diversion structures, especially in the San Francisco Estuary Delta system.

A. Pathway Elements

Agent(s):	Surface water diversions
Stressor(s):	Entrainment in diversion structures, alteration of surface water flow routes, elevated water temperature
Medium:	Surface water
Receptor:	Aquatic resources, fisheries, especially anadromous fish populations
Effect:	Physical destruction

B. Ranking Score (Total Score = 14)

Intensity:	3	Population effects on the fisheries (commercial, sport, and "natural"); potential effects on phytoplankton, zooplankton, and benthic community resources of the San Francisco Bay Estuary
Extent:	3	Fishery losses attributable to a number of factors, operating in concert, that have not been separately evaluated including: 1) Delta and upstream water diversion (entrainment), 2) reduced Delta outflows, 3) reduced San Joaquin River flow, 4) water pollution, 5) dredging and spoil disposal, 6) wetland filling, 7) illegal take and poaching, 8) disease and parasites. 9) natural variability in fish populations, 10) commercial fishery of prey items (bay shrimp), 11) exotic (introduced) aquatic organisms (including other commercial or sport species), 12) over-fishing; and, 13) unknown factors
Reversibility:	3	(5 to 20 years); some native species are listed as threatened or endangered species and non-indigenous species are reduced in numbers; fish species are relatively short-lived and their populations would be expected to increase substantially within this time frame if surface water diversions were discontinued
Probability:	5	Documented in a number of California Department of Fish and Game and California Department of Water Resources databases

C. References

California State Water Resources Control Board (1991)

Nehlsen *et al*. (1991)

D. Remaining Data Needs

Relative contribution of the various factors that have lead to decline in the fisheries in the San Francisco Bay Delta system so that (independent) control strategies may be devised.

EXPOSURE PATHWAY #29

Increased stress (demand) on surface water supplies resulting from losses of groundwater aquifer capacity due to sea water intrusion into groundwater aquifers, groundwater aquifer compaction, and land subsidence resulting from over-drafting (overuse) of groundwater aquifers.

A. Pathway Elements

Agent(s):	Groundwater Extraction
Stressor(s):	Salinization of groundwater (sea water intrusion), lowered groundwater table, aquifer compaction, land subsidence
Media:	Groundwater
Receptor(s):	Terrestrial habitats, groundwater resources; surface water fish, wildlife, habitats; terrestrial wildlife
Effect(s):	Increased stress on surface water supplies (surface water diversion effects); root-zone desiccation; loss of aquifer storage capacity; erosion, habitat alteration

B. Ranking Score (Total Score = 12)

Intensity:	1	loss of individual organisms; biological effects from shallow aquifer groundwater over-drafting documented, but not for deep aquifers
Extent:	1	less than five percent of known groundwater resources (250 million acre feet) effected
Reversibility:	5	(greater than 100 years); the only technically feasible ways to "reverse" loss of groundwater resources are to reduce demand and/or reinject groundwater that has been subjected to reverse osmosis; after ground subsidence has occurred, the "lost" portion of the aquifer volume cannot be recovered
Probability:	5	Documented occurrence; degradation of water quality

C. References

California State Water Resource Control Board (1991)

California State Water Resource Control Board (1990)

D. Remaining Data Needs

Data showing changes in groundwater uses directly attributable to salt content, contaminant pollution, and nitrates concentration.

Data showing changes in groundwater uses attributable to reductions in uses of polluted or saline surface water supplies.

EXPOSURE PATHWAY #30

Losses of riverine habitat, effects on fisheries, soil salinization, and hydrologic changes resulting from over-drafting (over pumping) of groundwater aquifers; increased stress (demand) on limited and unpredictable surface water resources as a result of contamination or depletion of groundwater resources.

A. Pathway Elements

Agent(s):	Groundwater Extraction
Stressor(s):	Salinity, Hydrological Flow Regime Alteration, Physical Alteration of Habitat
Medium:	Surface water
Receptor(s):	Riverine Habitat
Effect(s):	Loss of habitat

B. Ranking Score (Total Score = 11)

Intensity:	1	Effects documented on rivers and lakes ranged from local and more limited effects such as bank erosion and stream bed clearing, to widespread and more severe effects such as channelization; loss of lake habitat in Mono Lake
Extent:	1	Habitat alteration reported for 11 river reaches (sections) for a total of 1,374 lineal miles
Reversibility:	4	(20 to 100 years); the present water delivery system is unlikely to be changed; riverine habitat re-establishment would be expected to take 5 to 50 years, depending on the type of dominant tree canopy, and some channelized streams would not be expected to recover (irreversible loss)
Probability:	5	Effects on riverine and lake habitat are documented in California State Water Resources Control Board databases

C. References

California State Water Resource Control Board (1991)

D. Remaining Data Needs

Surface area data for lakes and reservoirs from State Water Resource Control Board. Surface area increases from original lake "footprint" to reservoir surface area and total surface area of reservoirs will be assumed to be equal to the amount of loss of a given type of terrestrial or wetlands habitat.

Total number of lineal miles of river and stream habitat in California.

Long-term monitoring to determine reversibility rate for different habitat and canopy types.

EXPOSURE PATHWAY #32

Dams and reservoirs includes long term change from free flowing to still water and temporary structures (summer dams, boat docks).

A. Pathway Elements

Agent(s):	Dams, reservoirs, and flood control structures
Stressor(s):	Physical alteration or destruction
Medium:	Water
Receptor(s):	Aquatic populations and communities
Effect(s):	Reduced population size or complete loss of aquatic community

B. Ranking Score (Total Score = 19)

Intensity:	5	For river systems involved there is complete destruction of the ecosystem for permanent dams. Temporary structures can also destroy parts of ecosystems (i.e., summer runs as shad)
Extent:	4	Many dams and reservoirs are constructed on major river systems throughout the State
Reversibility:	5	In most cases the dam or reservoir will not be removed
Probability:	5	Effects of dams are well known and there is a high probability that more will be built

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #33

Physical alterations and destruction includes: human trampling; off road vehicles; second home development in wild areas; and marina, golf course, tennis courts, ski area, and campground development. Development of visitor or support facilities in biologically sensitive areas.

A. Pathway Elements

Agent(s):	Habitat alteration or land-use conversion
Stressor(s):	Physical alteration or destruction
Medium:	Biological
Receptor(s):	Plant and animal communities
Effect(s):	Loss of habitat with subsequent elimination of population

B. Ranking Score (Total Score = 18)

Intensity:	5	This threat is considered significant because in many cases home development and other construction activities completely alters the ecosystem
Extent:	3	Trampling has been reported as a threat in 50 percent of the 300 State Parks surveyed. Large developments in ski areas and second homes effect selected ecosystems
Reversibility:	5	In the areas of recreational development, the complete ecosystem is destroyed. Desert alteration of off-road vehicles can take 20 to 100 years to recover
Probability:	5	Land alternation by recreational development is documented and is virtually certain to continue

C. References

D. Remaining Data Needs

Information on camping, trampling effects in recreational areas.

EXPOSURE PATHWAY #34

Introduced species from accidental, controlled, or sport related activities (includes feral animals, rough fish, invertebrates, plants).

A. Pathway Elements

Agent(s):	Animal maintenance
Stressor(s):	Introduced species
Medium:	Biological
Receptor(s):	High-altitude or high-latitude populations
Effect(s):	Loss of organisms and populations unable to compete with non-indigenous species

B. Ranking Score (Total Score = 17)

Intensity:	4	This threat was deemed significant because introduced species are often very opportunistic and can change gene pools by interbreeding.
Extent:	4	The occurrence of introduced species is widespread throughout the State. The California State parks system reported 184 units out of 300, or 61.3 percent, have a major treat of encroachment by nonnative or alien plant species. Feral animals, rough fish, and hatchery introduced fish are also widespread problems
Reversibility:	4	At some sites, removal of plant species could be done provided staff and money were available. In other cases, changes in gene pools or establishment in large ecosystems could not be reversed
Probability:	5	The extent of introduced species is well documented in many recreation areas and aquatic systems.

C. References

D. Remaining Data Needs

Information on the impact of introduced species on native populations.

Information on the success of reversing the effect by removing non-indigenous species.

EXPOSURE PATHWAY #35

Air pollution from wood burning at campsites and cabins. Emissions from recreational vehicles, off-road vehicles, and visitors' vehicles to recreational areas.

A. Pathway Elements

Agent(s):	Open burning
Stressor(s):	Atmospheric oxidants, Greenhouse gases, and Particulate/PM10
Medium:	Air
Receptor(s):	Terrestrial and aquatic communities
Effect(s):	Reduced productivity, chronic or acute injury to communities

B. Ranking Score (Total Score = 13)

Intensity:	3	This threat was lowered because of uncertainty of effect levels that could be directly related to recreational activity
Extent:	3	In some areas the effect may be difficult to determine. The California State park system reported over 42 percent of the 300 units surveyed indicated that "smog" (mix of auto and other gases) was a threat
Reversibility:	4	This was higher because it is not likely that the visitor usage will go down or that other means of controlling air pollution will be in effect. If source is removed, reversibility could occur faster
Probability:	3	Some direct evidence of effects from air pollution to forest land (along major highways) has been demonstrated

C. References

D. Remaining Data Needs

Information of volume of gases produced by vehicles using recreational areas Statewide.

EXPOSURE PATHWAY #36

Toxic metals and metal compounds, including boat bottom paints, and lead (e.g., shotgun pellets and fishing sinkers).

A. Pathway Elements

Agent(s):	Harvesting and pest management
Stressor(s):	Toxic metals and metal compounds
Medium:	Water and Land
Receptor(s):	Aquatic populations and communities
Effect(s):	Acute or chronic toxicity, exclusion of benthic communities

B. Ranking Score (Total Score = 13)

Intensity:	3	Select populations of birds, fish, and invertebrates can be effected by lead poisoning
Extent:	2	In some locations, like lakes and reservoirs and game bird hunting tracks, the effects can be heavy. The United States EPA is now considering control of lead fishing sinkers usage, use of lead shotgun pellets is now controlled in some states
Reversibility:	4	This was rated high because lead is very slow to dissipate from the environment and in some parts of the state it has been used for many years with large accumulations in sediment or soils
Probability:	4	Some studies have shown uptake in ducks and geese feeding in areas of high bird hunting pressure

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #37

Over-utilization of resources from sport fishing, hunting, and collection of biota (removing plants and animals).

A. Pathway Elements

Agent(s):	Harvesting
Stressor(s):	Physical collection of organisms
Medium:	Biological
Receptor(s):	Aquatic communities
Effect(s):	Decreased species diversity

B. Ranking Score (Total Score = 12)

Intensity:	3	This threat can be extensive for some species, however, reduced number are usually the sole result of over utilization by recreational activities
Extent:	3	Illegal removal or collection of plants and animals can be intensive in some recreational areas. The California State park system reported that 23.3 percent of the 300 units report removal as an important threat
Reversibility:	2	In areas where control of fishing, hunting, and illegal collecting is maintained at a high level, effected populations returns in one to five years. In some cases (i.e., marine intertidal) the return time may be closer to 5 to 10 years
Probability:	4	In a number of high use areas studies have documented effects or illegal collections and over-utilization of resources

C. References

D. Remaining Data Needs

Fishing and hunting collection information in relationship to other impacts at the species level. More documentation of effects of over-collection.

EXPOSURE PATHWAY #38

Wildfires started by campers, fishermen, hunters, and second home owners.

A. Pathway Elements

Agent(s):	Open burning
Stressor(s):	Wild fires
Medium:	Land
Receptor(s):	Terrestrial communities
Effect(s):	Removal or injury to plant and animal communities

B. Ranking Score (Total Score = 12)

Intensity:	4	Wild fires can cause large loss of populations and destroy old growth, rare species, and alter ecosystems
Extent:	3	Ecosystems that are normally found in recreational areas are affected more than those used for other activities. The California State park system reported that 34 percent of the 300 park units feel that wild fires are a major problem
Reversibility:	3	Depending upon the ecosystem involved, climax forests will not come back in our measured time while other forests may take 20 to 100 years to reach maturity
Probability:	2	This is ranked low because information about who or what caused many wild fires is not clear, therefore, relating this to recreational use only is difficult

C. References

D. Remaining Data Needs

Better knowledge of wild fire causes and better estimates of fires caused by recreational use.

EXPOSURE PATHWAY #39

Solid waste generated from national, State, and private parks, camp sites, seashore, and recreational vehicle parks.

A. Pathway Elements

Agent(s):	Land disposal
Stressor(s):	Solid waste
Medium:	Land
Receptor(s):	Terrestrial populations and communities
Effect(s):	Altered animal behavior, injury, and mortality during feeding at waste sites

B. Ranking Score (Total Score = 9)

Intensity:	1	Limited direct effect on ecosystems at point of origin. Becomes a part of a much larger problem if transported to large landfills. This rating assumes solid waste does not contain toxic materials
Extent:	4	Litter and dumping of refuse is widespread in recreational areas. The California State park system reported that 72.7 percent of the units consider this a major problems
Reversibility:	2	This is a major problem but only a threat where deposited and what is contained in the waste. Would be reversed quickly if source and use was modified
Probability:	2	Data Needs: Records of the volume of solid waste generated from recreational use

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #40

Hazardous materials or toxic materials from boating, recreational vehicles, generator emissions, biocide, and pesticides.

A. Pathway Elements

Agent(s):	Accidental releases
Stressor(s):	Atmospheric oxidants and Pesticides
Medium:	Air, water, and land
Receptor(s):	Terrestrial and aquatic communities
Effect(s):	Reduced productivity and chronic or acute injury to communities

B. Ranking Score (Total Score = 8)

Intensity:	3	Can have effects at the population level particularly by biocide
Extent:	2	Difficult to estimate extent, State Parks system reported 6.7 percent out of 300 units consider chemical pollution a threat
Reversibility:	2	Lack of information related to recreational use
Probability:	1	No direct evidence, although areas like Yosemite National Park indicate problems

C. References

D. Remaining Data Needs

Very little information is available on extent of chemical pollution from recreational use.

EXPOSURE PATHWAY #41

Pathogenic microorganisms from fish hatcheries (disease introduced to wild population) and transmission of disease from wild game to domesticated species.

A. Pathway Elements

Agent(s):	Animal maintenance
Stressor(s):	Pathogenic microorganisms
Medium:	Biological
Receptor(s):	Wild fish populations and wildlife
Effect(s):	Infection and mortality associated with infection

B. Ranking Score (Total Score = 7)

Intensity:	2	Loss of individual organisms is the common effect although some documentation that introduced pathogens have caused widespread disease in domesticated species is available
Extent:	1	Not widespread, occurring locally but in different ecosystems depending upon the pathogens
Reversibility:	2	Can be controlled by treatment at source (hatcheries) or by inoculation of domesticated species
Probability:	2	Not well documented although some cases of hatchery infestations being transmitted to native fish have been reported

C. References

D. Remaining Data Needs

Validation of effect pathway from hatchery or from wild populations to domesticated species indicating the size and frequency of cross-infection.

EXPOSURE PATHWAY #43

Aquatic ecosystem degradation in estuaries due to waste water discharge of persistent toxicants from industrial manufacturing practices.

A. Pathway Elements

Agent(s):	Waste water
Stressor:	Persistent Toxicants
Medium:	Water, Biological
Receptor:	Estuarine Ecosystems (e.g., benthic communities and wildlife)
Effect:	Decreased abundance, community structure alterations, possible reproductive effects

B. Ranking Score (Total Score = 12)

Intensity:	3	Population (multiple species) effects - elevated selenium levels in fish and wildlife in San Francisco Bay; elevated copper and silver levels in mollusc tissues and water in South San Francisco Bay
Extent:	4	10 to 50 percent of California estuaries impacted due to metals and other persistent toxicants
Reversibility:	3	Affected benthic communities may recover in 5 to 10 years, wildlife populations may take longer
Probability:	2	In some degraded estuaries, contaminant levels are high enough to be of concern. However, few cause and effect relationships have been established

NOTE: Although most of the estuarine acres in California are deemed impaired, the major sources of the impairment are neither persistent toxicants nor industrial sources. The ranked score above is based on a few highly publicized cases and probably over-estimates the threat from industrial sources. Other aquatic systems, such as rivers, coastal areas, etc., are not included in the exposure chain because the extent and intensity of degradation due to persistent toxicants is expected to be much less and more poorly documented than in estuaries.

C. References

California State Water Resources Control Board (1991)

Phillips (1987)

D. Remaining Data Needs

Mass loading of persistent toxicants from various sources.

Monitoring of persistent toxicants in estuarine sediments and biota.

Demonstration of cause-effect relationship between persistent toxicants and biological effects.

EXPOSURE PATHWAY #44

Degradation of forest ecosystems due to oxidants and acidic precursors released into the atmosphere due to contained burning/stationary sources from industrial practices.

A. Pathway Elements

Agent(s):	Stationary Sources
Stressor:	Atmospheric oxidants
Medium:	Air
Receptor:	Forest Ecosystems
Effect:	Decreased tree growth (e.g. conifers); altered biogeochemical cycling

B. Ranking Score (Total Score = 12)

Intensity:	3	Population effects - ponderosa pine in South Coast Air basin and Jeffrey pine in Sierra Nevada
Extent:	2	Less than five percent of total forest resources (e.g., mostly limited to the forests surrounding heavily urban areas)
Reversibility:	4	Recovery of forest ecosystems is generally slow (20 to 100 years), especially if the effects are severe
Probability:	3	Effects of oxidants are widely documented in California. However, the assigned rank value is three because the relative contribution from stationary sources is probably much less than that from mobile sources (automobiles)

C. References

California Air Resources Board (1991)

U.S. Environmental Protection Agency (1993)

D. Remaining Data Needs

Quantitative assessments of tree damage on a regional scale.

Maps of forest acreage - Statewide.

Exposure-response data for sensitive species.

EXPOSURE PATHWAY #45

Aquatic ecosystem degradation in rivers/lakes/estuaries due to sediment contamination by persistent toxicants from historic (pre-existing) industrial practices.

A. Pathway Elements

Agent(s):	Pre-existing contamination
Stressor:	Persistent toxicants
Medium:	Water, Biological
Receptor:	Benthic Communities
Effect:	Decreased abundance; community alteration; possible reproductive or carcinogenic effects in fish

B. Ranking Score (Total Score = 11)

Intensity:	3	Population effects - elevated pesticide levels in molluscs and fish in Los Angeles/Long Beach Harbor and San Diego Bay; in highly contaminated sediments, benthic organisms can be absent, however, due to the small size of these "hot spots" the effects on the larger ecosystem is limited
Extent:	2	The extent of severe sediment contamination is probably close to five percent in urban rivers and estuaries, but less than one percent elsewhere
Reversibility:	3	Natural recovery (capping by clean sediments) expected to occur in less than 10 years
Probability:	3	Although there is a good understanding of the principles of sediment toxicity, documentation of cause-effect relationships (especially in California) is limited

C. References

California State Water Resources Control Board (1991)

Phillips (1987)

D. Remaining Data Needs

Mass loading of sediment contaminants from various sources.

Extent of sediment "hot spots."

Demonstration of cause-effect relationship between sediment contaminants and biological effects.

