

COLORADO: Options for the Future

Final Report

of the

Colorado Environmental

Commission

March 1972

Colorado
Environmental
Commission

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March 20, 1972

The Honorable John A. Love
Governor, State of Colorado
and
The Honorable Members of the
Colorado General Assembly

Gentlemen:

I have the honor to transmit herewith the final report of the Colorado Environmental Commission, as called for by the provisions of Senate Joint Resolution Number 23, Forty-seventh General Assembly.

The report contains thirty-three recommendations for your consideration. These recommendations encompass those changes required in Colorado to develop the planning and policy mechanisms necessary for retaining control of our future. We urge the adoption of all of these measures over the next few years.

The Commission terminates its official life on April 1, 1972. Our Commission members have appreciated the opportunity to be of service to their fellow citizens.

Respectfully,

Max S. Peters

Max S. Peters
Chairman

MSP:jv

PREFACE

The Colorado Environmental Commission was jointly appointed by Governor John A. Love and the Colorado General Assembly in April, 1970, in response to Senate Joint Resolution Number 23. This resolution charges the Commission with identifying and studying the environmental problems of the state and advising the Governor and General Assembly of the alternative courses of action which may be necessary or advisable to preserve or improve the quality of environment. In the conduct of its studies, the Commission was directed to give particular attention to existing and potential environmental hazards; the immediate and long-range effects of present and projected activities of government, industry, agriculture, and mining; existing local, state, and federal programs on environmental control and management; and the need for additional programs and coordination of present programs. The Commission was to submit its final report and recommendations, and terminate its activities, by April 1, 1972.

During the initial discussions of the Commission's planned activities, it was decided that a major component of the effort would be devoted to the development of recommendations designed to enable Coloradans to retain control of their environment for an indefinite period into the future. Additionally, there would be specific recommendations related to subjects of urgent environmental concern in the state. There might also be consideration of Commission resolutions on specific environmental issues occurring during the Commission's lifetime.

To facilitate action, the Commission was organized into six operating committees, in addition to the Executive Committee appointed in the resolution. All Commission members were given the opportunity to participate on one or more of these committees. The committees were:

Food/Health/Hazards/and Related Problems

Government/Research/Education/and Related Problems

Land Use and Related Problems

Population and Related Problems

Transportation/Energy/Air Pollution/Noise/and Related Problems

Water/Water Pollution/Sewage/and Related Problems

All committees used the committee-hearing approach to develop the information on which Commission recommendations are based. These hearings are outlined in the report appendix. In addition, the Executive Committee and local Commission members conducted public hearings in Denver, Grand Junction, Fort Collins, and Pueblo. Finally, the Commission met as a full commission six times during its lifetime.

While the Commission has been moving forward with its efforts, there have been concurrent studies bearing on its recommendations. In this category are the activities of the Colorado Land Use Commission, the Air Pollution Control Commission, the Water Pollution Control Commission, the Rural Development Commission, and the Balanced Population Committee of the General Assembly. The Commission has remained aware of the activities of these groups, and their viewpoints have been taken into account in preparing this report.

The Commission has submitted three reports during its lifetime: Interim Report Number One, December 1970; Interim Report Number Two, December 1971; and this Final Report of March 1972. Interim Report Number One contained tentative conclusions and recommendations; it was designed primarily for educational and informational purposes and preparation of the public for some of the controversial issues expected to come in later reports. Interim Report Number Two was designed specifically for the short legislative session of 1972; it contained only those eleven items considered urgent for action by the General Assembly at that session. This Final Report contains all the recommendations of the Commission, including those retained or changed from the previous two reports. This report is designed to provide a basis for action by the elected officials and citizens of the state for some time to come.

There are fifty-seven members on the Commission. With this large a membership, there could be no unanimity on all recommendations. Some members were in disagreement with the nature of some of the recommendations; others, while agreeing with the recommendations in general, would have preferred different wording of the recommendations themselves or their rationale.

It is significant, considering the diverse backgrounds of the members and the fact that few of them considered themselves environmentalists prior to their appointment to the Commission, that there has been majority agreement with every recommendation contained in the report.

Three temporary resolutions were passed by the Commission during its lifetime. The first reflected the concern of the Commission that the I-70 Glenwood Canyon decision was being made without adequate consideration of all possible alternatives; it requested that all federal and state officials concerned with the decision be sure that they had taken proper cognizance of all factors before making a final decision on construction of an interstate highway through the canyon. The second resolution related to the Commission's primary emphasis on long-term retention of control of Colorado's future, through support of proposed State Constitutional Amendments 1, 2, and 3 in the general election on November 3, 1970. The Commission felt that passage of all three of these amendments was indispensable to the structure of state government for the future. The third resolution related to the acquisition of Roxborough Park by the State; it reflected the Commission's uneasiness over the apparent inability of the State to act in timely fashion for the benefit of its citizens and posterity on an issue of such importance. Since the timeliness of each of these issues has now faded, the three resolutions are not included in this final report.

Lack of time, the part-time nature of the Commission, and the limited staff resources available to the Commission have prevented consideration of anything but the broad, statewide aspects of environmental problems. **The main emphasis of the study was necessarily on the physical impact of man upon the earth.** This does not mean that the Commission was unaware of urgent human and social problems of man's existence, nor that these aspects of the problem were totally ignored. **The Commission feels that the human environmental problems are part and parcel of the total impact of man upon his surrounding: only if the State assumes its proper role as trustee of the total state environment can there be any hope for long-term solving of the human problems created within that environment.**

In preparing this report, the Commission has profited from testimony and information provided by numerous public citizens, organizations, and governmental personnel. This assistance was extremely useful and is acknowledged. The report, however, represents the views of the Commission itself, as tempered and balanced by the large Commission membership. The report is the responsibility of the Commission alone.

Finally, this report is not a partisan document. The Commission is a non-partisan body, composed of Coloradans from all walks of life and representing all points of view. There is no implication of fault or negligence on the part of any official or person. **If we are failing to realize what is happening to us, if we are failing to develop the policies and plans to retain control of our future, if we are failing to take advantage of the opportunity and challenge available to us--as this Commission feels that we are--then it is the fault of all Coloradans and we have no one but ourselves to blame for the tragedy.**

Max S. Peters

Max S. Peters, Chairman
Colorado Environmental Commission

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SUMMARY OF REPORT

This final report of the Colorado Environmental Commission is designed to provide the facts, projections, recommendations, and options regarding the environmental problems of Colorado. The report is divided into four chapters.

Chapter I, Environmental Problems Confronting Colorado, is devoted to a factual analysis of those environmental problems which are peculiar to the State of Colorado. The analysis indicates the relationship of Colorado's problems to those of the other states and the nation, and considers the implications of our situation for the future. **Basically, Colorado's problems stem from the fact that the state is semi-arid and has a finite supply of water which can support only a finite population; there is danger that the state's capacity for human support will be exceeded. Related to this is the fact that Colorado has certain natural resources which are of interest to the nation. In the future, difficult choices will have to be made as to the use of all Colorado resources.**

Chapter II, Colorado's Present Course of Action, indicates where Colorado is headed. It discusses certain trends of the future. **If these trends are permitted to develop without change, Coloradans will, within the next several decades, have relinquished their control over the future. Colorado citizens and government will have to devote a major portion of their time to a continuous struggle to keep pace with recurring crises, at ever-increasing costs, with no time to be devoted to the improvement of the quality of life.**

Chapter III, Recommendations, speaks to the goals which the State should adopt and the legislative changes which the State should make if we are to fulfill our role as trustees of the environment for the future. Eight goals and thirty-three recommendations are set forth in this chapter, as follows:

GOALS:

1. Institute, in all three branches of state government, those permanent legal, structural, and financial arrangements required for planning, coordinating, and enforcing the protection, preservation, and enhancement of the quality of the environment.
2. Develop the massive educational effort and political consensus required for protecting, preserving, and enhancing the quality of the environment. *of the nation, as a consequence of need.*
3. Stabilize and plan the distribution of the future population of Colorado, with consideration for the ecological balance, present and future.
4. Achieve integration of state water, land use, environmental, and population policies.
5. Create balanced transportation systems within the state.
6. Adopt the principle of recycling in resource use throughout the state.
7. Prevent the loss of the agricultural industry to the state.
8. Determine the wisest use of the energy resources of Colorado, from both a state and a national viewpoint.

RECOMMENDATIONS (short titles):

Environmental Planning and Policy--

1. Environmental restructuring and adoption of an Environmental Policy Act.
2. Consideration of structural changes within the General Assembly.
3. Adoption of a constitutional amendment providing for a right to a healthful environment.
4. Appointment of an environmental committee by every public and private school district and every public and private institution of higher learning.
5. Participation of citizens in the complex decision-making of the future.
6. Establishment of a conservation trust fund.

7. Creation of a long-range planning mechanism for the State Capitol/City Hall complex.
8. Requirement that every political jurisdiction in the state be a member of a state planning region.

Population Planning and Policy--

9. Adoption of a state population policy and establishment of a council of population advisors.
10. Enactment of a policy to revitalize rural development in Colorado, without encouraging in-migration.
11. Enactment of legislative limitations on the growth of metropolitan areas.
12. Enactment of incentives to birth-rate reduction.
13. Funding of all aspects of fertility control.
14. Adoption of a policy on abortion.

Water Planning and Policy--

15. Adoption of measures to establish a state water-management policy; and broadening the authority and funding of the water pollution regulatory function of the Department of Health.

Land Planning and Policy--

16. Conversion of the present Land Use Commission into a permanent land-use regulatory agency.
17. Assignment of responsibility for the coordination and development of new communities in Colorado.

Transportation Planning and Policy--

18. Creation of a department of transportation.
19. Conversion of the Highway Users Fund to a transportation fund, and enactment of legislation taxing vehicles in proportion to the absolute quantity of pollutant emitted.
20. Encouragement of use of means of transportation other than individual automobiles within core-city areas.

Air Planning and Policy--

21. Expansion of the authority and funding of the air-pollution regulatory function in the Department of Health.

Energy Planning and Policy--

22. Establishment of a committee to develop a state energy policy.

Environmental Health Planning and Policy--

23. Expansion of the authority and functions of the Colorado Department of Health.
24. Amendment of the current state radioactive-waste policies.
25. Amendment of the current state pesticide policy.
26. Creation of a council with the authority to inspect operations of potential hazard to the people of Colorado.
27. Compensation for permanent loss of hearing due to noise exposure at work.
28. Amendment of the legislation pertaining to establishment of maximum permissible noise levels and noise-abatement procedures.

Solid Waste Planning and Policy--

29. Provision of funds for study of a Front Range recycling system and the marketing of the products derived therefrom.
30. Provision for solid-waste districts; and consideration of consolidation of solid-waste disposal systems, with emphasis on recycling where feasible.
31. Enactment of incentives to the disposal of unusable automobiles.

Areas of Research and Study Need--

32. Support for applied research projects having direct applicability to the formulation of state environmental goals and policies.
33. Assignment of responsibility for the study of questions unresolved by the Colorado Environmental Commission.

All of these goals and measures are indispensable to retention of control of our future and should be enacted over the next few years.

Chapter IV, Options for Colorado's Future, considers the basic options available to Coloradans. Continuation of present trends into the future constitutes a choice which has already been made by default. Exercise of that choice will require no effort or change of present direction. That choice leads unmistakably and irrevocably to relinquishment of control and a crisis-oriented future. Any alternative to such a future will require policies, planning, disciplined decisions, and effort of a nature which we have not found necessary to accept in the past. The price of such alternatives, while it may seem high in the beginning, will be extremely inexpensive compared to what we will pay to live in continuous crisis. **Colorado still has the time and the space in which to solve its problems, a luxury which few of our sister states have. We must use our time and space wisely. Coloradans must make a choice soon, or their present course will become irreversible.**

CHAPTER I

ENVIRONMENTAL PROBLEMS CONFRONTING COLORADO

Colorado, the "Centennial State," sits astride the Continental Divide. The eighth largest state, it has an area of 104,247 square miles. Its mountains are the dominating topographic feature, separating the plains to the east from the high plateau region of the western slope.

The eastern plains were once a treeless, grass-covered area with the landscape broken by isolated buttes and sandy beds of intermittent streams. By mid-twentieth century this area was transformed; wheat fields checkered the area, and irrigated farms bordered the South Platte and Arkansas valleys.

The mountains, though, give Colorado its unique character. Here lie the mineral riches that attracted early settlers. Here still come millions annually to enjoy the quiet majesty of natural splendor.

The climate complements the scenery. Sunshine is abundant. Average annual precipitation is sixteen inches, and the humidity averages thirty-eight percent at noon. Winters are usually mild, with only short periods of extreme cold. Nights are always cool.

Fauna and flora vary from alpine species in the high country to desert types in the arid south and southwest. Two national parks and six national monuments testify to the variety of natural assets. National forests, embracing most of the mountain region, cover one-fifth of the state.

Colorado is truly the mother of rivers. Its streams, fed by the mountain snows, radiate like spokes of a wheel from the Continental Divide. Nearly all waters in the state originate here, and eighteen states share in their use. The Platte and Arkansas rivers eventually reach the Mississippi; the Rio Grande flows to the Gulf of Mexico; and the Colorado system joins the Pacific. All of these streams have cut canyons and gorges, contributing to the character of the mountains. They have determined the routes of land transportation, the areas of irrigated agriculture, and the location of cities and towns.

Agriculture is a leading basic industry, with annual cash receipts from crop and livestock sales of \$1,400,000,000 in 1971. Tourism has become a major industry, with over seven million visitors spending more than

\$500,000,000 here in 1971. The minerals industry is a third major sector of the economy: minerals mined in 1970 were valued at \$437,718,000, with Colorado being the world's leading producer of molybdenum; the value of molybdenum production in 1970 was \$114,716,000, exceeding the value of precious metals production in their peak year of 1900.¹

Oil, gas, and coal are produced in quantity in the state, and Colorado has the potential to become a key state in the nation's future energy economy. Oil shale deposits in the northwest part of the state are estimated to contain from 440 to 1,200 billion barrels of economically recoverable oil, at least equal the world's present known recoverable reserves of petroleum.

Colorado is home for 2,207,259 people.² Although problems have arisen, it would appear that gainful, productive lives could be provided for this number of inhabitants for the foreseeable future without necessarily ruining the state's natural assets. But what of the future? Will we be able to bequeath to future generations those qualities of life which we cherish in Colorado? If we are to do so, we must change certain disturbing and ominous trends which could destroy those very qualities.

Colorado's future is threatened by overpopulation. Population increased 25.8 percent in the 1960's, about half that increase coming from in-migration.³ The very attractiveness of the state to people disenchanted with overcrowded cities elsewhere could trigger a dramatic increase in migrants to the state in the near future. As these people move in, they tend to settle in urban areas, especially along the east corridor of the Front Range. This urbanization of the state has been "allowed to happen," with no planning other than the stimulation of growth. Such undirected and uncontrolled growth creates environmental

¹ Figures compiled from: Colorado State Division of Commerce, 1971; also, *Encyclopaedia Britannica*, vol. 6, pp. 87-91, 1968; also, Communication from A. L. Hornbaker, Colorado Geological Survey, Denver, Colorado, December 1971.

² U. S. Department of Commerce, Bureau of the Census, 1970 *Census of Population, Colorado, Advance Report*, January 1971.

³ *Ibid.*

degradation, as dramatized by destruction of natural areas and increasing air and water pollution. Our limited water resources are being shifted from agricultural to municipal-industrial uses. If growth continues, we will encounter limits on critical resources. Some areas of the state, because of geographical features and meteorological conditions, are susceptible to serious air pollution. Many of our high-mountain alpine areas are vulnerable to degradation by human traffic, especially vehicular.

The more important factors affecting Colorado's environmental quality include population growth, the development and use of water resources, the need for and development of energy and mineral resources, land-use patterns and problems, the various pollution problems, and finally the impact of man's activities on the biosphere. These critical environmental factors are now discussed in some detail.

POPULATION GROWTH

THE POPULATION EXPLOSION

Population explosion means an historically unprecedented growth in world population, a growth that threatens the welfare of all peoples; a scarcity of food and depletion of finite resources; and a serious upset of the biological system on which we depend. This population explosion may very well be the foremost threat to the future of mankind, the most likely trigger to a nuclear holocaust.

The population problem we face is unique, and how we cope with it will be fundamental to the future of the world, the United States, Colorado, and every member of future generations. We have a grave responsibility in this respect.

To understand the problem, one must understand the historical changes. Today, some 3.6 billion people inhabit the earth, possibly four to five percent of all people who have ever lived. Population grew very slowly until about 150 years ago. World population in 1650 A. D. was about 500 million people, possibly twice what it was at the time of Christ. Population doubled again to one billion people between 1650 and 1850 A. D. It doubled again in the next eighty years, to two billion people in 1930. By 1975, world population will have again doubled, to four billion people, a doubling time of only forty-five years.⁴

⁴ Paul R. Ehrlich and Anne H. Ehrlich, *Population, Resources, Environment*, Chapter 2, W. H. Freeman and Company, San Francisco, 1969.

Doubling time is one way of expressing the "compound interest" nature of population growth. A two percent per year growth rate, close to the present world growth rate, is equivalent to a doubling time of 34.6 years. Between 1960 and 1970, U. S. population increased 13.3 percent, an average annual increase of 1.25 percent, equivalent to a doubling time of 55.4 years.

What does this mean for the future? Various studies have attempted to estimate the world's ability to meet the needs of future populations. Future food supplies are a focal point; and the picture is very gloomy, at best, when considering the present world population and the present growth rates. Assuming food production can be increased by farming new lands, by increasing productivity per acre, and by technological innovations, an eight-fold increase in food production from the land is viewed as the probable limit.⁵ Food increases to be expected from the sea are not nearly as large as some "pie-in-the-sky" prognosticators would have us believe. The open sea, about ninety percent of the ocean, is a biological desert; food production occurs in areas of upwelling currents and along coastal regions. The most likely future safe, sustainable production from the sea is in the vicinity of 150-160 million metric tons per year, 2.5 times the 1967 production.⁶ This ultimate yield from the sea would supply about thirty percent of **minimal** protein requirements for the expected world population in 2000, and only three percent of its biological energy requirements.⁷ All told, we might expect no more than a nine-fold increase in food production over the world. That indicates the earth's ultimate carrying capacity at about thirty billion people, at a level of **chronic near-starvation for the great majority** (and with massive immigration required to now less-densely populated lands).⁸

A world population of thirty billion is three doublings away. At the present doubling time of thirty-five years, the world will have thirty billion people by 2075. If adequate nourishment is to be achieved, if any semblance of

⁵ Committee on Resources and Man, National Academy of Sciences - National Research Council, *Resources and Man*, Chapter 4, W. H. Freeman and Company, San Francisco, 1969.

⁶ *Resources and Man*, *op. cit.* (ref. 5), Chapter 5; Paul R. Ehrlich, et al, *op. cit.* (ref. 4), pp. 101-109; also, S. J. Holt, "The Food Resources of the Ocean," *Scientific American*, vol. 221, no. 3, pp. 188-189, September 1969.

⁷ *Resources and Man*, *op. cit.* (ref. 5), Chapter 5.

⁸ *Ibid.*, p. 5.

quality living is to be realized, and if we are to preserve much of the natural state of the earth, an upper limit of ten billion people is indicated.⁹ That population will be reached in fifty years.

The United States has its own population problem, even though it is the world's most affluent nation. The nation has experienced a rapid population growth since World War II, with annual increases of nearly 1.6 percent per year having been reached.¹⁰ At the same time, we have been in the midst of a population implosion, a rush of people to the cities. These two population trends are worldwide, and we see today their direct impact right here in Colorado.

Population increase, nationally, was concentrated in one-fourth of the counties, reflecting a trend toward metropolitanization of the American people. Today, one in four Americans live in ten "super cities." The 243 Standard Metropolitan Statistical Areas (cities and environs of 50,000 or more people) increased by 16.6 percent in the 1960's, absorbing eighty-four percent of the national increase. The rest of the country grew by 6.5 percent, with over one-half of all counties showing a net loss in population. Urbanization is greatest in the West, where 82.9 percent of the people live in urban areas.¹¹

Colorado's population increased 25.8 percent in the 1960's, going from 1,753,947 to 2,207,259,¹² a rate of increase nearly double the national average. In our state, 78.5 percent of the people live in urban areas. 1,779,337 people (80.4 percent) reside in thirteen counties along the east side of the Front Range, with 1,227,529 concentrated in the five-county Denver-Boulder area. While the urban areas increased in population, thirty-two of Colorado's sixty-three counties had a net loss.¹³

Colorado's population increase in the 1960's was 51.4 percent by natural increase and 48.6 percent by net migration into the state. One

⁹David M. Gates, "The Flow of Energy in the Biosphere," *Scientific American*, vol. 224, no. 3, pp. 89-100, September 1971.

¹⁰Nathan Keyfitz and Wilhelm Flieger, *Population, Facts and Methods of Demography*, p. 73, W. H. Freeman and Company, San Francisco, 1971.

¹¹U. S. Department of Commerce, Bureau of the Census, *1970 Census of Population, United States, Advance Report*, February 1971; also, Philip M. Hauser, "The Census of 1970," *Scientific American*, vol. 225, no. 1, pp. 17-25, July 1971.

¹²1970 *Census of Population, Colorado*, op. cit. (ref. 2).

¹³*Ibid.*

out of five residents in our state today arrived in the last ten years.

Colorado is a prime choice of people leaving other parts of the country for a "better life." The movement nationally is from north and east to south and west. The West grew by 24.1 percent in the 1960's, about twice the national rate. Colorado's growth, percentage-wise, was exceeded only by California (27 percent), Alaska (33.6 percent), Nevada (71.3 percent), Arizona (36.1 percent), Maryland (26.5 percent), and Florida (37.1 percent). Biggest gainers in people were California, with 4.2 million new people, and Florida, with an additional 1.8 million.¹⁴

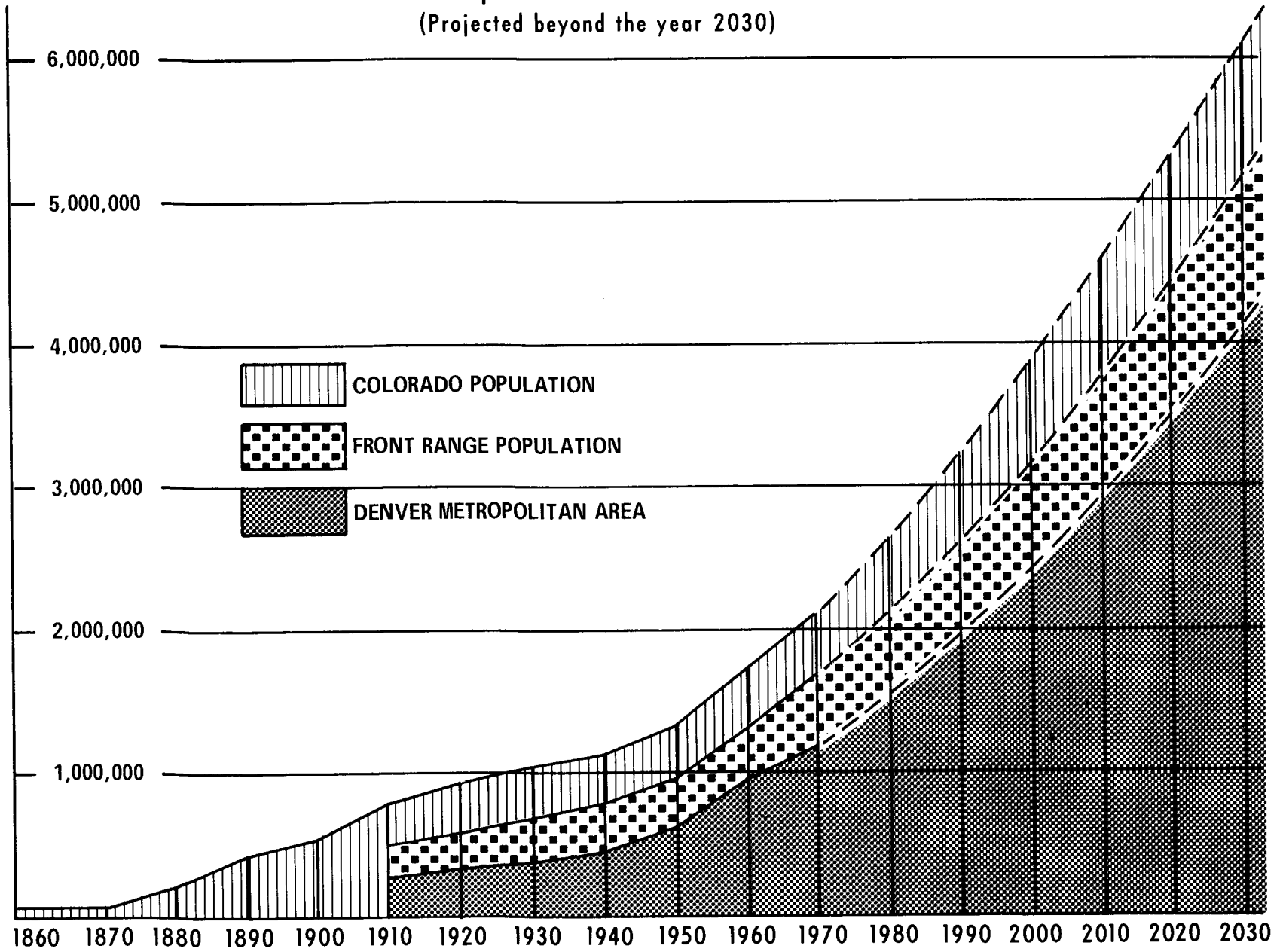
POPULATION PROJECTIONS FOR COLORADO

Population changes and trends are important to Colorado's future. As long as the population continues to increase nationally, our state will be faced with a disproportionately large number of people wanting to move here. There are indications that we will be a prime target for an out-migration of people leaving California in the coming years, people disillusioned with the "golden life" of the "golden state," tired of overcrowding, tired of air pollution, and weary of the financial burdens associated with hectic, rapid uncontrolled growth. Net in-migration into California was high following World War II, peaking at about 600,000 per year in the 1960's. In 1970, it had dropped to 25,000 per year, leading to speculation that California's population might not increase in the coming decade because of a net out-migration, with Colorado being a choice alternative.

Carrying speculation a step further, it is important to consider what Colorado's future population structure will be, assuming present trends continue and no attempt is made to control population or to direct development. Our 25.8 percent increase in the last ten years corresponds to an annual growth rate of 2.3 percent, or a population doubling every 30.1 years. At this rate, the state could expect 4.4 million people in the year 2000. The Colorado State Planning Office and the U. S. Department of Housing and Urban Development actually predict a lower growth rate for the future, projecting a state population of 3.8 million by 2000 and six million by 2030. Their projections, shown in Figure 1, page 8, are actually conservative.

¹⁴Hauser, op. cit. (ref. 11).

Population of Colorado (Projected beyond the year 2030)



BASED ON FIGURES SUPPLIED BY THE COLORADO STATE PLANNING OFFICE

Figure 1

Without effective action to forestall current trends, there could be nearly four million people crowded into the Front Range Corridor from Wyoming to New Mexico by the year 2000. The Denver metropolitan area alone may have a population of 2.5 million, possibly sixty percent of Colorado's citizens.

While the Front Range area and metropolitan Denver experience explosive growth, most of the rest of the state could face economic stagnation, even decline, with the possible exception of the communities near mining operations (such as coal and oil shale) or those dependent on tourism. Even now, rural Colorado is economically less well off. The per capita adjusted gross income is \$3,129 in the Denver metropolitan counties of Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson, while it is \$2,152 for the rest of the state; it is much lower in Costilla and Conejos Counties, being \$702 and \$930 respectively.¹⁵

By the year 2000, jurisdictional lines in Colorado will probably have started to resemble the picture shown in Figure 2,¹⁶ with eighty-five to ninety percent of the people living in a strip megalopolis east of the Front Range. This will create diverse problems. In the "strip," incomes may be higher, but so will per capita costs of government services, air- and water-pollution control, etc. The population will be younger, hence with a higher dependency ratio. In contrast, most of the rest of the state could expect to lose young people to the cities because of lack of local jobs. The remaining population would be older; the smaller communities would likely be plagued by a depressed economy, and many would be too small to afford even adequate government services.

SOCIAL AND ECONOMIC CONSEQUENCES OF POPULATION GROWTH

Growth has been a basic tenet of our society. It has been assumed that prosperity required growth, growth based upon a growing population and an expanding economy. This premise is being seriously questioned today as the economic and social burdens of a growing population become more apparent. Governor Love, in testifying before the Subcommittee on Rural Development of the U. S. Senate and Agricultural Forestry Committee on April

29, 1971, said, ". . . The traditional American ethic that bigger is better seems to have run its course. It is increasingly apparent the tremendous concentration of people creates economic problems, social problems, psychological problems, and perhaps even biological problems."

A growing population means a higher dependency ratio, vividly apparent in the United States today. As a result of the post-World War II baby boom, nearly thirty-one percent of our people are under fifteen years of age. In a stable population, this age group would constitute only about twenty percent of the population.¹⁷ This high dependency ratio in a growing population is a primary factor behind the increased tax burden needed to meet ever-expanding government services, increased educational and welfare costs being most noteworthy.

The more slowly a population grows, the greater is the per capita income, according to a recent study.¹⁸ Several things contribute to this. More capital is available to invest in tools, increasing worker productivity. There should be less unemployment, as the economy would not be under as much stress to create new jobs. A lower fertility rate would mean a reduction in the children/worker ratio, thus reducing the costs of the dependent population. Domestic savings would increase, contributing to overall family welfare. Finally, per capita costs of government services would tend to stabilize.

Economic vitality of a nation is related more to successful innovation of applied technology than to any other factor. A stable population would allow more time for the development of technology and release more capital for its support. Population growth, on the other hand, usually benefits only those who own something valuable and scarce and who can sell it for a profit. A growing population increases the scarcity of land and other natural resources, with a consequent redistribution of wealth that brings no increase in general economic welfare. Scarcity, in fact, will eventually depress an economy.

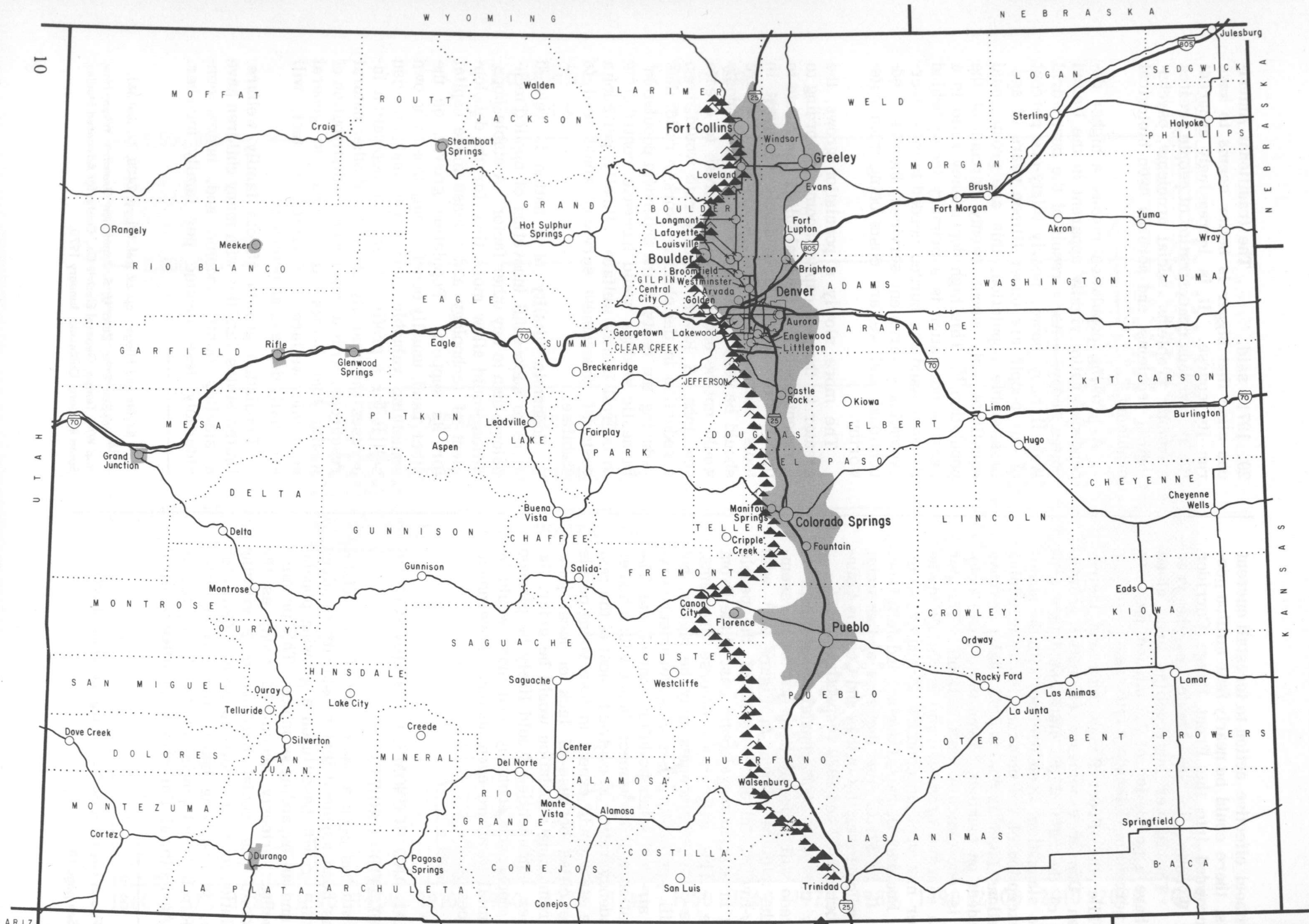
Population growth affects family welfare. United States families with many children have a smaller family income and, hence, considerably less income per family member.

¹⁷ Keyfitz and Flieger, *op. cit.* (ref. 10), pp. 24-30, 72, 360-361.

¹⁸ Stephen Enke, *Zero U. S. Population Growth -- When, How, and Why*, Tempo, General Electric Co., Center for Advanced Studies, Santa Barbara, California, January 1970.

¹⁵ Figures supplied by the Colorado Legislative Council, 1971.

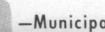
¹⁶ See page 10.



(Not drawn to scale)

A SUGGESTION OF THE POSSIBLE COLORADO POPULATION DISTRIBUTION PATTERN BEYOND THE YEAR 2030, GIVEN NO CHANGE IN CURRENT TRENDS

SYMBOLS:  -Front Range

 -Municipal Growth Pattern

SOURCE: Office of Coordinator of Environmental Problems

With increasing family size, a higher percentage of families have incomes below the poverty level. In 1968, 17.2 percent of all families in the United States were classified as "poor." Of those families with two or fewer children, only 9.9 percent had incomes at or below the poverty line. In contrast, 29.7 percent of all families with four or more children were living in poverty; 42.1 percent of all families with six or more children were living in poverty.¹⁹ Besides the economic burden, there are social burdens. Children of large families may be less well fed. Undernourishment may result in impaired physical and even mental ability later in life, and generally children from large families advance less far scholastically.²⁰

A contributing factor to our population growth is the extent of unwanted births. This is particularly true for the poor. Between 1960 and 1965, at least nineteen percent of all births were reported as unwanted. For those families earning less than \$3,000 per year, thirty-four percent of the births were unwanted; this compares to fifteen percent for those earning \$7,000 or more per year. In all cases, additional children are less desired as family size increases, the fourth and higher births being unwanted in thirty to fifty percent of the cases; it exceeds sixty percent for the sixth and higher births among the poor.²¹

The inability or lack of opportunity for parents to control the number of children they have is obviously a major factor in the economic and social stress on families. The more affluent can afford birth control; whereas, the poor have been forced to depend on public health services which, until recently, were barred from offering such help. The burden of the poor in this respect is illustrated further by differences in fertility rates. In 1960-1965, the average annual fertility rate for poor women was 152.5; for non-poor women, it was 98.1.²² Since then, these rates have dropped, but the discrepancy between poor and non-poor still holds.

