ENVIRONMENTAL QUALITY IN OREGON 1971

A Summary of Current and Future Problems

A Report from the Advisory Committee on Environmental Science and Technology

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ENVIRONMENTAL QUALITY IN OREGON–1971

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PREPARATION OF THIS REPORT

Contributions to this report have come from many sources and have included preparation of entire chapters or sections of chapters, addition of significant information, and review and correction of manuscripts by appropriate Oregon State University and Department of Environmental Quality and Executive Department personnel, thus the exact sources and authorship for each small section will not be shown.

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FOREWORD

The Advisory Committee on Environmental Science and Technology was established in 1970 to provide a more effective interchange of information and mobilization of resources to meet environmental problems in Oregon. The goals or functions are stated as follows:

Establishment of more effective communication channels between university research organizations and the executive and legislative branches of state government to aid in long-range planning of state and regional programs which may have environmental side effects.

Mobilization of information resources concerned with environmental science and technology in a systematic and analytical manner to provide state government, local government and the general public with accurate and understandable information and advice.

Identification and assessment of emerging and potential environmental quality problems on an annual basis primarily for the benefit of state government officials.

Dissemination to the public of scientific and technological information related to the environmental sciences through a continued science extension program.

One of the initial activities of the committee has been to prepare this report which, it is hoped, will be the first in a series of reports reviewing the status of environmental quality in Oregon. In this report, the basis for public concern about problems of environmental quality is established, the broad problems are identified and classified, and, to the extent that the limitations of time and availability of data permit, assessments of the level of quality or degree of pollution are included. Detailed compilations of pollution level measurements are not included, but the reader is directed in the bibliography to university, state and federal reports which contain these data. Some of these are available for limited distribution or purchase, but all can be found in the state library and most university libraries.

Limited recommendations for future action by the universities and the state government have been made. Where environmental problems are to some degree amenable to individual response, and in some cases where the choice of solutions and their effects are clear, these facts have been presented.

This report does not pretend to deal comprehensively or equally with all environmental problems. Future reports will consider various problems in more detail and will identify emerging environmental concerns. The nature of the problems considered, the manner of presentation and the type of assessments which are made will doubtless be varied in succeeding reports, but it is intended that they will provide continuing communication on the status of our environmental problems in Oregon.

SUMMARY

AIR QUALITY IN OREGON

The contaminant gases which are serious air pollutants elsewhere in the country are not a significant problem here; however, particulates, primarily from smoke, are a major problem. Primary emissions from combustion, principally in forest and agricultural residue disposal, will probably decrease in the next decade, but other sources which are a function of population will increase. The problem of the future will be a mix of pollutants from many sources associated with urbanization and industrialization.

Western Oregon has the highest potential, on a meteorological basis, for an air pollution problem of any area in the continental United States. The capacity of the atmosphere in this area to accept and disperse or assimilate air pollutants is extremely limited. Low wind movement and frequent inversions are principal factors in this restricted natural ventilation.

Intense air pollution incidents have occurred during the summer or fall periods of each of the last several years. The fall 1970 episode lasted four to five days. The important point to recognize is that the stagnation condition is more severe in western Oregon than elsewhere in this country and will continue to be so. It contributes to the severity of the air pollution problem because the pollutants released are trapped and accumulate. The added pollutants may increase the intensity and persistence of the stagnation situation by restricting natural forces such as the warming effect of the sun. More information is needed on meteorological conditions in Oregon and the effect of man's activities.

The nature of the persistent haze and increasing visibility loss in western Oregon needs to be studied. The relative contribution of fine particulates from combustion sources, as compared to noncombustion sources including secondary pollutants produced in the atmosphere, should be determined.

WATER QUALITY IN OREGON

Major progress has been made in the abatement of Oregon's primary water pollution problems—the heavy loadings of streams with organic wastes, principally from the pulp and paper industry and domestic sewage; certain toxic releases; and possible contamination with pathogenic organisms from sewage wastes. Implementation of existing abatement directives will further reduce loadings of wastes from these gross sources with the year 1972 as the target date for bringing them under control.

While progress is being made with abatement of gross and obvious organic and toxic wastes and possible pathogenic organisms, certain other problems are increasing in relative importance. New problems continuously emerge with technological advancement. Other mounting water quality problems are simply functions of our expanding population, its concentration in urban centers, and associated activities that impinge on environmental quality.

The problem of disposal of the increasing amounts of treatment plant sludge is one of immediate concern. Disposal of sludge represents a major factor in plant operating costs. The nutrients from the breakdown of organic wastes, from detergents and from other sources which foster the regeneration of organic material in water bodies will pose an increasingly difficult problem. Withdrawals of water for irrigation and for other consumptive uses can have a major effect on water quality. The progress made to date in abating organic wastes and nutrients for regeneration could be reversed easily by any large-scale diversions.

SOLID WASTES MANAGEMENT

Man's activities and consumption of goods result in the accumulation of solid wastes which are a threat both to the environment and man's health. A moderate amount of such wastes can be assimilated by the environment. In a technologically advanced and affluent society, particularly at high population densities, the volume of wastes generated greatly exceeds the assimilative capacity. Cellulose products (paper, wood wastes) comprise 40 to 65 percent of solid wastes generated; other wastes are: metal (cans, car bodies, refrigerators), glass, plastics and food refuse.

Oregon, like the rest of the nation, is confronted with solid wastes problems. This is particularly true in the more highly urbanized areas where the production of in excess of 5 pounds of wastes per individual per day results in a volume of material that is difficult to collect, transport and dispose of. Though the sanitary landfill is adequate for disposal of many of these wastes, the number of suitable sites is limited, and some wastes are not amenable to disposal in this manner. Many of the products now called wastes could, by the application of present technology and appropriate planning, be recycled. Implementation of recycling and utilization will probably require both encouragement and support by governments. To initiate such programs, imaginative approaches in partnership with government may be necessary.

Solid wastes management, like air pollution control, must recognize the multisource origin of the problem. Like air pollution control, solid wastes can be dealt with more efficiently on a larger unit basis. Thus, the creation of solid wastes management districts with larger resource recycling bases could result in greater efficiency and economy and allow for more innovative approaches to solution of the problem.

CHEMICAL WASTES AND ENVIRONMENTAL QUALITY

The physical portion of the world is comprised largely of the elements: carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, sodium, potassium, magnesium, calcium, iron, and small amounts of a few other elements. Their reactions are the basis for the living processes such as formation of tissue and conversion of food into energy. Foreign chemicals may interfere with these processes.

Though nitrogen and phosphorus are indigenous to the environment, an abundance of these elements in water promotes eutrophication. The nitrates of wastes and the phosphates arising from detergents, agricultural and industrial processes are undesirable when introduced into bodies of water. Similarly, though such elements as mercury, arsenic and lead are natural and ubiquitous constituents of the environment, man's employment of them may result in concentrations that are capable of doing harm. Organic chemicals that are synthesized by man and are new to the environment may be troublesome above certain levels.

In Oregon, chemical pollution of the environment is not yet the serious problem that it is in many other areas of the nation. There have been instances of environmental damage from use of pesticides, often the result of inappropriate use or careless application. DDT, while appearing to be ubiquitous in the Oregon environment, has reached significant levels in only a few areas and a limited number of species. The use of this compound in Oregon has been declining for several years. Since a wide array of chemicals are both produced and used in this state, concern for both man and the environment dictate close continuing attention to the problem.

Appropriate data are of basic importance in assessing any problem. In the case of chemicals, this requires a knowledge of the background levels and the levels resulting in contamination of air, water, soil and the biota. Such data are needed over a period of time in order to assess the trends and effectiveness of measures undertaken to abate the problem. Monitoring of chemicals in the environment is an expensive but necessary operation. Though Oregon has not developed a highly sophisticated monitoring system, several agencies have been assessing chemical pollution.

Oregon has long been a leader in forward-looking programs to insure proper and safe employment of chemicals. Legislative acts going back to 1949 established one of the early and better programs of regulating commercial application of agricultural chemicals. The original act has been improved and updated by subsequent legislatures. Two years ago the legislature established the Advisory Committee on Synthetic Chemicals in the Environment and charged it with the responsibility of studying the problem and providing suitable technical advice to the Department of Agriculture and other state agencies.

Recommendations to insure against chemical pollution of the environment currently under consideration are: suggestions to institute prescription buying of certain more toxic or environmentally hazardous chemicals, development of specific sites for disposal of waste chemicals, more stringent requirements for training of persons applying chemicals commercially and development of methods of better utilization of scientific information in application and use of chemicals. To further assist in controlling chemical pollution of the environment, the monitoring system in Oregon must be improved.

PHYSICAL FACTORS AFFECTING ENVIRONMENTAL QUALITY

Unwanted or unplanned sound in the human hearing range may vary in intensity to produce actual permanent damage to hearing or mere annoyance. Different types of sound may cause various reactions in the listener such as the fright resulting from sonic boom and nervous tension resulting from high-pitched continuous sound. Much research remains to be done at the level of health impairment, but much progress can be made on the basis of present knowledge to reduce the distribution, source and intensity of noise which cause dissatisfaction and distress.

The earthquake history of Oregon indicates that earthquakes noticeable to the populace occur on an average of once each six months, and damaging earthquakes once each ten months. As urbanization continues, particularly in the Willamette Valley, it will become increasingly necessary to know more about the details of the seismic stability of the region, especially when considering potential sites for power plants, large construction projects, large office buildings or home developments. The present seismic network, consisting of five stations, is inadequate to provide the needed data. A continuing and expanding statewide seismology program is needed.

ENVIRONMENTAL RADIATION IN OREGON

The status of ionizing radiation in Oregon can best be analyzed with respect to the various sources of this type of radiation in the environment. Natural radiation levels in Oregon are comparable to locations elsewhere in the nation. The levels of radioactive fallout from nuclear bomb testing have been much reduced during the past decade. Radioisotope releases from the Hanford nuclear complex are presently at low levels due to the shutdown of several production reactors in the past few years. Releases of radioisotopes from industrial, medical and research practices are much below the acceptable levels. Therefore, it can be concluded that environmental ionizing radiation does not constitute a significant problem to the public in Oregon at the present time.

The only projected increase of ionizing radiation in Oregon will be from the operation of the Trojan nuclear power plant scheduled for operation in the St. Helens-Portland area in 1974. However, judging from the operation experience of similar modern power reactors, and in view of recent technological advancements, the radioactive releases from that plant will probably be of low magnitude in comparison to natural radiation levels.

Medical uses of x-rays will remain the principal source of public exposure to ionizing radiation. However, the situation will be much improved once the State Board of Health completes its inspection program, which is aimed at the reduction of excessive exposure due to faulty equipment. Home exposure to low-energy x-ray derived from TV sets does not appear to be a serious problem.

Nonionizing radiation from the expanded use of microwave and laser equipment for domestic, industrial and research operations may present a problem in the forthcoming decades. Since low-powered laser beams can be concentrated by the lens of the eye to cause destruction of the retina, it is imperative that all users be safeguarded. Lasers are now being used commonly in classroom instruction and in certain construction operations for precision alignment. Microwaves can result in invisible, painless production of heat in deep body tissues and around the eyes. Adequate protection for the increasing number of users of microwaves ovens in the home and restaurants is needed. Other users in medicine and communications should also have adequate warning and protection. Adequate regulatory and compliance programs are urgently needed to eliminate excessive hazards derived from both these devices.

LAND MANAGEMENT FOR ENVIRONMENTAL QUALITY

Widespread concern about land use and population distribution has recently been expressed in Oregon. Numerous factors have undoubtedly contributed to the concern which is evident at present. The development and inhabitation of the land surface of Oregon has diminished the natural beauty of the state for many people. Divergent population trends are creating problems in the provision of social services in many countries. In sparsely populated countries the population base and economic activity make it difficult to maintain the desired level of social services required for a quality life. At the other extreme, population growth is placing a heavy demand on the resources of some communities, particularly on coastal developments. There is evidence that the use we are making of the land surface of our state is generally uncoordinated or poorly coordinated.

It would be inaccurate, however, to conclude that the state has done nothing in the face of these developments. The last session of the legislature passed legislation requiring that all land in the state be zoned or that reasonable progress be made toward zoning by 1972. Steps have been taken to encourage coastal zone planning and orderly development. Oregon has a State Parks program that is among the nation's finest. Planning procedures pioneered by the Oregon Water Resources Board have been copied by numerous other states and are now being used for other resource problems.

It appears that population growth will continue in Oregon at least through the next decade. Uneven population density probably will become even more accentuated during this period; the pressure on natural resources will become even more severe in the more densely populated areas. The beauty of the landscape is likely to be diminished further unless action is taken promptly to bring about a better coordinated settlement pattern.

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INTRODUCTION

The concerns of Oregonians over the degradation of environmental quality and its relationship to the quality of life and the livability of Oregon have increased rapidly within the last decade. The awareness that man has caused changes in his environment, and that these changes may affect man, has altered the thrust of environmental concerns.

The early conservation movements were focused on abating the reckless exploitation of natural resources which had caused diminution of our forests and the erosion of our agricultural land, and the preservation of critically small populations of wildlife and natural areas. The present environmental movement has broadened to include the effects of pollution of air and water, by chemicals and other wastes, on man and on presumably stable populations of wildlife; the problems resulting from a continually increasing population; the high rate of consumption of nonrenewable resources such as mineral ores and fossil fuels; the sprawl and other problems caused by uncoordinated land usage; and the effects of noise, crowding, microwaves and dirt. The realization that our land, space, forests, minerals, water and air are limited in their ability to supply our needs and absorb our wastes, and that these limits apply to the entire earth and all of mankind, has led to a determination to limit our actions to those which are compatible with a livable environment. The 1970's will be the decade in which we must find and agree on the solutions to our environmental problems.

Common resources, such as streams, lakes and air, are by their very nature subject to exploitation. Such resources are difficult if not impossible to reduce to individual ownership, thus they are subject to overuse or congestion. In early periods of low population and limited use, a new user would not impose a hardship on others, but as use increases, the point is reached at which each added use will cause an increment of harm or cost to existing users. The individual user of a common resource has not had to consider these external costs or effects, but has passed them on for others to bear in the form of pollution. As each user, individual or corporate, imposes to an increasing degree on the rights of his neighbors, an increasing degree of restraint will be needed to preserve ecological and social balance.

Greater economic security and increased leisure time, resulting from technological advances over the past century, have permitted man to consider the impact of his activities on the quality of life and have given him the freedom to make choices which will improve his environment. The public now seeks a higher level of environmental quality than it asked for only a few decades ago, and is questioning whether economic and population growth are identified with progress. Society is now more inclined to seek a balance between the goals of development and livability.

Because of our massive industrial capacity and the increasing speed with which new technologies are adopted, the impact of a technological innovation is felt by the environment, for better or worse, very rapidly after its conception. There is an urgent need for formalized forecasting of the effects of any large technological change. The rate at which we are now able to alter and degrade our environment because of our complex technology and increasing population is so great that merely holding the line against pollution and exploitation is not good enough. This nation has frequently violated the aesthetic limits of pollution and is now occasionally violating the health and ecological balance limits. Accurate forecasting of effects and careful balancing of benefits and risks can at the least make the quality of the environment the result of deliberate acts and may prevent an ultimate deterioration in the quality of living.

Maintenance and renewal of environmental quality is the responsibility of all citizens, institutions, and all levels of government. The recent response of the federal government can perhaps be dated from passage of the Interstate Water Quality Act in 1965, followed by the Air Quality Act in 1967. These enabled state governments to deal with water and air pollution on the basis of regional watersheds and airsheds and to require minimum quality standards. Most recently, the federal reorganization of institutions and programs for environmental protection has resulted in the establishment of the Council on Environmental Quality, which functions at the cabinet level, and the Environmental Protection Agency, which combines related programs previously in the Departments of Health, Education and Welfare; Interior; Agriculture; and the Atomic Energy Commission. The belated recognition of the utility of the federal government's 1899 Refuse Act, which prohibits the dumping of materials of any sort into navigable water without authorization and permits civil, criminal or injunctive action by agencies or by individuals, may prove to be one of the most significant developments on the environmental front.

Oregon has led the states in many innovative practices to protect environmental quality. The 1967 and 1969 Legislative Assemblies are considered to have produced more good law for environmental enhancement than all previous efforts. The Environmental Quality Commission and the Department of Environmental Quality were established. The DEQ was given increased staff and strengthened laws in both air and water pollution abatement. The state, federal and county governments cooperated to form three multicounty regional Air Pollution Authorities which facilitate local control of air quality problems.

The water quality standards established for all the waters of the state were the first in the nation to be accepted by the Department of Interior. A permit system was developed and is proving to be a very powerful administrative tool with which to control the discharges of liquid wastes into Oregon's waters. An injunctive procedure was adopted which makes pollutors of air or water subject to court order to cease and desist.

Oregon voters approved a constitutional amendment which increased the bonding capacity of the state and provides for 30 percent grants to local governments for the construction of anti-pollution facilities. Full funding will be available and repayable on a contract basis. Since the bond limit is set at 1 percent of the true cash value of the state, the funds available will increase as the state grows.

A tax incentive program to aid industry in the installation of pollution abatement facilities was created. By 1970, tax credit certificates had been issued for 68 air pollution control facilities and 57 water pollution abatement facilities. Research aimed at solving the problems of the wigwam burner has received industry financial support.

The statewide land use planning and zoning legislation has become nationally known and is projected to accomplish its goals by the end of 1971. This will be a big step forward in solving a critical problem in environmental quality.

The establishment of a statutory Committee on Synthetic Chemicals in the Environment to provide the Department of Agriculture with expert and socially conscious advice will assure continuous attention to some of the most complex environmental problems.

A significant change in penalties for litterbugs may finally bring these pests under control. Persons convicted of littering are now subject to loss of state licenses—including driving, hunting, fishing and boating licenses. Convicted litterbugs may also be required to clean up roadways while wearing the "LP" (Litter Patrol) arm band.

Among the numerous new measures affecting environmental quality which are expected to be considered by the 1971 Legislative Assembly are: controlling air pollution by a discharge permit system; regulating car traffic on the basis of air pollution; requiring that automobiles meet emission standards prior to licensing; taxing vehicles to provide for removal and disposition of abandoned cars; providing for the restoration and reclamation of mined lands; establishing guidelines for land use planning, including special protection for estuaries; establishing a Nuclear Energy Council with statutory guidelines for siting nuclear power plants and providing for beneficial uses of nuclear power; and placing full responsibility for solid wastes, toxic or hazardous wastes, and radioactive wastes with the Department of Environmental Quality.

Citizens of Oregon are concerned over the issues of environmental quality. A single environmental issue—the "Beach Bill", field burning, nerve gas—will result in tens of thousands of letters, phone calls and telegrams to the officers of state government. Continuous expressions of concern about phosphates, mercury, pesticides, nuclear power plants, field burning, gasoline additives claimed to reduce pollution, and all manner of other environmental problems bring letters to the state government at a rate of about 400 per day—nearly ten times the rate only seven or eight years ago.

An agency for environmental information divorced from either regulation or promotion is needed—a sort of environmental ombudsman's office to which citizens can turn for facts on environmental problems. An Environmental Quality Index should also be developed for Oregon in order that monitoring programs can be related to an agreed upon quality level, and all segments of society can be alerted to changes. More rapid dissemination of information between state and federal agencies, the media, and the citizens is a necessity. There is a need for an annual declaration of the State of the Environment.

Every citizen must share in the responsibility for achieving a high level of livability in Oregon. It is important that each citizen consider that we will always be faced with choices and compromises between various alternatives. We cannot have wood and paper and not cut trees. We cannot have nickel and yet not dig it out of the ground. We cannot have light and heat and transportation, yet not produce energy. Some of the problems associated with the choices to be made in Oregon are considered in this document. The problems associated with air and water pollution and some chemical wastes are discussed. Factors which are often omitted from consideration—microwaves, x-rays, noise and seismicity—are treated as well. Nuclear radiation in the environment is placed in perspective with data on its extent. The solid wastes problem is shown to be one of our more significant pollution problems because less progress has been made in its management than in air and water pollution. The problem of resource management—particularly land management—is another environmental problem that is termed critical because of the difficulty in finding solutions.

To make the best choices, it is important that citizens be informed on all aspects of environmental problems. It is hoped that this document will be a beginning.

AIR QUALITY IN OREGON

THE NATURE OF AIR POLLUTION IN OREGON

Oregon's air pollution problems are not typical of the problems nationally. The contaminant gases which are serious air pollutants elsewhere in the country presently constitute little problem in Oregon, but suspended particulates, primarily from smoke, are a major problem in western Oregon and a significant problem in other parts of the state. The gaseous pollutants of most serious concern elsewhere in the United States are those associated with photochemical smog, typical of Los Angeles, and sulfur dioxide in the eastern states. Neither of these constitutes a problem of significance in Oregon at the present time. Carbon monoxide is considered a problem only in high density urban centers, and foul odors are a problem in certain limited localities.

Emission of pollutants, however, is only one of the factors that combine to create an air pollution problem or potential problem. Other key aspects are the physical factors of meteorology and topography and the presence of people, other living things, or property that can be harmed by the air pollutants. In western Oregon, all of these factors are present. Natural ventilation is restricted by topography, lack of wind movement and frequent inversions; and Oregon's population is centered in this region. Three unique aspects of air quality in Oregon are the restricted natural ventilation, the major smoke problem and the persistent haze and visibility loss.

Restricted Natural Ventilation

The capacity of the atmosphere in many parts of the state to accept and disperse or assimilate air pollutants is highly limited. Restricted natural ventilation occurs primarily in the late summer and fall and into the winter. The areas of most concern are the Willamette, Rogue and Umpqua Basins of western Oregon. Physically, all are valleys surrounded by mountains. The Coast and Cascade Ranges, which form the sides of the Willamette Basin, act as barriers to wind movement. Meteorologically, the upper layer of air in these valleys acts to limit dispersion in lower layers during much of this period. The upper layer of air is decoupled from the lower layer, and, as a result, the low level polluted air is not swept from the valley by the stronger winds aloft. The stable layer thus acts as a lid on the lower valley air so that pollutants accumulate and persist. Technically, the stagnation and the decoupling are associated with the slow sinking of stable air in the large semipermanent anticyclone that is found in late summer and fall over the northeastern Pacific area. This is the northern section of the same anticyclone that contributes to persistent smog in California. During the fall period, wind speed is restricted, with average speed between 0 and 3 miles per hour occurring 40 to 45 percent of the time in the Willamette Basin, as determined from airport records. This is in contrast to the Chicago or Detroit area where the figure would be 10 to 15 percent. Inversions are frequent, occurring some 9 out of 10 nights during the late summer, fall and winter periods and persisting into at least half the days. Thus, meteorological and topographical conditions combine to produce a high air pollution potential in these western Oregon basins, probably the highest in the country. A high potential exists in southeastern Oregon as well, but the area is not now heavily urbanized or industrialized, so a problem has not materialized. The potential exists, however, if any significant number of polluting sources are added.

A National Air Pollution Control Administration study on meteorological potential for urban air pollution shows western Oregon as having the highest potential of any place in the continental United States due to the restricted natural ventilation. The southern portion of the state, presumably the southern portion of the Willamette Basin and the Rogue and Umpqua Basins, was singled out in this regard. The potential was considered to be appreciably higher than, and possibly double, that of the Los Angeles Basin. According to this study, if major urban and industrial developments occur in this critical section of our state, air pollution could be extreme—in fact, the most extreme in the country.

The severe pollution incidents occurring in western Oregon in the summer or fall of each of the past several years are not isolated and rare events. Rather, they can be expected to occur with regularity in the future. They are a result of air pollutants released into and held by a naturally occurring stable atmosphere.

Oregon's Smoke Problem

Oregon's most troublesome current air pollution problem is associated with smoke emissions from the disposal of agricultural and forestry residues in western Oregon. The smoke sources from residue disposal include wigwam waste burners at sawmills and wood processing plants, slash disposal in the forest, the burning of straw residues from grass seed and cereal production, and open burning in backyards and refuse dumps. The minute carbon and ash particles which remain suspended in the atmosphere are a source of visibility loss and are considered the most troublesome form of particulates in respiratory effects in humans. Unfortunately, much of the residue burning from agriculture and forestry is of a seasonal nature and takes place during the period of restricted atmospheric conditions in the late summer and fall.

The Department of Environmental Quality's *Rapid Survey of 1968 Air Contaminant Emissions in Western Oregon*, an annual survey, showed 28 percent of the fine, suspended particulates coming from field and slash burning and 25 percent from the wood products, including pulp and paper, industry. Other major contributions were 18 percent from the metals industry, 11 percent from motor vehicles and 9 percent from heating and related fuel burning.

Persistent Haze and Visibility Loss

A persistent haze hangs over much of western Oregon during the late summer and fall stagnation period. The suspended particulates from residue disposal practices are recognized as a significant component of this haze. The contributions to this haze from other primary gases and particulate sources and secondary pollutants produced in the atmosphere need to be determined. The question regarding secondary pollutants is whether photochemical or other type reactions are occurring in the atmosphere and producing new chemical products which are contributing to the loss of visibility. It has been shown that a typical photochemical reaction, such as occurs in the Los Angeles Basin, is not occurring here to any significant extent. The monitoring that has been done of air pollutants in the atmosphere at various locations throughout the Willamette Basin shows that ozone and total oxidant levels are relatively low compared to Los Angeles and other areas of the country where photochemical smog is a major problem. But it is recognized that certain of the air pollution components in the basin are unique–organic sulphur compounds from kraft mills, various exotic releases from metal processing plants–along with the fine particles (carbon and ash) from residue disposal and various industrial sources. Another factor in the persistent haze is thought by some to be terpenes produced by the forests and wood processing industry of western Oregon.

Recent studies, as well as general observation ("There are fewer days when we can see the mountains."), indicate a significant visibility loss in the post-World War II period in most of western Oregon. One study by Oregon State University using airport records for the month of June, before the field or slash burning season begins, in the years 1951-69, showed a significant visibility loss at Salem but none at Eugene. Thus, while some of the visibility loss in western Oregon can be associated with smoke from forestry and agricultural residues disposal, other pollutants, including secondary pollutants which may be produced through reactions in the atmosphere, must also be implicated.

It appears that a major reduction in certain sources, such as wood residues in the post-war period, compensated for increases in visibility restricting pollutants from other sources in the Eugene area, resulting in no visisbility loss.

SIGNIFICANCE AND EFFECTS OF MAJOR SOURCES OF POLLUTION

Wood Products

Production of lumber and manufactured wood products is Oregon's major industry and a large contributor to air pollution. The principal emission source is residue disposal, and the wigwam waste burner is, as noted in a recent Department of Environmental Quality report, "the state's principal controllable year-round source of visibility restricting emissions, as well as of fallout." Other emission sources are veneer dryers, steam plants and pneumatic material handling systems. Major abatement efforts have centered on utilization of residues rather than burning disposal. In 1953 one-half of the wood residues at processing plants were not used. This figure had dropped to 12 percent in 1968. Currently the bulk of the wood residues in the form of chips, shavings and sawdust are being used in pulping and in board manufacture. A market for bark, however, is proving more difficult, with only limited outlets such as hogged fuel and mulch. Only about half the available bark is now used; thus, the wigwam burner air pollution problem is now closely tied to bark disposal. Extensive research programs have contributed both to improved operation of wigwams still being used and to utilization alternatives, with recent emphasis on bark. In addition to regulatory pressure, another factor which is influencing wood residues utilization is the growing demand for these former wastes due to both export of chips, particularly to Japan, and the expanding domestic pulp and particle board utilization.

Perhaps the most promising immediate outlet for expanded bark use is in boiler or hogged fuel. Projections for increased outlets are based on the shift of wood residues to pulping and other uses and their replacement by the bark residues. It is also anticipated that use of bark for soil mulch will expand, and research results for use of bark in composition board are also promising.

Pulp Mills

The obvious and troublesome air pollutant emissions from pulp mills have been the malodorous organic sulfur gases from the Kraft plants. These compounds are the mercaptans and hydrogen sulfide, technically referred to as reduced sulfur compounds, which are produced by reactions of organic components of the wood residues with inorganic sulfur compounds used in the cooking process.

A strong regulatory program has been adopted jointly in Oregon and Washington to drastically cut the emission of the odorous sulfur gases. The regulations also limit emissions of particulates from recovery furnaces, lime kilns and smelt dissolving tanks. Fine particle emissions that contribute to suspended material in the atmosphere have been another problem in the pulp and paper industry. The principal source of organic sulfur odor is the recovery furnace, so replacement of these units in older Kraft mills has been ordered. The regulations which have been adopted by Oregon and Washington are at present the most stringent in the country.

