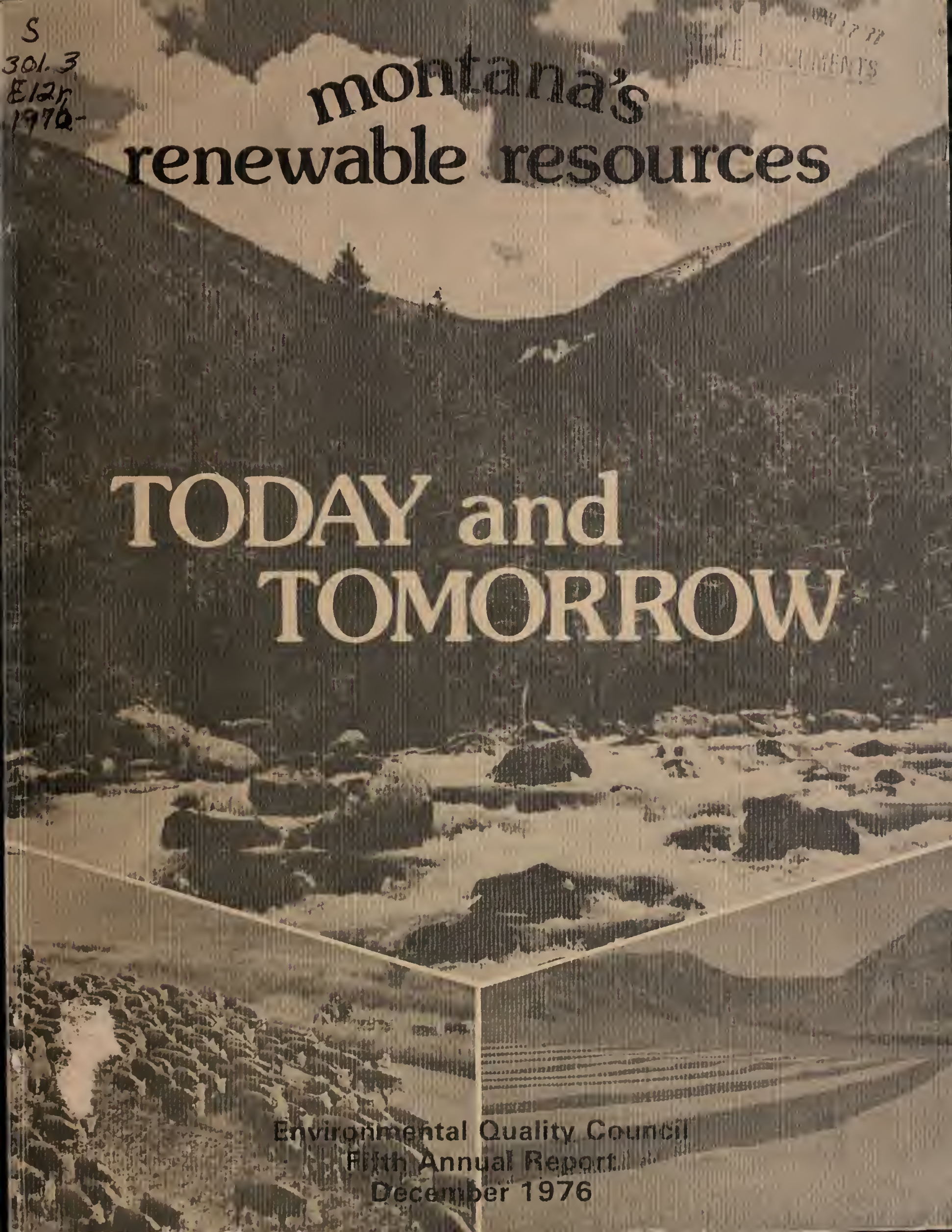

montana's renewable resources

TODAY and TOMORROW

Environmental Quality Council
Fifth Annual Report
December 1976

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LETTER OF TRANSMITTAL

Honorable Thomas L. Judge
Governor
State of Montana

Members of the Legislative Assembly

The People of Montana

The Environmental Quality Council herewith submits its *Fifth Annual Report* for the fiscal year ending June 30, 1976, in accordance with Sec. 69-6514 of the Montana Environmental Policy Act.

Rep. Thomas O. Hager
Chairman

John W. Reuss
Executive Director

THIS REPORT PRINTED ON RECYCLED PAPER.

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Preface

During this past year, the Environmental Quality Council continued to make steady progress in fulfilling its mandate under the Montana Environmental Policy Act (MEPA).

MEPA established the Environmental Quality Council as a legislative agency in 1971. Thus, the EQC is a relative newcomer to state government. Much of the past year was devoted to exploring ways to make MEPA and EQC more effective. The Council met for two days in Red Lodge in June 1976 to review MEPA, to discuss ways of strengthening the EQC, and to evaluate different approaches of securing greater compliance with the requirements of MEPA. The Council left Red Lodge with a greater understanding of MEPA and with a commitment to identify ways to secure greater compliance with MEPA's substantive and procedural requirements.

The Council also served as a forum for examining important issues. In April 1976 the Council reviewed the impacts on northeastern Montana of the coal-conversion developments of the Saskatchewan Power Corporation. The Council petitioned the parties involved and the International Joint Commission to expand their consideration of Poplar River water quantity to a full assessment of all transfrontier impacts. Important background material for the Council's actions was contained in *The Transboundary Effect: Safeguarding the Poplar River in Montana*, an EQC staff report by Ronald J. Schleyer.

Reviewing Montana's natural gas supply situation was a second major EQC initiative designed to provide information for the assessment and resolution of an important problem confronting the state. At its October meeting, the Council reviewed a draft of Tom Frizzell's EQC staff report *Montana's Natural Gas Supply Crisis* and scheduled a public hearing on the issue in December. It is anticipated that as a result of the staff report and the hearing, the Council will make recommendations to the 1977 Legislature on how it can best respond to the natural gas supply situation.

In addition to these activities, the Council has continued to review state agency programs under a longer-term EQC project designed to assess how best to structure state government operations to implement MEPA. EQC staff attorney Steve Perlmutter prepared an *Environmental Permit Directory*. Perlmutter's work on a state environmental index, a comprehensive and systematic compilation of the state's environmental and natural resource statutes and programs, will be available following the 1977 Legislature.

The Council's actions during its first five years have emphasized developing a stock of knowledge about MEPA and Montana's environment. In the years to come, the Council will turn its attention increasingly to evaluating the effectiveness of state agencies in carrying out the policies established by MEPA. It is my hope that this will be a cooperative effort shared by all Montana's citizens.

Representative Thomas O. Hager
Chairman
Environmental Quality Council

Introduction

Publication of the EQC Fifth Annual Report *Montana's Renewable Resources: Today and Tomorrow* continues our tradition of issuing each year a major document addressing a significant issue.