¹⁹ *Ibid.*

²⁰ *Ibid.*

²¹ Larry Bumpass and Charles F. Westoff, "The 'Perfect Contraceptive' Population," *Science*, vol. 169, pp. 1177-1181, September 18, 1970; also, *Population Growth and America's Future*, An Interim Report by the Commission on Population Growth and the American Future, March 16, 1971, Superintendent of Documents, Washington, D. C.

²² Frederick S. Jaffe, "Toward the Reduction of Unwanted Pregnancy," *Science*, vol. 174, pp. 119-127, October 8, 1971.

IMPACT OF CITY SIZE

Recent studies relate city size with government costs, police protection, and crime.²³ Size does not seem to matter for cities up to 250,000 people. Neither economies nor diseconomies of scale are significant. In cities of over 250,000 population, however, size does make a difference. The law of diminishing returns sets in, and there are significant diseconomies of scale. Size made the most difference in police protection, more police being needed per capita. Studies by Dr. Kenneth Watt²⁴ in California indicate all types of crime increase on a per capita basis as city size increases.

As the number of commuters increases in an urban area, the roadway requirements per capita increase exponentially, a one-hundred-fold increase in population requiring a twelve-hundred-fold increase in roadways.²⁵ Other government services tend to follow a parallel pattern, with per capita taxes increasing as cities grow.

There is even some evidence that as concentration of people increases, their susceptibility to communicable and even noncommunicable diseases increases. In particular, emphysema death rates seem to increase with city size and degree of industrialization, suggesting a tie-in with air pollution.²⁶

The 1970 census figures show that in Standard Metropolitan Statistical Areas (SMSA) of one to three million people, the suburbs grew by 31.9 percent, eight times the growth rate in central cities. The larger the SMSA, the lower was the growth rate. SMSA's with a population greater than three million grew only 10.7 percent, less than the national average. Dr. Philip M. Hauser, in analyzing this problem,²⁷ suggests that three million inhabitants in an urban area may represent an upper limit of reasonable size, beyond which urban problems begin to become unmanageable.

²³ Information Bulletin, Advisory Commission on Intergovernmental Relations, Washington, D. C., Bulletin No. 70-8, September 16, 1970; also, Kenneth Watt, "Growth in Malibu (California)," *National Reporter*; also, Kenneth Watt, *A Model of Society*, Ford Foundation, New York, 1970.

²⁴ Watt, *op. cit.* (ref. 23).

²⁵ R. J. Smeed, "Studies on Traffic Systems," cited in Watt, *op. cit.* (ref. 23); also, in *Town Planning Review*, vol. 35, pp. 133-158, 1964.

²⁶ Health, Education and Welfare Task Force on Environmental Health and Related Problems, *A Strategy for a Livable Environment*, June 1967, Superintendent of Documents, Washington, D. C.

²⁷ Hauser, *op. cit.* (ref. 12), p. 20.

CONCLUDING THOUGHTS

Many problems face this nation and the State of Colorado in the decades ahead. These include poverty, racial tensions, social disorder, decay of the cities, air and water pollution, environmental degradation, shortage of resources, energy crises, and many others. Solution of these problems will make enormous demands on our resources. Can we find the means to solve these problems if we add 100 million people to this country in the next thirty years and double the population of Colorado? There is reason to doubt that we can.

Zero population growth is an inescapable fact. The only question is when and how. Do we take steps now to set population goals and establish programs to limit our population growth voluntarily, or do we wait for natural methods to achieve zero growth? The former can lead to a quality life; the latter can only lead to disaster. The Commission on Population Growth and the American Future²⁸ clearly points the way. We must alter our idea of what constitutes a desirable family size. All economic groups contribute to the population explosion. Something like 2.1 children per family would eventually stabilize population;

but even then, stabilization would be seventy years away. The difference in impact of two- and three-child families is striking, as shown in Figure 3. If a two-child family became the norm now, the population would still not stabilize until well into the next century and would do so at close to 300 million people. In contrast, if three children per family becomes the norm, population growth will be explosive, reaching an estimated 700 to 800 million people by 2070 (400 million in 2014).

Population trends in the United States in recent years suggest that people are reacting against a continued rapid population growth. Our crude birth rate peaked at 25.16 births per thousand people in 1954-56. Since then, it has been slowly declining. Concurrently, the total fertility rate (children/woman/lifetime) declined from a peak of 3.69 in 1959-1961 to 2.57 in 1967.²⁹ More recently, in the first eight months of 1971, births declined three percent over the previous year, even though there was a three percent increase in the number of women of childbearing age. The total fertility rate in late 1971 was about 2.2, slightly above the replacement rate of 2.1.³⁰

WILL THE U.S. ADD A FOURTH 100 MILLION TO ITS POPULATION?
EFFECT OF 3-CHILD FAMILY vs. 2-CHILD FAMILY.

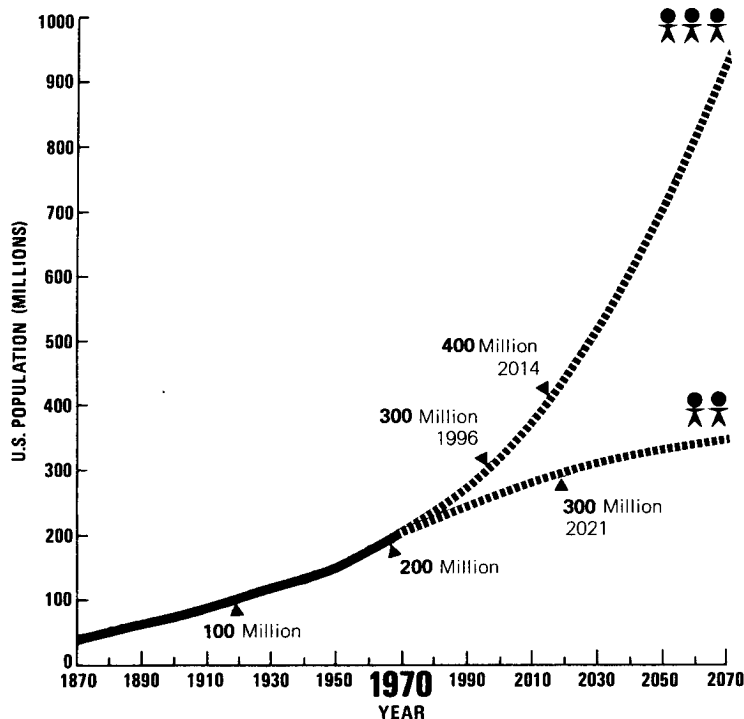


Figure 3

²⁸ *Population Growth and America's Future*, op. cit. (ref. 21).

²⁹ Keyfitz and Flieger, op. cit. (ref. 10), pp. 74-75.

³⁰ *The Denver Post*, November 10, 1971, p. 8AA.

Although the recent decline in birth rates and fertility rates has been dramatic, we are just now approaching the lower rates characteristic of Europe, rates still generating a significant population growth.³¹ These trends do suggest that if all people had equal opportunity to control their reproductive lives, then a significant step toward stabilizing the population would have been accomplished.

WATER RESOURCES

Water is the most abundant single substance in the earth's biosphere. It is the medium of life processes, continually circulating through the water cycle, constantly used, but essentially never destroyed. The earth contains about 1.5 billion cubic kilometers of water in one form or another. About ninety-seven percent of this is present as salt water in oceans and seas. Of the remaining, three-fourths is locked up as solid in polar ice caps and glaciers. Only about 0.15 percent is present as liquid water in streams and lakes.³²

Average annual precipitation over the world is about forty inches. Over land areas, it is twenty-eight inches. Over the United States, it averages about thirty inches, or 4,310 billion gallons per day.³³ Average annual precipitation is sixteen inches in Colorado; however, it varies from a high of more than fifty inches in some mountainous areas, to a low of seven inches at Alamosa in the Rio Grande Basin.³⁴

The maximum dependable stream flow in the United States is 1,080 billion gallons per day, about twenty-five percent of the average precipitation. However, it is not uniformly distributed. The eastern portion of the country, roughly everything east of a line through the Kansas-Missouri border, claims 790 billion gallons per day, or 73.1 percent. The Pacific Northwest, mostly Washington, Oregon, and Idaho, claims 136 billion gallons per day. The remaining 14.2 percent, 154 billion gallons per day, is shared by fourteen western states comprising over one-half of the country's land

area. Colorado literally sits at the apex of this dry western region.³⁵

Water usage falls into three classes; namely, (1) consumptive uses, (2) stream-flow uses, and (3) on-site uses. Consumptive use comprises municipal-industrial-type diversions and agricultural irrigation; it means ultimate consumption by evaporation or transpiration, or incorporation of water in manufactured products. Stream-flow use includes stream uses for navigation, recreation, maintenance of fish habitat, hydroelectric power generation, and probably most important of all, waste carriage and disposal. Several stream-flow uses can be accommodated simultaneously. On-site use includes water for swamps, wetlands, wildlife preserves, and certain soil conservation projects (including farm ponds).

In assessing water needs for the future, all three uses defined above must be considered. The quality of the environment will depend on the quality of water as affected by type of use, and the quality of human existence will depend partly on our policies defining the use hierarchy.

WATER RESOURCES IN THE WEST

In the western fourteen states, stream flow can be divided into eight subregions, each essentially a river drainage basin. About sixty percent of the water supply occurs in two of these subregions, the Western Gulf Basin (essentially central and southeast Texas) and the Central Pacific Basin (northern California, including the Sacramento Valley). The central portion of the West, the Rocky Mountain Region, is most deficient in supply relative to existing and projected uses; and here the stringency is most serious in the Rio Grande and Pecos basins, the Colorado River Basin, and the South Pacific Basin. Much of Colorado is included in these water-deficient regions.³⁶

Irrigation accounts for the major consumptive use of water in the West. In 1970, irrigation consumed 57.7 billion gallons per day, or 93.7 percent of consumptive uses. In contrast, power plants consumed 0.1 billion gallons per day, municipalities consumed 2.9 billion gallons per day, and manufacturing consumed 0.9 billion gallons per day. By the year 2000, Resources for the Future, Inc.,

³¹ Keyfitz and Flieger, *op. cit.* (ref. 10), pp. 86-107.

³² H. L. Penman, "The Water Cycle," *Scientific American*, vol. 223, no. 3, pp. 99-103, September 1970.

³³ *Ibid.*

³⁴ *Mineral and Water Resources of Colorado*, Report compiled by United States Geological Survey, p. 233, U. S. Government Printing Office, Washington, D. C., 1968.

³⁵ Hans H. Landsberg, Leonard L. Fischman, and Joseph L. Fisher, *Resources in America's Future*, pp. 378-380, The Johns Hopkins Press, Baltimore, Maryland, 1963.

³⁶ *Ibid.*, pp. 259, 382-383.

predicts consumptive use of 91.7 billion gallons per day for the West, with irrigation taking ninety percent of that. This is 59.6 percent of the maximum dependable stream flow for the region.³⁷

When stream-flow uses and on-site uses are added to consumptive uses, total water demand for the West is put at 215.4 billion gallons per day in 2000, nearly forty percent above the maximum dependable stream flow of 154.1 billion gallons per day. The situation is more serious than these figures indicate, since actual available stream flow is less than the maximum dependable and is a function of water storage facilities, as well as annual rainfall. For example, with 1954 storage facilities, stream flow available fifty percent of the time was 69.3 billion gallons per day, only thirty-two percent of projected requirements for the year 2000.³⁸ Even today, water needs exceed supply, meaning inadequate water is available for some needs; in particular, stream flow is insufficient at times for diluting waste, thus resulting in water pollution.

For the West, the choice is clear. Either total use is brought into line with supply, or one type of use must be sacrificed to maintain another. The only other alternative is to import water from water-surplus areas. Importation, however, is an illusory solution. Many questions need to be answered regarding the environmental impact of such transfers but, more significantly, they are not a permanent solution to increasing water demand. The Pacific Northwest surplus in 2000 will just about equal the West's deficiency at that time, leaving no extra supply for increasing demand beyond the year 2000.³⁹ Water transfer from Canada is often proposed as a solution. Speculation usually envisions the transfer of about seventy million acre-feet per year.⁴⁰ Formidable political obstacles stand in the way of this proposal, and costs would be great, possibly around a quarter trillion dollars. What would such a transfer accomplish? Assuming one-half goes to agriculture, with five hundred gallons per day being required to feed one person, this transfer would feed an additional 128 million people. That is about equal to the likely increase in United States population during the thirty to fifty years required to implement this proposal. So, once again we are

³⁷ *Ibid.*, pp. 260-269.

³⁸ *Ibid.*, pp. 380-383.

³⁹ *Ibid.*

⁴⁰ Ehrlich, et al, *op. cit.* (ref. 4), pp. 93-94.

faced with the question, "What have we really accomplished, and what do we do next?" A final thought: water transferred at such cost is likely to be too expensive for agricultural use.

COLORADO'S WATER RESOURCES

Nearly all waters within the state originate here. Little water flows into the state from outside, and eighteen states share in the use of our waters. All waters originating in Colorado are allocated for interstate use by interstate compacts or Supreme Court decisions, the Colorado Compact being the major one. The State Engineer of Colorado is charged with administering the state's water resources.

The stream systems in Colorado produce about sixteen million acre-feet of virgin stream flow annually. Of this, the Colorado River and its tributaries in Colorado produce eleven million acre-feet; but, by interstate compact, Colorado is restricted to 34.7 percent of this part of the upper Colorado River supply; the rest is allocated to other states. Annual virgin stream flow in the South Platte Basin is 2.2 million acre-feet; Colorado is legally entitled to 2.1 million acre-feet, or nearly all of this. Annual flow in the Arkansas Basin is 1.17 million acre-feet; Colorado's legal share is 1.12 million acre-feet. Virgin annual stream flow is 1.4 million acre-feet in the Rio Grande Basin; Colorado's share is 1.01 million acre-feet. Thus, Colorado is entitled to some eight million acre-feet of total stream production, about one-half of the total.⁴¹

Underground water supplies are extensive in Colorado, but vary in type and quality. There is little ground water on the western slope. Some ten million acre-feet are estimated to be in place under the South Platte River, and two million acre-feet under the Arkansas River. These waters are largely recharged with percolated waters from the respective rivers, their tributaries, irrigation, and precipitation; therefore, these waters are actually part of the stream-water system. Some two billion acre-feet of water underlies the Rio Grande Basin, but most of it is too deep for economic development.⁴²

The major designated ground-water basins in Colorado, however, are the northern high

⁴¹ Data supplied by C. J. Kuiper, State Engineer, Division of Water Resources, Colorado Department of Natural Resources; also, Testimony by Felix L. Sparks, Director, Colorado Water Conservation Board, before the Committee on Water and Related Problems of the Colorado Environmental Commission, January 1971.

⁴² *Ibid.*

plains and the southern high plains. The northern high plains are essentially that area covered by the Republican River and the Smoky Hill River drainages in Colorado. The southern high plains consist of Baca County and that portion of Powers County lying southeast of Two Buttes Creek in Colorado. There is essentially only one aquifer present in the northern high plains, the Ogallala Formation; while in the southern high plains there are three substantial aquifers: the Ogallala Formation, the Dakota Formation, and the Cheyenne Formation. The estimated recoverable water from the Ogallala Formation in the northern high plains is forty-eight million acre-feet, or fifty percent of the total storage. About thirty million acre-feet of recoverable water are stored in the three major aquifers of the southern high plains (Ogallala, Dakota, and Cheyenne Formations).⁴³

Of the underground waters, it is estimated that 100 million acre-feet might be economically recoverable,⁴⁴ but steady-state production is a function of aquifer characteristics and recharge rates. We might expect a net potential sustainable supply of 1.5 million acre-feet per year. This resource must be carefully managed or we can deplete in decades what took tens of thousands of years to accumulate.

WATER-USE PATTERNS IN COLORADO

In 1970, irrigated acreage in the state totaled 4,205,000 acres. Water distributed to this acreage was 16,500,000 acre-feet; of this, some 5,700,000 acre-feet are estimated to have been consumed by evaporation-transpiration.⁴⁵ About thirty-seven percent of irrigation-water diversion in Colorado occurs in the South Platte and Arkansas basins. In the South Platte Basin, some 4.4 million acre-feet are diverted, with 1.6 million acre-feet of this being pumped from wells. In the Arkansas Basin, 2.17 million acre-feet are diverted for irrigation, 170,000 acre-feet of this by subsurface pumping. Since 1935, major pump installations along the Platte and Arkansas rivers, those delivering 1,000 to 3,000 gallons per minute, have increased from 350 to 17,500; countless pumping installations are smaller.⁴⁶

⁴³ Data by Kuiper, *op. cit.* (ref. 41).

⁴⁴ *Ibid.*

⁴⁵ *Ibid.*

⁴⁶ *Ibid.*

On the high plains of Eastern Colorado, water is being pumped from the Ogallala, Dakota, and Cheyenne formations to sustain irrigated agriculture; and, generally speaking, the water withdrawal rates exceed the replenishment rates. In the northern high plains, there are approximately 3,200 wells presently pumping about 560,000 acre-feet of water annually from the Ogallala Formation. Eighty-five percent, or 476,000 acre-feet, of water withdrawn by pumping is consumed and amounts to depletion of the aquifer. The estimated recharge to this aquifer is 405,000 acre-feet per year and has not changed as a result of pumping development. Prior to development, this recharge maintained equilibrium of the water storage and generally does not replace depletion by well pumping. The Colorado Ground Water Commission, which administers the use of water in designated ground-water basins, is limiting the maximum allowable appropriation of water in the northern high plains so that there will be a possible maximum aquifer depletion of forty percent in twenty-five years. In connection with this limitation, there is a minimum well spacing of one-half mile between wells.

There are approximately 930 wells presently withdrawing an estimated 100,000 acre-feet of water annually from the aquifers of the southern high plains. About 85,000 acre-feet of this water are consumed annually and represent a net depletion of the aquifer. The total recharge to the three aquifers is estimated to be 95,000 acre-feet per year, the point of equilibrium of storage prior to large-scale withdrawal. None of this recharge is considered to be available for replacement of water withdrawn by well pumping. At the present time, because of a serious lack of data on the geology and hydrology of the southern high plains, the only administrative policy which the Colorado Ground Water Commission exercises in this area is one-half-mile spacing between wells.

There are four smaller designated ground-water basins wherein the withdrawal of underground water exceeds the recharge in about the same proportion as the two major basins.

In summary, underground water is being "mined" as a finite resource in designated ground-water basins to the extent that at some point in time the economic base for a large geographic area of the state will be eliminated.⁴⁷

⁴⁷ *Ibid.*

Municipal-industrial uses withdraw considerable water but completely consume only a small fraction. Manufacturing generally consumes less than five percent of water used, while thermal power plants consume about 0.5 percent of water used; however, these two uses account for about fifty-five percent of all water diversions. Municipalities divert a small amount of the water, about 4.5 percent, and account for about the same proportion of consumptive use. Lawn irrigation and air conditioning are responsible for most of the municipal consumptive use.⁴⁸

Colorado's water-consumption pattern closely parallels the rest of the West. Currently, irrigated agriculture accounts for 93.9 percent of consumptive use. Municipalities are responsible for three percent of total consumption; industry another 2.8 percent; while other uses account for 0.3 percent.⁴⁹

Denver is probably typical of western cities as far as water use is concerned. Per capita consumption is higher than the national average, being 204 gallons per day per person compared to municipal averages of 125 to 165 gallons per day per person. In 1970, the Denver Water Board delivered 59.5 billion gallons of water (182,700 acre-feet) to 800,000 people.⁵⁰ Of the water delivered, about thirty-five percent was actually consumed. Consumptive water use by Denver is 46.6 percent of all municipal water consumption in the state, or 1.4 percent of the state's consumptive use.⁵¹ At the end of 1970, Denver had 499,039 acre-feet of water in storage, in six reservoirs with a combined storage capacity of 500,000 acre-feet, sixty percent of this on the west slope. Future plans call for expanding Denver's water supply to 600,000 acre-feet by 2008. With water reuse schemes, the usable supply is expected to be 800,000 acre-feet, enough to supply 3.5 million people.⁵²

⁴⁸ Landsberg, et al, *op. cit.* (ref. 35), pp. 262-266.

⁴⁹ *The Denver Post*, Bonus Section, December 14, 1971, p. 8.

⁵⁰ Testimony by James Ogilvie, Manager, Denver Water Board, before the Committee on Water and Related Problems of the Colorado Environmental Commission, January 1971.

⁵¹ *The Denver Post*, *loc. cit.* (ref. 49); also, Testimony of James Ogilvie, *op. cit.* (ref. 50).

⁵² Testimony of James Ogilvie, *loc. cit.* (ref. 50).

WATER AND COLORADO'S FUTURE

How is Colorado's future to be affected by the water-resource picture? The supply is limited, and fifty percent of the surface water goes downstream in two months, May and June. Storage is necessary if we are to utilize the water to which Colorado is entitled. However, water development on a major scale is approaching an end.

Two major projects planned for the future are in the South Platte Basin; these are the Lower South Platte Water Conservation Project (Narrows Dam) and possibly the Two Forks Project. Both projects are aimed at conserving water lost to us through flooding and winter flow. Five projects planned in the Colorado River Basin will approach Colorado's allowable depletion in periods of low water supply.

We are out of surface-water supply in the Rio Grande Basin, and as a result of suits brought against Colorado by the State of Texas and the State of New Mexico, we are under obligation to assure these states at least the scheduled compact delivery each year; Texas and New Mexico allege that we are in arrears by 800,000 acre-feet in meeting past commitments.⁵³

There is an overall water shortage in the Arkansas Basin. The future of water development there hinges more on efficient management of water.

As water use becomes more intense, being reused more as it moves downstream, we face the problem of salt. Repeated use increases salt content, progressively reducing water quality; too much salt renders water useless for agriculture. Salt content in the Arkansas River now reaches 3,000 parts per million as it leaves the state. California expresses concern for the increasing salt content in the Colorado River, saying salt content could be up to 1,200 parts per million by 2020.

Too much salt could halt water development in the state. The Environmental Protection Agency is studying the adoption of water-quality standards which put a ceiling on salt

⁵³ Testimony by Sparks, *loc. cit.* (ref. 41); also, Data by Kuiper, *loc. cit.* (ref. 41).

content. The situation is most critical in the Colorado River Basin, and water diversion from the west slope to the east slope intensifies the problem as this removes high-quality water, increasing the percentage of salt content of the remaining water.⁵⁴

What are the possibilities of augmenting our water supply both to provide more water and to maintain stream standards? Tests with cloud seeding indicate we might increase precipitation in selected locales by possibly fifteen to twenty percent. As for desalinization, Colorado has no apparent significant supply of salty or brackish water to desalt, and economics preclude importing desalted sea water.

Colorado's original water supply, then, is what it was one hundred years ago. Weather modification may have some impact, and our supply is not likely to be increased by water importation for at least thirty to fifty years, if ever. We must plan our future within these constraints.

Colorado's assets include the natural beauty of this state. Water is an integral part of that asset. At reservoirs constructed in Colorado by the Bureau of Reclamation, visitation is now over two million man-days per year. More thought now goes into landscaping and development of shorelines.⁵⁵ Water is essential to the streams for support of wildlife and waste dilution, as well as providing recreational assets. These are part of our stream-flow and on-site uses.

If we assume stream-flow and on-site uses are typical of such needs projected for the West,⁵⁶ then possibly nine million acre-feet of our water resources should be reserved annually for these two uses, including flow on the Colorado River claimed downstream. That leaves some 5.5 million acre-feet of surface water annually (after compact commitments), plus possibly 1.5 million acre-feet of ground water, for consumptive uses. Presently, Colorado consumes 7.2 million acre-feet a year: 6.1 million acre-feet of this from stream flow, the rest from underground sources.⁵⁷ Assuming stream-flow and on-site uses as projected for the West and current consumptive use, some uses will have to be curtailed in preference to others. Invariably, municipal-industrial interests have "outbid" agriculture and

other uses, and stream-flow needs are often sacrificed. It, therefore becomes important for the citizens of Colorado to set goals for the type of state they want and to decide what part water-resource management will play in attaining these goals.

COLORADO AND ENERGY

Looking ahead to the next one hundred years, energy use looms as a major factor of environmental concerns, and Colorado will play a major role in the world's energy story. Three things stand out in assessing the future use of energy. These are:

1. Energy consumption is very large today, but if predictions being made hold, then future uses will be enormous.
2. The fuel "mix" will change, and Colorado is likely to become a major energy state.
3. Environmental concerns, especially for air and water pollution, will become an economic factor.

Until the industrial revolution, energy consumption was very small. Wood was the primary fuel consumed, and manpower and animal power did the work. With the coming of the industrial revolution, man first used fuel-consuming machines to do some of the work. With the invention of the internal-combustion engine and electrical power, the modern industrial age arrived. With it, energy consumption on a large scale began.

In the nineteen and one-half centuries up to 1950, it is estimated that the world may have consumed 13×10^{18} Btu* of energy, the equivalent of 540 billion tons of coal or 1,590 billion barrels of oil.⁵⁸ In the last half of this century, the world is expected to consume that same amount of energy again. In fact, if growth in energy demand continues as it has since World War II and as predicted by many studies, the world will consume in any thirty-to forty-year period as much energy as in all previous history. Between 1960 and 2050, world consumption of energy is predicted to

⁵⁸ Chauncey Starr and Craig Smith, "Energy and the World of A.D. 2000," *Engineering for the Benefit of Mankind*, A symposium held at the Third Autumn Meeting of the National Academy of Engineering, pp. 1-24, National Academy of Engineering, Washington, D. C., 1970.

*Btu = British thermal unit, the amount of heat required to increase the temperature of one pound of liquid water by one degree Fahrenheit. Boiling water, at atmospheric pressure, absorbs 970 Btu's per pound vaporized.

⁵⁴ *The Denver Post*, December 15, 1971, p. 78.

⁵⁵ Testimony by Sparks, *loc. cit.* (ref. 41).

⁵⁶ Landsberg, et al, *op. cit.* (ref. 35), p. 271.

⁵⁷ Data by Kuiper, *loc. cit.* (ref. 41).

be about 70×10^{18} Btu, the equivalent of 11,000 billion barrels of oil and about ten times the estimated initial reserves.⁵⁹

The United States today consumes about forty percent of the world's energy. By 2000, the United States is expected to account for thirty percent of world energy consumption. In the century ending in 2050, we could consume 13×10^{18} Btu of energy, if demand for energy continues to grow; that amount of energy equals about twenty-seven percent of all our initial reserves of hydrocarbon fuels (coal, oil, gas, shale oil).⁶⁰

This brings us to the energy source problem. Fuel uses have changed because of economic factors and special needs. Coal was "king" when steam engines were the dominant power source. When the internal-combustion engine was developed, petroleum and natural gas displaced coal from the dominant role. As a result, the nation's coal reserves remain barely tapped while petroleum and natural-gas supplies are well on the way to depletion.

Today, the United States imports about twenty-three percent of its petroleum. By 1985, we may need to import about fifty-seven percent, and our domestic reserves are expected to be on a steady decline.⁶¹ Our oil imports in 1985 are estimated at fifteen million barrels per day. This will require a ship of 100,000-ton capacity to leave port every one and one-tenth hours, and ships of the tanker fleet will never be out of sight of a sister ship on the high seas (assuming the oil will come from the Middle East).

In the future, fuel-use patterns are likely to be determined by the mechanism consuming the fuel, just as they are today. Motive power units--engines that drive surface vehicles, ships, and planes--operate ideally and conveniently on liquid hydrocarbon fuels; today, over ninety-five percent of energy consumed by transportation is in this form.⁶² Permanently located power units such as electrical generating plants can be designed to operate with any type of fuel. Gas is more and more preferred for space heating and many small installations.

There will not be sufficient petroleum and natural gas available to supply the country's future energy needs. Within the next fifty

years, these fuels will cease to be major energy sources, and they may well be conserved as chemical feedstocks. Thus, to produce liquid and gaseous hydrocarbon fuels, we will be compelled to turn to "synthetic crude processes" utilizing coal, oil shale, and tar sands as the primary feedstocks.

COLORADO'S ENERGY RESOURCES

Fossil-fuel energy reserves in the United States constitute about nineteen percent of the estimated ultimate world supply. These fuels (coal, petroleum, natural gas, natural gas-liquids, tar sands, and shale oil) contain an estimated 48×10^{18} Btu of energy. Coal is our largest source, eighty-two percent of the total, and seventeen times as large as our combined oil and gas reserves.⁶³

Colorado has about fifteen percent of the U. S. supply of fossil fuels. The state has about 2.5 percent of the coal reserves and most of the economically recoverable shale oil.

Coal

Colorado has an estimated 81.7 billion tons of coal in place, underlying 29,600 square miles (twenty-eight percent) of the state. About half of this is considered economically recoverable. Coal is located in twelve regions in all sections of the state. However, about seventy-three percent is located on the western slope; fifty-eight percent is in two regions of the northwest, the Green River and Uinta regions. Seventy-seven and three-tenths percent of the coal is bituminous, 22.6 percent is sub-bituminous, and less than one percent is anthracite.⁶⁴

There is an increasing trend toward strip-mining of coal, particularly in the West. In thirteen states west of the Mississippi River lie seventy-seven percent of this country's economically strippable reserves of 45 billion tons of coal. Twenty-five and five-tenths billion tons of this strippable western coal is low-sulfur coal; Montana and Wyoming have 21 billion tons alone, and Wyoming's low-sulfur supply is eight times as great as that in West

⁵⁹ *Ibid.*

⁶⁰ *Ibid.*

⁶¹ *Hydrocarbon News*, October 1971, pp. 38-39.

⁶² Starr and Smith, *op. cit.* (ref. 58), p. 7; also, Landsberg, et al, *op. cit.* (ref. 35), pp. 856-857.

⁶³ *Resources and Man*, *op. cit.* (ref. 5), pp. 157-206.

⁶⁴ *Mineral and Water Resources of Colorado*, *op. cit.* (ref. 34), pp. 35-44.

Virginia and Kentucky combined. Western low-sulfur coal is now being shipped as far as Chicago and Michigan.⁶⁵

Colorado has about 1.2 billion tons of strip-pable coal reserves (less than one hundred feet of overburden). About 500 million tons is low-sulfur, and these reserves are mostly on the Colorado Plateau.⁶⁶ Today, the Navajo strip mine of the Utah Construction Mining Company near Farmington, New Mexico, is the largest single coal producer in the United States.⁶⁷

Natural Gas

Natural gas has become an extremely popular fuel, especially for space heating and industrial use. Demand for this fuel has increased at an average annual rate of 6.3 percent recently. In 1968, the United States consumed 21.5 trillion cubic feet, and cumulative demand to 1990 is estimated at 760 trillion cubic feet, assuming supply can meet demand.⁶⁸ Proved reserves to date are about 600 trillion cubic feet; of this, over 314 trillion cubic feet have been produced. The ultimate supply is estimated at 1,290 trillion cubic feet.⁶⁹ It appears, therefore, that the projected demand cannot be met by domestic reserves. Imports can be expected to meet part of the deficit, but eventually synthetic gas produced from other hydrocarbons will have to be substituted.

Colorado presently has about 1.63 trillion cubic feet of economically recoverable natural gas.⁷⁰ This is so small that it would supply current U. S. demands for less than one and one-half months. The future, though, could be quite different, and for two reasons. First, the United States Bureau of Mines estimates that possibly 317 trillion cubic feet of gas may be locked up in low-permeability formations in Colorado, Wyoming, Utah, and New Mexico. Secondly, these same states possess the low-sulfur coal ideal for coal gasification.

The gas locked in the tight formations of the Rocky Mountains presents a possible short-term solution to our gas-supply problem, but it is necessary to stimulate production to economic rates by fracturing the formations. Private industry, in cooperation with the Atomic Energy Commission, under the AEC Plowshare Program established in 1957, is studying the feasibility of using nuclear stimulation. To date, two experimental projects have been carried out: "Gasbuggy" in 1967 in the San Juan Basin of northwestern New Mexico; and "Rulison" in 1969 in western Colorado. The next proposed scheduled project is "Rio Blanco" in the Piceance Basin in western Colorado.

Coal gasification is likely to be the long-range source of gas, and, as noted above, Rocky Mountain coals are ideal for this. Gasification plants at the mine sites are a possibility, with the product being transported by existing gas pipelines. One study indicates that coal gasification is about seventy percent efficient in converting coal (coal-char is a by-product). Six hundred million tons of coal per year (twice the present U. S. production) would be required to produce ten trillion cubic feet of gas (less than half of the present U. S. production). An estimated twelve million acre-feet of water would be needed annually to supply the plants.⁷¹

Oil Shale

Oil shale is Colorado's big hydrocarbon energy reserve, possibly more than six times as large as the state's coal reserves. The richest and thickest oil shales in the world occur in the Green River Formation, which was deposited in Eocene time in three large lakes in Colorado, Wyoming, and Utah. Colorado's Piceance Creek Basin contains most of the oil-rich oil shales. The richest and thickest deposit underlies 1,400 square miles between the Colorado and White rivers.

In some places, shale beds are nearly 2,000 feet thick. Oil content varies. In the vicinity of Rifle, the Mahogany ledge is seventy to one hundred feet thick and contains an average of twenty-five to thirty gallons of oil per ton of shale. The richest five-foot sequence of oil shale in the Mahogany ledge contains an average of sixty gallons of oil per ton.

There are 440 to 1,200 billion barrels of recoverable oil in Colorado's oil shales,

⁶⁵The Denver Post, August 22, 1971, pp. 1 and 14.
⁶⁶Ibid.; also, Communication from John W. Rold, Director, Colorado Geological Survey, Department of Natural Resources, Denver, Colorado, December 1971.
⁶⁷The Denver Post, op. cit. (ref. 65).
⁶⁸Future Natural Gas Requirements of the United States, vol. 3, September 1969, Published by the Future Requirement Agency, Denver Research Institute, University of Denver, Denver, Colorado.
⁶⁹Resources and Man, op. cit. (ref. 5), pp. 187-190.
⁷⁰Rold, op. cit. (ref. 66).

⁷¹The Denver Post, October 12, 1971, p. 44.

depending upon what figure is used to define the lower economic limit of oil content. If all shales are included which are fifteen feet or more in thickness and which yield an average of thirty gallons of oil per ton of shale, then there is about 440 billion barrels of economically recoverable oil underlying 1,300 square miles. By including all shales fifteen feet or more in thickness and yielding an average of fifteen or more gallons of oil per ton, then the recoverable reserves increase to 1,200 billion barrels.⁷²

How and when the oil shales will be exploited depends on many things: on developing technology, on the world petroleum supply and market picture, and on government policy. When an oil shale industry does get underway, it is very likely to be based on a mining-retorting technology. If so, then two big environmental problems confront the state. First, how are the enormous quantities of spent shale to be handled? Secondly, how are mined areas to be rehabilitated, especially strip-mined regions?