The principal gaseous contaminant from the older sulfite pulp mills is sulfur dioxide from the digestor blow and recovery systems. Sulfur dioxide levels are projected to increase with the conversion of the sulfite mills at Oregon City, Newberg and Salem to processes that permit burning of waste liquors and recovery of pulping chemicals. The conversion has been necessitated to reduce the discharge of waste sulfite liquors into the Willamette and Columbia Rivers.

Field Burning

Approximately one million tons of straw residues are burned annually on some 260,000 acres in the Willamette Valley. This straw is burned to accomplish residue disposal, yield maintenance and field sanitation (disease and other pest control) in perennial grass seed crops, and an inexpensive residue removal and weed control method for annual crops. Acreage burned is about equally divided between perennials and annuals, but an estimated two-thirds of the straw volume is from the annual crops. Agricultural operations are exempted from the general authority of the Department of Environmental Quality and the Regional Air Pollution Control Authorities; however, special legislation provides a smoke management pattern aimed at reducing harmful effects of the emissions. Implementation of the program during the past year was aimed at reducing emissions affecting the Eugene-Springfield area.

During the past two years there has been a reduction in the volume of the cereal grain straw components of annual crop residues burned. In 1968, acreage of grain straw burned in the Willamette Valley was estimated at 85,000 acres. A 1970 survey indicated that an estimated 25,000 acres of grain straw, 125,000 acres of perennial grass seed straw, and 112,000 acres of annual ryegrass straw were burned that year. The survey also indicated that straw volume burned was in excess of one million tons.

Research is underway to find beneficial uses for the straw, particularly from the annual crops now being burned. Utilization alternatives being considered include livestock feed, pulp, building materials, industrial cellulose, fuel for heat and power generation, and other industrial possibilities. This work, financed by a combination industry-federal grant, has developed a number of promising leads. Another research effort is development and testing of a mobile field incinerator, designed to provide nearly complete combustion and minimize emissions while furnishing the growth stimulus and field sanitation now provided by open burning. Primary attention is being given to use of the incinerator for perennial crops. Field tests in 1970 were considered very encouraging. A second more mobile model of greater capacity is being developed for testing in the 1971 burning season. Other research is aimed at improving smoke management practices for the interim period and at improving soil incorporation and planting methods for annual crops.

The principal air pollution problem with field burning is the suspended carbon and ash particulates of the smoke. Monitoring data show that the volume of these particulate emissions average 15 pounds per ton of straw burned. Based on a million tons of straw burned, this means that particulate emissions total 7,500 tons annually.

Slash Burning

Substantial volumes of residue from logging operations and from natural processes in the forest environment are burned each year as a forest management practice. For example, in western Oregon in 1965, the slash on 71,000 acres of clear-cuttings was broadcast-burned, and an estimated 3 million tons of residues were consumed by these fires. The burning aids in reforestation of the site, reduces the chances of wildfires, and helps to control pests without use of chemicals.

Most slash burning takes place in the fall period after the first rains. The impact of slash fires on air quality is of most concern in western Oregon because of the restricted ventilation conditions and the type of forest areas located there. The older timber stands in western Oregon, concentrated on national forests, are highly defective, and much cull and rotten material cannot be economically utilized. Thus, residue volumes averaging 120 tons per acre often remain following harvesting operations.

Several forces have been at work in both reducing the amount of slash burning and in rendering the practice less harmful to livability. A regulatory pattern now provides for restricted areas and the issuance of permits for burning. Another smoke management plan on a voluntary basis calls for timing the burning operations with most favorable meteorological conditions. The Department of Environmental Quality, along with public and private timber owners, is involved in this cooperative effort. Other factors that have worked for a reduction in slash burning have been (1) an improved technology that leads to increased utilization of certain materials which formerly were left in the forest as debris after harvesting operations, (2) clean logging or complete yarding of residue that either makes burning unnecessary or permits off-season burning, (3) more flexibility in timber sale procedures and pricing practices that stimulate utilization, (4) a gradual replacement of old growth timber by second-growth stands and substitution of partial cutting for complete utilization, (5) pressure brought about by passage of the federal Environmental Quality Act and an executive order from the Office of the President which permits federal agencies to engage in polluting practices only as a last resort.

Old growth or other timber stands will have substantial debris that will not be salvagable. At the present rate of cutting, old growth stands in western Oregon will not be completely harvested for about forty years.

Metal Processing and Use

Air pollution from the processing of metals has generally been localized in the areas immediately adjacent to plant operations. This is particularly true with the hydrogen fluoride emissions from the aluminum reduction plants located on both the Oregon and Washington sides of the Columbia River. Evidence from initial operations of these plants clearly indicated that damage had occurred to adjacent vegetation and grazing livestock. Subsequent process changes and control measures have substantially reduced the fluorine emissions that were causing the problems, and at present it appears that a substantially smaller area is affected. These plants have also contributed to the fine particulate loading in the lower Columbia Gorge and upper Willamette Valley. The plants in and near Albany associated with rare metal processing are a second area of concern. Under increased regulation during the past two years, certain steps have already been taken, and others are underway to reduce harmful emissions from these plants. The effects of some of these exotic emissions are clearcut, while the effects of others are not clear. It is possible that some of these emissions may be contributing to certain climatic changes and the persistent haze problem in the mid-Willamette Valley area.

Recent studies have indicated the possibility of increased mining and metal processing utilizing relatively low-grade deposits of ore in Oregon. It must be recognized that such operations can contribute to air pollution. There is national concern regarding environmental health effects of several metals that can enter the air through processing and use. Those receiving the most attention are asbestos and lead.

Asbestos, long recognized as an industrial hazard, is now being found increasingly in the ambient air. Many of its uses have environmental side effects. When used in construction, it can be released to the air from spraying and other application methods for fire-proofing, from demolition operations, and from the use of asbestos sheets exposed in air ducts in buildings. The occupational exposure problem has been the lung disease, asbestosis, among workers. The concern over asbestos as a generally distributed air pollutant is that it may cause a type of lung cancer. This lung cancer, mesothelioma, is growing in significance at the national level, and is associated almost exclusively with asbestos exposure.

The acute effects of lead poisoning are well known; however, there is concern that lead pollution in the air, essentially all of which comes from auto exhaust, may have chronic effects. There is evidence that low-level exposure can produce lead levels in blood and urine in certain individuals in urban populations high enough to interfere with the body's ability to produce blood. Other physiological problems may possibly result from this exposure. Three quarters of the over 300,000 tons of lead used annually in gasoline is emitted in auto exhaust. Up to 40 percent of the lead entering the respiratory tract is absorbed, compared to less than 10 percent of that ingested.

Motor Vehicles

Automobiles and other motor vehicles contribute to air pollution through their release of (1) carbon monoxide emissions which at higher concentrations can have a detrimental, though probably not a cumulative, effect on man, (2) particulate emission that can add to the visibility loss and to other problems, (3) aldehydes and other odorous compounds from diesel buses and trucks, and (4) hydrocarbons and oxides of nitrogen which are ingredients for photochemical smog. Carbon monoxide has reached levels during periods of stagnant air in high density urban areas that can cause physiological impairment, particularly to cigarette smokers. Older and untuned vehicles can release substantial particulate emissions. Emission factor data gathered in 1969 indicate that 11 percent of the total fine particulate load in western Oregon comes from motor vehicles. The problem is that this source simply adds to those reviewed earlier. Although Oregon does not have a Los Angeles-type photochemical smog problem at present, it is possible that hydrocarbon and nitrogen oxide releases from automobiles may be participating in other types of chemical reactions in the air environment.

Regulation of motor vehicles is essentially a federal function. Engine modifications and control devices have already brought about reductions in emission levels. The federal regulations will require substantial further reductions in emission levels. The National Air Quality Standards Act of 1970 requires the automobile industry to achieve a 90 percent reduction from 1970 emission levels by 1975. The most promising method of helping achieve this reduction is a catalytic reactor. Extensive research is underway in perfecting such a device. In order for this device to operate effectively, lead, which fouls the device, must be removed from gasoline. Projections are that the device will operate effectively for 50,000 miles with unleaded gasoline.

Based on projections of automobile numbers and planned control of emissions, it appears that levels of carbon monoxide and hydrocarbons will continue to be reduced in the state for at least the next ten-year period. Other polluting sources associated with the auto, such as asbestos and rubber particles, are expected to increase in proportion to vehicle numbers.

PRESENT STATUS OF AIR POLLUTION CONTROL IN OREGON

Responsibility for air pollution control in Oregon is now divided between three regional agencies and one state agency. Oregon was the pioneering state in establishing a statewide air pollution control agency with enforcement powers. A comprehensive law passed in 1951 created a separate Air Pollution Control Board. In 1959, air pollution responsibility was shifted to the State Sanitary Authority, now the Department of Environmental Quality.

Legislation was passed in 1967 authorizing the creation of regional air pollution control agencies. Three—the Columbia-Willamette, mid-Willamette and Lane Regional—have now been established covering ten of Oregon's 36 counties. These regional agencies have taken over the regulation and enforcement activities from the state in their jurisdiction, but their rules, including standards, must be as stringent as those of the state. The state has retained jurisdiction over certain major sources including automobiles, pulp mills, field and slash burning and aluminum reduction. The state agency maintains full rule-making and enforcement activities for the remaining 26 counties not under a regional authority.

Air quality standards were adopted several years ago to cover smoke discharge, particulate fallout and suspended particulate matter. Air quality standards for the ambient air are defined as an established concentration, exposure time, and frequency of occurrence of a contaminant or multiple contaminants which shall not be exceeded. They provide goals or objectives for the quality of the ambient air and the basis for implementation of these goals through emission standards for specific polluting sources. With passage of the federal Clean Air Act of 1963 and its subsequent amendments, more complete standards were needed. Thus, more precise and rigid air quality standards on smoke and particulates and other contaminants were developed.

Specific emission standards have been adopted for Kraft pulp mills, rendering plants, hot mix asphalt paving plants, wigwam waste burners, and open burning dumps. Special rules are provided through legislation for field burning. In the areas where both the state and regional authorities have jurisdiction, all air quality and emission standards are comparable.

The 1967 amendment to the Clean Air Act, termed the Air Quality Act, was particularly significant in bringing federal involvement into the air quality field. It provided for the establishment of air quality regions and a timetable for development and approval of implementation plans, ambient air standards and other regulations and data. The Portland Interstate Air Quality Region was established early in 1970 in conformance with this act. It includes the Willamette and Columbia Basin counties now in the three regional authorities and Clark and Cowlitz counties in Washington. Federal legislation just enacted will require (1) that the entire country be broken down into air quality regions, (2) that national air quality standards be set, and (3) that uniform national emission regulations be adopted for the principal air pollution sources.

OUTLOOK

The outlook for air quality in Oregon is inextricably linked to the restricted atmospheric conditions or natural ventilation that prevails here. Western Oregon has the highest air pollution potential on a meteorological basis of any area in the country. Air pollution incidents, as experienced during each of the past several years, will continue since they are associated with this restricted natural ventilation condition.

Progress is being made in abating the more gross and obvious controllable sources. All indications point to continued progress. But sources related to population, such as automobiles and home heating, will worsen as the population grows and concentrates in urban centers. As the problem shifts to that of a complex urban mix, assigning blame and providing control will become more difficult. The situation can be further complicated by additional chemical reactions in the atmosphere to produce new secondary pollutants. These factors all point to the need to further abate the large controllable sources to simply keep pace.

Increasing recognition will be given to the link between land use planning and maintenance of air quality. Constraining urban sprawl and its accompanying detrimental interface with agricultural and other existing activities will help prevent air pollution and other environmental problems from developing. Other air quality problems can be averted through siting of industrial plants and power stations with enhanced understanding of meteorological conditions.

WATER QUALITY IN OREGON

The quality of water in a stream or other body of water can be impaired by adding pollutants, including heat, or by withdrawing water. A lower quantity of water reduces dilution capacity for a given volume of pollutants. Increasingly stringent regulations have been imposed to decrease the amount of waste discharge. Withdrawal has not, in the past, generally been a factor of equal concern in regard to maintenance of water quality. The water quality-quantity relation is of most significance in western Oregon due to the poor seasonal distribution of rainfall in this region. Streamflows are drastically reduced in the dry summer months. Some smaller streams dry up entirely. In a few, the major flow comes from sewage and industrial water releases. Flow is augmented materially in a number of streams by water released from upstream dams. During the summer period, around 40 percent of the normal flow of the Willamette River in its middle reaches is water released from storage reservoirs. Low streamflow reduces the volume of water available to dilute wastes, and to absorb heat units from solar radiation and the air-water interface.

Oregon's water resources are varied and each is subject to multiple use. Thus far, major attention has been given to water quality in Oregon's rivers, lakes, and streams. Greater attention is now being given to the quality of our estuaries and coastal waters. Water quality-quantity relation in an estuary is deceptive. Wastes discharge practices cannot be based on the assumption that the estuarine waters are renewed with each tidal cycle, as in the continuous flow of a river. The relation is more analogous to that of a lake, for in bays fed by small rivers, the incoming tide returns much of the same water removed on the outgoing tide.

The gross water pollution problem associated with sewage, pulp mills, food processing plants, and other large sources of organic wastes, which motivated Oregonians in 1938 to establish a water quality enforcement program, is rapidly coming under control. Other problems which caused concern in the past include siltation, toxic industrial release, and pathogenic organisms from raw sewage. The year 1972 is regarded as the bench-mark year for bringing these gross and obvious water pollutants under control. The task after 1972 will be to maintain this control program and attack the increasing number of small contributors. The principal forces that will bear on the maintenance of water quality in the future include an increasing population with associated economic development; withdrawal of water from streams, particularly for irrigation during low-flow periods, resulting in reduction of their dilution and assimilation capacities; and further demands for multiple use of Oregon's water resources.

NATURE OF OREGON'S SIGNIFICANT WATER QUALITY PROBLEMS

Organic Wastes, Nutrients, and Oxygen Depletion

The water quality problem which has received principal attention in Oregon since the state enforcement program was established in 1938 has been the discharge of organic wastes from municipalities and industries, and the resultant depletion of dissolved oxygen. The maintenance of a high level of dissolved oxygen is considered a critical factor in maintaining a clean, viable and aesthetically pleasing river or stream. Not only are all forms of aquatic animal life directly dependent on a satisfactory dissolved oxygen supply, but a low oxygen content is a reflection of the fact that the water is overloaded with organic wastes. The water body receiving most attention has been the Willamette River and its tributaries. In the late 1930's, the problem had reached the critical stage of complete oxygen depletion in the Portland Harbor area in the low-flow summer period. Aspects of the problem were foul odors from anaerobic conditions, obnoxious floating sludge rafts, and destruction of fish and other aquatic species of economic importance.

The breakdown of organic matter is a natural and continuing process in the water environment as well as in land and air environments. It is nature's way of treating organic wastes. Certain levels of organic material are needed to keep the body of water productive, but excessive levels are harmful. When organic material enters a stream or other water body, organisms—principally bacteria—start immediately to break down the material into its components —principally nitrate, phosphate, and simple carbon compounds. This breakdown process is normally an oxidation or respiration process which is dependent upon the oxygen from the air. This oxygen is available to aquatic organisms, including the bacteria breaking down the organic wastes, in the form of dissolved oxygen (DO) in the water. The extent to which the oxygen is used depends upon the amount and potency of the organic material, as assessed by its biochemical oxygen demand (BOD). A second stage in the breakdown process, in which oxygen is again consumed, is nitrification. The nitrogen from the organic material, primarily ammonia, is first changed to the nitrite form, then to a nitrate.

The pollution discharge of organic wastes into a stream is often referred to as a certain number of pounds of BOD. This is somewhat misleading and might give the impression that a pound of BOD represents a substance which is discharged into the water. Rather, it represents the demand placed on the dissolved oxygen content of the receiving stream by the discharged organic wastes. Use of the term "a pound of BOD" means that a pound of dissolved oxygen will be required to degrade the organic wastes through a biological process.

If the amount of organic material is high, dissolved oxygen may be exhausted. As this occurs the degradation process becomes anaerobic. Anaerobic bacteria use chemically incorporated, rather than dissolved oxygen. Gases such as methane and hydrogen sulfide with its foul odor are released. Fish and other aquatic life requiring oxygen are destroyed in an anaerobic breakdown.

Water temperature and the presence of toxic substances can have an influence on the degradation process. The presence of toxic substances can harm the bacteria and other organisms that degrade the organic materials. High water temperature accelerates the degradation and oxygen depletion process and reduces the capacity of the water to retain dissolved oxygen. Thus, during the summer when air temperatures are high, pollution from organic wastes becomes critical. Unfortunately, elevated air temperatures coincide with periods of low stream flow and with removal of high volumes of water for domestic and irrigation use.

Another aspect of the organic wastes problem is that of regeneration of organic material within the body of water itself. The nitrogen, phosphorus, and other plant nutrients, available either through the decomposition of organic materials, through direct nutrient discharge from outfalls, or via ground water and land runoff, fertilize water bodies and foster plant growth. Lower plant forms such as algae as well as rooted plants may flourish, and animal life then develops to feed on the plant life. As the newly produced plant and animal life die, a new source of organic material is created. If amounts become excessive, an organic pollution problem and loss of dissolved oxygen result.

In Oregon significant progress has been made in reducing the amount of organic matter released, particularly into the Willamette River system. Substantial abatement has been effected in the major problem sources; domestic sewage, pulp and paper mill wastes, and food processing wastes. With reductions in direct organic release, however, release of nutrients from the decomposition process in wastes treatment has become more significant, and this problem will grow proportionately as population and industrial activity increase. The only solution will be advanced or tertiary treatment in which the nutrient materials (as well as such other materials as exotic chemicals) are removed before the effluent is released into the environment. Such a step will be very costly. As a rule of thumb, tertiary treatment to remove essentially all nutrient material will cost three to five times as much as present secondary treatment. The waste water treatment plant at Lake Tahoe in California is such a tertiary plant.

Other nutrient sources for the regeneration of organic materials come from the direct discharge of nutrient materials by certain industrial plants, from phosphorus-containing detergents in sewage, by return flow of irrigation water containing nutrients, by runoff, air transport and seepage from animal production facilities such as feedlots, and by runoff from urban developments such as streets and parking lots. An example of this is the substantial volume of ammonia which has been released into the Willamette River from industrial operations in the Albany area. A fertilizer production operation being initiated by the Wah Chang Albany Corporation should help materially in reducing this nutrient source.

In regard to nutrient contribution from animal production facilities, recent research indicates that airborne ammonia may contribute more nitrogen enrichment to downwind lakes or streams than runoff or seepage from the land. The same situation has occurred with water bodies adjacent to tertiary sewage treatment facilities. Rainfall also brings down nutrients in the form of oxides of nitrogen formed by industrial and automotive combustion. This effect is particularly marked downwind from large industrial cities in some parts of the nation.

The principal nutrients entering streams from irrigation water return are nitrogen and phosphorus. Phosphorus tends to be tied up in the soil so, typically, enters with soil particles. The Department of Environmental Quality (DEQ) has initiated monitoring and other survey programs to determine the magnitude of nutrient levels in Oregon's streams attributable to agricultural operations. It is difficult to distinguish between the nutrients coming from cropland as a result of fertility practices and those that result only from the practice of cultivation. From these preliminary studies it appears that irrigation return may be influencing water quality in a number of Oregon streams. These include the Klamath, Rogue, Deschutes, John Day, Umatilla, Grand Ronde, Powder, Burnt, Owyhee, Malheur, Snake and certain of the lesser streams in the closed basins in interior Oregon.

Pathogenic Organisms

High concentrations of bacteria from fecal sources, as indicated by coliform organisms, resulting from raw sewage discharges, constituted a significant water pollution problem before sewage treatment was initiated in the state. The most difficult problem existed in the Willamette River system, and the goal for all cities on the mainstream of the Willamette was to achieve primary treatment plus chlorination for destruction of pathogenic organisms by 1957. With the recent completion of municipal secondary treatment facilities for all cities along the Willamette, considerable additional improvement has been made. It has been required that similar improvement be made for cities along the Columbia River and the coast by 1972.

Even with the effective sewage treatment and disinfection programs in all urban communities in Oregon at the present time, the coliform level is still significantly high in a number of streams. This coliform level is higher than can be accounted for through sewage sources alone. Recent studies by the Department of Environmental Quality (DEQ) have revealed major sources other than sewage runoff to be animal agriculture, urban paved surfaces, and storm drains. Another factor in coliform levels is the regeneration or regrowth that takes place in the stream itself. Enrichment materials such as wood sugar in pulp wastes serve as excellent media for the reproduction of these organisms. The extent to which pathogenic forms are also reproduced on this basis is not known.

As an example of coliform from animal sources, the levels of coliform bacteria in the Klamath Basin system are increased by the presence of waterfowl and livestock in the region between Klamath Falls and Keno. During the summer the most probable number values (8-year average 1959-1966) for coliform bacteria range from 93 to 3,469 per millileter at various points in the basin system.

The possibility of release of pathogenic viruses through sewage effluents has been of particular concern nationally in recent years. Technology for their destruction in conventional sewage treatment systems is considered inadequate at present. Viruses, unlike pathogenic bacteria, are not easily destroyed in sewage treatment processes, including chlorination. Many infections of man such as polio and hepatitis are caused by viruses.

Toxic Materials

Certain inorganic chemicals in addition to a vast number of organic materials can be toxic to plant and animal life in water environments. Refractory materials which are not readily broken down either in the water environment or in treatment processes are particularly troublesome. Among the materials of concern are certain pesticides, a number of industrial chemicals, and even the hexachlorophene used in household products. The toxic material receiving the most attention recently is the metal mercury, which can enter the food chain in a stream upon conversion in the bottom muds to an organic form. There is concern nationally with other toxic metals such as cadmium in the water environment.

Another class of materials causing concern in the water environment are the polychlorobiphenyls. These are synthetic chemicals which are used as ingredients in a number of industrial products, such as solvents, plasticizers, and brake fluids. Limited monitoring data indicate that these organic compounds are becoming widely distributed in water environments and can have a detrimental effect on certain aquatic species and fish-eating birds. They appear to be implicated in the problem of thin-shelled bird eggs and the resultant population decreases.

Sediments

Considerable effort on the part of Oregon's water pollution regulatory agencies has been directed at the gross and obvious sources of man-caused sedimentation in streams. Progress has been made in reducing sediment problems created by such sources as gravel operations. Most of these operations now employ settling facilities and other techniques for reducing sediment loads. Even so, at the present time, nearly every stream in the state has rather heavy sediment loads during periods of heavy runoff from adjacent lands. A high percentage of the sediment loads are related to man's activities rather than a natural source. They can be traced to poor land management practices associated with logging, roadbuilding, overgrazing, mining and urban land development.

Thermal Effects

Debate generated by the proposal for nuclear power plants in the state has directed attention to the problem of thermal pollution, or excess heat, in the water environment.

Man's activities can bring about changes in water temperature in many ways and can add to those produced through such natural forces as air-water interchange and the warming effect of the sun. The principal man-made sources are environmental alteration such as removal of vegetation; impoundment for water storage; diversion of streamflow for such uses as irrigation and domestic consumption; and addition of heat, principally coolant waters, from industry and power generation. All these sources of thermal effects are of importance in Oregon. Forestry operations remove vegetation and can lead to higher water temperatures in small streams of the upper watershed. It is clearly recognized that the impoundments on the Columbia, as well as on other streams in the state, have increased water temperatures. Techniques are available for making adjustments in reservoir release to minimize this effect, but most impoundments in the state were not constructed on this basis. The diversion of water from streams during low-flow high temperature periods is of major significance in stream temperature conditions in Oregon, and is a cause of a number of streams exceeding existing temperature standards. Finally, a number of industries utilizing water in their operations return the water back to the stream at a higher temperature than when withdrawn.

Present public policy in Oregon under existing water quality standards does not permit once-through cooling with thermal power generating stations. Perhaps the most significant factor in stream temperature in the state, as far as the future is concerned, is diversion of substantial volumes of the streams during low-flow periods for irrigation. Flow volume is low in most streams during the summer period in the state. An exception is the Columbia, which flows more heavily in the late spring and summer period due to snowmelt. Thus, withdrawals from the Columbia, during the summer period would have less impact than from other streams in the state as far as water quality maintenance is concerned.

A problem associated with increased water temperatures is the greater incidence of fish diseases occurring under these conditions. Direct effects on fish and shellfish, such as decreased growth rate and reproductive cycle changes, can also be shown. Sudden and pronounced changes in water temperatures can kill certain fish outright, and nontolerant species can be eliminated. More broadly, the entire ecosystem of a body of water can be altered through temperature change. While a specific species of economic significance, such as a sport fish, might not be unduly harmed by increased water temperatures, lower order species in the food chain, upon which higher species are dependent, can be eliminated, leading in turn to removal of the economically important species.

The Sphaerotilus Problem

A biological process of significance to water quality in Oregon is the growth of the aquatic bacterium, *Sphaerotilus natans.* This slime organism, falsely called the sewage fungus, thrives on stream enrichments containing sugars and carbohydrates. Thus, it is found in heaviest concentrations immediately downstream from pulp and paper, food processing and municipal sewage outfalls. It grows in long chains, both on the bottom of streams and attached to floating material in streams. In shallow streams, the growth is conspicuous, attached to rocks and submerged plants. *Sphaerotilus* also forms directly in the open water, on floating material such as leaves, grass, and bits of wood fiber. As soon as the floating *Sphaerotilus* body passes the nutrient area, it dies and sinks to the bottom. Frequently this material is carried in suspension through the swifter regions and is deposited in downstream pools where it adds to the sludge beds. A recent study which identified the type and source of material in the sludge beds on the bottom of the Willamette River found that *Sphaerotilus* was the principal contributor to these deposits. Surveys have indicated that most *Sphaerotilus* in both the Columbia and Willamette Rivers is formed in open water. Wood fiber has been implicated as an important attachment site. In the Willamette, practically all *Sphaerotilus* bodies settle to the bottom, contributing to sludge deposits. Sludges from *Sphaerotilus* are reported to occur in a few tributaries of the Columbia, but not in the main stream. Fouling by *Sphaerotilus* becoming attached to fishing nets and other objects is a significant problem. Abatement measures include both reductions in the organic wastes on which the organism feeds and the wood fibers on which it attaches. Present abatement programs of the pulp mills should go far in abating the *Sphaerotilus* problem by 1972.

POLLUTION SOURCES AND CONTROL MEASURES

Municipal Sewage

In 1938, when the State Sanitary Authority, forerunner of the Department of Environmental Quality, was created, less than 100,000 people were served by 49 sewage treatment plants. Today about 1,500,000 people are served by some 300 domestic sewage plants. These range from small privately owned, aerobic digestion plants serving recreational facilities to major treatment plants in the larger cities and provide sewage treatment service to approximately 65 percent of Oregon's population. The remaining 35 percent are served by individual systems such as septic tanks. There is excess capacity of some 20 percent in these community facilities for expanded population. Of the population served by collection and treatment systems, 62 percent have secondary treatment. All of the cities in Oregon with sewage systems have secondary treatment with the exception of certain ones discharging into the Columbia River or the Pacific Ocean. These are on schedules of compliance to meet Oregon water quality standards to provide secondary treatment systems to all of the remaining communities by July 1972.

Another sewage waste problem that remains in the state is the large number of combined sanitary and storm sewer systems in older sections of many cities. Systems constructed prior to 1940 are nearly all combined; those after that date are separate.

The problem with such combined systems is that even if the interceptor lines are the standard two or three times larger than the dry season flow requires, they still are generally not large enough to carry all the runoff which occurs during a storm. This runoff, unseparated from domestic sewage, often has to be dumped directly into the river, bypassing the treatment plant. Typically, 2 or 3 percent of the total annual sewage flow in a combined sewage system is so discharged, but during periods of heavy rains, the percentage of untreated sanitary sewage may be large. The BOD and suspended solid content of the bypassing flow is often particularly high because the water's greater velocity has churned up debris in the sewers. In Oregon it is required that all new systems have separate sanitary and storm sewers, and that all extensions of existing systems be separate if possible. Runoff content varies a great deal, with some high in solids, BOD, and even in coliform count. In western Oregon, where heavy rains occur chiefly in the winter when streamflow is high, storm water released to the river is well diluted except for the first rains of the fall.

Disposal of large volumes of sludge, the solids resulting from sewage and industrial wastes treatment, remains another problem in the state. Older methods of fertilizer use and incineration frequently fail to meet proper public health and air quality requirements. The possibility of large scale combined composting of garbage, other organic municipal refuse and sludge offers an intriguing possibility for the future.

Another remaining problem is the contribution of nutrients from treated sewage effluents, particularly phosphorus. During the past two decades, phosphorus content in sewage has increased markedly, attributed primarily to detergents. Some four billion pounds are now used annually in this country. Phosphorus has been used as a base or builder, mostly in the form of polyphosphates. By the time the sewage effluent is released, these polyphosphates have been changed to orthophosphates, a form readily used by plants as a nutrient. Most detergents contain 20 to 40 percent polyphosphates, but some contain as high as 50 percent. At some locations, as much as half the phosphorus in sewage effluents comes from detergents.