The theme of this year's report could not be more timely. Sooner or later the transition must be made from a society based on finite resources to one using renewable resources. *Montana's Renewable Resources: Today and Tomorrow* provides the framework for beginning that transition in Montana here and now.

In outlining a long-term strategy for Montana's future, the EQC Fifth Annual Report contains a descriptive overview of Montana's renewable resources and explains how the major renewable resource sectors operate. The report assembles for the first time most of what is known about Montana's renewable resources: where they are, how they are used, and the role they play in Montana's economy.

Montana's Renewable Resources: Today and Tomorrow argues that Montana's future is linked to how its renewable resources are developed and managed. The report examines the opportunities and constraints of maintaining and enhancing the productive capability of Montana's renewable resource base. The long-term objective of a state renewable resources policy must be to sustain indefinitely the productive potential of the land's renewable resource outputs. From this standpoint, the report identifies the ecological issues that limit land uses and practices in implementing a renewable resources policy.

The EQC Fifth Annual Report illustrates a number of trends threatening to erode Montana's renewable resource-based economy and culture. Federal policies designed to increase coal production and the prospect of increased mining activities in Montana in response to worldwide energy and materials shortages will make Montana a much different place. To the extent Montanans can shape their future and to the degree they desire to use their land in ways that are indefinitely sustainable, this report outlines a course of action that should be given prompt and serious consideration.

Major responsibility for writing and coordinating *Montana's Renewable Resources: Today and Tomorrow* was assumed by Richard L. Bourke, EQC staff economist. Bourke's determination to synthesize what is known about Montana's renewable resources and his skill at pinpointing key interactions and issues is evident throughout the report. Sections treating ecological aspects of current and increased use of Montana's renewable resources were skillfully prepared by Loren L. Bahls, EQC staff ecologist. Steven J. Perlmutter, EQC staff attorney, and Eileen Shore, EQC research assistant, sifted through mounds of reports and statutes in preparing the review of state and federal policy and program trends included in the report. That task proved so complex that much of that review is not included here. What has been omitted will be used as introductory material in Perlmutter's *Environmental Index*, which will be published following the 1977 Legislature. The several drafts were ably edited by Ronald J. Schleyer.

The Environmental Quality Council reviewed and commented on earlier drafts of the report and endorsed a number of recommendations that are presented in the Executive Summary. Action on these recommendations would initiate important steps in the long-term quest to maintain and enhance the quality of Montana's environment and quality of life.

John W. Reuss
Executive Director
Environmental Quality Council

Montana Environmental

Quality Council

FIFTH ANNUAL REPORT

MONTANA'S RENEWABLE RESOURCES TODAY AND TOMORROW

EXECUTIVE SUMMARY

Introduction

The Montana Environmental Policy Act (MEPA) establishes a comprehensive state environmental policy placing major emphasis on creating and maintaining "conditions under which man and nature can coexist in productive harmony..." (69-6503). MEPA requires, more specifically, that state policy should "enhance the quality of renewable resources. . ." [69-6503(a)(6)].

How agricultural and forestlands are utilized is the major factor determining the environmental and economic setting in which Montanans live. For the remainder of this century, there will be increasing demands for the renewable outputs of Montana's land resources. Recent state policy stressing economic development may be misdirected unless conscious efforts are made to place at least co-equal emphasis on the ability of Montana's land base to sustain production of its renewable outputs indefinitely. Achieving economic stability and preserving Montana's high quality of life are major challenges facing all Montanans and the principal focus of *Montana's Renewable Resources: Today and Tomorrow.*

Assumptions and Objectives

In assembling and analyzing the material presented in this report, the EQC based its assessment of Montana's renewable resources on four principal assumptions:

1. Montana citizens and their elected representatives are concerned with the "quality of life" in Montana.

2. The "quality of life" in Montana is today, and will be in the future, inextricably linked to the quality and use of its major land resources.

3. The renewable nature of many of the products means that these land resources will play an increasingly important role in Montana's future.

4. Montana is experiencing broad and rapid change in institutional objectives and economic forces that threaten to alter the utilization and productivity of these resources.

Today, the outputs of Montana's renewable resources—forestlands and crop and range lands—are the driving force behind Montana's economy. Pressures to increase these outputs may limit the ability of the land base to sustain production indefinitely. The gradual transformation of Montana from a rural to an urban state increases the political and economic power of city and industrial interests. This may result, over time, in a situation in which public and private decision makers will become more removed and less familiar with the land base that is so vital to Montana's renewable resource based economy. An additional factor that affects Montana's renewable resources is the increasing competition between the use of Montana's land base to produce renewable outputs or nonrenewable energy and nonenergy minerals.

These factors—increasing demands for renewable resource outputs, the rural to urban shift, and significantly greater production of nonrenewable outputs—will shape the future of Montana. It is from this perspective that the Environmental Quality Council undertook its examination of *Montana's Renewable Resources: Today and Tomorrow.*

The principal goal of this report is to present an accurate and coherent description of the operation of Montana's renewable resource sectors, concentrating especially on identifying how they function and interact, the forces, both in- and out-of-state, that affect these sectors, and the implications of these forces for the future productivity of Montana's land resources. In this effort, the EQC examined Montana's renewable resources from the standpoint of three cardinal objectives: 1) maintaining ecological integrity, 2) improving resource productivity, and 3) increasing economic stability.

Montana's Renewable Resources: Today and Tomorrow is a document presenting basic information and analyses which may be used to make informed decisions about the uses of Montana's resources. The aim is to guide a constructive public discussion concerning the future of Montana's two major land resources—agricultural and forestlands—which have the potential of providing renewable outputs indefinitely.

Contents

Part I *Montana's Renewable Resources and the Quality of Life* establishes the framework within which the EQC examines the uses of Montana's land base. The focus is on the policy established by MEPA which emphasizes renewable resource development as contrasted to the development of nonrenewable resources. Chapter 1 *MEPA, Resource Policy and the Future* outlines the three basic principles of a MEPA-based natural resource policy for Montana: a) the high quality of Montana's natural resources, particularly its renewable resources, must be maintained and enhanced; b) Montana's natural resources must be allocated to the widest variety of beneficial uses while minimizing degradation of the resources; and c) the timing and intensity of resource use must not deny the coequal right of succeeding generations to use natural resources.

Chapter 2 *Public Policy and the Future: The Need to Encourage Reliance on Renewable Resources* reviews the recent literature on world population growth, materials scarcity, and the rising demand for food and fiber. Resource scarcities, increasing costs for energy and capital, and rising levels of pollution generated by our industrial system imply that long-term conflicts are inherent in an economic system heavily dependent on nonrenewable resources. It is argued that ultimately the world must make the transition from an economic system heavily dependent on finite resources to one which maximizes the use of renewable resources. This chapter concludes by urging Montanans to consider using their unique opportunity to begin that transition here and now.