Colorado's shale-oil reserves at least equal the present estimated world's petroleum supply. They contain possibly as much as fifteen percent of all the hydrocarbons in the United States, possibly more than three times as great as our petroleum and gas reserves combined. Such a resource is hard to ignore. As petroleum reserves become depleted, oil shale is likely to become a major source of liquid hydrocarbons in the nation's energy supply.

Petroleum and Natural Gas Liquids

Compared to the reserves of oil shale and coal, petroleum and natural gas liquids in the state represent a very minor energy supply. Recoverable oil reserves are estimated at 441 million barrels; natural gas liquids add another 18.8 million barrels. Since the United States now consumes nearly fifteen million barrels of oil per day, this is just about a month's supply for the nation.⁷³

Nuclear Energy

Electrical power demand is predicted to grow from six to eight times the present level by the end of this century. Of necessity,

⁷² *Mineral and Water Resources of Colorado, op. cit. (ref. 34), pp. 67-73.*

⁷³ *Hydrocarbon News, loc. cit. (ref. 61); also, Communication from John W. Rold, loc. cit. (ref. 66); also, Mineral and Water Resources of Colorado, op. cit. (ref. 34), pp. 45-66.*

nuclear energy will have to become the dominant energy process for producing electricity within the next fifty years if these use levels are to be sustained.⁷⁴ In fact, development of the breeder reactor and its use as soon as possible is mandatory. Without the breeder reactor, the United States' uranium supply could be depleted within the next twenty to thirty years.⁷⁵ With the breeder reactor, there is some justification for thinking in terms of an unlimited energy supply.

As nuclear plants are phased into the energy pool, fossil-fuel plants will continue to play a dominant role in electrical power generation for probably the next fifty years. After that, they may be phased out completely. Again, as the nuclear industry grows, the Rocky Mountain West becomes a focal point of the energy industry because of the uranium reserves located here. It is estimated that over ninety-five percent of the United States' uranium supply is in New Mexico, Wyoming, Colorado, and Utah.

Colorado's reserves (as U₃O₈) are estimated at 10,000 tons. About ninety percent of the reserves are in the Morrison Formation in Mesa, Montrose, and San Miguel counties.⁷⁶ In comparison, New Mexico has 75,000 tons, Wyoming 55,000 tons, and Utah 5,000 tons.⁷⁷ These are reserves that can be produced at economically realistic costs.

The United States has been the principal consumer of uranium in the past twenty years. Between 1947 and 1962, 108,000 tons of U₃O₈ had been produced from about forty million tons of ore mined in the United States, about twenty percent of this from Colorado.⁷⁸ One can quickly see that such production rates could not be sustained for long in light of reserves mentioned above. Without the breeder reactor, our nuclear fuels will soon be depleted. If the breeder reactor becomes a reality, then lower-grade uranium and thorium ores scattered over the United States would become economically mineable, and the energy reserves increased by orders of magnitude.⁷⁹

⁷⁴ *Resources and Man, op. cit. (ref. 5), pp. 218-228.*

⁷⁵ *Ibid.*

⁷⁶ *Mineral and Water Resources of Colorado, op. cit. (ref. 34), pp. 136-144.*

⁷⁷ *Encyclopaedia Britannica, vol. 22, p. 779, 1968.*

⁷⁸ *Mineral and Water Resources of Colorado, op. cit. (ref. 34), pp. 136-144.*

⁷⁹ *Resources and Man, op. cit. (ref. 5), pp. 218-228.*

Again, it must be emphasized that the development of the breeder reactor is absolutely essential if energy consumption of a high level is to be met in the future.

OTHER ENERGY SOURCES

Magnetohydrodynamics, nuclear fusion, and solar energy are often discussed as possible energy sources of the future. Magnetohydrodynamics is theoretically more efficient than conventional thermal power plants. Maximum efficiency of conventional power plants to date is forty-two percent, with most nuclear plants until now being less efficient than coal-fired plants. The limiting factors are metallurgy and high temperatures and pressures.

Magnetohydrodynamics requires that the fuel be burned at temperatures of 4,000 degrees Fahrenheit or more. This process, thus, is capable theoretically of efficiencies of forty-five to sixty percent.⁸⁰ It would not only conserve fuel resources, but could help minimize pollution. One problem with magnetohydrodynamics is how to handle the large volume of nitrogen oxides likely to be produced by this process. In the long term, coal is likely to be the fuel, since by the time this process becomes an economic factor, gas and oil will be largely depleted. In the long term, however, magnetohydrodynamics is not the answer to the energy problem since fuels on which it depends will eventually be depleted. Only some type of nuclear energy is capable of meeting the enormous energy demands of the future.

Controlled thermonuclear fusion, the harnessing of the reaction of the hydrogen bomb and the sun, offers enormous potential, as its source of fuel is essentially water. Controlled thermonuclear research has been carried out in several countries for the last two decades. Up until two years ago, fusion researchers were not at all confident that fusion power would be possible, but recent advances have encouraged optimism.⁸¹ The obstacles are tremendous. Three criteria must be met simultaneously. First, an ignition temperature must be achieved. Temperatures

of at least forty million degrees Kelvin are required for the deuterium-tritium reaction. For other reactions, temperatures in excess of 100 million degrees Kelvin are required. Secondly, the plasma within which the reaction takes place must be confined long enough to release a significant net output of energy. For a controlled fusion reaction to be technically feasible, the product of plasma density and confinement time for the plasma must be higher than a certain limit. Finally, energy must be recovered in a useful form. Some of these critical factors have been achieved in the laboratory machines to date, but no machine has met all requirements simultaneously.⁸²

When technical feasibility of the fusion reaction is demonstrated, this technology will be at about the same stage as was fission when it was first accomplished at the University of Chicago. Following this, engineering studies must be made.

Realistically, we have to accept the possibility that fusion energy may never be realized. Even if technical feasibility is demonstrated, it will not guarantee the ultimate development of a large-scale power plant utilizing the process. Finally, even with success, the lead time required for engineering and development places fusion power some thirty to fifty years into the future.⁸³

The energy of the sun is limitless, and the idea of harnessing solar energy directly is appealing. Presently, it would appear that utilization of solar energy by collecting devices and conversion to electricity offers very limited possibilities because of the required size of collectors, the low efficiency of conversion, and the large capital costs. Very likely this process will be limited, at least in the foreseeable future, to very specific applications where cost is not a factor.⁸⁴

In sum, none of the exotic processes discussed here are likely to be a major source of energy in the next fifty years. Therefore, the nuclear fission reactor, and most particularly the breeder reactor, will have to be depended upon as the major energy source during that time, and possibly for the long-range future of mankind.

⁸⁰ Harry Perry, "The Energy Crisis," *Britannica Yearbook of Science and the Future*, p. 138, 1972, Encyclopaedia Britannica, Inc.; also, Claude M. Summers, "The Conversion of Energy," *Scientific American*, vol. 224, no. 3, p. 157, September 1971.

⁸¹ Michael Seif, "Fusion Power: Progress and Problems," *Science*, vol. 173, pp. 802-803, August 27, 1971; also, R. F. Post, "Fusion Power," *Proceedings of National Academy of Sciences, USA*, vol. 68, no. 8, pp. 1931-1937, August 1971.

⁸² William C. Gough and Bernard J. Eastlund, "The Prospect of Fusion Power," *Scientific American*, vol. 224, no. 2, pp. 50-64, February 1971; also, David J. Rose, "Controlled Nuclear Fusion: Status and Outlook," *Science*, vol. 172, pp. 797-808, May 21, 1971.

⁸³ Rose, *Ibid.*; also, *The Denver Post*, November 11, 1971, p. 23.

⁸⁴ *Resources and Man*, *op. cit.* (ref. 5), pp. 206-207; also, Summers, *op. cit.* (ref. 80), pp. 158-159.

RADIOACTIVE WASTE DISPOSAL

With accelerated use of nuclear energy becoming imminent in the next few decades, we will acquire a power system often billed as clean. It produces none of the usual pollutants such as sulfur and nitrogen oxides. Fission-based plants do, however, present two potential hazards. They are:

1. Possible emission of radioactive particles;
2. Production of radioactive fission products.

The safe management and disposal of radioactive wastes will become an essential requirement of the nuclear-power industry, and the quantity will increase approximately proportionately to the power being generated by nuclear plants. Other sources of radioactive wastes will be insignificant by comparison.

Radioactive wastes are composed of radioactive isotopes, each having a characteristic radioactive decay rate. There is no method of treating these materials to counteract their innate biological harmfulness. Radioactive wastes must be totally isolated until radioactivity decays to a level safe for biological exposure.

The Health Physics Division of the Atomic Energy Commission has used twenty half-lives as the minimum period a given type of high-level radioactive waste should be permitted to decay. This would require that long-lived isotopes such as strontium-90 and cesium-137 be isolated for six hundred to one thousand years to render them biologically harmless.⁸⁵

Three principles must guide the disposal of radioactive wastes; namely:

1. All radioactive materials are biologically injurious and must be isolated from the biological environment during their period of harmfulness, possibly up to a thousand years.
2. No waste-disposal system should be initiated unless it will be safe for the much larger quantities of radioactive waste to be generated in the future. Nuclear power plants produce radioactive waste roughly equal in mass to the quantity of fuel consumed.
3. No compromise of safety in the interest of economy should be tolerated.

THE FUTURE IMPACT OF ENERGY ON COLORADO

Moving into the future, as Colorado becomes a key energy state, it is important to begin thinking about the management of the related activities. How are mining operations to be directed relevant to shale-oil development and coal mining? How will strip-mine areas be rehabilitated? Is there adequate water? What pattern should community development take? What are the transportation needs? These are just some of the problems confronting us. It may be necessary to prohibit or restrict mining-production operations in some areas to preserve natural features or protect the environment.

Much of the future energy-related activities in Colorado will be located on the Western Plateau where water is scarce. Geographical-meteorological conditions also make some communities susceptible to air pollution. This means that the environmental impact of these operations should be carefully examined and the true costs properly included in the economic assessments. How we tackle these problems will determine whether we preserve our natural assets or destroy them and turn Colorado into another "Appalachia."

CONSUMPTION OF MINERAL RESOURCES

A characteristic feature of a modern technological society is the transformation of the world's mineral resources to produce goods and services for the people. The United States has been singularly successful in this respect in that this country's citizens enjoy a material affluence unprecedented in history. Our standard of living in the future will depend on continued access to the mineral resources of the world and readily available energy supplies. Let us now examine the use pattern in the United States for some of these critical resources.

There are some 1,800 to 2,000 minerals, but only about one hundred are of economic importance. They are limited in supply, in some cases scarce, and they are not equitably distributed around the world.

At the present time, the United States, with six percent of the world's population, consumes thirty to fifty percent of most of the world's mineral resources and about forty percent of the energy. Of the one hundred minerals most important to industry, the United States has adequate supplies of about a dozen; we depend on imports for most of them. Our uses of iron, lead, and copper are typical.

⁸⁵ *Resources and Man*, op. cit. (ref. 5), pp. 233-237.

In 1967, consumption of iron in the United States was about one ton per person per year. The comparable figure for the rest of the world was .12 tons per person per year. Americans consumed thirty-five percent of all the iron used. Assuming the world population goes to six billion people by the year 2000 and that the rest of the world could be raised to the present affluence level of the United States, iron consumption would have to be increased twelve-fold in the next thirty years. The same picture applies to the consumption of copper. The United States now consumes thirty-eight percent of the world's copper, 8.4 times as much per capita as the rest of the world. The United States consumes forty-eight percent of the lead in the world, 14.5 times as much as the rest of the world on a per capita basis.⁸⁶

Without imports, this nation's position would be critical. In a sense, the United States is a mineral-poor nation. We import forty percent of our iron ore, forty-five percent of our tungsten, fifty-five percent of our lead, seventy-five percent of our mercury, ninety percent of our nickel, ninety-five percent of our manganese, and essentially one hundred percent of our columbium, tin, tantalum, and beryllium.⁸⁷ Many of these minerals come from underdeveloped countries. What is true for the United States is true for every advanced industrialized nation today. Without access to mineral resources through the channels of world trade, the stability of these countries would be immediately jeopardized.

At the present, iron and aluminum are in abundant supply worldwide, although the United States imports eighty-five percent of the bauxite from which aluminum is made. Scarce minerals are mercury, tin, and silver. The rest are abundant enough to meet current demands and allow for moderate expansion in use, but the supply is unlikely to keep abreast of the rapid increase in world population. Substitutes can be found for some of the minerals. However, others have such unique properties that substitutes appear unlikely; for example, aluminum and copper for electrical transmission, beryllium for certain copper alloys, cobalt for the manufacture of permanent magnets, mercury in temperature- and

pressure-control equipment, steel for large low-cost structures of high strength, and the precious metals with their unique properties.

The doctrine of affluence is based upon the assumption that this earth's mineral supplies are adequate for universal affluence. Are they adequate? Will the underdeveloped nations continue to tolerate the exportation of their valuable mineral resources to the advanced nations, thus depriving themselves of a critical natural resource? As with the energy picture, minerals consumption is increasing at such a high rate that if the trend continues, consumption in any thirty- to fifty-year period will equal or exceed previous historical consumption. How long can this continue? It would appear that in the long run it will be impossible to support a constantly expanding world economy, keeping step with a growing population, simply because the mineral resources are not available in unlimited supply. It must be remembered that the United States is not self-sufficient in mineral resources. The United States cannot isolate itself from the international community, and this nation must take a responsible position in achieving a balance between demand and supply of the world's critical resources.

COLORADO'S MINERAL INDUSTRY

Colorado has rich and varied mineral resources. In order of value in 1970, the principal mineral products (metals) were molybdenum, vanadium, uranium, zinc, tungsten, lead, silver, copper, and gold. In the United States, Colorado ranks first in the production of molybdenum and vanadium, second in gold, and third in silver and tungsten.

The largest molybdenum mine in the world is at Climax, Colorado. In fact, since 1924, the entire production of molybdenum in Colorado has come from this mine. Although molybdenum is comparatively rare in the world, the United States has large deposits. Since 1925, between sixty-five and ninety percent of the world's molybdenum has been produced in the United States; fifty-seven percent of the world's total production to date has come from Colorado.⁸⁸

Molybdenum is of prime importance in the ferrous metals industry. It imparts properties

⁸⁶ Charles F. Park, Jr., *Affluence in Jeopardy, Minerals and the Political Economy*, pp. 11-18, Freeman, Cooper, and Co., San Francisco, 1968.

⁸⁷ *Ibid.*, Chapters 4-8; also, *Resources and Man*, *op. cit.* (ref. 5), Chapters 6-7.

⁸⁸ *Mineral and Water Resources of Colorado*, *op. cit.* (ref. 34), pp. 102-108; also, Communication from John W. Rold, *op. cit.* (ref. 66).

of hardness, toughness, and resistance to wear and corrosion when alloyed with iron and steel. About eighty percent of the molybdenum consumed in the United States is used in high-temperature alloy steels, stainless steels, and castings.

Colorado's mineral resources can play a vital role in the economic future of this nation. Not only do they provide the nation valuable and essential materials, but they provide export commodities required in world trade to assure adequate supplies of critical materials which are in short supply in the United States.

And yet, resources are finite. This is emphasized once more by the reserve picture of molybdenum. Colorado is estimated to have one billion tons of molybdenum ore containing 4.25 billion pounds of metal.⁸⁹ This will sustain the present rate of production (ten to twelve million tons of ore per year) for just eighty to eighty-five years. If demand continues to increase, it could last less than fifty years.

LAND USE PATTERNS AND PROBLEMS

Today's land-use patterns are not the result of a systematic, planned allocation to uses for which the land is best adapted. Land is cultivated that should be grazed. Cities take over good farm land, and some poor soils are farmed that should never be. Land, like water and mineral resources, is a key resource in

producing food and fibre. In a real sense, agriculture and forestry mine the land. In building cities and highways, land is permanently removed from production.

The continental United States (excluding Alaska and Hawaii) contains 1,904 million acres of land, including internal waterways less than one-eighth of a mile wide and lakes and reservoirs of less than forty acres in extent. Colorado's land area is 66,718,000 acres, 3.5 percent of the United States total.

CHANGES IN LAND USE

Land use in the United States has changed the first half of the twentieth century, as shown in Table 1.⁹⁰

By far the biggest uses of land, accounting for nearly ninety percent of all land use in 1950, are for agriculture, commercial forestry, and grazing. Transportation systems and cities do not occupy much of the total land surface (2.2 percent in 1950). The United States today has about 470 million acres of crop land, with some of this in permanent pasture. Land used for recreation is becoming more important, this use tripling between 1930 and 1950.

In 1920, twenty-five percent of the crop land, about one hundred million acres, was needed to produce feed for mules and horses. In 1960, on the other hand, less than two percent of the land was required for this purpose.

Table 1
CHANGES IN LAND USE IN THE UNITED STATES, 1900-1950

Uses of Land	Land Area, millions of acres		
	1900	1930	1950
Cities (2500 or more population)	6	12	17
Public recreation areas	5	15	46
Agriculture	449	531	523
Crops	(319)	(413)	(409)
Pastured Cropland	(77)	(73)	(69)
Non-producing (farmsteads, etc.)	(53)	(45)	(45)
Commercial forestry	525	495	484
Grazing	808	735	700
Transportation	17	24	25
Reservoirs and Water Management	*	3	10
Primarily for Wildlife	*	1	14
Other uses (deserts, swamps, mountain tops, etc.)	94	88	85
TOTAL	1904	1904	1904

⁸⁹ Rold, *Ibid.*

⁹⁰ Landsberg, et al, *op. cit.* (ref. 35), pp. 332-335.

Thus, by becoming mechanized, agriculture added about ninety-two million acres of productive crop land to the United States' economy without increasing acreage. If the population of the United States increases at rates of one or two percent per year, it could necessitate the utilization of all crop land for production of food by the end of the century.⁹¹

Land-use changes in Colorado parallel the national picture. Changes for the years 1958 to 1967 are summarized in Table 2.⁹²

Note again that urban land has increased while crop land has decreased. An example of rapid and almost complete conversion to non-farm use is Pitkin County; there are no longer any operating farms or ranches in Pitkin County.⁹³

Comparing urbanization of land with population increase and using the Greeley area as an example, one acre of land is urbanized for every four people added.

Approximately 800,000 acres of land in Colorado is committed to public roads in the state. Each mile of interstate highway requires approximately forty acres of land.

LAND EROSION

Land erosion in Colorado affected 8,412,000 acres in 1967. The most serious damage has taken place in the Colorado River drainage, where 6,573,700 acres suffer. The next most serious problem is in the Arkansas-White-Red River drainage, where 1,124,700 acres are affected. Erosion leads to silting of streams. In the state this is most serious in the Arkan-

sas drainage, where silting is even affecting irrigation systems.⁹⁴

WATERSHED DAMAGE

Various activities present actual or potential threats to the viability of watersheds in the state. These include:

1. Oil-shale development activities in Rio Blanco County, affecting the White River drainage.
2. Strip-mining activities in Routt and Moffat Counties, affecting the Williams Fork River and Yampa River drainages.
3. Ski-development activities in Pitkin County, affecting the Snowmass Creek, the Roaring Fork River, and the Brush Creek drainages.
4. Interstate highway construction from Gypsum to west of Vail in Eagle County, affecting the Eagle River drainage.
5. Recreation development (Denver water supply) in Summit County, affecting the Blue River and Snake River drainages.

Improperly managed activities such as these can cause rapid runoff of water, soil erosion, stream silting, and damage to the vegetative ecology of the watershed.⁹⁵

LAND USE PROBLEMS IN THE MOUNTAINS

Many areas in the mountains are easily damaged by human activity. Land erosion and water pollution can be serious side effects, and alpine tundra is very easily destroyed by careless people. Strip mining in the state is already a threat to watersheds and other environmental features. Oil-shale development presents a great potential for pollution of the

Table 2
LAND USE CHANGES FOR COLORADO, 1958-1967

Use	Acres		
	1958	1967	Change
Urban and Buildup	972,375	1,031,170	+58,795
Cropland	12,616,994	11,786,036	-830,958
Pasture and Range	21,547,979	22,644,570	+1,096,591
Forest	7,787,958	6,963,501	-824,457
Other (roads, ditches, mineral land)	514,158	1,012,319	+498,161

⁹¹ *Ibid.*, pp. 348-349.

⁹² Communication from M. D. Burdick, State Conservationist, United States Department of Agriculture, Soil Conservation Service, Denver, Colorado, December 17, 1971.

⁹³ *Ibid.*

⁹⁴ *Ibid.*

⁹⁵ *Ibid.*

Colorado River drainage. Road construction, especially roads built for access to private and commercial developments, presents a high erosion potential. The rapid development of many ski areas and recreational projects is already presenting serious erosion and sediment problems. Finally, an increasing problem is the uncontrolled use of recreational vehicles (four-wheel drive and motorcycles). The problem is most serious in the alpine areas away from designated trails and roads.⁹⁶

SPECIAL GEOLOGICAL PROBLEMS

The geology of a region presents an environmental problem if the geological characteristics are unknown or ignored, or if inadequate engineering solutions are undertaken to counteract the potential problem.

Almost anywhere in the state where cretaceous shales such as the Pierre, Mancos, the Denver formation, Morrison formation, or Wasatch occur at the surface, serious problems can be expected from swelling bentonitic clays.

Nearly all areas in the state, which combine moderate to steep relief, soft or weak bedrock strata, and high moisture content, present the possibility of landslides and mud flows. Any construction work, changes in drainages, or increases in the water content can activate such potential landslides or mud flows. These slides, in turn, can affect building subdivisions, highways, and tunnels. It is, therefore, important to define these hazard areas before encroaching into a region with construction and human habitation.⁹⁷

FLOOD PLAIN ENCROACHMENT

Encroachment of human activity on natural flood plains presents an environmental impact. Such environmental impact can be of two types: first, encroachment can alter the environment and ecology of the flood plain; and secondly, such encroachment usually generates pressure for flood-control measures which further alter the stream environment.

The Task Force Report on Federal Flood Control Policy to the President of the United States in 1966⁹⁸ states that:

⁹⁶ *Ibid.*

⁹⁷ Communication from John W. Rold, Director, Colorado Geological Survey, Department of Natural Resources, State of Colorado, December 30, 1971.

⁹⁸ Superintendent of Documents, Washington, D. C.

1. The cost of flood damage exceeds \$1 billion per year in the United States and is increasing in spite of an annual federal investment of \$500 million.
2. The increase in flood damage is due to the increased occupancy and investment in unprotected flood plains.
3. People settle in flood plains usually because of:
 - a. Ignorance of the hazards;
 - b. Anticipation of federal protection;
 - c. Profit to be made, even though settling there makes heavy burdens on society.

When flood-control measures are taken by constructing flood-control dams, one can sometimes question whether the trade-off is worth it. For example, Cherry Creek Dam creates a 4.1 square-mile flood pool in order to protect 8.1 acres on the flood plain below the dam. The Chatfield Dam on the South Platte, now under construction, will create a 7.5 square-mile flood pool to protect four square miles of flood plain.⁹⁹

Flood-control structures present us with both benefits and penalties. Among the benefits are recreation facilities, multiple use of land around the flood pool, and protection of the flood plain below the dam. Penalties paid for flood control include displacement of people and businesses where the flood pool is created, and the flooding of natural resources; it usually costs the taxpayers money; and, finally, all reservoirs eventually fill with sediment. Therefore, in reality, the solution is temporary.

One side effect of creating water reservoirs by damming streams is to increase the exposure for evaporation. In the arid West, as much as six feet of water can evaporate each year from the surface. Evaporative water losses from reservoirs in the United States now exceed the amount used for public supplies in the entire country.¹⁰⁰ Therefore, evaporative (and seepage) losses must be considered when projects for flood control, irrigation, or water-supply development are planned.

⁹⁹ Communication from Perry Eberhart, Former Director of the South Platte Area Redevelopment Council, to the Colorado Environmental Commission, Denver, Colorado, September 23, 1971.

¹⁰⁰ Charles B. Hunt, *Physiography of the United States*, pp. 126, 303, W. H. Freeman and Company, San Francisco, 1967.

FINAL THOUGHTS ON LAND USE

Land, forest, water, and mineral resources of the Rocky Mountain States have been major factors in the national economy. There has been pressure to utilize these resources for developing local industry. Because of the shortage of water, the topographical features, and in some cases meteorological conditions, it has been suggested that these resources should be utilized in a different way: that the mountains should be industrialized as little as possible; that development should be limited to production of raw materials; and that the land should be reserved for recreational uses, wildlife preservation, and watershed protection.¹⁰¹ Many Colorado valleys preclude any concentration of industry, especially heavy industry, as prevailing winds are not able to sweep the air pollutants from them.

THE EFFLUENT PROBLEM

Per capita consumption of resources and energy is closely related to the standard of living realized by a people, but a by-product is "waste" production which is again directly related to the number of people and the per capita consumption pattern. When the wastes, or effluents, so generated overtax the ability of the environment to act as garbage collector, we have pollution problems which can threaten all forms of life.

For the long run, the choices are clear: either we control our population and learn to collect and process our wastes to protect the environment, or we will have to reduce our consumption level, and with it our standard of living.

The major effluents can be conveniently classified as (1) air pollution, (2) water pollution, (3) solid waste, (4) waste heat, and (5) noise. Let us now examine these waste problems in some detail so as to estimate the magnitude of the problem and future trends.

AIR POLLUTION

Air pollutants of major concern are carbon monoxide, sulfur dioxide, hydrocarbons, nitrogen oxides, and particulates. Some 600,000 tons per day of this material are dumped into our air. The National Air Pollution Control Administration has classed three hundred cities as suffering from severe air pollution, and every community of over 50,000 people has some air pollution problems.¹⁰²

Practically all air pollution is the result of some form of combustion. The annual production of major air pollutants in the United States and their sources are summarized in Table 3.¹⁰³

Table 3
MAJOR AIR POLLUTANTS IN THE UNITED STATES, 1970

Source of Pollution	Quantity, Millions of Tons Per Year					
	Carbon Mon-oxide	Sulfur Oxides	Nitro-gen Oxides	Hydro-carbons	Partic-ulates	Total
Transportation	63.8	0.8	8.1	16.6	1.2	90.5
Fuel combustion in stationary sources	1.9	24.4	10.0	0.7	8.9	45.9
Industrial processes	9.7	7.3	0.2	4.6	7.5	29.3
Solid waste disposal	7.8	0.1	0.6	1.6	1.1	11.2
Miscellaneous*	<u>16.9</u>	<u>0.6</u>	<u>1.7</u>	<u>8.5</u>	<u>9.6</u>	<u>37.3</u>
Total	100.1	33.2	20.6	32.0	28.3	214.2

*primarily forest fires, agricultural burning, and coal waste fires

¹⁰¹ *Ibid.*, pp. 275-276.

¹⁰² *Our Poisoned Planet*, pp. 93-116, Book by U. S. News and World Report, Washington, D. C., 1970.

¹⁰³ *Ibid.*

Presently, serious air pollution in Colorado is concentrated in the urbanized areas along the Front Range. Denver has the worst air-pollution problem, but Colorado Springs and other cities are not immune.

The incidence and intensity of air pollution over an area depends on (1) wind speed, (2) temperature change with height above ground, and (3) local factors, such as location and intensity of pollution sources, and topographic features. Colorado has two special features to consider. First, many of our valleys are poorly ventilated, making them particularly vulnerable to air pollution. Secondly, at our high altitudes, a well-tuned automobile emits about twice the hydrocarbons and carbon monoxide as one does at sea level.

The production of air pollutants in Colorado is summarized in Table 4.¹⁰⁴

Transportation sources are responsible for sixty-eight percent of the visibility-reducing pollutants (sulfur oxides, nitrogen oxides, hydrocarbons, and particulates) and ninety-nine percent of the carbon-monoxide production. Space heating and power generation account for nineteen percent of the visibility-reducing pollutants; process losses cause another five percent; and all other sources, including solid-waste disposal, generate the remaining eight percent.

The Denver area produces fifty-seven percent of the state's air pollution. Per capita production of air pollutants in the state is .91 tons per year, very nearly equal the national rate of 1.05 tons per person per year (compare Tables 3 and 4, pages 27, 28).

Photochemical-oxidant concentration in downtown Denver averages about three times the odor threshold. At times it has been high

enough to cause nose, throat, and eye irritation; high enough in some cases to be in the range where adverse health effects have been reported; and high enough to cause vegetation damage in the downtown area.

Particulates are serious in the Denver area. At Twenty-first Street and Broadway, particulate concentrations have been measured which are two to two and one-half times higher than the concentration range suspected of causing increased mortality and morbidity for people over fifty years of age. In fact, the whole Denver area is above this danger level and is four times higher than the background level outside Denver.¹⁰⁵

Because of the altitude, because of special meteorological and topographical features, and because of the tendency for stable temperature inversions to develop over many areas, care must be taken in locating industry and transportation corridors in certain parts of the state.

WATER POLLUTION

Water pollution occurs because most of the water used is returned to the water system with added ingredients which alter its quality for subsequent uses. Into our water go sewage in various degrees of untreated, chemicals, detergents, and runoff from farms and feedlots. At one time our streams and lakes had sufficient fresh-water capacity to biologically absorb wastes, but they have become overtaxed. Effluent must be reduced to a level which streams can carry, meaning more treatment at the source. In order to adequately handle effluent and sustain fishlife, water must have a minimum of four milligrams per liter (4 ppm) of dissolved oxygen.

Table 4

AIR POLLUTION PRODUCTION IN COLORADO, 1970

<u>Component</u>	<u>Quantity, tons per year</u>
Carbon monoxide	1,462,240
Sulfur oxides	55,670
Nitrogen oxides	165,210
Hydrocarbons	285,960
Particulates	64,920
Total	2,034,000

¹⁰⁴ Air Pollution Control Commission, Colorado Department of Health, *Report to the Public- 1971*, pp. 14-24.

¹⁰⁵ *Ibid.*

If there is too much organic discharge into a stream, the biochemical oxygen demand (BOD) increases, reducing oxygen content, endangering marine life, and turning the stream into an open sewer. On the other hand, complete degradation of organic waste reduces it to plant nutrients (nitrogen, phosphorous, carbon) which, if discharged into a stream, may foster algae growth. Algae, when alive, produce oxygen; but when they die, the BOD again increases sharply. Any effluent treatment approach must consider these effects before discharging into a stream.

Municipalities and industry today discharge about 123 trillion gallons of liquid/solid wastes into our nation's water daily, over ten percent of our average daily stream flow; industry's share is sixty-nine percent.¹⁰⁶ Water waste from municipalities and industries, prior to any treatment, is expected to increase about three-fold in the United States between 1954 and 2000. By then the waste load on our waters will be about 900 million population equivalents of BOD*.¹⁰⁷

Colorado's major water-pollution problems at present are:

1. Water pollution of the South Platte River Basin;
2. Water pollution associated with septic-tank installations in mountain cabins and mountain subdivisions;
3. Mine-waste effluent entering streams and underground waters.

Problems on the western slope have generally been less of a problem because of a lower density of population and industry, plus the fact that seventy percent of Colorado's waters are located there.¹⁰⁸

The South Platte is the most polluted stream in the state, simply because most of Colorado's population, industry, and feedlots are located in that area of the state. Agriculture is a major contributor of stream pollution, from feedlots, irrigation return flow, fertilizers, chemicals, etc. Nitrate pollution of groundwaters has been found in the South

Platte Basin, with agriculture suspect. The Water Pollution Control Commission has been working closely with feedlot operators. However, to alleviate the problem, withholding basins are sometimes being provided for feedlot runoff.

Many mountain properties have been built on the basis of the owner providing his own waste-disposal system, usually a septic tank system. Due to lack of adequate soil mantle, much property is located on fractured granite. Fractured granite affords a good percolation rate of septic-tank effluent, but it quite often provides direct contact to nearby wells. Many people are, therefore, contaminating their own and their neighbors' wells by installing septic tanks in these mountain areas.

Mine waste has been a long-time problem in Colorado, and mine wastes are quite often highly acidic. In August, 1971, the U. S. Geological Survey began a study of the mine-waste problem in Colorado. This is necessary before the extent of the problem can be defined and adequate control measures specified.

SOLID WASTE

Garbage now makes the headlines--when it is not collected. We, as a nation, produce a veritable mountain of trash, junk, and litter: some 3.5 billion tons a year, ninety-eight pounds per person per day. It costs \$4.5 billion to collect and dispose of it. This waste includes seven million junked cars, 100 million tires, twenty million tons of paper, twenty-eight billion bottles, and forty-eight billion cans. Agricultural waste is 550 million tons per year, animal waste about 1,500 million tons, and mineral waste another 1,100 million tons per year. A year's trash accumulated by 10,000 Americans would cover an acre of ground to a depth of seven feet.¹⁰⁹

A somewhat detailed breakdown of the solid-waste problem (sources, composition, and disposal methods) is presented in Tables 5, 6, and 7 on pages 30 - 31.¹¹⁰ Table 5 does not include mining and agricultural waste, so the figures are somewhat different from those cited above.

¹⁰⁶ *Our Poisoned Planet*, op. cit. (ref. 102), p. 74.

¹⁰⁷ Landsberg, et al, op. cit. (ref. 35), pp. 273-274; also, *Our Poisoned Planet*, op. cit. (ref. 102), pp. 61-64.

¹⁰⁸ Communication from Frank J. Rozich, Technical Secretary, Water Pollution Control Commission, Colorado Department of Health.

*One "population equivalent" is the amount of BOD exerted, on the average, by the domestic organic wastes generated by one individual.

¹⁰⁹ *Our Poisoned Planet*, op. cit. (ref. 102), pp. 127-144.

¹¹⁰ Percy H. McGauhey, "Buried in Affluence," 1972 *Britannica Yearbook of Science and the Future*, pp. 356-359, Encyclopaedia Britannica, Inc.

Table 5
SOLID-WASTE LOAD ON U.S. LAND
NATURE AND AMOUNT OF WASTE

Total Solid Wastes, All Types

(but not including mining and field wastes of agriculture)
30 pounds per capita per day (national average)
1,200,000,000 tons per year

Some Components of the Waste Load

Municipal Refuse:

250 million tons per year
900 million pounds per day
3 to 4.5 pounds per capita per day (national average, 1965)
6 to 8 pounds per capita per day (some localities, 1968)

Paper and Paper Products:

50 million tons per year (1967)

Glass:

14 million tons per year

Metals, Mostly Junked Automobiles:

10 million tons per year

Rubber:

2.2 million tons per year

Packaging Wastes:

29,000,000,000 + glass containers per year (1967)
54,000,000,000 + metal containers per year (1967)
600 million plastic containers per year (1967)
total tonnage per year: 83 million tons (1969)

Industrial Residues:

13-14 pounds per capita per day

Agricultural Residues:

total, including portion left in fields: 2,280,000,000
tons per year

Demolition and Construction Debris:

variable and seasonal; no estimate of total

Cannery Wastes:

varies regionally and seasonally; for example, five canneries
in the San Francisco Bay area produce some 4,000 tons per
week during canning season.

Animal Manures:

national problem of unestimated dimensions; for example,
20 million cubic yards per year produced at margins of
major California cities by dairies, animal feedlots, and
egg- and poultry-producing installations.