Cities in Oregon from 1946 to the present have spent in excess of $200 million for sewage treatment facilities. The annual cost of constructing facilities approximates $25 million per year. At present costs, the Department of

Environmental Quality estimates that future main-interceptor sewage and sewage treatment needs will cost at least $170 million.

Forestry Industry Wastes

Oregon's wood products industries generate a number of wastes disposal problems. Oregon's principal industrial water polluting source has been the large volumes of organic wastes and wood fibers released from pulp mills. Pulp operations employ, with limited exceptions, the sulfite or the Kraft processes. The initial plants built on the Willamette River system some 75 years ago, utilized the calcium-base sulfite process. They were characterized by large volumes of liquid wastes of high organic (BOD) content and contained the processing chemicals. These wastes contained, dissolved or in suspension, about half the weight of the wood used for pulping. To permit recovery of process chemicals and destroy the organic wastes (about half lignin and half wood sugar), these mills are converting to a magnesium-base process. With this process BOD is reduced by 85 to 90 percent, but there is an increase in sulfur dioxide released into the atmosphere.

The principal pulp industry expansion in the past 30 years—and now the major segment of the industry—has been with mills using the Kraft process. This process is based on chemical recovery. While the water pollution problem is less severe, reduced sulfur gases (H_2S and mercaptans) have constituted a major air pollution problem.

The major water pollution problem associated with pulp and paper mills has been in the Willamette River system. The problem is depletion of dissolved oxygen during the low-flow summer period, buildup of the slime growth, *Sphaerotilus*, and the creation of bottom sludge deposits. The initial abatement program which started in 1952 involved holding wastes during the summer period. The strong pulping wastes were discharged into storage lagoons and released on a metered basis after fall rains provided greater stream volume. One mill, Publishers Paper at Oregon City, because of the lack of space for lagoons, barged its waste liquors to the Columbia River. The next abatement step was a requirement for primary treatment to remove settleable solids and wood fibers which served as a medium for the buildup of *Sphaerotilus* and added to bottom sludge. All mills on the Willamette system have now installed primary treatment. An estimated 200,000 pounds of solids are removed daily from the waste effluents of these plants.

A third step in the abatement process has been the requirement for secondary treatment or equivalent control on a year-round basis. Three pulp mills—Weyerhaeuser at Springfield, American Can Company at Halsey, and Crown Zellerbach at Lebanon—and one fabricator of pulp products, the Evans Products Plant in Corvallis, have installed secondary facilities. The remaining mills have programs to provide these facilities by July 1, 1972. Compliance schedules are written into the wastes discharge permits of these mills.

In other abatement efforts, the Crown Zellerbach plant at West Linn has closed its pulp manufacturing facilities, and the Publishers plant at Oregon City has converted its pulping process to a magnesium base, which permits burning of the condensed waste liquor and recovery of the processing chemicals to handle the wastes formerly barged to the Columbia for release. With the completion of the abatement program that requires secondary treatment and chemical recovery, the wastes discharge to the Willamette River system by the nine pulp mills will have been reduced from an amount equivalent to that which would be produced by a population of 4 million persons, to the equivalent produced by 250,000 persons.

Other pulp mills in the state discharge into the Columbia River and the Pacific Ocean. The Georgia-Pacific mill at Toledo, and the International Paper Company at Gardner, after primary treatment, discharge into the Pacific Ocean. The Coos Head Timber Company discharges into Coos Bay. The Menasha Corporation has been discharging pulping wastes into seepage lagoons on a sand spit between Coos Bay and the ocean. Improved discharge practices are being required of the latter two mills. The mills on the Columbia River in both Oregon and Washington provide primary treatment. The St. Helens mill is currently constructing secondary treatment facilities.

A primary water pollution problem associated with the plywood industry has been the discharge of glue wastes. These wastes, although of small volume, are high in organic content and are toxic. A number of mills are now recirculating and reusing the glue, and other mills are in various stages of adoption of this procedure.

Another type of water quality problem is associated with the Pacific Northwest practice of storing logs in ponds or streams. This practice is not only convenient but also provides sufficient moisture to prevent drying and splitting of the logs. Unfortunately, this storage practice has some inherent problems relating to the pollution of the storage waters. Soluble leachates from the logs add color and biodegradable organic matter to the water. Studies at Oregon State University have shown that although this source of pollution is measurable, it is not significant in most storage areas. Little toxicity was found to be associated with log leachates.

The loss of bark from the logs during unloading operations and subsequent storage is a more serious problem. Some of the bark floats for a short period of time before it absorbs sufficient water to sink. Surface bark is not only aesthetically displeasing but can give rise to problems at water intakes and with recreational uses of a watercourse. Bark in bottom deposits provides a usable food source for organisms, which in turn use oxygen from the overlying waters. An unanswered question regarding bark deposits concerns the effect this bark deposit has on the movement and function of benthic microorganisms which are important links in the aquatic food chain.

Abatement efforts by the industry are aimed at reducing bark losses by improved log dumping and transport practices. Other abatement measures include storing logs in man-made ponds isolated from natural waterways; debarking logs prior to water storage; and removing all logs from the water and placing them in cold decks on dry land, where water is sprayed over the logs to prevent splitting.

Food Processing

Food processing, particularly of vegetables, has been expanding rapidly in Oregon in recent years. The Salem area now supports the largest concentration of food processing plants in the United States. From the standpoint of environmental quality control and wastes management, the concentration of processed food production can lead to intensification as well as a reduction of wastes disposal problems. The consolidation of effluents from several plants can lead to centralized by-product and/or treatment facilities where the economies of size can be realized. On the other hand, the highly organic nature of food processing wastes can easily lead to water quality problems if these wastes are not strictly controlled. The high BOD of organic wastes can contribute to the dissolved oxygen (and possible anaerobic breakdown) problem.

The problem that previously existed, discharge of large volumes of untreated food processing wastes with high BOD loads directly into streams, has been essentially corrected. The two most important abatement programs followed by the industry have been (a) in-plant process changes to both reduce wastes production and/or to treat concentrated sources and (b) "joint treatment" through agreements with municipalities for handling wastes at the local sewage treatment plant.

A potential problem with joint treatment is the possibility of municipal plants becoming more and more dominated by local food processing effluents. The rapid and continued growth of the industry has in several cases led to overloading within 3 to 5 years of start-up of municipal plants designed for operational lives of 15 to 20 years. This has often led to serious operational problems in the plants themselves. Reasons for this are an apparent inability on the part of industry to accurately forecast its growth over a 5-to-20-year period, and a lack of familiarity on the part of industry, consulting engineering firms, and enforcement officials with the characteristics of the wastes themselves. Research is currently underway to correct our deficiency in knowledge about the characteristics of the various wastes streams from the processing of specific commodities. The problem of predicting production levels, and therefore processing levels, in the future still remains to be solved.

With the current regulatory emphasis on effluent standards and on the encouragement of industrial cost-sharing on an equal basis, and with the frequent and notable lack of success in designing, building, and operating combined municipal-industrial wastes treatment plants for their predicted useful lives, it appears that a greater trend toward at least partial on-site treatment of wastes by the industries themselves is developing. The next 10 years in Oregon should bring a significant increase in the number of these treatment systems specifically for industrial wastes. These will prove more costly to the industries than the combined treatment systems now being used, but will offer several advantages including complete autonomy of operation and increased opportunity for by-product development.

Metal and Chemical Processing

Toxicity, taste and odor problems in water and in fish flesh, and nutrient enrichment of streams are water pollution problems associated with the processing of metals and chemicals in the state. Those which have come under most consideration have been the Chipman Chemical plant near Portland and the Wah Chang Albany plant.

The problem with the Chipman operation came from the release of residues from herbicide manufacture and other chemicals to impart an undesirable flavor fo fish flesh. The installation of an activated carbon absorption system has brought the release problem under more adequate control. Certain changes have been made in the Wah Chang operation to reduce toxic and enriching discharges, but only partial control has been achieved.

Abatement Methods

The redrafting of water quality standards for Oregon was started in 1967. The first step involved the adoption of general water quality standards which applied broadly to all waters of the state and established minimal acceptable criteria. Specific standards were also adopted for the Rogue, Umpqua, Clackamas, Sandy, Mollala, Deschutes, McKenzie, North and South Santiam, and Tualatin Rivers. These standards specified numerical limits for pH, temperature, dissolved oxygen, turbidity, coliform bacteria, and certain chemical ions. Where treatment of wastes more efficient than conventional secondary treatment is required, the standards also include treatment requirements and effluent standards. A monitoring program is conducted in the enforcement of standards. Samples are collected and tested on a periodic basis in all eighteen river basins of the state and in major lakes and estuaries.

It has been stated that Oregon's standards and requirements are among the highest in the nation. In two basins in the state, the standards are so high that no effluents, regardless of the degree of treatment that is provided, can be discharged into the river systems. In certain other river basins, extremely high degrees of advanced wastes treatment are required and, in addition, augmentation of the low stream flow must be provided during the critical summer and fall months.

The Waste Discharge Permit Program, which was passed by the 1967 legislature, is a second major tool in Oregon's water quality maintenance program. The law requires that all wastes dischargers obtain a permit to release wastes into Oregon waters. All major point-source wastes dischargers and many minor ones are covered by specific wastes discharge permits. The duration of permits issued has varied from 2 months to 5 years. Most have been for less than 2 years. Short duration permits have been used to force periodic review of progress in cases where water pollution control improvements seem necessary. The discharge permits contain specific limits on quantities and strengths of wastes that can be discharged and characteristically include numerical limits on pounds of BOD, suspended solids, pH and bacteria. In addition, permits may spell out limits on temperature, turbidity, toxicity, and troublesome chemical ions. Where present treatment or control is inadequate, a detailed program and timetable for providing fully adequate treatment is written into the permit itself. Permits are issued to all cities as well as to industries ranging from the largest pulp mill to small log pond dischargers. To obtain a permit, new industries are required to install the highest and best practicable treatment prior to starting production.

EFFECTS AND PRESENT STATUS OF POLLUTION IN OREGON'S WATER RESOURCES

Pollution Effects on Recreation and Fish Life

Water-based recreation, which requires a very high water quality, is a significant activity in Oregon. The state's many streams, lakes, impoundments, and estuaries and the Pacific Ocean are all heavily used for this purpose. Deterioration in quality can impair or destroy this resource use for Oregon residents and will have a detrimental economic effect on the state's important and expanding tourism industry as well.

The effect of various pollutants on aquatic life is a complex situation. Impact will vary with physical properties and chemical composition of the water. Sensitivity of fish to toxic materials will vary greatly with altered water conditions. Addition of certain materials may lessen the harmful effect of others. In some cases, combinations may be more harmful than the sum of the same levels of the single materials independently. The time-concentration relationship is another factor in determining tolerance of aquatic life to pollutants. A single or short-term exposure to higher concentrations may show no apparent harmful effect, whereas repeated exposures to the same concentration or continuing exposure at a lower concentration may cause harmful effects or death. Over a period of time, organisms can also develop tolerances for concentrations which, before initial exposure, would have been toxic even at lower levels.

Low levels of dissolved oxygen have posed major problems in waters through which anadromous fish must migrate to spawning areas. Water temperatures above the necessary level for certain species and the effects of toxic substances are now of increasing concern. A great deal of current research is being devoted to the effects of pesticides, detergents, and toxic industrial wastes on development, growth and mortality of important aquatic species. Direct effect on the desired species itself is only a portion of the problem. Bottom fauna and flora on which the species depends for food supplies can also be harmed or destroyed.

Proper levels of both organic and inorganic material can be highly beneficial to aquatic life. Low levels of organic wastes serve as enrichment, and it is only as the levels become high enough to cause oxygen depletion, excess algal growth, or other harmful effects that deleterious pollution occurs.

River Pollution

As a river moves from its inception in snow melt, outpouring of underground springs, or in rainfall runoff, it acquires many substances both natural and man-made. Rivers are incomplete ecosystems in that the principal influx of nutrients comes from adjacent land systems. In the case of many rivers and streams in Oregon, the level of natural nutrient enrichment is very low. Rainfall or snow melt moving over basaltic or granitic soils does not contain high levels of dissolved nutrients; thus, to a large extent man is responsible for the quality and quantity of entering waste materials. Control of these wastes is accomplished by means of domestic and industrial wastes treatment, effective management of agricultural and forestry enterprises, and other aspects of river management. Public policy in Oregon calls for the use of river systems for maximum benefit; water supply, fish production, flood control, irrigation, recreation and power are some of the multiple uses for Oregon rivers.

Three river systems which have been particularly affected by man's activities in the past are the Willamette, Tualatin, and Klamath. Improvements have been made in all three systems, but current status is subject to increased pressure by expanding population, increased industrialization and agricultural practices.

In the late 1920's, studies of the Willamette River showed portions of the river so polluted as to endanger health and fish life and render the river useless for recreation. There were instances of complete oxygen depletion in the Portland harbor area during the low-flow summer period. Aspects of the problem included foul odors, obnoxious floating sludge rafts and a destruction of aquatic species of economic importance. The principal causes were untreated municipal and industrial wastes being directly discharged into the river. In November of 1938, Oregon voters approved a comprehensive water pollution control law which created the State Sanitary Authority—the forerunner of the Department of Environmental Quality. The regulations required a dissolved oxygen content of 5 parts per million in the Willamette at the Portland harbor area and a disinfection of municipal wastes to destroy enteric bacteria. The minimum oxygen level is that necessary for salmon and other anadromous species.

The Sanitary Authority ruled that primary treatment and chlorination for all municipal wastes were necessary to achieve the required oxygen levels and reduce the bacteria population. In 1949, the first two primary treatment plants became operational in Junction City and Newberg, and in 1957, the project was completed with the Harrisburg plant. Primary sewage treatment involves screening of the wastes material followed by settling and clarification, and removes approximately 35 percent of the BOD, 60 percent of the solid material, and 15 percent of the total nitrogen-phosphorus content.

As municipalities along the Willamette River were completing their primary treatment plants, further studies showed that industries, primarily the pulp and paper mills, were responsible for 85 percent of the total BOD load being discharged into the river. Immediate improvements were deemed necessary and have resulted in a reduction of present wastes discharges from these sources to 1/16 the levels which existed in 1952 when the program was initiated.

During the time industry was initiating wastes control measures, municipalities along the Willamette began construction of secondary treatment facilities which remove 85 to 90 percent of the BOD, 90 percent of the solids and 40 percent of the total nitrogen-phosphorus content. At the present time, secondary treatment for domestic wastes is uniform along the river.

The water quality standards for the Willamette are now being implemented by waste discharge permits. The permits require bacterial disinfection with chlorine and definite limits on the number of pounds of BOD discharged, hydrogen ion concentration (pH), toxic chemicals, color, etc. The pollution abatement efforts have had positive results. This past summer the dissolved oxygen content in the Portland harbor area did not fall below the 5 parts per million minimum level. The fish population is being brought back. Runs of both chinook and coho (silver) salmon are improving as pollution abatement progresses. In 1970, some 35,000 coho and 7,500 chinook salmon were tallied at the newly installed fishway at the Willamette Falls.

The river is beginning to meet the quality standards set for it, but the situation is tenuous. Residents of the valley comment and are curious about the murky appearance of the Willamette. In part, the appearance of the water is due to dissolved nutrients from treatment plants fostering plant and animal life. The turbidity does not arise from direct wastes discharge. Tertiary treatment plants on the Willamette may become necessary to maintain and improve on the present quality of the river in the face of increased population and industrialization.

The waters of the streams in the Tualatin River Basin have been very seriously affected by man's activities. In 1966, the population of Fanno Creek and other drainages in the Tualatin Basin had increased to the point that even a high degree of secondary treatment was no longer adequate to prevent the creation of nuisance conditions. Analyses of the Tualatin River for dissolved oxygen, BOD of organic constituents, coliform bacteria levels, and total solids all show clearly the decreasing water quality from Gaston downstream to Fanno Creek. New construction had to be halted in some areas, and a plan for a master sewer system is being developed.

The municipalities in the Tualatin Basin will be bringing new and improved domestic sewage treatment plants into operation this year and during the next several years, which will result in very advanced tertiary sewage treatment systems. However, two other problems remain. During the summer a large volume of water is withdrawn for irrigation purposes, further reducing an already low stream flow. In addition, runoff and ground seepage from dairying and similar operations contribute to both the high nutrient levels and high coliform bacteria levels in the Tualatin. This problem will be relieved in the next few years as regulations concerning disposal of animal wastes are implemented.

The eutrophication problem in the Klamath Lake-River system is reviewed under the section on Eutrophication of Lakes.

Special Problems of Small Headwater Streams

Water quality problems on large rivers receive a great deal of attention. Also signficant, however, are the problems encountered on small headwater streams. Small streams in the forested mountains of the state provide the source of water for Oregon's major rivers and a significant portion of the spawning and rearing area for anadromous fish. Man's use of headwater areas is increasing. Forest management activities, including logging, roadbuilding, and the use of chemicals, are concentrated in these areas. Increased recreational pressure, demands for better access roads and more campgrounds in these zones from a greater number of users, will continue to grow.

Less is known about man's impact on the quality of small streams or the organisms that reside there than on large rivers. Recently, studies in headwater areas have been initiated. The Logging-Aquatic Resources Study in the Alsea Basin, a cooperative research project involving state, federal, and private agencies, was designed to evaluate the impact of logging on salmon and cutthroat trout populations in small coastal streams. This study demonstrated that while clearcutting followed by burning could cause large changes in water temperature, oxygen, sediment and fish production, clearcutting without burning but with streamside protection such as an uncut barrow buffer strip produced only small changes in water quality and no change in fish production. The Alsea Study also focused attention on several significant gaps in existing knowledge about small streams and the organisms that live there. The wide variations in sediment loads and fish numbers need more study, as does the response of fish to sediment and temperature changes. Variation in natural levels of sediment and the ability of resident fish to withstand environmental changes are but a few of many problems that require the attention of both research organizations and control agencies.

Roads are the greatest source of sediment in the steep, often unstable topography of Oregon's mountain regions. Since road slides and landslides triggered by roads can scour small stream channels and add tons of sediment to rivers downstream, such engineering design problems as road location and soil stability in headwater regions have significant water quality implications.

Increasing timber yields from upstream watersheds to meet the growing demand for wood products will continue to foster the use of such chemicals as pesticides and fertilizers. The potential impact of these chemicals is probably greatest in the small streams that drain the treated areas.

The mineral and bacteriological quality of undisturbed headwater streams are generally excellent. Such streams are often used for municipal water supplies. The impact of heavy recreation use of Oregon's headwater streams and lakes has not been determined. Wastes handling facilities in many headwater areas are primitive but must accommodate large volumes of wastes during peak periods of summer weekend and holiday use.

Eutrophication of Lakes

Eutrophication of natural and man-made lakes as a water quality problem has been receiving wide attention nationally. Limnologists have classified lakes into two broad types: oligotrophic or underfed, and eutrophic or well-fed. In the normal aging process all lakes pass from oligotrophic to eutrophic and eventually revert to marshes, then to dry land. Under normal conditions, this transition would be measured in geological time, but man's activities in producing enrichment are dramatically speeding up the process of eutrophication.

Artificial nutrient enrichment and microbial action in bottom sediments foster the growth of algae and phytoplankton. The increase in plant production in turn leads to an increase in microscopic animals, the zooplankton. Higher animal forms also emerge as the food chain develops. The process continues until deposits from biological activity fill the lake to the extent that rooted aquatic plants begin the process of conversion to marshland. Artificial fertilization simply hastens the onset of aging and shortens the lifespan of lakes.

Lakes are fragile ecosystems in comparison to rivers and streams. They are self-contained systems, and pollutants entering a lake either have to be physically removed, converted, or assimilated. Studies are revealing that Oregon's lakes are generally in good condition. There are many that are actually pristine, including Crater and Waldo lakes, as well as many alpine systems. Natural eutrophication is proceeding rapidly in Upper Klamath Lake. Devil's Lake on the coast is also in an advanced state of eutrophication. More encouraging are the lakes where the opportunity to preserve inherent aesthetic and recreational values does exist. Diamond Lake in southern Oregon is very popular with tourists and residents alike. Many campgrounds, a resort, organizational camps, and private residences surround the lake. The ever-increasing number of people using the lake means a greater possibility of pollution from pit toilets and drain fields. Consequently, a sewer system and treatment facility have been built to help protect this valuable resource. Cultus Lake is another that is showing signs of man's activities. The Woahink on the coast and Odell Lake in the Cascades are threatened by human activities and recreational use without the presence of coordinated wastes treatment facilities. It appears that this process can be alleviated. A monitoring program for lake quality has been established at Waldo Lake because of the marked increase in the number of visitors in the past few years. Small package wastes treatment facilities may be required in the future on a number of Oregon's lakes in order to maintain the high quality of water necessary for recreational use.

The Klamath Lake-River system is undergoing a rapid natural eutrophication, and man's activities are aggravating a deteriorating situation. The basin is composed of interconnected marshes, sluggish rivers, irrigation drains, and shallow lakes. The water is used for irrigation, power and industry. In addition, migratory waterfowl nest in the area and livestock are abundant.

The waters are naturally rich in nutrients, and algal blooms are a common occurrence. The effect of irrigation and enhancement of natural eutrophication can be traced to the Lost River tributary. Water for irrigation goes through two and one-half cycles before returning to the Klamath River between Klamath Falls and Keno with increased quantities of dissolved solids and nutrients. Between Klamath Falls and Keno, the region's large sewage treatment facilities and industries discharge their effluents. These combined effects plus low stream flows in the summer lead to dissolved oxygen depletion and algal blooms. However, the natural BOD loading of the Klamath River from Upper Klamath Lake and subsequent development of algal blooms coupled with water quantity manipulation are the most important factors leading to eutrophication and oxygen depletion. The addition of treated waste materials only aggravates the natural condition of the river system.

Problems of the Coastal Zone

Increasing attention, both in Oregon and on a national basis, is being given to water quality in estuaries and coastal margin waters of the ocean. Intense development is taking place at this interface between the land mass and the ocean to facilitate the ocean's use as a resource for food, minerals, power, transportation, recreation and other benefits.

Estuaries and the open ocean have been the natural recipients of most of man's liquid-borne wastes, as well as certain air pollutants and solid wastes. The ocean is vast, but its ability to assimilate these wastes without significant degradation is still limited; it is a finite resource. The waste products created by increasing population and associated activity are, in some cases, severely stressing the ecosystems in the waters over the continental shelf. These comprise only 8 percent of the total volume of the ocean but are among the most economically productive areas to man.

Global concern is being expressed about the contamination of oceans in general, by nuclear wastes, oily materials of both shore and offshore origin, the persistent pesticides, the organo-mercury compounds, lead, other toxic materials and phenolic compounds. So far no major oil spills have occurred in the open ocean off Oregon. Two spills have occurred in the Portland area. There is evidence, however, of the release of oil and oil slop from the cleaning of tankers and other activities in Oregon's marine waters. Among other sources, pulp and paper wastes are being released through several ocean outfalls. In addition, there is still some discharge of sewage which has not undergone secondary treatment into the marine environment.

Recent studies by Oregon State University have shown that ultimate disposal of properly treated waste materials can be accomplished through ocean outfalls under proper conditions of design and management with minimal side effects. Such practice is regarded as more desirable than discharge into estuaries.

The coastal waters will continue to be the ultimate recipient of the residual, nonreclaimable fraction of the wastes from man's activities; however, it is recognized that wastes management systems must be made more effective and new concepts and practices developed. The narrow coastal margin environment must be maintained in a healthy and aesthetically attractive condition if the ocean is to continue to satisfy multipurpose requirements.

Present Status of Oregon's Estuaries

The estuaries of North America have served this nation for 300 years. They have provided harbors which serve as the junction of overland and overseas trade routes, served as breeding grounds for open ocean fish, provided extensive shell fisheries, and are areas for recreational and industrial development. Many estuarine environments, however, are suffering severe degradation as population and economic activities expand. The harbors are becoming unnavigable due to siltation; breeding grounds and shell fisheries are being destroyed by sediment or pollution; domestic and industrial wastes discharges are fouling the estuaries; and alterations of river systems and the drainage basins of the estuaries are changing circulation patterns within the estuaries themselves.

Oregon is not blessed with an abundance of estuarine area. The total area of our estuaries is only slightly more than 58,000 acres, which can be divided into equally valuable tidelands, those portions of the estuaries with six feet or less of water, and channel areas. The following description of Oregon's estuaries with respect to water quality has been adapted from the Oregon State University report "Crisis in Oregon Estuaries".[1]

In general, the major factors responsible for degradation of Oregon's estuarine environment now and in the future include increased pollution by industrial and domestic wastes; sedimentation resulting from increased erosion due to logging or fires in the watershed; filling of the tidal flats for industrial and domestic development; and other degradation resulting from such causes as improper dredging and log storage.

At present, pollution of certain of Oregon's estuarine waters is affecting the quality of shellfish and other marine life and aesthetic and recreational values. Water quality is being lowered by the use of estuaries for log storage and in a few areas by the indiscriminant discharge of wastes, both domestic and industrial.

The Columbia River Estuary and Young's Bay comprise a total of approximately 15,000 acres. This estuary, which has salt water intrusion for about 18 miles from its mouth, is an important ocean shipping and industrial area and a commercial and sport salmon fishing and processing center. Industrial, thermal, and sewage pollution constitute a problem affecting the salmon fisheries.

Nehalem Bay comprises 3,766 acres, 1,180 of which are tideland. It supports a significant population of softshell clams in the upper reaches; crabs, salmon, flounder, perch, and other fish are important in the bay and across the bar. Filling presents a threat that would reduce the volume of rich, brackish water and change the flow patterns necessary for clams, crabs, and larval fish.

Tillamook Bay is Oregon's second largest estuary. It covers 8,839 acres and has the largest tidelands, 5,147 tideland acres. More than 90 percent of oysters produced in Oregon come from Tillamook Bay. Sport and commercial clam digging and crabbing are important. Salmon and perch sport fishing is excellent within the bay. Sport boats fish for salmon offshore and commercial crab, salmon, shrimp, and groundfish boats operate offshore. There is a seasonal pollution problem with abatement efforts underway. Log storage and fish processing are major industrial uses of this bay. Major fires in the watershed have caused excess sedimentation in this estuary and have reduced the tidal prism (the volume difference between mean high tide and mean low tide) and bay productivity.

Netarts Bay is a high-salinity, nearly pristine estuary covering 2,406 primarily tideland acres, with excellent clam populations and a small oyster industry. Plans are underway to correct minor pollution which occurs through septic tank seepage near the town of Netarts. The upper bay joins Cape Lookout State Park, and interest has been expressed in designating the bay as an estuarine natural area. The productive area of this bay is threatened by filling and road building.

Sand Lake is a high-salinity, small embayment of approximately 700 acres. This estuary is in a near-primitive condition and could be considered for designation as an estuarine natural area. Sedimentation from logging, road building, and potential filling threatens to make this shallow bay less productive.

[1] *Crisis in Oregon Estuaries: A Summary of Environmental Factors Affecting Oregon Estuaries.* Oregon State University Sea Grant Publication No. 4, Edited by W. Wicks, OSU. 1970.

Nestucca Bay, a small bay comprised of 1,149 mostly tideland acres, contains excessive fresh water. Although low salinity restricts clam production, salmon and cutthroat trout fishing are excellent, and flounder and perch are also taken. Siltation from logging runoff has seriously reduced the depth and flushing pattern, creating dangerously low salinity in this estuary. Domestic sewage is becoming a serious problem.

The petite 438-acre Salmon River estuary contains small quantities of soft-shell clams and supports a fishery for flounder, perch, salmon and cutthroat trout. This estuary could also be considered for designation as an estuarine natural area. Developments in the upper reaches of the Salmon River foretell domestic pollution in this pristine estuary.

Siletz Bay is comprised of 1,203 acres, most of which are tidelands. This small bay supports important sport fisheries for coho and chinook salmon, cutthroat trout, flounder, and perch, as well as softshell clams. Housing developments encroaching on the estuary threaten the value of the bay by dredging and filling of the valuable shallow marsh. Abusive land management in the Siletz River watershed has caused excessive siltation resulting in lowering of salinity and presently poses a danger of filling.

Yaquina Bay is a large estuary covering 2,853 acres, of which 1,741 are tidelands. This large bay is an important industrial, commercial, and natural resource bay. Cockle, gaper, and softshell clams are important recreational and commercial resources. Crabbing, bay fishing for salmon, flounder, perch and other species are popular. Large quantities of herring are taken for salmon bait. Sports boats fish offshore for salmon, and commercial fishermen take crabs, shrimp, groundfish and salmon offshore. Yaquina Bay is a major industrial bay with fish processing, log storage, pulp manufacturing, lumber shipment, and other industrial uses. Recent dredging programs have destroyed valuable shellfish and waterfowl areas by dredging and filling. Even with a long-range water and land use plan, serious problems could occur in this major bay from industrial wastes, oil spills from ships and other unforeseen pollution sources. Land filling continues.