Chapter 3 *Montana's Renewable Resources: Their Importance Today and Potential for Tomorrow* examines the demands that will be placed on Montana's vast land base for its renewable outputs, the potential conflicts which may arise from continued management at less than full productivity, and the competing demands for renewable and nonrenewable outputs. A development policy for Montana must consider the pace and level of nonrenewable resource development, a more professional understanding of the state's renewable resource system, and increased emphasis on maintaining the long-term productivity of these systems. Montana cannot afford less than a serious, long-term commitment to these issues of worldwide importance.

Part II *Montana's Agricultural and Forestland Resources* describes the economic and ecological importance of Montana's land base. Chapter 4 *Agricultural Land Resources in Montana* and Chapter 6 *Forestland Resources in Montana* present basic data on the location, use, and condition of Montana's land base. Chapter 5 *Agriculture and the Grassland Ecosystem of Montana* and Chapter 7 *The Forestland Ecosystem of Montana* contain important material on the ecological characteristics of Montana's land base. Chapter 8 *Economic Characteristics of Montana Agricultural and Forestland Resources* examines the contribution to Montana's economy of agricultural and forestland outputs. This chapter outlines clearly the dominant economic role played by these renewable resource sectors and establishes the basis of a state policy which should seek to devise programs to sustain these sectors indefinitely.

Part III *Trends and Prospects: Implications for the Future of Montana's Renewable Resources* identifies certain trends which outline the direction of state and national policies for agricultural and forestlands and the economic and ecological forces acting upon these resource sectors. The objective of Chapter 9 *National Trends in the Use of Agricultural Land*, Chapter 10 *National Trends in the Use of Forestland*, and Chapter 11 *Emerging Federal Political and Institutional Policies Affecting the Use of Land* is to identify more clearly the extent to which the political and economic systems act to either limit or expand the opportunity for Montana to maintain and enhance a society based on renewable resources. Chapter 12 *State Development Policies and Montana's Renewable Resources* reviews the current literature on state and regional economic development efforts. It finds that state action designed to promote economic development is limited in effectiveness. In the face of increasing demands for Montana's natural resources, a development policy stressing maintenance of renewable resource productivity will offer the best long-term strategy for Montana. Chapter 13 *Ecological Issues Arising from the Use of Montana's Agricultural and Forestland Resources* identifies major issues limiting the development of renewable resources. At this point, the report returns to its major premise that unless carefully managed and unless particular attention is devoted to understanding the ecological constraints of certain land use practices, biological integrity will be irreversibly damaged, inhibiting the land's self-sustaining properties.

Major Findings

1. The Montana Environmental Policy Act has important natural resource implications. The high quality of Montana's resources, especially its renewable resources, must be maintained and enhanced. Montana's natural resources must be allocated to a wide variety of beneficial uses while minimizing degradation of the resource base. Lastly, the timing and intensity of the use of Montana's natural resources must not deny the coequal right of succeeding generations to the use and value of resources.
2. Nonrenewable resources (non-energy minerals and fossil energy resources) will become scarcer and more costly to society as the higher quality, more accessible reserves are depleted. Concurrently those resources which are biologically sustainable, though depletable, (renewable resources such as food and fiber, recreational opportunities, wildlife, etc.) will become more valuable to society, both socially and economically.

3. An important distinction must be made between resources: some are *intrinsic* resources and some are *derived* resources. Intrinsic resources, such as land, wildlife, water, air, and natural beauty, exist independently as part of self-perpetuating ecological systems and require little application of factors of production (energy, capital, labor) to be of value to man. Derived resources, such as minerals, timber, and agricultural products, only become valuable to man through the production system. Intrinsic resources are unique and non-substitutable. Their value is independent of the production system and can only increase over time. The value of derived resources is closely linked to the availability and costs of production factors and to the emergence of potential substitutes.
4. Agricultural and forestlands, the origin of Montana's abundant renewable resources, cover nearly the entire state and constitute the land base upon which the best qualities of Montana's environment depend.
5. Agricultural and forestland resources are conservatively estimated to generate three of every five dollars of personal income statewide and three of every five Montana jobs by producing timber, water, wildlife, wilderness, recreational opportunities, food and animal feed grains, and forage for livestock. Most rural communities in Montana are completely dependent on the products of agriculture or forestry.
6. Projections show a steady increase in demand for Montana's renewable resources. Demand for cereal grains is expected to double by the year 2000; consumption of forage by livestock will increase 50 to 100 percent over the same period of time; timber demand will be up 35 to 80 percent; water consumption in the Missouri and Columbia river basins is expected to increase by over 50 percent; and demand for recreational opportunities is projected to increase 40 to 80 percent.
7. Current land management practices in Montana and changes in basic Montana environmental qualities—the integrity of the land, water and air quality, and some forms of wildlife—indicate a trend toward ecological impairment that may endanger resource productivity.
8. Increasing demand for the renewable products of agricultural and forestland resources in Montana is increasingly likely to cause conflict over use and allocation of resources and resource products. Expansion of protected wilderness, for example, may conflict with the need to harvest mature timber; prevention of water pollution, wind and water erosion may conflict with desires to bolster production, expand cropland and plow rangeland; preservation of wildlife may conflict with uses by man of the forest and the range.
9. Currently there is a lack of knowledge of the compatibilities between resource uses. Increasing conflicts over the allocation and use of agricultural and forestland resources will require a more professional understanding of the compatibilities between either simultaneous or successive separate uses to which the same, or contiguous, parcels of land may be put.
10. Evidence indicates that the ability of Montana's land resources to sustain the production of high quality renewable outputs is in doubt:
    a. Grain yield increases have slowed.
    b. Wheat protein content has declined.
    c. There is a large backlog of unmet land conservation and timber stand improvement needs.
    d. Montana's highly productive (in terms of timber) forest sites receive little intensive management.
    e. Montana's rangeland and forestland, in general, are at less than full productive potential, for all outputs.
    f. The current level of timber harvest on forest industry land cannot be sustained. Intensive timber management may not be keeping pace with the cut; old growth forests may be cut over faster than they are being regenerated.
    g. Nationally, there are indications of declining returns to agricultural technology; there has been a slowing in increases in agricultural production efficiency.
    h. Adverse ecological impacts due to agricultural and forestry practices, such as wind and water erosion, saline seep and stream sedimentation, dewatering, and elevated temperatures, are increasing.
    i. Conversion of these land resources to urban and built-up uses is on the increase and will in many cases be irreversible.
11. Transportation rates to major markets for Montana agricultural and forest products and for supplies necessary to sustain agriculture and forestry discriminate against Montana producers.
12. Montana's dependence on distant markets and the unstable nature of prices for wood and agricultural commodities has made those sectors particularly susceptible to economic forces beyond the state's influence.
13. Increasing dependence on scarce production factors—such as energy and capital—endangers the financial stability of ranchers, farmers, and wood producers in Montana. Changes in the economics of agriculture and forestry in Montana are forcing a concentration of ownership and contributing to the economic decline of rural communities.
14. When confronted with *uncertainty* over the ability of natural systems to provide for future generations and the *risk* that inadequate information about the effects of current management techniques may lead to

reduced productivity, prudent resource policy should weigh carefully any decision which might irreversibly alter natural ecological systems and should be designed to keep options open.