Table 6
AVERAGE PERCENTAGE COMPOSITION OF
HOUSEHOLD REFUSE; AND CHANGES OVER A 15-YEAR PERIOD
(BERKELEY, CALIFORNIA)

Type of Material (Values in Percent of Total) *

Year	Metal Cans	Bottles, Broken Glass	Rags	Metals	Shoes	Plas- tics	Decom- posable Organic Matter †	Misc. Wastes (No Value)
1952	10.0	11.4	1.5	0.6	0.2	trace	69.0	7.4
1967	8.4	11.3	1.1	0.3	0.3	1.9	69.7	7.1

* Estimated 2 pounds per person per day, 1952; 3-4 pounds, 1967

† Paper, yard trimmings, grass

Table 7

SUMMARY AND EVALUATION OF DISPOSAL PROCESSES IN THE U.S.A.

<u>Process</u>		<u>Evaluation</u>
Open Dumps	75%	Generally unsatisfactory
Sanitary Landfills	8%	Satisfactory, although land limited
Incineration	12%	75% of 300 incinerators substandard because of incomplete burning and air pollution
Compost	} 5%	Generally satisfactory
Discharge to Sewer		
Salvage		

When it comes to disposing of solid waste, present methods have not improved much over those of the ancients. Our favorite disposal method is dump and bury, the same as that of centuries ago. Archaeologists have discovered old cities built on the debris and waste of their predecessors. Are we repeating history?

Of the mountains of waste generated, only some 194 million tons is collected annually. The rest enters the environment in some uncontrolled way--much of it contributing to air pollution, water pollution, and proliferation of such pests as flies, rats, and insects.

Solid-waste disposal is primarily a management decision, not a technical one, with the method of disposal heavily influenced by cost. Costs range from \$1/ton to \$420/ton for collection and disposal. The \$1/ton figure is representative for direct disposal at sea from barges, while the \$420/ton figure applies to unusually hazardous wastes. Sanitary landfill costs \$4 to \$5 per ton, depending on location.¹¹¹ Incineration costs can vary considerably, depending on size and type of incinerator and cost of utilities. Costs from less than \$10 per ton to as high as \$35 per ton are quoted.¹¹²

Solid wastes contain many valuable components: iron, other metals, glass, etc. Some could be recovered by waste recycling methods; other components have a heating value that could be converted via incineration for power generation. Both economics and environmental considerations are likely to stimulate increased interests in recycling solid

wastes. For example, from the ash of one ton of incinerated municipal refuse, the U. S. Bureau of Mines has recovered from two to nine ounces of silver and from .02 to .05 ounces of gold. These same residues contain as much as thirty percent iron, 1.5 percent nonferrous metals, and forty-four percent glass.¹¹³

Wrecked and abandoned automobiles constitute a major source of discarded steel, copper, and other metals. Presently, it is estimated that there are 200,000 such cars piled up in the State of Colorado, with an additional 22,000 being added each year.

Matter is indestructible. Means must therefore be sought to efficiently transform the mountains of waste for reasons of aesthetics, health, environmental protection, and conservation. It may be advisable to encourage recycling of waste by means of tax penalties or government subsidies.

WASTE HEAT

Calefaction of rivers, lakes, and coastal waters is certain to increase as electrical power generation increases. Calefaction (state of being warmed) is commonly referred to as "thermal pollution." However, heating of water may not be detrimental; it might very well be turned toward positive ends. In any case, heat from power plants can be controlled by cooling towers, retaining basins, or similar approaches--but at a cost.

Thermal power plants now operate at something like thirty-five percent efficiency. Assuming forty-five percent efficiency by 2000 A.D., the waste heat load per kilowatt-hour of electricity generated is 4,170 Btu. For a 1,000 megawatt power plant, heat loss is 100

¹¹¹ Philip A. Witt, Jr., "Disposal of Solid Wastes," *Chemical Engineering*, pp. 62-78, October 4, 1971.

¹¹² *Ibid.*; also, W. C. Achinger and L. E. Daniels, "An Evaluation of Seven Incinerators," *Proceedings of 1970 National Incinerator Conference*, pp. 32-64, The American Society of Mechanical Engineers, New York.

¹¹³ McGauhey, *op. cit.* (ref. 110), pp. 361-362.

billion Btu per day. If a cooling tower is used, twelve million gallons of water would need to be evaporated daily to cool the water for this plant. Makeup water would be greater than this because of losses and blow-down.

By 2000 A.D., electrical power plants in the United States are expected to generate a high of possibly 8,000 billion kilowatt-hours per year; waste heat (forty-five percent efficiency) will be 33.2×10^{15} Btu per year; cooling water evaporation needs will be eleven billion gallons per day.¹¹⁴ If, instead, this heat is dumped into streams, with a fifteen-degree Fahrenheit temperature rise, some 730 billion gallons of such warm water will be released per day. This is equivalent to about sixty percent of the entire daily stream flow in the United States. Very obviously, water recycling and use of cooling towers will be required.

Warmed water can have disruptive effects on aquatic life. Raising water temperature increases the metabolic rate of fish. This, in turn, increases the need for oxygen, but the solubility of oxygen in water decreases with increasing temperature. Therefore, a crisis situation can quickly develop. On a greater scale, the balance of an entire water system may be changed due to changes in metabolism, reproduction, feeding habits, and growth of aquatic species.¹¹⁵

As suggested above, warm water might be used to our benefit. Warm water from power-plant condensers is a low-quality heat source. Suggestions made for its use include warm-water fish farms and space heating. Use of warm water for irrigation has been suggested, with the claim that crop yields increase. Further study of approaches to handling waste heat would undoubtedly yield other ideas.

NOISE

Noise, especially irritating noise, has been a problem for thousands of years. The City of Sybaris, as far back as 720 B.C., created zoning laws isolating noisy industrial parts of town from residential areas.¹¹⁶ Because of excess noise, the Romans banned chariots from some streets at night. Noise in the United States cities is an old problem. The clatter of horses' hooves and iron wheels on

cobblestone pavement created such noise as to render conversation difficult. Boston and New York City early passed laws controlling traffic because of noise.¹¹⁷

In recent decades, largely because of machinery and other technological devices, the noise level has steadily increased. It has doubled in the last fifteen years in the United States, and there is every indication it may double in the next fifteen years. Noise has usually been accepted as a necessary irritant of progress; however, the health-hazard aspects of noise have become more recognized.

Excess noise may contribute to mental, even physical disorders. More importantly, it can cause irreparable loss of hearing. Simply stated, otologists have determined that regular exposure to noise intensities of eighty-five decibels and frequencies above 3,000 hertz * may result in serious hearing loss.¹¹⁸ Permanent noise-induced hearing loss is due to destruction of certain inner-ear structures that cannot be replaced or repaired. More research needs to be done to fully understand the impact of noise on environmental health.

From an environmental-health point of view, we are interested in the sound pressure level impinging on the eardrum. Sound pressure level is measured with a sound-level meter and a frequency analyzer, and results are expressed in decibels (dB) defined by

$$\text{dB} = 20 \log_{10} \frac{P_S}{P_R}$$

where

P_S = sound pressure level, dynes per square centimeter

P_R = reference sound pressure level (usually 0.0002 dynes per square centimeter)

\log_{10} = logarithm to the base 10.

Sound pressure level decreases with distance from the source, therefore is a function of both sound source intensity and distance from the source; acoustics of the environment further modify sound pressure level at a point.

¹¹⁴ Landsberg, et al, *op. cit.* (ref. 35), p. 844.

¹¹⁵ John R. Clark, "Thermal Pollution and Aquatic Life," *Scientific American*, vol. 220, no. 3, pp. 19-26, March, 1969.

¹¹⁶ *Our Poisoned Planet*, *op. cit.* (ref. 102), pp. 145-158.

¹¹⁷ Joel A. Tarr, "Urban Pollution—Many Long Years Ago," *American Heritage*, vol. XXII, no. 6, p. 67, October 1971.

¹¹⁸ *Our Poisoned Planet*, *op. cit.* (ref. 102), pp. 145-158.

*Hertz is a unit of frequency equal to one cycle per second.

The lowest sound pressure level the average person can hear is 0 dB. A 6-dB change in sound level corresponds to a two-fold increase in sound pressure level; a 10-dB increase corresponds to a 3.16-fold increase in sound pressure level. Sound pressure levels associated with some common sources are presented in Table 8.¹¹⁹

The threshold of pain is at 120-125 decibels. Sound levels greater than eighty-five decibels are dangerous, and the U. S. Air Force recommends a maximum noise level below this. Exposure to sound levels of ninety decibels for eight hours can cause hearing loss.

The Colorado Department of Health's Rules and Regulations Pertaining to Occupational Health requires an effective hearing conservation program if sound levels exceed the permissible levels noted in Table 9.

TACKLING THE EFFLUENT PROBLEM

What will be required to meet these problems? Very obviously, it will cost money—some \$71 billion for the country over the next five years, and more after that—just to clean up the air and water and handle solid waste.¹²⁰ Secondly, it will take a large input of technology. But ultimately, the problem relates to the number of people and the per-capita consumption rate of mineral and energy resources. If population is not stabilized within the next few decades, there is serious doubt that these high per-capita consumption rates can be permitted. In the immediate future, the \$71 billion national cost breaks down as \$54 billion to clean up the water, \$13 billion to clean up the air, and \$4.2 billion to dispose of solid waste. In a real sense, these costs are an investment, since pollution costs money. Steel corrodes two hundred to four hundred percent faster in air-polluted urban

Table 8

SOUND PRESSURE LEVELS OF COMMON SOURCES

Sound Source	Sound Pressure Level (dB)
Threshold of hearing	0
Average residence	40
Conversational speech (3 feet)	60
Automobile (20 feet)	75
Inside sedan in city traffic	85
Heavy truck (20 feet)	95
Pushing a power lawnmower	95
Pneumatic hammer (6 feet)	108
Pneumatic chipper	120
Many rock bands (at bandstand)	120
Jet plane at takeoff (80 feet from tail)	135

Table 9

PERMISSIBLE NOISE EXPOSURE

Duration, hours per day	Sound Pressure Level, decibels (A Scale)
8	90
6	92
4	95
3	97
2	100
1-1/2	100
1	105
1/2	110
1/4 or less	115

areas; farm losses caused directly by air pollution are put at \$500 million per year. All in all, air pollution costs the economy of the United States about \$13.5 billion a year.¹²¹ Additional costs will be required to control waste heat and noise.

THE ECOLOGICAL QUESTION

Environmental problems can be defined to encompass a broad spectrum: pollution problems, preservation of natural features, location of highways, physical structure of communities, environmental health, and ecological

¹¹⁹ *Encyclopaedia Britannica*, vol. 16, p. 556, 1968; also, *Our Poisoned Planet*, op. cit. (ref. 102), p. 147.

¹²⁰ *U. S. News and World Report*, August 17, 1970, pp. 38-42.

¹²¹ *Ibid.*

problems being just a few. Of all the concerns, the ecological consequences of environmental degradation are by far the most fundamental in terms of long-range impact.

Biological communities are composed of plants, animals, and micro-organisms. These elements plus their environment constitute the ecosystem, and ecology is concerned with the interrelationships of this complex structure, of which man is a part. The relationships between organisms are critical to two processes upon which the entire biosphere depends; namely, (1) the flow of energy via the food chain and (2) the flow of essential chemical elements. Thus, we speak of the carbon cycle, hydrologic cycle, nitrogen cycle, oxygen cycle, and phosphorous cycle. Any upset in the environment which interferes with the ecological structure is a threat to many, if not all, organisms which are a part of that system. This is the basis of the ecological concern.

Man depends entirely for his existence on energy fixed by other organisms. All terrestrial life depends on the sun for energy, and this energy can enter the biological cycle only through the photosynthetic production of organic matter by chlorophyll-bearing plants. All other creatures must eat plants directly or eat other creatures in the food web. Loren Eisley, in his book, *The Unexpected Universe*, states it well when he says: "The human brain, so frail, so perishable, so full of inexhaustible dreams and hungers, burns by the power of the leaf."

It is becoming more apparent that some of man's actions are posing a threat to ecological systems on which he and other creatures depend. We directly destroy biological communities by such activities as clearing forest land for other uses, building cities and factories, constructing highways, damming rivers, substituting agriculture in place of existing ecosystems, and by directly killing off certain species. Indirectly, man has become a threat by introducing a host of new substances into the environment. Industrial chemicals, air and water pollutants, and particularly pesticides and herbicides are of major concern.

Ecologists generally agree that the more complex the food web in an ecosystem, the more stable it is and the better its chances of compensating for changes imposed upon it. In contrast to natural ecosystems, agriculture is a simplified ecosystem, manmade. It needs careful management to avert disaster. In recent decades, there has been a trend toward single-crop farming because it is more efficient with machine techniques. Insecticides

and herbicides are now used profusely to control insects and weeds. This, in turn, has endangered ecosystems throughout the world, as evidenced by the impact of DDT on many species.

Of particular concern is the impact of some non-biodegradable chemicals on the estuaries, the coastal regions where fresh-water streams meet the sea. This region is the nursery of many marine species, fresh and salt water. Pollutants which enter the streams, in Colorado or any place else, ultimately end up in the sea, posing a threat to the estuarian biosphere. Furthermore, many estuaries and aquatic regimes are being reduced by shoreline developments and dredging operations.

In preventing crop losses, the use of insecticides has been accompanied by many related problems. Many times in destroying a certain pest we have only succeeded in allowing a new pest to intrude, or the target pest has rebounded because its natural enemies were eliminated. Despite increased use of pesticides, the percentage of crop losses in the United States seems to have remained about the same for more than twenty years.¹²² Furthermore, the effect of such chemicals on the soil is not fully understood; soil is really a complex biological community and not an inert medium as sometimes assumed.

We must take more seriously the impact on the environment when natural vegetation is reduced. Deforestation and defoliation remove the transpiration effect on climate. This apparently has contributed to an increase in the amount of desert and wasteland. In 1882, such land comprised 9.4 percent of the earth's land area; in 1952, it had risen to 23.3 percent.¹²³ Transpiration by plants is considerable. To produce one pound of dry organic matter, a plant consumes, on the average, about four hundred pounds of water; *¹²⁴ 396.4 pounds of this is transpired into the atmosphere, absorbing 385,000 Btu of heat as heat of vaporization. This makes plants quite effective air conditioners. Even the elimination of so-called useless plants should not be taken lightly.

¹²² Ehrlich, et al, *op. cit.* (ref. 4), pp. 170-179.

¹²³ *Ibid.*, p. 166.

¹²⁴ Penman, *op. cit.* (ref. 32), pp. 105-108; also, Georg Borgstrom, *The Hungry Planet*, pp. 414-415, Collier Books, New York, 1967.

*Actual water consumed depends on the plant, the temperature, and the humidity. Water consumption can vary for grains from a low of 200 to a high of 2,000 pounds per pound of dry matter produced.

A second effect of eliminating vegetation or altering an ecosystem is to increase erosion. Silt deposited in streams and estuaries can threaten biological species. Some 500 million tons of soil are washed or blown off the land and into bodies of water annually in the United States. Protection of existing vegetation and systematic planting of trees, shrubs, and grass can prevent a large share of this.¹²⁵

In weighing threats to the environment, preservation of the ecological system must be of utmost concern; the very future of all life depends on it. Destroy the biosphere, and we are dead--literally.

Finally, as we contemplate massive alterations of our environment, we would do well to behold the impact of the Aswan Dam on Egypt.¹²⁶ This dam was intended to boost food production by one-third for Egypt's teeming millions, increasing in population at a rate of one million per year. Ironically, by the time the project is completed, the increased food production will be absorbed by the increased population. But what else did this dam do? Tragically, it disrupted the ecological balance of the Nile Valley, an ecosystem that had sustained man for eons. The mineral nutrients were cut off from the mineral-deficient Mediterranean--the result: the destruction of a thriving sardine fishing industry. Today, the Nile no longer deposits silts and nutrients annually on the flood plain; they now accumulate behind the dam, triggering explosive growth of weeds in the reservoir. Meantime, the Nile farmer must turn to chemical fertilizers, at added cost. Most tragic, though, has been the spread of a snail through irrigation canals which carries a parasite called trematode, or blood fluke. It, in turn, infects man, causing an agonizing and incurable disease called schistosomiasis (also called snail fever). Before construction of Aswan, one and one-half million Egyptians had the disease. Currently, some eighteen

million Egyptians, nearly half the population, are estimated to be infected.

Schistosomiasis is becoming a most serious disease in the warmer regions of the world; it is estimated to now infect some two hundred million people. The recent spread of this disease has followed the construction of new dams in tropical and subtropical countries. Some of the worst snail hosts for schistosomiasis thrive only in stagnant water such as the reservoirs and irrigation ditches associated with these dams. Year-around farming, being employed more and more in tropical regions, also creates ideal conditions for spread of the disease.¹²⁷

Colorado is not in the moist tropics, so why focus attention on the Aswan Dam and the blood fluke? It is done simply to emphasize two points. First, some of the most grandiose projects devised to solve a human problem may be spectacular engineering triumphs, but ecological disasters. Secondly, when such projects are undertaken solely to increase food production, they are doomed for failure unless human populations are stabilized. Grandiose water transfer and storage schemes are being proposed for Colorado and the West which dwarf Aswan in scope. As we evaluate these proposals, we would do well to ponder the lessons of Aswan.

TURNING TO THE FUTURE

An attempt has been made in this chapter to summarize the critical environmental problems confronting Colorado with, at times, projections into the future. At another time, and under different circumstances, the problems might be viewed differently. But, because of the urgency of the environmental problems, we must proceed to solutions from our present base of knowledge. The remainder of this report is devoted to a discussion of those solutions.

¹²⁵ U. S. News and World Report, loc. cit. (ref. 120).

¹²⁶ Ehrlich, et al, op. cit. (ref. 4), pp. 298-299; also, *Our Poisoned Planet*, op. cit. (ref. 102), pp. 26-31.

¹²⁷ Clifford O. Berg, "The Fly that Eats the Snail, that Spreads Disease," *Smithsonian*, vol. 2, no. 6, pp. 9-17, September, 1971.

CHAPTER II

COLORADO'S PRESENT COURSE OF ACTION

Chapter I has given an analysis of the facts which give rise to the environmental problems of Colorado. It is important next that we ask what these facts and problems are doing to our state, what changes will be taking place in the state in the future, and what state policies are guiding these changes. Unless our citizens become aware of where we are heading, there will be no understanding of the measures required for changing our present course and the reasons for those measures.

The cool, colorful, clean Colorado most Colorado citizens know is an agricultural, recreational, mining, and service-oriented state, not heavily engaged in manufacturing and not greatly urbanized except for the Denver metropolitan area. This functional outlook for the state has slowly developed, over the last one hundred years, in response to the state's natural attributes and natural resources. This is not the Colorado of the future, however. If present trends are allowed to continue unchanged, Colorado will become a different kind of state in the foreseeable future. The differences will be discernible within the lifetimes of most of the readers of this report; and the transformation will be completed within the lifetimes of almost all of the children of the readers of this report.

While there are many complex forces at work shaping Colorado's future, it is only necessary to look at a few of the major trends to see the pattern of things to come. These relate to population, urbanization, recreation, energy, transportation, and agriculture.

Extremely rapid population increases constitute the major trend in the changing nature of Colorado for the future. At present trends, we will be doubling our population, to approximately four million, by the year 2000; within thirty years thereafter we will be doubling again, to approximately eight million. This means that we will have to accomplish as much in thirty years - in terms of such things as schools, housing, highways, public buildings, factory production, services, etc. - as we have accomplished in the last one hundred years; or that we will have to accomplish three times as much in sixty years as we have accomplished in the last one hundred years. This latter rate of activity is six and two-thirds times as fast as our accomplishment rate of our first hundred years. This rapid growth in population will place strains on our human and natural resources unlike anything we have ever experienced before in Colorado. We are totally unprepared for this kind of an onslaught. Our lack of preparation can only lead to chaotic conditions.

A second major trend in Colorado's future is the urbanization of the Front Range Corridor. Given present trends, some ninety percent of our expected future population will locate along the Front Range. Moreover, some sixty percent of the expected population will locate in the Denver metropolitan area. The result of this disproportionate concentration of location in one part of the state will be a continuous strip-city sprawl running from Fort Collins to Pueblo, with all the ugliness, pollution, congestion, costs, commitment of resources, and detriment to the rest of the state which these conditions imply. Allowance of this trend to continue can only result in a totally unbalanced state.

Recreational development of the state is a third major trend of our future. Colorado is a national playground for out-of-state visitors. We are hosting millions of visitors annually, and the number increases each year. We are increasing our recreational facilities for both summer and winter visitors at rapid and uncontrolled rates. The rate has been so rapid that in some parts of the state - Aspen, as an example - uncontrolled growth threatens to destroy the natural beauty which gave rise to the attraction in the first place. This trend will result in loss of control of the quality of development, overloading of the recreational capacity of the state, degradation of the natural attributes of the state, and probably subsidization of national tourism by Coloradans.

The fourth major trend in Colorado's future will be energy production for the nation. The trend is based on Colorado's abundance of coal and oil-shale resources. This trend is just beginning to be discernible and will accelerate rapidly in the future. Its primary impact will be felt in the despoliation of vast tracts of land, the use of large quantities of water, and the pollution of Colorado's air and waters. Very little is known in Colorado today about the long range implications

of our becoming an energy-production state, or whether this role is consistent with our national recreational role.

Transportation imbalance is the fifth major trend to be noted. Almost exclusive reliance is placed upon highway-based transportation, to the detriment of air, rapid transit, mass transit, and other forms of modern transportation. In this respect, we are following much in the footsteps of California, and the results will be similar for us. This path leads to the servitude of state plans and policies to the forces of highway construction and those forces becoming one of the major influences on the future of the state.

The final trend to be noted is the future decline in the importance of irrigated agriculture in the state. This trend results from the conversion of agricultural water rights to municipal water rights as urbanization of the state proceeds. Colorado has a finite quantity of water, all of which is already appropriated. New eastern slope municipalities have to purchase their water rights from current owners of such rights, many of whom are agriculturalists. We do not know the full implications of this trend for Colorado. It seems clear, however, that we cannot support both the irrigated agricultural industry and a heavily urbanized population. Some choice may have to be made between the two.

All of these trends are interrelated with each other in various ways. Rapidly increasing population tends toward urbanization. Concentration of the urbanization on the Front Range results in a commitment of resources to one place in the state, to the detriment of the rest of the state. Transportation imbalance is related to failure to consider the needs of a rapidly changing society. Decline in agriculture is related to the conversion of water resources for municipal, industrial, and energy-production uses.

What is more important, however, is the lack of state policy in each of these trends. The trends are occurring as a result of outside forces impinging on our state. There is no explicit state policy for these trends which are shaping the future of Colorado; and it is extremely doubtful that Coloradans, if given the choice, would vote affirmatively for the continuation of all or any of the trends.

Coloradans, in short, are losing control of the future of the state. Our future is not being determined either by ourselves or our elected representatives; it is being determined by external forces. This is the story of most urbanized states and urban areas of the world. We are repeating the mistakes of those areas which have already experienced unwarranted environmental degradation before us.

The environmental future of Colorado, given our present course of action, is bleak. We can expect steadily increasing deterioration and loss of control from this point on. Government, under these conditions, becomes nothing more than a series of belated reactions to never-ending crises. Citizen apathy sets in. The longer these conditions continue, the more difficult it is to ever again regain control; our path tends to become irreversible.

If we in Colorado are to retain control of our future, we must develop the consensus, the policies, the plans, and the governmental structures for a state trusteeship of the environment for the indefinite future. The means for achieving such a protective system are set forth in the recommendations which follow in the next chapter.

CHAPTER III

RECOMMENDATIONS

The Commission has considered more than two hundred possible recommendations, all of them of legitimate concern and worthy of being passed on to the General Assembly. We have selected from this number those ideas which we felt had long-range significance.

We found it desirable, in making our recommendations, to first identify the goals which we were trying to achieve. In environmental matters, which are currently highly controversial, there is need for the development of consensus before we can all move ahead together to solutions. If there is consensus about goals, then specific recommendations will be better implemented.

These goals are:

- (a) Institute, in all three branches of state government, those permanent legal, structural, and financial arrangements required for planning, coordinating, and enforcing the protection, preservation, and enhancement of the quality of the environment.
- (b) Develop the massive educational effort and political consensus required for

protecting, preserving, and enhancing the quality of the environment.

- (c) Stabilize and plan the distribution of the future population of Colorado, with consideration for the ecological balance, present and future.
- (d) Achieve integration of state water, land use, environmental, and population policies.
- (e) Create balanced transportation systems within the state.
- (f) Adopt the principle of recycling in resource use throughout the state.
- (g) Prevent the loss of the agricultural industry to the state.
- (h) Determine the wisest use of the energy resources of Colorado, from both a state and a national viewpoint.

To help achieve these goals, we make thirty-three recommendations to the Governor and the General Assembly. These recommendations are designed to provide the type of governmental framework required to retain control of our future. All of them should be considered for adoption over the next few years.

ENVIRONMENTAL PLANNING AND POLICY

RECOMMENDATION #1. THE GENERAL ASSEMBLY SHOULD PROCEED IMMEDIATELY TO REVIEW AND RESTRUCTURE THE ENVIRONMENTAL DECISION-MAKING AGENCIES IN THE STATE SO AS TO PROVIDE STRONG ENVIRONMENTAL CONTROLS THAT ARE COMPLETE, EFFECTIVE, AND COORDINATED; AND, AS AN INITIAL STEP TOWARD THAT OBJECTIVE, THE GENERAL ASSEMBLY SHOULD ENACT AN ENVIRONMENTAL POLICY ACT.

The Commission finds -- as the single, most important structural deficiency in the Colorado State Government in terms of gaining control of the complex future problems of the state -- that there is no integrated, professionalized system of environmental management in Colorado. Responsibility and expertise on environmental-quality control is fragmented among a multitude of state agencies: Department of Health; State Land Board; Game, Fish and Parks Division; Department of Highways; State Planning Office; Department of Natural Resources; Land Use Commission; Public Utilities Commission; Air Pollution Control Commission; Air Pollution Variance Board; Water Pollution Control Commission; Coordinator of Environmental Problems; and others. This fragmentation results in prevention of long-range environmental planning; lack of interagency coordination and cooperation; inadequate authority for environmental control; insufficient public participation in the decision-making process; duplication of funding and personnel; and failure of state agencies to recognize environmental problems.

The Commission recommends that the General Assembly begin now to review, restructure, and coordinate the environmental decision-making agencies in the state. As an initial step toward such restructuring, the General Assembly should enact an Environmental Policy Act. Such an act should provide for a legislative environmental policy, for mandatory assessment of the environmental impact of proposed actions, for an Environmental Quality Council or Commission to carry out the act, and for citizen participation in the review processes of the act.

The Colorado Environmental Policy Act should be patterned after the National Environmental Policy Act of 1969.¹²⁸ The act should

direct that all state programs shall be improved and coordinated to the end of protecting, preserving, and enhancing the quality of the environment of the state for the benefit of the citizens of the state. This act should articulate statewide environmental-quality goals and policies and should direct that all policies, regulations, and public laws of the state, including its political subdivisions, shall be interpreted and administered in accordance with the policies set forth in the act. Such a declaration would provide the conceptual framework within which to make major environmental decisions at all levels of state activity.

In addition, the Commission recommends that an Environmental Quality Council or Commission, similar to the National Council on Environmental Quality,¹²⁹ be established initially in the Office of the Governor. The council or commission could consist of either three full-time members or five-to-seven part-time members, to be appointed by the Governor. Each person appointed to the council or commission should, as a result of his training or experience, be well qualified to analyze and interpret environmental trends, and appraise state programs in light of the environmental policy set forth in the act.

The duties of the council or commission should include the following:

1. To formulate and from time to time revise a statewide environmental plan for the management, improvement, and protection of the environment and natural resources of the state in furtherance of the environmental policy and purposes expressed in the act.
2. To formulate and publish criteria or guidelines to assist state or local agencies in making environmental impact statements before proposed actions are undertaken significantly affecting the environment.
3. To advise and cooperate with municipal, county, regional, or other local or state agencies regarding the conservation or improvement of environmental quality.
4. To conduct continuing investigations, studies, research, and analyses relating to ecological systems and environmental quality and improvement.

¹²⁸P. L. 91-190, 91st Congress, S. 1075, January 1, 1970.

¹²⁹cf. P. L. 91-190, 91st Congress, S. 1075, January 1, 1970.

5. To periodically transmit to the Governor and the General Assembly reports setting forth the status of the overall environmental management program in the state, a review of the programs and activities of the federal government with particular reference to their effect on environmental programs and activities in the state, and setting forth a specific program for remedying deficiencies of existing programs and activities in the state together with recommendations for legislation.

In addition, the council or commission should be authorized to conduct investigations, hold hearings, and compel appearance of witnesses; and should be authorized to issue cease and desist orders and apply to the courts for injunction.

The current single-man position of Coordinator of Environmental Problems, in the Office of the Governor, should have its functions absorbed into the new council or commission.

In recommending the establishment of a new Environmental Quality Council or Commission initially in the Office of the Governor, the Commission is of the opinion that the establishment of such new council or commission should provide a framework for future consolidation or reorganization of existing state agencies.

The Commission urges a study of the restructuring of the environmental decision-making agencies of the State and the adoption of an Environmental Policy Act as indispensable prerequisites toward achieving a future, total, statewide environmental protective system.

RECOMMENDATION #2. THE GENERAL ASSEMBLY CONSIDER CERTAIN STRUCTURAL CHANGES WITHIN THE GENERAL ASSEMBLY ITSELF, TO ENABLE IT TO COPE WITH THE COMPLEX PROBLEMS OF THE FUTURE.

Legislative Goals Committee

The item which probably impressed the Commission more than any other during its deliberations was the observation that the State seems to be losing control of its own future. There are detectable and ominous trends, about which the State seems unable or unwilling to do anything. Prime agricultural land, for example, is being converted to non-agricultural uses. The agricultural industry itself, the state's second largest industry, is in grave danger of being relegated to a minor role in the state's economy within the foreseeable future, due to the conversion of agricultural water rights to municipal water rights. The bulk of the state's population is being concentrated into a small fraction of the state's usable area, causing unprecedented pollution problems. There are many similar examples of our seeming inability to control the forces shaping the state's future.

Coupled with this observation, and related to it, is the seeming absence in our state governmental system of any permanent goal-setting mechanism. Persons running for elective office occasionally state their personal goals to the electorate; elective officials, while in office, influence the course of government through their personal philosophies; some statutes carry legislative policy as a guideline to executive action; some statutes delegate policy-making to executive agencies; and there are various other ways in which goals are implicit in the system. Most of these existing mechanisms, however, are transitory in nature and give little permanent direction to our governmental effort for the future.

Colorado may be getting close to the point where it is ready for a full-time legislature, where elected representatives would be in session for part of the time and engaged in bill-writing research the remainder of the time. In the absence of a full-time legislature, the Commission feels that one answer to regaining control of the future would be a permanent, statutory Legislative Goals Committee in the General Assembly, perhaps similar in structure to the Joint Budget Committee. Its mission would be to continually guide the direction of Colorado's future by setting statewide goals, seeing that such goals are incorporated into

statutory policies and criteria, and monitoring the execution of the goals within the executive branch. Such a committee should be composed of legislators, who have the primary responsibility and prerogative for statutory goals and policy, with possibly the Governor and some of his key administrators as ex officio members. The committee could call upon citizens, executive-branch advisors, and outside experts for testimony, and could conduct public hearings on statewide goals. The committee should have a permanent staff director and a small research and administrative staff of its own; both the Legislative Council and the Legislative Drafting Office are far too busy to take on these additional tasks. It should come into being on approximately April 1, 1972, and attempt to have certain goals discussed and adopted by the 1973 session.

Coloradans must participate in the decisions as to the type of state which Colorado will become. The Commission feels that a Legislative Goals Committee is indispensable to any participation by Coloradans in the control of their own future. In the absence of a mechanism such as this, Colorado will become more and more buffeted by outside forces of change and less and less able to effect any control over its own destiny.

Joint Legislative Committee on Environmental Policy and Planning

In addition to a permanent Goals Committee, the General Assembly may wish to consider the formation of a Joint Standing Committee on the Environment. The environmental problems of the future will be extremely complex and may require concerted attention by the two houses of the General Assembly.

An alternative to this proposal would be a new, permanent Standing Committee on the Environment in each house.

Environmental Impact Notes

The General Assembly may wish to consider also a legislative procedural requirement for environmental impact notes to be attached to all bills with potential for affecting the environment. Such a procedure, if enacted, could be carried out by either the Goals Committee or the Joint Legislative Committee on Environmental Planning and Policy mentioned above, or by the Environmental Quality Council or Commission suggested in Recommendation #1.

RECOMMENDATION #3. COLORADO ADOPT A CONSTITUTIONAL AMENDMENT PROVIDING FOR A RIGHT TO A HEALTHFUL ENVIRONMENT.

Policy guidance for the judicial branch of government, under our system of institutional arrangements, comes first from the written constitution and secondly from the enacted statutes.

Our Colorado State Constitution provides specifically for the right to property. An entire body of statutory law and judicial interpretation has been built around that right. Almost all of our states have similar rights built into their constitutions. The notion that property, even though in private hands, might be so misused as to constitute a threat to societal environmental health and ecological balance in places far remote from the scene of the misuse is relatively new in our experience. At least eight of our states,¹³⁰ and Switzerland,¹³¹ have considered their experience with uncontrolled environmental impact so important that they have changed their constitutions to include new environmental clauses.

The Commission recommends that the General Assembly propose to the people a constitutional amendment providing for a right to a healthful environment. The use of the words "healthful environment" would provide a broad base for judicial interpretation, similar to the concepts of freedom of speech, due process, and other such concepts which require continuous change in content and interpretation. Such an amendment would juxtapose environmental rights equally alongside property rights for policy guidance to the judiciary. Where the two rights come into conflict with each other, the courts would have to balance the interests. A body of law would gradually come into being relating to this adjustment of conflict and balancing of interest. Adoption of such a constitutional amendment would provide Coloradans with a means for a careful and orderly interpretation by the courts of how environmental rights and property rights are to be adjusted to each other in the future.

¹³⁰ New York, Illinois, Pennsylvania, Rhode Island, Michigan, Virginia, California, and Massachusetts.

¹³¹ Cited in Bureau of Outdoor Recreation, Department of the Interior, Denver, Colorado, *Mid-Continent Memo*, August 23, 1971.

RECOMMENDATION #4. EVERY PUBLIC AND PRIVATE SCHOOL AND SCHOOL DISTRICT, AND EVERY PUBLIC AND PRIVATE INSTITUTION OF HIGHER LEARNING, IN THE STATE APPOINT AN ENVIRONMENTAL COMMITTEE TO STUDY ITS CURRICULUM, RESEARCH, AND ADMINISTRATION, AND MAKE RECOMMENDATIONS FOR CHANGE TO MEET FUTURE ENVIRONMENTAL AND ECOLOGICAL REQUIREMENTS.

Control of our complex environmental future can only be achieved if we can gain consensus about the nature of the individual self-discipline, the change in life styles, and the new governmental regulatory measures needed. This consensus can be achieved only through a major reorientation of our educational system, beginning with the pre-school child. The principles of ecology should permeate the entire education of every citizen of our state.

This Commission feels that, as a start in the reorientation of the school system, every public school district and private school association in the state should appoint an environmental study committee. The function of such a committee would be to study the educational programs and make recommendations to the school authorities for reorientation of those programs to meet future environmental and ecological considerations.