Alsea Bay, covering 2,227 acres, is an excellent sport fishing bay for salmon and cutthroat trout. Perch, flounder, herring, and crab fishing are fair, and softshell clams, cockles and gapers are present in small numbers. This bay appears to have some potential for oyster production. Industrial use is limited to log towing. Watershed logging, polluted streams, domestic wastes, and a lack of an integrated land and water use plan threatens this basically pristine estuary.

Siuslaw Bay, which covers 1,589 acres, of which 597 are tideland, provides excellent fishing for salmon, cutthroat trout, flounder, and perch. Softshell and gaper clamming are productive. Water quality appears to be good although some log towing and barging is carried on. Increased industrialization, especially upstream, and possible nuclear plant thermal enrichment are current and potential water quality problems on this estuary.

Winchester Bay (Umpqua) is a sizeable estuary comprising 5,612 acres, of which 1,548 are tidelands. Fishing and clamming are excellent in and near this bay. This estuary is an important industrial area with fish processing, pulp manufacturing, lumber shipping, and other uses. Siltation from gravel washing operations and logging, and industrialization constitute problems.

Coos Bay is the largest Oregon estuary in total acreage, with 9,543 total acres and 4,569 tideland acres. It is an important industrial bay with log storage, lumber shipment, pulp manufacturing, fish processing and other commercial uses. The lower bay contains excellent beds of gaper and cockle clams, and other species are abundant but small in size. Historically, Coos Bay had tremendous populations of native oysters, but none have survived. Salmon, striped bass, shad, perch, and other fish are caught by sportsmen in the bay. Commercial boats take quantities of groundfish, shrimp, crabs, and salmon offshore. Industrial pollution in the form of pulp mill effluent, log storage, tideland filling and other incompatible uses threaten this bay. An integrated land and water use plan appears necessary to protect this estuary.

Coquille River, a 703-acre low-salinity bay, contains limited beds of softshell clams, and a small commercial and recreational crab fishery is located there. Striped bass, shad, and salmon are taken in the bay. The bay is a valuable shad and salmon-rearing area. Fish processing plants are active. Domestic sewage and reduced salinity from sediment are creating problems for this estuary.

Further south, the geology of the coast changes and the estuaries become smaller. However, their significance is not reduced. Quality in the estuaries of south coastal streams, such as the Rogue, Elk, Sixes, Pistol, Chetco and Winchuck is necessary for the survival of the chinook salmon which use the rivers. During the summer, juvenile chinook feed and grow in these protected bodies of water and move seaward with the fall freshets. Tremendous silt loads are occurring, caused by continued extensive logging on unstable soils.

OUTLOOK

Organic wastes from municipal and industrial sources will continue as a significant problem in the future. Material progress is being made in abating organic wastes sources and should continue. However, population and industry growth will partially offset the progress. Requirements for more efficient and sophisticated treatment facilities indicate that more and better trained plant operators are needed. No matter how well designed, engineered, and constructed a pollution abatement system is, the system is only as good as the operator.

The nutrients or enrichment from the breakdown of organic wastes, from detergents and from other sources will pose an increasingly difficult problem. These nutrients will foster the regeneration of organic material in water bodies.

The need for advanced and tertiary treatment will become more acute to remove nutrients as well as chemicals, viruses, and other materials not fully removed at the present time.

Toxic materials from industrial sources, from agricultural and forestry practices, and from municipal sources will continue to be a problem of major import. Several forces are at work here. Human inventiveness will keep new materials entering the market and the environment. Humans tend also to overuse and to be careless about the use of many toxic materials. Synergistic effects of new products with other man-made materials and with natural environmental components can magnify this problem.

Uncontrolled runoff from parking lots, streets and other surfaced areas poses a special problem. In most Oregon municipalities the storm sewers are connected to the domestic sewer system. During times of high flow, as in the winter, the runoff plus part of the city's untreated raw sewage may have to be directly discharged into the river. The concept of system overload as a pollution factor is as important as the need for trained operators. A trained operator can do only so much with his equipment and cannot effectively handle large fluctuations in BOD loading, whether from storms or from seasonal food processing activities. It is inevitable that increased amounts of BOD will be discharged into the river or stream at such times.

Thermal pollution or increased water temperature will become a water pollution problem of considerably increasing concern and could well become a more limiting factor in salmonid production than oxygen depletion in certain streams.

Withdrawals of water for irrigation and for other consumptive uses will continue to have a major effect on water quality. The progress made to date with abating organic wastes and nutrients for regeneration could be easily reversed by significant diversions.

Higher agricultural productivity has been based on irrigation and use of chemical fertilizers and pesticides. The runoff from farm lands, coupled with that from concentrated feed lot operations, will become of greater relative significance. These diffuse wastes sources are most difficult to control or treat. The problems of runoff and wastes treatment will be compounded if urban sprawl and the proliferation of septic tanks and poorly planned sewage connections are permitted to continue. Improved land use planning is an essential ingredient to the prevention of many water quality problems.

Although the estuaries of Oregon have not suffered to the extent that those elsewhere in the United States have, increased demands due to population growth have, and will continue to have, an increasing effect on the use and thereby on the quality of the estuaries in Oregon. During the period from 1930 to 1960, the population of the Oregon Coast grew 93 percent. During the same period, the national population growth rate grew only 46 percent, and the national growth rate of other estuarine economic regions grew only 78 percent. It has been estimated that by the year 2000 the population density along the Oregon Coast will increase by 50 percent over what it is today.

The environmental problems in the Oregon estuaries will undoubtedly increase during the latter third of the century as the population of the Oregon Coast increases. To date, only limited development has taken place along the Oregon Coast. It can be expected that further developments will occur with expanding population, industry, and tourism-recreation activities. With such economic development, pressures are sure to develop for such alterations to the ecosystem as dredging and filling of estuaries. Expanded economic activities may also be placing stress on the estuarine watershed. In order to maintain and to further develop both the sport and commercial fishery, as well as general recreation, water quality maintenance and the tideland acreage preservation are important, as is the management of coastal watershed lands. In all likelihood, the greatest conflict will arise over the use of the tidelands. With improved management, it should be possible to preserve the multiple values of the estuaries for harbors, recreational areas, breeding grounds, and shell fisheries.

SOLID WASTES MANAGEMENT

Oregon is one of the most beautiful states in the nation. Preservation of the state's natural beauty is the responsibility of all Oregonians, as is reflected in the motto "Keep Oregon Clean and Green". Disposal of solid wastes is a problem of increasing importance that must be resolved in order to assure this quality of our environment.

NATURE AND SIGNIFICANCE OF SOLID WASTES DISPOSAL PROBLEMS IN OREGON

Solid wastes disposal problems have taken on increased importance in Oregon, partly because of the impact of the problems, but primarily because so little progress has been made. In the past, the large size of the state and the relatively sparse population produced a situation where causual dumping of wastes was convenient and economical. However, with increasing population, increasing per capita wastes production, changing composition of wastes, imposition of environmental quality standards and the increased understanding of the effects of disposal practices on the quality of the air and water, better solutions to these problems are needed.

The fragmented development of systems for collection and management of solid wastes disposal has been a serious deterrent to the solution of the solid wastes problem in Oregon. In a majority of communities this system is comprised of one or more franchised refuse collectors who discharge their collections at a privately or publicly owned disposal site. Financing of this system is by fees collected by the operator plus whatever public costs may be assessed through taxes. This situation has prevented the development of systems organized on a geographic basis that can optimize the total effort for collection and disposal and allocate costs on a realistic and equitable basis. As a result of fragmentation, proper systems for disposal of specialized solid wastes such as petroleum products, septic tank sludges, tires, auto bodies, appliances and others has been a practical impossibility since each small system in itself cannot support a proper disposal system. The inability of each small unit to make an adequate investment in proper equipment, personnel and land for disposal of solid wastes has been a serious deficiency.

While the technology for handling most of the present solid wastes problems is available, the legal authority for organization and finance has not been established. Most of the present problems originating in urban or densely populated areas could be resolved with present-day technology through a system that would permit a unified regional approach with proper financial suport obtained through user charges.

EFFECTS OF POORLY MANAGED SOLID WASTES DISPOSAL

Under the present system, the technology used to handle and dispose of solid wastes in Oregon lags well behind that used to control air and water pollution. Refuse collection methods in most regions do not differ substantially from what they were when workers picked up the trash in horse-drawn wagons before the turn of the century. The principal innovations have been the compactor truck and perhaps the domestic garbage grinder which, in turn, has contributed to increased domestic sewage loads.

The obvious effect of poorly managed solid wastes disposal is the aesthetic problem. In addition to being unsightly, solid wastes can prevent the use of the land they occupy and diminish the value of nearby land. The effects on the health of man are more difficult to establish, and data required to support quantitative estimates of direct relationships between solid wastes and disease are lacking. This is not surprising because disease pathways are obscure, and reliable methods of study are scarce. Epidemiological data generally support the conclusion that a relationship between solid wastes and disease does exist, particularly since such wastes support a population of rats, flies, insects and other disease vectors.

The handling of solid wastes disposal in Oregon has progressed at some sites from open dumping to open burning dumps, to simple burial or landfill, to carefully managed compacted sanitary landfill, which is the presently recommended burial system. Each of these steps has been considered an improvement, but each step has had concomitant defects. Open burning reduced the bulk and the population of rodents and flies, but caused air pollution problems. Burial eliminated the air pollution problem, and sanitary landfill eliminated rodent and fly problems and facilitated returning the land to a further useful purpose. Although landfill is a popular and efficient means of handling wastes disposal, it is not a panacea. It has recently become obvious that even these operations create a new set of problems.

The high rainfall, soil characteristics, and terrain of Oregon contribute to a leachate problem in landfills. Ten percent of the authorized disposal sites have a leaching problem, while an additional 30 percent have a potential drainage problem. Recently, when the construction of a highway necessitated cutting into a sanitary landfill near Portland that had been completed for several years, it was learned that buried wastes had not decomposed or composted into a pleasant mulch. The intact wastes and noxious odors which were revealed provided a graphic demonstration of the slow rate of decay when waste materials are placed deep in the ground below the level at which microorganisms normally thrive. Since rainfall can percolate through this mass and dissolve out many of the noxious waste products, it is easy to see that both surface water and ground water can become polluted from this type of disposal.

Selection of suitable sites has been a problem to the larger cities in Oregon for several years and is becoming a problem to even smaller communities as present locations are filled and relocation becomes necessary. Along with unsightliness, rodent and fly control, and blowing of litter, site location is a major concern of the public in regard to disposal of solid wastes. In order to be most economical, a landfill site must be located reasonably close to the municipality or source of the wastes, but with population growth and industrialization, this land has increasing value for other uses. A properly constructed sanitary landfill should be available for reuse upon completion; however, only 9 percent of the authorized sites in Oregon have definite plans for future use upon completion. Unless the completed sites are advantageously and expeditiously returned to society's use, the acquisition of future sites will become continuously more difficult.

PRESENT WASTES DISPOSAL SYSTEMS

Facilities for Disposal

The solid wastes generated in the state of Oregon originate from such sources as municipal, commercial, agricultural, forest and industrial practices, and the individual problem of littering. According to national studies, solid wastes are collected and transported to disposal sites at a rate of 5.75 pounds per urban dweller per day. In Oregon over 1.75 million tons of collectible residental and commercial wastes are generated each year. Although precise amounts of solid wastes not collected–such as straw, manure and mine tailings–are lacking, it is estimated that when they are included, the average weight of solid wastes generated per person per day is 2 to 4 times greater.

There are 231 authorized disposal sites–of which 11 are sanitary landfills, 73 are landfills, 146 are open dumps, and one is an incinerator–and 650-700 unauthorized sites, presumably open dumps, in the state. Of the authorized sites, 63 percent are owned by government agencies. Public and private collection vehicles transport 75 percent of the volume of solid wastes to these sites, 93 percent of which are located in agricultural, undeveloped or forest areas. Although salvage markets have been developed for some metals and glass, and salvaging is permitted at 68 percent of the authorized sites, it is conducted at only 39 percent of them. Forty percent of the sites need rodent control measures, while only 15 percent are providing adequate measures. Only 2 percent are providing fly control measures, while 69 percent need such measures.

Types of Solid Wastes

Municipal wastes are composed of useless materials discarded by citizens such as household garbage, leaves, hedge and tree trimmings, automobile bodies, old appliances, tires, dead animals, demolition wastes, crankcase oil and sewage sludge. Although municipal refuse, which does not include all of these wastes materials but only those which are collectible, is heterogeneous and its composition depends on the geographical location and the season of the year, it generally contains over 50 percent paper and paper products, and approximately 15 percent garbage, 10 percent metals, 10 percent glass and smaller concentrations of other components.

In all of the 114 Oregon communities surveyed by the Oregon State Board of Health in 1967, garbage is collected at least once each week and discarded in landfills at an annual cost of about $24.00 per household. Solid wastes collection services are provided for 85 percent of the urban population. Car bodies, demolition wastes and dead animals are not collected routinely, but will be collected upon request in some communities. Auto bodies are compacted and buried; burned, compacted and stockpiled for scrap salvage; or accumulated without plans for disposal or salvage. Dead animals may be processed by a rendering plant, buried on private property, transported to a landfill or dumped illegally. Demolition wastes are burned, sold for scrap, or discarded in a landfill. The quantity of demolition wastes, dead animals, and auto bodies disposed of each year is unknown since no wastes disposal facilities keep weight records of the material brought to the sites.

Commercial refuse is obtained from retail and wholesale business establishments, and most of it is discarded in landfills. Although the total quantity produced in Oregon is unknown, a large percentage of these wastes consists of paper and plastic packaging materials. Specific businesses, such as restaurants, groceries and hardware stores, produce high concentrations of other materials, such as food wastes, metals and rubber.

Agricultural residues consist primarily of plant residues such as straw, and animal wastes or manure. Straw is produced by the grass seed and cereal grain industries. Approximately 260,000 acres of land are used for grass seed production in the state each year, with 245,000 acres located in the Willamette Valley. An additional 1,300,000 acres of land are used for cereal grain (wheat, barley and oats) production, 300,000 acres of which are located in the Willamette Valley. Field incineration has been used in the Willamette Valley as an inexpensive means of disposing of approximately 237,000 acres of grass seed straw and 25,000 acres of cereal grain straw. Although this technique results in desirable levels of field sanitation for disease and weeds in some crops, the large volume of air polluting smoke generated by this practice has resulted in public pressure to develop alternative disposal methods. In other parts of the state most of the straw is plowed under, but in the Willamette Valley the high straw yields, dense clay soils and wet environment are not conducive to straw decomposition. The mechanical removal of this straw from the field and subsequent sanitation by other means present a financial problem for the farmer. With no economic return for the straw, the cost of removal affects the profit and price structure of his business.

Utilization of this straw is hampered by the fact that it is nearly all produced during two months of the late summer and by its low bulk density (10 pounds per cubic foot when baled, and 30 pounds per cubic foot when cubed, pelleted or similarly compacted). The weight of straw produced by these crops varies from 1.5 to 6 tons per acre. Assuming an average of 3.2 tons per acre, over 1 million tons of straw are burned annually in the Willamette Valley while an additional 850,000 tons are plowed under, used as bedding for animals, or disposed of by some other means. The storage requirements for the straw now being burned would be 200 million cubic feet. While cubing or pelleting will contribute to a reduction of the storage space requirements, processes designed to utilize straw as a raw material on an industrial scale are being developed. Pulp and paper, cattle food, and particle board are three products with industrial potential.

Animal wastes in Oregon are produced from dairy and beef cattle, swine, poultry and sheep. The approximate animal populations in the state are 1,600,000 cattle, 200,000 swine, 4,000,000 chickens, 1,400,000 turkeys and 500,000 sheep. Assuming total wastes excretion figures of 64 pounds per head per day for cattle, 6 for swine, 2.5 for sheep and 0.25 for poultry, the annual production of animal wastes exceeds 20 million tons, which is comparable to a population equivalent of 10 million people, 5 times the population of Oregon. Many of these wastes are returned to the land, but severe animal wastes disposal problems result when large numbers of animals are confined in a limited area, as in the feedlots at Dayton and Eugene and in eastern Oregon, where odor, flies and water runoff are problems.

Wastes disposal systems have been developed for handling wet or dry cattle wastes. The wet system involves the biological conversion of dissolved solids, whereas the dry system involves incineration. The annual costs of these systems range from $11 per animal when the dry system is used for 25,000 animals to $97 per animal when the wet system is used for 500 animals. The higher costs would clearly put a burden on the owner. Regulations have been proposed by the Department of Environmental Quality to insure that animal wastes disposal processes are used.

Forest industry residues in the Pacific Northwest consist mainly of bark and forest slash. In Oregon an estimated 2,500,000 tons of bark are generated annually. Although some is utilized as a fuel or horticultural mulch, most is disposed of by incineration. Some forest slash is burned on the site where it is generated. Ten to twenty times as much waste plant residue per acre is generated in clear cutting as in grass seed or cereal grain fields, but the total annual acreage involved is less.

Industrial solid wastes residues in Oregon include cannery wastes, metal wastes and petroleum wastes. Fruit and vegetable canneries are located in the Willamette Valley and in eastern Oregon. A typical corn processor produces from 25,000 to 50,000 tons of wastes each year depending on the yield and the method of processing. Most of the corn wastes are used as animal food. A bean processor produces from 15,000 to 32,000 tons of wastes per year and disposes of most of it in a landfill, although a small amount is fed to cattle. Fruit and vegetable wastes also are utilized in only limited amounts and are principally disposed of in landfills.

Seafood processing plants are clustered along the coastal areas of Oregon. In 1968 approximately 15,000 tons of fish wastes were produced, as well as 8,000 tons of shrimp and crab wastes. Approximately 35 percent of the seafood wastes is discharged to the coastal waters, while about 65 percent is processed by a rendering plant to produce mink food, fish meal, fish food oil or protein concentrate.

Mineral wastes from metal processing plants are usually discarded in piles on the land. Some wastes are reprocessed to extract an additional quantity of metal from the ore. Although there is not a large volume of metal processing wastes present in Oregon, they can have a substantial influence on the local environment and can be expected to increase if the metal processing industry experiences growth.

The problem of disposal of waste lubricating and bunker oil is extremely severe. About one-half or 3 million gallons of the waste oil in Oregon is crankcase oil from automobiles, trucks and other engines, while another 3 million gallons is produced by railway car cleaning, tank truck cleaning, ship bunkers and bilges, and fuel oil tank cleaning. This oil cannot be discarded by dumping in rivers or on the land because of the obvious detrimental effects it has on the wildlife and water supplies. Consequently, much of the waste oil is stored in tanks for later disposal, while it is estimated that about 2 million gallons a year are rerefined. Some of the oil is dumped at sea, which surprisingly enough in this age of concern for well and tanker spillage, has been considered an acceptable disposal practice, provided the dumping takes place far out to sea. Although some of the remaining oil is used to settle dust on unpaved roads, a considerable quantity is unaccounted for. Regulation of waste oil disposal is especially difficult in the absence of any suitable disposal system to which the spent oil can be directed. Although the oil disposal problem seems remote to most citizens, each citizen who drives a car is contributing to this refractory disposal problem.

OUTLOOK

The solid wastes generated in the state of Oregon are projected to at least double by 1985 if the estimates of increases in population to 2.9 million persons and in collectible solid wastes to 8 pounds per capita materialize. Although landfill disposal will out of necessity be required for some time in the future, it is necessary to begin the implementation of improved systems for managing wastes. A more intensive system of salvage, reclaiming, reusing and recycling the valuable materials contained in solid wastes is needed.

Recycling waste materials into the economy has not been widely applied in the United States. Economic considerations and the abundance of virgin resources have forestalled the development of recycling technology and markets. Although 50 percent of the steel products and 42 percent of the copper products manufactured in the U. S. are made from reclaimed scrap, this proportion needs to be maximized, not only to aid in solid wastes disposal problems but to protect the nonrenewable natural resources. Other metals, glass products, and even paper and other cellulose wastes need to be recycled. Some of these wastes, particularly paper, oil and tires, may need to be chemically transformed into entirely new compounds to recover their value. The well-known American penchant for convenience packaging may need to be rechanneled. The reusable, returnable container needs to be reinstituted to aid in solving that special segment of the solid wastes disposal problem–litter. There has been little attempt to tie the production of consumer goods together with the disposability of those parts that end as wastes. Disposal costs are not included in the price paid by the consumer, rather they are borne by society in general. With few exceptions, manufacturers do not accept responsibility for the costs of getting rid of products that have been sold and served their purpose.

The ultimate solution to the solid wastes problem will be the virutal elimination of solid wastes through reuse and reprocessing. Intensive applications of engineering technology, chemical transformation and marketing incentive must be combined to recycle most of the presently wasted material. For those materials which, finally, cannot be reclaimed, a system of accelerated mechanical composting can be used to prepare a product which more appropriately returns these materials to the soil. Although composting rubbish has not been successful in the several communities in which it has been tried, the criterion for failure has been the absence of profit. This needs to be reexamined, including the environmental cost as a part of total cost. It is imperative that we ultimately find a workable system because the problem cannot be thrown away.

CHEMICAL WASTES AND ENVIRONMENTAL QUALITY

Chemical wastes are ordinarily regulated by one or all of the procedures applied to air, water or solid wastes control; however, as the special toxicities and environmental effects of identifiable chemicals become known, special treatment is required to preclude special effects. This might be based on their acute toxicity to man, other mammals (domestic or wild), birds, fish, amphibia, or to the ecological system. Other special considerations include the degree of ease of movement in systems, resistance to degradation, ability to accumulate within the tissues of organisms, ability to be transferred between prey and predator organisms if this results in an increase in concentration, and the possible chronic effects of these low-level residues.

The chemicals commonly requiring special attention are: pesticides, toxic metals, chlorinated organics, phenols, waste medicines and other chemicals with a high biological activity. Special chemical wastes cannot be managed properly in the municipal sewage collection and treatment system. Some may interfere with microorganism activity in sewage ponds; others may pass unchanged through the treatment system into rivers where they can be transported through the environment, producing deleterious effects in unexpected places. Some chemical wastes can be modified by the producer so that they are acceptable to a municipal sewage treatment plant; others are simply produced in volumes too large for treatment.

Large industrial plants are constructing their own specially designed wastes treatment facilities. Some industries have tried many possible solutions, even high temperature furnaces, and found them inadequate. Some have had to resort to continued storage in steel drums and railway tank cars while awaiting the solution to the problem.

Possible treatments of chemical wastes include reclaiming the chemical for beneficial uses, complete destruction by chemical degradation or combustion in special furnaces, degradation by microorganisms in specially operated types of sewage lagoons and by soil microorganisms in carefully managed land surface disposal operations. Experimental designs of land surface disposal systems are being tested in Oregon for disposal of some industrial chemical wastes, waste pesticides and pesticide containers.

Many deleterious effects of chemicals in the environment arise during normal usage through exposure or losses, as in the case of pesticides; as an almost inevitable consequence of their use, as in the case of gasoline; or as a result of what appeared to be a satisfactory use or disposal system which resulted in unexpected damage, as in the case of phosphates or polychlorobiphenyls. These problems must be identified and a procedure found for abatement of the damage.

The problems of chemical effects in the environment cannot yet be categorized in the manner of air, water or solid wastes problems because of their diversity, broad range, and the fact that many are undefined and must be considered individually. A few problems are selected here on the basis of significance and public interest. The problem of high levels of mercury present in various species of fish and birds has not been included in this report in order to make possible the utilization of the information which will be brought together at a regional conference to be held in Oregon in February of 1971. A report on the status of mercury in the environment will be issued as a supplement to this report shortly after the regional conference.

PESTICIDE PROBLEMS IN THE ENVIRONMENT

Nature of Persistent Pesticides

DDT and other pesticides have performed a useful service in food production and the control of diseases which are spread by insects, however they also have had some undesirable effects. They appear to have contributed to the decline of certain bird populations in some areas as well as to fish kills. The most serious possibility is that more subtle effects may be occurring.

Some pesticides, particularly the chlorinated hydrocarbons, are persistent in the environment. They are only slowly broken down by natural processes, and significant amounts remain in the environment for 1 to 5 years, or even longer under certain conditions. They are accumulated by living organisms and transferred between trophic levels. When used in large amounts, they have the potential to cause global as well as regional environmental problems. Global use of DDT, dieldrin, heptachlor, chlordane, toxaphene, BHC and others may affect Oregon's marine life and migratory birds. Conversely, pesticide practices in Oregon may cause problems in other parts of the world. Evidence of air and water transport causing the global distribution of some pesticides appears to be well documented.

Inorganic pesticidal chemicals, containing mercury, lead, copper, or arsenic, as well as some industrial chemicals such as polychlorinated biphenyls (PCB's), phosphates, nitrates, and possibly many more unidentified chemicals, are also persistent. Environmental problems associated with these chemicals are cause for concern. Their influence in the environment has only recently been widely recognized; hence, there are no detailed monitoring data on the amount of some of these chemicals in Oregon.

The use of chlorinated hydrocarbons in the U. S. and other parts of the world has been declining drastically, however, there are no accurate specific data for Oregon. The sharp decline has been caused by recent knowledge about some of the potential hazards of these chemicals on the environment and the development of newer less stable compounds.

Significance and Effects of Persistent Pesticides

A thorough study of the levels of chlorinated hydrocarbons in the environment of Oregon has never been made, but the pesticide information available suggests that the level are comparatively low compared to some other global areas. DDT and its analogs are the principal chlorinated hydrocarbon compounds found in Oregon. DDT and dieldrin are relatively stable in soils, thus Oregon's farmers have sought soil analyses where DDT or dieldrin were previously applied. The mean for DDT in mid-Willamette Valley soils analyzed since 1963 is approximately 0.2 parts per million. This level of DDT will safely permit planting of root vegetables where the tolerance is 1 part per million. However some soils contain sufficient amounts of dieldrin to prevent planting of the root vegetables. After repeated analyses of contaminated fields, it appears likely that DDT and dieldrin will be present for another 5 to 10 years.

Concentrations in rivers are generally below detectable levels (5 parts per trillion) and the concentrations in freshwater fish are generally less than 0.1 parts per million; however, the data on fish are limited. Levels in marine albacore tuna caught off the coast of Oregon averaged 0.02 parts per million. Although localized fish kills have occurred and others may have gone undetected, chlorinated hydrocarbon levels are not high comparatively. Mercury levels are of serious concern and will be reported on at a later date, but contributions from agriculture are low.

Chlorinated hydrocarbon levels in wildlife are higher than in fish. A survey of starlings showed that levels of DDE, the most persistent metabolite of DDT, average 1.3 parts per million with a range of 0.13 to 4.7 parts per million. Another survey of Mallard and Black ducks showed a mean DDE level of 0.36 parts per million. While other factors are probably responsible for most diminishing avian species, some predatory bird populations may have declined because of chlorinated hydrocarbon pesticides. Little experimental research exists to show cause and effect, but a correlation between DDT usage and some species population declines may exist.

In England there is evidence of an increase in avian wildlife population since the decline in dieldrin use. In Sweden avian populations have been on the rise since the use of methyl mercury compounds was discontinued. DDT levels in Oregon wildlife should also decline, but the decline may be gradual, owing to the stability of DDT. Most of the DDT levels currently being measured are probably due to the heavier applications in the early 1960's.

Present Status

Replacements for the chlorinated hydrocarbons in agriculture have been recommended wherever possible. Organophosphates are being substituted for some of the chlorinated hydrocarbons, and possible substitutes are being studied for the organo mercurial fungicides. Substitutes have not yet been found for some uses of DDT and other chlorinated hydrocarbons. Presently orchardists need DDT and dieldrin to control such pests as shot hole borers, peach tree borers and climbing cutworms. Other uses are for the control of termites in homes, root weevils in soil and occasional cutworm attacks. Such applications are relatively minor in comparison to past employment of these pesticides.

The U. S. Forest Service has suspended nearly all uses of the chlorinated hydrocarbons since 1965, and only minor amounts have been used on Oregon's forests since then. This is in contrast to the peak years of 1950, 1951 and 1958 when 800,000 pounds of DDT were sprayed on Oregon's forests during each of these years.

The application and handling of pesticides has also improved. Some of the misuse of pesticides in the past was a result of a lack of knowledge. As a result of experience and research, more accurate and extensive information is now available. Fish kills and loss of wildlife have occurred in Oregon through carelessness or ignorance of chemical effects. Today the chlorinated hydrocarbons are no longer recommended near streams where fish may be contaminated, blanket aerial forestry applications are no longer employed, contamination of food products is avoided, and low volume spray applicators are used.