15. There are limits to the ability of state government to positively affect economic growth. Given these limits and the increasing demands for Montana's resources as much attention should be devoted to the capability of the land to sustain the increasing demands that will be placed upon it as is devoted to developing and promoting those demands. Such a coequal emphasis is necessary since in the long run the land's productivity will be the major determinant of Montana's quality of life.

16. Economic growth and the development of natural resources entail dilemmas which arise unavoidably from the mutually interdependent nature of resource demands, resource management, and resource integrity. To assure Montana's long term wealth Montana should intensify its efforts toward identifying and making investments aimed at enhancing the productivity of its land resources and their renewable outputs.

17. Montana's richness in renewable and nonrenewable natural resources can be an opportunity. The opportunity lies in recognizing that the resources Montana has in abundance are vital to the resolution of important policy issues confronting the nation and the world. Energy, food, and water are only the beginning. Ultimately there will have to be a transition from an economic and social system heavily dependent on finite resources to one which minimizes the use of nonrenewable resources and maximizes the utilization of renewable resources. Montana's public and private institutions should consider a long-term research program designed to respond to this opportunity. Many questions arise naturally: how much of each resource should be allocated toward what uses; how intensively should nonrenewable resources be used; how can renewable resources best be preserved; and how can the transition to a renewable resource economy be encouraged with the least disruption? These are not merely biological and economic questions, but social and political as well. With a serious commitment Montana could do much to assist in resolving these complex and far-reaching questions.

Recommendations

At its meeting in Helena on October 1, 1976, the Environmental Quality Council reviewed *Montana's Renewable Resources: Today and Tomorrow* and made the following recommendations:

1. The EQC staff should initiate discussions with the Governor's Office with the objective of integrating the following resource policy initiatives into executive branch policies toward natural resources and economic planning:

- **A state resource policy which recognizes the enduring wealth of the renewable outputs produced by Montana's agricultural land and forestland and that encourages maximum understanding of the ecosystem upon which these outputs depend. The goal here is that the state not take, either explicitly or implicitly, actions with the potential to irreversibly impair the productivity of these land resources.**

- **A state resource policy distinguishing between the intrinsic and derived outputs of Montana's agricultural and forestland, and which recognizes that the long-term resilience of Montana's socio-economic system is equally dependent upon intrinsic and derived outputs and ultimately on the stability and integrity of ecological systems. The policy must consider the maintenance and enhancement of the land's ability to produce intrinsic and derived outputs as equally important.**

- **A state resource policy which recognizes the interdependence of resource and economic policy, and which encourages resource and economic planning to make a priority the development and use of the state's renewable resources consistent with the first two policy objectives.**

2. A thorough analysis should be made of the authorizing legislation for Dept. of Community Affairs, Fish & Game, Dept. of Natural Resources & Conservation, State Lands, Agriculture, Livestock, and Dept. of Health and Environmental Sciences. This study should be conducted as part of the Environmental Policy and Planning Process and should result in a set of legislative recommendations which will establish coordinated statements of policy to guide these agencies' actions with respect to natural resources.

3. The Governor and legislative leadership should appoint a special committee to:

a. Undertake a comprehensive review of current and proposed in-state agricultural and forestland research projects.

b. Explore methods of encouraging research consistent with EQC Renewable Resources Project objectives.

4. Montana state government should investigate alternative methods of systematically measuring the condition of the state's land resources and the quantity and condition of the state's renewable resource outputs. The data should be integrated and fashioned for public use (similar to EQC Environmental Indicators effort).

5. Montana state government should initiate a coordinated investigation of all feasible methods to eliminate the backlog of land treatment needs. Implementation suggestions include:

a. Use of federal manpower funds disbursed through the state Employment and Training Council to provide needed manpower, or
b. Use of state revenues or earmark coal tax to establish a "conservation corps" program to put unemployed Montanans to work, or
c. Combine a. and b.

6. Timely data should be regularly compiled and made available on request documenting changes in ownership patterns and use of Montana's agricultural and forestland.

7. The EQC supports amending state statutes authorizing operation of the Conservation and Range Districts to provide specific policy directives to the Districts consistent with a policy that the land's productivity be maintained and enhanced for both intrinsic as well as derived outputs.

8. The EQC supports legislative resolutions calling for increased funding for 1) Forest Service Region 1 management activities, particularly for timber stand improvement and 2) SCS and ASCS programs designed to conserve water and soil resources.

9. The EQC endorses the establishment of an interim legislative committee to study the feasibility of replacing the present forestland taxation system with a severance tax on timber at the time of harvest.

10. The Legislature should adopt a joint resolution, directed to the Congress of the United States, requesting amendment of the Enabling Act which would permit the management of School Trust Lands for natural areas purposes.

11. A better understanding of the economic and biologic potential of the outputs of agricultural and forestlands is needed. A first step toward this goal would include:

a. Complete land capability mapping and resource inventory for Montana.
b. Update 1967 and 1968 soil conservation needs inventories for private and public land.
c. Accelerate completion of modern county soil surveys.
d. Investigate the responses of the production of forestland outputs to various levels of management, beginning with determining growth data by site class for all Montana's commercial forestland.

12. State government should investigate fully the relationship between the rate of cut of Montana's mature forests and the supply of potentially harvestable mature stands to discern when the original-growth timber resource will be depleted. Other investigations should cover the physical and economic potential for timber production of the state's mature forests to minimize the risk that a reduction in the availability of timber for lumber production will accompany the transition from old growth to second growth forests. A principal criterion should be the avoidance of ecological impacts detrimental to the forest's productivity for other outputs.

13. The state should encourage a professional understanding of the compatabilities between either simultaneous or successive separate uses to which the same, or contiguous, parcels of land may be put in order to reduce the potential for conflict. First order needs include information on:

a. Ecological impacts of present and alternative crop production practices, especially as they relate to the growing problem of saline seeps and reduction of water quality.
b. Impact of irrigation levels and techniques on water salinity levels.
c. Relationship between intensified use of range by ruminant animals and continued provision of adequate forage and habitat for wildlife.
d. Feasibility of managing for timber production in highly productive roadless areas while maintaining attractiveness for continued recreational use.
e. Relationship between levels of use and quality of wilderness and dispersed recreational activities.
f. Ecological impacts of present and alternative forest road construction and logging techniques.
g. Relationship between the urbanization of a scenic area (e.g., Gallatin Canyon) and the recreational value of that area for residents and nonresidents.
h. Identification of natural areas in Montana which would include representative forest, grassland, shrub land, alpine, wetland and aquatic areas to provide baseline ecosystems.