The Congress has enacted the National Environmental Education Act (P.L. 91-516, 91st Congress, HR 18260, October 30, 1970). The purpose of this act is to encourage and support the development of new and improved curricula in environmental education and to provide a program of federal financial assistance and grants to institutions of higher education, and state and local educational agencies to support research, demonstration, and pilot projects designed to educate the public on problems of environmental quality. The Commission notes that the Colorado Department of Education was among the first to apply for and obtain a grant under this act for the development of a Master Plan for Environmental/Ecological Education for the State of Colorado. Further, the Commission notes that the Department of Education has been assessing local education resources in the state and has encouraged local school districts to develop and implement environmental education programs. The State of Colorado is urged to put its full support behind the development of this statewide plan, and all schools are urged to take full advantage of the provisions of this act.

The problem is much more complex in the colleges and the universities. These institutions of higher learning have complex systems of administration, undergraduate and graduate study, extension study, and research.

Several of our larger institutions of higher learning have already taken the initiative to form environmental study groups. The University of Colorado, as an example, formed a study group first; and the recommendations of that study group have already led to the formation of a permanent University of Colorado Environmental Council. That council provides leadership in environmental policy matters, examines current programs of academic departments to determine how the university can foster research in areas of environmental problems, and explores how the university and other educational and scientific organizations in the state can work effectively in promoting public understanding of environmental issues.

Colorado State University has established an Environmental Resources Center, to facilitate and encourage interdisciplinary environmental research and educational programs. In addition, a Task Force on Environmental Programs was appointed and has submitted extensive recommendations for academic and research efforts in environmental fields.

Similar programs are under way or under consideration at other colleges and universities in the state, and the Commission urges that every school start such activity. This should not be construed to mean necessarily that new courses and new degree programs should be started, although some new programs may be required. It should mean that environmental consciousness and awareness should be a part of all appropriate courses.

The Commission recommends that every public and private institution of higher learning in the state appoint an environmental committee to study its curriculum, research, and administration and make recommendations for change to meet future environmental and ecological considerations.

RECOMMENDATION #5. THE GENERAL ASSEMBLY ENCOURAGE THE PARTICIPATION OF CITIZENS IN THE COMPLEX DECISION-MAKING OF THE FUTURE BY STATUTORILY INSTITUTIONALIZING CITIZEN PARTICIPATION IN EVERY WAY POSSIBLE.

Decision-making in a future of extremely rapid technological change will become exceedingly more complex. It will require the talents, the imagination, the efforts, and the participation of citizens to a degree never before experienced in society. It will particularly require consensus and responsibility, both of which will become more and more difficult to achieve in a society of change and diversity. Participation encourages and fosters consensus and responsibility.

The Commission urges the General Assembly to encourage the participation of citizens in governmental decision-making, by institutionalizing such participation in every manner possible: citizen advisory groups to agency heads; citizen advisory groups to elected officials; ad hoc citizen study groups; citizen advisory actions in administrative proceedings; citizen testimony at public hearings; citizens as interested parties in various kinds of proceedings; citizens as the "eyes and ears" of executive agencies.

We would urge that every statute relating to the executive decision-making process from this point on should have in it one or more forms of potential citizen participation. An example would be the Environmental Policy Act proposed in Recommendation #1. Citizen participation could easily be institutionalized into the executive review process of that statute.

RECOMMENDATION #6. A CONSERVATION TRUST FUND, SIMILAR TO THE HIGHWAY TRUST FUND, BE ESTABLISHED IN THE STATE TREASURY, WITH SPECIFIED STATUTORY INPUTS TO THE FUND AND WITH THE PROCEEDS OF THE FUND DEDICATED TO A STATE SYSTEM OF CONSERVATION AREAS.

The Colorado Highway Trust Fund operates as a single-purpose, constitutionally dedicated fund. There are monies from many sources, all dedicated to a single purpose: highway funding. There is no review of the appropriations by the General Assembly, the body constitutionally charged with the appropriation process. To assist in its overall operations, the Department of Highways has statutory condemnation authority.

In contrast to this method of funding for highways, the Commission was surprised to learn, principally through the Roxborough Park episode, that apparently the State sets aside no money on a regular basis for any state system of conservation areas. Moreover, the State itself seems to have no system of condemnation for public purposes other than highways, even though the agencies of the State, the counties and municipalities, do have such authority.

Colorado is a recreational state because of her natural attributes. We who live here are singularly blessed in that the national government has had the wisdom to set aside vast acreages of natural area as national park, recreation, and conservation areas. These areas now serve the entire nation. The State, however, has the responsibility to see that its own residents are served with a state system of recreation and conservation areas. At the present time, the State is deficient in this respect and far behind other states.¹³²

The Commission urges the General Assembly to create a Conservation Trust Fund, as one of the basic structures in an environmental protective system for the future. The monies would be used for a state system of: parks and recreation lands; green-belt and agricultural buffer zones to prevent sprawl; scenic easements; flood-plain parks, paths, and trails; historic monuments; wild rivers and wilderness areas; wildlife habitats; ecological research areas; community open space around public works projects; and State matching of local

¹³² Division of Game, Fish and Parks, Colorado Department of Natural Resources, 1970 Colorado Comprehensive Outdoor Recreation Plan.

initiative for similar purposes. Colorado at the present time has no such systematic conservation planning tool.

The Conservation Trust Fund should be created in the State Treasury and be administered by some such department as the Department of Natural Resources. The fund should have regular, statutory inputs such as: a fixed percentage of the General Revenue flow annually, or a fixed annual appropriation; grants from non-State agencies; conservation gifts and trusts; real-estate sales tax; the proceeds of the proposed constitutional sweepstakes measure, if it passes; special legislative appropriations for specific conservation purposes; the proceeds of an abandoned-and-unclaimed property enactment; special bond issues; mandatory State-collected sales tax with returns to local areas; user fees; and other similar monies. **The department administering the fund should have condemnation authority, in accordance with standards for such authority already well established in the law; and requests for expenditures from the fund should have the approval of the Governor.**

We urge the establishment of this basic conservation planning tool for the future.

RECOMMENDATION #7. THE GENERAL ASSEMBLY CREATE A LONG-RANGE PLANNING MECHANISM, IN COOPERATION WITH THE DENVER CITY GOVERNMENT, FOR THE STATE CAPITOL/CITY HALL COMPLEX.

The State Capitol area contains the seat of government of Colorado; it belongs to all the citizens of the state. The Denver City Hall area performs a similar role for the citizens of Denver. Each of these areas has its own small planning mechanism to suit its own needs, with varying degrees of communication.

The joint State Capitol/City Hall complex, with its beautiful open space and gardens, has already been noted as one of the beautiful areas of America. We must plan now to keep it that way for the indefinite future. Future plans for the area should take into consideration: enlargement of the open space and malls; large auto-free areas in and around the complex and nearby downtown areas; consolidated bus and mass-transit terminals under the mall; shops, parks, museums, and other public facilities in, around, and under the mall; coordination of all plans with those of the Regional Transportation District.

The Commission urges the General Assembly to create a long-range planning mechanism now, in conjunction with the Denver authorities, to plan for the required future development of the State Capitol/City Hall complex area. The current state resolution on the subject, SJR 14, 1971 Session, is too narrow in scope to bring about the type of coordinated planning required. It is not beyond reason that the development of this entire complex might be accomplished with self-generating revenues and development bonds. One possibility for the mechanism could, therefore, be the establishment of a State Capitol/City Hall development authority as a semi-autonomous agency, with powers similar to the Urban Renewal Authority of Denver and other similar redevelopment agencies throughout the nation. **Whatever the structure of the agency, it is urgent that the planning for the complex start soon, while the planning is under way for the mass-transit system of the metropolitan area.**

RECOMMENDATION #8. EVERY POLITICAL JURISDICTION IN THE STATE BE STATUTORILY REQUIRED TO BE A MEMBER OF A STATE PLANNING REGION HAVING REVIEW POWER OVER MATTERS AFFECTED WITH A REGIONWIDE INTEREST.

We in Colorado have always taken pride in our local governments and in our ability to solve problems at the local level. The tradition of strong local governments which resulted from this pride has served the state well for many years.

In this day of rapid transportation and instantaneous, world-wide communication, however, we are learning that local governments are not immune from each other's problems. Jurisdictions once geographically separated have become contiguous. Problems of every type spill over jurisdictional lines; the actions of individual citizens affect the lives of citizens in other jurisdictions as they never have before. If existing trends are permitted to continue, this problem will become increasingly severe, to the point of being unmanageable, as our state population doubles in approximately the next thirty years, and doubles again in approximately thirty years thereafter.

If we in Colorado want to retain local government, if we do not want to see all authority move to the state and federal levels -- we must create regional agencies with the authority to review and resolve regional problems. Every local jurisdiction must belong to a regional body; decisions of one local jurisdiction which affect other jurisdictions must be reviewed for their impact before being carried out; regional bodies must be given a veto power over decisions adversely affecting the regional interest. These arrangements must be made a matter of statutory requirement. Local governments are the statutory agents of the state and derive their powers from the state. They must be given statutory guidance and standards on matters affecting more than one jurisdiction. The State Planning Office has already delineated twelve planning districts for the state; these should become the basis for the new regional review agencies.

In the case of the large urban metropolitan areas, we must go even further and create regional service areas, under State Constitutional Amendment Number 3 of November 1970, with authority to actually operate certain regionwide services which affect all jurisdictions in the metropolitan region. Such services should include: drainage and flood control; sewage disposal; air pollution control; water and

sanitation; water pollution control; solid waste disposal; mass transportation, roads, and bike-ways; parks, recreation, greenbelt, and conservation lands; noise control; regional planning; regional land-use control; police and fire functions.

The Commission urges the General Assembly to take the necessary steps to take cognizance of those local decisions which are affected with a regional interest and provide for regional review and regional service.

POPULATION PLANNING AND POLICY

RECOMMENDATION #9. THE GENERAL ASSEMBLY ENACT A STATE POPULATION POLICY, INCLUDING THE ESTABLISHMENT OF A COUNCIL OF POPULATION ADVISORS.

Man's activities cause a variety of disruptions to the ecological balance of the universe, and the geometric progression of human numbers is the single most important force on all social and natural environments. As Governor John Love stated in proclaiming Population Concern Week, 1970: "The problems associated with population growth begin, but do not end, with millions of births each year. Crowded living conditions produce profound psychological pressures in the individual and produce tremendous social pressures in our society. Our consumption of a natural resource magnifies the population problem through pollution and deterioration. Lest these problems overwhelm us, it is vitally important that we become aware of the necessity for making some basic changes in our values, goals, and life styles."

To the end of making the necessary changes in life styles, so essential to any environmental protective system, this Commission believes that it is time to challenge some of the historic assumptions which influence public policy, including the policies governing the growth and development of the state. That population growth is essential to economic growth and vitality; that more people lessen tax burdens; that there is safety in numbers; that human and natural resources are infinite -- are those kinds of credos and dogmas essential in one age but disastrous in another.

As already pointed out in Chapter I, Environmental Problems Confronting Colorado, there is reason to be concerned over both the growth and distribution of population in this state. Colorado's 104,247 square miles are finite, and her delicate ecosystems cannot support unlimited growth or an environmentally exploitative economy. Although future growth in Colorado will be grossly maldistributed if current trends are unchanged,¹³³ redistribution per se is not a solution¹³⁴ to the population and ecological problems with which we are confronted. Although some environmental, social, and economic problems may

be temporarily alleviated by redirecting growth, this alone will not solve the problem. In short, the question of optimum population is an issue which our state, the nation, and the world must face in the immediate future. With consideration for the carrying capacity of the land, diseconomies of scale, dependency ratios, social costs, environmental health hazards -- as well as many other demographic and ecological factors -- **planned change, rather than adaptation and accommodation, must become the criterion for solutions.** Furthermore, unless we can accurately assess the impact of population on both the natural and social environments with precision and accuracy -- by grappling with the ecological, social, and economic issues related thereto -- we will not have fulfilled our obligation to the future of this state and its citizens.

The existence of the President's Committee on Population Growth and the American Future; the recent formation of the Coalition for a National Population Policy; introduction into the United States Senate, during the 92nd Congress, of Senate Joint Resolution 108, concerning a United States policy of population stabilization -- simply underscore the urgency and critical nature of the problem. Colorado, with its unique problems which demand immediate solution, has the opportunity to lead the nation, and the world, in the establishment of a population policy.

A State Population Policy would recognize that zero population growth is an inescapable fact. The only question is when and how. We must take the steps now to establish population goals and establish programs to limit population growth voluntarily, or natural methods will bring about zero growth by violent means while we wait. The former approach can lead to a quality life; the latter can only lead to disaster. The policy should establish state objectives, methods for their achievement, and a means of evaluating progress in meeting these objectives. **To this end, the Commission recommends that the General Assembly adopt a policy of population stabilization for Colorado, to be achieved at the earliest possible date, and to be accompanied by the coordination of all activities of State Government to be consistent with such a policy. Within the framework of a stable population policy, we recommend:**

1. **The institution of a state population distribution and planning process which**

¹³³ See Figure 2, page 10.

¹³⁴ See Figure 4, page 51.

takes into consideration geological, sociological, economic, and environmental impact.

2. A statutory requirement that the economic, sociological, and ecological activities of all communities be coordinated and that state subsidy of a growth policy be ended.
3. A statutory requirement that all political jurisdictions be involved with state planning agencies in determining population limitation patterns and keeping open space between jurisdictions.

Population growth is caused by natural increase (births minus deaths) and in-migration. To achieve population stabilization, it is necessary to deal with both factors.

A principal cause of population growth in the United States can be attributed to the reproductive behavior of the majority of Americans, who aspire to families of three or more children, thereby generating a growth rate which exceeds that required for population stability. Therefore, any policy designed to influence reproductive goals must concern itself with all fecund Americans and must also relate to family-sized goals -- not just methods of contraception.

It is also important to recognize that if a two-child family norm were established in the United States today, the "braking distance" would preclude stabilization until well into the next century (2037) at close to 300 million people. By contrast, a three-child family norm would result in 400 million people by 2014, and an estimated 700-800 million people by 2050.¹³⁵

Obviously then, in addition to giving high priority to the funding of all aspects of fertility control, the General Assembly should:

4. Enact all possible legislative incentives to birth-rate reduction, including tax incentives for small families.
5. Recognize the importance of education in changing individual attitudes and social goals. Programs in population dynamics should be encouraged (by funding if necessary) at all levels of academic endeavor, both public and private; and all mass communications should be enlisted to aid in the education process.

A policy of population stabilization would necessitate the following:

6. The utilization of a competent environmental resource inventory and systems modeling for intelligent, predictable, long-range planning.
7. Revision of Colorado's commerce and development policy, to represent a philosophy of stabilization, not growth. Its purpose should be to channel industry desirous of moving to Colorado to those parts of the state which need it.
8. Adoption of an industrial site selection law, similar to Maine's, giving the State new controls over the location of new industry.
9. Utilization of water policy, utility-service distribution, and transportation to control and direct growth.
10. Encouragement of Colorado's congressmen to hasten development of a national population stabilization policy.

Finally, we urge that the Governor have a Council of Population Advisors to conduct research and to make recommendations on the following subjects:¹³⁶

1. Demographic implications of population growth: patterns and trends (fertility rates, migration, explosion, implosion, etc.).
2. Effects of cultural influences, attitudes and pronatalist policies on population growth.
3. Social costs of a rapidly growing population: urban decay, mental and physical health, housing, employment, crime, etc.
4. Economic costs of a growing population: government, taxes, schools, highways, facilities, dependency ratio, etc.
5. Ecological costs of a growing population: environmental degradation, resource depletion, carrying capacity, etc.
6. Aesthetic costs of a rapidly growing population: urban sprawl, desensitization or impersonalization of most facets of life, reflecting in lack of concern for the environment.
7. Population distribution, within the framework of a stable population.
8. Public education in population dynamics and responsible parenthood.
9. Means by which the State of Colorado can broaden provision of, and access to, fertility-control services.

¹³⁵ Commission on Population Growth and the American Future, *op. cit.* (ref. 21).

¹³⁶ See Statement of Rufus E. Miles, Jr., at the Hearings of the President's Commission on Population Growth and the American Future, *Population Bulletin*, vol. 27, no. 3, pp. 7-27, Population Reference Bureau, Inc., Washington, D. C.

10. Means by which the State of Colorado can help to promote research related to human reproduction and population genetics.
11. Systematic evaluation of progress toward stated objectives, which would include the development of systems modeling for intelligent, predictive, long-range planning.
12. The function and structure of a permanent population agency within the framework of the governmental reorganization being recommended in Recommendation #1 of this report.

RECOMMENDATION #10. THE GENERAL ASSEMBLY ENACT A POLICY OF RURAL REVITALIZATION, WITHOUT STIMULATING IN-MIGRATION.

During the 1960's, 400,000 of Colorado's 453,000 population increase settled in the nine counties of the Front Range, and more than half of this in the counties around Denver.¹³⁷ The Denver metropolitan area represents the largest population complex in the state, and its growth tends to be self-generating. This complex attracts the bulk of the new economic and population growth in the state, even to the extent of causing migration from the rural areas within the state. Because of the location of industry, schools, job opportunities, and diverse cultural offerings, newcomers are attracted to the capital and to the opportunities of the largest city; industry is attracted to the labor pool and services; finance and services are attracted to the job opportunities of the state's largest complex; developers are attracted to the opportunities for land value appreciation; new governmental jurisdictions come into being, alongside old ones, to take care of the needs of new subdivisions and developments; new schools, roads, and services are required to take care of the needs of increased population and the industry base.

On the other hand, rural Colorado, like much of rural America, has stagnated and is beginning to decay. As rural Colorado loses people, the aging of the remaining mix creates major social, political, and economic problems. The poverty in rural Colorado is a classic for all America. In the Denver metropolitan counties, the annual average per capita income is \$3,129; the figure for the balance of Colorado is \$2,152. Typically, the young people in rural Colorado leave the farms to seek careers in the city. For the rural areas, this represents future disaster. Nevertheless, as a state, we continue to put our colleges "where the people are." We do the same with medical facilities, highways, cultural amenities, government services, and every economic aspect of our society. By example, we say to the young: "The jobs, money, education, and prestige are all in the city." In short, no jobs in rural Colorado will mean that no young people can stay there.

Size of community makes a difference, too. At a given point, a community becomes so

¹³⁷See Figure 1, p. 8. Data also supplied by Colorado Legislative Council, 1971.

small it cannot afford the price of police, fire protection, medical service, schooling, and other governmental services. Similarly, at a given point a community becomes so big that the per capita cost of services increases, so that economies of scale are lost.¹³⁸ This problem of "higher taxes" or "no service" is what economists call "diseconomies of scale."

Ironically, the policies of the federal government, as well as those of the state, point in the wrong direction. Aid to rural communities is available for communities of more than 25,000 persons.¹³⁹ Below that, a community is supposed to lack "economic vitality." Under this policy, only the impacted Front Range has communities of the size to qualify, yet many have already passed the point of diminishing returns in size. At this point, it costs more in taxes to provide water, build sewers, pave streets, provide police and fire protection, pay for education, and provide health services. At the same time, crimes increase, pollution increases, and the problems of growth begin to outrun public revenues.

Coloradans can ignore the symptoms and pay the extreme price later, or they can take action now to cure the interlocked problems of rural stagnation and urban sprawl. Tax incentives and policy changes are needed if the trends are to be halted and turned. Figure 4, page 51, is intended to show graphically how the state might look in the future if policies were adopted to reverse current trends shaping the state. It is only one of many possibilities.

The revitalization of rural Colorado alone will not solve the population problem nor preclude ecological disaster. However, avoiding the development of a metropolitan strip city along the Front Range Corridor would be mutually beneficial to the impacted areas where growth has become counter-productive, as well as out-state Colorado, which needs vitality. To protect the environmental integrity of the state, population growth must be stabilized; to prevent its further decay, the revitalization of rural Colorado, accompanied by the limitation of metropolitan Denver's growth, must begin immediately. To do otherwise is to commit all Colorado to progressive sociological, economic, and ecological decline.

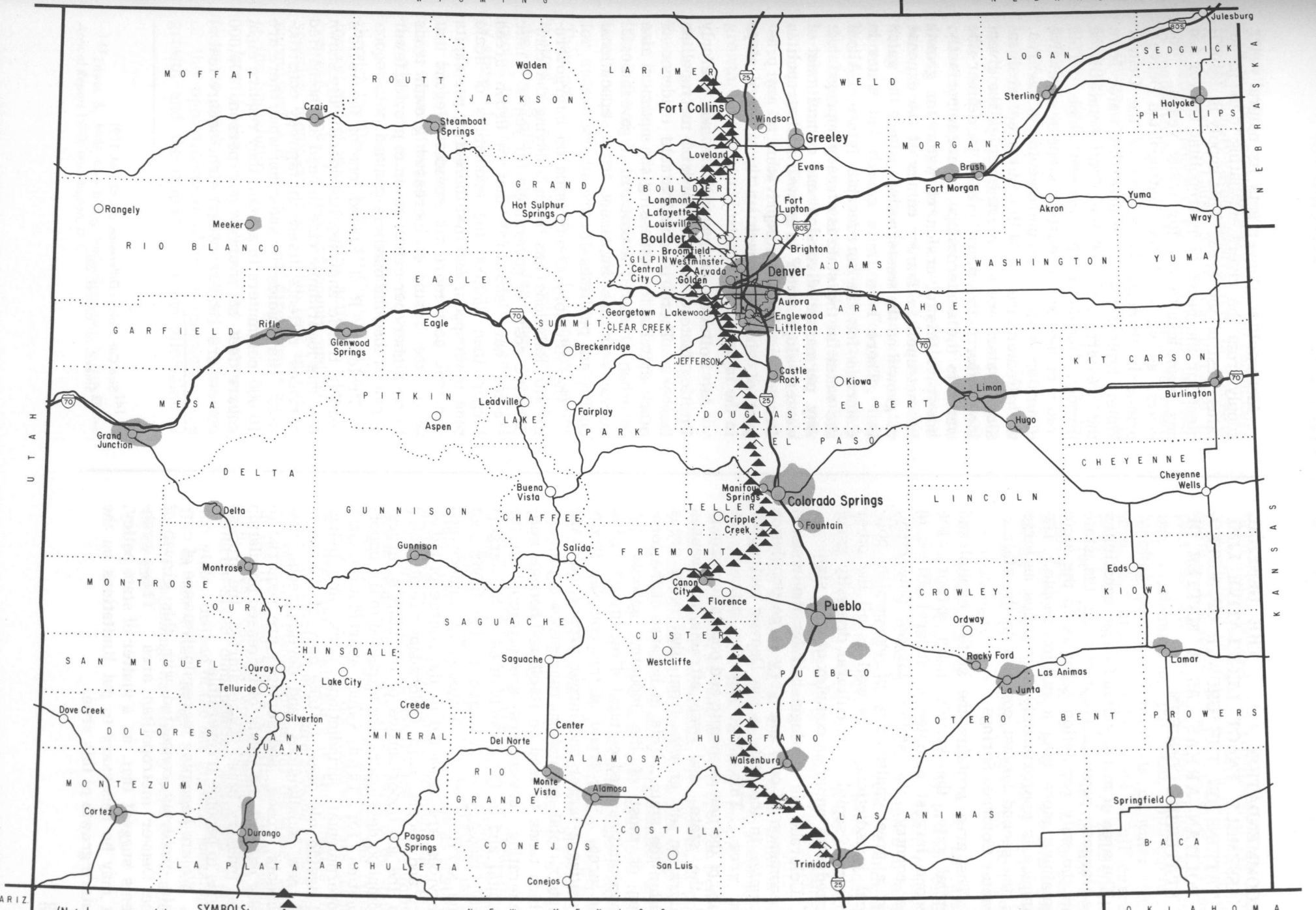
¹³⁸ Advisory Commission on Intergovernmental Relations, *Size Can Make a Difference*, September 16, 1970, Superintendent of Documents, Washington, D. C.

¹³⁹ *Ibid.*

To these ends, the Commission recommends that the General Assembly enact a policy, with all possible incentives, of revitalizing rural Colorado, without stimulating in-migration. Masses of people need not move in order to accomplish these goals. State and federal policies, coupled with tax incentives, could direct and redistribute the economy in an orderly manner. These measures should include:

1. Revision of Colorado's commerce and development policy,¹⁴⁰ to represent a philosophy of stabilization, not growth. Its purpose should be to channel industry which does want to move to Colorado to those parts of the state which need it. It should represent a policy of stabilization, rather than one of "selling Colorado."
2. Adoption of an industrial site-selection law, similar to Maine's, giving the State new controls over the location of new industry.
3. Encouragement of any industry locating in Colorado to employ local or indigenous skills and talents rather than importing them.
4. State governmental decentralization and relocation of state offices, institutions, and services.
5. Encouragement of federal government decentralization; for example, a "Durango" mint instead of a new Denver mint.
6. Utilization of water policy to direct growth; for example, no further inter-basin diversion to other areas.
7. Statutory limitations on the size and growth of metropolitan Denver.
8. Tax and loan incentives to stimulate the rural economy.
9. State airport development outside the Denver metropolitan area.
10. Transportation-system planning and development to direct growth.
11. Utility-service distribution to direct growth.
12. Preservation of agricultural land.
13. Improvement of the economic return for agriculture.

¹⁴⁰ Chapter 3-18-2, Colorado Revised Statutes, 1963.



(Not drawn to scale)

SYMBOLS:

▲▲▲ Front Range

■ Municipal Growth Pattern

Figure 4

A POSSIBLE COLORADO POPULATION DISTRIBUTION PLAN FOR BEYOND THE YEAR 2030
 SOURCE: Office of Coordinator of Environmental Problems

RECOMMENDATION #11. THE GENERAL ASSEMBLY ENACT LEGISLATIVE LIMITATIONS ON THE GROWTH OF METROPOLITAN AREAS, AS A MATTER OF STATEWIDE CONCERN.

The area of metropolitan Denver constitutes the largest population complex in the state and the only population complex in the state containing more than a million people. The complex is approximately four times as large as the second largest complex in the state -- greater Colorado Springs.

The area contains the state's capitol and capital city, the state's main airport, the second largest complex of federal offices in the country, the state's largest university, and a great multiplicity of independent political jurisdictions -- as well as all the other physical, social, and cultural diversity associated with an urban complex of such size.

Colorado is distinguished by the unusual phenomenon of only one very large population complex in the state -- the Denver metropolitan area. This large complex attracts the bulk of the new economic and population growth of the state, and even attracts and causes migration of growth from the rural areas within the state. This is because of the location of most of the industry, schools, job opportunities, and cultural diversity offered in the area. The trend of this complex incorporating a larger and larger proportion of the state's total population represents a process which tends to feed on itself and become self-generating: newcomers are attracted to the capital and to the opportunities of the largest city; industry is attracted to the labor pool and services of the largest city; finance and services are attracted to the source of industry and people; rural Coloradans are attracted to the job opportunities of the state's largest complex; developers are attracted to the opportunities for land value appreciation; new governmental jurisdictions come into being, alongside old ones, to take care of the needs of new subdivisions and developments; new schools, roads, and services are required to take care of the needs of increased population and industry base. Once started, the process tends to become irreversible.

We are becoming increasingly aware of certain problems connected with this growth of the Denver metropolitan area. These problems suggest that, as a matter of state policy, it may be necessary to put limitations on the future growth of this area.

Metropolitan Denver gets its natural water supply from the rivers emanating in the mountains west of the area. This supply is insufficient for the needs of metropolitan Denver and has been insufficient for many years. For years, as we all know, metropolitan Denver, primarily through the efforts of the Denver Water Board, has been diverting water from the western slope of the Continental Divide through tunnels to the eastern slope. This water comes to the eastern slope at expensive diversion costs. The more people in the area, the greater the need for diverted western-slope water; and the more complex the diversion effort, the more costly to deliver the water to the eastern slope. **More importantly, however, this diversion of water for growth in metropolitan Denver comes at the expense of growth on the western slope where the water is.** There is a finite quantity of water in Colorado for the foreseeable future. All of the water in the state is already appropriated. Any permanent diversion and commitment of western-slope water to growth in metropolitan Denver constitutes a deprivation of any prospect of similar growth on the western slope in the future.

Air pollution and water are not the only limiting factors in the growth of metropolitan Denver. There is considerable evidence of other criteria for assessing the optimum size of urban areas. The unit cost of governmental services is one important index; educational quality and public health are others.

The Advisory Commission on Intergovernmental Relations has been studying the comparative costs of government for years. Their studies have shown¹⁴¹ that in urban areas larger than 250,000 the economies of scale tend to disappear and that thereafter per capita services cost more to provide. Beyond that point, the result of increased growth tends to be higher per-capita taxes to provide fewer services than the numbers demand.

Professor R. J. Smeed, one of the world's leading traffic analysts, has specifically shown how this logarithmic rise in need for intensified services reflects itself in highway construction. His studies¹⁴² show that when there are 10,000 commuters in a town, they require eight square feet of roadway per person; 100,000 commuters require twenty-eight square feet of

¹⁴¹ *Size Can Make a Difference, op. cit. (ref. 109).*

¹⁴² *Smeed, op. cit. (ref. 25).*

roadway per person; and 1,000,000 commuters require ninety-seven square feet of roadway per person. Thus, a 100-fold increase in population requires not a 100-fold increase in roadways but a 1200-fold increase in roadways.

Other studies tend to corroborate these showings of higher social costs of environmental degradation, congestion, and public services in larger cities.¹⁴³

The Commission suggests that the accumulated facts indicate that metropolitan Denver has possibly already surpassed her optimum size and may well surpass her ecological carrying capacity within a matter of some twenty to thirty years. It is imperative, therefore, both from the viewpoint of the well-being of metropolitan Denver and also of the economic stagnation of rural Colorado, that the necessary steps be taken now to develop the necessary consensus and understanding to plan for an eventual limitation on the size of metropolitan Denver. The limitation could take the form of a population limitation, an area limitation, a time limitation on further growth, or any combination of these.

As a matter affecting the entire state, the decision to delimit the size of metropolitan Denver, in the opinion of this Commission, can be made only by the State Legislature. The 200-odd governmental jurisdictions in the area are placed in competition with one another for annexation, tax base, rezoning, and water. They could not possibly act in concert on the matter of limiting their respective portions of the metropolitan pattern unless they were directed to do so by the Legislature, as a matter of statewide policy.

These jurisdictions could, however, carry out such a mandate from the Legislature if they were directed to do so and were given the time to work it out. It would require cooperation between the municipalities, acting through the Denver Regional Council of Governments; and it would require action in concert between each metropolitan county and its respective municipalities. The task is not insurmountable if the sense of direction is given by the Legislature.

It will take several years for the jurisdictions to work out their respective problems of the apportionment of the remaining future growth and the demarcation and allocation of

open space between the perimeter of delimited metropolitan Denver and other existing or new towns. The tools for accomplishing this complex task are already at hand. These are zoning, condemnation, purchase, limitations on building permits, limitations on water transfers, and other similar tools -- all current powers at the disposal of every municipality in the state. It will require no new legal concepts, merely the recognition on the part of the General Assembly that the matter has compelling statewide interest and therefore requires special legislation affecting metropolitan areas only.

Limitations of this kind will not mean denial of freedom of mobility to individuals, even after the limitation has been reached. Individuals or businesses determined to locate in metropolitan Denver could rent available empty space, could purchase available space, or could wait their turn for one of the number of building permits given annually for limited growth or renewal purposes.

What is lacking at the present time is the consensus and the will necessary to accomplish such a complex task. Many people do not understand that as long as metropolitan Denver continues to be available for growth, it constitutes an attraction several times as powerful as the attraction of other, smaller towns on the Front Range and that therefore most of the growth of the Front Range will go to Denver; conversely, practically no growth will go to the western slope or the eastern plains as long as metropolitan Denver is available as an alternative.

The Commission urges the Legislature to recognize that the growth of metropolitan Denver has by now become self-generating, inevitable, and almost irreversible, unless positive planning steps are taken now to institute a process of planning as contrasted to predictive accommodation. Daily, in all parts of the state, decisions are being made, shaping the future of this state fifty to one hundred years ahead. We urge the Legislature to serve notice now of its determination to turn present trends into ecologically viable options for the state. Within the framework of a stabilized state population, these choices would include a series of different-sized communities scattered around the state, instead of the one gigantic megalopolis on the Front Range, which, for lack of positive planning, has already been decreed for Colorado.

¹⁴³Edwin S. Mills and Irving Hoch, *Resources for the Future Annual Report 1970*, Washington, D. C.

RECOMMENDATION #12. THE GENERAL ASSEMBLY ENACT ALL POSSIBLE LEGISLATIVE INCENTIVES TO BIRTH-RATE REDUCTION:

- (1) ELIMINATION OF INCOME-TAX DEDUCTION FOR OFFSPRING;**
- (2) MONETARY INCENTIVES FOR STERILIZATION;**
- (3) REMOVAL OF TAX DISCRIMINATION AGAINST SINGLES;**
- (4) TAX INCENTIVES FOR SMALL FAMILIES;**
- (5) REALIZATION OF A NEW ETHIC OF PARENTHOOD.**

Historically, our laws, institutions, and culture have reflected the pronatalism which evolved as a means of survival in a hostile, mysterious environment, during a time when high death rates balanced high birth rates. Plagues, famines, wars, and filth killed adults; and high infant mortality rates meant that a mother who had nine children would be lucky to see one or two reach maturity. However, nineteenth- and twentieth-century medical and scientific discoveries universally improved public health, prolonged life, and lowered death rates. Death control, without birth control, paved the way for today's population crisis.

Our world has changed, and it is essential now that man begin to cope with the population explosion by reversing the pronatalistic policies, attitudes, and patterns. To this end, the Commission believes that new policies consistent with the widely recognized need for population stabilization should be adopted.

One such policy could be achieved through changes in the tax laws, which have historically been instruments of social change in America. For example, people are encouraged to buy homes, employ minorities, purchase municipal bonds, and lend their support to endless other social goals by tax laws. Excise taxes place a premium on pleasure; while other taxes, fines, and penalties are aimed at anti-social conduct.

A limitation of two-child tax deductions -- or their elimination altogether -- would encourage parents to have smaller families, without usurping their freedom of choice. Furthermore, it would establish a policy against having the childless subsidize unlimited numbers of other people's offspring. It would be symbolic of the government's recognition that while child-bearing and family size are a matter of individual choice, small families, as opposed to large families, are in the public interest. Further, it would recognize that

parenthood and family size are more cultural than biological. Although most men and women can become parents, this biological possibility in no way dictates that all of them should become parents. Biological ability is only a small part of the immensely complex, demanding, and important parental role. In making reproductive decisions, there are emotional, psychological, mental, physical, financial, and social considerations, among others, which should be taken into consideration. Yet cultural forces often demand parenthood, especially of women, many of whom might otherwise seek different goals and opt for alternative means of fulfillment. For many women, motherhood is a valid goal; for others, alternative roles are equally valid, even preferable. The acceptance of alternative roles for women would make a substantial contribution to lowering fertility patterns, while at the same time enhancing human dignity. Responsible and voluntary parenthood -- for both men and women -- will better serve the welfare of children, add new perspective to the roles of both women and men, strengthen interpersonal relationships, and contribute to the overall health of families and communities.

Similar considerations have prompted this Commission to recommend the elimination of tax discrimination against single taxpayers. Although such discrimination is not present in Colorado tax laws, it does exist -- and should be eliminated -- at the federal level.