Outlook

Currently, considerable study is being given to reducing the impact of pesticides in the environment. Research on methods for reducing drift and volatility losses of all types of pesticides should be supported. It is estimated that 50 percent of DDT, a comparatively nonvolatile compound, is lost from the target site with aerial applications. The loss may be much greater for the more volatile organophosphate insecticides. Increasing the application efficiency will reduce the quantities of pesticides required. In the past the most effective control method was chosen, but environmental effects resulting from control methods must also be given consideration. Since many pesticides are stable in soil, records on their application should be kept. Thus when crops are rotated or land is sold, potential food contamination could be avoided.

Based on present knowledge, it appears that the restricted 1970 usage recommendations for chlorinated hydrocarbons represent, at most, only limited risks. The addition of any foreign chemical into our natural environment is a matter of concern, especially if the chemical is persistent. A total ban of the chlorinated hydrocarbon pesticides is unwarranted and would be unfortunate for society. Application should be limited and restricted by state and local governments to certain essential uses until more knowledge is obtained about effects of pesticide usage.

DETERGENTS, PHOSPHATES AND EUTROPHICATION

Nature and Significance of the Problems

An important question in Oregon and across the nation concerns the role of home and industrial detergents in the overproduction of algae and subsequent loss in water quality. This problem has been related to the phosphorus content of detergents. Solutions are being sought on the national and industrywide scale and, to some degree, through the consumer choices of low phosphate detergents.

The evolution of the types of cleaning agents in general use is an example of the subtle, unforseen consequences of technological change. Until the mid-1940's, the principal cleaning agent was soap alone or combined with alkaline chemicals. Although classified chemically as a detergent, soap differs in several important respects from the modern synthetic "detergents". Soaps are obtainable from animal or vegetable fats. They can be broken down and used as food by many microorganisms, thus when discharged as wastes, soaps do not pose as great a pollution problem as synthetic detergents. Although sodium soaps as used in washing compounds are water soluble, calcium and magnesium soaps are not. Since calcium and magnesium are present as natural salts in hard water, they can react with sodium soaps and produce the familiar soap curd seen in the bathtub ring, prevent sudsing and interfere with the cleaning process.

In the early wringer washers, soap curd was pressed out of clothes along with the wash water; however, in the automatic washing machines introduced in the late 1940's, the clothes filtered the curd from the water in the emptying cycle and retained it. The development of synthetic detergents which do not produce curd or precipitate in hard water served to reduce this problem. Because of these factors, along with the availability of raw materials, synthetic detergents were effectively substituted for soap. The sales of soaps declined from a high of 4 billion pounds per year in 1945, to 1 billion pounds in 1966, while the sale of synthetic detergents rose from a negligible amount in 1945, to 5 billion pounds of formulated product in 1966.

One type of synthetic detergent suitable for laundry use was alkyl benzene sulfonate, commonly known as ABS. The alkyl or hydrocarbon portion of the molecule was a branched carbon chain. These compounds resist breakdown by microorganisms in sewage treatment plants and in nature. The degradative mechanisms are blocked by the branching, thus these new detergents persisted in the environment; in other words, they are not biodegradable. These persistent residues rarely exceeded 0.5 parts per million in receiving waters and presented no toxicity problems in drinking water or in fish, but they did cause sudsing or foaming. Foam was visible and unacceptable in sewage plants and in the rivers and lakes receiving their discharge. The first environmental foaming incident was observed in Pennsylvania in 1947, and by 1950, isolated reports of foaming were being reported in the press. Considerable research was necessary to demonstrate that the foaming was due to the synthetic detergents and to find an acceptable substitute. In 1963 and 1964, when the cause was well established, the solution available, and congressional prodding in progress, a program of industrywide conversion was implemented.

The family of substitute surface active agents, or surfactants, which were developed, is known as LAS, or linear alkyl sulfonates. The molecule is quite similar to ABS, except that the carbon chain is linear rather than branched. The structure of these detergents resembles the alkyl chain in soaps and permits more rapid degradation by microorganisms than the branched chain in ABS. The conversion to LAS detergents was completed by 1966 at an estimated cost of $150,000,000 to the three major manufacturers of detergents. It provided some relief for the problem of biodegradability in that there was not only less detergent being discharged by sewage treatment plants (30 to 60 percent breakdown of the ABS surfactant and 70 to 98 percent breakdown of the LAS surfactant), but there was less surfactant entering the sewage treatment plants due to degradation of the LAS in sewer pipes.

During the changeover from ABS to LAS surfactants, manufacturers felt that they needed to increase the amount of phosphate (sodium tri poly phosphate or STPP) in the detergent formulation. It appears that a way to reduce this amount is now feasible as the industry has recently announced that they have already reduced their annual consumption of phosphate by 100 million pounds and plan to reduce it by another 700 million pounds down to 1.3 billion pounds over the next 2 years. Polyphosphates are used as builders in detergent formulations; that is, they are themselves cleaning agents which keep soil particles suspended in the wash water and prevent their redeposition on clothes, furnish the necessary alkalinity to aid in the cleaning process and enable the detergents to function most effectively. They also help to emulsify oils and greases, contribute to the reduction of germs and soften the wash water by chelating or tying up objectionable minerals, such as iron, calcium and magnesium, which can interfere with detergent action. A box of household detergent contains the LAS surfactant, a builder or polyphosphate, and minor amounts of bleaches, brighteners and perfumes. On the other hand, soap formulations contained either none or only a small (usually less than 5 percent) amount of phosphates.

Detergents formulated for different purposes and by different manufacturers contain varying amounts of phosphates. The pre-soak detergents contain 60 to 70 percent phosphate, the heavy duty laundry detergents contain 40 to 60 percent, and the lighter duty laundry detergents contain 15 to 50 percent phosphate. Light duty liquid detergents contain 1 to 15 percent phosphate, while automatic dishwasher detergents contain 35 to 60 percent phosphate. The relationship of the phosphate content to the working capacity of the detergent is related to the building function of phosphate.

Unfortunately, phosphates are not sufficiently removed by conventional secondary sewage treatment plants and remain in the effluent passed into the receiving river or lake. Since phosphorus is an essential plant nutrient, this effluent can stimulate algal blooms which are quite offensive and can lead to degradation of the quality of lakes. Thus, attempts to solve the soap problem led to the ABS problem, and the attempt to solve the ABS problem with the biodegradable LAS surfactant has led to the phosphate problem and resultant algal blooms and eutrophication.

Effects of Phosphate Detergents

The relationship of phosphates to eutrophication is causing demands for an industrywide changeover to phosphate-free detergent formulations. Eutrophication is a natural process which all lakes undergo, ultimately ending in their transition to a terrestrial environment. Natural eutrophication is a continual process, not a state, which takes place over many tens of thousands of years. Even a nearly barren or oligotrophic lake is proceeding toward a eutrophic state; however, man-induced eutrophication can be an almost explosively rapid process which occurs in a few decades. The difference in rate is so great that the distinction is almost one of kind rather than degree, and thus the terms cultural eutrophication and putrefaction have been suggested for the man-induced process. The term putrefaction, while not exact, does describe the state or degree of eutrophication which people find objectionable. It includes fouling of shorelines with plant slimes and water weeds, obnoxious odors and tastes, oxygen depletion of bottom waters, changes in fish populations from sport fish to rough fish, and a general deterioration of the aesthetic aspects of the environment.

The importance of phosphates in promoting accelerated algal growth is variable, depending on the exact condition of the lake or river. The major components of plant tissue besides hydrogen and oxygen are: carbon, nitrogen, phosphorus, calcium, magnesium, sulfur and numerous essential minor elements inlcuding iron, manganese and cobalt. Hydrogen and oxygen are derived from water, carbon can be obtained from the carbon dioxide in the atmosphere or from the decomposition of organic matter in the water, and a moderate amount of nitrogen and a small amount of phosphorus exists in rainfall; however, most of these nutrients, as well as the minor elements, are received from runoff and wastes discharge. Algal growth is determined by the least available or limiting factor, which may be one of the above nutrients or sunlight, turbulence or temperature. The limiting factor may be quite different in different bodies of water, but only rarely is it one of the minor elements. Since carbon, hydrogen and oxygen are generally in abundant supply, this leaves as the principal controlling factor the supply of phosphorus or nitrogen, or one of the physical factors. Algal blooms are generally associated with wastes discharge, in which the ratio of phosphorus to nitrogen discharged is high in relation to the ratio of phosphorus to nitrogen required by the algae. It is generally held by investigators in universities and public agencies that phosphorus is most commonly the limiting nutrient, and that wastes discharge high in phosphates is the triggering factor that permits rapid and excessive algal growth.

Whatever nutrient should be shown to be the limiting factor for algal growth in a body of water, it is most likely that phosphate will be the nutrient which is easiest for man to control either by removal from usage or by removal in wastes treatment systems. If phosphate can be made to become the limiting plant growth factor, then control of other nutrients for the purpose of controlling algal growth becomes less essential.

Present Status

The sources of phosphate entry into rivers and lakes are difficult to assess because, while some are point sources such as sewage plants and other wastes discharge sources, the runoff from forest, farmland, rangeland and urban areas is variable and disperse. The best estimates are that domestic wastes contribute 200 to 500 million pounds per year. More exact input studies can be done on a single watershed. The annual phosphorus input to Lake Erie has been determined as follows: 38 million pounds from municipal sources, 4 million pounds from industrial sources and 17 million pounds from all other sources such as farmland and woodland, for a total of 60 million pounds.

The impact of various sources is unevenly distributed, and their significance will depend on local source concentration and distribution and on many factors concerning the receiving body of water. The contribution of phosphate from domestic sources is about 50 to 60 percent from detergents and 40 to 50 percent from human excrement, which derives from the phosphate previously contained in food. Domestic wastes are the largest single source, and phosphates from detergents comprise the majority of that source.

Although elimination of phosphate from detergents may not prevent all instances of rapid algal growth, most investigators agree that it will significantly delay the eutrophication process in the nation's lakes and will permit some lakes in an advanced state to begin recovery. The restoration and maintenance of fresh water quality in the face of an expanding population will probably also require the control of phosphate input from domestic sewage and industrial effluent and erosion to prevent phosphorus-containing silt from entering the streams. (Phosphate in the soil, whether naturally occurring or placed there as fertilizer, is carried away in significant amounts on soil particles and is not actually dissolved in the water.)

The question at issue is what is the best way to achieve a reduction in phosphate input caused by detergents. Two apparent remedies are (1) to require that a substitute builder be incorporated in detergent formulations within a specified time period, or (2) install third stage or tertiary treatment in sewage plants to remove phosphate from both detergents and human wastes.

The problem of substitutes for the phosphates has received considerable attention. Some light duty detergent formulations contain less than 15 percent phosphate (1/3 to 1/4 the amount contained in most brands). Some brands in the United States and Sweden have incorporated sodium nitrilotriacetate (NTA) in detergent formulation. NTA is an alkaline organic chemical with several of the desirable properties of sodium tripolyphosphate as a builder. It does not presently appear that this chemical would contribute to the problem of accelerated eutrophication. It is not quite as effective as phosphate and has the disagreeable property of caking in the detergent package, if used alone with a surfactant; therefore, the formulations using NTA have continued to incorporate approximately 1/3 the usual level of phosphate for added cleaning power and as an anticaking agent. NTA is a more effective chelating agent than the phosphates, resulting in easier rinsing and reduced mineralization. The arguments as to whether NTA could or should be substituted for phosphates may be academic because, in December 1970, the Department of Health, Education and Welfare issued a warning jointly with the Environmental Protection Agency of possible dangers from the use of NTA. Officials of the agencies stated that major detergent manufacturers had agreed to stop using NTA in soap and detergent products "pending further tests and review" of research studies. This step was taken because it was found that NTA, when administered in conjunction with cadmium chloride or methyl mercury, caused birth defects and stillborn offspring in rats and mice; however, details of the experiments are lacking at this time. The relationship between the amount and route of administration of the experimental dose and the expected exposure resulting from its use as a washing compound or subsequent discharge into the environment are not clear.

A number of other potential phosphate substitutes have not been discussed as widely as NTA, but are under consideration. Polyelectrolytes such as the polycarboxylates are being studied, but have not yet been shown to perform as well as phosphate, and there are indications that their rate of biodegradability may be slow. A similar situation exists in relation to the development of some starch derivatives as substitutes. Other compounds which have been considered are some silicates and borates. Each possible substitute has its attributes and defects. At present there is no substitute generally agreed to equal the performance but not have the defects of current detergent formulations. A benefit, which is not often given consideration, that would result from finding a substitute for phosphates is the conservation of a nonrenewable resource for the future, when it is possible that a more essential use may be of paramount importance.

It is possible to remove phosphates in an advanced sewage treatment plant with current technology by adding alum, lime or an iron salt to form with the phosphate one of the insoluble salts, such as aluminum, calcium or ferric phosphate. This precipitate is then filtered from the effluent and either reclaimed or disposed of as solid wastes. Such an operation can be expected to be at least 95 percent efficient in removing phosphate. A pilot plant at Ely, Minnesota is operated at 99.9 percent efficiency, and this could be increased to 99.99 percent efficiency by the addition of ion exchange and carbon filtration. (The ultimate solution resulting from this degree of purification may very well be the recycling of such treated water within the city—the conversion of sewage to usable water.) One difficulty with this solution is that it would very likely take quite a long time before all the municipalities within a given watershed approved and installed adequate facilities. The advantages are that it would remove all the phosphate from domestic wastes, not just those from detergents and that it will probably become necessary to make such installation in any event. The cost of the choices is not entirely clear. It would cost more but not twice as much to precipitate phosphates from detergents as well as human wastes. Whether the ultimate costs of advanced treatment facilities would cost more in taxes than would be paid in increased price or decreased performance if some change were made in detergent formulation is not known. The cost of operation of advanced treatment facilities has been estimated at $1.80 per person per year.

Many people are asking whether they can choose a cleaning agent which will not contribute to the accelerated eutrophication problem in order to do their share to benefit environmental quality. The answer cannot be given as a flat yes or no. There are cleaning agents which contain only small amounts of phosphates and some which contain none at all. If these meet an individual's cleaning needs satisfactorily, then they can be used to wash without contributing excess phosphate to the environment. This is likely to be a highly personal choice, and since quantitative measurement of cleaning effectiveness involves complex testing facilities not available in Oregon, no recommendations can be made. Most detergent manufacturers build their formulations so that they will clean heavily soiled as well as lightly soiled clothes in hard or soft water across the nation. Instructions often advise additional detergent in extremely hard water areas, and it is possible that lightly soiled laundry in a soft water area may require less than the optimum amount recommended for general use. An individual may find that satisfactory performance can be achieved by varying the amount of detergent according to the type of laundry and local water condition, thus achieving a decrease in phosphate effluent.

The question still remains as to whether such reduction in phosphate effluent improves water quality. The answer depends on where the waste water is discharged. If it is discharged into a properly functioning septic tank system, no reduction is necessary because the phosphate will be tightly held in the subsurface soil and will not reach any surface or underground water supplies. The exceptions to this are septic tank systems which are poorly designed or placed in soil situations that permit channeling. Along some lakes, particularly small ones, the discharge from residential septic tank systems may have a significant impact on the quality of the water because of high water table or poor soil type conditions. In this case, a reduction of phosphate effluent even to a septic tank system will have beneficial effects. If it is discharged into a sewer system which eventually discharges directly into the ocean, reduction in phosphate usage will not ordinarily be beneficial because, in the marine environment, nitrogen rather than phosphate is usually in short supply, though there are some local exceptions. If discharged into a lake, it is likely that a reduction in phosphate wastes will reduce the man-induced algal growths. If the lake is in an advanced state of eutrophy, it may be imperative to reduce the phosphate input. If the discharge goes into a river, the answer depends on the condition of the river and the rate of flow. Nutrients added to a river system will enhance algal growth, but in many cases the effect is not as severe as in a lake. If there is a downstream lake or impoundment, the effect will be the same as if the nutrients were discharged into that body of water. These affect the rate of eutrophication by slowing the rate of water flow, thus reducing turbulence and creating more favorable growing conditions for algae. By allowing the soil particles to settle out, tubidity is reduced, allowing the sunlight to penetrate more deeply, and plant growth is therefore enhanced. For a river such as the Willamette, it is not known if the eutrophic effect is significant, although the introduction of nutrients must cause some increased plant life growth.

In Oregon there are only a few lakes presently classified as being in an advanced state of eutrophication. Upper Klamath Lake is a well-known example, although it is generally believed that the impact of man has not accelerated the rate of eutrophication significantly beyond its natural rate. Other such lakes are Silver Lake and Lake Abert. Devil's Lake on the coast is in an advanced state of eutrophication because of man-induced wastes discharge. Odell, Diamond and Woahink Lakes are on the verge of eutrophication because of man's activities. The Snake River may be moving into a similar state because of the impoundments on it.

In general the rivers of Oregon, particularly those west of the Cascades, are less susceptible to deterioration from algal growth than most eastern rivers because of a good rate of flow, the low nutrient content of the runoff waters from the mountains, and the low temperature. Most of the river waters in Oregon contain from 0.01 to 0.20 milligrams of phosphate per liter, or 10 to 200 parts per billion. There is variation in the content between high-flow to low-flow conditions and between sampling sites and times. There are certain locations, such as the Tualatin, Klamath and South Umpqua Rivers and Bear Creek which exceed this range. These levels are considered moderate in relation to other continental U. S. rivers, but are higher than the pristine rivers of Alaska.

Outlook

Undoubtedly, the amount of phosphate discharged into the waters of the state will be reduced in the future, but the most effective means of accomplishing this is not yet clear. The immediate steps are likely to be that: (1) the manufacturers will clearly label their products with regard to phosphate content in terms of amount of phosphate discharged per load of wash, which will enable the user to easily make the personal choice of using a low phosphate detergent; (2) the manufacturers may include directions for the use of less detergent in soft water areas or for certain types of wash loads; (3) the detergent industry will reduce its phosphate consumption by 35 percent (from 2 billion pounds per year to 1.3 billion pounds per year) by 1972 through a reduction in the amount of phosphate incorporated in the detergent formulation; (4) a substitute for phosphates in detergents which is environmentally safe and which poses no hazard to human health will be found and incorporated within the next few years; and (5) the municipal sewage treatment plants will be improved to remove phosphates from the discharge water.

VAPONA® STRIPS

Nature and Significance of the Problem

A solid solution of Vapona® (dichlorvos) insecticide in polyvinylchloride resin has gained wide acceptance as an effective agent for controlling houseflies and mosquitos in homes and businesses. Some familiar brand names are No-Pest Strip®, Vaporette® and Star-Bar Strip®. The dichlorvos insecticide, also known as DDVP for dimethyl dichlorovinyl phosphate diffuses from the plastic and vaporizes to provide air concentrations which are toxic to insects for up to three months when used as directed (one strip per 1000 cubic feet of space, limited ventilation for part of the time, changed at the end of three months). This type of formulation has some inherent acute safety advantages over sprays and aersols. It is handled only twice and cannot be spilled or left uncapped, and the DDVP cannot be chewed out of the strip by toddlers; however, its safety relative to chronic human health hazards has been challenged due to several observed problems. Information is lacking on chronic effects of long-term, low-level exposure, especially of groups with possible increased sensitivity such as alcoholics, the malnourished and those with chronic respiratory diseases. Although the effects of temperature on the rate of release and the subsequent fate of the DDVP are not known, the strips have been hung from light fixtures and ceilings in rooms with heat sources. Areas where insects are absent or otherwise controlled are sometimes treated, thus people in the area are unnecessarily exposed.

The Food and Drug Administration has approved these strips, but recently ruled that they may not be used in areas where food might become contaminated, such as kitchens, restaurants and stores. They are also proscribed from nurseries and areas containing the aged and infirm. Nevertheless, they can commonly be found in places contraindicated by the label instructions.

No survey has been made to determine the extent of use or abuse of the DDVP strips in Oregon. Casual observations indicate that the convenience prompts people to use them in situations where other flying insect control measures are not called for or neglected (e.g., in houses without screens), that areas are usually treated with too few strips relative to label recommendations, that many restaurants and stores continue to use the strips, and that the strips are popular and regarded as highly effective.

Effects of the Strip

Only two reports of possible ingestion of DDVP (by toddlers chewing on the strip) have been made in Oregon, as compared to 13 nationwide in 1969. No instances of death or morbidity due to the strips have been reported. Limited use studies on humans have thus far failed to indicate statistically significant effects on normal, healthy adults and infants. However, hospital patients with liver disease showed a significant lowering of blood cholinesterase, an enzyme which has come to be used routinely as the indicator of possible organophosphate poisoning, at a lower level of exposure than other patients. Instances of subjective insult such as headache or nausea have been reported only sporadically and have not been systematically investigated. One case of possible hypersensitivity is currently under investigation in California. There are no indications of any acute hazard, and the only suggestions of chronic human health hazard are difficult to detect and relate to the use of the strips.

Present Status

Research is currently underway to derive the physical and chemical principles involved in describing the possible risks of exposure. This is a direct consequence of studies on a similar formulation, the dichlorvos-resin flea collars used on cats and dogs, which resulted in a mathematical model of the rate of DDVP release from the strips and collars. The DDVP is broken down into harmless materials by moisture in air, but is also trapped into and onto materials in the treatment area, from which it may be re-emitted. Improved techniques of sampling DDVP in the vapor phase and of determining the amounts present at low levels have been developed.

Outlook

Application of this superior methodology is needed to provide accurate data to further refine the current mathematical modeling of the exposure set. More accurate determination of the effects of temperature and humidity on the rate of release, breakdown and sorption of the DDVP is also needed. Although research on the effects of dichlorvos pellets as a deworming treatment have shown no adverse effects on swine, further research on the chronic vapor-phase exposure under controlled conditions is indicated, since material taken in by the lungs is not as rapidly detoxified as is material from the gut acted on by the liver.

The possible susceptibility of various groups within the general population should be studied more thoroughly. Further investigation of subjective insult might provide other clues as to possible hazard. Research on the physical and chemical parameters needed to describe exposure accurately should be continued and expanded, while the biological effects of vapor-phase exposure, especially as related to groups with indicated susceptibility, should be undertaken in carefully controlled conditions with both man and appropriate substitute test organisms such as primates or pigs. Concurrently, specific information on the use patterns and conditions particular to Oregon should be obtained so that experiments can be made more relevant and recommendations more explicit for nonhazardous use.

Dichlorvos resin strips do not appear to present any substantive hazard in Oregon, but any problem would likely not be too obvious or acute. As with all insecticides and toxic agents, the public should be educated more deeply regarding the "do's and don'ts" on the label and should be given a better appreciation of the conditions which warrant application and the time limits for effective use.

TETRAETHYL LEAD IN GASOLINE

Nature and Significance of the Problem

The removal of lead from gasoline has been proclaimed to be the only possible solution to cleansing our atmosphere by some authorities and has been condemned as a measure which will increase pollution by others. Conflicting statements by automobile manufacturers, petroleum refiners and government agencies have created confusion among individuals who would like to make individual choices to help reduce pollution.

Several marketers of gasoline have recently announced the availability of a low-lead or unleaded gasoline. This resulted from the news made public earlier last summer that the 1971 automobile models would be produced for operation with unleaded or low-lead 90-octane gasoline. With the appearance of the new unleaded gasolines, the super premium grades of gasoline have largely disappeared from the market. The private auto owner is wondering what these developments will mean in terms of his auto's performance.

Effects of Lead in Gasoline

There appear to be two basic reasons for removing tetraethyl lead from gasoline. In order to significantly reduce emissions to the new 1975 auto emission standards established by the federal government, it may be necessary to attach auxiliary equipment such as the direct flame afterburner or the catalytic reactor to the auto exhaust pipe. Research has shown that tetraethyl lead oxidation products in auto exhaust will poison the catalyst and reduce its efficiency. With the elimination of tetraethyl lead, the catalytic afterburner may prove to be practical for reducing emissions to the 1975 standard. There is still some question about the availability of the catalyst and the longevity of the afterburner unit in operation. It has not been proven that the afterburner is 100 percent successful. There appears to be no other valid mechanical reason for removing the tetraethyl lead from gasoline.

The most important reason may be biological. The tetraethyl lead oxidation products are emitted as condensed particulate matter which have quite small diameters. The transport and distribution of these particulates have not been satisfactorily worked out. While the production of tetraethyl lead constitutes about 19 percent of the annual consumption of lead (other principal uses are metal products, storage batteries and pigments), it represents 25 to 35 percent of lead added to the environment from all sources because a very large fraction of the lead used in metal products and storage batteries is recycled. The fact that lead is released from gasoline in the form of small particulates (less than 1 micron) suggests that distribution from this source to the general environment is of more significance than that from lead used in pigments.

Biologically significant distribution of lead does occur along freeways and city streets. It has been shown that vegetation along Interstate 5 in Oregon contains 10 parts per million lead, which exceeds the tolerance level for agricultural commodities and forage. The levels of lead in the blood of persons living and working in large cities can be twice that of persons living in suburban or rural areas, and the blood-lead levels of persons, such as traffic policemen or garage mechanics, who are especially exposed to automobile exhaust can be three times as high as those in suburban areas. Possible chronic physiological effects from these levels are another concern during times of heavy smog. As scientists have begun to look for lead in various remote situations, appreciable levels of lead have been found in tissues from seals, pelicans or even in glaciers. Furthermore, it appears that lead may be involved in the problem of thin eggshells of birds.

Present Use

Automotive gasolines are a multicomponent blend of the products from different refinery processing units. Each unit is used for the specific purpose of increasing either the quantity of gasoline available from a barrel of crude oil or increasing the quality of gasoline. Quality might be improved by removal of sulfur or alteration of the carbon chain structure with an increase in the octane number. Refinery processes which improve the quality of gasoline blending stock by altering molecular structure are catalytic reforming, hydrogenation and isomerization. The processes affecting quantity of recovered gasoline stock are cracking, polymerization or alkylation.

The petroleum material being processed has its own boiling range and hydrocarbon type; and the gasoline product also has a distinctive boiling range and hydrocarbon type and, in addition, is assigned an octane number which reflects its finished quality. The octane number is a relative measure of the knock resistance of a particular blend. It describes the "pinging" sound heard from an engine operating at high power demand and low speeds as when a car is climbing a hill or accelerating. This sound results from a very rapid preflame reaction process in the combustion chamber. Preflaming has often been loosely termed "preignition" in common usage; however, in automotive engineering, the term "preignition" is reserved for the premature firing from an incandescent source. Normally, the spark plug produces a steady flame which travels slowly across the chamber and ignites the gas-air mixture smoothly. When knock occurs, the rapid preflame reaction takes place ahead of the flame and produces a sonic shock wave. Knocking can be destructive to an engine in various ways. Piston rings can be broken, spark plug electrodes damaged and engine temperatures can rise to the danger point.

To establish octane number, the measuring stick for gasoline knock, a standard single-cylinder engine is fueled with various mixtures of two pure hydrocarbon compounds and operated under specific conditions: N-Heptane, a straight chain of seven carbon atoms which is particularly prone to knocking, is given an arbitrary octane number of zero; and iso-octane, a branched chain of eight carbon atoms, is assigned a value of 100. Various gasolines can then be compared for knock resistance using this reference scale.

Tetraethyl lead prevents engine knock by preventing preflame reactions in the combustion chamber. The rate of preflame reactions is also dependent on the hydrocarbon structure in the fuel mixture. Normal paraffin hydrocarbons (straight chains of carbon) undergo preflame reactions at a rather rapid rate, thus they have low octane numbers or low resistance to knock. On the other hand, aromatic hydrocarbons (rings of carbon) such as benzene or toluene react much slower, have a high octane number and will function in a manner similar to tetraethyl lead when added to paraffin hydrocarbons. At present, in order to raise the octane number of a commercial gasoline, a refiner must either eliminante some paraffinic hydrocarbons, add aromatic hydrocarbons or add tetraethyl lead.

The finished gasolines are blended to specifications filling the needs of the automobile population and market competition. Until recently there were three grades of gasoline available at the service station: a regular grade with an octane number of about 93, a premium grade with an octane number of about 99 and a super premium grade with an octane number in excess of 100. A refiner must make the proper quantity of each grade of gasoline, considering the quantity and octane number of each available blending stock. Tetraethyl lead is used solely for the purpose of improving octane number. Each different hydrocarbon type compound responds to a different degree to octane improvement from tetraethyl lead. Normal and isomerized paraffins show the greatest improvement, while aromatic compounds show very little improvement. All compounds follow the law of diminishing return; that is, the first milliliter of tetraethyl lead per gallon is more effective than the second, and the second is more effective than the third. The Surgeon General of the United States has limited the amount of tetraethyl lead in automotive gasolines to 3 milliliters per gallon, an amount which gives a 7-to-8-octane-number improvement to the base gasoline. A refiner uses a computer program to make the most economical use of his available blending stocks adding tetraethyl lead to produce the specification octane number.