EXPOSURE PATHWAY #46

A. Pathway Elements

Agent(s):	Pre-existing Contamination, Landfills (e.g. includes DOD sites)
Stressor:	Toxic metals, toxic organics (e.g., leachate)
Medium:	Water
Receptor:	Estuarine and Riverine Communities
Effect:	Ecosystem degradation

B. Ranking Score (Total Score = 8)

Intensity:	3	Population effects - potential for decreases in species abundance and community structure alterations
Extent:	1	Less than one percent (e.g., effects limited to areas immediately adjacent to landfills). Not a major or minor source of threatened/impaired water bodies in California
Reversibility:	2	Because intensity and extent is limited, affected populations should quickly recover after removal of source
Probability:	2	Examples unknown. However, large number of leaking hazardous landfills suggests possibility exists

NOTE: Although not listed as a major source of threatened or impaired water bodies in California, land disposal was indicated as a factor in 5 to 20 percent of impaired water bodies Nationwide.

C. References

California State Water Resources Control Board (1991)

U.S. Environmental Protection Agency (1992)

D. Remaining Data Needs

Demonstration of field effects (cause-effect) from landfill leachate.

Maps of landfill locations.

Monitoring of contamination levels in leachate and adjacent water bodies.

EXPOSURE PATHWAY #48

Shifts in ecological zones caused by greenhouse gases

A. Pathway Elements

Agent(s):	Mobile sources, stationary sources
Stressor:	Greenhouse gases
Medium:	Air
Receptor:	Ecosystems
Effect:	Shifts in ecological zones; redistribution/loss of marginal ecosystems

B. Ranking Criteria (Total score = 16)

Intensity:	4	Population-scale losses due to changes in weather patterns
Extent:	5	10 to 50 percent of forest, arid, aquatic ecosystems
Reversibility:	4	50-year time frame for effects on soils and long-lived species
Probability:	3	Outcomes probable based on known ecological principles

C. References

Botkin *et al.* (1991)

California Department of Forestry and Fire Protection (1988)

California Energy Commission (1990)

California Energy Commission (1991)

Jaeger (1989)

MacDonald (1989)

Peters (1989)

Robinson (1989)

Samson *et al.* (1989)

U.S. Congress, Office of Technology Assessment (1991)

Worrest *et al.* (1989)

D. Remaining Data Needs

Maps of the ecological zones of California.

Output from simulation models for predicting changes in weather patterns.

EXPOSURE PATHWAY #49

Decreased forest productivity caused by atmospheric oxidants

A. Pathway Elements

Agent(s):	Mobile sources, Stationary sources
Stressor:	Atmospheric oxidants
Medium:	Air
Receptor:	Forests
Effect:	Decreased tree growth (e.g., conifers); altered biogeochemical cycling

B. Ranking Criteria (Total score = 15)

Intensity:	3	Population effects - ponderosa pine in the South Coast air basin; Jeffrey pine in the Sierra Nevada
Extent:	4	10 to 50 percent of the mixed conifer vegetation zone
Reversibility:	3	Losses of pine species will enable fir species to dominate
Probability:	5	Effects of ozone are widely documented in California

C. References

California Air Resources Board (1990)

California Air Resources Board (1991)

California Air Resources Board (1992)

California Air Resources Board (1993)

California Department of Forestry and Fire Protection (1988)

Coyne (1981)

Edinger *et al.* (1972)

Evans and Miller (1972)

Fishman (1991)

Little (1992)

MacDonald (1989)

Miller (1969)

Miller (1989)

Miller and Millecan (1971)

Olson and Lefohn (1989)

Patterson and Rundel (1990)

Peterson and Arbaugh (1988)

Peterson *et al.* (1987)

Reich and Amundson (1985)

Stolte *et al.* (1991)

Taylor and Hanson (1992)

Walker (1985)

Williams (1980)
Williams *et al.* (1977)

D. Remaining Data Needs

Quantitative assessments of tree damage on a regional scale.

Statewide maps of forest acreage.

Exposure-response data for sensitive species.

EXPOSURE PATHWAY #50

Stratospheric O_3 depletion caused by releases of hazardous materials.

A. Pathway Elements

Agent(s):	Waste sites, Mobile sources
Stressor:	Hazardous materials (e.g., CFCs and other ozone depleting compounds)
Medium:	Air
Receptor:	Global airsheds
Effect:	Stratospheric ozone depletion; loss of organisms sensitive to UV-B, potential extinction of species

B. Ranking Criteria (Total score =14)

Intensity:	2	Losses of sensitive organisms from exposure to UV-B
Extent:	4	10 to 50 percent of the state; high elevation ecosystems
Reversibility:	5	Destruction of CFCs will take decades or longer
Probability:	3	Probable based on field data and known chemical principles

C. References

California Energy Commission (1990)

California Energy Commission (1991)

Cullen *et al.* (1992)

Gibbs *et al.* (1992)

Intergovernmental Panel on Climate Change (1992)

Rhodes (1991)

Smith *et al.* (1992)

Worrest *et al.* (1989)

D. Remaining Data Needs

Amount of land and sensitive ecosystems considered to be at high elevation.

Population data on sensitive species.

EXPOSURE PATHWAY #51

Soil contamination from hydrocarbon fuels/hazardous materials.

A. Pathway Elements

Agent(s):	Accidental releases, stationary sources, waste sites
Stressor:	Hydrocarbon fuels, hazardous materials
Medium:	Soil
Receptor:	Local soils
Effect:	Soil Contamination

B. Ranking Criteria (Total score = 12)

Intensity:	3	Moderate/serious soil contamination depending on chemical composition and amount of spilled substances
Extent:	1	Local - less than one percent of the state
Reversibility:	4	In the absence of soil removal, about 50 years or more
Probability:	4	Observed (e.g., military installations)

C. References

Kimball (1975)

Kostecki and (1990)

Ryti (1993)

D. Remaining Data Needs

Records of waste types deposited in waste disposal sites.

Pipeline leakage data from fuel storage/processing facilities.

Numbers and sizes of pollutant sources.

EXPOSURE PATHWAY #52

Increased tropospheric O_3 from volatile organic compound emissions.

A. Pathway Elements

Agent(s):	Mobile sources, Stationary sources
Stressor:	Hydrocarbon fuels, VOC emissions
Medium:	Air
Receptor:	Local airsheds, regional airsheds
Effect:	Increased concentrations of O_3 in the troposphere; adverse ecological effects

B. Ranking Criteria (Total score = 12)

Intensity:	2	chronic health effects on vegetation and wildlife
Extent:	3	regional-scale; 5 to 10 percent of the state is exposed to harmful levels
Reversibility:	3	5 to 20 years to implement controls to reduce emissions
Probability:	4	Measured increases of ozone in areas with high VOC:NO_x ratios

C. References

California Air Resources Board (1991)

California Air Resources Board (1992)

California Air Resources Board (1993)

California Air Resources Board (1990)

Chameides *et al.* (1992)

Finlayson-Pitts and Pitts (1977)

Isaksen *et al.* (1978)

MacDonald (1989)

Samson *et al.* (1989)

D. Remaining Data Needs

Additional monitoring data to chart the effectiveness of control measures.

Exposure-response data for sensitive organisms (e.g., ponderosa pine).

EXPOSURE PATHWAY #53

Decreased diversity of aquatic species from siltation.

A. Pathway Elements

Agent(s):	Land-use practices - road construction
Stressor:	Siltation
Medium:	Water
Receptor:	Aquatic ecosystems
Effect:	Decreased species diversity

B. Ranking Criteria (Total score = 11)

Intensity:	3	Population effects; mortality of sensitive species
Extent:	3	5 to 10 percent of aquatic ecosystems in the state
Reversibility:	2	One to five years with artificial propagation
Probability:	3	Probable; effects documented for selected bodies of water

C. References

California Department of Transportation (1977)

D. Remaining Data Needs

Quantitative estimates of statewide siltation rates.

Residence times for the most toxic components of silt.

Exposure-response data for sensitive organisms.

EXPOSURE PATHWAY #54

Loss of marine habitat and keystone species from accidental spills.

A. Pathway Elements

Agent(s):	Accidental releases from mobile sources (e.g., oil tanker spills)
Stressor:	Hydrocarbon fuels, hazardous materials
Medium:	Water
Receptor:	Marine ecosystems
Effect:	Loss of habitat

B. Ranking Criteria (Total score = 11)

Intensity:	3	Population effects/loss - widespread losses of organisms
Extent:	1	Local; about one percent of the state
Reversibility:	3	Estimated at 5 to 20 years
Probability:	4	Spills to marine habitat are observed

C. References

Galt *et al.* (1991)

Maki (1991)

D. Remaining Data Needs

Frequency data on spills by oil tankers.

Frequency data on spills of other hazardous materials.

Exposure-response data for sensitive organisms.

EXPOSURE PATHWAY #55

Displacement of native animals and plants by introduced species.

A. Pathway Elements

Agent(s):	Mobile sources
Stressor:	Introduced organisms (i.e., plant, animal, microbial)
Medium:	Air, water, soil, biota
Receptor:	Vegetation, soil, aquatic ecosystems
Effect:	Loss of native species and habitat alteration

B. Ranking Criteria (Total score = 10)

Intensity:	2	Organism loss; exotic species are better competitors for niches
Extent:	2	Local; estimated one to five percent of the state
Reversibility:	3	5 to 20 years, if ever (highly speculative)
Probability:	3	Probable; changes in native fish and vegetation have occurred

C. References

California Department of Forestry and Fire Protection (1988)

U.S. Congress Office of Technology Assessment (1993)

D. Remaining Data Needs

Evidence linking introduced species to shipping vessels or air transportation.

Records on the population dynamics for native and introduced species.

EXPOSURE PATHWAY #56

Decreased aquatic species diversity from acidic deposition.

A. Pathway Elements

Agent(s):	Mobile sources, Stationary sources
Stressor:	Acid deposition
Medium:	Water
Receptor:	Freshwater ecosystems
Effect:	Decreased species diversity

B. Ranking Criteria (Total score = 10)

Intensity:	2	Organism loss; amphibian and fish mortality, heavy metal effects on birds and small mammals
Extent:	2	One to five percent of surface waters in the State (reasonable estimate)
Reversibility:	3	About 5 to 20 years; management practices are key (e.g., liming)
Probability:	3	Probable; based on occurrences in the eastern United States

C. References

Baker *et al.* (1991)

California Air Resources Board (1991)

California Air Resources Board (1992)

California Air Resources Board (1993)

California Air Resources Board 1990

MacDonald (1989)

Melack and Stoddard (1991)

Pierson and Brachaczek (1990)

Rowe *et al* (1992)

Sparling (1990)

D. Remaining Data Needs

Emission estimates for precursor compounds (e.g., SO_x and NO_x).

Deposition rates of surface waters.

Exposure-response data for sensitive species.

EXPOSURE PATHWAY #57

Loss of habitat and native species from accidental spills.

A. Pathway Elements

Agent(s):	Accidental releases from mobile sources (e.g., train derailments)
	Land-use practices -- Bridge maintenance
Stressor:	Hazardous materials
Medium:	Water
Receptor:	Surface water ecosystems
Effect:	Loss of habitat; decreased species diversity

B. Ranking Criteria (Total score = 9.5)

Intensity:	3	Population effects - species-specific
Extent:	1	Local (e.g., Cantera Loop spill)
Reversibility:	2	About one to five years, but largely unknown; depends on extent of recovery effort and management practices
Probability:	3.5	Observed; frequency of events uncertain (e.g., DOT study on the Middle River Bridge)

C. References

California Department of Transportation (1977)

Carey (1988)

CDHS (1992)

CDHS (1992)

Patte *et al* (1990)

Wolsko *et al* (1991)

D. Remaining Data Needs

Frequency data on accidental spills (e.g., reports from the Cantara Incident).

Exposure-response data for sensitive organisms.

EXPOSURE PATHWAY #58

Decreased aquatic species diversity from surface runoff.

A. Pathway Elements

Agent(s):	Stationary sources
Stressor:	Surface runoff
Medium:	Water
Receptor:	Aquatic ecosystems
Effect:	Decreased species diversity

B. Ranking Criteria (Total score = 9)

Intensity:	3	Population effects; depends on contaminant chemistry (e.g., content of PAHs, salts, oxygen-demanding substances) and species-sensitivity
Extent:	2	Up to 5 to 10 percent of ecosystem populations
Reversibility:	2	Within one to five years; achievable through artificial propagation
Probability:	2	Possible; effects of non-point source pollution are documented, but sources are limited

C. References

Still (1991)

D. Remaining Data Needs

Estimates of surface runoff rates - Statewide.

Detailed chemistry of local and regional runoff.

Extent of surface waters exposed to surface runoff.

Exposure-response data for sensitive organisms.

EXPOSURE PATHWAY #59

Decreased mammalian species diversity from physical barriers.

A. Pathway Elements

Agent(s):	Land-use practices -- Highway development
Stressor:	Physical barriers
Medium:	Soil
Receptor:	Terrestrial organisms (e.g., cougars)
Effect:	Decreased species diversity

B. Ranking Criteria (Total score = 8)

Intensity:	1	Organism effects; death or injury to cougars in the Santa Ana mountains from vehicle collisions
Extent:	2	Up to one percent of mammal populations
Reversibility:	2	5 to 20 years; dependent upon efficacy of propagation methods
Probability:	3	Probable; studies indicate that road kills are a factor contributing to population declines in cougars

C. References

Carey (1988)

Wolsko *et al* (1991)

D. Remaining Data Needs

Frequency of road kills and non-fatal collisions.

Records on statewide, large mammal population dynamics.

EXPOSURE PATHWAY #61

Removal of terrestrial habitat for development of municipal landfills.

A. Pathway Elements

Agent(s):	Land disposal
Stressor(s):	Hazardous or toxic materials
Medium:	Land
Receptor(s):	Terrestrial community
Effect(s):	Loss of habitat

B. Ranking Score (Total Score = 14)

Intensity:	5
Extent:	1
Reversibility:	4
Probability:	4

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #62

A. Pathway Elements

Agent(s):	Urban storm water runoff
Stressor(s):	Toxic metals and metal compounds Toxic organic compounds
Medium:	Water
Receptor(s):	Aquatic communities
Effect(s):	Physical impairment by smothering, loss of fish populations

B. Ranking Score (Total Score = 12)

Intensity:	2	Physical impairments and populations losses documented, but difficult to separate from other contributing sources
Extent:	4	In proximity to all developed areas of California
Reversibility:	3	Documented recovery of fish populations in California and other parts of the United States
Probability:	3	Effects of documented impairments and population losses difficult to separate from the impacts created from other sources (agricultural runoff, municipal waste water, and industrial waste water).

C. References

California State Water Resources Control Board (1992)

Brown and Caldwell (1984)

Phillips (1987)

Association of Bay Area Governments (1992)

D. Remaining Data Needs

Contribution of urban runoff to the degradation of ecosystem health as compared to other sources (i.e., agricultural runoff, municipal wastewater, and industrial wastewater).

EXPOSURE PATHWAY #63

Decreases in fish populations due to acute and chronic toxic effects associated with metals and organic compounds in non-point source urban runoff.

A. Pathway Elements

Agent(s):	Urban runoff
Stressor(s):	Toxic metals and metal compounds
	Toxic organic compounds
Medium	:Water
Receptor(s):	Aquatic communities
Effect(s):	Decrease in fish populations

B. Ranking Score (Total Score = 12)

Intensity:	2
Extent:	4
Reversibility:	3
Probability:	3

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #64

Loss of wetland communities due to land-use conversion associated with urban development.

A. Pathway Elements

Agent(s):	Habitat alteration or land-use conversion
Stressor(s):	Physical alteration or destruction
Medium:	Water
Receptor(s):	Wetland communities
Effect(s):	Loss of habitat

B. Ranking Score (Total Score = 12)

Intensity:	4
Extent:	2
Reversibility:	2
Probability:	4

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #65

Loss of riparian and terrestrial communities due to land-use conversion associated with urban development.

A. Pathway Elements

Agent(s):	Habitat alteration or land-use conversion
Stressor(s):	Physical alteration or destruction
Medium:	Water, Land
Receptor(s):	Riparian and terrestrial communities
Effect(s):	Loss of habitat

B. Ranking Score (Total Score = 12)

Intensity:	4
Extent:	2
Reversibility:	2
Probability:	4

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY # 66

Loss of managed agricultural systems due to land-use conversion associated with urban development.

A. Pathway Elements

Agent(s):	Habitat alteration or land-use conversion
Stressor(s):	Physical alteration or destruction
Medium:	Land
Receptor(s):	Managed agricultural communities
Effect(s):	Decreased productivity due to lost acreage

B. Ranking Score (Total Score = 12)

Intensity:	4
Extent:	1
Reversibility:	3
Probability:	4

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #67

Decreases in vertebrate and invertebrate aquatic populations due to toxic metals and organic compounds discharged in municipal wastewater.

A. Pathway Elements

Agent(s):	Wastewater
Stressor(s):	Toxic metals and metal compounds
	Toxic organic compounds
Medium:	Water
Receptor(s):	Aquatic community
Effect(s):	Decrease in vertebrate and invertebrate populations

B. Ranking Score (Total Score = 11)

Intensity:	2
Extent:	3
Reversibility:	3
Probability:	3

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #68

A. Pathway Elements

Agent(s):	Wastewater
Stressor(s):	Toxic metals and metal compounds
	Toxic organic compounds
Medium:	Water
Receptor(s):	Aquatic communities
Effect(s):	Decrease in vertebrate and invertebrate populations

B. Ranking Score (Total Score = 10)

Intensity:	2
Extent:	3
Reversibility:	3
Probability:	2

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #69

Loss of woodland and grassland community due to land-use conversion associated with urban development.

A. Pathway Elements

Agent(s):	Habitat alteration or land-use conversion
Stressor(s):	Physical alteration
Medium:	Land
Receptor(s):	Woodland and grassland communities
Effect(s):	Loss of habitat

B. Ranking Score (Total Score = 10)

Intensity:	3
Extent:	1
Reversibility:	2
Probability:	4

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #70

Physical impairment in aquatic communities due to toxic metals and organic compounds redistributed in the ecosystem by dredging.