Finally, this Commission recommends a tax incentive for sterilization, as a means of encouraging responsibility in reproduction, a social policy objective without coercion.

RECOMMENDATION #13. THE STATE GOVERNMENT, AND ALL LEVELS OF GOVERNMENT IN THE STATE, GIVE HIGH PRIORITY TO THE FUNDING OF ALL ASPECTS OF FERTILITY CONTROL (CONTRACEPTION, ABORTION, STERILIZATION), INCLUDING THE PROVISION OF SERVICES, EDUCATION, AND RESEARCH IN HUMAN REPRODUCTION.

The historic assumption that man was capable of adapting infinitely to a changing environment dominated his approach to the two greatest environmental forces of the modern age: population growth and technological change. The threatening cloud on our horizon -- the population bomb -- has compelled us to question this assumption.

The individual act of reproduction has, for the first time in history, far-reaching social consequences. It is becoming increasingly evident that we must achieve population stability, at the earliest possible time, by adopting a new ethic of parenthood, which argues a social responsibility for small-family norms. Helping parents to bring their child-bearing patterns in line with their reproductive aspirations is important to the health and stability of individual family units. Encouraging all couples to adopt small-family (two-child) norms is important to the health and stability of all society. Both are functions of education.

Attitudes toward child bearing, sex, parenthood, family, and social responsibility are formed early in life; they generally reflect parental attitudes and cultural atmosphere. At the same time, however, the importance of education in motivation cannot be underestimated. **This Commission feels, therefore, that great emphasis should be placed on education which will raise the level of ecological awareness and concern by helping future generations of parents to understand the demographic and sociological impact of their reproductive patterns.** Such education in population dynamics would address itself to the social, political, economic, biological, ecological, historical, psychological, and ethical determinants and consequences of population growth and reproduction.

Population changes are some of the most important factors determining our progress -- or lack of progress -- toward the high aims of quality of life, environmental integrity, and ecological balance. So long as we are concerned with quality of life, we have no choice but to be concerned with quantity of life. **The decisions which we Americans -- Colo-**

radans in particular -- make about population limitation today will, to a great extent, determine the kind of society and world we live in tomorrow.

Though population growth does not appear to have great importance for our short-term welfare, the point at which it is stabilized will have serious consequences for succeeding generations. Their level of living, and the degree of freedom and dignity possible to them, will depend on the point at which stability is achieved.

The economically advantaged have always been able to exercise options in child-bearing, as well as contraception, abortion, and sterilization. Economic discrimination, in conjunction with fear, ignorance, and cultural patterns, precludes the same advantages to the disadvantaged. **For the poor, methods of fertility control -- and services related thereto -- have not been, and in many instances are still not, available. Using the Dreyfoos-Polgar formula, the estimated need for such services in Colorado is 66,558 low-income women. In 1970, the needs of about 19,113 were served, leaving an unmet need of 47,445.**¹⁴⁴

For reasons described above, the economically disadvantaged often have very large numbers of children per individual family unit, although studies indicate that their child-bearing aspirations are no higher than two-tenths of a child more than the national average of 3.4.¹⁴⁵ Addressing the problem of fertility control requires a two-pronged approach: making fertility-control measures universally available -- irrespective of age, sex, geographical location, or economic status -- so that all Coloradans are able to exercise responsible choice in reproduction, as contrasted to biological accident; further, educating all people to the demographic necessity for small-family norms, and motivating them to limit their procreative patterns.

It is important to emphasize that if the numbers of people in any given unit or social structure -- individual, family, state, nation -- outstrip the human and natural resources needed for their support, poverty is the result; and this cycle of poverty repeats itself. Just as overpopulation in individual family units

¹⁴⁴ Testimony of Robert McCurdy, Chief, Maternal and Child Health Services Division, Colorado Department of Health, before the Population Committee of the Colorado Environmental Commission.

¹⁴⁵ Testimony of Patrick C. Jobs, Assistant Professor, Department of Sociology, University of Colorado, before the Population Committee of the Colorado Environmental Commission.

makes escape from poverty and the ghettos an impossible dream, so overpopulation in states and nations precludes self-determinism and social stability. Therefore, if cities are ever to become better places to live and if environmental integrity and ecological balance are ever to be a reality, man must learn to control his own proliferation.

Beyond its ecological impact, fertility control is recognized to be an important aspect of preventive medicine, as related to the mental, emotional, physical, and social well-being of individuals, as well as the health of communities, states, and nations.¹⁴⁶ It should, therefore, be the right of each new member of the human family to be born to responsible parents, in a society that not only wants but needs him.

Whether the next generation of parents opts for two or three children may well decide the course of history, as well as the environmental issues.¹⁴⁷ Furthermore, whether we like to admit it or not, the young of our state and the nation are getting a tremendous amount of negative education from movies, magazines, books, and other sources in which sex is associated with violence and perverse behavior. The soaring rates of increase in venereal disease, sex crimes, illegitimacy, battered children, and divorce would certainly argue the need for a positive balance of reasoned, accurate, appropriate information to be provided through the schools and the mass media.

In order to help prepare the young to meet the challenge of the future, the Commission strongly urges the General Assembly to encourage the institution and development of vastly augmented health-education programs in all public schools in Colorado, including curriculum development and teacher training. (Health is defined as mental, physical, and social well-being, not merely the absence of disease.) Special emphasis should be placed on responsible parenthood and small-family norms.

By passing Senate Bill 230 during the 1971 session, the Colorado Legislature established an important precedent by making it part of public policy that all members of society have access to medically and aesthetically sound birth-control methods. **We urge the immediate**

implementation of this legislation by public and private institutions encompassed by its provisions to assure that all members of Colorado society -- irrespective of age, sex, economic status, or geographic location -- have access to effective methods of birth control and accurate information concerning human reproduction.

In addition, this Commission further recommends that the General Assembly provide matching monies adequate to meet the provisions of any federal programs which serve to provide services and/or research in fertility control.¹⁴⁸

¹⁴⁶ See report of President's Committee on Mental Retardation, MR 68--The Edge of Change, p. 24, Superintendent of Documents, Washington, D. C.

¹⁴⁷ See Figure 3, p. 12.

¹⁴⁸ HR 19318, Family Planning Services and Population Research Act of 1970, PL 91-572, Superintendent of Documents, Washington, D. C.

RECOMMENDATION #14. COLORADO ADOPT AS LEGISLATIVE POLICY THE PRINCIPLE THAT ABORTION IS A MATTER BETWEEN A WOMAN AND HER PHYSICIAN.

Economic discrimination, ignorance, and method failure are all contributing factors in illegitimacy¹⁴⁹ and unwanted births.¹⁵⁰ Punitive, restrictive laws compound these problems by compelling the unwilling to bear the unwanted.

By precluding to the indigent and medically indigent the option of free or inexpensive legal abortions, the State is denying these women an opportunity for self-determinism through control of their fertility.

Expensive, demanding, time-consuming requirements impose unreasonable and unnecessary hardship on women who are desperate -- not psychotic. That a simple medical procedure should be turned into a hazardous, clandestine, and sometimes criminal procedure is not consistent with an ethic of humanitarian concern. As expressed by the Group for the Advancement of Psychiatry: "There can be nothing more destructive to a child's spirit than being unwanted, and there are few things more disruptive to a woman's spirit than being forced, without love or need, into motherhood."¹⁵¹

It is this Commission's strong conviction that no woman should be forced to bear a child against her will. In the interest of the child, the mother, and society, it is imperative that abortion be recognized and treated as a responsible alternative to compulsory pregnancy. In this sensitive medical and moral area, where people of differing religious persuasions, equally concerned about the sanctity of life, reach different conclusions, the law should permit each woman to make her own medically guided decision on abortion or parenthood. Furthermore, the State should provide adequate funding, personnel, and facilities to eliminate the economic discrimination which presently exists.

Dr. Brandt Steele, renowned authority on battered children, made the following observation: "Unwanted, unloved, abused, neglected,

and failure-to-thrive infants may die or they may be permanently damaged physically or intellectually. The exposure in infancy and childhood to parental aggression and disregard may lead to antisocial behavior. Studies show that a majority of first-degree murderers and approximately seventy-five percent of juvenile offenders have such backgrounds."¹⁵²

This Commission strongly urges that the General Assembly of this state revise the existing abortion statute to make abortion an unencumbered private decision between a woman and her doctor, providing also that the opportunity and facilities for medically safe, legal abortions be made easily available to all women in Colorado, irrespective of geographic area or economic status.

¹⁴⁹ McCurdy, *op. cit.* (ref. 115): "Approximately 9-1/2% of all Colorado births are illegitimate."

¹⁵⁰ *Ibid.*, citing the Westoff Study, to indicate that one-fifth of all births were unwanted at conception.

¹⁵¹ *Menninger Perspective*, October/November 1970, p. 12, The Menninger Foundation, Topeka, Kansas.

¹⁵² Professor of Psychiatry, University of Colorado School of Medicine; and Chief, Psychiatric Liaison Division, University of Colorado Medical Center, Denver, in a statement before the State Affairs Committee of the Colorado Senate, 1971.

See also, J. Salten, K. Menninger, I. Rosen, and M. Mayman, "Murder without Apparent Motive," *American Journal of Psychiatry*, 117:48-53, 1960.

See also, G. M. Rimean, S. H. Frazier, E. M. Litin, S. M. Johnson, and A. J. Barron, "Etiological Factors in First Degree Murder," *Journal of American Medical Association*, 168:1755, 1958.

WATER PLANNING AND POLICY

RECOMMENDATION #15. THE GENERAL ASSEMBLY ADOPT MEASURES TO ESTABLISH A STATE WATER-MANAGEMENT POLICY THAT WOULD:

- (1) COORDINATE WATER-RESOURCE MANAGEMENT WITH LAND-USE PLANNING, NATURAL-RESOURCE MANAGEMENT, POPULATION POLICIES, AND ENVIRONMENTAL POLICIES;
- (2) ESTABLISH OPTIMUM PRACTICAL WATER-CONSERVATION PRACTICES AND EFFICIENT UTILIZATION OF WATER TO ASSURE ADEQUATE SUPPLIES FOR ALL TYPES OF WATER USE;
- (3) PROTECT THE QUALITY OF THE STATE'S WATERS THROUGH EFFECTIVE WATER-POLLUTION CONTROL MEASURES.

With water being such a critical factor in Colorado's future, we urge that this resource be managed so as to attain statewide long-range goals. In particular, policies on water management should be coordinated with policies on land use, natural-resource management, and policies on population and environment.

Water is a key in determining the economic and demographic future of the state, and proper management is vital if state goals relative to population growth and economic development are to be realized.

Some of our recommendations here will require legislative action. In a broader sense, it is probably time to reexamine our water laws to see if they are in harmony with the needs of the future. Fundamental, even constitutional, changes may be in order.

Water Management and Conservation

Because water is a finite resource in Colorado, effective management of its use is very important. In addition to present laws applying to the administration of water, improved management should be provided through statutory direction for river-basin management in each river basin in the state. Each basin should be sub-districted to facilitate administration and management of water, with the State Engineer being the chief administrator of the total system, if existing entities default their responsibility for management.

Water must be recognized as a key resource in a complex water-use system. Ade-

quate supplies must be assured for three basic types of use. These are:

1. Consumptive Use

This is complete consumption of water for agricultural, domestic, municipal, and industrial purposes (actual withdrawal of water is usually much greater than consumption). As population increases, consumptive use will increase, and the tendency is for agricultural water to be diverted to municipal/industrial uses. Likewise, we tend to "steal" water vital to stream-flow and on-site uses.

2. Stream-Flow Uses

A certain amount of water is required to maintain adequate stream flow for maintenance of fish habitat, wildlife support, recreation, power generation, interstate compact commitments, and waste carriage and disposal. In Colorado, these are uses critical to environmental quality, and the water supply for these needs must be protected against the increasing demands of consumptive use.

3. On-Site Uses

On-site waters in Colorado include many lakes, especially in the mountains, and marshlands vital to wildlife support. Preservation of these uses is vital to environmental quality.

We, therefore, recommend the enactment of a minimum-flow provision to existing water laws so as to prevent total appropriation of stream flow to the detriment of fish and wildlife habitat. In the same manner, on-site water needs should be defined and protected. Existing statutes should also be amended to include stream-flow and on-site uses as beneficial uses of water.

Fundamental to effective water management is an accurate inventory of water resources. Engineering studies now underway should be given sufficient priority and adequate funding so that an accurate picture can be developed of all hydrologic regimes in all river basins. Such a study should encompass both surface-water flow and underground systems. Mathematical modeling of entire basins should follow. Only in this way can the most beneficial and efficient uses of our waters be assured. It will be invaluable in determining the part water should play in directing Colorado's future, even to defining the limits of population and economic development in the state.

We recommend that effective water management encompass the following additional features:

Measurement of Water

All water should be measured as accurately as possible. All water rights should be measured in the same terms. The determining factor in the amount of water to which users have rights should be the average yearly historic use as adjusted by irrigation requirements.

Administration of Wells and Tributary Aquifers

Because virtually all surface decrees are senior to diversions from underground sources, well owners should be responsible for the satisfaction of these senior decrees, but only up to their average historic diversions as adjusted by irrigation requirements. Once these senior decrees are satisfied, wells should be free to use all the average annual recharge of the underground aquifers, according to priorities among wells. All well administration, however, should be subject to examination for its long-term ecological impact.

Return Flow

The use of water is rarely entirely consumptive. A part, quite often a very large part, of the water diverted is returned, after use, to the streams and aquifers. The quality of return flow should be such that it does not preclude subsequent beneficial use of the water or injure the stream ecology.

Augmentation of Water Supplies

Research efforts should be continued on means of augmenting water supplies by weather modification and water recycling. The General Assembly should also amend the existing law relating to weather-modification licensing to provide more comprehensive control of these operations. Specifically, there should be an environmental impact statement required on all modification efforts before any permit is granted. This impact statement could be filed with the Environmental Quality Council or Commission described in Recommendation #1.

Diversion of Water

We urge the General Assembly to statutorily halt any further diversion of water from one basin to another in Colorado until the statewide environmental implications of such diversions are examined objectively by an agency charged with such examinations, such as the Environmental Quality Council or Commission described in Recommendation #1.

Dams, Channels, and Flood Plains

Dams are usually constructed for conservation purposes, flood control, water diversion, or hydroelectric power generation. Such structures are bound to have an impact on the ecological systems along streams. We recommend that before dams are built or channels of streams are altered, the long-range environmental impact be determined by some agency such as the Environmental Quality Council or Commission described in Recommendation #1.

Of particular concern is the encroachment of human activity on the flood plains of streams. We, therefore, recommend that criteria be established for defining flood plains and that standards be set for regulating encroachment.

Flood plains should be preserved as greenbelts, recreation areas, and nature preserves, with the use of proper flood-control measures; dams should not be built solely to allow floodplain encroachment. Damage to watersheds upstream increases the potential for flooding downstream. Thus, proper regulation of land use in the headwaters is vital if flooding is not to increase.

Colorado State Water Plan

The Colorado Water Conservation Board, under its delegated legislative authority, initiated steps in 1970 leading to the formulation of a **State Water Plan**. In fiscal year 1970, federal funds were budgeted by the Bureau of Reclamation for making the study.

Although this is a cooperative effort between the Bureau of Reclamation and the State of Colorado, the Bureau has primary responsibility for the study. Work will be accomplished in three regional offices: (1) Salt Lake City, (2) Denver, and (3) Amarillo. The final report is due in 1974. Stated objectives for the study are:

1. Compilation of statistics on, and an inventory of, the natural resources of the state and the current status and development and use of these resources;
2. An in-depth review of the legal and institutional considerations which have and will govern the development and management of water and related resources;
3. Development of a plan for determining the best manner by which water requirements for the projected distribution of population and economic activities might be met with supplies available to the state under existing interstate agreements, court decrees, and potential augmentation.

This is primarily a federal study. However, if properly conducted, it could be invaluable in developing state water policy and in providing efficient water management. It is important, therefore, that the State of Colorado exert every effort to assure that this study produces that information so vital for future plans.

Protection of Water Quality

The General Assembly has established the Water Pollution Control Commission as a water-pollution regulatory agency in the Department of Health. That commission has been doing an excellent job in cleaning up the waters of the state. In order to make their work even more effective, we recommend that the following additional authorities be provided to them:

1. **Enforced establishment of sanitation districts in areas where septic-tank systems are numerous and malfunctioning:**

Presently, the Water Pollution Control Commission has the authority, after a hearing, to designate areas as being unsuitable for septic-tank systems, but it does not have authority to force or encourage installation of municipal-type sewer systems.

2. **Requirement for consolidation of sanitation districts, where feasible and economical, into fewer and larger districts.**
3. **Establishment of a state sewage and/or industrial-waste permit system:**

Colorado is one of three states in the nation that does not now require a permit for discharges into streams or tributaries thereof. Such a permit system should greatly enhance our water-pollution enforcement program. A permit system should also provide a sufficiently severe penalty for noncompliance, in order to be effective; this penalty could be similar to the Corps of Engineers penalty of \$2,500 per day, or six months' imprisonment.

4. **Certification of waste-water and sewage-plant operators:**

The Water Pollution Control Commission feels that every waste-water and sewage plant should be under the direction of a certified or licensed operator, in order to assure proper and efficient operation. It is recommended that the water-pollution control laws be amended to allow the Water Pollution Control Commission to appoint a certification board, whose duty it would be to examine waste-water and sewage-treatment operators for certification purposes.

5. **Provide authority for the Water Pollution Control Commission to establish effluent standards:**

Presently, the commission can invoke effluent standards only when stream standards are violated. Effluent standards would allow control of effluent at the source and would force the highest standards compatible with type of discharge and present control technology. Furthermore, the federal government is proceeding to prepare effluent standards for specific industries. Once these federal standards are established, it is likely that states will be required to adopt similar standards in order to receive federal assistance for their programs.

6. **Allocation of sufficient funds to underwrite sewage plant construction:**

Colorado could have its Federal Sewage Construction Grant increased from thirty-three percent to fifty-five percent if the State also had a twenty-five percent grant program. With a twenty-five percent grant from the State and a fifty-five percent grant from the federal government, the cost to a municipality or sanitation district would be reduced to twenty percent of the total cost of constructing waste-treatment facilities. In the coming years, it is estimated that construction of waste-water treatment facilities will average \$7.5 million per year. We recommend that the State allocate, over the next ten fiscal years, the \$1.875 million-per-year state money required to obtain the federal grants for this program.

All of the additional authorities described above have already been cited by the Federal Water Quality Control Administration as deficiencies in the Colorado water program.

LAND PLANNING AND POLICY

RECOMMENDATION #16. THE GENERAL ASSEMBLY CONVERT THE PRESENT LAND USE COMMISSION INTO A PERMANENT LAND-USE REGULATORY AGENCY AND GRANT IT THE ADDITIONAL AUTHORITY IT NEEDS TO BE SUCH A REGULATORY AGENCY.

Colorado is one of the fastest growing states in the United States. People from all parts of the United States are coming here to live permanently or to develop second homes for recreational purposes. This has resulted in a land boom of gigantic proportions all over the state.

There has been reliance in the past on county and municipal regulations with respect to land purchase and development. This was acceptable while populations were small and communities were spread far apart, land development was slow, zoning changes and annexations were infrequent, and the environmental impact of development was slight.

Conditions have changed today. Colorado is now an urban state, projected to have four million people within the next thirty years. Along our populous Front Range, hundreds of governmental service jurisdictions have been created, with questionable tax bases and overlapping authorities. There has been little recognition, in this rapid development, of the geological and engineering constraints of present and potential land slides, mud slides, and avalanche areas; swelling and settling soil areas; unstable, steep slopes; fractures, faults, and earthquake-prone areas; subsidence of land due to withdrawal of waters and minerals. Neither has there been adequate recognition of the geological problems in septic-tank pollution, mine tailings, solid-waste disposal in landfill and gravel-pit areas, and sanitary water availability. The environmental impact of these developments, most notable in the mountain communities, has created regional and statewide recognition of the need for protective controls.

The Commission recognizes that there is need for much greater emphasis on the use of the geological and engineering sciences in research and mapping of hazardous areas in which developments are taking place. The General Assembly created the Land Use Commission in 1970, but thus far has limited its authority primarily to non-regulatory functions. Thus the State has given strong regulatory control over air and water pollution but has

not yet created a compatible and coordinating agency over land use to work with these other control agencies for the best interests of all the people of Colorado.

The Commission believes that it is now time for a permanent state-level land-use regulatory agency, on a par in authority and stature with the Air Pollution Control Commission and the Water Pollution Control Commission, to be created. Such an agency regulating statewide land use would work with local governments and regional planning commissions. It should set minimum standards and criteria, together with regulations for their implementation, to guide the land-use patterns of this state in the future. These standards and criteria should be carried out through regional planning commissions, with a review and appeal authority in the State Land Use Commission. The Commission urges that the General Assembly grant the Land Use Commission the following types of authority:

1. Statewide master land-use planning, into which regional and local land-use planning would mesh;
2. Flood-plain use criteria and minimum standards;
3. Geological and engineering criteria and minimum standards;
4. Performance-bond and construction-guarantee criteria and minimum standards;
5. Planning and zoning criteria and minimum standards;
6. Variance criteria and minimum standards;
7. Planned-unit-development criteria and minimum standards;
8. Criteria for the evaluation of optimum size and land-development carrying capacity of communities;
9. Mobile-home development criteria and minimum standards;
10. Open space and conservation criteria and minimum standards;
11. Land-sale notice and prospectus criteria and minimum standards;
12. Highway strip-development criteria and minimum standards;
13. Criteria for multiple land-use for the recovery of mineral resources, such as gravel, or other economic utilization of land for landfill, recreational facilities, or building sites;
14. Mine-reclamation and strip-mining criteria and minimum standards;
15. Methods to protect prime agricultural

land, together with incentives to promote agricultural and open-space land utilization;

16. Building-codes criteria and minimum standards;
17. Hearings and appeals authority;
18. Cease and desist authority in instances of non-compliance with minimum state standards.

RECOMMENDATION #17. THE GENERAL ASSEMBLY ASSIGN RESPONSIBILITY FOR THE COORDINATION AND DEVELOPMENT OF NEW COMMUNITIES IN COLORADO.

If recent trends continue, the state's population will be doubling, to four million, in approximately thirty years. Thus, the state will have to accomplish as much in thirty years as it has accomplished in the last one hundred years. We should be planning and preparing now for this huge task.

Each community in Colorado should be preparing plans for the additional population it will be serving in the very near future. This means, in many instances, provision for new community additions almost the size of the present communities. In some instances, additionally, it means the planning of entire new towns.

Many communities in Colorado are not prepared for this type of planning. They will need the assistance of the State Government. The General Assembly should formulate and adopt a State New Community Development Policy, with an effectuating agency and programs. Such an agency and its programs should plan and coordinate the development of new communities and new towns with other state policies on population, rural revitalization, land use, and water management.

The basic consideration in the formulation of this policy must be the restoration and preservation of the quality of Colorado's natural and human environments through combined government-and-private action for new communities. The policy should consider population growth and distribution, natural-resource and economic development, geological problems, agriculture, transportation, housing, health, education and welfare, parks and recreation, land use, flood-plain and conservation areas, etc.

A major focus of the policy must be to relieve growth stresses acting in metropolitan areas by promoting new-community development in other areas of the state having need and potential for growth. To be successful, the policy must foster the creation of healthful, safe, stimulating, viable, and efficient new communities which are responsive to the needs and aspirations of all their citizens, regardless of age, sex, race, or creed. The policy offers an opportunity for a fresh start in municipal affairs by the planning of new quality communities of optimum size, designed to meet the needs of their citizens.

TRANSPORTATION PLANNING AND POLICY

RECOMMENDATION #18. THE GENERAL ASSEMBLY CREATE A DEPARTMENT OF TRANSPORTATION AS A PRINCIPAL DEPARTMENT OF STATE GOVERNMENT, WITH THE EXISTING HIGHWAY DEPARTMENT AS A DIVISION. INCLUDED WITHIN ITS JURISDICTION WOULD BE:

- (1) PLANNING, CONTROL, AND COORDINATION OF ALL FORMS OF TRANSPORTATION;**
- (2) COORDINATION OF TRANSPORTATION WITH OTHER AGENCIES TO MINIMIZE ENVIRONMENTAL DEGRADATION.**

It is necessary that the State of Colorado think in terms of total transportation systems rather than highways as the form of transportation. Until and unless the State of Colorado has comprehensive transportation planning, and has this as the function of a division or department of state government, all recommendations relative to transportation are moot.

The people of Colorado are highly dependent on the automobile as the primary mode of transportation. Few Colorado cities have municipal bus systems or other forms of mass transit; there is very little intercity bus or rail service. At one time, both mass transit in Denver and intercity bus and rail transportation may have been adequate; these forms of transportation were allowed to deteriorate in favor of an automobile/highway system. Per capita ownership of automobiles in Colorado is among the highest in the United States. Yet, a large number of Colorado citizens, notably elderly, poor, and minority groups, would depend on means of transportation other than the private automobile if it were available. Currently many of these people may have no means of transportation. We need to develop a completely balanced transportation system throughout the state.

Colorado also has a growing air-pollution problem, especially in the major urban areas. Automobile exhaust is the major contributor to air pollution, including irritation and un-aesthetic photochemical smog. Thus, the more heavily we depend on the private car for transportation the more cars there are on the road and the more polluted the air becomes. We must break out of this vicious cycle of autos/highways/air-pollution. **Transportation in Colorado must be viewed as one integrated function.**

State funds for transportation are spent almost exclusively on highways. This situa-

tion places an unusual burden both on the resources and decision-making processes of the State. A disproportionate share of the State's resources go for highway construction simply because there is little alternative form of transportation to the automobile. The expenditure of funds and resources almost exclusively for highways perpetuates the heavy dependence on the automobile. The Colorado Department of Highways, whose sole mission is highway construction and maintenance, has the second largest expenditure rate among the seventeen departments of state government. The decision-making process ultimately becomes self-defeating: lack of alternate modes of transportation leads to the need for more automobiles and more highways, and thus for more highway construction and widening and the dedication of more highway-user monies to highway construction, at the expense of other modes of transportation. It is necessary that the people of Colorado think in terms of total transportation systems, rather than highways as the one form of transportation. It may be more important in some instances to create an airport than a highway.

We are thus recommending the creation of a Department of Transportation, with the following features:

1. Planning, control, and coordination of air, bus, highway, rail, and other forms of transportation.
2. Transportation planning to include consideration of environmental factors, coordination with the Environmental Quality Council or Commission proposed in Recommendation #1, and that transportation planning be consistent with state policies on population growth and distribution.
3. Improvement of non-automobile mass transportation, including inter- and intra-city transportation and transportation to recreation areas.

The present highway department should be transferred into such a new transportation department. Its powers and duties should require consideration of other forms of transportation -- special bus, bicycle, and equestrian lanes -- in all highway construction. Requirements for the consideration of environmental factors -- including aesthetics, noise reduction, and tree planting -- should be incorporated into the cost of highway construction.

The Commission feels that the creation of a new transportation department is an indispensable step toward a future state environmental protective system and retaining control of the future.

RECOMMENDATION #19. THE GENERAL ASSEMBLY TAKE CONSTITUTIONAL ACTION TO CONVERT THE HIGHWAY USERS FUND TO A TRANSPORTATION FUND, WITH INCREASED AND NEW INPUTS TO THE FUND AND WITH THE PURPOSE OF THE FUND BEING STATEWIDE TRANSPORTATION SYSTEMS. NEW FUND INPUTS WOULD INCLUDE TAXATION OF THE AUTOMOBILE IN PROPORTION TO THE AMOUNT OF ITS POLLUTANTS.

All transportation-based revenues in Colorado are constitutionally dedicated. The revenues flow into a Highway Users Fund which is used solely for highway construction for motor vehicles.

At the time of its creation, the Highway Users Fund made good sense. The state was in need of highways for transportation and communication. The logic of the creation was that those who use the highways should pay for them; and, conversely, that taxes on gasoline and other forms of automobile ownership should not represent a hidden funnel of money into the general fund, but should only be used to support a governmental function which benefited the highway user directly. Now, some thirty-five years after initiation of this concept, it bears some re-examining.

Highways are not uniformly financed from the Highway Users Fund. Testimony before the Commission indicates that while state and federal highways are financed primarily by this fund, city and county roads are paid for largely by non-automobile-generated funds. In Boulder County, for example, sixty-one percent of the funds spent on county road right-of-way, construction, and maintenance is property-tax revenue; only thirty percent of these funds are automobile-generated revenue. While it is true that all automobile owners and gasoline users pay revenue which is used for highways, this revenue is not used for all highways in equivalent proportion. In fact, the predominantly urban highway user -- the person whose driving is mainly in the city and to and from work -- is subsidizing the user of state and federal highways -- the long-distance traveler, the tourist, the trucker. The Highway Users Fund can thus amount to a subsidy of the middle- or upper-income tourist, who uses state and federal highways to travel long distances, by the lower-income city dweller who buys gasoline for his car primarily to go to and from work in the city.

In 1935, when interstate and intrastate roads were very poor and there were too few of

them, it made a great deal of sense to designate sizable tax revenues for highway maintenance and construction. There is a growing awareness now that a highway is not an unmitigated blessing, but causes marked and irreversible environmental destruction; there are a growing number of instances in which there has been massive public opposition and questioning of construction, location, or widening of a highway. All this points to a public questioning of the ethic that if some highways are good, more are better; and if two lanes are good, four must be superior. Most important, the realization that the automobile is the prime cause of air pollution is resulting in a de-emphasis on the individual automobile as the major means of transportation and a realization that other modes of transportation must not be allowed to die. The Highway Users Fund provides a direct subsidy for one means of transportation which other modes do not now have.

The need now is for a greater expenditure of the public dollar on public transportation and common carriers, and less on highways. As long as the Highway Users Fund exists in its present form, all money collected from automobile operation -- even new revenue collected as a "tax on pollution" -- is constitutionally committed to promotion of automobile use at the expense of any other mode of transportation. The past decade has demonstrated that, except in a few major cities, investor-owned public transit systems cannot compete with the automobile, the highway, and city streets. In order to revive urban public transit and interurban common carriers, we must commit revenue to their development. Until such systems are operating efficiently and attracting a sizable proportion of the traveling public, they will not be able to pay their own way. Unless they are encouraged, we will be trapped in the vicious circle of more highways, increasing automobile use, increasing smog, increasing automobile taxes, and thus more highways.

A vehicle powered by an internal-combustion engine pollutes in direct proportion to its engine displacement, weight, and power, and in approximate inverse proportion to gasoline mileage, if the engine is properly tuned. Colorado already taxes the weight of the vehicle. An additional tax on any one or combination of these additional factors would be effectively a tax on pollution. It is recommended that the tax be in proportion to the automobile power-to-weight ratio. The Commission recommends that legislation be enacted to tax

vehicles for pollution emission and recommends further that revenues from this type of tax be used to promote anti-exhaust-pollution measures of all types. The revenues could be placed in the new transportation fund.

The most direct tax on exhaust pollution is a tax on gasoline. As long as this goes only for highways, the purpose of its use as an anti-pollution tax is defeated. Under the present Colorado Constitution, the purpose of any other "pollution tax" would be defeated by the same means. The Commission therefore recommends that the Colorado Constitution be amended to convert the Highway Users Fund into a transportation fund, the purpose of which would be the promotion of a planned statewide transportation system, consistent with state policy on population growth and distribution and including all forms of transportation. Current taxes for highway purposes should be increased, and new inputs to the fund should be developed. All revenues for the fund should then be used together to develop an integrated state transportation system serving all parts of the state. The use of this fund could be set up on a "local-option" basis.

When this is done, new forms of pollution tax can be developed to place the burden of cleaning up pollution on those who pollute.

RECOMMENDATION #20. THE USE OF MEANS OF TRANSPORTATION OTHER THAN INDIVIDUAL AUTOMOBILES BE ENCOURAGED WITHIN CORE-CITY AREAS, AND THAT CONSIDERATION BE GIVEN TO PROHIBITING INDIVIDUAL INTERNAL-COMBUSTION-POWERED VEHICLES WITHIN DESIGNATED CORE AREAS.

Consideration should be given to banning automobiles from selected core-city areas, as a means of encouraging other forms of transportation. Such a ban would not apply to limited-access highways where they might be part of the core-city area. Designation of a "core-city area" could depend on a number of factors; for example, any area of a city or other population center in which the ambient carbon-monoxide level exceeds the standard set by the Environmental Protection Agency to protect the general welfare. Within such an area, streets would be closed to all motor vehicles except mass-transit vehicles, trucks, and emergency vehicles.

Efficient and inexpensive mass transit within a core city should progress outward from the core in ever-widening circles. Eventual development of a good radial system from the core to outlying parts of the metropolitan areas would result in use of individual automobiles only in outlying suburban areas.

AIR PLANNING AND POLICY

RECOMMENDATION #21. THE GENERAL ASSEMBLY BROADEN THE AUTHORITY AND FUNDING OF THE AIR-POLLUTION REGULATORY FUNCTION IN THE DEPARTMENT OF HEALTH.

The Colorado General Assembly has instituted an air-pollution regulatory mechanism in the Department of Health: the Air Pollution Control Commission and its Air Pollution Variance Board. This mechanism, together with the Air Pollution Control Division of the Department of Health, is working at its tasks and is fairly well funded for its tasks for the current year.

The Commission recommends that this regulatory mechanism be broadened in authority and funding, over the next year or two, to take on these additional responsibilities:

1. Establish stationary-source siting regulations to assure that pollution dispersal is kept at a minimum, considering size of plant, meteorological conditions, type of fuel used, and transportation.
2. Require owners of stationary sources to install, maintain, and use instrumentation

to record emissions data and report to the State.

3. Require owners of stationary sources to construct and maintain the facilities necessary for the sampling and testing activities of the Air Pollution Control Division of the Department of Health.
4. Require owners of stationary sources to conduct performance tests, at their own expense, to determine compliance with emission-control regulations.
5. Establish motor-vehicle-inspection regulations which would allow the carrying out of a systematic program of inspection and testing of motor vehicles on a regular basis, in order to enforce compliance with applicable federal or state emission standards, including requirements for effective depolluting mechanisms.
6. Prevent the addition of new sources of stationary air pollution which would endanger or prevent maintenance or attainment of the applicable ambient air-quality standards.

The addition of these types of authority will enable the State to keep moving ahead in its program of air-pollution control.

ENERGY PLANNING AND POLICY

RECOMMENDATION #22. THE GENERAL ASSEMBLY ESTABLISH A GOVERNMENTAL/INDUSTRIAL/ACADEMIC/PRIVATE-CITIZEN COMMITTEE TO DEVELOP A STATE ENERGY POLICY AS SOON AS POSSIBLE. GOALS OF THE COMMITTEE WOULD BE TO:

- (1) CONSTITUTE AN ENERGY ADVISORY BOARD TO CONTINUALLY REVIEW THE POLICY.**
- (2) PROVIDE MEANS FOR SUPPORT OF RESEARCH TOWARDS THE DEVELOPMENT OF ENERGY SOURCES TO THE MAXIMUM EXTENT POSSIBLE.**

At present no one is responsible for determining how much energy, derived from what processes and with what effects upon the environment, the state needs now and in the future. Private industry has only one logical concern: economic return. Public utilities are meeting only those public needs for which they are certificated, and at the same time causing such public injury as air and water pollution.