14. Montana state government should encourage greater federal and state efforts to assess the productivity of rangeland for its different outputs, the ecological ramifications of converting rangeland to cropland or the production of energy, alternative means of utilizing forage for the production of protein, and new uses for native plants and grasses.

15. The state of Montana should encourage state agricultural research institutions to pursue, and should support funding for, the following recommendations:

a. Expand research on photosynthesis with the objective of increasing the efficiency of use of solar energy.

b. Increase understanding of biological nitrogen fixation with the objective of decreasing the dependence on chemical nitrogen inputs and increasing the supply of biologically fixed nitrogen by major grain and forage systems.

c. Develop biologically based weed and pest control systems.

d. Increase the efficiency of conversion of forage protein and energy to animal protein and energy.

An appropriate starting point for such research in Montana would be gaining a better understanding of the operations and economic feasibility of current Montana-based crop and livestock operations which minimize the use of inorganic chemical inputs and tillage in agricultural production.

16. The state of Montana should attempt to determine maximum sustainable biological ceilings on grain yields. Once such biological ceilings are determined state government should encourage a refocusing of in-state research efforts away from increasing yields toward maintenance of prevailing yields and crop quality while minimizing adverse environmental impacts from crop production techniques.

17. Montana state government should encourage research on the environmental and economic value to the state of its intrinsic resources and promote the use and enjoyment of them in environmentally sensitive ways which minimize the need for additional factors of production.

18. Montana state government should encourage more economic and resource research into:

a. The ability of Montana's human and renewable resources to produce, for in-state consumption, more of the goods currently being purchased from out-of-state sources.

b. The potential for the creation in Montana of more labor-intensive production processes while minimizing the need for capital, energy, and other scarce resources.

19. Montana state government should act to reduce cyclical variations in profitability of agricultural and forestland products through:

a. Investigating methods to expand supply of capital to agricultural and forestland economic sectors. Low-cost loans might be provided for financing the purchase of agricultural land, agricultural production, upgrading capital equipment in small and medium-size sawmills to increase use of available wood fiber and for purchase of advanced logging and road construction equipment, or for small mills to purchase timber from public land.

b. Encouraging agricultural research with the objective of increasing profits by minimizing the cost of maintaining present agricultural yields, rather than through increasing yields.

c. Analyzing more fully the economic structure and operation of Montana's transportation system to devise strategies for reducing the costs of transporting Montana agricultural and wood products to market, and to reduce the costs of importing necessary supplies.

d. Investigating the Saskatchewan Land Bank concept as a means to assure an economical supply of agricultural land for Montanans who want to be farmers and ranchers but lack needed capital.

20. To the extent that Montana state government considers the general decline in economic vitality and population in Montana's rural communities an undesirable trend it should realize that the principal cause of the trend is economic in nature. Stemming the decline in rural areas will require an economic incentive program with the specific objective of increasing the economic strength of rural communities by emphasizing locally-based wood products, recreation, and agricultural operations. Toward this end state government should support research investigating means of:

a. Stimulating the supply of capital to Montana rural communities.

b. Providing adequate transportation systems for rural communities.

c. Encouraging labor intensive production methods in rural communities.

d. Promoting the production of products satisfying local market demands.

21. Montana state government should encourage a coordinated effort to increase in-state research efforts devoted to renewable materials of agricultural and wood fiber origin with emphasis on local production of energy from products of renewable resources.

MONTANA'S RENEWABLE RESOURCES

TODAY AND TOMORROW

Research Coordinated

by

Richard L. Bourke

PART I

MONTANA'S RENEWABLE RESOURCES AND THE QUALITY OF LIFE

CHAPTER 1 MEPA, RESOURCE POLICY AND THE FUTURE

In 1971, passage of the Montana Environmental Policy Act [MEPA] established a broad state policy concerning use of resources, respect for ecological harmonies,[1] and citizen participation in environmental decision making. The new policy gave public recognition to the existence of the innumerable interactions between man and nature, evidence of which has long dominated much of Montana's landscape. But the modern scope and rapidity of man-induced environmmental change, even in Montana, evoked urgency and apprehension along with recognition. Public policy was obliged to face the fact that resources and environmental systems upon which we all depend for our lives are not limitless and immutable, that in fact they are under noticeable stress. MEPA set forth a public commitment to eliminate the environmental damage and relieve the strains that endanger human survival. But the act went beyond promoting treatment of symptoms. It encouraged a long-term view. It called for a state of affairs that encourages "productive and enjoyable harmony between man and his environment" and promotes the "health and welfare of man" through environmental protection [69-6502].[2]

Travel Promotion Unit, Mt. Dept. of Highways

[1]The Council on Environmental Quality defines *ecology* as the science of the intricate web of relationships between living organisms and their living and nonliving surroundings. These interdependent living and nonliving parts make up *ecosystems*. Forests, lakes and estuaries are examples. Larger ecosystems or combinations of ecosystems, which occur in similar climates and share a similar character and arrangement of vegetation, are *biomes*. The Arctic tundra, prairie grasslands, and the desert are examples. The earth, its surrounding envelope of life-giving water and air, and all its living things comprise the *biosphere*. Finally, man's total *environmental system* includes not only the biosphere but also his interactions with his natural and man-made surroundings.

[2]Section 69-6502, Montana Environmental Policy Act. In this part reference to MEPA is by section number only.

In other words, the act recognized what is clearly evident: conservation and preservation of environmental resources is not only vital to survival but constitutes the best protection of the base of wealth from which our affluence has sprung.

In MEPA, then, the integrity of ecosystems and the wise use of our natural resources are seen as prerequisites for the maintenance and enhancement of a liveable, productive environment for future generations of Montanans. Implied is a state responsibility to do everything possible to ensure that today's use of Montana's resources takes account of tomorrow's needs. Section 69-6503, indeed, declares a state policy to "use all practicable means. . .to the end that the state may fulfill the responsibilities of each generation as trustee of the environment for succeeding generations."

The concerns of environmental policy in MEPA extend beyond care of ecological systems and conservation of irreplaceable resources. The policy extends to the broad and varied relationships between many of our citzens, their means of livelihood and the state's natural endowment of resources. This is so because many Montanans are employed in agriculture, forestry, mining, the recreation industry and other activities that directly affect the resource base. The Montana economic system and its employment patterns also give rise to population patterns and attendant transportation corridors—each with impact on air, land, and water resources. In addition, increasing affluence has led to population patterns appearing in Montana independent of employment opportunities. Examples are second homes, seasonal resorts, and high amenity retirement areas.[3]

Understanding more about these subtle and diffuse man-nature interactions is important for the Environmental Quality Council to discharge its role under MEPA of providing "timely and authoritative information concerning the conditions and trends in the quality of the environment. . .to analyze and interpret such information" [69-6514(a)]. *Montana Environmental Indicators*, the EQC Fourth Annual Report, compiled available data toward fulfilling this responsibility.