Therefore the amount of tetraethyl lead used by a refiner varies from day to day in each grade of gasoline.

Each individual engine has its own octane requirement, the minimum octane number gasoline which will operate knock-free in the engine under stress conditions. In practice, the entire automobile population is examined statistically with regard to octane requirement. For example, 99 percent of the cars may be found to require greater than an 85-octane gasoline; 40 percent will require greater than 93-octane gasoline; and 10 percent may be found to require a greater than 100-octane number gasoline. Surveys are made annually to update this knowledge to include the latest model cars. Those automobiles found to require an octane number below 94 should burn the regular grade gasolines, those requiring between 94 and 100 should burn the premium grade, and those few which still knock on premium should use the super premium.

The engine octane requirement is dependent on the compression ratio, the ignition timing, the coolant and oil temperature, and many other engine design features. Each engine is different because of the manufacturing tolerances allowed on each dimension. The cumulative effect is to produce engines that have statistically different sizes and weights, following a normal distribution. The octane requirement is also dependent on the deposits within the engine combustion chamber. A new, clean engine may have an octane requirement of 88, but after about 5,000 miles of driving, it may require 93. The amount of deposits will vary depending upon the type of driving. City stop-and-go driving produces more deposits than does freeway driving. Heavy knocking and high temperature operation tend to remove deposits and lower the octane requirement.

Outlook

If the use of tetraethyl lead in automotive gasolines were prohibited, the refiners would have several alternatives to meet octane demand. They could reduce the octane number of gasoline as marketed and sold at the service station pump. They could use another additive. Aniline, for example, shows an anti-knock potential, but about 33 grams of analine are required per gram of tetraethyl lead for equivalent octane improvement. They could use selected hydrocarbons on a quantity scale approaching that of blending stocks, approximately 5 to 10 percent of total gasoline. Some examples of specific blending stocks and their research octane numbers are: benzene–greater than 120, toluene–120, xylene–118, isopropyl benzene–113. Aromatic hydrocarbons are produced in the catalytic cracking and reforming processes and thus are already present in gasoline.

When the automobile manufacturers announced in the summer of 1970 that the 1971 vehicles could use low-lead or lead-free gasoline, they were anticipating a lower octane number fuel. Therefore steps were taken to lower engine octane requirements by reducing compression ratios and retarding ignition timing. As a result, less power is produced from a given size engine and fewer miles per gallon are obtained. Reductions in power and efficiency for each individual car are small, but can be measured by analysis of the entire year's performance.

One can conclude that removing lead from gasoline without any refinery processing changes will result in lower octane nubmers. To market unleaded gasoline with the same octane numbers as are now available with leaded gasoline, the refiner must make some processing changes. Most likely he will increase the output of those refining process units which produce high aromatic content gasoline stocks. This will require some additional capital investments by the petroleum refineries with a concomitant time delay because of construction.

Low-lead gasoline now available at service stations will be satisfactory for those cars with lower octane requirements, such as the 1971 models. Existing model cars with high octane requirements operating on the new fuel will be subject to a considerable increase in knocking. One solution for the car owner is to lower the octane requirements by reducing the compression ratio which may be accomplished by adding additional head gasket thickness. Ignition timing may also be retarded. The octane requirement of the engine must match the octane number of the fuel if knocking is to be prevented. Thus, even with low-lead or no-lead gasolines available, not all cars can use these gasolines without some type of modification.

The unleaded gasolines seem to be beneficial from the standpoints of reducing particulate auto emissions, aiding the engineering of exhaust afterburners and removing a potentially hazardous material from our environment. Until 1975, or the time when the problem of auto exhaust emission contributions to smog and environmental contamination is greatly reduced by industrywide design changes involving the carburetion system, the compression chamber, manifold oxidation system and modified gasoline, the individual automobile owner may wonder what steps he can take to reduce emissions from his vehicle. If the engine is kept well tuned; that is, spark plugs are maintained in a clean and properly gapped condition; and a lean air-to-fuel ratio is maintained which requires an increased idle revolutions per minute, carbon monoxide will be reduced by a large amount and unburned hydrocarbons by a small amount. Gasolines formulated with a detergent or engine cleaner (a number of brands are, although they do not all emphasize this to the same degree in their advertising) will prevent the buildup of deposits in the carburetor, intake manifold and crankcase ventilation valve. The detergents will keep emissions at about the same level as when the car was manufactured. If the automatic choke is set as lean as possible, consistent with the ambient temperatures expected in the local area, emissions will be reduced, particularly in the warm-up period.

The use of unleaded gasolines will eliminate one source of lead contamination in the environment, but the octane rating must be consistent with the engine requirements, otherwise damage to the engine can result. Substitution of regular gasoline for premium gasoline in an engine designed for a high octane gasoline will not result in the reduction of lead or other emissions. The octane requirement of an engine can be lowered by reducing the compression ratio and retarding the timing. The use of afterburners, either thermal or catalytic, must await the marketing of approved devices. The substitution of a small car for a large car does not necessarily result in a lowered contribution to air pollution. Although better mileage is usally obtained with smaller cars, and lead emissions are thereby reduced, the grams of carbon monoxide and unburned hydrocarbons per mile traveled are not necessarily reduced. The use of car pools, walking, bicycling and public transportation unequivocally results in lowered emissions.

MONITORING PROGRAMS FOR CHEMICALS IN THE ENVIORNMENT

Nature and Significance of Monitoring Programs

Chemicals in the environment cannot ordinarily be seen, though their effects may be observed directly when they reach climax proportions and cause death of wildlife, destruction of plants or precipitate algal blooms. In order to relate cause and effect, the chemical must be identified, controlled exposure tests conducted, the dose-response relationship studied, and laboratory tests related to the amounts of the chemical found in the environment. If the intrusion of chemicals into the environment is to be controlled so that deleterious ecological responses can be avoided, we must understand not only the kinds of potential effects the chemicals can have on various living things, but whether they are appearing in the various phases of the environment in amounts that could lead to harmful effects. The trends, both increasing and decreasing, must be established if we are to anticipate problems and take corrective actions before the effects become significant. It may be that some potential problems do not warrant corrective action. Either course can only be established by measurement of the factors involved.

A problem in establishing monitoring programs is to anticipate which chemicals might become environmental problems so that natural background levels can be determined prior to the large-scale use of the chemical. This troublesome problem has recently become more widely appreciated because of the difficulty in determining whether the levels of mercury currently being detected in a number of species of fish are the result of man's use of mercury or whether such levels have always existed. Such difficulties are not always due to lack of foresight, but frequently are due to lack of a detection method suitable for work at the low levels often encountered in environmental studies.

Present Status of Monitoring Programs for Oregon

Data on the presence of chemicals in the environment are gathered by monitoring, surveillance and research programs. Monitoring is the continual collection of data according to an established schedule of times, places and substrates. Surveillance programs are monitoring programs carried out in relation to a particular use or activity involving a chemical. Research programs usually measure the amount of chemical present in relation to a set of variable conditions. All three types of programs are conducted in Oregon by several state and federal agencies, by the universities, and in some cases by the industries involved.

Monitoring for specific chemicals involved in air pollution problems is conducted principally by the Department of Environmental Quality. There are programs for detection of organic gases, primarily hydrocarbons, nitrogen oxides, sulfur oxides, carbon monoxide, and some other compounds such as fluorides, carbon-sulfur compounds, ozone and total oxidants. (Other programs are also carried out involving physical measurements on particulates, smoke density, and so forth.) These measurements are carried out frequently at permanent sampling sites, while others are conducted intermittently at various locations across the state. Details of the results are available in the biennial D.E.Q. report on Oregon's Air Quality Program.

Water quality chemical monitoring programs which are carried out by the Department of Environmental Quality are keyed to a large number of water quality standards. Chlorides, nitrates, phosphates, ammonia, sulfates and dissolved oxygen are all regularly determined in the major rivers, and intermittently in other locations. Some other chemicals such as zinc are included in these programs on a special basis.

Data on the presence of chemicals which are not governed by air or water quality standards are obtained in a variety of ways. While there is no formal, continuing monitoring program for a complete assessment of pesticides in the environment, some data are regularly collected. The Federal Water Quality Administration of the Environmental Protection Agency conducts a modest program of analysis of river water for chlorinated hydrocarbon pesticides, as does the U. S. Geological Service. The Plant Protection Division of the U. S. Department of Agriculture provides the National Pesticide Monitoring Program with some soil samples from Oregon, and occasionally obtains samples of specific agricultural products. The U. S. Department of Interior, Bureau of Sports Fisheries obtains some samples of fish from Oregon rivers as a part of their pesticide monitoring program, and the USDI, Bonneville Power Administration is commencing a program of analyzing soil and water for herbicide residues in relation to their use on power line rights-of-way. Although these represent many agencies and programs, the number of samples which they can accept from Oregon is limited, and the total contribution from Oregon to all of these programs is probably only about one hundred samples per year. The U. S. Forestry Service and the State Forestry Department require that surveillance programs be conducted in relation to all applications of pesticides, nearly all of which involve herbicides for brush management, on their lands. These programs involve about 200 samples per year and are analyzed by the Laboratory Services of the State Department of Agriculture. This department also does some monitoring of the pesticides in Oregon's food supply and analyzes some 400 food samples, primarily vegetables, fruit and dairy products, a year. The Food and Drug Administration also obtains some food samples in Oregon for pesticide residue analysis.

Oregon State University conducts research on and monitoring of pesticides in several departments and units. The Environmental Health Sciences Center and the Departments of Agricultural Chemistry, Fisheries and Wildlife, Entomology, Farm Crops, Horticulture, Food Science and Technology, Plant Pathology, and Zoology all contribute to these programs. Although most of this research involves laboratory studies, some is in response to special environmental problems and yields data applicable to assessment of pesticide levels in Oregon's environment. Examples are studies: on the recent seal deaths in collaboration with the University of Oregon, on the 1969 die-off of the Common Murre seabird in collaboration with the Department of Zoology, on the levels and distribution of mercury in pheasants in collaboration with the State Game Commission, and on fresh water fish in collaboration with the U. S. Bureau of Sport Fisheries. This group also provides analytical service to some state agencies, such as the Highway Department, Game Commission and Fish Commission, in their investigations of losses of plant or animal life. Persistence studies on pesticides are conducted in relation to the use of pesticides in agriculture in collaboration with various OSU departments. Special pesticide residue analyses in relation to particular on-farm problems are provided to the OSU Cooperative Extension Service. The various OSU programs provide, in the aggregate, about one thousand values per year on some aspect of problems related to pesticides in the environment. A summary of some of these results is available in the Environmental Health Sciences Center Newsletter on persistent pesticides in the environment.

Since all of the programs involved in environmental pesticide monitoring are for special purposes, they are not systematically planned to be comprehensive (although taken together they do provide a great deal of vital information) and thus cannot provide a continuous assessment of the levels of pesticides in the environment as do the air and water pollution monitoring programs.

Outlook

The levels of certain other chemicals of concern in the environment are being determined. The Department of Agriculture with the FDA is monitoring cadmium, nickel and the polychlorobiphenyls. The State Board of Health is studying the levels of lead and mercury in human tissues. The OSU Environmental Health Sciences Center is studying the levels and movement of hexachlorophene and the polychlorobiphenyls. There is a need for determination of acceptable levels of intrusion of chemicals in the environment, agreement on base lines reflecting the environmental background level, and publicity of the facts and results of monitoring.

PHYSICAL FACTORS AFFECTING ENVIRONMENTAL QUALITY

The classification of factors which deleteriously affect the environment usually is based on the state of matter involved or the state in which it is disposed (i.e. air pollution, water pollution or solid wastes) or on the special toxicity of the substance involved (chemical wastes). It is easy to omit consideration of the effects of such physical factors as mechanically propagated wave motions (as distinct from electromagnetic wave motions–or radiation) such as sound waves and seismic wave forms. These factors affect the health of man in that they confront his body with disturbance conveyed by a spatially distributed field. Their detection by instrumentation is frequently difficult without trained operators and complex equipment. These forms of energy are constantly with us and must be considered if we are to successfully plan to enhance the quality of our environment.

NOISE

Nature and Significance of the Problem

Noise is everywhere, especially in our heavily polluted urban areas. In the decade of the 1960's, the measured amounts and extent of urban noise rose significantly, as did the social awareness of noise and the discomfort caused by it. We are surrounded by a multitude of noise sources in homes, offices or places of work, even in recreational areas. The problem with noise, as with many other contaminants in our environment, is complex. This complexity is reduced if we define noise as sound vibrations in the air within the frequency range of 20 to 20,000 Hertz or vibrations per second. This eliminates the problems of vibration outside the range of normal hearing. Because the decibel, the unit used to measure noise levels, is expressed on a logarithmic scale, linear comparisons of decibel levels cannot be made. Thus, a noise level of 80 decibels is not twice as loud as one of 40 decibels but 10,000 times as loud.

The most severe noise conditions are generally encountered in the work environment. As our product output and mechanization increase, the sources and intensity of noise increase. Not all this noise is contained within the work environment. Noise generated by rock crushers and other construction equipment is inflected on many persons other than construction workers.

The worker exposed to noise during the working hours must also endure high levels of noise on his way to and from work. Traffic noise in a modern city may reach 90 decibels. In general, trucks, buses, motorcycles and rail systems are the worst offenders.

The rapid growth of aviation since World War II and the development of jets have created a major noise problem in airports and the areas around them. A four-engine jet at takeoff generates 100 to 105 decibels at 1/2 mile from the runway terminus, and homes are frequently located within this radius. A measure of the resulting annoyance is that about 50 of the 140 major American airports are involved with formal complaints concerning noise, including a sizable number of lawsuits. The Airport Operators Council International estimates that by 1975, 15 million people will be living near enough to airports to be subjected to intense aircraft noise.

Cities suffer from a variety of other noise sources which are rarely curbed by government. Compressors and jackhammers are major offenders. Garbage trucks, lawnmowers and rock and roll music blasting out of discotheques and jukeboxes all add to the din. What has passed unnoticed is that many noise levels encountered in the community exceed standards found to be injurious in industry.

Even in the home, we are constantly subjected to noise from small appliances. Sound production in a kitchen can reach a level of intensity such that exposure to it for a full working day over an interval of time would result in acoustic damage. When a single speed stove exhaust fan mounted in a metal canopy is operated, a sound level of approximately 84 decibels is produced. When a dishwasher is also operated, the level rises to about 88 decibels, and if at the same time a garbage disposal is run, the level ranges from 91 to 100 decibels. The lack of effective noise standards in building codes allows the construction of apartments and houses in which noise from the outside and from neighbors filters in. Walls of plaster or wallboard on 2" x 4" studs act like drums and the wall can vibrate like a loudspeaker. Noisy plumbing and heating systems are common. Other household noise producers such as TV (68 dB), vacuum cleaners (81 dB), bathroom–toilet and vent fan (72 dB), and slammed doors (116 dB) are likewise hard to avoid. Some persons have taken to adding a low level of constant noise to reduce the annoyance caused by other noise.

The urban dweller who seeks to escape to the country, the beach or other natural areas for relaxation and quiet is likely to find trailbikes, snowmobiles, dune buggies and motorbikes instead. It is becoming increasingly difficult for the average citizen to withdraw from the high noise levels of our society.

Effects of Noise

Noise can have many adverse effects, including damage to hearing, disruption of normal activity and general annoyance. The only area where precise information is available concerning the effects of noise is in hearing loss. It is well documented that exposure to noise levels above a certain point will result in a hearing loss, the degree depending upon the intensity and duration of the exposure. The loss is greatest in the highest frequency and usually decreases in seriousness as the frequency decreases.

The physical damage is incurred at the site of transformation of sound vibrations to electrical impulses for reception by the audiometric nerve. Once damage has occurred it is irreversible. Actual hearing loss in the speech perception range has been found in performers of today's electronic music. An accelerated loss of high frequency acuity may occur in the listeners even if hearing loss in the speech susceptibility range does not occur. The seriousness of this damage depends upon the point of view taken. Safe noise levels have been established in industrial plants as those that do not affect the audiometric threshold in the frequency bands where the perception of speech occurs. In accordance with national and state regulations, if the occupational exposure to sound levels is kept below 90 dB(A), 85 percent of persons exposed will be protected from accruing hearing loss in the range of 500 to 2000 Hertz.

This safe noise level is not effective in preventing a change in the audiometric threshold in the higher frequencies. If hearing acuity in the higher frequencies is to be maintained, the noise intensity to which the ear is exposed must be decreased.

Some studies have been conducted in the area of physiological reaction to noise. Subjects do not react to noise in a pleasurable way, rather the physiological reactions are usually associated with a degree of irritation. Noise is known to produce various temporary changes in man's physiological state, in particular a constriction of the smaller arteries. This can mean speeded-up pulse and respiration rates. Some medical authorities believe that continued exposure to loud noises could cause chronic effects such as hypertension or ulcers. Startling noises elicit involuntary muscular responses. Research is still necessary to permit quantitative prediction and understanding of the extra-auditory physiological impact of noise.

Psychological reaction to noise is also an area where little information is available. It is difficult to categorize reactions to noise. An individual who can easily tolerate noise of 80 decibels if encountered in a traffic-filled metropolitan area may react in an extremely negative manner to a noise of 40 decibels generated by a dripping faucet at 2 o'clock in the morning.

A person may be psychologically predisposed to tolerate and accept a given noise environment when he feels that the noise is an inevitable byproduct of a useful or valuable service. He also tolerates it if his health is not affected and it does not generate fear. One survey of noise around an airport indicated that people's general connection between noise and their fear of aircraft crashing has more effect on the degree of annoyance than did the actual level of noise.

According to the World Health Organization, "Health is a state of complete physical, mental and social well being." It is logical to consider noise a health hazard, not only when it results in hearing loss, but also when it interferes in a significant way with sleep or rest, when it is annoying or disturbing, or when it produces fear or other emotional effects.

As our communities become more dense, the number of persons exposed to domestic noise increases rapdily. Where dense airplane traffic has made noise a normal part of the environment, persons have suffered economic loss as the residental values decrease. Freeways may produce similar effects since they are often located near residential areas where traffic and speed density create a noticeable noise disturbance. In the future we may disturb the residential area even more with the SST. Experience has indicated that the new sound of SST sonic booms would not be acceptable to the residents under and adjacent to supersonic flight corridors. (The Department of Transportation has proposed banning all overland flights which would produce a detectable boom at ground level.) Similarly, the annoyance level of noise generated on the sideline areas of the SST on takeoff is currently expected to be three or four times as great as that of the loudest commercial subsonic jets. On the other hand, the SST is quieter along the takeoff path because of its faster ascent. Solutions to the sideline engine noise problem must be developed and effectively applied prior to widespread operation of the SST if it is approved for commercial development.

In addition to the effects of noise on man, its effects on wildlife must also be taken into consideration. Animals which make their homes in suburban residential areas are subject to the same deluge of noise from power lawnmowers, motorcycles, outdoor electrical equipment and other roadside sources as humans are. It has been reported that wildlife in remote areas react adversely to noise from such man-made intruders as trail bikes, chain saws and snowmobiles. The fear generated from the noise alone of a snowmobile may do additional damage to some winter-weakened animals.

Present Status

Implementation of noise abatement and control should not wait until all research is done and all effects of noise are completely understood. Working standards can be implemented on the basis of existing knowledge and then refined, if necessary, when more is known. Ultimately, however, decisions must be made as to how much noise must be reduced, how it should be done, who should do it, and who should pay for it.

In the industrial environment, efforts are already underway to reduce the loud noise sources which can cause hearing loss. These effects, however, are useful primarily in the speech perception range. No effort has been made as yet to preserve the high frequency acuity which the ear enjoys in youth. While speech may still be understood adequately, appreciation for high frequency sounds such as those generated in music will be lost.

Little is being done in Oregon to reduce the psychological effects of exposure to noise. While we cannot say exactly what the effects are, we do know that undesirable effects of noise increase as the decibel level increases; therefore, some effort should be made to limit

Table 1. Recommended Noise Limits[1] in Switzerland

Area	Background Noise[2]		Frequent Peaks[2]		Rare Peaks[2]	
	Night dB(A)[3]	Day dB(A)	Night dB(A)	Day dB(A)	Night dB(A)	Day dB(A)
Health resort	35	45	45	50	55	55
Quiet residential	45	55	55	65	65	70
Mixed	45	60	55	70	65	75
Commercial	50	60	60	70	65	75
Industrial	55	65	60	75	70	80
Traffic arteries	60	70	70	80	80	90

1 Measurement with microphone at open window recommended.
1 Desirable values 10 dB less, but not more than 30 dB less.
2 Background noise: mean value (average noise value without peaks).
2 Frequent peaks: 7-60 peaks per hour.
2 Rare peaks: 1-6 peaks per hour.
3 dB(A): decibels measured on the A scale, which takes into consideration both high and low frequencies.

the intensity of noise. In Switzerland recommendations for noise level limits were published in order to give authorities baselines for planning community noise control. The recommended noise limits are shown in Table 1.

Much of the disturbing noise within our homes and offices is unnecessary. Too often, noise problems go unsolved because the designers and builders are not sufficiently aware of noise control techniques. Many annoyances could readily be avoided without undue cost by simply educating designers and builders to some simple principles that govern the generation and transmission of noise. Even the appliances that go into our residential buildings can usually be modified to make them quiet servants rather than noisy pests.

Outlook

Nationwide codes are being adopted to restrict the decibel level of automobiles and trucks. Such codes should be investigated for use in Oregon. It is not acceptable to produce an ordinance which requires noise control but does not set a measurable standard, rather there must be definite baseline noise levels, which can be measured with a sound level meter, in order to assist enforcement of noise control.

Buildings and cities are for people; people's needs must govern their design. Noise from present-day sources can be controlled in our indoor or outdoor environments. For the most part, the technology is available, but public support for noise regulations and enforcement is needed. This support can come only when the general public is shown that noise pollution is not necessary.

EARTHQUAKES

Nature and Significance of Earthquakes in Oregon

Oregon is a relatively quiet island in the very active circumpacific earthquake belt. Earthquakes occur in Washington to the north, in California and Nevada to the south, in Montana and Wyoming to the east and in the ocean off the Oregon west coast. The people of Oregon are fortunate in not experiencing the level of activity of their surrounding neighbors; however, Oregon is not aseismic—that is, it is not free from earthquakes.

The severity of an earthquake is expressed in magnitude and intensity. Magnitude is a rating that is independent of the place of observation and that characterizes the amount of energy radiated from the source of an earthquake. Magnitudes are based on instrumental observations and range on a logrithmic scale, called the Richter scale, from less than 1 for small shocks to over 8-3/4 for the largest earthquakes observed to this time. Each unit increase in magnitude represents 250 times the energy of the next lower scale value; that is, an earthquake measured as a magnitude 6 has 250 times greater energy than one measured as a magnitude 5. The energy released by an earthquake of magnitude 6 is approximately equivalent to that released by a one megaton hydrogen bomb.

Intensity describes the amount of shaking or damage at a specific location; it is highest in the epicentral region and decreases away from the region. Intensities are based on observed or felt effects of the earthquakes. The Modified Mercalli Scale (1956 edition), abbreviated M.M., extends from intensity I, which is not felt, to intensity XII in which damage is nearly total.

An examination of the earthquake history of Oregon indicates that on an average, an earthquake of magnitude 3.5 and intensity M.M. IV or greater will occur in the state each six months. An earthquake of this size releases sufficient energy to be perceptible by the general populace within a 20-mile radius and to alarm those in close proximity to the epicenter. A vibration like the passing of heavy trucks or a jolt like a heavy ball striking the walls will be felt in the vicinity of the epicenter. Standing automobiles can be expected to rock. Windows, dishes and doors will rattle, hanging objects will swing and wooden wall and frames may start to creak.

On an average, an earthquake of magnitude 5 and intensity M.M. VI to VII or greater will occur in Oregon each 10 months. These are large enough to cause considerable damage in urban areas, particularly where the ground is unstable or not well consolidated. An earthquake with a Richter scale magnitude of 5 and an intensity of M.M. VII will be perceptible within a 90-mile radius of the center. In the vicinity of the epicenter, the shaking becomes noticeable in driving, and people find it difficult to stand. Furniture may be broken; plaster, loose bricks or tiles may fall; and there may be some damage to ordinary masonry. Small slides are likely to occur along sand or gravel banks, and concrete irrigation ditches may be damaged.

Figure 1 shows a compilation of earthquake epicenters in Oregon modified from Berg and Baker (1963). The black dots are those which have occurred since 1958. The map shows concentrations in the Willamette Valley, particularly in the vicinities of metropolitan Portland and Salem. Continued activity is also noted in the Milton-Freewater area in northeast Oregon. The Basin and Range province of southern Oregon, which extends eastward from Klamath Falls, also shows continued activity. In 1968, 24 earthquakes with magnitudes greater than 3.5 occurred in the Warner Valley near Adel, causing damage in an area which previously had exhibited no seismic activity in historical time.

Not included on the map are earthquakes which occur immediately outside the state but affect Oregon. Shocks occurring in the vicinity of Vancouver, Washington, affect Portland and those south of Walla Walla, Washington, are felt by people in the Milton-Freewater area. Considerably more than shown occur near the Snake River Canyon of Idaho, and these are felt across the river in Oregon. Coastal inhabitants also report shaking caused by tremors originating along the very active Blanco Fracture Zone west of Oregon. Other earthquakes are observed on OSU's seismograph records which cannot be located with the present facilities.

Present Status

A meaningful seismic history of Oregon extends back only to the late 1800's and is insufficient in length of observation to establish either the largest size earthquakes to be expected in Oregon or the rate at which lesser shocks will occur. The earliest reports extend from 1841 but are clearly dependent on the size and distribution of the population. The population of Oregon approximately tripled between 1920 and 1970, and during those 50 years, approximately twice as many earthquakes were reported as during the preceding 50 years.

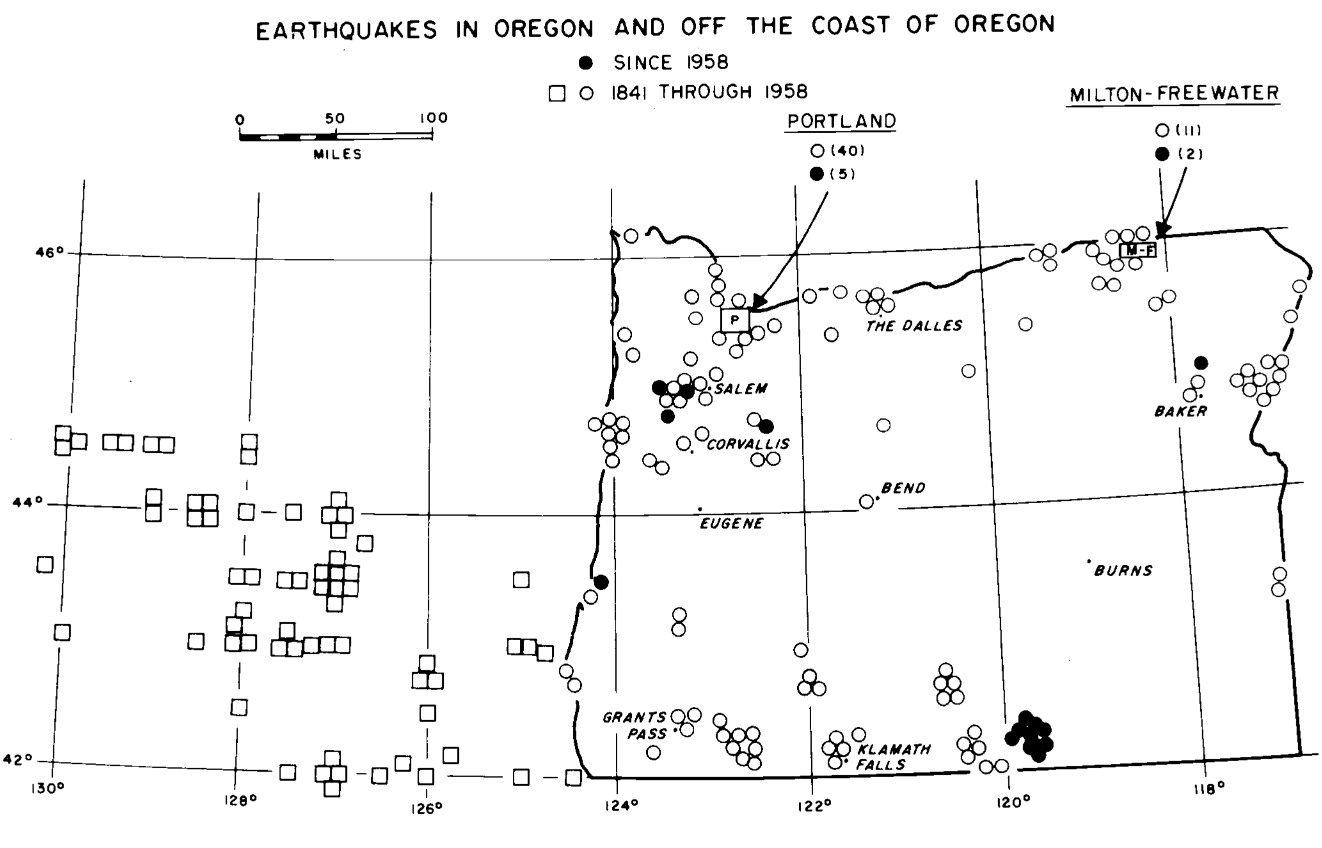

Figure 1. Earthquakes in Oregon and off the coast of Oregon, 1841 through 1970 (Modified from Berg and Baker, 1963). Onshore earthquakes are represented by open circles and dots; offshore, by squares.