The state is in need of an energy policy, which should result from study of each energy source: nuclear fission, fossil-fuel combustion, hydrogeneration, direct gasification of coal, magnetohydrodynamics, waste heat, incineration of wastes. Attention must be directed to the by-products of electric power generation. An improved means of handling radioactive wastes must be discovered.

The rate-making authority of the Public Utilities Commission should be studied so that conservation of fuels and electric power would be made desirable. An incentive should exist for conservation of electricity. Anti-pollution and land-preservation efforts should be rewarded.

The State should ensure that its tax structure is revised to maximize state revenues from natural resources taken from state lands.

The federal government should be petitioned to develop an integrated energy policy.

A State Energy Advisory Committee would do the following: maximize the thermodynamic efficiency of energy and power sources; conserve the use of power; minimize the undesirable effluent and waste resulting from the use of power sources; create an overall energy-use and power-generation policy; encourage the development of fast breeder nuclear-reactor as a power source; encourage the development

of magnetohydrodynamic power sources; encourage the use of incinerable wastes for power production; discourage advertising the sale of highly polluting fuels; encourage the development of low-polluting fuels.

Hydropower remains a severely limited energy source because there are only a limited number of dam sites available, and because in areas of heavy stream erosion, like the West, a large dam is estimated to have a lifetime of 100 to 125 years. While there is no undesirable effluent associated with hydropower and use is made of an energy source which would otherwise go totally unused, there are many undesirable environmental effects associated with construction of hydro dams.

Magnetohydrodynamic power generation (MHD) is fifty-five to sixty percent efficient, or about one and one-half times as efficient as conventional fossil-fuel power generation. The energy source for the MHD process is coal, and the process is such that virtually all particulate effluent must be trapped and recovered. Technical problems which remain to be solved are comparable to those in nuclear power generation and good effluent control of coal-fired plants. MHD is much closer to operable reality than solar power. The primary reason for encouraging MHD is its thermodynamic efficiency.

It is estimated that any community can produce about five percent of its total heat or power needs by incineration of wastes. Even this small percentage is better than nothing, and use of incinerable wastes for this purpose is definitely in keeping with wise resource use, and should be investigated. Similarly, the use of electric power for direct heating represents such a large wastage of fuel-heat content that it should be avoided. The efficiency of any direct heating process should be maximized wherever possible by good insulation as well.

One method for more efficient use of natural gas is the transfer of the gas by pipeline across state lines for regions experiencing varying seasonal demands. Instead of trying to equalize seasonal power loads by encouraging unnecessary power use in a given area, equalization of load by transmission must be realized. Even diurnal variations could be smoothed out by transmitting across time zones. This recommendation is only one more

facet of an overall national energy-use and power-generation policy.

In order for the State of Colorado to develop all known energy sources to the maximum extent possible, it is necessary that funds be made available from both the state and federal governments. This activity is mandatory from an environmental aspect as well as for conservation of worldwide energy resources.

Establishment of the energy committee need not result in the addition of another permanent agency to the state structure. This could be a temporary study body, with a limited lifetime. Alternatively, it could be one of the tasks taken on by the Environmental Quality Council or Commission proposed in Recommendation #1.

ENVIRONMENTAL HEALTH PLANNING AND POLICY

RECOMMENDATION #23. THE GENERAL ASSEMBLY EXPAND THE AUTHORITY AND FUNCTIONS OF THE COLORADO DEPARTMENT OF HEALTH.

The Colorado Department of Health is the state's primary agency for the protection of the health of her citizens. The department has made excellent use of the authority which has been granted to it, but it is lacking in certain powers. The Commission recommends that the Department of Health now be granted the following additional authority:

1. Designation as the State Central Environmental Testing Laboratory;
2. Regulation of the transportation of hazardous materials in intrastate commerce;
3. Regulation of the use of radioactive material in construction;
4. Licensing of medical radiologic technologists;
5. Implementation of environmental-health programs at all levels of government;
6. Encouragement of the development of health-education programs in the curricula of institutions of learning, emphasizing health as a community responsibility.

We would urge that the department be granted these additional authorities over the period of the next few years.

RECOMMENDATION #24. THE GENERAL ASSEMBLY AMEND THE CURRENT STATE RADIOACTIVE WASTE POLICIES TO PROVIDE BETTER CONTROL OF RADIOACTIVE-WASTE ACTIVITIES.

The General Assembly should amend the current state policies on radioactive wastes, as expressed in Articles 26 and 28, Chapter 66, CRS 1963, as amended, to reflect the following considerations:

1. That all applicants for licenses to establish radioactive-waste disposal areas should be required to file an environmental impact statement with the proper authorities, as suggested in Recommendation #1.
2. That more rigid stipulations should be enacted as to the permanent and perpetual care and maintenance of radioactive-material disposal sites.
3. That all fine-and-penalty provisions relating to the storage and disposal of radioactive wastes should be in proportion to the magnitude of the offense and the consequences.
4. That the licensing procedures for radioactive-waste disposal sites should set forth more specific criteria for applicants to meet. The burden should be statutorily placed upon the applicant to prove his proposed operations safe and reasonable in all respects, rather than have the burden lie with the State to show proposed operations hazardous.

RECOMMENDATION #25. THE GENERAL ASSEMBLY AMEND THE CURRENT STATE PESTICIDE POLICY, TO INCORPORATE PERMANENTLY INTO THE LAW THE CHANGES TEMPORARILY PUT INTO PRACTICE BY THE AGRICULTURE COMMISSION.

The General Assembly should amend the current State Pesticide Policy, as expressed in Articles 1, 12, 14, and 18, Chapter 6, CRS 1963, as amended, to permanently incorporate into the law the changes currently being practiced by the Department of Agriculture. These changes are:

1. Control over pesticide and agricultural-chemical use consolidated in a three-man board composed of the directors of health, agriculture, and natural resources; and
2. A scientifically qualified advisory board to assist this three-man panel in the development and implementation of pesticide and agricultural-chemical regulations.

The existing statutory advisory board should be abolished in favor of the new scientific advisory board; its members should be selected from as broad a spectrum of public interest as possible. All uses of pesticides and economic poisons, including those used domestically and those aimed at predator control, should be brought under the purview of this new three-man panel.

RECOMMENDATION #26. THE GENERAL ASSEMBLY CREATE A COUNCIL WITH THE AUTHORITY TO INSPECT OPERATIONS OF POTENTIAL HAZARD TO THE PEOPLE OF COLORADO.

The Commission finds a great need for some state authority to have the right to inspect operations of potential hazard to the citizens of Colorado. The current hazards in Colorado cut across the lines of our present operating departments. We therefore recommend:

1. That the General Assembly provide for a council of qualified authorities, to be appointed by the Governor of the State.
2. That such a council have, at their own discretion, the right to inspect any and all operations which they deem potentially hazardous to the people of the state.
3. That such a council have the authority to constantly monitor such operations and to take whatever action is necessary to protect the people of the state.
4. That such a council have authority for without-notice-visitation to any potential health hazard within the boundaries of the state, regardless of the ownership of the property.

The council envisioned here could be the same council recommended in Recommendation #1.

RECOMMENDATION #27. THE GENERAL ASSEMBLY AMEND THE INDUSTRIAL INSURANCE STATUTES TO PROVIDE FOR COMPENSATION FOR PERMANENT LOSS OF HEARING DUE TO NOISE EXPOSURE AT WORK.

Some protection against occupational noise hazards is provided by the Colorado Department of Health's "Rules and Regulations Pertaining to Occupational Health," Amendments to Part II, General Requirements and Control Methods, Section OH2.10, Protection Against Noise. Section OH2.10 requires protection for employees against the effect of occupational noise exposure when the sound levels exceed the values given in a table of "Permissible Noise Exposures." When the sound levels exceed the values shown in the table,¹⁵³ a continuing, effective hearing-conservation program is required.

There is no provision in the Colorado statutes, however, for compensation for permanent hearing loss due to noise exposure in work conditions. Other states -- Wisconsin, for example -- have enacted such statutes. The Commission recommends that the Colorado statutes be amended to provide for such compensation.

RECOMMENDATION #28. THE GENERAL ASSEMBLY AMEND THE 1971 LEGISLATION CONCERNING THE ESTABLISHMENT OF MAXIMUM PERMISSIBLE NOISE LEVELS AND NOISE-ABATEMENT PROCEDURES TO:

- (1) ESTABLISH OR DESIGNATE AN AGENCY WITHIN THE STATE GOVERNMENT TO HAVE THE RESPONSIBILITY FOR ALL NON-OCCUPATIONAL NOISE CONTROL;**
- (2) DESIGNATE AN AGENCY AS HAVING THE RESPONSIBILITY FOR NOISE ABATEMENT AND SETTING OF NOISE LIMITS.**

In 1971 Senate Bill Number 197 was enacted into law by the General Assembly, setting abatement controls for stationary sources in residential, commercial, and industrial zones of the state. Automobiles and other vehicles are covered by the act, but airplanes are not. The law allows any resident of the state to bring suit to enjoin a company or vehicle operator from exceeding allowable noise levels.

Noise abatement should be enforced by an agency charged with the responsibility, just as with the other forms of environmental pollution abatement. The only enforcement permissible under the 1971 law is an abatement of a nuisance. Although the law defines what a nuisance is, it is up to the injured party to prove a nuisance -- an action not likely to be brought by private citizens because of the cost to them plus lack of proper training to evaluate, and proper instrumentation to prove, a nuisance.

It is recommended that the existing law be changed to allow the designated agency to set the actual noise limits and to enforce these limits. This agency should probably be the Department of Health.

¹⁵³ See Table 9, page 33.

SOLID WASTE PLANNING AND POLICY

RECOMMENDATION #29. THE GENERAL ASSEMBLY PROVIDE FUNDS FOR STUDY OF A FRONT RANGE RECYCLING SYSTEM AND THE MARKETING OF THE PRODUCTS DERIVED THEREFROM, WITH FIRST STUDY EFFORT DIRECTED TO THE FEASIBILITY OF COMBINING A FRONT RANGE COLLECTING, RECYCLING, AND POWER-GENERATING SYSTEM WITH A REGIONAL TRANSPORTATION SYSTEM.

When it comes to the production of waste, Coloradans are no exception to the average. Per capita yields of solid waste in metropolitan areas range from four and one-half to six pounds per day per person. New codes have been created to meet the demands of citizens who are tired of trash blowing back in their faces or irritating and disagreeable odors smelling up the community. These codes and demands on the part of citizens have caused us to look into methods of solid-waste recycling as a means of disposal.

Our county and municipal disposal systems are, for the most part, in their embryonic stages of development and conversion. Essentially, they are trying to hide millions of tons of waste. Coloradans, along with their other fellow Americans, are rushing headlong into consumption of their natural resources. Our life style has encouraged us to consume a portion and discard the unused portion to be buried with all other waste. By habit, man has been throwing away valuable waste materials. Now, by necessity, man must recover these assets before they are disposed of forever. We must, by some means, capture and redirect these by-products of our society to reuse, thereby reducing the primary consumption of our natural resources.

Recycling has benefits to the community other than the preservation of resources. Consider the economic value of the material we are burying. Each ton of the waste we are presently paying \$3 per ton to bury has, for example, about \$4 worth of recyclable paper, \$1.20 worth of cullet glass, \$2.20 worth of aluminum, and another 80¢ for other non-ferrous metals. This adds up to \$8.20 worth of paper, glass, and metals per ton. In the balance of this ton of material, there is approximately another \$1.75 worth of heat values,

which would extend the value per ton to \$9.95.¹⁵⁴ If we add another \$2 per ton for the fee that the private contractor in Colorado is paying to the landfill authority, we come up with about \$11.95 total value that could be realized out of each ton of the material we are now burying.

Private industry has not always experienced great profits from recycling. The cycling of paper or cardboard products and ferrous and non-ferrous metals has, for the most part, been economically advantageous. The recycling industry has found that one of the problems of power generation from solid waste has been finding a steady market or steady use for the steam or power produced. Regional mass personal transit requires a network of rights-of-way. Approximately the same network would be required for a regional solid-waste transportation system. Both systems serve the home; waste is produced where people live. Thus, a regional mass-transit system could provide the type of constant power requirement to justify a large investment in waste power-generation.

In a combined personal and waste transportation system, people could commute at their pleasure according to the posted schedules. During idle hours, the system would be used to transport solid waste from terminals in outlying areas to a central solid-waste recycling center, without conflict or offense to the passenger service. One of the biggest expenses to a mass-transit authority is the energy required to move the waste. This, of course, is the major contribution of the recycling system. The cost of the system would be amortized to the total tonnage of people and solid waste, rather than to only people or only solid waste. The compatibility and logic of such a system would be as follows:

1. Regional mass transit requires power; a solid-waste recycling system will produce power.
2. To be financially successful, a solid-waste recycling system requires a constant market; a regional transit authority or system requires constant power.
3. The biggest problem to a solid-waste recycling system is transportation of

¹⁵⁴ Herschel Cutler, "Role of Transportation in Disposal of Obsolete Metallic Waste"; and P. H. McGauhey, "State of the Art"; both in *Waste Age*, July 1970, Three Sons Publishing Company, Niles, Illinois; also, M. J. Mighdoll, "Secondary Materials Industry Declares War on Solid Waste," *Waste Age*, September 1970, Three Sons Publishing Company, Niles, Illinois.

the waste from the source to the recycling center; the mass-transit authority could provide this service. The common use of rights-of-way for passengers and waste disposal would be of great economic significance to the community.

4. A regional mass-transit authority will require revenue from every possible source; a recycling operation could provide approximately \$12 per ton gross revenue.

The Commission feels that the combining of personal and solid-waste transportation operations is worthy of a feasibility study by qualified parties, as the first phase of a new and unique approach to resolving these two major regional problems.

RECOMMENDATION #30. THE GENERAL ASSEMBLY ENACT A BILL PROVIDING WASTE DISTRICTS WITH BOUNDARIES BASED ON POPULATION, PROJECTED GROWTH, TOTAL WASTE YIELD, AND GEOGRAPHIC LOCATION OF COMMUNITIES; AND THAT CONSOLIDATION OF SOLID-WASTE DISPOSAL SYSTEMS BE CONSIDERED, WITH EMPHASIS ON RECYCLING WHERE FEASIBLE.

The Commission endorses Senate Bill 132 of the 1971 General Assembly Session. However, the Commission recognizes that consolidation of solid-waste disposal systems by several communities offers a means of waste disposal beneficial to each community's respective problem that in some cases is presently beyond their individual means. Criteria for each system should comply with the state regulations, but operationally the regional system could be designed with more consideration to the local problems, facilities, and options available, including emphasis on methods for amounts of waste generated.

RECOMMENDATION #31. THERE BE INCENTIVES FOR THE DISPOSAL OF UNUSABLE AUTOMOBILES:

- (1) THAT THE GENERAL ASSEMBLY HAVE THE PUBLIC UTILITIES COMMISSION INVESTIGATE THE POSSIBILITY OF INCENTIVE RAIL AND TRUCK RATES FOR SOLID WASTE, TO ENCOURAGE THE MOVEMENT OF THE MATERIAL TO DISPOSAL OR RECYCLING POINTS.**
- (2) THAT THE GENERAL ASSEMBLY ENACT LEGISLATION FOR A STATEWIDE AUTO-SCRAP ELIMINATION EFFORT TO INCLUDE: A ONE-TIME DISPOSAL FEE ON EACH CAR CURRENTLY REGISTERED IN COLORADO AND ON EVERY CAR REGISTERED IN THE FUTURE, SUCH FEES TO BE DEDICATED TO A STATEWIDE DISPOSAL EFFORT; AND AMENDING THE LAWS PERTAINING TO AUTOTITLE REGISTRATION TO FACILITATE THEIR MOVEMENT INTO SCRAP-PROCESSING CENTERS.**

The number of wrecked and abandoned automobiles in the state increases steadily. It is

reported that at the present time there are more than 200,000 cars piled up in the state. This figure is reportedly increasing at the rate of approximately 22,000 per year. These autos are piled up in all parts of the state.

Mills in Colorado are in need of the metal in unusable autos; this material should be recycled and put to reuse. The secondary-metal industry, however, is handicapped in the collecting and recycling of this waste because of transportation and other costs which render the total process non-competitive with raw ore at the present time.

There is need for incentive freight rates in auto scrap, to encourage movement into recycling processes. There is also need for review of the title-registration process on abandoned autos, to facilitate movement of such vehicles into recycling processes.

The ultimate cost of disposal of every car should be assessed in advance, in the form of a one-time disposal fee dedicated to a statewide disposal effort.

The Public Utilities Commission should be involved in considering the setting of incentive freight rates.

AREAS OF RESEARCH AND STUDY NEED

RECOMMENDATION #32. THE GENERAL ASSEMBLY SHOULD SUPPORT CERTAIN APPLIED RESEARCH PROJECTS HAVING DIRECT APPLICABILITY TO THE FORMULATION OF STATE ENVIRONMENTAL GOALS AND POLICIES.

Many of the previous recommendations require further study and research before implementation. In addition, however, there are several areas of research which have direct relevance to the formulation of state environmental policy. The General Assembly should encourage, stimulate, and fund research in those areas where information basic to policy formulation is lacking. Examples of these areas are:

- Optimum size and costs of cities;
- Implications of stabilized growth;
- Cost/benefit ratios of economic growth;
- Cost/benefit ratios of the tourist industry;
- Effects of mine drainage;
- Effects of the loss of threatened species;
- Effects of the loss of prime agricultural land and the agricultural industry in Colorado;
- Ecological function of phreatophytes;
- Ecological impact of dams;
- Uses of waste heat;
- Taxation of agricultural and open-space lands;
- Use of land and population models for predictive analysis;
- Feedlot waste;
- Wood-waste disposal;
- Sanitary waste disposal;
- New energy sources;
- Effects of altitude on motor-vehicle emissions and standards;
- Biological research in human reproduction, the control of fertility, and population genetics;
- Research into the psychopathology and the sociopathology of overcrowding;
- Use of sewage-plant effluent for irrigation-fertilizer application;
- Effects of forest management on water yield of forest lands;
- Establishment of environmental baselines as a basis for further research.

RECOMMENDATION #33. THE GENERAL ASSEMBLY ASSIGN RESPONSIBILITY FOR THE STUDY OF QUESTIONS UNRESOLVED BY THE COLORADO ENVIRONMENTAL COMMISSION.

There are a number of questions which were unresolved by the Commission, due to the lack of time. These are:

- Future planning for public transportation to recreation areas;
- Extension of the Stream Protection Act to county roads, subdivisions, and other similar projects;
- Review of the authority and functions of the Public Utilities Commission for environmental considerations;
- Review of the authority and functions of the State Board of Land Commissioners for environmental considerations;
- Review of the authority and functions of the State Soil Conservation Commission for environmental considerations;
- Forest management on state and federal lands in Colorado;
- Coordination of planning between state, federal, and local levels in Colorado;
- Four Corners interstate agreements on pollution;
- Air Pollution Control Commission and Variance Board hearing officers;
- Environmental education opportunities in state parks;
- Future relationships between the Air Pollution Control Commission and the Air Pollution Variance Board;
- Exchange of land-use planning and zoning information at all levels;
- State technology assessment;
- Recreational vehicles in mountainous areas;
- Relationship of the Colorado Geological Survey and the land-use inventory efforts of the Land Use Commission;
- Needs for tourist information centers;
- The public-utility concept on private water projects;
- Need for coordination of state comment on impact statements of federal agencies required by the National Environmental Policy Act.

The Commission urges the General Assembly to consider these questions as part of the restructuring study suggested in Recommendation #1. Alternatively, these could become part of the new responsibilities of the Environmental Commission or Council suggested in Recommendation #1.

CHAPTER IV

OPTIONS FOR COLORADO'S FUTURE

We have seen in previous chapters the nature of the environmental problems which are peculiar to Colorado, the direction in which those problems are taking the state, and the types of measures which would be necessary to resolve the problems facing us. The final question of this report relates to the nature of the options for action available to Colorado citizens.

There are basically two simple options available for Coloradans, and the choice between the two must be made no later than the next few years: one, the choice already made by default and embodied in the direction in which the state is rapidly moving; or two, the choice to adopt policies which would result in a different direction for the state than that already discernible for the future.

Many of our Colorado citizens are unaware of the nature of the choice which is already being made in Colorado under the first option, through our current process of policy default. It is worth repeating here, from Chapters I and II, the overriding factor which will be the basis for most of our future problems. If recent trends remain unchanged, we will be doubling our population within the next thirty years and redoubling it within thirty more years, or a quadrupling by approximately 2030; some ninety percent of this unprecedented surge will take place on the Front Range of Colorado, and some sixty percent in the Denver metropolitan area. Most of the finite resources of the state will have to be devoted to the well-being of one small area of the state, while most of the balance of the state stagnates into insignificance. Colorado in sixty years will be predominantly an urbanized state, with almost her entire urban population concentrated in one portion of the state and with her agricultural resources sacrificed for urbanization purposes.

At this moment in history, Colorado is unique because of the quality of its natural environment. Too many of our citizens assume that this unique quality of life is attributable to special conditions existing only in our particular state. The fact is that Colorado's special quality of life is more a function of historical circumstance than environmental assets. All America was once in ecological balance and harmony. Colorado's advantage is that its ecology has not yet been destroyed by man. Three centuries ago, Manhattan Island was a location extraordinarily blessed by beauty. Now it is a typical example of a low point in the spiral of environmental degradation. Only twenty years ago, Southern California represented the realization of an American dream, a realization based upon environmental beauty. Today, Southern California, too, has descended the spiral to pollution, urban decay, and environmental degradation.

The path which we are presently following, and the accelerating rates at which it is happening, lead to complete loss of control of the future. Government under such conditions becomes a series of belated reactions to never-ending crises. Ultimately, there is a governmental chaos, followed by total apathy on the part of citizens, and followed by the potential breakdown of society itself.

The alternative to the choice which has been made for us by default can also be simply stated and easily understood. It is simply the determination to do whatever is necessary to achieve planned objectives, rather than those which are merely happening. Our present course of action is not inevitable. Present trends, even though accelerating, can still be turned and reversed. We do not have to accept unwillingly the plight which is facing us.

What is currently lacking in Colorado is the knowledge that we must act affirmatively to reject our current course of action, in order to plan positively for another. Once that awareness is achieved, there will be no insurmountable problem of deciding the specific goals for which we should plan, and developing the tools for implementing our decision. That is not to say that the task will be easy; it will not. The forces presently moving us are strong and rapid, and it will take equally strong and decisive determination to overcome those forces.

We in Colorado must determine that we will know the capacity of our state resources and that we will refrain from overloading that capacity with either temporary or permanent population. We must determine our own state policy with respect to the preservation of the agricultural industry--and carry out that policy. We must determine whether there is any inconsistency in our prospective roles in energy production and recreational development--and then develop policy to deal with such inconsistency. We must determine what proportion of our total population on the

Front Range makes sense from a statewide viewpoint--and develop a policy to prevent overconcentration beyond that point. We must determine what our total water resources are--and develop policy for the best utilization of those resources. We must determine which problems are local, which problems are regional, which problems are statewide, and which problems are national--and urge cooperation of all local, state, and national officials to solve all problems. We must determine those aspects of state policy which are dependent upon national policy--and press for the resolution of such policy. In sum, we must determine the kind of a state we want to be and then develop the policy to be that kind of state.

Colorado today stands at probably the most critical decision point in her entire history. A decision to accept without change the current trends shaping the state's future means ultimately the end of the cool, colorful, clean Colorado we have all known and admired, and a future of recurring crises at incredible cost. A decision to act, on the other hand, offers the most exciting, challenging, and stimulating prospect available to any state in the United States. Colorado has the opportunity, with the wise use of her time and space, to create a unique, balanced rural-urban environment: well-planned cities of diversified functions and optimum sizes, related to a quality state stabilized within available resources, in one of the outstanding natural environments of the world. The costs of developing the planning and the policy mechanisms now will be significantly less than the costs of attempting to deal with recurring crises later.

Our time and space within which to plan represent a luxury which few places in the world have. Failure to accept the opportunity and the challenge which is open to us will be a tragedy, both for Coloradans and the nation. The choice is ours and ours alone.

APPENDIX A

SENATE JOINT RESOLUTION NO. 23

(By Senators Armstrong, Birmingham, Strickland, Wogan, Stockton, H. Fowler, Minister, Garnsey, Denny, L. Fowler, and Anderson; also Representatives Edmonds, H. McCormick, Moore, Lamm, Fuhr, Johnson, Carroll, and Showalter.)

WHEREAS, Ecologists have demonstrated that the life of this planet is sustained by a thin global envelope known as the biosphere which contains a closed and finite ecosystem in which all human, animal, and plant life has been maintained in a balanced cycle; and

WHEREAS, There is worldwide concern that the technological achievements of mankind and the population explosion threaten the ecosystem and the balanced cycle upon which all life depends; and

WHEREAS, The problems of environment are among the most serious matters for consideration by our state and nation and are of far greater scope than has been previously understood; and

WHEREAS, Colorado is more fortunate than other areas of the United States in that Colorado's environment has been less damaged than elsewhere and yet Colorado is nonetheless experiencing many environmental problems which are growing steadily worse; and

WHEREAS, Environmental resources are among the most valuable assets of Colorado and are sources of enjoyment and pride as well as essential to the physical and mental well-being of its citizens and a wholesome environment is an important aspect of the heritage which this generation hopes to leave to future generations; and

WHEREAS, The General Assembly is concerned about the known effects of environmental deterioration and is apprehensive about long-range environmental changes which are not yet fully understood; and

WHEREAS, The President of the United States and the Governor of the state of Colorado have called for a broad program of environmental legislation and have articulated a deeply felt concern of the people of this country and state; and

WHEREAS, The General Assembly has provided for several programs of environmental management and control which are not presently coordinated in a single overall state policy and it is desirable to achieve such coordination; now, therefore,

Be It Resolved by the Senate of the Forty-seventh General Assembly of the State of Colorado, the House of Representatives concurring herein:

(1) (a) The General Assembly hereby requests the Governor to create a Colorado Environmental Commission, hereinafter called the "Commission", which should consist of thirty or more members to be appointed by the Governor.

(b) Ten members of the Commission shall be composed of five members from the Senate, three members of the majority party and two members of the minority party, appointed by the President of the Senate, with the consent of the Senate, and five members from the House of Representatives, three members of the majority party and two members of the minority party, appointed by the Speaker of the House.

(c) In appointing members to serve on the Commission, the Governor should appoint persons who are knowledgeable in ecological sciences, physical sciences, agriculture, industry, local government, mining, transportation, medicine, tourism, conservation, resources management, public utilities, demography, recreation, and such other matters as the Governor may deem advisable.

(d) The chairman and secretary, together with seven other members to be designated by the Governor, should constitute an executive committee of the Commission which shall conduct such hearings and render such other services as the Governor may direct.

(e) The Commission should be authorized to divide itself into such other committees as may be necessary for the purposes of conducting hearings and detailed research of particular questions.

(f) Vacancies in the Commission membership should be filled in the same manner as original appointments.

(g) The Legislative Council shall provide staff services to the Commission, and all expenditures of the Commission shall be approved by the chairman of the Legislative Council, and be paid by vouchers and warrants drawn as provided by law from the appropriation made for interim studies of the Legislative Council.

(2) (a) It should be the responsibility of the Commission to identify and study the environmental problems of the state and to advise the Governor and General Assembly of the alternative courses of action which may be necessary or advisable to preserve or improve the quality of environment in Colorado.

(b) In the conduct of its study, the Commission should give particular attention to existing and potential environmental hazards, the immediate and long-range effects of present and projected activities of government, industry, agriculture, and mining, existing local, state, and federal programs of environmental control and management, and the need for additional programs and the coordination of present programs.

(c) On or before December 1 of each year during its term, the Commission should render to the Governor and the General Assembly a report of its activities, findings, and recommendations.

(3) The term of the Commission should be for a period of two years commencing April 1, 1970.

Be It Further Resolved, That a copy of this Resolution be transmitted to the Honorable John A. Love, Governor of the State of Colorado.

APPENDIX B

COMMITTEE ASSIGNMENTS

FOOD/HEALTH/HAZARDS/ RELATED PROBLEMS COMMITTEE

Food and Related Problems:

Pesticides; Fertilizers; Food Chains; Agricultural Problems; Horticulture; Food; Energy Cycles; Game and Fish; Detergents; Enzymes; Chemical Research.

Health Problems:

Solid Waste Sites; Land Fill Dumps; Occupational Health; Allergies; Odors; Solid Waste Research; Air Pollution; State Dumping Control; Solid Waste Recycling; Research on Long-Term Effects of Various Forms of Pollution.

Visual Problems:

Billboards; Litter; Abandoned Cars; Auto Junkyards; Dumps; State Litter Control; Vertical Auto Parks; Mining Scars; Camper Waste; Beer Cans.

Emergencies and Hazards:

Power Generation; Nuclear Tests (Rulison); Domestic Radiation (TV, ovens); Medical (X rays, isotopes); Industrial Radiation (Rocky Flats); Radioactive Waste; Nerve Gas (Arsenal); Research on Indicator Systems; Mine Tailings; Nuclear Sites..

Committee Members

Chairman: Robert J. Strawn, Jr. -
President, Biogenic Research &
Engineering
Harvey E. Brewbaker -
Agriculturalist
Karl E. Carson - Mayor of
Fort Collins
Adrian G. Ehernberger - County
Commissioner (retired)
G. Crawford Follmer - President,
Loveland Hospital Board
Richard F. La Force -
Physician and Surgeon
William H. Lee - Administration
Manager - Dow Chemical Com-
pany, Rocky Flats Division

William A. McGilvray - Industrial
Hygiene Engineer - Shell Chemi-
cal Company, Rocky Mountain
Arsenal

Daryl E. Peterson - Professor of
Biology, Metropolitan State
College

Joseph A. Reich - President,
Swiss Chalet Products

Frank J. Rolla - Owner,
Village Inn Restaurant

Anthony Vollack -
Colorado State Senator

William H. Webster - Owner,
Webster Feed Lots, Inc.

Ruth Weiner - Professor of Chem-
istry, Temple Buell College

David C. Wilhelm - President,
Wilhelm Foods

GOVERNMENT/RESEARCH/EDUCATION/ RELATED PROBLEMS COMMITTEE

Government Problems:

State Government Organization; Local Gov-
ernment Relationships; Federal Relation-
ships; Government Coordination; Ombuds-
man; Regional Planning; Private Organiza-
tions; Long-Range State Goals; Coordinating
State Agency; State Government Assistance
to Local Planning; Environmental Tax;
Financing Environmental Regeneration and
Reclamation.

Research and Development:

Government-Sponsored Research and De-
velopment; Computer Systems Applications;
Electronics Applications; Government Re-
search and Testing Laboratory.

Information and Education:

Public Information; Pollution Handbook for
Public; Ecology Education at All School
Levels.

Committee Members

Chairman: Ralph Sargent, Jr. - Vice Presi-
dent, Public Service Company
of Colorado

Robert A. Briggs - Owner, Briggs
Carnation Farm

E. H. Crabtree - Consultant, Colo-
rado School of Mines Institute

Thomas C. Fischer - Business
Consultant and Insurance Broker

G. Crawford Follmer - President,
Loveland Hospital Board

Allegra Saunders - Colorado
State Senator

Ruth A. Steel - President,
Colorado Institute on Population
Problems

Raymond Wiggins - Staff Engineer,
Martin Marietta Corporation

LAND USE AND RELATED PROBLEMS COMMITTEE

Urban Problems:

Land Use; Open Space; Design; Regional
Development; Tourism; Urban Systems;
Urban Sprawl; Urban Renewal; Honky-
tonk Strips; Housing Patterns; Airport
Location; Urban Signs; Core City Problems;
Landfill Dumps; Billboards; Arenas; Small
Tracts; Cluster Development; Transporta-
tion Corridors; Functional and Aesthetic
Low-Cost Housing; Urban Research; Popula-
tion Density.

New Towns:

Design; Planning for New Towns; Promotion
of Industry; Zoning for Industry; Urban Sys-
tems; Housing Patterns; Shopping Facilities;
Schools; Rapid Transit; Architectural Con-
trols; Zoning Controls; Industrial Beauty.

Natural Areas:

Parks and Recreation; Wilderness; Open
Space; Tourism; Urban and Mountain Plan-
ning; Ecology Case Studies; Mountain Home
Development; Ski Area Sites; Fishing Areas;
Hunting Areas; Agricultural Areas; Recrea-
tional Vehicles; Natural Beauty; Trails;
Front Range Urban Parks; Scenic Views.

Conservation and Development:

Natural Resources; Mineral Land Reclama-
tion; Natural Habitat; Forest Management;
Natural Communities; Public Land Manage-
ment; Flood Plain Usage; Overgrazing; Oil
and Gas Development; Mining Development;

Underground Storage Development; Wildlife
Protection (animal and plant); Historic,
Archaeologic, Geologic, and Cultural Sites;
Ghost Towns; Central City/Blackhawk Area;
Water Development, Diversion, and Conser-
vation; Landscape Destruction; High-Fertility
Agricultural Land; Environmental Deteriora-
tion; Water Evaporation.

Geological Problems:

Geological Faults; Earthquakes; Avalanche
Sites; Floods; Swelling Soils; Mine Subsi-
dence; Dam Failures.

Problem Solutions:

Resource Survey; Statewide Planning; State-
wide Land Use Control; Control of Recre-
ational Areas; Flood Plain Control; Regional
Planning; Population-Environmental Balance;
Plant Location of Hazardous Industries;
Comprehensive Land and Space Planning;
Front Range Mass Transit; Public Land Law
Review Report; Goals in Urban/Rural Plan-
ning; Highway Location and Design Control;
Municipal and Governmental Public Works
Control.

Committee Members

Chairmen: Nick Paul Jannakos -
Professional Engineer
and
George H. Fentress - Colorado
State Representative
Charles R. Arment -
Professional Forester
Harvey E. Brewbaker -
Agriculturalist
Karl E. Carson -
Mayor of Fort Collins
W. Perry Eberhart - Research
Associate, Colorado State
Historical Society
Hugo A. Ferchau - Professor of
Botany, Western State College
of Colorado
Thomas C. Fischer - Business
Consultant and Insurance Broker
Wallace P. Hinman - Colorado
State Representative
Kenneth E. Johnson - Publisher,
Grand Junction Daily Sentinel
Steve Knowlton - Managing Direc-
tor, Colorado Ski Country U.S.A.
Richard W. Lemke -
Engineering Geologist

Clarence A. Rutz - Real Estate
 Robert J. Strawn, Jr. -
 President, Biogenic Research
 and Engineering
 Thomas W. Ten Eyck - Executive
 Director, Colorado Department
 of Natural Resources
 Ian Thompson - Associate Editor,
 Durango Herald
 Clifford C. Walker - Civil Engi-
 neer, Armco Steel Corporation
 William M. White - President,
 Great Western United
 Corporation

**POPULATION AND
 RELATED PROBLEMS COMMITTEE**

Population:

Family planning; Abortion; Family and
 Home; Population Control and Disincentives;
 Optimum State Population.

Committee Members

Chairman: Ruth Steel - President, Colorado
 Institute on Population Problems
 John R. Bermingham -
 Colorado State Senator
 J. William Bullock - Engineer
 Kenneth E. Johnson -
 Publisher, Daily Sentinel
 Richard D. Lamm -
 Colorado State Representative
 Joseph A. Reich - President
 Swiss Chalet Products
 Robert E. Schilson - Research En-
 gineer, Marathon Oil Company
 Eric P. Wendt -
 Secretary-Manager, Lower South
 Platte Water Conservancy
 District
 Raymond Wiggins - Staff Engineer,
 Martin Marietta Corporation

**TRANSPORTATION/ENERGY/AIR POLLU-
 TION/NOISE/RELATED PROBLEMS
 COMMITTEE**

Transportation:

Roads and Highways; Transportation Corri-
 dors; Mass Transit Systems; Bicycles;
 Highway Users Tax System; Recreational
 Vehicles.