A. Pathway Elements

Agent(s):	Habitat alteration (dredging)
Stressor(s):	Toxic metals and metal compounds
	Toxic organic compounds
Medium:	Water
Receptor(s):	Aquatic communities
Effect(s):	Physical impairment

B. Ranking Score (Total Score = 9)

Intensity:	2	Physical impairment losses documented, but difficult to separate from other contributing sources
Extent:	2	Dredged material has the potential for the greatest impact in close proximity to the disposal site, however, the disposal process allows for a dispersal and redistribution of contaminants to much larger areas of the ecosystem
Reversibility:	3	Documented recovery of fish populations in California and other parts of the United States. Long-term effect on individual species is unclear
Probability:	2	Effects of documented impairments difficult to separate form the impacts created from other sources (e.g., runoff, municipal wastewater, industrial wastewater, and urban runoff)

C. References

Association of Bay Area Governments (1992)

California State Water Resources Control Board (1992)

Gunther *et al* (1990)

Phillips (1987)

D. Remaining Data Needs

EXPOSURE PATHWAY #71

A. Pathway Elements

Agent(s):	Land disposal
Stressor(s):	Hazardous or toxic materials
Medium:	Land
Receptor(s):	Terrestrial communities
Effect(s):	Physical impairment

B. Ranking Score (Total Score = 8)

Intensity:	2
Extent:	1
Reversibility:	3
Probability:	2

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #72

A. Pathway Elements

Agent(s):	Land disposal
Stressor(s):	Hazardous or toxic materials
Medium:	Water
Receptor(s):	Aquatic communities
Effect(s):	Physical impairment

B. Ranking Score (Total Score = 8)

Intensity:	2
Extent:	1
Reversibility:	3
Probability:	2

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #73

A. Pathway Elements

Agent(s):	Habitat alteration or land-use conversion
Stressor(s):	Silt
Medium:	Water
Receptor(s):	Aquatic communities
Effect(s):	Loss of habitat

B. Ranking Score (Total Score = 8)

Intensity:	2
Extent:	1
Reversibility:	3
Probability:	2

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #75

Local extirpation of marginally distributed terrestrial and aquatic ecosystems due to shifts in climate patterns caused by release of greenhouse gases released from electrical generation plants burning fossil fuels.

A. Pathway Elements

Agent(s):	Contained burning
Stressor(s):	Greenhouse gases
Medium:	Air
Receptor(s):	Terrestrial and aquatic ecosystems
Effect(s):	Ecosystem degradation

B. Ranking Score (Total Score = 19.5)

Intensity:	4
Extent:	5
Reversibility:	5
Probability:	4.5

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #76

Acute toxicity to individual organisms and decreases in species diversity of terrestrial and alpine aquatic ecosystems due to decreases in pH and alteration of geochemical cycles caused by releases of pH-altering substances released from electrical generation plants burning fossil fuels.

A. Pathway Elements

Agent(s):	Contained burning
Stressor(s):	Acid deposition
Medium:	Air
Receptor(s):	Aquatic and terrestrial ecosystems
Effect(s):	Ecosystem degradation

B. Ranking Score (Total Score = 14.5)

Intensity:	4.5
Extent:	3
Reversibility:	3
Probability:	4

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #77

Acute toxicity to individual organisms and decreases in species diversity of terrestrial communities due to direct oxidation effects caused by releases of atmospheric oxidants or their precursors from electrical generation plants burning fossil fuels.

A. Pathway Elements

Agent(s):	Contained burning
Stressor(s):	Atmospheric oxidants
Medium:	Air
Receptor(s):	Terrestrial communities
Effect(s):	Community and population disruption

B. Ranking Score (Total Score = 14.5)

Intensity:	3.5
Extent:	3
Reversibility:	3
Probability:	5

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #78

Direct toxicity to individual organisms and changes in ecosystem function of aquatic and terrestrial ecosystems due to toxic metals released from electrical generation plants burning fossil fuels.

A. Pathway Elements

Agent(s):	Contained burning
Stressor(s):	Toxic metals and metal compounds
Medium:	Air and water
Receptor(s):	Aquatic and terrestrial ecosystems
Effect(s):	Community and population disruption

B. Ranking Score (Total Score = 14)

Intensity:	3
Extent:	2
Reversibility:	4
Probability:	5

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #79

Direct toxicity to individual organisms and changes in marine populations and communities due to exposure to crude oil released accidentally from electrical generation plants burning fossil fuels.

A. Pathway Elements

Agent(s):	Accidental releases
Stressor(s):	Crude oil
Medium:	Water
Receptor(s):	Marine communities
Effect(s):	Community and population disruption

B. Ranking Score (Total Score = 12)

Intensity:	3.5
Extent:	2
Reversibility:	1.5
Probability:	5

C. References

D. Remaining Data Needs

EXPOSURE PATHWAY #81

Individual plant loss and population effects on sensitive forest and crop species (white pines, birches, legumes, grapes, citrus, and other fruit trees) due to hazardous or toxic materials, hydrocarbon fuels, particulates and PM10, greenhouse gases, and atmospheric oxidants produced by uncontrolled contained and open burning that is part of residential practices.

A. Pathway Elements

Agent(s):	Contained and open burning
Stressor(s):	Hazardous or toxic materials
	Hydrocarbon fuels
	Particulates and PM10
	Greenhouse gases
	Atmospheric oxidants
Medium:	Air
Receptor:	Terrestrial vegetation; forest and crop plants
Effect:	Individual plant loss or toxic effects; population effects

B. Ranking Score (Total Score = 9)

Intensity:	1	Non-lethal effects on individual organisms
Extent:	1	Highly localized effects in direct path of air dispersion from individual residences
Reversibility:	2	Dependent upon frequency of practices
Probability:	5	Impacts of various air pollutants on vegetation are well documented; however, whether sources have been documented as coming from residential practices is uncertain

C. References

Connell and Miller (1984)

Shaheen (1974)

Luxmoore *et al* (1993)

Guzy and Heath (1993)

D. Remaining Data Needs

Determine the magnitude of uncontrolled residential burning.

Monitor localized effects - use indicator forest and crop species around residential areas.

EXPOSURE PATHWAY #86

Organism mortality, abnormal development, and bioaccumulation effects on aquatic fish and invertebrates, terrestrial invertebrates, birds, and mammals due to pesticides and their toxic and hazardous byproducts produced by pest management activities that are part of residential practices.

A. Pathway Elements

Agent(s):	Pest management activities
Stressor(s):	Pesticides
	Toxic and hazardous chemicals
Medium:	Air, Water, Biota
Receptor(s):	Fish, aquatic and terrestrial invertebrates, birds, and mammals
Effect:	Individual organism loss, abnormalities, bioaccumulation of toxics through the food chain

B. Ranking Score (Total Score = 14)

Intensity:	3	Whole populations affected, particularly fish and birds
Extent:	2	In localized areas, problems severe-waterways and coastal areas receiving treated wastewater from mostly residential sources
Reversibility:	4	Pesticides are persistent in environment, up to 20 years for organics; associated metal compounds up to 100 years
Probability:	5	Impacts of pesticides and associated compounds have been well documented, but residential sources only now being focused on (in wastewater studies)

C. References

City and County of San Francisco (1991)

Connell and Miller (1984)

K.P. Lindstrom and Associates (1985)

Washington Toxics Coalition (1990 - 1992)

D. Remaining Data Needs

Magnitude of pesticide use in residential practices; compounds used.

EXPOSURE PATHWAY #87

Loss of organisms and changes in habitat in aquatic, semi-aquatic (wetlands), and terrestrial systems due to hazardous or toxic compounds released by uncontrolled land disposal that is part of residential practices.

A. Pathway Elements

Agent(s):	Land disposal
Stressor(s):	Hazardous or toxic compounds
	Metals and metal compounds
Medium:	Land, Water
Receptor:	Terrestrial, aquatic or semi-aquatic plants, aquatic organisms, fish, invertebrates, birds, and mammals
Effect:	Individual organism loss or toxic effects; loss of sensitive species in favor of tolerant ones

B. Ranking Score (Total Score = 13)

Intensity:	2	Loss of individual organisms, particularly fish and birds
Extent:	1	Highly localized effects around sources
Reversibility:	5	Organic and metal compounds highly persistent once in the environment
Probability:	5	Effects are well documented, although perhaps not contributions from residential sources

C. References

City and County of San Francisco (1991)

Connell and Miller (1984)

K.P. Lindstrom and Associates (1985)

D. Remaining Data Needs

Surveys of individual residential land disposal practices.

Ecological monitoring and risk assessments of active or abandoned sites.

EXPOSURE PATHWAY #95

Individual organism loss and population/community changes on freshwater aquatic species due to irrigation leaching and drainage, erosion and runoff, nutrients, and dissolved oxygen depletion from fertilizer application and irrigation that are part of residential practices.

A. Pathway Elements

Agents(s):	Fertilizer application and irrigation
Stressor(s):	Dissolved oxygen depletion
	Irrigation Leaching and Drainage
	Nutrients
	Erosion
	Runoff
Medium:	Water
Receptor:	Aquatic plants, and animals
Effect(s):	Fish mortality, loss of sensitive populations, change in aquatic communities

B. Ranking Score (Total Score = 10)

Intensity:	3	Loss of individual organisms, such as mortality of fish; loss of algal and invertebrate species that are sensitive to organic pollution and sedimentation
Extent:	1	Highly localized effects in stream systems or ponds
Reversibility:	1	Less than one year - effects are usually seasonal
Probability:	5	Cultural eutrophication and sedimentation effects are well documented; however, percentage coming from residential practices alone not defined

C. References

Chapman and Hall (1992)

Connell and Miller (1984)

U.S. Environmental Protection Agency (1983)

D. Remaining Data Needs

Determine magnitude of problem coming from residential sources. Monitor localized effects in surface waters surrounding developments on specific types of fish species, the invertebrate population, and diversity indices.

EXPOSURE PATHWAY #102

Ecosystem alteration due to clear cutting timber harvest as an agricultural practice.

A. Pathway Elements

Agent(s):	Harvesting
Stressor:	Physical alteration
Medium:	Land
Receptor:	Forest ecosystems
Effect:	Change in vegetation structure and topography resulting in habitat alteration.

B. Ranking Score (Total Score = 13)

Intensity:	4	The intensity of this effect is difficult to score as it results in an altered ecosystem and possible erosion within the localized area. While the impacts are substantial in the specific locality, the overall threat is related to the portion of the total ecosystem affected
Extent:	1	This was scored low as only a very small portion of California forest lands are clear cut within any one year; however, it is recognized that more substantial percentages of more limited ecosystem types (old growth) may be affected
Reversibility:	4	The majority of timber lands under management would be largely renewed within 20 years with the exception of erosion impacts
Probability:	4	Although the effect on the localized ecosystem is virtually certain, there is some uncertainty of the effects of multiple localized harvesting on the overall forest ecosystem

C. References

D. Remaining Data Needs

Percent forest clear cut each year, particularly as it effects different ecosystems within the State.

EXPOSURE PATHWAY #103

Ecosystem destruction due to land-use conversion to agricultural uses.

A. Pathway Elements

Agent(s):	Land-use Conversion
Stressor:	Physical alteration
Medium:	Land
Receptor:	Terrestrial habitat and ecosystems
Effect:	Physical destruction of plants and habitats, alteration of water supplies

B. Ranking Score (Total Score = 13)

Intensity:	5	Although conversion of current habitat lands to agricultural uses most often results in complete destruction of the previous habitat, some uses (rice, timberland, rangeland) may result in alternative ecosystems
Extent:	1	This type of conversion is expected to be quite limited. Some conversion in very small, but sensitive areas such as wetlands may be of greater concern
Reversibility:	2	This type of change is likely to be reversible within five years
Probability:	5	This effect is virtually certain to occur

C. References

D. Remaining Data Needs

Acres converted from habitat to various agricultural uses each year. Acres of wetland converted would be an important subset.

EXPOSURE PATHWAY #104

Habitat degradation from selenium from agricultural irrigation (drainage) practices.

A. Pathway Elements

Agent(s):	Irrigation practices
Stressor:	Selenium
Medium:	Water
Receptor:	Wetlands organisms, aquatic and terrestrial
Effect:	Population reduction due to accumulated selenium

B. Ranking Score (Total Score =12)

Intensity:	3	Effect is directly related to concentration which varies widely in aquatic ecosystems. Since runoff/drainage waters contain relatively low levels, this stressor is likely to have the most pronounced effects in impoundment situations
Extent:	1	Although selenium is known to occur widely in California, receiving impoundments are comparatively less common
Reversibility:	4	Effects from such accumulations are expected to be relatively persistent
Probability:	4	Effects are known to occur at levels found in specific situations

C. References

D. Remaining Data Needs

Extent of receiving impoundments with significant concentrations.

EXPOSURE PATHWAY #105

Atmospheric degradation due to emission of oxidants from open burning of agricultural wastes.

A. Pathway Elements

Agent(s):	Open Burning
Stressor:	Atmospheric oxidants
Medium:	Air
Receptor:	Plant ecosystems
Effect:	Damage to crop plants and natural vegetation

B. Ranking Score (Total Score = 10)

Intensity:	2	Intensity is largely a factor of total burning within a particular area, substantially moderated by current regulation of agricultural burning
Extent:	2	Agricultural burning takes place during a limited time period (the winter months) in those agricultural areas where rice and tree crops are grown
Reversibility:	1	Oxidants rapidly dissipate under most circumstances
Probability:	5	This source is known to make a substantial contribution to atmospheric oxidants during specific times and locations

C. References

D. Remaining Data Needs

Total contribution of agricultural burning to atmospheric oxidants.

EXPOSURE PATHWAY #106

Ecosystem damage due to overgrazing of livestock as an agricultural practice.

A. Pathway Elements

Agent(s):	Animal maintenance
Stressor:	Livestock
Medium:	Terrestrial
Receptor:	Plant and animal communities
Effect:	Destruction of plant communities leading to habitat degradation

B. Ranking Score (Total Score = 8)

Intensity:	2	Intensity is highly variable. The highest intensity occurs in a very small extent. Less intense impacts occur on a more widespread basis
Extent:	1	This threat received a low ranking since the greatest impact is seen when land is converted from habitat to grazing land, which does not occur widely today. Overgrazing leading to additional ecological effects, such as erosion, is greater in intensity but also rare
Reversibility:	2	Most results of overgrazing are known to be reversible within two to three years of removal of livestock
Probability:	3	Although overgrazing results in observable effects on vegetation, the ecosystem effects are not well understood, particularly as they apply to altered animal species composition

C. References

D. Remaining Data Needs

Percentage of rangelands subject to overgrazing and data to characterize the extent of ecological damage in these areas.

EXPOSURE PATHWAY #107

Aquatic ecosystem degradation due to pesticide runoff from agricultural practices.

A. Pathway Elements

Agent(s):	Pest management
Stressor:	Pesticides
Medium:	Water
Receptor:	Aquatic plants, invertebrates and vertebrates
Effect:	Reduction or alteration of aquatic populations

B. Ranking Score (Total Score = 7)

Intensity:	1	While toxic levels have been found in localized areas, the effects in wider aquatic ecosystems are likely to be significantly more subtle
Extent:	2	Residues of currently used pesticides have been detected in relatively limited areas
Reversibility:	2	Pesticides currently used are comparatively short lived in the aquatic environment and reversibility is largely determined by reproduction and recruitment
Probability:	2	A number of pesticides have been found at low levels in aquatic ecosystems resulting from runoff from treated agricultural fields. The probability of population effects at these levels is generally unknown; however, they could be significant. Note that this does not include mobilization of sediments contaminated with organochlorine pesticides not currently used

C. References

D. Remaining Data Needs

Percentage of aquatic ecosystems carrying toxic levels of pesticides from agricultural runoff.

EXPOSURE PATHWAY #108

Degradation of aquatic ecosystems from surface water depletion resulting from overdrafts due to contamination of groundwater.

A. Pathway Elements

Agent(s):	Water allocation and use
Stressor:	Surface water depletion
Medium:	Water
Receptor:	Aquatic organisms
Effect:	Decreased populations of aquatic organisms due to reduced flows

B. Ranking Score (Total Score = 7)

Intensity:	2	Although this may have pronounced effects in very limited situations, it is expected to have little impact in overall systems
Extent:	1	Because of very limited amounts of surface water used to replace contaminated groundwater, the extent is expected to be very small
Reversibility:	2	Any effects from such diversions are expected to be rapidly reversible
Probability:	2	Although this effect is projected to occur, there is little information to characterize the nature of the effect

C. References

D. Remaining Data Needs

Amount of increased surface water use due to abandonment of contaminated groundwater source.

EXPOSURE PATHWAY #109

Aquatic ecosystem degradation due to nutrient runoff from agricultural practices.

A. Pathway Elements

Agent(s):	Fertilizer application
Stressor:	Nutrients
Medium:	Water
Receptor:	Aquatic organisms
Effect:	Population reduction of aquatic organisms and eutrophication

B. Ranking Score (Total Score = 6)

Intensity:	1	Significant levels have been found in localized areas; however, the effects on large scale ecosystems are likely to be less pronounced
Extent:	2	Nitrogen compounds and other nutrients are found in many aquatic systems
Reversibility:	1	In lower concentrations, nutrients are short lived in the aquatic environment and reversibility is largely determined by reproduction and recruitment
Probability:	2	Nutrients are often found at high levels likely to have significant effects in very localized areas. Much lower levels are found in larger systems. The probability of population effects at these levels is generally unknown

C. References

D. Remaining Data Needs

Percentage of aquatic ecosystems carrying significant levels of nutrients from agricultural runoff.

EXPOSURE PATHWAY #110

Production of greenhouse gasses from fertilizer application.

A. Pathway Elements

Agent(s):	Fertilizer application
Stressor:	Greenhouse gasses
Medium:	Air
Receptor:	Plant ecosystems
Effect:	Damage to crop and natural plants from oxidants

B. Ranking Score (Total Score = 6)

Intensity:	1	Intensity of impact is related to the portion of greenhouse gasses resulting from this source
Extent:	2	Although the phenomenon may be widespread, it may only be a significant source in limited areas
Reversibility:	1	Production of CH_4 changes rapidly under varying conditions
Probability:	2	Although production of greenhouse gasses is established, there is inadequate data to characterize the relation to other sources. Also, some studies indicate that vegetation change is the primary determinant. Indeed, fertilizer applications may reduce greenhouse gas production under some circumstances

C. References

D. Remaining Data Needs

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Social Welfare Committee Appendix

Summaries of Impacts Assessed for List II Topic Area Rankings

GENERAL CAVEAT

The "summaries of impacts assessed" are presented here as illustrative of the SWC's process (using the criteria and measures to rank the topic areas), rather than as definitive discussions of social welfare impacts of the areas covered. The Social Welfare Committee was unable to reach consensus on these summaries.

ASBESTOS

A class of magnesium-silicate minerals (chrysotile, crocidolite, amosite) that occur in fibrous form, asbestos is present in serpentine rock formations in California and is used in the manufacture of automotive brake and clutch linings, and a variety of building materials. Exposures to asbestos may occur: in homes, schools, and other buildings due to degradation over time of materials containing asbestos; during or following removal activities, or destruction of buildings containing asbestos; due to automobile braking; in drinking water; and in occupational settings such as asbestos abatement, automobile brake repair, materials manufacturing, and mining.

Environmental and Aesthetic Well-being -- LOW

Difficult to detect, asbestos exposure does not impact aesthetic or environmental well-being.

Economic Well-being -- MEDIUM

Given estimates that over half the buildings in the United States contain asbestos in a form that could give rise to indoor air exposures (ARB, 1986), the impact on property values of the presence of asbestos and the cost of treatment of asbestos-related diseases were the primary factors considered in ranking this criteria. The number of people impacted, the severity of the impacts (costs), and the involuntariness of the impacts were considered of medium concern.

Physical Well-being -- HIGH

The number of people exposed, the severity of the impact of exposure, the irreversibility of the impact, an uneven distribution and lack of detectability of exposure were all considered high. Occupational exposures present the greatest risk of asbestos-associated cancer mortality; the number of people impacted by current exposure levels was considered low.