Oregon earthquakes are predominantly shallow, generally having a focal depth of less than 10 miles. Some occur very near the surface. Surface displacements and accelerations caused by the earthquakes are both horizonal and vertical and generally are larger than average for a given magnitude. Ground motion is enhanced in Oregon due to relatively shallow foci, effective energy transmission in the lower crustal layers and the response of the surface layers. In most of the active areas of Oregon, the surface layers are composed of alluvial or fluviatile deposits. This type of material generally exhibits the maximum movement of any earth material during the passage of seismic waves. The surface layers in Oregon also tend to hide or mask the permanent deformation caused by the earthquakes; consequently, it is not possible at present to associate any Oregon earthquakes with mapped faults.

Because of the greater population density in the state and the continual monitoring of earthquakes by seismograph stations, the next few decades should provide a more accurate estimate of the seismicity of Oregon. The present seismic network in Oregon, consisting of five stations of varying degrees of sophistication, is inadequate for the task. The two principal stations are the Oregon State University World Wide Standard Seismic Station at Corvallis and the Environmental Data Service Station at Blue Mountain near Baker. Smaller stations are located at the Oregon Museum of Science and Industry in Portland, at Oregon Technical Institute in Klamath Falls, and at Pine Mountain near Bend. The stations at Portland and Klamath Falls are monitored by geophysicists at Oregon State University, and the Bend Station is operated by the University of Oregon. Another seismograph station is desperately needed in southeastern Oregon.

Outlook

A program needs to be carried out to more accurately map the active fault zones, particularly in the Willamette Valley where rapid urbanization is occurring. A portable microearthquake seismometer can accomplish this in a very short time, and in addition can locate active zones of continuing deformation which exist without displaying the more spectacular sudden release of elastic energy. This type of study should be of paramount importance when considering potential sites for nuclear generating stations or large public construction projects such as dams, airports, large office buildings and housing developments.

Recent evidence suggests that the size of earthquakes may possibly be controllable by injection of water into deep holes along fault lines. This would have a lubricating effect and would cause a number of small earthquakes to occur where a few large ones had been expected, thus reducing the hazards of violent activity.

In summary, Oregon is seismically active. The seismic history of Oregon is too short to be used as a predictor of earthquake size, number and distribution. However, rapid urbanization of the Willamette Valley and the extensive public works planned for other areas of Oregon make it imperative that the stabilities of the regions be known. The present seismic network is inadequate for the task, although specialized equipment has been developed to assist in local immediate problems. Oregon needs a seismologist and a continuing seismology program.

ENVIRONMENTAL RADIATION IN OREGON

IONIZING RADIATION

Ionizing radiation is one of the most important physical factors in the environment. The term ionizing radiation refers to high energy electromagnetic radiation, such as x-rays and gamma rays and high energy particles such as beta particles (electrons and positrons) and alpha particles (helium nuclei). By virtue of their high energy content, excessive exposure to ionizing radiation can cause both somatic and genetic effects to various biological species.

Nuclear Radiation

Nature and Significance. Environmental ionizing radiation in Oregon derives from (1) natural radiation, (2) radioactive fallout from nuclear bomb testing, (3) radioisotope release both in water and in air from the Hanford Atomic Works complex, and (4) release to air and water from other uses of x-ray or radioisotopes in medical and industrial practices. The natural level of ionizing radiation in the state of Oregon is comparable to any other state at approximately the same elevation. Thus, the average direct gamma dose equivalent for the Corvallis area, which is near sea level, in 1969 was found to be 113 mrem*, based on data collected at ten environmental radiation monitoring stations established by the Oregon State University Radiation Center. The level is similar to other locations at about the same elevation and is to be compared with 150 to 200 mrems per year in the Denver, Colorado, area which, since it has an elevation of 5,280 feet, receives a higher level of cosmic radiation.

The radioactive release into the environment from nuclear tests has been of concern to various state agencies. In the late 1950's, a comprehensive environmental radiation surveillance program was established by the U. S. Public Health Service in cooperation with various state health agencies. In 1961, the Oregon State Board of Health initiated their surveillance program. Under these programs, environmental radiation was measured in samples of milk, food, water, airborne particulates, and precipitation. In Oregon and Washington, the data collected under these programs reflect not only naturally occurring radioisotopes, but also uniquely reflect those originating from nuclear testing and those released from the Hanford site.

Present Status. In general, environmental radiation levels in the state of Oregon have been following a declining trend ever since the early 1960's, due to the programmed shutdown of the Hanford production reactors from eight in the early 1950's to two as of 1970, and to the nuclear test ban. Consequently, data cited in this paper are focused on that collected in recent years, with emphasis given to the present level of environmental radiation in Oregon. Data have been compiled from *Radiological Health Data and Reports of 1964 to 1970* to illustrate the downward trend of environmental radiation levels, which are usually measured in picocuries*, in several types of environmental samples. Beta radioactivity in raw surface water of the Columbia River in samples collected at Pasco, Washington, decreased from a monthly mean of approximately 703 pCi per liter in 1964, to 254 in 1965-66, and 157 in 1967-68. At Clatskanie, Oregon, levels dropped from a monthly mean of 150 pCi liter in 1964, to 77 in 1965-66, and to 34 in 1967-68. The significant reduction in the level of gross radioactivity starting in the year 1967 is evidently due largely to the shutdown of Hanford production reactors.

In Oregon's total diet samples, according to *Radiological Health Data and Reports 1964 to 1970*, strontium-90 decreased from an average of 18 pCi per kilogram in 1963 to 15 in 1965 and 5 in 1967, while cesium-137 went from 90 pCi per kilogram in 1963, to 48 in 1965 and 20 in 1967. Radioisotope concentrations in pasteurized milk samples collected in Portland also followed a downward trend, dropping below network averages in 1967, probably due to the nuclear test ban.

The research team at the Battelle Northwest Laboratory in their report *"Radioecological Studies on the Columbia River"* presented analytical data covering the period 1966 through 1967 on the radioactivity in water samples and in collected samples of various aquatic organisms including plankton, sponge, caddisfly larvae, limpets, small fish and large fish gut contents, and large fish muscle and carcasses. The concentrations of selected radionuclides in the Columbia River are depicted in Figure 1. There were significant declines in concentrations of three short-lived radioisotopes—chromium-51, zinc-65, and phosphorus-32—during a period of 40 days in July and August of 1966 when all reactors at the Hanford site were shut down during a labor dispute. The decline observed in the summer months of 1967 is presumably due to seasonal change, shutdown of reactors, and the construction of three low-level hydroelectric dams.

The research team found that concentrations of most radioisotopes in the biota followed a pattern of high levels in the winter followed by low concentrations in both spring and early summer. There were often indications of an increase in concentrations just after levels started to decline in the spring which may be attributed to improved light and temperature regimes favoring metabolic uptake. This increase, however, was soon overwhelmed by dilution during the spring runoff. This observation should be

*For definitions of technical terms, see the glossary on page 43.

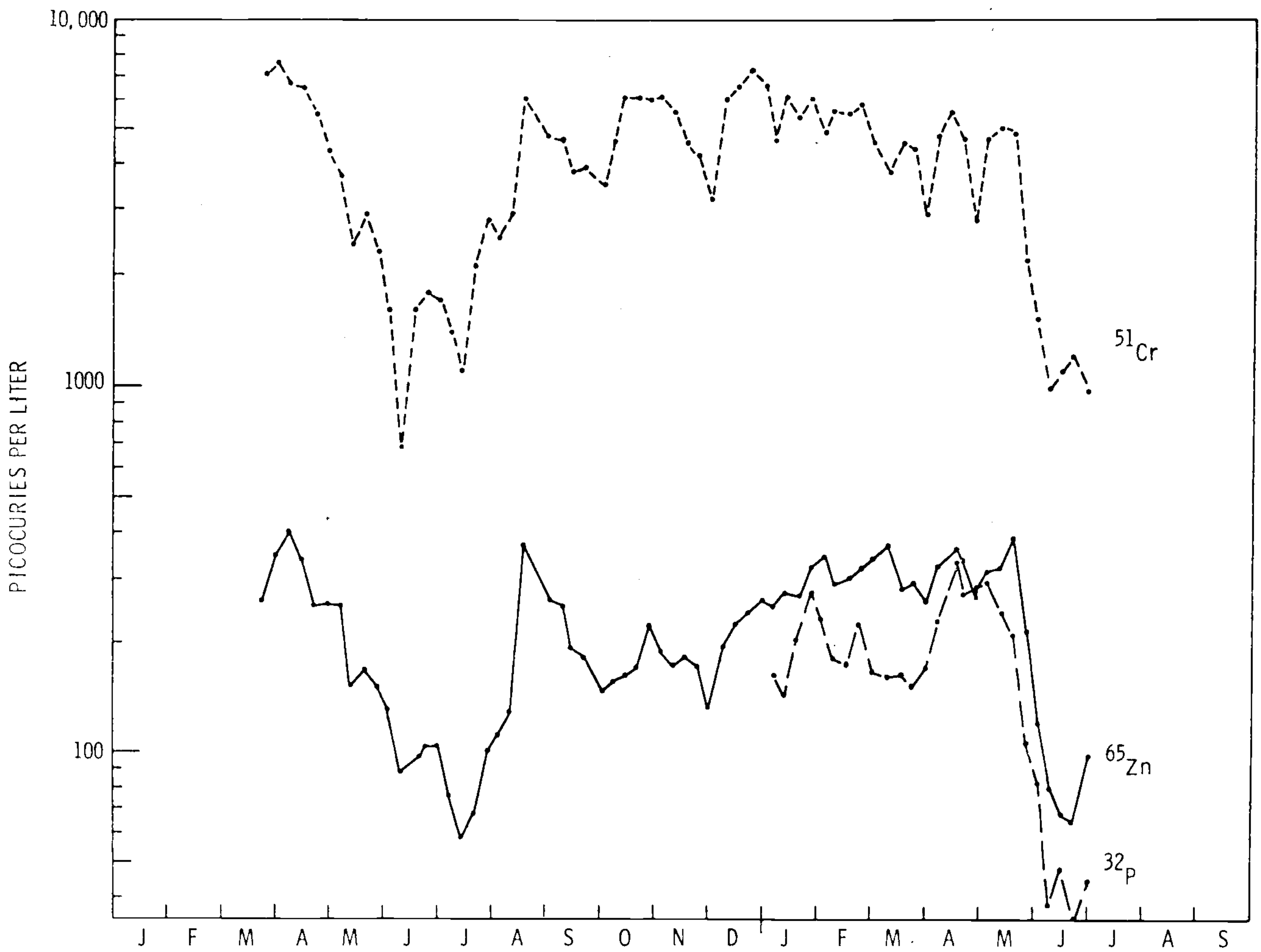

Figure 1. Concentration of Radionuclides in Columbia River Water March 1966 to July 1967. Modified from *Radiological Studies on the Columbia River*, Battelle Northwest Laboratory, Part 1, May 1970.

compared with the finding that concentrations of radioisotopes in the current Columbia River water are generally inversely related to flow rates, the lowest radioisotope concentrations occuring in the late spring and early summer when precipitation levels and runoff increase flow.

The concentration of radioisotopes in aquatic organisms can be expressed by the use of the term concentration factor (CF). The term is an expression used to estimate the degree to which an organism concentrates a particular radioisotope or element from the ambient water. It is calculated by dividing the pCi/gram of wet weight for the organism by the pCi/ml of the same radioisotope in the water. The findings of the Battelle Northwest research team indicate that zinc-65 and phosphorous-32 are concentrated CF values for zinc-65 ranged from 3,500 to 40,000 with low values occurring in the summer and high values in the values occurring in the summer and high values in the winter. The CF values for phosphorus-32 ranged from 9,000 to 68,000 and chromium-51 from 4,400 to 9,400. Despite the apparent high magnitude of concentration values, individual radioisotope content in aquatic organisms remains low in comparison to the maximum permissible concentration (MPC)* of individual radioisotopes in water, as stipulated by the state of Oregon and federal regulations.

The levels of environmental radiation in Oregon at the present time are generally similar to corresponding data observed on a nationwide basis. Thus, as shown in Table 1, the 1970 radioisotope concentrations in milk samples (evaluated with respect to strontium-90, iodine-131 and cesium-137) collected at various sampling locations in Oregon are slightly lower than corresponding data representing the average values of the entire nation. Similarly, as shown in Table 2, the concentration of radioisotopes in institutional total diets of individuals is of the same magnitude as national average values.

Table 3 gives the gross beta radioactivity (which reflects total radioactivity) in surface air and precipitation for samples collected in Oregon, and also corresponding data representing the network summary. Here again, the radioactivity in air samples collected in Portland is considerably less than corresponding data representing the network summary. With respect to concentrations of radioactivity in precipitation, the samples collected in

*For definitions of technical terms, see the glossary on page 43.

Table 1. Radionuclides in Milk Samples at Various Oregon Stations during the Period of May 1969 through April 1970[a]

Sampling Location	Type of Sample	Radionuclide Concentration (pCi/liter) Strontium-90 12-month average	Iodine-131 12-month average	Cesium-137 12-month average
Baker	P[c]	3	(b)	(b)
Coos Bay	P	6	(b)	(b)
Eugene	P	3	(b)	(b)
Medford	P	2	(b)	(b)
Portland composite	P	4	(b)	(b)
Portland local	P	5	(b)	(b)
Redmond	P	2	(b)	(b)
Tillamook	R	7	(b)	16
National Pasteurized Milk Network average		7	0	8

(a) *Radiological Health Data and Reports*, Vol. 11, No. 8, August 1970.
(b) Sampling results for the networks were equal to or less than the following practical reporting levels: Iodine-131–15 pCi/liter; Cesium-137–15 pCi/liter.
(c) P, pasteurized milk; R, raw milk.

Table 2. Concentrations and Intake of Radionuclides in Institutional Total Diets of Individuals[1]

Date/Location	Total diet weight (kg/day)	Strontium-89[2] (pCi/kg)	Strontium-89[2] (pCi/day)	Strontium-90[2] (pCi/kg)	Strontium-90[2] (pCi/day)	Cesium-137 (pCi/kg)	Cesium-137 (pCi/day)
Aug 1964							
Portland, Ore.	2.03	5		12		55	
National Average	1.95	5		17		70	
Jun 1965							
Portland, Ore.		5		14		55	
National Average		5		14		50	
Sep 1967							
Woodburn, Ore.	2.33			4	10	20	47
National Average	2.07			6	12	14	28
Oct 1969							
Portland	1.78	0	0	7	14	13	23
National Average	2.05	0	0	4	8	3	5
1969 Annual Average							
Portland, Ore.	1.84			5	10	3	6
National Average	1.98			5	9	5	10

(1) Data compiled from *Radiological Health Data and Reports*, Vol. 5 through 11, 1964-1970.
(2) Composite analysis of quarterly samples for each station.

Table 3. Gross Beta Radioactivity in Surface Air and Precipitation(1) (1970)

Station Location	Date	Number of Samples	Air Surveillance (pCi/M^3) Maximum	Minimum	Average	Number of Samples	Total Depth (mm)	Precipitation Field Estimation of Deposition Number of Samples	Depth (mm)	Deposition (pCi/ms,2)
Network Summary*	Jan 70	1,030	14	0	1	4	32	4	32	6
Portland, Ore.	Mar 70	22	1	0	0	9	76	9	76	5
Network Summary*	Mar 70	1,089	11	0	1	5	73	5	74	8
Portland, Ore.	Apr 70	22	4	0	1	13	97	13	97	3
Network Summary	Apr 70	1,122	12	0	1	5	65	5	68	9

(1) *Radiological Health Data and Reports*, Vol. 11, Nos. 5, 7, 8 (May, July, August 1970).
* Public Health Service Nationwide Network Environmental Surveillance Program.

Portland are approximately the same or slightly lower than the averages observed on a nationwide basis. The data summarized in this report substantiate the conclusion that the levels of environmental radiation in the state of Oregon at the present time are of the same magnitude as those in any other part of the nation.

Outlook. The only new source of radiation anticipated in Oregon in the next few years is the Trojan nuclear power plant scheduled for operation in the fall of 1974. However, in view of the existing radiation release data, as presented in the 1969 Joint Committee on Atomic Energy Hearings, which were obtained from operating nuclear power plants and present and anticipated technological advancements in controlling radiation associated with power reactors, the Trojan plant is not expected to introduce any significant amount of radiation into the Oregon biosphere. Aside from experimental reactors, radiation releases from the current generation of power reactors represent only a few percent of the levels permitted by federal regulations. It should also be noted that the Trojan nuclear power plant is of the pressurized water reactor type, comparable to the San Onofre reactor in California, which releases radiation in liquid effluents at only 2 percent of the permissible level. Hence, if a person continuously consumed this waste water directly from the discharge outlet, his dose equivalent would be only about 5 mrem per year. The dose equivalent* received by people in Portland, 40 miles away from the reactor site, will be less than 0.01 mrem per year. Such radiation exposure levels are not significant in comparison to the natural background radiation level, estimated to be near 100 mrem in the major portions of the state of Oregon.

It appears that in the forthcoming decade, radiation levels in Oregon will not be a serious environmental quality problem, even with the installation of nuclear power plants. However, radiation monitoring programs by an impartial organization, as well as by state agencies, are essential to provide the public with unbiased information. The Environmental Radiation Surveillance (E.R.S.) Laboratory under the Oregon State Board of Health has been carrying out a number of radiation surveillance tasks including the statewide surface water surveillance network, statewide ground water surveillance network, statewide milk network, Columbia River monitoring, and air particulate and precipitation monitoring in Portland. The findings of these programs have been provided to the U. S. Public Health Service throughout the past years and are of great importance to the assessment of environmental radiation in Oregon. In addition, the E.R.S. Laboratory has also been providing consultation services to the Department of Environmental Quality. However, in view of the forthcoming nuclear power plant development in the state, the capabilities and activities of the E.R.S. Laboratory need to be expanded to undertake additional radiation surveillance programs necessitated by the operation of nuclear power plants in Oregon and Washington.

Glossary

natural radiation. The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of men and animals. It is also called *background radiation.*

curie (Ci). The basic unit to describe the intensity of radioactivity in a sample of materials. The curie is equal to 220 billion disintegrations per minute, which is approximately the rate of radioactive decay of 1 gram of radium. One curie of any radioisotope is the quantity which will give 220 billion disintegrations per minute. In operations with smaller amounts of radioactivity, the term millicurie and microcurie are used; i.e., millicurie (mCi) = one-thousandth of a curie and microcurie (μCi) = one-millionth of a curie. In environmental studies, the term picocurie is used. One picocurie (pCi) = one-trillionth of a curie, or 2.2 disintegrations per minute.

dose equivalent (DE), rem and mrem. A quantity used in radiation protection which expresses on a common scale the amount of irradiation received by exposed persons from all types of ionizing radiation. The dose equivalent is expressed in terms of "rems" and is numerically equal to the absorbed dose from a particular type of radiation times the appropriate modifying factors for that type of radiation. (DE in rems = absorbed dose (in rads) x modifying factors.) The modifying factor is 1 in the cases of gamma or beta radioactivity. The dose equivalent from each type of radiation may be summed to give a total dose equivalent. Other related terms include millirem (mrem); i.e., one-thousandth of a rem. The natural background at sea level in the U.S. is about 100 mrem.

maximum permissible concentration (MPC). The amount of radioactive material in air, water or food, expressed in terms of concentration such as μCi/ml, which normally may be continuosuly consumed at a stardard rate without exceeding the appropriate maximum permissible dose (MPD). (Code of Federal Regulations 10 CFR Part 20).

maximum permissible dose (MPD). The dose of ionizing radiation established by competent authorities as an amount acceptable for no reasonable expectation of risk to human health. For any individual in the population, the MPD for whole body radiation exposure is 500 millirems per year. Where individual doses cannot be reasonably ascertained, the nonoccupational MPD is reduced to approximately one-third of 500, or 170 millirems per year. These values are exclusive of natural background and medical exposures.

radioisotope. A radioactive isotope. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. More than 1300 natural and artificial radioisotopes have been identified. Radioisotopes are identified by the name of the element and the mass number; e.g., uranium with an atomic weight of 235 is symbolized as U-235. Other examples are cesium-137, symbolized as Cs-137, iodine-131, symbolized as I-131; strontium-90, symbolized as Sr-90; etc.

Medical Uses of X-Ray

Significance and Effects. Exposure to medical x-rays will annually involve approximately 1,360,000 people in the state of Oregon through some radiographic or therapeutic procedure. The doses for these diagnostic procedures will range from as low as 50 mrem per exposure in a simple soft tissue x-ray to as high as 10,000 to 12,000 mrem per minute during a fluoroscopic procedure. Approximately 89,000 Oregonians will have the latter procedure this year. Therapeutic doses range from 100 to 500 rem for the care of some specific disease states.

These doses of radiation are important to the person in question because the radiographic procedure is usually essential to the diagnosis of an ailment which might otherwise go undetected resulting in severe illness or possibly death. Thus the risk of radiation exposure has been individually judged to be the lesser of the two risks.

X-ray machines that are incorrectly filtered produce unnecessary exposures two to four times as great as required to accomplish the appropriate radiographic procedure. Those machines that are incorrectly collimated contribute unnecessary exposure to a larger area of the patient's body as well as exposure to workers and other persons in the area. Of 227 initial inspections of medical x-ray machines, 31 percent had inadequate filtration and 38 percent had inadequate collimation. Of 135 initial inspections of dental x-ray machines, 16 percent were inadequately filtered and 12 percent did not have proper collimation. With the equipment available, the inspectors were able to correct 73 percent of the filtration problems and 28 percent of the collimation errors in the medical units, as well as 91 percent of the filtration and 64 percent of the collimation problems in the dental units. Those units which could not be corrected by the inspectors are required by law to be brought up to standards by the persons responsible for the machines.

Present Status. The use of diagnostic and therapeutic x-rays is essential to the health of all Oregonians. It is important that unnecessarily large doses of radiation are not given to the patient. At present, there are 2,739 registered x-ray machines. There are some machines that have not been registered although the law requires such registration. The purpose of the registration is to enable the inspector to establish the location of the unit and identify problems such as inadequate filtration or collimation, the correction of which could, in some cases, reduce the present level of unnecessary radiation by as much as 92.5 percent.

Outlook. The present rate of inspection of x-ray machines is approximately 500 per year. The present rate of increase of new machines in the state is about 10 percent of 2,739 per year, or 270 machines. This indicates that at the present rate of inspection, it will take 10 years to see all current and anticipated machine registrations. By reducing the unnecessary radiation from x-rays, we can reduce the total radiation exposure to all persons in the state to only that amount of radiation which is absolutely necessary. The simple process of adequately filtering the x-rays will eliminate a great deal of unnecessary radiation. We are reducing the overall population dose slowly, but more progress is required in this area.

Home Exposure to X-Rays

Significance and Effects. Home exposure to x-rays can also occur. The Oregon State Board of Health began conducting radiation surveys on color television sets in July 1967. The U. S. Public Health Service reported measuring radiation levels in excess of 0.5 mrem per hour at 5 centimeters for some TV sets of 27 different brands. A program of reworking certain television sets by the manufacturer was initiated which consisted of replacing shunt regulator tubes that were responsible for the excessive radiation and adjusting the high voltage to the cathode ray tube which, if too high, could also cause x-ray emission.

Present Status and Outlook. None of the reworked sets surveyed by the Board emitted radiation in excess of 0.5 mrem per hour at five centimeters from any external surface. In 1968 the state board surveyed approximately 40 color television receivers. Only one of these sets emitted radiation levels above the recommended permissible level of 0.5 mrem per hour at five centimeters from any external surface. In 1969 and 1970, the board continued to survey color television sets at the request of the owners. During this period, approximately 40 surveys were performed. Two of these sets emitted radiation levels in excess of the recommended standard. The maximum levels measured were 0.7 mrem per hour and 1.2 mrem per hour at five centimeters. In both instances, radiation exposure dropped to less than 0.1 mrem per hour at six feet away from the sets. This particular area is not considered a serious public health problem, but is one of the many areas in which the OSBH works with the public to reduce environmental risks.

NONIONIZING RADIATION

Lasers

Significance and Effects. Lasers were considered only a few years ago to be a laboratory curiosity, but their usefulness has now been recognized by industry and they are a common part of our industrial scene. They have applications in medicine, are used to align precision equipment in manufacturing plants, and are considered an important demonstration tool in some physics instruction courses. They have also appeared in construction work as a surveying device in the alignment of buildings and pipelines. Presently, the risk is limited to those whose occupations involve laser applications, such as research workers or military personnel, and only a few occupational exposures have been reported.

The laser beam is monochromatic in nature and shows an unusually small beam divergence. The net result is that the energy density of the laser beam is only slightly diminished by distance. The source of the laser beam dictates the frequency of the beam. The lasers gaining widespread use in industry for alignment and demonstration purposes are continuous gas-powered lasers of low wattage. The heat of the beam is usually not intense enough to cause a skin burn upon exposure, but a problem does exist with the eye exposure. The lens system of the eye has the ability to focus a light ray onto an area of the retina 10 thousand times smaller than the area of the emitting lens. In the case of the laser beam, this means that the energy density on the retina is increased by a factor of 10 thousand. Even with the small gas-powered lasers this is sufficient to cause permanent damage to the retina long distances away from the source of the laser beam. There are other lasers available, some not in the visible light spectrum, which can cause serious skin burns, but these are not in widespread use at this time.

Present Status and Outlook. At the present time lasers are not an environmental health hazard to the general public to the degree that water and air pollution are; however, at the current rate of technological progress this may not be the case 5 to 10 years from now. The laser industry is approaching a $100 million annual level and potential applications are increasing. In the future, they may be used extensively in communications, for airport traffic control, missile guidance and interception around cities, and for art and holograms or laser photography; so there is a possibility that the general public will be inadvertently exposed. Since the continuous gas lasers can create problems at long distances from the source, it may be necessary to place restrictions on their mode of use so that persons other than those working with the beam are also protected from potential damage.

Microwaves

Significance. The magnitude and extent of pollution of our environment by microwave radiation has not been systematically evaluated. The problems were initially confined to a small group of persons working with military radar sets; however, the use of microwave generators for military applications, radionavigation, diathermy, communications, food ovens and other industrial purposes has become widespread. Domestic microwave ovens are now in use in great numbers across the country, and any malfunctions could present a hazard to the homemaker. It has been conservatively estimated that nearly one-half of the U.S. population now lives in a measurable microwave environment. Increased urbanization will move even greater numbers into an energy field which did not exist one hundred years ago.

Effects. The radio frequency energy of a radar set is transmitted in that portion of the electromagnetic spectrum with wave lengths from a fraction of a centimeter to several centimeters. These are commonly known as microwaves. If the microwave is of the proper frequency, it can be absorbed within the human body. As with lasers, the principal problem is heat energy, and the most sensitive part of the body is the eyeball. The anatomical makeup of the eyeball is such that it has poor heat dissipating characteristics, and it is possible for detrimental effects to occur in the eyeball without the person being aware of the problem. Leaking microwaves can cause cataracts, skin burns and blood damage. The problem stems from the fact that the damage from the microwaves may be painless when it occurs and the sensation of pain is not felt until it's too late to take action. The microwaves heat deeper tissues where there are fewer nerves, unlike flames which produce immediate pain.

Present Status and Outlook. At the present time the United States Public Health Service, the Oregon State Board of Health and various manufacturers of microwave ovens have been addressing themselves to this problem in an effort to make sure that the ovens are safe when they are sold and continue to be safe while they are in use. Continuing efforts are necessary in this field to insure that the public utilization of this product does not present a hazard.