Air Pollution:

Domestic Pollution; Industry Pollution; Auto
 Pollution; Aircraft Pollution; Atmospheric
 Research.

Automobiles, Energy:

Fuel Research; Carburetor Devices; Exhaust
 Devices; Leaded Fuels; Carburetor Adjust-
 ments; Research on Effects of Altitude;
 Alternative Sources of Energy.

Noise:

Aircraft; Sonic Booms; Noise Standards;
 Trucks.

Committee Members

Chairmen: Ruth Weiner - Professor of
 Chemistry, Temple Buell
 College
 and
 Robert P. Tone - Mechanical Engi-
 neer, Gates Rubber Company
 John R. Bermingham -
 Colorado State Senator
 Ted Bryant -
 Colorado State Representative
 J. William Bullock - Engineer
 Hyman Chai - Head, Hospital Serv-
 vices Division - Children's
 Asthma Research Institute
 and Hospital
 W. Perry Eberhart - Research
 Assistant, Colorado State
 Historical Society
 Hugh C. Fowler -
 Colorado State Senator
 Leslie R. Fowler -
 Colorado State Senator
 Sheldon E. Friedman -
 Attorney at Law
 Edward Hirschfeld - Owner,
 Hirschfeld Press
 Kenneth E. Johnson - Publisher,
 Grand Junction Daily Sentinel
 Richard LaForce -
 Physician and Surgeon
 William H. Lee - Administration
 Manager, Dow Chemical Com-
 pany, Rocky Flats Division
 William A. McGilvray - Industrial
 Hygiene Engineer, Shell Chemi-
 cal Company - Rocky Mountain
 Arsenal

Maurice Parker -
Colorado State Senator
Rufe Romero -
Owner, Komak Paint Store
Jerome C. Rose -
Colorado State Representative
Robert E. Schilson - Research Engineer,
Marathon Oil Company
Robert J. Strawn, Jr. -
President, Biogenic
Research and Engineering
Samuel Sweet - Interior Designer,
Howard Lorton Galleries
Paul G. West -
Attorney at Law
William M. White -
President, Great Western
United Corporation

**WATER/WATER POLLUTION/SEWAGE/
RELATED PROBLEMS COMMITTEE**

Water:

Domestic Needs; Agricultural Needs; Industrial Needs; Recreational Needs; Power Development; Water Recycling Research; Water Resource Management; Water Development; Water Diversion.

Water Pollution:

Industrial Sources; Agricultural Feedlots; Fertilizers; Camper Litter; Detergents; Insecticides; Thermal Pollution; Deep Well Disposal; Contamination of Underground and Surface Water.

Sewage:

Septic Tanks; Municipal Sewage Systems; State-Financed Sewage Systems; Solid Waste Problems.

Committee Members

Chairman: Robert E. Schilson - Research
Engineer, Marathon Oil Company
Harvey E. Brewbaker -
Agriculturalist
Wallace P. Hinman -
Colorado State Representative
Charles J. Hobson -
Owner, Hobson Ranch
Ben Klein -
Colorado State Representative
Keith G. Mumby -
Attorney at Law

Richard E. Nenno - Principal Engineer,
Propulsion Laboratory -
Martin Marietta Corporation
Ted L. Strickland -
Colorado State Senator
Thomas W. Ten Eyck -
Executive Director, Colorado
Department of Natural
Resources
Clifford C. Walker - Civil Engineer,
Armco Steel Corporation
Ruth Weiner - Professor of Chemistry,
Temple Buell College
Eric P. Wendt - Secretary-Manager,
Lower South Platte Water
Conservancy District

APPENDIX C

HEARINGS

The following people and organizations testified before, gave information to, or attended the meetings of the Commission:

Executive Committee

Lyle C. Kyle -- Director, Legislative Council
Stanley K. Brown -- Director of Public Relations, Colorado Department of Highways
Walter J. Tomsic -- Colorado Division of Local Government, Department of Local Affairs
James C. Wilson -- Staff Director, Legislative Drafting Office
Elizabeth Richardson -- League of Women Voters
Judy Hamilton -- League of Women Voters
Claude D. Peters -- Director, Colorado Land Use Commission
Peggy Albers -- League of Women Voters
Hilda Eichenberger -- League of Women Voters
David W. Furgason -- Attorney, C.F. & I. Steel Corporation
Stanley Kerr -- Colorado Open Space Council
Elizabeth Matsch -- Artist who designed commission stationery
Dorothy Gumaer -- Sierra Club, Pikes Peak Area
Marilyn Miller -- Colorado Open Space Council
Vincent Winn -- Environmental Committee, Colorado Society of Certified Public Accountants

Food/Health/Hazards/Related Problems Committee

William N. Gahr -- Director, Engineering and Sanitation Division, Colorado Department of Health
Larry Gazda -- Federal Bureau of Solid Waste Management
Roy L. Cleere -- Director, Colorado Department of Health

George A. Prince -- Chief of Engineering, Colorado Department of Health
Robert A. Downs -- Director, Special Health Services Division, Colorado Department of Health
Ray Obrecht -- Colorado Grange
Pattie Haskins -- League of Women Voters
Orville Stoddard -- Project Director of Study on Solid Waste, Colorado Department of Health
Virgil Robinson -- Commission on Community Relations
Cecil Wadleigh -- Director, Soil and Water Conservation Research Division -- Agricultural Research Service, U.S. Department of Agriculture
Clinton E. Jeffers -- Executive Director, Colorado Department of Agriculture
Robert Sullivan -- Pesticides and Applicators, Plant Industry Division, Colorado Department of Agriculture
Conrad Heins -- Secretary, Chemical Division, Denver Research Institute
Orlen J. Weimann -- Chief -- Milk, Food, and Drug Section -- Engineering and Sanitation Division, Colorado Department of Health
Lawrence M. Mounce -- Colorado Community Pesticides Study, Greeley -- Colorado Department of Health
W. L. Gordon -- Colorado Agricultural Chemicals Association
Robert M. Edmiston -- Colorado Agricultural Chemicals Association
P. B. Smith -- Great Western Sugar Company (retired)
Alan L. Foster -- Project Director for Solid Waste and Urban Drainage Problems, Denver Regional Council of Governments
William Dunn -- Chief Chemist, Colorado Department of Health
P. W. Jacoe -- Director, Occupational and Radiological Health Division -- Colorado Department of Health
L. Todd Reynolds -- Public Health Chemist, Colorado Department of Health
Peter Metzger -- Colorado Committee for Environmental Information

David Evans -- Geologist, Colorado School of Mines
 Edward A. Martell -- National Center for Atmospheric Research
 H. H. Aronson -- CER Geonuclear Corporation
 R. S. Brundage -- CER Geonuclear Corporation
 John W. Rold -- Director, Colorado Geological Survey
 Dick Pearl -- Colorado Geological Survey
 Robert Beebe -- Colorado Pollution Control Association
 Harry L. Parrish, Jr. -- Executive Director, Regional Transportation District

Government/Research/Education/Related Problems Committee

Cliff Lewis -- (sitting in for E. H. Crabtree)
 James C. Wilson -- Staff Director, Legislative Drafting Office
 Mitch Beville -- Legislative Council
 Larry Bohning -- Legislative Drafting Office
 Ronald Lehr -- (sitting in for Ruth A. Steel)
 Roger P. Hansen -- Director, Rocky Mountain Center on Environment
 Hilda Eichenberger -- League of Women Voters
 Ann Hallock -- League of Women Voters
 Bob Welborn -- Attorney at Law
 Frank Stork -- Rocky Mountain Farmers Union
 Elizabeth Richardson -- League of Women Voters
 George A. Ek, Jr. -- Consultant, Office of Continuing Education -- Colorado Department of Education
 John Thompson -- Consultant, Improved Learning Unit -- Colorado Department of Education
 Chuck Holtzer -- Consultant, Conservation and Outdoor Education -- Colorado Department of Education
 Frank C. Abbott -- Executive Director, State of Colorado Commission on Higher Education
 Susan Cole -- Sierra Club Population Committee
 Margot Zallen -- Sierra Club Population Committee

Robert Beebe -- Colorado Pollution Control Association
 Olie Webb -- Colorado Association of Commerce and Industry

Land Use and Related Problems Committee

David G. Rice -- Executive Vice President, Colorado Cattlemen's Association
 Frank Morison -- Colorado Association of Commerce and Industry
 Ray Obrecht -- Colorado Grange
 Dean Kittel -- Colorado Farm Bureau
 Kenneth G. Bueche -- General Counsel, Colorado Municipal League
 Jack Orr -- Colorado Cattlemen's Association
 Nate Patton -- Colorado Cattlemen's Association (past president)
 John W. Rold -- Director, Colorado State Geological Survey
 Ralph Atkins -- Director, Land and Water Department -- C. F. & I. Steel Corporation
 Joseph Schieffelin -- Colorado State Senator
 Dietz Lusk -- Vice Chairman, Colorado Land Use Commission
 Claude D. Peters -- Director, Colorado Land Use Commission
 Leon DuCharme -- Colorado Land Use Commission
 Harry Cornell -- Colorado Land Use Commission
 J. Fred Schneider -- Colorado Association of County Commissioners
 Roberta J. Bradbury -- League of Women Voters
 Ann Hallock -- League of Women Voters
 Nancy Urquhart -- League of Women Voters
 Judy Hamilton -- League of Women Voters
 Elizabeth Richardson -- League of Women Voters
 George T. O'Malley, Jr. -- Assistant Director, Parks and Recreation Services - Game, Fish & Parks Division -- Colorado Department of Natural Resources
 Andy Wenchel -- Game, Fish & Parks Division -- Colorado Department of Natural Resources
 Bob Carlson -- Game, Fish & Parks Division -- Colorado Department of Natural Resources

Harold L. Kayser -- Concerned Citizen
 Robert B. Sennett -- Colorado Geological Survey
 Al L. Hornbaker -- Colorado Geological Survey
 Ron Blewitt -- Colorado Soil Conservation Service
 Clifton R. Merritt -- The Wilderness Society
 Jim Cox -- Architect
 Robert Beebe -- Colorado Pollution Control Association
 Dick Pearl -- Colorado Geological Survey
 Olie L. Webb -- Colorado Association of Commerce and Industry

Population and Related Problems Committee

Howard K. Holme -- Student Practice Program, University of Denver Law School
 Ronald Lehr -- Colorado Institute on Population Problems
 Lyman Rhoades -- University of Denver Law Student
 William Droegemueller -- Assistant Professor, Ob/Gyn -- University of Colorado Medical Center
 Robert McCurdy -- Chief, Maternal & Child Health -- Child Health Services Division, Colorado Department of Health
 Horace Thompson -- Director of Services, Ob/Gyn -- Denver General Hospital
 Charline J. Birkins -- Director, Division of Public Welfare -- Colorado Department of Social Services
 Hilbert Schauer -- Executive Director, Colorado Department of Institutions
 Hans M. Schapire -- Chief of Mental Health, Colorado Department of Institutions
 Kayo Sunada -- Superintendent, Ridge Home and Training School -- State of Colorado
 Marvin Meyers -- Chief, Division of Mental Retardation -- Colorado Department of Institutions
 Robert Beebe -- Colorado Pollution Control Association
 George A. Ek, Jr. -- Consultant, Office of Continuing Education -- Colorado Department of Education
 John Thompson -- Consultant, Improved Learning Unit -- Colorado Department of Education

Chuck Holtzer -- Consultant, Conservation and Outdoor Education -- Colorado Department of Education
 Frank C. Abbott -- Executive Director, State of Colorado Commission on Higher Education
 Susan Cole -- Sierra Club Population Committee
 Margot Zallen -- Sierra Club Population Committee
 Robert Steenrod -- University of Denver Law Student
 Bruce Imfeld -- Zero Population Growth
 Richard Bruce -- Colorado State Planning Office
 Lee Whitney -- Colorado State Planning Office
 Edison Cabacungan -- Colorado State Planning Office
 Patrick Jobses -- Professor, Sociology Department -- University of Colorado
 Olie L. Webb -- Colorado Association of Commerce and Industry
 Dwight E. Neill -- Director, Division of Commerce and Development -- Colorado Department of Local Affairs
 J. Kent Miller -- Attorney at Law

Transportation/Energy/Air Pollution/Noise/Related Problems Committee

John Fleming Kelly -- Chairman, Regional Transportation District
 Harry L. Parrish, Jr. -- Executive Director, Regional Transportation District
 Fred K. Merten -- Assistant Chief Engineer, Operations -- Colorado Department of Highways
 Adolph Zulian -- Assistant Chief Engineer, Engineering -- Colorado Department of Highways
 Albert G. Melcher -- Colorado Highway Commission (former member)
 George Beardsley -- Glenwood Canyon Advisory Committee
 Harry R. Woodward -- Director -- Game, Fish & Parks Division -- Colorado Department of Natural Resources
 Alan Gass -- Denver Regional Council of Governments
 Stanley Kerr -- Colorado Wildlife Federation

Pete Barrows -- Game, Fish & Parks Division -- Colorado Department of Natural Resources

John W. Rold -- Director, Colorado State Geological Survey

Elizabeth Richardson -- League of Women Voters

Nancy Urquhart -- League of Women Voters

Judy Hamilton -- League of Women Voters

Robert C. Chanaud -- Architectural Engineer

Ray Brennan -- Chief, Occupational Health -- Colorado Department of Health

Harold Weber -- Audiologist, Colorado Department of Health

Richard Krug -- University of Colorado Professor

Thomas Martin -- Noise Control Officer, Boulder Police Department

C. M. Edmonds -- Colorado State Representative

John Gartin -- Interested Citizen

Forrest Douglas -- The Trane Company

James P. Lodge -- Chairman, Colorado Air Pollution Control Commission

R. G. Beverly -- Vice Chairman, Colorado Air Pollution Control Commission

Mary Alice Munger -- Air Pollution Variance Board, Colorado Department of Health

Elmer M. Chenault -- Air Pollution Variance Board, Colorado Department of Health

Thomas R. Heaton -- Air Pollution Variance Board, Colorado Department of Health

Clair H. Iverson -- Air Pollution Variance Board, Colorado Department of Health

Arthur M. Krill -- Air Pollution Variance Board, Colorado Department of Health

Lucy Thompson -- League of Women Voters

Donald G. Fullerton -- Air Pollution Variance Board, Colorado Department of Health

Myron L. Corrin -- Air Pollution Variance Board, Colorado Department of Health

Joseph Palomba -- Air Pollution Control Division, Colorado Department of Health

William Tucker -- Attorney General's Office

Don Turk -- Tri-County Health Department

Frank Thurston -- Denver Air Pollution Control

Robert A. Downs -- Director, Special Health Services Division -- Colorado Department of Health

Robert Beebe -- Colorado Pollution Control Association

Mary Krane -- Citizens for Clean Air

Tod Martin -- Colorado Interstate Gas Company

Ken Klein -- Interested Citizen

William F. Hedrick -- American Pollution Controlled, Inc.

R. E. Barber -- Barber/Nichols Engineering

Jim Real -- Colorado Interstate Gas Company

Fred Wehrle -- Colorado Interstate Gas Company

William N. Gahr -- Director, Engineering and Sanitation Division -- Colorado Department of Health

Frank J. Rozich -- Technical Secretary and Director, Water Pollution Control Division -- Colorado Department of Health

Hilda Eichenberger -- League of Women Voters

Russell Cameron -- President, Cameron Engineers

Lane Kirkpatrick -- Technical Secretary, Air Pollution Control Commission -- Colorado Department of Health

J. E. Cannon -- Colorado Interstate Gas Company

John J. Schanz -- Denver Research Institute

W. S. Landers -- Public Service Company of Colorado

Oscar Lee -- Public Service Company of Colorado

Robert V. Hugo -- Western Systems Coordinating Council and Public Service Company of Colorado

Bob Bryant -- Colorado-Ute Electric Association

Frank Scussel -- Salt River Project

J. L. York -- Stearns-Roger Corporation

Dalton Ford -- Public Utilities Commission, Colorado Department of Regulatory Agencies

Lesley T. Julian -- Citizen of Boulder

Gerald P. Wood -- Director, Air Pollution Control Division -- Colorado Department of Health

Don Sorrels -- Chief, Technical Services --
Air Pollution Control Division,
Colorado Department of Health
Olie L. Webb -- Colorado Association of
Commerce and Industry

**Water/Water Pollution/Sewage/
Related Problems Committee**

John Moran, Jr. -- Water Pollution Control
Commission, Colorado Department of
Health
Frank J. Rozich -- Director, Water Pollu-
tion Control Division -- Colorado
Department of Health
Bob Scott -- KHOW Radio Station
Mary Alice Munger -- Colorado
State Board of Health
David W. Furgason -- Attorney, C. F. & I.
Steel Corporation
Jack Orr -- President, Colorado
Cattlemen's Association
Robert A. Downs -- Director, Special Health
Services Division -- Colorado Depart-
ment of Health
Peggy Albers -- League of Women Voters
Olga Carroll -- League of Women Voters
William Korbitz -- Manager, Metropolitan
Denver Sewage Disposal District
Number 1
Howard Lewis -- General Manager of Envi-
ronmental Control, Adolph Coors
Company
Earl J. Stephenson -- Director, Construction
Grants -- U. S. Department of
the Interior
Mary Lou Parmelee --
League of Women Voters
Josephine Garrett --
League of Women Voters
James Ingles -- Director, Region 7 --
U. S. Bureau of Reclamation
Morris Droskin -- U. S. Bureau of
Reclamation
Dick Eggen -- U. S. Bureau of Reclamation
Edmund Barbour --
U. S. Bureau of Reclamation
Jim Ogilvie -- Manager, Denver
Water Board
Roger Willbanks -- Public Relations
Director, Denver Water Board
Ken Ball -- Denver Water Board

Felix L. Sparks -- Director, Colorado
Water Conservation Board
John W. Rold -- Director,
Colorado Geological Survey
Dick Pearl -- Colorado Geological Survey
Elizabeth Richardson --
League of Women Voters
Richard H. Rossmiller -- Trout Unlimited
Steve Sherman -- Trout Unlimited
Archie M. Kahan -- Chief, Division of Atmo-
spheric Water Resources Management
-- U. S. Bureau of Reclamation
Paul Mielke, Jr. -- Associate Professor,
Department of Statistics --
Colorado State University
H. Leo Teller -- Associate Professor,
Colorado State University
Howard Mielke -- Student, University of
Michigan
Jerry Klazura --
U. S. Bureau of Reclamation
Robert Beebe -- Colorado
Pollution Control Association
F. N. Bosco -- Professional Engineer
Clarence J. Kuiper -- State Engineer of
Water Resources, Colorado
Department of Natural Resources
William N. Gahr -- Director, Engineering
and Sanitation Division -- Colorado
Department of Health
Hilda Eichenberger --
League of Women Voters
Russell Cameron -- President,
Cameron Engineers
T. J. Longley -- Colorado
Water Conservation Board

Full Commission Meetings

Lyle C. Kyle -- Director, Legislative
Council
Charles E. Shumate -- Executive Director,
Colorado Department of Highways
Clinton E. Jeffers -- Executive Director,
Colorado Department of Agriculture
John W. Rold -- Director,
Colorado Geological Survey
Roy L. Cleere -- Executive Director,
Colorado Department of Health
Stanley Kerr --
Colorado Open Space Council

Ty Patterson -- Coordinator,
Colorado State Planning Office

Sandy Arnold --
Colorado State Representative

Jan Rich -- League of Women Voters

Sonya Ellingboe --
League of Women Voters

Barbara Salery -- League of Women Voters

Virginia Bruns -- League of Women Voters

Kathleen Brand --
League of Women Voters

Peggy Albers -- League of Women Voters

Shirley Fitzgerald --
League of Women Voters

Ann Hallock -- League of Women Voters

Robert Gonring -- Chief, Health Education --
Colorado Department of Health

Stanley K. Brown -- Director,
Public Relations -- Colorado
Department of Highways

Hilda Eichenberger -- League of Women
Voters

Bernie Bovee -- Game, Fish & Parks Divi-
sion -- Colorado Department of Natural
Resources

Robert A. Downs -- Director, Special Health
Services Division -- Colorado
Department of Health

Dale Hollingsworth -- Manager, Grand Junc-
tion Area Chamber of Commerce

Arthur W. Moss -- Executive Director,
Club 20 for Colorado West

Robert B. Sennett -- Engineering Geologist,
Colorado Geological Survey

Judy Hamilton -- League of Women Voters

Ralph Hill -- Colorado Wildlife Federation

Tim Flores -- Colorado Labor Council

Robert Schafer --
Colorado State Representative

Frank Lee -- Interested Citizen

David G. Rice --
Colorado Cattlemen's Association

Dick Pearl -- Colorado Geological Survey

Elizabeth Richardson --
League of Women Voters

Ralph Yoder -- Colorado Cattlemen's
Association

Bruce Imfeld --
Zero Population Growth

Robert Person --
Public Service Company of Colorado

Roy Stromme -- Colorado Environmental
Legal Services

Douglas Seba -- Rosensteil School of Marine
and Atmospheric Sciences,
University of Miami

Cynthia Jessel -- League of Women
Voters

Mary L. Parmelee -- League of Women
Voters

Public Hearing, Denver

Roger P. Hansen -- Executive Director,
Rocky Mountain Center on Environment

Douglas P. Jones -- President,
Mountain Area Planning Council

Don Tesitor -- President, Environmental
Wildlife Consultants, Incorporated

Sylvia Brockner -- Evergreen Naturalists

Lee Dalberg -- REKALM,
Reclamation of Solid Waste

Alabama Glass -- REKALM,
Reclamation of Solid Waste

E. M. Cleaver -- Director,
Weld County Health Department

Dorothy B. Strubel -- President, Colorado
Public Health Association

Harry Folk -- Planned Parenthood
of Colorado, Incorporated

E. N. Akers -- Coordinating Council
for Family Planning

Nancy Goldstein -- Women's Liberation

Ronald Lehr -- Colorado Institute
on Population Problems

David Waddington --
Concerned Citizen -- Englewood

Grant Strong -- Roads and Transportation
Committee, Colorado Open Space
Council

Gerry Dixon -- Consumers for Better Signs

Duffie White -- Consumers for Better Signs

Amy Roosevelt --
Thorne Ecological Foundation

Joan Wolther -- Secretary,
Arkansas Valley Conservation Council

Edwin C. Vare -- Chairman,
Aspen Open Space Committee

Peter Groth -- President, Association
for Beautiful Colorado Roads

S. Morton Baker -- Co-Chairman,
Colorado Planning Society

C. R. Batten -- Free-Lance Writer --Boulder
 Richard G. Beidleman -- Biology
 Department, Colorado College
 E. James Wilson -- Vice Chairman of
 Executive Committee, Big Country
 Headwaters
 Don F. Marmande -- Boulder City-County
 Health Department
 K. M. Brink -- Head, Department of Horti-
 culture -- College of Agricultural
 Sciences, Colorado State University
 Clement J. Todd -- Assistant Chief, Office
 of Atmospheric Water Resources --
 Bureau of Reclamation, U. S. Depart-
 ment of Interior
 Lorraine Burgess -- Concerned Citizen --
 Colorado Springs
 D. Blake Chambliss -- Club 20
 Parks and Recreation
 Citizens Advisory Committee -- Denver
 Metropolitan Area Transportation Study
 Evelyn I. Clark -- Concerned Citizen --
 Fort Collins
 T. J. Longley -- Chairman,
 Clear Creek Redevelopment Committee
 Arthur W. Moss -- Executive Director,
 Club 20 for Colorado West
 E. A. Martell -- Subcommittee Chairman,
 The Colorado Committee for
 Environmental Information
 George A. Ek, Jr. --
 Colorado Department of Education
 Mary Huntington -- Chairman,
 Colorado Federation of Women's Clubs
 Joy Coombs -- Director, Community Center
 for Creative Arts
 Colorado Water Congress
 Mr. and Mrs. Glenn Cushman -- Concerned
 Citizens -- Boulder
 Mr. and Mrs. A. Lewis Dahm -- Concerned
 Citizens -- Westminster
 Louis R. LaPerriere -- Senior Planner,
 City and County of Denver Department
 of Planning
 W. T. Garrett -- Chairman, The Nature
 Conservancy
 Kurt Gerstle -- Natural Areas Committee,
 University of Colorado
 Jay L. Groom, Jr. -- Concerned Citizen --
 Longmont
 W. E. Marshall -- Executive Director, The
 State Historical Society of Colorado

Hooker Chemical Corporation -- Denver
 Richard D. Lamm -- Colorado State Rep-
 resentative
 Charles B. Lennahan -- Concerned Citizen --
 Denver
 Howard Morrison -- Attorney at Law
 Michael Owen -- Trout Unlimited
 Robert W. Parker -- Vice President, Mar-
 keting -- Vail Associates, Inc.
 Harry L. Parrish -- Executive Director,
 Regional Transportation District
 Mrs. Roger Perkins -- Concerned Citizen --
 Boulder
 Richard and Sue Sawyer -- Concerned Citi-
 zens -- Denver
 Lee Sayre -- Concerned Citizen -- Colorado
 Springs
 Lewis W. Story -- Concerned Citizen --
 Denver
 Ronald R. Tidball -- Concerned Citizen --
 Lakewood
 Judy von Ahlefeldt -- Biology Faculty, Colo-
 rado College
 John Andrick -- Recreation Resource Spe-
 cialist, Bureau of Outdoor Recreation
 V. P. Cline -- Chairman, Keep Colorado
 Beautiful, Incorporated
 James M. Hurley -- Assistant Executive
 Director, National Environmental Health
 Association
 William B. Twine -- Vice President, Colorado
 Environmental Health Association
 Robert Chanaud -- Architectural Engineer
 Richard F. Krug -- Professor, University
 of Colorado
 Kenneth G. Bueche -- General Counsel,
 Colorado Municipal League
 Thomas A. Martin -- Noise Control Officer,
 Boulder Police Department
 Rodman L. Tidrick -- President, Aardvark
 Limited; President, Denver Audubon
 Society
 Frederick K. Conover -- Preserve Our
 Way of Urban Residence (POWUR)
 Eugene D. Sternberg -- Architect
 James R. Wade -- Colorado Mountain Club
 Marvin Hatami -- Chairman, Commission
 on Environment -- Colorado Central
 Chapter, American Institute of
 Architects

Alan G. Gass -- Vice Chairman, Citizens Advisory Committee -- Denver Regional Council of Governments

Mrs. Richard Garnand -- League of Women Voters

Charles E. Dowding -- Chief, Colorado Health and Environmental Council

Wayland J. Walker -- Environmental Planner, Denver Regional Council of Governments

Frank Allen -- Open Space Planning Administrator, Denver Regional Council of Governments

Alan Merson -- Associate Professor of Law, University of Denver

George Hovey III -- Environmental Action Committee, University of Colorado, Denver Center

Beth Robinson -- Citizens Concerned about Radiation Pollution

Morey Wolfson -- Citizens Concerned about Radiation Pollution

Sid Brooks -- Law Student, University of Denver

Victor Perry -- Law Student, University of Denver

Michael C. Moore -- Study Committee on the Vulcan Chemical Plant, Colorado Open Space Council

David Large -- People United to Reclaim the Environment (PURE)

Jim Monaghan -- Chairman, Environmental Corps -- Colorado State University

William Elfenbein -- Rocky Mountain Chapter of the Sierra Club

Patrick Jobes -- Professor, University of Colorado

Edwin H. Montgomery -- Concerned Citizen -- Morrison

Charles Mackin -- Acting Chairman, Environmentalist Club -- Metropolitan State College

Jo Ann Moon -- Concerned Citizen, Denver

Martin H. Shore -- President, Colorado Open Space Council; also representing PLAN-Boulder

Karen Porter -- Glenwood Canyon Subcommittee of the Roads and Transportation Committee, Colorado Open Space Council

Lowell H. Watts -- Director, Cooperative Extension Service -- Colorado State University

Vim Crane Wright -- Colorado Field Ornithologists; Denver Field Ornithologists

Lesley T. Julian -- Concerned Citizen, Boulder

Bruce Imfeld -- Zero Population Growth

Howard K. Holme -- Colorado Council on Population

Ted Glauth -- Ecological Cooperation Organization

Public Hearing, Grand Junction

Arthur W. Moss -- Executive Director, Club 20 for Colorado West -- Grand Junction

Frank Cooley -- Attorney at Law -- Meeker

Ray J. Boggs -- Concerned Citizen -- Grand Junction

Dick Edmondson -- Manager, Tri-County Water Conservancy District -- Montrose

Jack Orr -- President, Colorado Cattlemen's Association -- Kremmling

Roy Craig -- Concerned Citizen -- Durango

Rebecca L. Roskowski -- Secretary, Uncompaghre Section -- Rocky Mountain Chapter, Sierra Club -- Grand Junction

Glenn Berry -- President, Comanche Milling Corporation -- Ohio City

Samuel M. Baseler -- President, Greenbelt, Inc. -- Grand Junction

Johann Vennekate -- German Student attending Grand Junction High School

Lawrence Aubert -- Concerned Citizen -- Grand Junction

Richard Martin -- Garfield County Zoning and Farm Interests -- Carbondale

Allen Nossaman -- Publisher, Silverton Standard -- Silverton

H. A. Lawrence -- Delta Chamber of Commerce -- Delta

Pat Willett -- Judge of Delta City Court -- Delta

Scott Gorsuch -- Concerned Citizen -- Glenwood Springs

Dave Gorsuch -- Concerned Citizen -- Vail

Raymond Paruch -- Councilman at Large -- Grand Junction

Mrs. Walter Orloff -- League of Women Voters -- Grand Junction

Roger Henderson -- Chamber of Commerce -- Glenwood Springs

Orville Boge -- Chemistry Professor, Mesa College -- Grand Junction
 James B. Johnson -- Department of Geology, Mesa College -- Grand Junction
 Robert Rice -- Concerned Citizen, Mesa County -- Grand Junction
 Herbert Snyder -- Secretary, National Council of Public Land Users -- Grand Junction
 Ralph Myers -- President, Paradise Oil, Water & Land Development, Inc. -- Denver
 Tim Pace -- Student, Grand Junction High School
 Betsy Graef -- Student, University of Colorado -- Denver
 Wally Foster -- Publisher, News Champion -- Gunnison
 T. M. Ford -- Mesa County Budget Officer -- Grand Junction
 Larry and Doris Helfter and Children -- Concerned Citizens -- Grand Junction
 Walter Wieben -- Concerned Citizen -- Snowmass

Public Hearing, Fort Collins

Doris Dawdy -- Trout Unlimited -- Fort Collins
 Robert P. Adams -- Assistant Professor of Botany, Colorado State University -- Fort Collins
 William M. Klein -- Curator, Colorado State University Herbarium -- Fort Collins
 Peggy Reeves -- American Association of University Women -- Fort Collins
 Evelyn Clark -- Concerned Citizen -- Fort Collins
 Myron L. Corrin -- Chairman, Environmental Quality Committee -- Environmental Resources Center, Colorado State University -- Fort Collins
 Janet Armstrong -- League of Women Voters -- Loveland
 Robert E. Dils -- Dean, College of Forestry and Natural Resources -- Colorado State University -- Fort Collins
 Ross Whaley -- Colorado State University Task Force on Environment -- Fort Collins
 Robert W. Giacomini -- City Attorney -- Sterling

Richard T. Ward -- Ecology Committee, Environmental Resources Center -- Colorado State University -- Fort Collins
 Frederick F. Wangaard -- Chairman, Forestry and Forest Industries Committee -- Environmental Resources Center, Colorado State University -- Fort Collins
 Henry P. Caulfield, Jr. -- Chairman, Water Committee -- Environmental Resources Center, Colorado State University -- Fort Collins
 Norman Evans -- Director, Environmental Resources Center -- Colorado State University -- Fort Collins
 Richard A. Perchlik -- Mayor, City of Greeley
 Emily Wilmarth -- League of Women Voters -- Fort Collins
 James A. Bailey -- President, Poudre Valley Greenbelt Association -- Fort Collins
 Oscar Schmunk -- State Forest Service -- Fort Collins
 Steven Williams -- PLAN-Boulder -- Boulder
 Richard Weppner -- Rocky Mountain Chapter, Sierra Club -- Boulder
 Philip S. Miller -- Concerned Citizen -- Fort Collins
 Dorothy Spanjer -- Housing Committee, Area Development Group, Inc. -- Haxtun
 Perry Ragouzis -- Art Department, Colorado State University -- Fort Collins
 Iris Bonar -- Ecology and Environment Committee, Colorado State Grange -- Broomfield
 Donald L. Miles -- Concerned Citizen -- Fort Collins
 Walter Rath -- Concerned Citizen -- Orchard
 Barbara Petit -- Concerned Citizen -- Fort Collins
 Amos Allard -- Chamber of Commerce -- Loveland
 Martin Bittinger -- Water Integration Committee -- Fort Collins
 Frank Anders -- Professor, University of Northern Colorado -- Greeley

Public Hearing, Pueblo

W. R. Kincaide -- President, Pueblo County Farm Bureau -- Pueblo
 Lewis H. Hoyle -- Director, Pueblo City-County Health Department -- Pueblo

Frank J. Allman -- Committee for South-
west Pueblo Storm Sewers -- Pueblo
Norris B. Hecox -- Committee for South-
west Pueblo Storm Sewers -- Pueblo
Lorna Giles -- Environmental Chairman,
League of Women Voters -- Pueblo
Dee Clary -- Concerned Citizen -- Pueblo
C. Wayne Williams -- Interim Director, Air
Pollution Control -- Pueblo
County Health Department -- Pueblo
Richard Francis -- Right to Life Association
-- Colorado Springs
Gerald Faust -- Southern Colorado Econo-
mic Development District -- Las Animas
Joan Wolther -- Secretary, Arkansas Valley
Conservation Council -- Pueblo
James S. Stone -- President, Pollution Con-
trol Systems, Inc. -- Golden
Michael Horan -- Builders Realty -- Colorado
Springs

Stu Huntington -- Southern Colorado Econo-
mic Development District -- Pueblo
Donald A. Rapp -- Planning Director, San
Luis Valley Regional Development and
Planning Commission
Mrs. Pat Kelly -- Vice President, Pueblo
City Council -- Pueblo
Kay Everson -- Concerned Citizen -- Colo-
rado Springs
Gladys Comi -- Pueblo Beautiful Association
-- Pueblo
Jerry Mallett -- Chairman, Wilderness
Workshop -- Colorado Open Space Coun-
cil -- Colorado Springs
Antone Butkovich -- Concerned Citizen --
Pueblo
Al Blomquist -- Director, Pueblo Regional
Planning Commission -- Pueblo
Beverly Poor -- Concerned Citizen -- Pueblo

APPENDIX D

COMMISSION LIBRARY

The Commission has collected a small library of reference materials during its twenty-two-month lifetime. This library consists of such materials as: Bibliographies of federal, state, and local agencies engaged in environmental work; environmental books and pamphlets; activities in other states and other

jurisdictions; files on environmental problems; etc.

All of these materials have been turned over to the Coordinator of Environmental Problems for permanent reference.