Peace of Mind -- MEDIUM

With widespread occurrence and public concern about the potential hazards associated with exposure, the impact on peace of mind is of medium concern. The major impact considered was anxiety, especially for parents of children in schools where the potential for exposure exists, as well as for individuals exposed at home or in the workplace. While the involuntariness of the exposure was considered to be of high concern, the number of people impacted, severity of impact, and distribution of exposure were considered to be of medium concern, with low levels of concern for reversibility (of the peace of mind impact).

Future Well-being -- MEDIUM

Concerns regarding the future health impacts of exposures occurring now in schools, and the costs of controlling hazards associated with destruction of older buildings which have asbestos-containing materials were the primary factors considered in assessing this criteria. High levels of concern were noted for the involuntariness and uneven distribution of exposure, with low levels of concern for the number of people impacted and the severity of the impacts.

Equity of Impact -- MEDIUM

Equity was of medium level of concern primarily because of the impact of exposures which occur or have occurred in occupational settings. Severity and irreversibility of impact, and uneven distribution of exposure, were of high concern. The number of people impacted was considered low, particularly for current or future occupational exposures, assuming better controls are in place than were used previously. Based on an estimate by Lilienfeld *et al*. (1988), over 700 deaths per year from asbestos-related cancers will occur in California between 1985 and 2009 due to past exposures. Manufacturing facilities using asbestos, and an asbestos mine, operate in California (ARB, 1986).

Community Well-being -- MEDIUM

An impact on community cohesiveness, such as loss of cooperation or willingness to solve problems together, resulting from decision-making on removal of asbestos from schools and other community buildings was the primary impact considered. Involuntariness of exposure and the severity of the impact were of medium concern and primary importance in assessing this criteria.

Overall Ranking -- MEDIUM

Impacts on current economic and physical well-being, concerns about impacts on future well-being, and peace of mind and community well-being concerns are summarized overall as a medium level of concern for the social welfare impacts of asbestos.

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ELECTROMAGNETIC FIELDS (EMF)

Wherever there is electric current there are also electric and magnetic fields, which are created by the electric charges. Exposure to electromagnetic fields (EMF) occurs as a result of proximity to radio and television transmitters, power lines, radar, microwave transmissions, and various home and office appliances and wiring.

Environmental and Aesthetic Well-being -- LOW

No impacts were considered to exist relative to this criteria, given that EMF is not detected by the senses nor does it influence recreational activities or experience of wilderness.

Economic Well-being -- LOW

Costs associated with attempts to avoid exposure to EMF were considered low for most people. Concerns about possible hazards of EMF may impact property values of houses located near high power lines. Because the extent to which EMF is causing disease is uncertain, costs associated with such disease cannot be estimated.

Physical Well-being -- UNABLE TO ESTIMATE

Health studies of workers and children have suggested that increased cases of cancer may occur in locations thought to have high magnetic fields, and preliminary studies suggest behavioral and reproductive effects, but the scientific information now available is insufficient to draw definite conclusions. While the number of people exposed and the involuntariness and lack of detectability of exposure is of high concern, the severity of the impact cannot presently be estimated.

Peace of Mind -- HIGH

The major impact considered is anxiety in those people who are aware of and concerned about the possible health effects, particularly parents concerned about effects on their children. While the number of people impacted is low, the severity of the impact and the involuntariness and lack of detectability of the exposure are of high concern.

Future Well-being -- UNABLE TO ESTIMATE

Because the impact on physical well-being is not possible to estimate at this time, the impact on future well-being cannot be estimated. The pervasiveness and increasing abundance of sources of EMF in modern society make the pursuit of more definitive information about the possible health hazards critical for future well-being.

Equity of Impact -- MEDIUM

While exposure to EMF is variable and widespread throughout the population, people living near high power lines, transformers and other potentially important sources, and those heavily exposed in occupational settings may be inequitably impacted. The number of people impacted is of medium concern, as is the severity of the impact and the involuntariness of the exposure, with high concern for lack of detectability.

Community Well-being -- MEDIUM

The scientific evidence for regulatory action is currently considered inadequate. For those with concerns about possible health impacts, the perceived lack of action by government officials to control existing exposures may lead to a breakdown in community cohesiveness, with individuals feeling left out of the decision-making. The number of people impacted is low, with a high level of concern for voluntariness, and medium concerns for the severity and irreversibility of the impact.

Overall Ranking -- UNABLE TO ESTIMATE

Driven by the lack of definitive information on the physical impact of exposure to EMF, the overall ranking is that the Social Welfare Committee was unable to estimate the social welfare impact of EMF. Despite high concerns for peace of mind impacts and medium concern for equity and community well-being, the need for further research on the health effects lead to this overall assessment.

ENVIRONMENTAL TOBACCO SMOKE (ETS)

Environmental Tobacco Smoke primarily comes from sidestream smoke emitted by the burning tobacco between smoker's puffs as well as from mainstream smoke, which is drawn through the cigarette into a smoker's mouth and then exhaled. Exposures to ETS occur as a result of other people's cigarette smoking in homes, workplaces and public places. These exposures lead to social welfare impacts (disturbances of well-being) experienced by the individual as well as society.

Environmental and Aesthetic Well-being -- HIGH

The eye, nose, and throat irritation associated with exposure to ETS were the main factors considered in assessing this criteria. The number of people exposed and impacted, and the involuntariness of the exposure were considered high, as was the severity of the impact on aesthetic well-being.

Economic Well-being -- HIGH

Costs associated with the illnesses caused by exposure to ETS were the main factors considered in assessing this criteria. Such costs include direct medical costs, lost productivity due to illness and disability, and lost future earnings due to premature death. Additional costs are associated with workplaces where smoking is allowed, such as employee absenteeism, medical insurance, and higher costs for fire insurance.

Physical Well-being -- HIGH

The impact of exposure to ETS on lung cancer incidence, aggravation of asthmatic children's conditions, and development of respiratory infections in young children as reported by the U.S. EPA's (1992) report were the main factors considered in assessing this criteria. The number of people exposed and impacted, the severity of the impact and the involuntariness of the exposure were all considered high. The Social Welfare Committee was especially concerned about the impacts on children of smokers.

Peace of Mind -- HIGH

Several impacts were considered in assessing this criteria, including anxiety in those exposed to ETS regarding the health impacts, the conflict experienced by those exposed in workplaces who feel they do not have other employment options, and concern (of both nonsmoking spouses and smoking parents, and others) for the health impacts on children of smokers.

Future Well-being -- MEDIUM

The impaired health of children of smokers was considered to have an impact on future well-being, because of the economic and physical well-being impacts expected in the future due to current exposures. The growing trend toward no-smoking ordinances in public places and workplaces led the SWC to estimate that other impacts could be expected to decrease in the future, with fewer people being exposed.

Equity of Impact -- HIGH

The main impact considered by the SWC to be inequitable was the health impact on children of smokers. In addition, an estimated 2.2 million nonsmoking workers were exposed in indoor workplaces in California in 1990; nonsmokers with more exposure were disproportionately young (18 to 24 years old), male, Hispanic, or had less than a high school education.

Community Well-being -- MEDIUM

Controversy regarding smoking ordinances and bans was the main factor in assessing this criteria. Such controversy may be divisive in communities, impacting a medium number of people, with a medium level of severity.

Overall Ranking -- HIGH

The assessment of five of the seven criteria was a high, therefore the SWC felt the overall ranking of the ETS problem area must be high. The Social Welfare Committee's overriding concern was the continuing exposure experienced in the homes of smokers by their children, and a concern for their spouses.

One member of the SWC dissented with this rank, suggesting that this topic area be ranked low based on smoking prohibitions and restrictions currently in place in most workplaces and public places (e.g., restaurants, transportation systems) in California. These controls have greatly reduced the ETS exposure of nonsmokers, with the primary remaining risks occurring in the home, to children and spouses of smokers. In addition, the number of smokers is decreasing, suggesting that the problem of ETS exposure will be further reduced in the future.

References

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VOLATILE ORGANICS

A wide range of compounds in different chemical classes, volatile organics have a variety of impacts on human populations. (Impacts associated with other environmental topic list II items, such as ozone and ozone depletion, are not included here.) Examples are: compounds found in drinking water (e.g., 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), chloroform), widespread toxic air contaminants (e.g., benzene, methylene chloride, perchloroethylene), and compounds occurring in consumer products or services (e.g., formaldehyde, hexane, xylene, toluene). Occupational exposures occur in a wide range of industries. Many of the volatile organics are considered to be carcinogenic, while others have been identified as reproductive toxins.

Environmental and Aesthetic Well-being -- MEDIUM

Impacts considered include odors and unpleasant tastes. Many of these compounds have odors, which may adversely impact people living near facilities which release volatile organics into the air (e.g., dry cleaners) or as they are released from consumer products (e.g., formaldehyde in pressboard furniture). The presence of these compounds in drinking water may impart an unpleasant taste. The lack of voluntariness of these exposures, the number of people exposed and impacted were of high concern, with medium levels of concern for severity of impact and distribution of exposure and low concerns for reversibility.

Economic Well-being -- MEDIUM

The impacts considered were costs associated with health care for people impacted by exposure to the volatile organics (e.g., carcinogens and reproductive toxins), and with avoidance of these compounds when there are choices of consumer goods and services. Examples include filtering tap water or using bottled water to avoid exposure to a drinking water supply containing these compounds; use of more expensive (and less toxic) consumer products and services to avoid these compounds (e.g., solid wood furniture versus pressboard furniture, full service gasoline versus self service gasoline).

Physical Well-being -- HIGH

Because of the pervasive presence of volatile organics, a large number of people are exposed to these compounds. The impact is expected to be greatest for the higher exposures (e.g., to the carcinogens and reproductive toxins) occurring in occupational settings. In addition, some people may be more sensitive to the impact of these compounds (e.g., individuals with so-called "multiple chemical sensitivity"). The number of people exposed, and the severity and irreversibility of the impact were of high concern, with medium levels of concern for the number of people impacted, and the involuntariness and distribution of exposure.

Peace of Mind -- MEDIUM

Impacts include anxiety due to odors and to an inability to distinguish the most hazardous (e.g., carcinogens) from the less hazardous ones (e.g., noncarcinogens), and lack of much choice about exposures (e.g., using contaminated drinking water, or moving from a home beside an emission source such as a dry cleaner) once a person learns of a hazard. In the case of many consumer products, people may not have access to reliable information about potential hazards, ways to reduce exposure, or alternative products. The number of people impacted and the severity of the impact were of medium concern and primary importance in assessing this criteria.

Future Well-being -- MEDIUM

The primary impact considered was contamination of drinking water supplies which may limit future generations' ability to use these supplies. There were high levels of concern for the irreversibility and the involuntariness of this impact, with medium levels of concern for the number of people impacted and the severity of the impact.

Equity of Impact -- HIGH

Impacts considered inequitable include: health risk to individuals living near roadways and near facilities which emit volatile organics into the air; access to safe drinking water due to income; occupational exposures (e.g., semiconductor manufacturing workers); and availability of safer consumer products due to income. The number of people impacted and the severity of the impact were of primary importance and were considered high, with medium concern for irreversibility of impact, and lack of detectability and involuntariness of exposure.

Community Well-being -- MEDIUM

Impacts of concern include a breakdown in community cohesiveness resulting from individual solutions to avoiding exposure to volatile organics, rather than contributing to a common solution. For example, purchase of bottled water supplies to avoid drinking water contamination, or self-isolation of individuals with "multiple chemical sensitivity" to avoid exposures. While the number of people impacted was considered low, the severity of the impact was considered high.

Overall Ranking -- HIGH

The major driving concerns were for the pervasive exposures to a wide range of volatile organic compounds, many of which have health impacts with serious consequences, reflected in high levels of concern for impacts on both physical health and equity. Additional concerns for impacts on environmental and aesthetic well-being, and peace of mind, lead to the overall rank of high.

AGRICULTURAL USE OF PESTICIDES

This topic area addresses issues relating to the application and use of currently registered pesticides in agricultural settings and to the associated residues in food, water, and the environment. It does not address problems associated with the manufacture, transport, or storage of pesticides. It also does not consider the regulatory uses of pesticides such as vector control or eradication programs, nor does it address issues that are better discussed in other problem areas (e.g., persistent organochlorines and volatile organic compounds). Only problems associated with pesticide use will be considered, not benefits.

Environmental and Aesthetic Well-being -- LOW

Most of the undesirable effects of pesticides on the environment have been avoided or mitigated in California. Pesticides may still be present locally in state waterways, but effects on aquatic ecosystems are subtle and not likely to be observed by the general public. Effects on the terrestrial environment are not significant. However, some pesticides (e.g., molinate) and plant growth regulators (e.g., tribufos), which are regulated as pesticides, are malodorous and can effect people in rural areas and at the rural/suburban interface.

Economic Well-being -- MEDIUM

Many people, believing that foods treated with pesticides during production are not healthful, pay higher prices for organically grown products. Workers who are exposed to pesticides and pesticide residues as part of their jobs (e.g., applicators, farmworkers), may lose wages during pesticide-induced illnesses or may have additional medical costs. Problems associated with workplace exposure are not evenly distributed through the population as a whole.

Physical Well-being -- MEDIUM

Exposure to pesticides may cause illness. However, the distribution of the exposure is not equal through the population. Mixer/loaders have the highest risk from their exposures, but farm workers may also have significant exposures. A large portion of the general population may be exposed involuntarily to small quantities in air and food.

Peace of Mind -- HIGH

Surveys have indicated that many people are very concerned about pesticide residues on food (especially food consumed by children), environmental contamination, and worker safety. Risks are perceived to be associated with involuntary exposures.

Future Well-being -- MEDIUM

There is concern that the widespread use of pesticides helps promote agricultural production methods that are not sustainable for future generations and therefore may ultimately threaten rural economies. Pest species will continue to develop resistance to pesticides, presenting new challenges to growers. Valuable crop protection chemicals may lose their registrations if environmental problems associated with them cannot be mitigated. Each of these problems are examples of those whose "costs" will be borne by future citizens.

Equity of Impact -- HIGH

Risks associated with exposure are borne disproportionately by those in agricultural occupations and by those who live in agricultural areas. Often those who are most exposed (i.e., mixer/loaders, farmworkers) are least prepared economically to reduce their exposure or risk by taking other employment or moving.

Community Well-being -- MEDIUM

Pesticide issues can be very divisive for communities. For example, rural residents are often upset regarding herbicide use during reforestation efforts. Logging companies and associated local interests favor the herbicide use. It is also evident that as suburbs expand into farming areas, new residents object to many farming practices including pesticide use. Such situations have been very controversial in many Central Valley towns.

Overall Ranking -- HIGH

The "high" rankings for "Peace of mind" and "Equity" were very strong and outweighed the influence of the relatively low environmental and human health category ranking. In this case, the perceived risks were more important than the actual risks. There was no dissension on the SWC regarding this ranking.

EXOTIC SPECIES

Exotic species are those species of living organisms which have been introduced into California rather than being native to California. Ninety percent of California's serious pests are exotic. More than 10 percent (>3,000 species) of California's vegetation is now exotic. For California's grasslands, the figure is closer to 90 percent. In general, problems associated with exotic species include displacement of native species; aggressive colonization and encroachment of lands, and disruption of fragile environments and ecosystems; unrestricted destruction of resources, property, and products due to lack of natural controls. The actual ecological impacts of exotic species were not considered as these impacts were felt to be better addressed by the Ecological Health Committee. Human pathogens were also excluded form consideration.

Environmental and Aesthetic Well-being -- MEDIUM

The ranking was based on degradation of both aesthetics and recreation. For example, introduced weeds choke out and displace native wild flowers and other native vegetation, destroying wildlife habitat as well as scenic areas. Boating waterways and fish populations can be adversely impacted by the choking aquatic weeds. Introduced insects and diseases such as Dutch Elm Disease can attack and destroy ornamental plants.

Economic Well-being -- HIGH

The ranking was based on the very serious economic costs, especially to agriculture. Exotic animals and plants are responsible for 67 percent of all reported crop losses. For example, in 1992, Imperial County alone experienced an agricultural crop loss in excess of eighty-five million dollars, largely due to a single exotic pest, the strain B sweet potato whitefly. The State of California spent twenty-five million dollars to control Dutch Elm Disease between 1975 and 1990. Local California municipalities have spent millions more to survey and remove elms infected with this European tree disease and destruction of trees has reduced property values for homeowners.

Physical Well-being -- LOW

Exotic species were considered to cause generally low concern with respect to physical well-being. Some individuals may develop annoying or activity-limiting allergies to exotic weed species or insect stings.

Peace of Mind -- LOW

Exotic species were considered to cause a low amount of concern with respect to peace of mind since most Californians are unaware that the ecological and economic consequences of exotic species are extremely serious.

Future Well-being -- HIGH

This ranking is based on the consideration that exotic pests continue to increase in California. It is estimated that one new species becomes established in the State every 60 days. Thus, the impacts of exotic organisms are likely to continue to worsen rather than improve and future generations will be paying the social welfare costs. For example, the Africanized honey bee can be expected to cause serious peace of mind problems when it becomes established in California. Other pests will cause increasing economic problems to agriculture.

Equity of Impact -- LOW

In general, exotic organisms affect most Californians uniformly. The agricultural sector suffers the most direct economic damage, however, when agricultural damage from exotic pests adversely affects food prices, the poor feel the "squeeze" the most. Residents of poor neighborhoods tend to depend more heavily upon the shade of large street trees, landscape trees, etc., to provide relief from summer heat than do affluent residents who can afford air conditioning. Therefore, these poorer residents suffer most when trees are lost to exotic pests.

Community Well-being -- MEDIUM

Conflicts in priorities pertaining to exotic species can cause community divisiveness. For example, to horse owners, yellow starthistle is a killer, but to beekeepers, it is a wonderful resource for honey production. Eucalyptus trees are a fast growing, high biomass-producing species to some, a desirable ornamental to others, and an invasive weedy fire hazard to still others. Quarantines to prevent the introduction of new exotic pests may be viewed by some in the community as a biological and environmental necessity, and by others as government interference in commerce or a restriction to trade.

Overall Ranking -- MEDIUM

The individual criteria rankings for this topic are mixed, but the SWC felt that, taken together, all of the criteria indicated that an overall ranking of medium was appropriate.

Two Social Welfare Committee members felt that the overall ranking should be "high," based on the economic and ecological effects which were felt to outweigh the other criteria.

GENETICALLY ENGINEERED ORGANISMS

Genetic engineering, also called recombinant DNA technology, may be defined as deliberate changing of the make-up of living cells by transferring a fragment of DNA from the cells of one organism to the cells of a different organism so that the latter can produce new substances. Genetically engineered organisms (GEOs) include viruses, bacteria, fungi, plants, and animals that produce pharmaceutical agents ("Pharm" animals) for use by humans and animals. Current applications of recombinant DNA technology include the development of biopesticides (to control pests and diseases and to protect plants against frost), transgenic plants (plants that produce pesticides, plants resistant to pests or diseases, and plants with improved agronomic characteristics such as tomatoes with delayed softening), and microorganisms that produce pharmaceutical agents (e. g. insulin). This definition includes only genetically engineered organisms, not products produced through genetic engineering, such as bovine somatotrophin or insulin.