LAND MANAGEMENT FOR ENVIRONMENTAL QUALITY

While the land surface of Oregon remains constant over time, our population is growing. In addition, the choices we make in the use of our land surface frequently reduce the number of options for the future use of land. For example, the decision to commit land to a subdivision precludes the use of that land for many other purposes for decades to come.

The use of land, the rate of development of metal ores and fossil fuels, and the management of our coastal zones bring into sharp relief the great need to mesh government planning and the economic incentive system so that public and private decisions will not be antagonistic. The situation in Oregon is serious in the sense that numerous decisions will be made during the next decade that will greatly affect future land use in Oregon. They should not be made without adequate planning and consideration of the long-run consequences.

POPULATION DEPLOYMENT AND MAN/LAND RATIOS

Nature and Significance of Population in Relation to Environmental Quality

At the present time much of the concern over the relation of population to environmental quality which has had an impact on policy making is focused on numbers of people. Relatively less attention has been directed to the production and consumption habits of a given population and their location, rather state and federal agencies concerned with natural resources planning have generally extrapolated past trends in future planning. The assumption has been that the public will assume responsibility to provide certain public services such as water and other natural resource items to whatever population decides to settle in a given place.

There are two major limitations to such procedures. First, the assumption is that air, water and space are unlimited and their quality is irrelevant to the well-being of people. Second, the procedure has seriously underestimated the extent of technological change that occurs through time and the responsiveness of the economic system in adjusting to stimuli reflected in the price system. Enlightened public policy must recognize these limitations and come to grips with a means of influencing the location and behavior of the human population.

The United States has had a long history in the deliberate use of special governmental programs to serve as an incentive to the location of population. The Homestead Act and the Reclamation Act are examples of federal legislation designed to encourage settlement in particular areas. It is being increasingly recognized that if man is to achieve his desires for a quality environment, he must consider adaptation to, as well as outright control over, his natural environment. This constitutes explicit recognition that man must be considered as an endogenous variable in the management system whose reactions must be considered, rather than as an exogenous factor whose numbers and actions are accepted as immutable in the planning process.

Present Status

In Table 1 the counties of Oregon are grouped into three major categories, those counties that are judged to be dominated by the Portland Metropolitan Area, those that are outside the Portland area but are experiencing population growth, and those that have been losing population. Population densities are calculated for each county.

These data are quite rudimentary, but analysis of such information and the collection of additional data are becoming fundamental to the solution of the problems of environmental quality. Certain areas in the state are quite fragile with respect to human population, given existing life styles and technology. The quality of life is also affected by social services, such as health and education facilities, as well as by attributes of the natural environment, such as air and water quality, the sound level, and the visual appearance and crowding of the countryside. While the separation of economic activity from the location of people has been accomplished on a limited basis, it can be predicted that there will be a high correlation between the two for the forseeable future.

The table supports the hypothesis that Oregon must consider both the social as well as the natural environment in environmental planning. Those areas that are losing population are doing so largely for lack of economic opportunity. The areas of low density are experiencing difficulty in maintaining viable social services at a reasonable cost. On the other hand, there are areas of the state that are experiencing serious problems of environmental quality as they attempt to accommodate an influx of population.

Outlook

These trends have not yet run their course, and undoubtedly there will continue to be declines in the most sparsely populated counties and growth in other counties for some time to come. Even so, it seems likely that population exodus from the most sparsely populated counties has begun to diminish and may reverse itself for some of the counties in the next decade. If present policies remain in force, there seems little prospect of population growth in the other county groups ceasing for some time to come.

The location of population has not yet been considered on a statewide basis. Local communities have

Table 1. Population in Oregon Counties

	1970	Population 1960	1950	Percent Change 1960-1970	People per Square Mile 1969
Portland Vicinity					
Clackamas	164284	113038	86716	45.3	87.1
Columbia	28498	22379	22967	27.3	44.1
Marion	147602	120888	101401	22.1	125.8
Multnomah	547865	522813	471537	4.8	1292.1
Washington	153937	92237	61269	66.9	215.0
Yamhill	39598	32478	33484	21.9	55.9
Subtotal	1081784	903833	777374	19.7	194.7
Increasing Population					
Benton	53269	39165	31570	36.0	79.7
Clatsop	27868	27380	30776	1.8	34.0
Crook	9842	9430	8991	4.4	3.3
Deschutes	29575	23100	21812	28.0	9.8
Douglas	70812	68458	54549	3.4	14.0
Harney	7057	6744	6113	4.6	0.7
Jackson	92990	73962	58510	25.7	33.0
Jefferson	8611	7130	5536	20.8	4.8
Josephine	35678	29917	26542	19.3	22.0
Klamath	48464	47475	42150	2.1	8.1
Lane	212644	162890	125776	30.5	46.6
Lincoln	24948	24635	21308	1.2	25.3
Linn	69443	58867	54317	18.0	30.4
Malheur	23012	22764	23223	1.1	2.3
Polk	34967	26523	26317	31.8	47.3
Union	19344	18180	17962	6.4	9.5
Subtotal	768524	646620	555452	14.7	23.1
Decreasing Population					
Baker	14711	17295	16175	-15.0	4.8
Coos	55396	54955	42265	-0.8	34.4
Curry	12735	13983	6048	-8.9	7.9
Gilliam	2209	3069	2817	-28.0	1.8
Grant	6192	7726	8329	-10.5	1.5
Hood River	12951	13395	12740	-3.3	24.5
Lake	6247	7158	6649	-12.7	0.8
Morrow	4258	4871	4783	-12.6	2.1
Sherman	2052	2446	2271	-16.1	2.5
Tillamook	17130	18955	18606	-9.6	15.4
Umatilla	44050	44352	41703	-0.7	13.7
Wallowa	19417	20205	15552	-3.9	8.2
Wheeler	1762	2722	3313	-35.3	1.0
Subtotal	2056171	218234	188515	-5.7	5.8
OREGON	2056171	1768687	1521341	16.3	21.4

Source: U. S. Census of Population for respective years, as of April 1 that year.

varied in their aggressiveness in stimulating and planning for growth. There is every indication that the issue of population deployment is receiving considerable attention at the national level and that the medium-size communities will be judged to be the most desirable areas for accommodating increased employment. If federal legislation and federal programs emerge, all states will need to decide the extent of their own participation. Intelligent participation will depend on recognizing the interrelation and interdependency that exist among the areas of the state as well as their special needs and unique resources.

Oregon needs a systematic collection of information pertaining to: the relation of population densities to specific attributes of environmental quality under alternative management plans; the kinds of economic activity required to sustain various population densities and the relation of those densities to environmental quality; the relation of the quality and cost of selected social services to population densities; the interrelation and interdependency of population density and economic activity among areas. Such information appears to be basic to the development of policies and programs of a state that wishes to provide a quality life for a changing population.

LAND USE PLANNING

Nature and Significance of the Problem

Many areas in Oregon have a critical need for better control of land development. A "strip sprawl", consisting of residences, commercial operations and industrial plants, together with an occasional farmstead, exists along many of the highways in the Willamette Valley. The result is not pleasing aesthetically, makes inefficient use of the land and probably of other resources as well, and holds the promise of developing into an urban slum.

In the transition from a rural to an urban fringe environment, special problems develop. Much land is held for speculative purposes and taxed at the market price, thus taxes are higher than they would be if the land was valued on the basis of present use. Those holding land for speculative purposes tend to resist zoning and other measures that may prevent them from realizing windfall gains.

There are numerous factors giving rise to these undesirable effects. Traditionally we have relied almost exclusively upon private property and the land market to allocate space and organize land use. Our social policies have tended to accentuate the land use problem regardless of their original motivation or other desirable effects. The development of an excellent highway system by the use of public funds tended to decrease the cost of distance to the individual decision-maker. The provision of many social services to people regardless of their location tends to encourage strip distances and a highly dispersed development.

Present Status

Oregon has taken some steps toward the allocation of land by design. In 1969 the Oregon Legislature passed Senate Bill 10 which insured that all land would be zoned or that reasonable progress would be made toward that goal by 1972. At the present time, all counties have planning commissions. Over one-half of the land is zoned, with zoning of the remaining land underway.

It is apparent, however, that there is a limit to what local zoning can accomplish in this respect. Land use and environmental quality are a common problem of the citizenry. Ways must be found to harmonize individual decisions with group decisions and, at the same time, to bring together the decisions made by various groups in the state. Cities and counties may not be the logical units to confront all environmental problems. Decision units both public and private may need to yield autonomy if the problems of a larger unit are to be confronted.

Outlook

The human population of Oregon is expected to continue to grow, although the growth will not be uniform throughout the state. The U. S. Public Health Service predicts that the population of the rural counties of the Willamette Valley will increase 85 percent by 1985. This means that nearly another million people will be competing for the land area that is already showing signs of distress.

COASTAL ZONE MANAGEMENT PLANNING

Nature and Significance of the Coastal Zone

The development of the coastal zone in Oregon and in the nation as a whole has intensified so rapidly that local governments are experiencing difficulty in planning for orderly growth and in resolving conflicts. Their job has been complicated by the lack of knowledge and procedures necessary for formulating sound decisions and by confusion over division of responsibilities among the various levels of government. The uses of valuable coastal areas generate issues of intense state and local interest, but the effectiveness with which the resources of the coastal zone are used and protected often is a matter of national importance. They can be considered to be the nation's most valuable geographic feature, as the greater part of trade and industry takes place in these areas and the offshore waters are among the most biologically productive regions. Navigation and military uses of the coast and waters offshore clearly are direct federal responsibilities; economic development, recreation and conservation interests are shared by the federal government and the states.

The coastal zone is a region of transition between the land and the sea. Such activities as urban development, pollution of streams and maintenance of recreational areas, as well as commercial fishing, shipping and ocean pollution, may influence coastal zone usage. In addition, there are numerous activities carried on within the zone itself, such as shellfishing, pleasure boating, offshore oil production, and sand and gravel dredging, which should be planned for.

Present Status

In Oregon, 1970 was a year of both crisis and action with respect to the coastal zone. Environmental problems in the Coos Bay area were widely publicized and are not yet completely resolved. On March 3, 1970, the Governor issued an executive order ordering a halt to certain state agency coastal activities as a result of proposed highway projects in Tillamook County that would possibly be detrimental to the coastal environment.

Since a coastal planning program proposed by the Governor on May 4 was not favorably received, the latter half of the year was spent in formulating a revised program, titled the Coastal Development Program, in cooperation with local and state interests. Four Area Coordinating Committees representing Clatsop-Tillamook Counties, Lincoln County, coastal portions of Lane and Douglas Counties, and Coos-Curry Counties will assume major responsibilities for detailed program administration. Overall policy guidance will be provided by the Coastal Review and Evaluation Committee consisting of four representatives from each Area Coordinating Committee and two representatives from the Governor's Office. Staff assistance is provided by a coordinator assigned from the state agencies and by a technical task force now being organized.

Currently, it cannot be said that environmental problems have decreased nor that there has been a significant improvement in governmental control. There does seem to be, however, an improved climate of respect and understanding between state and local interests. This is due primarily to the need to bring the economy and the environment into balance and to the belief that if state and local governments default in their coastal responsibilities, the federal government will be forced to exercise its prerogative in the national interest.

Outlook

To achieve more effective use of our coastal land, a management system permitting conscious and informed choices among development alternatives is necessary. In order to ensure both the enjoyment and the sound utilization of coastal resources, there must be adequate planning and recognition of the importance of maintaining the environmental quality of this productive region. The benefits and problems of achieving such management and the inadequacy of present federal, state and local machinery are apparent. It is hoped that our Coastal Development Program will provide a rational and effective management system for Oregon. Time, however, is the essential element if we are to protect the coastal environment, enhance economic productivity, retain citizen sovereignty over the coastal area and qualify for federal planning assistance.

MINERAL RESOURCE DEVELOPMENT

Nature and Significance of Mineral Resource Development

Whenever a large block of land is allocated for a particular use, a value judgment is made between the relative benefits and costs of pursuing such goals as the disposal of waste products, the building of housing, the installation of industrial facilities, the maintenance of ecological activities and the distribution of our natural resources.

In Oregon we have allocated large segments of our land to agriculture, forestry, recreation and individual use. Our allocation to mining use has been insignificant to date in comparison to that of other states. However, development of mineral resources will receive increasing attention in Oregon in the next decade. Consideration is being given to allocation, where economically feasible, for the working of both known and as yet undiscovered ore deposits. Before such allocations can be made, careful examination of the methods used in the development of metal industries is essential to eliminate or minimize possible adverse ecological effects such as those resulting from intensive copper mining in Arizona and coal mining in West Virginia. Questions of resource allocation are of concern to all citizens, and information on the extent of ore deposits and their varying degrees of depletion should be readily available to the public if intelligent choices are to be made.

Present Status

Currently, the mineral deposits of Oregon are generally undeveloped. Production in 1969 was valued at only $63,000,000. Exploration activities will increase in the coming years as parts of the state are geologically favorable for the discovery of base and precious metals, ferroalloys, coal, and possibly uranium and petroleum. Extensive exploration and development have been delayed because of adequate reserves elsewhere or because known deposits were too small or low-grade to be profitably mined. New techniques and the depletion of ore deposits in nearby states have led to a resurgence of exploration activities in Oregon during the past three years.

The Hanna Mining Company continued their nickel operations at Riddle (mined one million tons of ore from which 25,991 tons of ferronickel was extracted in 1969), and conducted exploration elsewhere resulting in the discovery of 30 million tons of ore at several localities in Josephine and Curry Counties in addition to the 15 million tons at the mine. Hanna is also actively drilling in the Pueblo Mountains of southern Oregon, exploring a prospect for copper discovered this past summer.

Reynolds Metals announced that they had acquired the ferruginous bauxite holdings of the Aluminum Company of America in Columbia, Washington, and Multnomah and Marion Counties. They own hundreds of acres of land in the extensive low-grade ferruginous aluminum deposits of Tualatin Hills, Salem Hills and adjacent regions. In October they carried out test mining operations which consisted of removing topsoil, mining the ore, which was sometimes 30 feet thick or more, and replacing the topsoil. The Oregon deposits are the most important untapped suplies of aluminous raw material in the entire United States. They are favorably located near existing aluminum reduction plants and contain appreciable amounts of iron which will supply an important by-product. Eventual exploitation of these deposits is inevitable.

Prospecting took place in the Wallowa and Klamath Mountains by several major companies interested in metals. These geologically favorable areas are certain to yield major ore deposits when they are at long last prospected by modern exploration methods.

"Black sands" are natural concentrations of minerals having high specific gravity and dark color. They are the residuum of wind and wave action that carries away the lighter, more common minerals. Black sands are found at numerous places along the Oregon Coast, both on the present beach and in ancient terrace deposits. Chromium, titanium, zirconium, iron, platinum and gold may well be eventually recovered from these deposits. In 1963 the Bunker Hill Mining Company explored Clatsop Spit with a series of drill holes, going down nearly 86 feet, but decided the deposit was too low-grade for mining at 1963 prices. Under a joint research contract, the Office of Marine Geology and Hydrology of the U. S. Geological Survey and the Department of Oceanography at Oregon State University are investigating possible occurrences of black sand deposits on the sea floor off the Oregon Coast. It seems that some of these deposits will be exploited eventually.

Large areas of Harney and Malheur Counties were explored by the Nuclear Fuels Division of Gulf Oil Corporation by both airborne sensing equipment and drilling.

Texaco and Standard Oil Company of California leased over 200,000 acres of land in central Oregon during the summer of 1970, apparently hopeful of Cretaceous oil production. Offshore activity is presently low but will no doubt be revived in the future.

The Coos Bay coal field produced approximately 2.5 million tons of coal from 1854 to 1950. There are probably 50 million tons of recoverable coal remaining in the field, and this figure may be significantly revised upward with the development of new extraction techniques. The Eden Ridge coal field in the extreme southern part of Coos County appears comparable in reserves to the Coos Bay field, but no careful exploration has been attempted. With a rise in population and demand for power and exhaustion of the California oil fields, these fields will be carefully scrutinized in the years to come. Their eventual use may be speeded up by the development of aluminum and iron fabricating plants in the Willamette Valley.

Outlook

The discovery and exploitation of major mineral deposits in the state would significantly benefit the economy but would also pose serious ecological problems. In addition to the direct impact of mining on the landscape and the soil, the inevitable development of mills and smelters with effluent waters and gases must be reckoned with, and the health and safety of employees in the mineral industries must be protected. Some of the physical disadvantages for man and his environment which have, in the past, resulted from mineral industries can be observed locally in the Albany area. These effects range from mild nuisances to serious hazards and include atmospheric pollution, contamination of surface and ground waters, industrial accidents and disease, collapse and subsidence of the landsurface, and outright destruction of the terrain and vegetation. Preservation and restoration of the natural environment necessitate a massive effort of research and implementation directed towards correcting existing substandard procedures or developing alternatives.

An adequate and dependable supply of minerals and fuels is essential to the national economy, and a substantial share of that supply may eventually come from Oregon. It would appear desirable to start planning immediately to cope with problems associated with expanded mineral production and parallel industrial growth.

BIBLIOGRAPHY

Government agency and university reports which are available in limited quantity from the source are indicated in boldface type.

INTRODUCTION

"Adapting to Pollution"
Rene Dubois
Scientist and Citizen, January-February 1968.

"The Convergence of Environmental Disruption"
Marshal Goldman
Science 170, October 2, 1970.

"How to Think About the Environment"
Max Ways
Fortune, February, 1970.

"The Historical Roots of Our Ecologic Crisis"
Lynn White, Jr.
Science 155, March 10, 1967.

"Physical and Social Dimensions in Environmental Quality"
Robert M. Alexander, Air Resources Center, Oregon State University
presented at Annual Meeting Pacific Northwest International Section
Air Pollution Control Association.
Spokane, Washington, November, 1970.

"The Tragedy of the Commons"
Garrett Hardin
Science 162, December 13, 1968.

Technology: Processes of Assessment and Cost.
National Academy of Sciences. July, 1968.

AIR QUALITY IN OREGON

Report on Oregon's Air Quality and Program for Years 1968 and 1969.
State of Oregon
Department of Environmental Quality
Air Quality Control Division.

Rapid Survey of 1968 Air Contaminant Emissions in Western Oregon.
State of Oregon
Department of Environmental Quality.

"Trends in Visibility at Salem, Oregon, 1958-1967"
N. Berg, Columbia/Willamette Air Pollution Agency
W. P. Lowery, Department of Atmospheric Sciences, Oregon State University
presented at the Annual Meeting of Pacific Northwest International Section,
Air Pollution Control Association,
Vancouver, British Columbia, 1968.

A Study of the Natural Ventilation of the Columbia-Willamette Valleys.
Department of Atmospheric Sciences
Oregon State University. 1970.

A Study of Wood and Bark Residue Disposal in the Forest Products Industries.
George H. Atherton and Stanley E. Corder
Forest Research Laboratory
Oregon State University. 1969.

Research Relating to Agricultural Field Burning: A Progress Report.
Agricultural Experiment Station, and Air Resources Center.
Oregon State University. 1971.

WATER QUALITY IN OREGON

Proposed Water Quality and Waste Treatment Standards for Clackamas, Molalla and Sandy River Basins.
State of Oregon
Department of Environmental Quality. 1969.

Crisis in Oregon Estuaries: A Summary of Environmental Factors Affecting Oregon Estuaries.
Oregon State University, Sea Grant Publication No. 4,
Edited by Bill Wicks.
Oregon State University. 1970.

Water Quality Standards: Columbia River, Oregon.
Oregon State Sanitary Authority. 1966.

Proposed Water Quality and Waste Treatment Standards for Deschutes River Basin.
State of Oregon
Department of Environmental Quality. 1969.

Water Quality Standards: Goose Lake, Lake County, Oregon.
Oregon State Sanitary Authority. 1966.

Proposed Water Quality and Waste Treatment Standards for the McKenzie and Santiam River Basins.
State of Oregon
Department of Environmental Quality. 1969.

Water Quality Standards: Grande Ronde River (Wallowa-Union Counties, Oregon) and Walla Walla River (Umatilla County, Oregon).
Oregon State Sanitary Authority. 1966.

Water Quality Standards: Klamath River (Klamath County, Oregon).
Oregon State Sanitary Authority. 1966.

The National Estuarine Pollution Study.
Report of the Secretary of the Interior to the United States Congress pursuant to Public Law 89-753, Clean Water Restoration Act of 1966.
Senate Document No. 91-58. 1970.

Oregon Ultimate Water Needs.
Oregon State Water Resources Board. 1968.

Proposed Water Quality and Waste Treatment Standards for the Rogue River Basin.
State of Oregon
Department of Environmental Quality. 1969.

Water Quality Standards: Snake River (Malheur County, Baker County, and Wallowa County, Oregon).
Oregon State Sanitary Authority. 1966.

Proposed Water Quality and Waste Treatment Standards for the Tualatin River Basin.
State of Oregon
Department of Environmental Quality. 1969.

Proposed Water Quality and Waste Treatment Standards for the Umpqua River Basin.
State of Oregon
Department of Environmental Quality. 1969.

Tentative Water Quality Standards for the Willamette River and Multnomah Channel.
Oregon State Sanitary Authority. 1967.

Water Quality Standards for Marine and Estuarine Waters of Oregon (South Coast, Mid-Coast and North Coast).
Oregon State Sanitary Authority. 1967.

Oregon's Long-Range Requirements for Water.
Oregon State Water Resources Board. June, 1969.

Waste Management Concepts for the Coastal Zone.
National Academy of Science, National Academy of Engineering. 1970.

Water Resources Allocations Extra Market Values, and Market Criteria: A Suggested Approach.
Emery N. Castle and Herbert H. Stoevener,
Department of Agricultural Economics, Oregon State University.
presented at a conference entitled "Competition for Water in an Expanding Economy".
American Society of Civil Engineers.

SOLID WASTES MANAGEMENT

Waste Disposal and Environmental Quality in Oregon: An Assessment of Public Policy.
Robert M. Alexander
Agricultural Experiment Station
Oregon State University. 1968.

Solid Waste Management Practices. Oregon Status Report: 1969.
Oregon State Board of Health
Solid Waste Section.

Environmental Quality Problems: A Case Study of Field Burning in the Willamette Valley.
Frank S. Conklin
Department of Agricultural Economics
Oregon State University
presented at the Western Agricultural Economics Association Meeting, Tucson, Arizona. 1970.

CHEMICAL WASTES AND ENVIRONMENTAL QUALITY

The Biological Impact of Pesticides in the Environment: Proceedings of the Symposium.
James W. Gillett, Editor.
Environmental Health Science Center
Oregon State University. 1970.

The Environmental Sciences Center Newsletter: Environmental Research and Reports, Vo. 2, No. I.
Environmental Health Sciences Center
Oregon State University. 1970.

Accelerated Eutrophication of Lakes–Ecological Response to Human Activities.
A. F. Bartsch.
Department of the Interior, Federal Water Pollution Control Administration, Pacific Northwest Water Laboratory

"Biodegradable Detergents and Water Pollution"
Theodore E. Brenner.
Advances in Environmental Sciences, Vol. I
James N. Pitts and Robert L. Metcalf, Editors.
Wiley-Interscience. 1969, p. 147-196.

"Canada's Lakes and the Phosphate Problem"
Fisheries of Canada 23, No. 2, 1970.

Phosphates in Detergents and the Eutrophication of America's Waters.
Hearings before a Subcommittee of the Committee on Government Operations, House of Representatives, 91st Congress, December 15 and 16, 1969.

"Vehicle Emissions"
Society of Automotive Engineers.
Progress in Technology Series Part I. Vol. 6; Part II, Vol. 12, 1968.

Control Techniques for Carbon Monoxide, Nitrogen Oxide, and Hydrocarbon Emissions from Mobile Sources.
National Air Pollution Control Administration Publication No. AP66. March, 1970.

"Almost Pollution-Free Powerplants are Scheduled for Early 1975"
John J. Brogan.
Automotive Engineering. December, 1970.

"Catalytic Removal of Potential Air Pollutants From Auto Exhaust"
Robert H. Ebel
Advances in Environmental Sciences 1,
James N. Pitts and Robert L. Metcalf, Editors
Wiley-Interscience. 1969, p. 237-288.

"Gasoline: Antipollution Forces Bring Marked Changes to Petroleum Refining Industry"
Bruce K. Greed.
Chemical and Engineering News. November 9, 1970.

"Taking Another Look"
Lawrence E. Blanchard, Jr.
Automotive Engineering. December, 1970.

PHYSICAL FACTORS AFFECTING ENVIRONMENTAL QUALITY

"Effective Noise Control Through Planning"
James J. Kaufman
presented at the American Medical Association's Sixth Congress on Environmental Health, April 28-29, 1969.

"Evaluation of Transportation Noise"
Karl K. Kryter
presented at the American Medical Association's Sixth Congress on Environmental Health, April 28-29, 1969.

The Fight For Quiet
Theodore Berland
Englewood Cliffs, N. J.: Prentice-Hall, 1970.

"Noise—An Environmental Health Problem"
Herbert H. Jones
National Center For Urban and Industrial Health
Journal of Environmental Health 31 No. 2,
September/October, 1968.

Noise and Psychological State.
Alexander Cohen
U.S. Department of Health, Education and Welfare
July, 1968.

"Noise Effects on Health, Productivity, and Well-Being"
Transactions of the New York Academy of Sciences 30,
Series II, No. 7, Pages 910-918, 1968.

"Quiet Please"
Robert B. Lewman.
Architecture Environmental Health 20, 1970.

"Sound Pollution—Another Urban Problem"
Peter A. Breysse
The Science Teacher, Journal of the National Science Teachers Association, April, 1970.

"Oregon Earthquakes, 1841 through 1958"
Joseph W. Berg and Charles D. Baker
Bulletin of the Siesmological Society of America.

"The Portland Earthquake of May 13, 1968 and Earthquake Energy Release in the Portland Area"
Richard Couch, Stephen Johnson, and John Gallagher
ORE BIN 30, No. 10.

ENVIRONMENTAL RADIATION IN OREGON

An Ecological Evaluation of the Effects of Estimated Radioactive Liquid Effluents From the Trojan Nuclear Reactor.
For Portland General Electric Company
David L. Willis, General Science Department
Peter J. Mellinger, Environmental Health Sciences Trainee
Oregon State University. November, 1970.

Northwest Conference on the Role of Nuclear Energy: Report on the Second Annual Governor's Conference on Conservation.
Sponsored by Governor Tom McCall,
The Governor's Nuclear Development Coordination Committee and the Natural Resources Agencies of Oregon. 1969.

Radiological Health Data and Reports.
1964-1970.

Radiological Studies on the Columbia River.
Battelle Northwest Laboratory
Part 1, May, 1970.

Joint Committee on Atomic Energy (JCAE) Hearings on Power Plant Environment.
Statement by Theos. J. Thompson, AEC Commissioner
November, 1969.

LAND MANAGEMENT FOR ENVIRONMENTAL QUALITY

Land Use in Oregon: 1970 Directory of County Planning Officials, and Status of Planning and Zoning.
Cooperative Extension Service
Oregon State University. 1970.

Natural Areas--Needs and Opportunities: Proceedings of a Symposium Held at Northwest Scientific Association Forty-Third Annual Meeting.
March 27-28, 1970.
William J. Dittrich and James M. Trappe, Editors
Continuing Education Publication
Oregon State University. 1970.

Our Nation and the Sea.
Stratton Commission
U.S. Commission on Marine Science Engineering and Resources.

U. S. Census of Population.
1950, 1960, and 1970.

GENERAL REFERENCES

Cleaning Our Environment: The Chemical Basis For Action.
Subcommittee on Environmental Improvement,
Committee on Chemistry and Public Affairs,
American Chemical Society. 1969.

Environmental Quality.
Council on Environmental Quality
U.S. Government Printing Office. 1970.

Man's Health and the Environment: Some Research Needs.
Task Force on Research Planning in Environmental Health Science.
U.S. Government Printing Office. 1970.

Man's Impact on the Global Environment: Assessment and Recommendations for Action.
Report of the Study of Critical Environmental Problems (SCEP),
sponsored by the Massachusetts Institute of Technology
Colonial Press Inc., 1970.

Marine Science and the Oregon Economy.
Oregon Rural Areas Development Committee
Oregon State University. 1970.

Oregon's Agricultural Potential
Oregon Rural Areas Development Committee
Oregon State University. 1970.

The Potential of the Forest Industry in the Oregon Economy
Oregon Rural Areas Development Committee
Oregon State University. 1970.

Toward Balanced Growth: Quantity With Quality.
National Goals Research Staff
U.S. Government Printing Office. 1968.

The Annals of the American Academy of Political and Social Science.
May, 1970.

Wastes in Relation to Agriculture and Forestry.
Cecil H. Wadleigh
U.S. Department of Agriculture, Misc. Publ. No. 1065
U.S. Government Printing Office. 1968.