Even when it is available, factual information about the status of Montana's natural environments and resources is only the first step in assessing progress toward the ideal state of productive harmony. Data gathered regarding trends, status, and current utilization of resources must be viewed in a coherent, overall context. Three essential principles of a state natural resource policy, implicit in MEPA, provide one such context:

1. The high *quality* of Montana's natural resources, particularly its renewable resources, must be maintained and enhanced [69-6502 and 69-6503(a)(6)]. The first difficulty here is the need for up-to-date information on the status of natural resources. Even more difficult are questions of definition and value: What is "quality"? Who should benefit from "enhancement"?

2. Montana's natural resources must be *allocated* to the widest variety of beneficial uses while minimizing degradation of the resources [69-6503(a)(3)]. When uses conflict, though, regulating the relative intensities of the competing uses can be a controversial public issue. What values will be used to guide allocation of resources?

3. The *timing* and intensity of resource use must not deny the coequal right of succeeding generations to use natural resources [69-6503(a)(1)]. Important here is an understanding of current resource management and its likely effect on resource quality in the long run.

These three principles, *quality*, *allocation*, and *timing*, are the core elements of a state policy of use and management of natural resources. Although the policy itself is important, public recognition and understanding of the *need* for a coherent resource policy is even more crucial. Resources, especially renewable resources, represent the common treasure and ultimately the source of all individual wealth. Certainly the use of these resources, all legal mandates aside, merits the intense public inquiry and wide debate given to all issues vital to the health and welfare of people. Resolution of the many questions of value associated with these issues necessarily will require a reasoned consideration of the interdependence between several factors: use of Montana's natural resources; national economic and political goals; and other elements contributing to Montana's quality of life, such as the prevention of environmental degradation, maintenance of a healthy economy, population size and distribution, and social welfare.

The interdependence referred to can be illustrated best by examples. When the national economy is strong more pressure will be exerted for timber harvesting. With recent international grain shortages, Montana farmers have been trying to capture higher profits from the wheat export trade by plowing under more land. The high level of oil imports has worsened the balance of payments situation, encouraging a desire for energy "self-sufficiency," primarily through strip mining of western coal. Montana's reaction to national factors essentially beyond its control involves resource *allocation* decisions (conversion of native range to cropland and harvesting of forests for fiber); resource *quality* impacts (strip mining of rangeland, conversion of rangeland); and *timing* of resource use decisions (consumption of wood fiber and coal now, rather than saving it for a later date).

Management of Montana's endowment of minerals, air, land, water, and ecosystems—a factor at least in part within Montana's power to control—influences the demographic, economic, and social characteristics of the state no less than national and international events. Wise use and management of these resources can provide jobs and buttress economic health; overuse and mismanagement can ruin the economy. Land can provide second homes or recreational developments, or be left undeveloped to

[3]Such as lakeshores or condominium complexes near year-round recreation areas.

provide wildlife habitat and opportunities for recreation. Shifts in the demands for and value of resources can lead to boom towns in sparsely settled areas, or depressions in rural areas where small towns once prospered.

Thus, development of a state resources policy would have to reckon with interests both controllable and uncontrollable, though nonetheless affecting the physical, social, economic and political factors that contribute to Montana's quality of life. To make the best of this situation, the state's relationship to national public and private goals and interests must be clarified as fully as possible within the limits of the federal system. Effects of resource policy initiatives on the social and economic structure of the state must be thoroughly explored. In short, institution of a coherent resource policy must step carefully; but it must keep moving. The price of inaction will be inevitably a diminution of the chances for continued public health and welfare.

Several specific characteristics of resources in the United States and their place in human affairs here put limits on the debate over resource policy and define the role government can play in encouraging their wise use. Principal among the characteristics are these:

Ownership Some resources—air, water and certain lands—are publicly owned, and obviously are more amenable to public policy than are private resources, particularly private lands. Policies toward private resources have to take careful note of their owners' desires.

Market Forces Policies must be shaped to reflect differences in the degree of control that can be exercised by any given level of government. Building patterns can be guided by local zoning authorities; certain industrial sites may be controlled by the state; the price of grain, though, is beyond state control but can be influenced nationally by federal agriculture policies.

Resource Importance Some natural resources are more important than others. The use of land (see *EQC Third Annual Report* [1974]) is perhaps the overriding resource issue facing Montanans today. Land use decisions will affect water quantity and quality, ecosystem integrity, wildlife habitat, recreational opportunities, population patterns, air quality, and the structure and operation of the state's economic system. Land use decisions are rarely reversible.

Current Use Montana's land currently is used for a variety of purposes depending on ownership and market forces. These uses may conflict with one another on the same parcel of land (for example, second home development and wildlife habitat) or on adjacent parcels (strip mining and ranching). Time may be a central factor in judgments about competing uses. Today's use may be sustainable in the long term (timber harvesting) or only in the short term (mineral extraction). Therefore, resource policy must recognize the special importance of resources and resource uses that are sustainable indefinitely.

Renewability Renewable resources admit of sustained production, so it is helpful to distinguish between renewable and nonrenewable resources. For example, Montana's land resources produce wood fiber, minerals, agricultural products, water, wildlife, wilderness and recreational opportunities. Except for minerals, all of these outputs can renew themselves biologically. However, man also has the capacity to alter and degrade the land, water, and environment which sustains the renewability. For this reason a resource policy should be conceived with particular awareness of man-nature interactions affecting the productivity of renewable resources.

CHAPTER 2 PUBLIC POLICY AND THE FUTURE: THE NEED TO ENCOURAGE RELIANCE ON RENEWABLE RESOURCES

Burgeoning population, booming industrial production to sustain a rising standard of living and the need to dispose of by-products of the industrialized civilization all have forced a recognition that there are self-destructive elements in the way we live.

First came a concern about the ability of ecosystems (themselves important renewable resources) to absorb polluting wastes generated by the current system. Although locally apparent long before this time, environmental deterioration began to be recognized as an integral by-product of the industrial system only in the mid-1960s. The pattern and rate of economic growth since World War II finally made it apparent that air and water do indeed have limited capacities to absorb the effluents produced by the industrial economic system. Public and private decision making processes had simply not been organized or designed to protect public health, much less the environment, from ruin. Public regulation was deemed necessary and in the United States emerged most strongly in the federal Clean Air Act [1963] and Water Quality Act [1965]. Water and air pollution always have been visible, and to a certain extent measurable. Misleadingly so when compared with more recent, subtle manifestations of environmental degradation, such as the cancer-causing agents believed to be diffused widely in the nation's air and water, or the hypothesized slow destruction of ozone in the stratosphere. As time progresses events reveal more and more the limits of man's understanding of the workings of the biosphere and its capacity to absorb the effluents of the industrial system.