Environmental and Aesthetic Well-being -- LOW

The Social Welfare Committee could find no evidence of current environmental or aesthetic impacts of GEOs.

Economic Well-being -- LOW

The Social Welfare Committee could find no evidence of current economic impacts of GEOs.

Physical Well-being -- LOW

The Social Welfare Committee could find no evidence of current physical welfare impacts of GEOs.

Peace of Mind -- MEDIUM

Ranking is based on public awareness and concern about issues surrounding transgenic tomatoes, crop plants engineered to be resistant to herbicides, and the potential for engineering food plants that contain animal genes and vice versa.

Future Well-being -- UNABLE TO ESTIMATE

Currently, the impact of GEOs appears to be low in California. However, many new GEOs are under development. No data was available that the SWC could use to estimate whether current or newly developed GEOs will have any future effects on social welfare and, if there are effects, how severe these effects might be. Without such information, the SWC felt that it was not possible to make any ranking for this criterion.

Community Well-being -- LOW

Ranking is based on the low incidence of any community disruption due to GEOs.

Equity of Impact -- LOW

Currently, there appear to be no disproportionately affected subgroups.

Overall Ranking -- UNABLE TO ESTIMATE

The Social Welfare Committee felt that the *current* impact of GEOs in California appears to be low; however, this low impact is due primarily to the fact that so far few GEOs have been released into the environment. More GEOs are being developed and will be used, but currently available information was insufficient for the SWC to make any estimate of the kind or severity of future impacts of GEOs on social welfare. The lack of information about the future was so critical that the SWC agreed that it was not possible to estimate any sort of ranking for GEOs.

ORGANOCHLORINES

Organochlorines include a wide variety of organic compounds that resist narrow categorizations. During topic ranking procedures, compounds identified in the California Comparative Risk Project's final ranking template were considered. Specifically, they include DDT and other persistent chlorinated insecticides no longer in use in California, DBCP, pentachlorophenol, chlorinated dibenzo-p-dioxins (including TCDD) and dibenzofurans, and polychlorinated biphenyls (PCBs).

Environmental and Aesthetic Well-being -- MEDIUM

Because of their resistance to degradation, their resulting widespread persistence in the environment, their high acute toxicity to organisms at the base of the food chain, and their high potential for bioaccumulation, persistent organochlorines are hazardous to the environment. In California, wildlife and aquatic organisms continue to be exposed to these compounds, in some instances at concentrations that compromise aesthetic and recreational values. For example, fishermen have been advised to limit their intake of fish from certain areas because concentrations of DDT-related compounds in fish flesh remain high. To heighten the concern for these compounds and their effects on the environment, their solubility in water is low, confounding efforts to identify sources and understand their distribution in water, sediments, and biota.

Economic Well-being -- MEDIUM

Aquifers in the San Joaquin Valley have been contaminated with DBCP and are no longer fit as drinking water supplies. Individuals and communities, including the city of Fresno, have had to procure alternative water supplies.

Physical Well-being -- HIGH

Persistent organochlorines are very widespread in the environment and in human tissues. They are even found in breast milk. In addition, all of the chemicals listed in the final ranking template, except the chlorinated dibenzofurans, are listed as carcinogens under Proposition 65; DBCP is also listed as a male reproductive toxin. Given the large number of people, including children, who continue to be involuntarily exposed to these chemicals, concern for physical well-being is high.

Peace of Mind -- MEDIUM

Many people associate DDT with declines in predatory bird populations; TCDD with Seveso, Times Beach, and Agent Orange; and DBCP with contaminated groundwater and low sperm counts in formulation plant workers. There have been instances when government evacuated areas in response to contamination with persistent organochlorines. People regard these chemicals as technologic "mistakes;" the hazards were not known until contamination of the environment was widespread. In addition, people live with the knowledge that they are still continuously exposed. As a result, trust in the chemical industry, agriculture, and the government institutions that regulate them suffered.

Future Well-being -- MEDIUM

Inputs of persistent organochlorines into the environment have been greatly reduced. However, the persistence of these chemicals allows those already in the environment to remain available to enter the food chain and potentially affect ecological and human health for many years. In addition, inputs of chlorinated dibenzodioxins and furans remain (e.g., incinerators) and are of concern.

Equity of Impact -- HIGH

While persistent organochlorines are ubiquitous in the environment and all people are exposed to them, certain subpopulations have higher exposure than others. Those whose diets rely on fish caught from affected waters, for reasons of economic necessity, ethnic custom, or avocation, may be exposed to relatively high concentrations of these compounds, particularly PCBs and chlorinated hydrocarbon insecticides. Nursing infants are exposed to compounds present in breast milk. People who drink well water in the San Joaquin Valley historically had greater exposure to DBCP until the wells were closed.

Community Well-being -- MEDIUM

Problems associated with some of these chemicals could potentially be devastating to a community. For example, detections of DBCP in San Joaquin aquifers and of pentachlorophenol in groundwater under lumberyards have already created discord within communities.

Overall Ranking -- MEDIUM

The Social Welfare Committee assigned high rankings to "Physical Well-being" and "Equity," based primarily on the numbers of people involuntarily exposed to persistent organochlorines and the uncertainty of effects. The weight of the medium rankings of the other criteria justified the final ranking of medium. There was no dissension in the SWC on this ranking.

NONAGRICULTURAL USES OF PESTICIDES

Nonagricultural use of pesticides includes use in structural pest control, on landscapes and on rights-of-way, as well as home and garden use. It also includes regulatory and public health uses. These regulatory uses include pesticides used for eradicating exotic pest species like Mediterranean fruit fly. Sanitizers and disinfectants were not included. The Social Welfare Committee felt that the social welfare issues concerning eradication programs far outweighed issues concerning all other non-agricultural uses Therefore these rankings are based, except where noted, on considerations of eradication programs.

It should be noted that the definition of non-agricultural pesticide use used by the California Comparative Risk Project (CCRP) differs from the definition in California state law. The Social Welfare Committee used the CCRP definition. The Social Welfare Committee looked solely at the social welfare problems associated with non-agricultural pesticide use and did not consider benefits arising from this use.

Environmental and Aesthetic Well-being -- LOW

There are some effects such as loss of landscape plants due to improper homeowner use of pesticides and noise associated with helicopters used for eradication. The Social Welfare Committee felt the overall impact was low.

Economic Well-being -- LOW

There are some economic losses due to paint damage from aerial sprays used for eradication. During eradication programs, some people may seek medical treatment for perceived illness or illness due to stress and thus incur costs. Overall, these costs were considered low.

Physical Well-being -- LOW

This ranking is based on the fact that there are few documented cases of illness due to the pesticides used during eradication programs. Some people may suffer from stress-related illness which is not directly caused by the pesticides.

Peace of Mind -- HIGH

An environmental impact report for an eradication program summed up the peace of mind concerns: "Public apprehension and anxiety are recognized adverse impacts of pest eradication projects. It is not unusual for people to feel uneasy and anxious over unfamiliar chemical exposures. Even though a chemical may have been studied extensively, the concern of some is that current studies are somehow inadequate and their next test may reveal an adverse effect. In addition to anxiety and apprehension, some members of the public are angered and upset over what is characterized as 'involuntary exposure.'" The Social Welfare Committee agreed that these concerns were very real, very widespread, and very serious.

Future Well-being -- MEDIUM

This ranking is based on contamination of groundwater from pesticides used in landscape, right-of-way, and golf course maintenance. Such contamination may be long-term. Additionally, old pesticides continue to accumulate in garages, basements, storage sheds, and other areas around homes, presenting a disposal problem that will have to be addressed in the future.

Equity of Impact -- MEDIUM

The effects of this problem area are disproportionately felt by those in urban areas where most eradication projects occur. Furthermore, in these urban areas, projects occur in residential, rather than commercial or industrial areas. Historically, more projects have occurred in low or middle-income neighborhoods than high income. In addition, there was a SWC consensus that the risks are disproportionately borne by people other than the beneficiaries, i.e., the eradication projects benefit farmers, but the risks are borne by the urban public. Two members dissented from this consensus. These members felt that the establishment of pests such as Medfly in California would have significant negative aesthetic, health, and economic effects on all Californians, for example, increases in the cost of food and in the use of pesticides on food crops, and decreases in the availability of food, particularly organically-grown food and backyard gardening. Therefore, the beneficiaries of the projects are not limited to farmers.

Community Well-being -- HIGH

Historically, eradication programs have caused great disruption in communities. Distrust of community institutions is high. According to one EIR "The public has become dubious about accepting government declarations of safety, particularly when it pertains to chemical hazards. In California, there is a long history of public opposition to government application of pesticides in urban areas, especially aerial applications." Given the well-known and well-publicized community disruptions that have occurred in areas where eradication programs are being conducted, the SWC felt these effects were very serious.

Overall Ranking -- HIGH

The most important considerations in the overall ranking of this topic area were the very serious negative impacts on peace of mind and to the community, particularly those caused by pest eradication programs.

RADIONUCLIDES

Radionuclides include a variety of radioactive elements that are released by a variety of human activities, including energy production, medical or scientific activities, development and testing of nuclear weapons, and waste disposal practices. Radiation resulting from nuclear accidents is included, as are associated radioactive emissions occurring as a result of uranium mining and milling. Radiation associated with waste disposal includes both high-level and low-level wastes as well as wastes from the decommissioning of nuclear facilities. Our rankings also incorporate concerns about possible radiation from future nuclear accidents and existing unmonitored exposures.

Environmental and Aesthetic Well-being -- LOW

Ordinarily impacts here are slight; but in the case of a serious leak from an operational facility or from a waste site, impacts could be considerable.

Economic Well-being -- HIGH

The costs of storing wastes, in the form of taxes and higher prices, are unknown but are assumed to be considerable.

Physical Well-being -- MEDIUM

The precise number of people exposed to radionuclides is unknown (kept secret by the military), but we assume that a fair number of workers (e.g., industrial radiographers in hospital settings) and residents have been exposed, either by normal industrial handling, leaks, or illegal dumping. The consequences of exposure to low-level radiation are controversial; some studies indicate that there is no safe level of exposure (i.e., there is no dose without risk).

Peace of Mind -- HIGH

Many people are deeply concerned about nuclear power and radioactive waste. An example of the depth of concern was the widely-publicized public referendum in the Sacramento metropolitan area in which citizens voted to shut down the Rancho Seco nuclear power plant; a major issue was safety. Accidents at Three Mile Island and Chernobyl, media reports of poor safety records elsewhere, and the secrecy of widespread contamination at Hanford, have generated considerable distrust of nuclear institutions.

Future Well-being -- HIGH

Benefits from using radioactive materials are reaped now, while costs persist for thousands of years (e.g., storage of wastes). The impacts of a serious leak from an operational facility or from a waste site would be immense.

Equity of Impact -- HIGH

Some workers and residents are most directly affected, but many of the concerns and costs are widespread.

Community Well-being -- HIGH

Many communities near potential waste sites or along transportation corridors are intensely aroused and mobilized over the issue of radioactive waste. Several communities in California have voted to become nuclear-free zones.

Overall Ranking -- HIGH

The Social Welfare Committee felt that the issue of "Peace of Mind" and "Future Well-being" are especially important with radionuclides. The current lack of long-term storage sites for low-level and high-level wastes, and the problems inherent in storing radioactive wastes for thousands of years, remain a serious concern. The high costs of storage of wastes, and the potential for catastrophic economic and environmental costs in the event of an accident, also are important considerations.

One member thought that incremental exposures and other effects from human activities should have been ranked lower, given their resemblance to natural background exposures, and current United States and California nuclear safety vigilance.

OXIDES OF NITROGEN (NO_X) AND SULFUR DIOXIDE (SO_X)

Two oxides of nitrogen, nitric acid (NO) and nitrogen dioxide (NO_2), are formed during the combination of fossil fuels. Although the reactions at high temperature are reversible, the oxides of nitrogen (NO_x) formed are "frozen" when the exhaust gases cool down rapidly. Nitric oxides constitutes 90 percent or more of the NO_x in most combustion reactions. The NO reacts slowly with air to form NO_2 which is toxic and a human irritant. Some portion will subsequently be converted into nitrate in a particulate or acidic form. Biogenic sources of NO_x are still under investigation but may be substantial. In 1992 there were no exceedences of the federal standard in California, the California standard was exceeded twice (for one hour at two monitoring sites). NO_x can be an ozone precursor, but ozone is considered as a separate topic area.

Sulfur dioxide (SO_2) is a clear gas produced during the combustion of sulfur-containing fossil fuels, refining of non-ferrous metals, and a variety of chemical processes. SO_2 slowly oxidizes to sulfuric acid (H_2SO_4) in air. H_2SO_4 is a strong acid, linked to acid deposition in some parts of the country. In the presence of ammonia, the acid forms ammonium sulfate and ammonium bisulfate, both as particulates. California was in attainment for SO_x in 1992.

NOX and SO_X are considered as precursors to particulates. Particulates are considered as a separate topic area.

Environmental and Aesthetic Well-being -- MEDIUM

Ranked medium based primarily on visibility impact of NO_2.

Economic Well-being -- MEDIUM

Ranked medium based primarily on health care costs.

Physical Well-being -- MEDIUM

Ranked medium based on health impacts in areas of non-attainment and among sensitive individuals.

Peace of Mind -- MEDIUM

Ranked medium based on acid deposition and toxic impact concerns.

Future Well-being -- LOW

Ranked low based on controls in place that seem to be effective and plans for more stringent controls.

Equity of Impact -- MEDIUM

Ranked medium based on geographic distribution of non-attainment an differential sensitivities.

Community Well-being -- MEDIUM

Ranked medium. Often a concern combined with other air quality issues.

Overall Ranking -- MEDIUM

Driving forces are widespread sources and visibility concerns relative to NO_2.

ALTERATION OF AQUATIC HABITATS

Alteration of aquatic habitats includes five sub-categories; surface water diversion, dredging and filling wetlands, damming and channeling rivers, groundwater extraction, and coastal development. As with other topic areas (given the charge to the SWC), we considered only the costs of alteration of aquatic habitats and overlooked any benefits.

Environmental and Aesthetic Well-being -- HIGH

Recreational opportunities are negatively impacted by coastal development and wetland development; and the number of people aesthetically impacted is high. The functioning of natural ecosystems is also upset by these types of development, and by dredging and filling wetlands. Damming and channeling rivers and surface water diversion have decimated certain fish stocks (e.g., salmon), to the detriment of recreational fishermen. Damming of rivers has impaired natural processes of beach formation, leading to coastal erosion.

Economic Well-being -- MEDIUM

The potential costs from dam failures have negative impacts on economic well-being. Surface water diversion poses an uneven distribution of exposure to negative economic impacts. Of particular note would be the lost farming of the Owens Valley, impacts on the recreation industry at Mono Lake, and the costs of decimated fish stocks (e.g., salmon) for commercial fisherman. Subsidence from groundwater overdrafting damages buildings and reduces property values.

Physical Well-being -- LOW

For most of the sub-categories the impacts on physical well-being are low. There is the possible consequence of intrusion of agricultural toxics into rural drinking supplies in the event of groundwater extraction. We assume, however, that this is considered in other topic areas and avoid double-counting here. A dam failure could involve considerable loss of life, but such a failure is considered unlikely.

Peace of Mind -- HIGH

In the absence of data, we assume that the political clout of developers in obtaining approval of developments in coastal and wetland areas has bred some degree of cynicism about our governing institutions. Additionally, many people worry about the implications of unsustainable reliance on diminishing aquifers and the unwillingness of politicians to deal with this problem. This and other water wars have also contributed to some loss of faith in political institutions. The involuntariness of exposures (to filling wetlands, damming rivers, and surface water diversion) is high.

Future Well-being -- MEDIUM

The costs of many alterations to aquatic habitats are deferred to the future, while most benefits are realized immediately. Some of these costs include the costs of lost habitats from wetland filling and coastal development. Dams are also temporary solutions to perceived problems such as flood control and hydroelectric power; but problems of dams, such as silt buildup, are deferred to the future.

Equity of Impact -- HIGH

Of particular note for equity is surface water diversion, especially the disappearance of Owens Lake, the shrinking of Mono Lake, and reduced water flows through the Delta. The people impacted by diversions generally are not those who benefit. The involuntariness of the exposure to the diversion, especially in Owens Valley, was a big concern here. The impacts of dams fall heavily on people dislocated from the flooded valleys and people living below dams that fall. Reduced fish stocks (e.g., salmon) have big impacts on fishermen.

Community Well-being -- HIGH

The severity of the impact of surface water diversion for the communities at Mono Lake, in the Owens Valley, and the Delta are high. These communities are mobilized over the issue of water diversion, and local conflicts are intense. When valleys are flooded for dams, whole communities can be displaced (e.g., the town of Berryessa). Channelization also impacts the appearance of entire communities.

Overall Ranking -- HIGH

The sheer amount of information included in this category made it such that there was a serious impact for at least one of the five sub-categories (e.g., surface water diversion, coastal development, etc.) for each of the criteria.

ALTERATION AND DISTURBANCE OF TERRESTRIAL HABITATS

As human populations and their support systems expand, natural habitats and the populations they support are disturbed, altered, or destroyed. Habitat loss results in elimination of some native species from the affected area and at some point, may cause species extinctions. Social welfare impact include reduced access to and enjoyment of nature, reduced variety of educational and recreational experiences, and reduced genetic variability from which to strengthen agricultural crops and develop new medicines.

Environmental and Aesthetic Well-being -- HIGH

Ranked high based on severe environmental impacts of natural habitat removal and resulting aesthetic impacts.

Economic Well-being -- MEDIUM

Ranked medium based on economic implications of reduced genetic variability resulting from reductions in natural populations of plants and animals.

Physical Well-being -- LOW

Ranked low on the basis that habitat loss does not impact physical well-being.

Peace of Mind -- HIGH

This was ranked high based on general public concern about loss of biological diversity and natural habitats. Major development projects often generate widespread community concern.

Future Well-being -- HIGH

Ranked high based on expanding nature of the problem. There is little chance that pressure on natural habitats will be reduced. This problem will most likely get worse over time.

Equity of Impact -- MEDIUM

Ranked medium based primarily on irreversibility of impacts in areas affected. There are also equity concerns with owners of property that are restricted in their use because of, for example, endangered species concerns.

Community Well-being -- HIGH

Ranked high based primarily on contentiousness that arises in communities in disputes over environmental protection vs. job losses (e.g., spotted owl controversy).

Overall Ranking -- HIGH

The driving force is the irreversibility of the impact of natural habitat alteration and its expanding nature in the future.

THERMAL POLLUTION

This primary source of elevated-temperature discharges in California are 24 coastal power plants. These plants use large quantities of sea water for condenser cooling. The water is warmed during this process and returned to the sea at temperatures approximately 10 to 20|F above ambient. Biological effects of these discharges have been documented up to 2 km from the point of discharge. These effects are generally highly localized. Heat stress was not considered.

Environmental and Aesthetic Well-being -- LOW

Ranked low based on localized extent and minor nature of impacts.

Economic Well-being -- LOW

Ranked low. No discernible economic impacts.

Peace of Mind -- LOW

Ranked low. This was not seen as an expanding issue.

Equity of Impact -- LOW

Ranked low. Not a community issue.

Overall Ranking -- LOW

Ranking is based on limited extent and minor nature of impacts. Essentially no social welfare impacts were identified.

RADON

Radon (radon-222) is a naturally occurring radioactive gas from the natural breakdown of uranium and radium in rock and soil. It is odorless, colorless, and tasteless. Its existence is widespread in soil, water, air, and confined structures. Approximately 82 percent of all current human exposure to ionizing radiation comes from natural sources, and radon accounts from 55 out of this 82 percent.

The mitigation costs for radon contamination in properties and water were not included in the rankings but could be very significant.

Environmental and Aesthetic Well-being -- LOW

Being invisible, odorless, and colorless, radon does not usually present an environmental nuisance or aesthetic problem.

Economic Well-being -- MEDIUM

Economic impacts from radon include inability to work, medical costs due to health impacts and the loss of property values. About two percent of California homes surveyed exceeded the U.S. EPA action level of 4pCi/L (Source - 1989-92 survey by California Department of Health Services).

Physical Well-being -- HIGH

Radon can cause lung cancer, and it is estimated that exposure to radon may have caused approximately 1,000 deaths last year in California (Source - Human Health Committee). Radon is widespread in California and it is non-detectable by humans without special equipment.

Peace of Mind -- LOW

Public awareness of radon is low because the problem of radon has not been well publicized. Radon does not remind people of its existence. The anxiety level therefore is low among the general public.

Future Well-being -- MEDIUM

Even though modern technology can detect and building techniques can reduce indoor radon, these technology and techniques are not expected to be widely used because of high costs and low public concern. Consequently, radon exposure is unlikely to be significantly reduced in the future. Mitigation of relocation costs related to radon contamination are likely to be passed on to future generations.

Equity of Impact -- LOW

Although there are a few spots in California having a relatively higher level of radon, the problem is so widespread that equity is not an issue here.

Community Well-being -- LOW

Radon has not caused communities in California to lose mutual respect, cooperation and control, nor does it cause any other serious disruption to communities.

Overall Ranking -- MEDIUM

The rankings on physical well-being and the economic well-being are the two driving forces giving the overall ranking of medium for radon.

OZONE

Ozone is a colorless gas formed in the atmosphere as a result of a complex set of photochemical reactions involving both oxides of nitrogen (NOx) and reactive organic gases (ROG).[10] Both of these compounds and sunlight must be present in order to generate elevated ozone concentrations. Because elevated ozone concentrations are usually associated with characteristic meteorological conditions, and because of the possibility of carryover from day to day, elevated ozone concentrations tend to occur over periods of two to five days, referred to episodes.

Environmental and Aesthetic Well-being -- HIGH

Because elevated ozone concentrations may lead to acute impairment of lung function and symptoms, especially among heavy exercisers (see physical health impacts below), it was judged that ozone leads to decreased recreational opportunities for many Californians.

Economic Well-being -- HIGH

A recent report prepared for ARB (Howitt, 1990) estimated that the total economic loss from ozone damage to crops in California is approximately $333 million (1990 dollars) annually, more than 90 percent of which occurs in the San Joaquin Valley. This figure was judged to be of high concern.

Physical Well-being -- HIGH

The most well-studied health effects relate to transient, apparently reversible effects that follow acute exposures lasting from 5 minutes to 6.6 hours in controlled, clinical studies (Lippmann, 1989). These effects include changes in lung capacity, flow resistance, epithelial permeability, and reactivity to bronchoactive challenges; they may also include symptomatic responses, such as throat dryness, chest discomfort, cough, wheeze, pain on deep inspiration, shortness of breath, headache, and nausea. Such effects can be observed within the first few hours after the start of the exposure, and may persist for many hours or days after exposure ceases. Repetitive daily exposures over several days or weeks can exacerbate and prolong these transient effects.

More serious acute impacts have been addressed in epidemiological studies (Thurston *et al*., 1992; Portnoy and Mullahy, 1986; Ostro and Rothschild, 1989; and Whitmore and Korn, 1980). On the basis of these studies and current ozone levels in California, the Human Health Committee of the CCRP has estimated that the attainment of California's ozone standard would result in reductions of hospital admissions, asthma attacks, and minor restricted activity days per year, in addition high ozone levels are generally covariant with those of other pollutants, so that attribution of impacts to ozone is often problematic, the epidemiological evidence suggesting widespread acute impacts was judged to be strong enough to warrant high concern.

Additional concern pertains to a recent U.S. EPA study of the effects of chronic ozone exposure on human health (Whitfield *et al*., 1991), based on the expert judgments of six prominent researchers on respiratory impacts of ozone exposure. Although no consensus was reached, all experts expected a

[10]Stratospheric ozone may very occasionally intrude into the troposphere contributing to elevated ozone concentrations.

significant number of people (22 to 99 percent) to experience at least mild lung lesions, and five expected a significant number of people (10 to 67 percent to experience moderate lung lesions from exposure for one year at ozone concentrations characteristic of the worst parts of the South Coast Air Basin. Such lesions are believed to be related to accelerated depletion of lung reserves with age, which may result in a reduced ability to perform normally later in life. However, because younger people generally have excess lung capacity, the accelerated depletion would not be noticed without clinical testing until the excess capacity is depleted, raising the social welfare concern about delectability.

Peace of Mind -- HIGH

Because of the magnitude of attention that violations of the ozone standard have gotten, the frequency of public "smog alerts" in recent years, and the experience of respiratory symptoms among a portion of the population, it was judged that concern about elevated ozone concentrations is high among the public.

Future Well-being -- LOW

Because elevated ozone is not persistent in the atmosphere, its current generation will not impact people in the future with respect to health. Its impact on future generations through damages to ecosystems today is expected to be minor.

Equity of Impact -- MEDIUM

Because ozone is a secondary pollutant formed in the atmosphere, its impacts tend to be spread over wide areas without sharp gradients. However, because ozone formation is enhanced by particular meteorological conditions which may be associated with characteristic air flow patterns, peak concentrations tend to occur in specific regions of an urban area.

Moreover, because there are significant differences in ozone concentrations among geographic regions of the state, it was judged that the impacts of ozone are distributed somewhat inequitable. Also, there is some transport of ozone and its precursors among air basins, so that some of exposure may occur among people who have not contributed to the generation of ozone.

Community Well-being -- LOW

It was judged that the issue of ozone concentration is not currently causing community dissension or disruption.

Overall Ranking -- HIGH

Because of the widespread and potentially serious health impacts leading to decreased recreational opportunities, the high level of agricultural economic losses, and the general public concern about the healthfulness of the air with particular focus on "smog," of which ozone is a large component, ozone was judged to be of high social welfare concern overall.

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PARTICULATE MATTER

This problem area includes both primary particulate matter and secondary particulate matter formed within the air basin. Secondary particulate matter resulting from long range transport of sulfates and nitrates are not included. Acidic deposition is also not included here.

Air toxics in particulate form other than metals (e.g., PAHs) are also included in this topic area.

Environmental and Aesthetic Well-being -- HIGH

Because of its impact on visibility, which is a serious problem many urban air basins in California, the aesthetic impact of particulate matter was judged to be of high concern. We note that NAPAP (1990) estimates that on average man-made contributions account for about one-third of the average light extinction in the rural West, and that visibility in large metropolitan areas is usually lower than the surrounding regional background.

Economic Well-being -- MEDIUM

Although the SWC did not have any quantitative estimates of soiling damages from particulate matter, the issue was judged to be of medium concern.

Physical Well-being -- HIGH

Because of epidemiological evidence suggesting serious health impacts, including increased premature mortality (Schwartz and Dockery, 1991a; 1991b) and increased emergency room visits (Samet *et al*., 1981), and because violations of the PM_{10} standards are widespread in California (49 counties in violation of the California 24-hour standard in 1991), the health impacts and their associated social welfare impacts were judged to be of serious concern. It should be noted, however, that the issue of premature mortality associated with particulate matter is a controversial one (see Kalkstein, 1991, for evidence to the contrary). The portion of the particulate matter that is specifically toxic, such as PAHs, is of additional concern, although the SWC did not have data on the extent of exposure to such material in California.

Peace of Mind -- HIGH

The visibility of particulate matter brings it to attention of the public when concentrations are high and exacerbates concern over the healthfulness of the air. Therefore, particulate matter was judged to have a high impact on peace of mind.

Future Well-being -- LOW

Because elevated levels of particulate matter are not persistent in the atmosphere, its current generation will not impact people in the future with respect to health. Any accumulation of toxic

particulates in soil, however, could potentially have impacts in the future. Due to lack of data on the extent of the particulate toxic problem in California, it was not considered in evaluating this criterion.

Equity of Impact -- HIGH

Because primary particulate concentrations tend to be higher near emission sources, such as industrial facilities and roads, people living in the generally lower income neighborhoods near such sources may be disproportionately impacted. Moreover, those people living in the vicinity of such sources may not be benefiting from their activities. Therefore, the impacts of particulate matter were judged to be inequitably distributed.

Community Well-being -- MEDIUM

The issue of the siting of particulate matter emission sources, such as industrial facilities and roads, has been known to create some dissension in communities.

Overall Ranking -- HIGH

Because of the widespread and potentially serious health impacts and their associated social welfare impacts, and the high impact on visibility exacerbating general public concern about the healthfulness of the air, particulate matter was judged to be of high social welfare concern overall.

OIL AND PETROLEUM PRODUCTS

Includes routine operations - exploration, production, transportation, refining, and distribution. Also includes crude oil spills on land and in the marine environment. Air quality impacts of refining and product use are considered elsewhere.

Environmental and Aesthetic Well-being -- HIGH

Ranked high based on high aesthetic impact of major marine spills and living near refineries, moderate (i.e., generally short-term, ecological impacts of spills, and generally low impacts of routine operations).

Economic Well-being -- MEDIUM

Ranked medium based on limited economic impacts of exploration, production, refining, and transportation. Limited negative economic of spills due to claims procedures in place. However, many people live near gas stations. This could have property values impacts, especially where there is contamination from underground tank leaks.

Physical Well-being -- LOW

Ranked low on the basis that physical health impacts of routine operations or spills are not generally severe or widespread.

Peace of Mind -- MEDIUM

This was ranked medium based on concerns regarding community concerns about offshore platforms, oil spills, and refineries.

Future Well-being -- MEDIUM

Ranked medium based on wide distribution of products.

Equity of Impact -- MEDIUM

Ranked medium based primarily on the involuntariness and severity of aesthetic and peace of mind impacts to individuals living near refineries and gas stations. One Social Welfare Committee member dissented from consensus expressing concerns that highly inequitable impacts are experienced by communities of low-income individuals near refineries that was not adequately reflected in the medium ranking.

Community Well-being -- MEDIUM

Ranked medium based primarily on fear regarding emergency releases, lack of trust and ability to participate in decision-making,

Overall Ranking -- MEDIUM

This ranking was driven by the generally low impacts of routine operations combined with the high concern over the aesthetic impacts of spills and refineries and the equity issues involved in living near refineries.

LEAD

Our assessment considers costs but not benefits of environmental lead, except as noted. Legislation now prohibits lead in paints and gasoline, which were the main sources of environmental contamination; thus the problems with lead now revolve mainly around persistence of past contamination rather than the creation of new contamination. The principal sources of exposure to lead today are in older homes (e.g., lead paint chips, contaminated soil) and in certain industrial processes and products.

Environmental and Aesthetic Well-being -- LOW

Lead seems to have no impact here.

Economic Well-being -- HIGH

The impact considered here is the reduced schooling and employability of people who experienced acute or chronic lead poisoning as children, and of industrial workers who experience lead poisoning as adults. Many people alive today may have been exposed to lead as children (and some children continue to be exposed), and the SWC considers these impacts serious and essentially irreversible.

Physical Well-being -- HIGH

The principal impacts considered here are impaired cognitive development and functioning, and premature births and birth defects. There is some controversy in recent studies regarding the number of people impacted and the irreversibility of impacts from childhood exposure. Most studies suggest that when children actually ingest lead the impacts are serious. An important concern is that we often do not know whether children have ingested lead; screening programs are weak, and detectability is low.

Peace of Mind -- MEDIUM

The impact considered here is the anxiety of people living in old homes who wonder if their children are exposed to lead poisoning. We assume that such people have many other, equally pressing problems, and the intensity of their anxiety about lead is substantial but not consuming (i.e., medium).

Future Well-being -- MEDIUM

Since children are the principal victims, costs are deferred to the future while current taxpayers and landlords benefit. Aside from removing lead from paint and gasoline, little currently is being done to mitigate the problem of environmental lead (or, perhaps, much more could be done). There is little new contamination, but existing environmental lead will decompose very, very slowly; thus the problem will persist, but fortunately it will not worsen.

Equity of Impact -- HIGH

The distribution of impacts is highly unequal (predominantly low income people and minorities). Little can be done, at least in the short run, to reduce this inequality.

Community Well-being -- MEDIUM

Old houses tend to be concentrated in certain neighborhoods, so the problem is spatially concentrated. Some communities have become politically mobilized over the issue of lead poisoning.

Overall Ranking -- HIGH

The economic and physical well-being impacts are very important; but equity is perhaps the most important criterion driving our ranking.

One Social Welfare Committee member ranked this topic area MEDIUM on the basis that major input sources of lead (in paint, gasoline) have been eliminated. In addition, blood lead levels in the United States population have decreased by two-thirds since the mid-1970's. Remaining risks are from lead paint in old buildings and residual lead in soils. This member felt that the old paint will gradually be replaced, so this is a decreasing risk over time; and that lead residues in soils remain a potential source of exposure and a concern, although risks are generally lower in the West than the "lead belt" of the East.

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INORGANICS

Metals occur naturally in soils, sediments, marine and freshwater, at varying background levels. Most metals seldom occur in configurations or at concentrations that would pose a threat to organisms. Notable exceptions are mercury and cadmium. Several areas in California have been mined for metals. Metals are also used in many manufacturing processes. Metal-rich wastes from these activities are concentrated during waste water treatment and may accumulate in soils, sediments, and water. Metals considered: cadmium, chromium, copper, mercury, nickel, silver, arsenic, and selenium. Lead is not considered here but as a separate topic area.

Environmental and Aesthetic Well-being -- MEDIUM

Ranked medium based on relatively low impacts of most metals, contrasted with the few metals with high impacts (e.g., mercury).

Economic Well-being -- MEDIUM

Ranked medium based on limited distribution (near sources) and localized impacts.

Physical Well-being -- MEDIUM

Ranked medium on the basis that localized impacts from particular metals can be significant.

Peace of Mind -- MEDIUM

This was ranked medium. There is public concern over the presence of toxic metals in the environment (e.g., mercury, arsenic).

Future Well-being -- MEDIUM

Ranked medium based on concerns about the most toxic metals combined with controls in place.

Equity of Impact -- HIGH

Ranked high based primarily on potential impacts to individuals living near smelters.

Community Well-being -- MEDIUM

Ranked medium based primarily on the SWC's perception of a moderate level of community concern about the issue. Local concerns can be significant (e.g., Kesterson/selenium).

Overall Ranking -- MEDIUM

This ranking is based on high equity concerns balanced against the generally low impacts of most metals in the environment and the potential high impacts from a few.

GREENHOUSE GASES

There are four major anthropogenic "greenhouse gases": carbon dioxide, chlorofluorocarbons (CFC's) and halons, nitrous oxide, and methane. Since 1800 it is estimated that atmospheric CO_2 has increased 25 percent as a result of the combustion of fossil fuels, as well as agricultural practices leading to deforestation and humus oxidation. During the same time period, atmospheric methane is estimated to have more than doubled, due to increasing cultivation of wetland rice, increasing numbers of ruminant animals, and leakage of natural gas.

There is a broad scientific consensus that greenhouse gases play a major role in the Earth's heat balance. Increasing atmospheric concentrations of these gases leads to concern about the possibility of elevated ambient temperatures, or "global warming." Historical data suggest that global average temperature has increased by approximately 0.4 to 0.5 degrees C over the past 100 years (Lawrence Livermore National Laboratory, 1990). Whatever portion of the observed warming may be due to higher concentrations of greenhouse gases is not yet distinguishable from natural variation. (U.S. Weather Service climatologists have not been able to distinguish any signal that would indicate a climatological effect of greenhouse gases [Karl, 1993].) Major uncertainties pertaining to the potential for future global warming are the magnitude and speed of the change in global average temperature as the atmospheric composition is altered, including whether offsetting processes are likely to occur; and, how potential temperature changes compare to natural variations, which are also not well understood.

Potential health impacts of global warming include the possibility of increased prevalence of pests and other disease vectors, and increased numbers of warm and hot days, which may be associated with increased mortality. Potential ecosystem effects include enhanced growth of some nonwoody plants, with possibly a disproportionate impact on weeds. Potential climate impacts include changes in precipitation patterns, snowline locations, and evaporation rates that could significantly increase stresses on water resources, possibly making drought conditions more frequent. A rise in sea level, which projections indicate could range from one-half to one meter in the next 100 years, would threaten many coastal areas, especially during storm surge conditions. Possible ecosystem impacts are highly uncertain but could be quite severe. Studies suggest that ecosystems could be very different and individual species could be highly disrupted.

Potential changes in extreme weather events, such as greater frequency of hurricanes for example, may be very expensive. The impacts of weather changes associated with any significant global warming would be highly variable among regions, and are not predictable with current models. It is predictable that if extreme weather events should increase in frequency or shift to poorly prepared locations, national economic consequences would be high.

There is no evidence that global warming is currently causing any adverse impacts in California. Therefore, the relevant criteria for this issue would be peace of mind and future well-being.

Peace of Mind -- HIGH

This issue has received a great deal of attention in the popular and scientific media. It was judged by the SWC that many people are concerned about the potential future impacts of global warming (see below).

Future Well-being -- HIGH

For a worst case scenario (e.g., major ecosystem impacts with regional climate shifts leading to severe drought and/or coastal damage in California; increased frequency of extreme weather events):

Impacts on the sustainability of ecosystems are highly uncertain, but under a worst-case scenario the impacts would be high. Similarly, increased frequency of extreme weather events under a worst-case scenario would impact the well-being of future generations. Number of people potentially impacted in this respect is high. Potential environmental, and subsequent economic, impact severity would be high. Reversibility of environmental threat would take more than 10 years with current technology.

Overall future well-being impact would be high for a worst-case scenario. In spite of the uncertainty of the occurrence of such a scenario, the SWC judged that the potential warranted serious concern.

Overall Ranking -- HIGH

Because of the impact on peace of mind and future well-being, the problem of global warming was judged to be of high social welfare concern overall. Due to the high level of scientific uncertainty concerning greenhouse gases and global warming, the SWC would like to highlight the need for further scientific research.

References

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OZONE DEPLETION

The stratosphere, a layer of atmosphere surrounding the Earth starting approximately eight miles above the surface, contains high concentrations of ozone, which shield the Earth's surface from much of the UV-B radiation generated by the sun. Elevated UV-B radiation can damage DNA in living systems, and chronic exposure is known to lead to nonmelanoma skin cancer. Other likely but uncertain human health effects include melanoma skin cancer, cataracts, and immune system impairment. Researchers have found that enhanced UV radiation adversely affects many, but not all, plant varieties.