Moreover, national boundaries no longer are an adequate context within which to resolve problems of environmental pollution. Airsheds and watersheds know no political boundaries, as evidenced by two recent conflicts between Montana and her northern neighbor, Canada. Citizens in the Flathead Valley and in northeastern Montana are rightly concerned about British Columbian coal development and thermal electric generators in Saskatchewan—each with the potential for adverse environmental consequences in Montana. And efforts to stop the accelerating pollution of the world's oceans have only begun.

Gradually with pollution awareness came the realization that clean air and water are natural resources and that all resources are interrelated. In their *Economic Theory of Natural Resources* [1974], Orris Herfindahl and Allan Kneese state the problem concisely (153):

> Recent concern is a product of a renewed awareness of the finiteness of our natural resources base, in this nation and the world. This means concern with scarcity of the traditional natural resources commodities in the face of rapidly growing population and industrial production. To many it means, even more urgently, scarcity of resources which had long been regarded as infinitely great in supply—"free goods" in the economist's terminology.
>
> Clean water and pure air are now perceived as being natural resources—scarce ones, and in many areas urgently scarce. Ecologists have made it impossible for anyone who can hear or see to be unaware of the problems we face with respect to the natural environment. It appears that all natural resources issues can best be thought of as part of the general problem of wise use and management of the natural endowment of minerals, fuels, land, air, water, ecosystems, electromagnetic properties of the natural world, and landscape.

Travel Promotion Unit, Mt. Dept. of Highways

[4] Throughout, all numbers within parentheses refer to materials cited in the Bibliography section of this report.

Pollution of the biosphere is a serious problem, but modern environmental concern extends further to the only gradually appreciated but plain fact that there are not enough resources to sustain indefinite growth. The competition for resources, of course, is due primarily to continued population growth, which is seen as containing the most serious long-term threat to the future of civilization. Projected population growth worldwide seems to dwarf other problems. Currently, world population is growing at 2.2 percent per year, at which rate it will double to 8 billion in the next 30 to 35 years. Only 25 years ago the world's population was 2 billion.

Two resources with close links to population and industrialism have cornered the most international attention in the past several years: energy and food. Discussion of either resource immediately reveals that they have several themes in common with each other and with the nature of all resources: their adequacy in the face of burgeoning demand; whether world political and economic institutions can allocate them fairly among the have and have-not nations; the ability of the international money markets to finance the tremendous increase in trade envisaged between the resource rich and poor nations; and the threats to world order from the inevitable competition and conflict over (in this case) these two most basic and vital, and increasingly scarce, resources.

Some distinctions should be made between problems of energy and food. The energy "crisis," as it is commonly called today, primarily was the result of a domestic demand for petroleum exceeding supply. Throughout the 1960s and early 1970s, a progressively larger share of our petroleum consumption had to be met by importing oil. The nation became acutely aware of its dependence on foreign oil when oil exporting nations coordinated an embargo against the United States (and other countries) in 1973. The national government reacted by scrutinizing the entire energy production and consumption picture. The conclusion: there are many, unsettling long-term implications of current energy use patterns in the United States. So far, only two basic public policy initiatives have emerged. First, that fuels are finite and that in the long run there must be a commitment to energy conservation. Second, dependence on foreign oil imports worsens the nation's balance of payments and makes the economy vulnerable to further cutbacks. One response therefore has been a call for greater national self-sufficiency in energy production.

The United States emerged from the international food "crisis" in a relatively strong resource position. In retrospect, the sudden rise in international grain prices signaling a food shortage, which occurred between 1972 and 1974, was due principally to a combination of two events. First, since the late 1960s U.S. public policy had been to reduce its stocks of grain in storage. Second, in 1972, for the first time in two decades, world food production fell due to crop failures—mainly in the Soviet Union and the developing countries. Crop failures increased pressure for export of already diminished grain reserves. Once again, a resource shortage, in this case food, caused a reexamination of the future outlook for production and consumption and again some unsettling problems came to light. Because food is more vital to human needs than energy, the United States, in its position as the world's largest food exporter, found itself confronting policy questions with moral as well as political overtones. But as with energy, there is a long-range concern about the adequacy of world resources to provide the food necessary to avert death for millions of hungry people.

Recognition of the problem-ridden connection between resources and growth was slow to develop. Since the early settlement of the eastern seaboard the United States has grown and developed on a base of prodigious natural resource wealth that yielded minerals, fuels, fiber, foodstuffs, fish, water, and space to house the necessary and inevitable population growth. The wealth of resources was so vast that conflicts in their use rarely arose. If they did, there was always room to move on. In the 350 years since the landing at Plymouth Rock, Americans have consumed immense quantities of nonrenewable resources in the form of energy and nonenergy materials. Land was dedicated to certain uses in support of citizens.[5] Many renewable resources, such as local ecosystems, have been degraded or destroyed through overuse and misuse. Out of the environmental movement arose concern for environmental resources. Today, problems with the management and use of environmental resources are closely linked with the interaction between the production system and natural ecological systems through the extraction and use of natural resources.

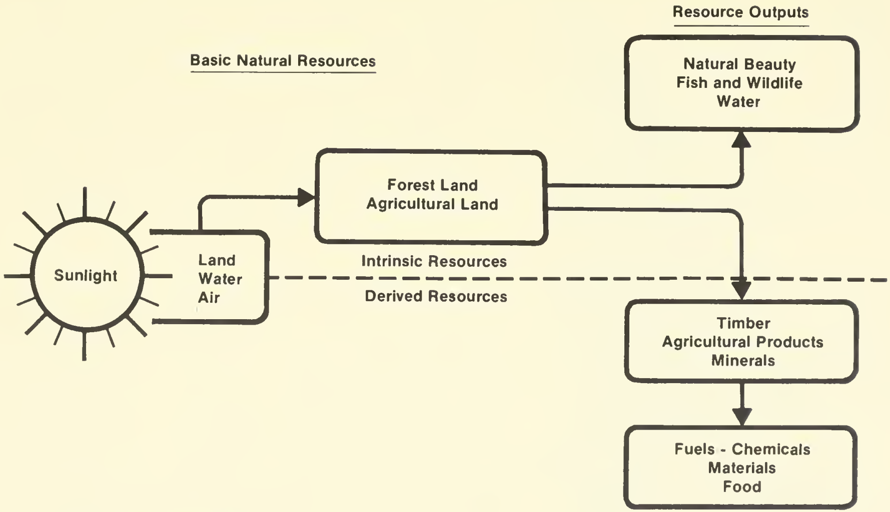
Because it was out of the mainstreams of transportation and settlement patterns, Montana was sparsely settled until the last 100 years. Since the mid- to late-1800s Montanans have tamed the wilderness in search of natural resource wealth. First, it was furs and minerals, later range and cropland, and still later wood fiber. With the exception of furs and some minerals, these resources are still in demand. Today, this demand has expanded to include coal, water and recreational amenities. More and more, scarcity of these resources is the central factor in their appeal. This is true for nonrenewable resources which are finite (such as coal, gas, oil, copper, iron, platinum, uranium and potassium) and those biologically renewable, although depletable, resources such as land producing agricultural products (grains and livestock), wood fiber, wildlife and recreational amenities, and water.