In 1985 scientists discovered significant thinning of ozone in the stratosphere (about 50 percent decrease) in the Antarctic region during the early Spring season. At this time, however, the levels of UV radiation at the Earth's surface experienced as a result of the Antarctic ozone hole are still lower than normal levels experienced at locations closer to the equator, due to the differences in orientation with respect to the sun. A smaller and less significant thinning has also been observed over the Arctic region.

Current theories about the chemical mechanisms that lead to destruction of ozone molecules in the stratosphere implicate two kinds of pollutants, both of which are thought to be necessary to result in observed levels of ozone destruction. One is a class of compounds known as halocarbons, the most prominent of which are chlorofluorocarbons of CFCs. Similar compounds, known as halons, can contribute bromine, as does methyl bromide. The second class of pollutants required for the theoretical chemical mechanisms is sulfate particles, formed from transformation of SO_X emissions. Such emissions may be natural (e.g., volcanoes and bioorganisms) or anthropogenic.

Evidence that the ozone layer is currently thinning is strong. The probability of thinning continuing into the future for several decades is high, in spite of the current mitigation strategy to eliminate the use of CFCs, because of the long lifetime of chlorine in the stratosphere. However, there is still a great deal of uncertainty about the impact of estimated ozone depletion, because researchers have not confirmed a corresponding increase in UV-B radiation at the Earth's surface, except in the vicinity of the ozone hole. This suggests that either the current global monitoring network is inadequate, or that some other phenomena are occurring to offset the potential of stratospheric ozone depletion.

There is no evidence that ozone depletion is currently causing any adverse impacts in California. Therefore, the relevant criteria for this issue would be peace of mind and future well-being.

Peace of Mind -- HIGH

This issue has received a great deal of attention in the popular and scientific media. It was judged by the SWC that many people were concerned about potential future impacts (see below), and, in spite of the lack of supporting evidence, the possibility of current impacts.

Future Well-being -- HIGH

For a worst-case scenario (i.e., UV radiation levels in California eventually become high enough so that many people experience adverse health impacts or ecosystems are impacted; and/or UV radiation levels in other parts of the world eventually become high enough to adversely impact ecosystems, with consequent impacts on California's ecosystems).

Impacts of ozone depletion on the sustainability of ecosystems are highly uncertain. However, under a worst-case scenario the impacts on the well-being of future generations would be high. A very large

number of people potentially may be affected involuntarily. Although the most likely health impacts are treatable, the social welfare impacts of widespread treatment could be high. Reversibility of environmental threat would take more than 10 years with current technology, so reversibility impact is high. Although risks are widespread, light-skinned people and outdoor workers are at increased risk, so there is a concern about equity.

Overall future well-being impact is high for a worst-case scenario. In spite of the uncertainty of the occurrence of such a scenario, the SWC judged that the potential warranted serious concern.

Overall Ranking -- HIGH

Because of the impact on peace of mind and future well-being, the problem of ozone depletion was judged to be of high social welfare concern overall.

CARBON MONOXIDE

Carbon monoxide (CO) is a tasteless, odorless gas formed in the atmosphere from a variety of sources. Burning of carbonaceous fuel produces carbon dioxide (CO_2) and CO, and CO_2 predominates when oxygen is present in excess of requirements for complete combustion. If oxygen is deficient, CO predominates. Motor vehicles produce 87 percent of the anthropogenic CO emissions in urban areas. Natural sources include forest fires. Significant concentrations of CO may occur near major roadways when air is stagnant. A small number of exceedances of the California standard may occur during winter months. The human central nervous system is especially sensitive to CO exposure.

Environmental and Aesthetic Well-being -- LOW

Ranked low based on low number of exceedances per year and limited extent of impact.

Economic Well-being -- LOW

No major economic impacts due to CO alone.

Physical Well-being -- MEDIUM

Ranked medium on the basis of potential severe impacts from high exposures balanced against the generally low exposures and limited extent of impacts. Potential high exposures to, for example, toll takers, users of some home heaters.

Peace of Mind -- LOW

This was ranked low. No major concerns identified.

Future Well-being -- LOW

Ranked low based on low number of exceedances and increasingly stringent controls in place.

Equity of Impact -- MEDIUM

Ranked medium based primarily on concentration of potential impacts on individuals living near major highways.

Community Well-being -- LOW

Ranked low. This issue does not appear to be a major community concern.

Overall Ranking-- LOW

The driving force is generally low levels of CO.

MICROBIOLOGICAL CONTAMINANTS

"Microbiological contaminants" includes microorganisms that can cause human disease (e.g., *E. coli* and Lyme disease bacteria, the protozoan *giardia* and *cryptosporidium*, and Valley Fever fungus), HIV virus as a contaminant of improperly disposed medical waste, and tuberculosis as an occupational risk to public hospital and prison workers.

Environmental and Aesthetic Well-being -- MEDIUM

Impacts: loss of recreational water use and, to some extent, associated beaches due to sewage spills or improper discharges, reduced aesthetics of the wilderness experience due to restrictions on water use as a result of protozoan threat, and inhibiting effects on recreational experiences for some people related Lyme disease bacteria threat. Estimated number of people impacted is less than one million. The severity of the impact is moderate in its effects on recreational lifestyles. Water contamination is generally undetectable without appropriate tests, and without contact with a posted notice, the presence of most Lyme disease-carrying ticks in the environment cannot be detected.

Economic Well-being -- MEDIUM

Impacts: costs for lost work, medical support, medication, and hospitalization associated with illness. Costs also include purchase of bottled water or water filters where water quality is questionable.

Physical Well-being -- MEDIUM

Impacts: pain, suffering, and activity limitations related to Giardiasis, Valley Fever, enteric illness caused by *E. coli*, Lyme's disease, and tuberculous (cases due to occupational exposure). There are no known cases of AIDS in California contracted as the result of contact with improperly disposed medical waste. Impact is medium in terms of overall number of people exposed and impacted, severity, inability to detect exposure in many cases, and reversibility (except for drug-resistant tuberculosis and some cases of Lyme's disease, and illness in immunosuppressed individuals, all of which are not really reversible).

Peace of Mind -- MEDIUM

Impacts: anxiety about the safety of recreational waters and drinking waters particularly after spills, contamination incidents, or illness outbreaks are reported in the news, fear of Lyme disease-carrying ticks when in the country and anxiety about being able to detect any exposure, workers' anxiety related to exposure to and possible contraction of tuberculosis and the difficulty of detecting infectious persons. In terms of number of people concerned and the severity, the impact is medium. The potential for a catastrophic impact on peace of mind is high related to waterborne illness. There is an uneven distribution in terms of workers' peace of mind (related to tuberculous), but the impact is low in terms of involuntariness (much exposure can be avoided) and reversibility (generally less than 10 years).

Future Well-being -- LOW

Primary impact is related to the increasing presence of giardia in water and to the exposure of workers in prisons, jails, detention centers, and hospitals to people with infectious tuberculosis. Due to the fact that people to whom workers are exposed are not adequately screened in many cases, it appears that money and effort is being saved now without recognizing the adverse impact on the future of personnel available for these occupations.

Equity of Impact -- MEDIUM

Primary impact is related to occupational exposure. Although to some extent, choice of occupation may be seen as voluntary in nature, many of these workers were not aware of the risk when entering their occupations.

Community Well-being -- LOW

An outbreak of water-borne illness potentially disrupts a community, raising issues of trust in institutions/agencies; however, there have not been any significant outbreaks in California reported in recent years.

Overall Ranking -- MEDIUM

The overall ranking is medium, driven primarily by the risk of tuberculous infection and disease among prison and hospital health care workers, as it impacts economic well-being, peace of mind, and equity. In addition, peace of mind, as well as environmental and physical well-being, are also adversely impacted by other categories of microbiological contamination-protozoans, *E. coli*, and Lyme's disease bacteria.

SUBSTANCES WHICH ALTER PH, SALINITY, HARDNESS

"Substances which alter pH, salinity, hardness" includes the following pollutants of ambient waters and/or drinking water sources: pH altering substances such as ammonia, hydrochloric acid, and sulfuric acid from wastewaters, salinity from industrial effluents, irrigation, salt brines, highway use, and the ocean; and hardness as the result of naturally occurring levels of polyvalent cations (calcium and magnesium).

Environmental and Aesthetic Well-being -- LOW

Impacts: Environmental- adverse effects on aquatic animal and plant life and consequent degradation of the quality of recreational experience in certain areas. The normal function of approximately 5,000 square miles of groundwater, 120 miles of rivers and streams and 255,000 acres of saline lakes has been impaired due to salt build-up in irrigated soils and subsequent discharge of waters with high concentrations of salt, discharges of industrial solvents (inorganic salts are a major constituent), salt-water intrusion into the Delta due to insufficient outflow of river water, and salt-water intrusion into groundwater in some areas (e.g., Salinas valley) due to overpumping. Aesthetic-natural hardness in water affects the "feel" of water and inhibits the sudsing quality of soap.

Physical Well-being -- LOW

Impacts: none known; no conclusive evidence related to either levels of salt or hardness in drinking water; there are no existing drinking water quality standards for either.

Economic Well-being -- LOW

Impacts: costs associated with finding other sources for drinking water in cases where drinking water utilities have wells that have become too brackish for use; decreased agricultural productivity due to build up of salt in agricultural soils; loss of fish as a food source for some people; loss of income for recreational facilities due to decreased use.

Peace of Mind -- LOW

Impacts: loss of Delta fisheries as the result of salt water intrusion influenced by upstream fresh water diversions which impacts many people; loss of drinking water sources feels threatening.

Future Well-being -- MEDIUM

Impacts: loss of fish species in the Delta (smelt, salmon), degraded aquifers due to salt water intrusion, and loss of agricultural land. The loss of diversity and trend toward greater loss indicates that

current practices are unsustainable and suggests a lack of assurance for future generations in terms Delta use. The degradation of aquifers also indicates that existing practices are unsustainable.

Equity of Impact -- LOW

Impacts: some localized impacts for a few Northern California drinking water utility areas due to salt water intrusion into aquifers, for recreational facilities in Delta area, and for drinking water utilities in Southern California and elsewhere which use State Water Project water from the Delta and must struggle to deal with the levels of bromide in the water.

Community Well-being -- MEDIUM

Impacts: where overpumping has occurred, community strain results due to possible lack of other sources and limited financial resources; when the situation is a result of agricultural use of groundwater, conflict exists between urban and agricultural interests and there can also be disruption of agricultural communities due to the impact on agriculture. Also, the residential development and quality of life are affected if the drinking water is poor quality or the supply is inadequate.

Overall Ranking -- LOW

The overall ranking is low, due to the relatively low impact these contaminants have on social welfare as a result of contamination in the Delta and in other water bodies in the state. However, intrusion of salt water into drinking water aquifers is of major concern, since once degraded, aquifers generally can't be restored.

NEW CHEMICALS

"New chemicals" includes new industrial chemicals introduced into commerce. These chemicals are defined as chemicals not already listed on the TSCA Inventory of Existing Chemical Substances. New substances typically enter the market as substitutes for existing chemicals and other materials.

Environmental and Aesthetic Well-being, Physical Well-being, Economic Well-being, Future Well-being and Equity of Impact-- UNABLE TO ESTIMATE

Impacts: none known since "new chemicals" were not specifically identified for the CCRP.

Peace of Mind and Community Well-being -- LOW

Impacts: although no "new chemicals" were specifically identified, the SWC believes that the current impact in these two areas can be estimated. There is no known public expression of anxiety over any new chemicals, nor any known community disruption due to such.

Overall Ranking -- UNABLE TO ESTIMATE

The overall ranking is "unable to estimate" which means that there is no data available on which to base an assessment.

TOTAL SUSPENDED SOLIDS, BIOLOGICAL OXYGEN DEMAND, NUTRIENTS

"Total suspended solids, biological oxygen demand nutrients" includes the following pollutants of water: sediment in ambient waters as a result of erosion particles suspended in drinking water, oxygen-demanding organic and inorganic wastes, and excessive levels of nutrients.

Environmental and Aesthetic Well-being -- MEDIUM

Impacts: Anthropogenic eutrophication of many ambient waters due to excess nutrients (700 acres of bays/harbors, 1,037 acres of estuaries, 112 square miles of groundwater, 145,800 acres of lakes, 312 miles of rivers and streams, and 261 acres of wetlands) adversely impacts both recreation and aesthetics, degradation of 635 acres of estuaries and 13,140 acres of lakes due to low dissolved oxygen as a result of high biological oxygen demand substances entering the waters. Erosion from logging activities results in siltation of spawning grounds and dairy industry practices result in high nutrient loadings in ambient waters. The number of people impacted and the severity are of medium concern, driving the total environmental/aesthetic well-being impact to a medium.

Economic Well-being -- LOW

Impacts: Costs to drinking water utilities to remediate levels of suspended solids which exceed the current drinking water quality standards (some millions of dollars, but also required to meet microbiological standards); costs due to loss of waters for recreational and commercial uses due primarily to excess nutrients; and costs due to treatment for taste and odor of drinking water sources with excessive growths of algae. Economic well-being impact is relatively a high low, due to the fact that the costs for water treatment are somewhat indirect in nature.

Physical Well-being -- LOW

Impacts: none

Peace of Mind -- MEDIUM

Impacts: Eutrophication is difficult to reverse; the excess nutrients causing the problem are due to current practices which will have ramifications for many years, impacting future generations. In terms of severity, peace of mind impact is a low medium.

Future Well-being -- LOW

Impacts: Eutrophication is difficult to reverse; the excess nutrients causing the problem are due to current practices which will have ramifications for many years, impacting future generations. In terms

of severity of impact and number of people impacted, however, this is not a wide-spread problem in California.

Equity of Impact -- LOW

Impacts: Means of living for those who depend on the commercial/recreational uses of degraded waters. This is not a major problem in California.

Community Well-being -- LOW

Impacts: In north coast area, logging activities have severely impacted the environment, causing conflicts between various interests.

Overall Ranking -- LOW

The overall ranking is low, due to the relatively low impact these pollutants have on waters in California. The Clean Water Act of 1972 requiring secondary treatment of all wastewaters, significantly reduced the biological oxygen demands loadings and suspended solids discharges into state waters, however, impairment of normal function of ambient waters is still a problem related to nutrients.

Education Committee Appendices

THE CALIFORNIA DEPARTMENT OF EDUCATION: FOCUS ON ENVIRONMENTAL EDUCATION FOR 1993-1994

This description of the California Department of Education projects is included as an example of the breadth and depth of environmental education projects in the school setting. Many of these projects have been created as collaborative ventures with other agencies and groups. It should be acknowledged that there are a multitude of programs and projects that have been created by other agencies and departments, teachers in various school districts, grassroots groups and others.

SUMMARY OF RESULTS FROM THE REGIONAL ROUNDTABLES AND SURVEY INSTRUMENT

SURVEY NO._____

PUBLIC SURVEY FOR THE CALIFORNIA COMPARATIVE RISK PROJECT

Introduction

Thank you for your interest in the California Comparative Risk Project. We are very interested in your opinions and thoughts about environmental decision-making in California.

We have designed this short survey so you can record your thoughts about environmental risk management. We will use the results of this survey to help guide Cal/EPA as it evaluates its approach to understanding and managing environmental risks.

Please take a few minutes now to complete this survey.

Important Factors Affecting Environmental Policy Decisions

Listed below are several factors that a person can consider when deciding if an environmental problem poses a risk to human health, ecological health or quality of life. Please review the following list of factors listed below.

1. When the State is focusing on solving an environmental problem how much importance do you think should be given to each of the following factors.

Check One Number for Each Item between 1 (not important) to 5 (most important)

		Importance to Direct Resources to Solve				
		Not an Important Factor				Most Important Factor
Decision Factors		1	2	3	4	5
_____ 1.	Economics/cost of regulation	|_____	|_____	|_____	|_____	|_____|
_____ 2.	Environmental sustainability	|_____	|_____	|_____	|_____	|_____|
_____ 3.	Environmental justice/equity	|_____	|_____	|_____	|_____	|_____|
_____ 4.	Distribution of costs and benefits	|_____	|_____	|_____	|_____	|_____|
_____ 5.	Aesthetics	|_____	|_____	|_____	|_____	|_____|
_____ 6.	Effects on future generation	|_____	|_____	|_____	|_____	|_____|
_____ 7.	Peace of mind	|_____	|_____	|_____	|_____	|_____|
_____ 8.	Public participation in decision making	|_____	|_____	|_____	|_____	|_____|
_____ 9.	Number of people impacted	|_____	|_____	|_____	|_____	|_____|
_____ 10.	Severity of the problem	|_____	|_____	|_____	|_____	|_____|
_____ 11.	Reversability of the problem	|_____	|_____	|_____	|_____	|_____|
_____ 12.	Potential for a catastrophic problem	|_____	|_____	|_____	|_____	|_____|

Comparing Different Environmental Concerns

2. Please review the following list of environmental concerns and indicate how important you feel it is to direct resources to solve it.

Try to rate each on its own merits; we realize that all of these issues are important.

For each issue, **check one number** between 1 (least important) to 5 (most important).

Importance to Direct Resources to Solve

	Not an Important Factor				Most Important Factor
Envinronmental Issues	1	2	3	4	5
Air Pollution					
_____ 13. Emissions from vehicles	_____	_____	_____	_____	_____
_____ 14. Emissions from factories and other industrial facilities	_____	_____	_____	_____	_____
Water Pollution					
_____ 15. Industrial releases	_____	_____	_____	_____	_____
_____ 16. Sewage plant discharge	_____	_____	_____	_____	_____
_____ 17. Groundwater Pollution	_____	_____	_____	_____	_____
_____ 18. Urban and agricultural runoff	_____	_____	_____	_____	_____
Land Pollution					
_____ 19. Industrial waste	_____	_____	_____	_____	_____
_____ 20. Active hazardous waste sites	_____	_____	_____	_____	_____
_____ 21. Abandoned hazardous waste sites	_____	_____	_____	_____	_____
_____ 22. Landfills	_____	_____	_____	_____	_____
_____ 23. Underground gas tank releases	_____	_____	_____	_____	_____
Health Stressors					
_____ 24. Asbestos	_____	_____	_____	_____	_____
_____ 25. Vehicular exhaust	_____	_____	_____	_____	_____
_____ 26. Second hand tobacco smoke	_____	_____	_____	_____	_____
_____ 27. Greenhouse gases	_____	_____	_____	_____	_____
_____ 28. Lead	_____	_____	_____	_____	_____
_____ 29. Genetically engineered organisms	_____	_____	_____	_____	_____
_____ 30. Pesticides	_____	_____	_____	_____	_____

Environmental Issues	1	2	3	4	5
Health Stressors					
_____ 31. Radon	_____	_____	_____	_____	_____
_____ 32. Electromagnetic fields	_____	_____	_____	_____	_____
_____ 33. Indoor air pollution	_____	_____	_____	_____	_____
_____ 34. Smog	_____	_____	_____	_____	_____
Natural Resource Management					

_____ 35. Alteration of wetlands |_____|_____|_____|_____|_____|

_____ 36. Alteration of natural lands or wildlife habitats |_____|_____|_____|_____|_____|

_____ 37. Mining practices |_____|_____|_____|_____|_____|

_____ 38. Forestry practices (logging) |_____|_____|_____|_____|_____|

_____ 39. Livestock grazing on public lands |_____|_____|_____|_____|_____|

_____ 40. Commercial fishing practices |_____|_____|_____|_____|_____|

_____ 41. Water practices |_____|_____|_____|_____|_____|

Importance to Direct Resources to Solve

	Not an Important Factor				Most Important Factor
Land Use and Energy Use	1	2	3	4	5
_____ 42. Bad Land use planning					
_____ 43. Inefficient military facilities/base reuse					
_____ 44. Transportation systems					
_____ 45. Oil and geothermal wells					
_____ 46. Inefficient energy use					

Other Concerns (fill in your own)

_____ 47. _____ |_____|_____|_____|_____|_____|

_____ 48. _____ |_____|_____|_____|_____|_____|

_____ 49. How important do you think that environmental education should be in California's public schools? **Check One**

___1. Very important

___2. Somewhat important

___3. Not important

_____ 50. In general, do you believe that you have access to enough information to make informed decisions about environmental issues? **Check One**

___1. Yes

___2. No

_____ 51. Do you think your opinions about environmental issues are based on factual evidence (scientific reports or the opinions of recognized experts), or your personal feelings? **Check One**

___1. Factual Evidence

___2. My personal feelings

_____ 52. What advice would you give the State about the way that it manages the environment?

_____ 53. Please write down what you think are the biggest obstacles that make it difficult for the State to manage environmental problems.

Background Information

Filling out this section is optional but this information will help to give us an accurate picture of you and your interest in environmental risk management.

_____ 54. Which of the following best describes the kind of community where you live? **Check One**

___1. Large city (greater than 100,000 in population)
___2. Small to medium sized city (up to 100,000 in population)
___3. Suburban area
___4. Rural or farm area

_____ 55. Which of the following best describes your ethnicity? **Check One**

___1. African American
___2. Latino/Latina
___4. Native American
___5. Asian American
___6. Pacific Islander
___7. Caucasian
___8. Other_____

_____ 56. Which best describes your educational training? **Check One**

___1. Elementary school or high school
___2. High School graduate
___3. Specialized college program (e.g., AA, Nursing, Trades, etc.)
___4. College graduates (BA, BS or similar)
___5. Graduate degree (MA, MS, JD, Ph.D., etc.)

_____ 57. Which best describes your average annual household income? **Check One**

___1. Less than $5,000
___2. $5,000 - 10,000
___3. 10,000 - 25,000
___4. 25,000 - 40,000
___5. 40,000 - 55,000
___6. 55,000 - 70,000
___7. 70,000 - 85,000
___8. 85,000 - 100,000
___9. More than $100,000

_____ 58. Are you?:

___1. Female ___2. Male

_____ 59. Are you participating in the Comparative Risk Project as a representative of a group?

___1. Yes ___2. No

_____ 60. If you answered "yes" to Question 59, which of the following groups most accurately describes your affiliation?

___1. Small business
___2. Large business
___3. Environmental group
___4. Community organization
___5. Government
___6. Agriculture or forestry
___7 Labor
___8. Other _____

Thank you for taking part in this survey.

If you would like to receive a summary of the results, please write down your name and address below.

PUBLIC SURVEY FOR THE CALIFORNIA COMPARATIVE RISK PROJECT FRESNO AND LOS ANGELES REGIONAL ROUNDTABLES SURVEY RESULTS SUMMARY

Background

The California Comparative Risk Project (CCRP), sponsored by the California Environmental Protection Agency (Cal/EPA), has come to a successful close. Initiated in early 1992, the CCRP identified and ranked the environmental threats of greatest concern in California from a human, ecological, and social welfare perspective. The California Comparative Risk Project modified the model for decision-making, incorporating economic analysis, public involvement and education, pollution prevention, and environmental justice concerns with risk-ranking. The process of ranking environmental issues included input from scientists, policymakers, business and community groups, and other concerned individuals.

As part of the effort to incorporate public opinion in the CCRP, Cal/EPA held three regional roundtables, public forums which brought together individuals representing environmental and civic organizations, business, local government, labor, ethnic groups, and universities. The roundtables' purpose was to identify those issues of most concern to California's citizens, so that future environmental policy can truly respond to the needs of our communities. A survey was distributed to roundtable participants as a means of assessing public opinion regarding specific environmental issues.

This report contains the results of the survey distributed to participants at the roundtables in Fresno and Los Angeles. The results are based upon the responses of 62 individuals who completed the survey. When considering the analysis of these data, it is important to keep in mind the small sample size of the survey. An analysis of the results obtained from the Hayward roundtable is contained in a separate report, since the surveys distributed differed slightly.

Report Format

The presentation of response data follows the order in which questions were presented in the original survey. The first table analyzes respondents' ratings of decision factors and specific environmental issues according to their impact on human health, ecological health, and quality of life. A list of additional concerns mentioned by survey respondents follows. The next page examines answers to questions regarding environmental education, access to information, and the basis for forming personal opinions. A list of the advice and obstacles mentioned most frequently by survey respondents follows.

The final section of the survey examines responses to specific questions according to respondents' background characteristics. A table indicating the frequency of certain background characteristics among respondents is included. The importance rating of economics, environmental justice, public

participation, and environmental education, and the accessibility to environmental information, are examined in light of such factors as gender, ethnicity, income, affiliation, and educational background.

Analysis

Survey respondents rated the severity of the problem as the decision factor of greatest importance when addressing environmental threats. Respondents also rated the potential for a catastrophic problem and the effects of a problem on future generations as extremely important factors. Survey respondents are clearly concerned about identifying and addressing the gravest environmental hazards, those problems that threaten the health of Californians not just today, but in the decades to come. The environmental issues they rated most important were emissions from vehicles and transportation systems. Decreasing emissions from vehicles and improving transportation systems will not only improve the quality of life for today's generation; taking these steps also ensures a healthy environment for California's children.

A large number of respondents cited politics as a major obstacle to the State's management of environmental problems. Respondents expressed concern that the economic power of special interest groups interfered with the creation and execution of health-protective environmental policy. While some respondents suggested that industry exercised too much power over the State's regulatory process, an equal number suggested that the State should provide more incentives to industry in order to facilitate environmental clean-up. Regardless of the individual stance on the influence of industry, many respondents stated that political concerns are adversely affecting environmental decision-making.

Government inefficiency recurred as a major concern for many respondents. Respondents suggested that the overlap among government agencies wastes valuable resources, impeding the government's ability to effectively mitigate environmental threats. Respondents suggested that bureaucracy be streamlined to reduce organizational waste. Respondents faulted the legislative branch of government as well, claiming that over-regulation was a serious problem. They expressed concern that regulations were both excessive and ineffective at addressing the specific realities of different environmental threats.

Many respondents advised the State to increase environmental education in schools and communities. Eighty-four percent of respondents thought that environmental education in California's public schools should be very important. One third of all respondents (34%) believed they lacked access to enough information to make informed decisions about environmental issues. Men were more likely than women to feel they had enough access to environmental information (70% of men, 55% of women).

Many respondents suggested that increasing public participation in environmental decision-making was extremely important. Women were much more likely than men to rate public participation as an important factor, with 82% of women and 63% of men selecting high importance ratings (4 or 5). As the educational levels of respondents increased, respondents were less likely to rate public participation as an important factor.

Roughly half of both women and men viewed environmental justice as a highly important issue (rating of 4 or 5). People of color were more likely than Caucasians to rate environmental justice as an important factor, with an average of 66% of people of color and 50% of Caucasians selecting a 4 or 5 for this factor. As the income levels of respondents increased, respondents were less likely to rate environmental justice as an important factor. Individuals representing community, government, agriculture or forestry, and labor groups were more likely than individuals representing small and large business and environmental groups to see environmental justice as an important factor.

Men were slightly more likely than women to rate economics as a highly important factor, with 63% of men and 55% of women selecting a 4 or 5 for this decision factor. Individuals representing small business, labor, and government were more likely than individuals representing large business, environmental groups, community organizations, and agriculture or forestry to see economics as an important factor. Ratings of the importance of economics in the process of environmental decision-making did not vary greatly according to differences in ethnicity.

Conclusion

Survey respondents from all three roundtables (Hayward, Fresno, and Los Angeles) expressed concern about government inefficiency, identifying lack of enforcement, duplication of programs, and over-regulation as major problems. Evidently, respondents feel that government agencies are not making the best use of available resources.

Respondents from all three regions felt that political considerations are adversely affecting the formulation of environmental laws and regulations. Californians clearly want State environmental policy to protect the interests of all the State's citizens, not just those citizens represented by special interest groups. They want the State to take a long-term view when addressing environmental issues, so that Californians can be healthy not just today, but also in the years to come.

Respondents from all three regions stressed the importance of improving environmental education and encouraging public participation in environmental decision-making. The message is clear: Californians want to be a part of the decision-making process.

It is our intention to respond to this message by including the information we have gathered from the regional roundtables in our assessment and prioritization of California's environmental risks. The opinions of California's citizens will be incorporated with environmental justice concerns, economic concerns, and the latest scientific data to create environmental policy that protects and preserves the health of California's communities and the environment.

Major Concerns

At least seventy-five percent of Survey Respondents selected "4" or "5" (high importance rating) for the following Decision Factors and Environmental Issues:

Effects on future generation
Severity of the problem
Reversibility of the problem
Potential for a catastrophic problem
Emissions from vehicles
Groundwater pollution
Active hazardous waste sites
Abandoned hazardous waste sites
Vehicular exhaust
Smog
Water practices
Bad land use planning
Transportation systems

At least ninety percent of Survey Respondents selected "4" or "5" (high importance rating) for the following Decision Factors and Environmental Issues:

Severity of the problem
Emissions from vehicles

Transportation systems

Other concerns identified in survey responses

Abandoned mines
Assess total body burden of toxic chemical exposure
Assess willingness-to-pay for risk
Birth defects related to environmental pollution
Community education
Determining the costs/benefits
Devote resources to bicycle freeways
Dioxin pollution (especially related to the timber industry)
Educating our children about the earth
Environmental elements in land use planning
Hazards at work (toxins, hydrocarbons, solvents)
Idiot regulations
Immigration
Inadequate public transport
Industrial accidents
Involvement of communities of color
Lack of access to and mobility to make use of public lands by the public including streams, lakes, and rivers
Lack of emphasis on consumers/commuters
Maximize cost/benefit of regulatory control
Medical and hospital waste disposal
Mishandling nuclear waste
Nuclear pollution
Over-consumption
Planned urban growth
Population growth
Private land use protection
Recycling
Regulations for money generation
Salt buildup and management
Socio/economic impacts
Spraying in agricultural environment
Unplanned growth
Use of "good" Science
Using Ward Valley to bury high level radioactive waste
Variances from use plans due to lobbying

How important do you think that environmental education should be in California's public schools?

83.9% (52)	1. Very important
12.9% (8)	2. Somewhat important
3.2% (2)	No Answer

In general, do you believe that you have access to enough information to make informed decisions about environmental issues?

64.5% (40)	1. Yes
33.9% (21)	2. No
1.6% (1)	Multiple Answers

Do you think your opinions about environmental issues are based on factual evidence (scientific reports or the opinion of recognized experts), or your personal feelings?

82.2% (51)	1. Factual evidence
8.1% (5)	2. My personal feelings
9.7% (6)	No Answer or Multiple Answers

What advice would you give the State about the way that it manages the environment?

The following lists identifies the recurring themes found in the responses to the previous question.

Depoliticize the regulatory process

Reduce over-regulation

Streamline bureaucracy

Encourage more public participation

Focus on community health

Provide more public education regarding environmental issues

Please write down what you think are the biggest obstacles that make it difficult for the State to manage environmental problems.

The following list identifies the obstacles most frequently mentioned by Survey respondents.

Over-regulation

Overlap among government agencies

Special interest groups

Lack of public participation

Lack of resources

Excessive influence of industry on the regulatory process

Not enough government assistance to industry

PUBLIC SURVEY FOR THE CALIFORNIA COMPARATIVE RISK PROJECT HAYWARD REGIONAL ROUNDTABLE SURVEY RESULTS SUMMARY

Background

The California Comparative Risk Project (CCRP), sponsored by the California Environmental Protection Agency (Cal/EPA), has come to a successful close. Initiated in early 1992, the CCRP identified and ranked the environmental threats of greatest concern in California from a human, ecological, and social welfare perspective. The California Comparative Risk Project modified the model for decision-making, incorporating economic analysis, public involvement and education, pollution prevention, and environmental justice concerns with risk-ranking. The process of ranking environmental issues included input from scientists, policymakers, business and community groups, and other concerned individuals.

As part of the effort to incorporate public opinion in the CCRP, Cal/EPA held three regional roundtables, public forums which brought together individuals representing environmental and civic organizations, business, local government, labor, ethnic groups, and universities. The roundtables' purpose was to identify those issues of most concern to California's citizens, so that future environmental policy can truly respond to the needs of our communities. A survey was distributed to roundtable participants as a means of assessing public opinion regarding specific environmental issues.

This report contains the results of the survey distributed to participants at the Hayward roundtable held on November 20, 1993. The results are based upon the responses of 56 individuals who completed the survey. When considering the analysis of these data, it is important to keep in mind the small sample size of the survey. An analysis of the results obtained from the Fresno and Los Angeles roundtables is contained in a separate report, since the surveys differed slightly.

Report Format

The presentation of response data follows the order in which questions were presented in the original survey. The first table analyzes respondents' ratings of decision factors and specific environmental issues according to their impact on human health, ecological health, and quality of life. A list of additional concerns mentioned by survey respondents follows. The next page examines answers to questions regarding environmental education, access to information, and the basis for forming personal opinions. A list of the advice and obstacles mentioned most frequently by survey respondents follows.

The final section of the survey examines responses to specific questions according to respondents' background characteristics. A table indicating the frequency of certain background characteristics among respondents is included. The importance rating of economics, environmental justice, public participation, and environmental education, and the accessibility to environmental information, are examined in light of such factors as gender, ethnicity, income, affiliation, and educational background.

Analysis

The decision factors and environmental issues of greatest importance to survey respondents were effects on future generations, environmental sustainability, emissions from vehicles, and inefficient energy use. Many respondents advised Cal/EPA to take a long-term view when formulating environmental policy. The issues and factors respondents selected as most significant suggest that California's citizens are concerned about preserving environmental health for decades to come, not just protecting the health of the current generation. Decreasing vehicle emissions and using energy more efficiently will enhance environmental sustainability, ensuring a healthy environment for California's children.

An overwhelming number of respondents identified politics as a major obstacle to the State's management of environmental problems. Respondents expressed concern that the economic power of special interest groups interfered with the creation and execution of health-protective environmental policy. While some respondents suggested that industry exercised too much power over the State's regulatory process, an equal number suggested that the State should provide more incentives to industry in order to facilitate environmental clean-up. Regardless of the individual stance on the influence of industry, most respondents stated that political concerns are adversely affecting environmental decision-making.

Enforcement recurred as a major concern for many respondents. Respondents suggested that environmental protection depends upon consistent enforcement of existing laws and regulations, and that lack of enforcement only perpetuates the daily damage inflicted upon the environment. Participants also identified government inefficiency and duplication of programs as major concerns.

Many respondents advised the State to increase environmental education in schools and communities. Eighty-eight percent of respondents thought that environmental education in California's public schools should be very important. Nearly half of all respondents (43%) believed they lacked access to enough information to make informed decisions about environmental issues. Men were slightly more likely than women to feel they had enough access to environmental information (59% of men, 52% of women). In general, access to environmental information increased with income and education level.

Many respondents suggested that increasing public participation in environmental decision-making was extremely important. Women were more likely than men to rate public participation as an important factor, with 86% of women and 68% of men selecting high importance ratings (3 or 4). As the educational levels of respondents increased, respondents were less likely to rate public participation as an important factor.

Women were more likely than men to see environmental justice as a highly important issue (rating of 4), although the percentage of women and men selecting 3 or 4 (very important) were roughly equal. People of color were much more likely than Caucasians to rate environmental justice as an important factor, although this conclusion is somewhat shaky due to the small number of people of color participating in the survey. Individuals representing environmental, government, or agriculture or forestry groups were more likely than individuals representing small and large business to see environmental justice as an important factor.

Ratings of the importance of economics in the process of environmental decision-making did not vary according to differences in gender. Individuals representing small and large business were more likely than individuals representing environmental groups, government, community organizations, or agriculture or forestry to see economics as an important decision factor

Conclusion

Survey respondents from all three roundtables (Hayward, Fresno, and Los Angeles) expressed concern about government inefficiency, identifying lack of enforcement, duplication of programs, and over-regulation as major problems. Evidently, respondents feel that government agencies are not making the best use of available resources.

Respondents from all three regions felt that political considerations are adversely affecting the formulation of environmental laws and regulations. Californians clearly want State environmental policy to protect the interests of all the State's citizens, not just those citizens represented by special interest groups. They want the State to take a long-term view when addressing environmental issues, so that Californians can be healthy not just today, but also in the years to come.

Respondents from all three regions stressed the importance of improving environmental education and encouraging public participation in environmental decision-making. The message is clear: Californians want to be a part of the decision-making process.

It is our intention to respond to this message by including the information we have gathered from the regional roundtables in our assessment and prioritization of California's environmental risks. The opinions of California's citizens will be incorporated with environmental justice concerns, economic concerns, and the latest scientific data to create environmental policy that protects and preserves the health of California's communities and the environment.

Major Concerns

At least eighty percent of Survey Respondents selected "3" or "4" (high importance rating) for the following Decision Factors and Environmental Issues:

- Emissions from vehicles
- Emissions from factories and other industrial facilities
- Industrial releases
- Groundwater pollution
- Urban and agricultural runoff
- Industrial waste
- Abandoned hazardous waste sites
- Pesticides
- Vehicular exhaust
- Alteration of wetlands
- Alteration of natural lands or wildlife habitats
- Mining practices
- Water practices
- Bad land use planning
- Transportation systems
- Inefficient energy use
- Environmental sustainability
- Effects on future generations

At least ninety percent of Survey Respondents selected "4" or "5" (high importance rating) for the following Decision Factors and Environmental Issues:

Emissions from vehicles
Inefficient energy use
Environmental sustainability
Effects on future generations

Other concerns identified in survey responses

Chemical disasters
Community based economics
Contradicting regulations (1 solution creates another problem)
Coordination between agencies; elimination of duplication and conflict between agencies
Delta Island development
Education
Enforcement of current laws
Environmental racism
Exposure to EPA Class A carcinogens (i.e. vinyl chloride)
Government efficiency
Government ruling
Government's inability to enforce the laws
Harmful household products
Impact of depositing toxic dredge spoils in urban areas
Lack of education at all levels regarding inter-related environmental effects
Level playing field in enforcement
Loss of open space
Over-consumption
Over-population
Politics
Population management
Recycling
Risk assessment as a tool to look at environmental damage
Sustainable Development
Sustainable energy policy
Uncontrolled consumption of resources
Under-education
Unplanned pregnancies
Urban sprawl