The critical distinction between renewable and nonrenewable resources still leaves room for disagreement on the relative importance of individual natural resources and the role each can play in shaping the future. It will help to examine the nature of resources more closely.

Hidden behind any list of resources—water, wildlife, timber, minerals, fuels—are factors that connect each with the land, with other resources, or with the complex

[5]Many consider land as a nonrenewable resource in that its occupation is practically a form of consumption.

Figure 1 The Flow of Resource Outputs from Basic Natural Resources.



Source: Derived from Reference 285.

economic system created by man. Some resources obviously are very close to the earth, able to exist independently as part of self-perpetuating ecological systems and having intrinsic values. Land, wildlife, water, air and natural beauty are intrinsic resources. Intrinsic resources require little application of additional factors of production (energy, capital, labor) to be of value to man. Their use and enjoyment is not dependent on the availability and costs of production factors. As far as we can be certain, intrinsic resources are unique to this planet and will remain valuable indefinitely.

Other resources, though, are valued not so much for what they are but for what they can do (food can satisfy hunger, for example). These are derived resources and include chemicals, timber and agricultural products. They appear only through the use of technology, labor, capital and energy: the production system. The value of derived resources is closely linked to the availability and costs of production factors and to the emergence of potential substitutes through technological advancement.

Figure 1 illustrates the distinction between intrinsic and derived resources and reveals that all resource outputs—goods and services of the earth—depend closely on forest and agricultural land resources. In fact, it should be evident from the diagram that the two land resources—Montana's land resources—stand out as the major influence on the quality of all remaining natural resources. The value of many of Montana's natural resources and resource outputs, then, depends first on how the two major land resources are used. It is true that in the case of water, for example, the value of adjacent farmland may depend on the quality and quantity of water passing by, but it is also true that the characteristics of the water supply first are heavily influenced by land uses and water withdrawals upstream.

It should be further evident that most of Montana's resource outputs are renewable and should be intuitively obvious that the land can, if properly managed, sustain its productivity indefinitely, barring wholesale damage to the general planetary biosphere.

The land base, with its associated renewable resource outputs, can now be seen to have the major role in Montana's future environmental quality, economic life and patterns of settlement. The renewable nature of the resources by definition implies their capacity for sustained influence on Montana's future.

It seems inarguable that renewable resources inevitably will become more important to communities as nonrenewable resources become scarce. But does it follow that public policy should at once move toward encouraging reliance on renewable resources? Only if there is a clear understanding and appreciation of the perils that will arise from delay.

Too often resources are viewed in simplistic economic terms. Nonrenewable resources are seen as a bank account from which amounts can be drawn to supplement real income: the products of renewable resources. It seems therefore reasonable to conclude that the day when real income will have to suffice is of no particular concern. Why not enjoy the benefits of a fat bank account while it lasts? Because that economic analogy is inexact. The two sources of wealth are not independent. For one thing, the use of resources occurs in a vast, complex social system that may not survive the transition to real income after growing ever more accustomed to withdrawals from the endowment of nonrenewable resources. More importantly, unbridled exploitation of nonrenewable resources has, in many cases, detrimental effects on the (largely biological) systems that sustain renewable resources.

THE INTERNATIONAL VIEW

Many of the difficulties inherent in an economic system too heavily dependent on nonrenewable resources (resource scarcity, high costs of capital and energy) have yet to manifest themselves in Montana. One need only look to the national and world levels for clear evidence of the problem. The history of consumption of metals, fuels and other minerals provides a ready illustration.

Fossil fuels, metals, and minerals comprise the world's stock of important nonrenewable resources. United States and world consumption of these resources has been increasing exponentially for several centuries. In the last 100 years science and technology have worked in two important ways to increase the availability of these resources, effectively expanding the resource base[6] (102):

1. By increasing the efficiencies of extraction and processing, making possible the mining of less concentrated, more remote deposits.

2. By developing new ways of using previously worthless materials.

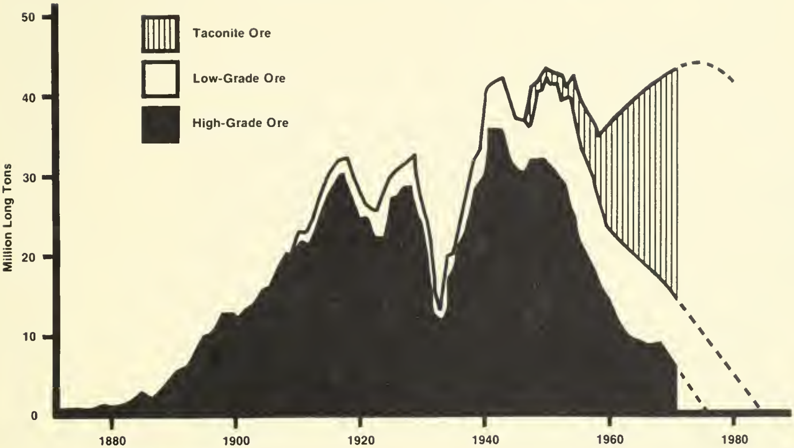
An example of the first process with regard to the use of iron ore is shown in Figure 2. In 1930 close to 90 percent of the iron ore mined was high-grade; by 1970 only 10 to 15 percent of the available supply was high-grade. Another example of the same process at work is the tremendous expansion of the geographical area from which comes the supply of natural gas and oil. Thirty years ago the continental U.S. was supplying its own needs. Today, places as distant as the North Slope of Alaska and the North Sea are producing gas and oil for U.S. consumption.

Evidence abounds for the second process that has expanded the resource base, that of finding uses for previously valueless material. The development of nuclear technology gave uranium value and made it a "resource." The aviation industry demanded a lightweight, strong metal, hence there arose a demand for bauxite for aluminium production. Today, the advancing developments of fusion power and new high-power batteries could cause a significant increase in the demand for lithium, a diffuse and rare element (144).

These two processes, increased efficiency of resource supply and expanded uses, have been made possible by

[6] The resource base is the total supply of useful raw materials in the earth.

Figure 2 Iron Content of Ore Mined—Lake Superior District.



Source: Reference 102.

steadily increasing the supply of low-cost energy. The declining real price[7] of energy, enabling more work at the same or lower costs, has extended the life and usefulness of nonenergy resources. It also contributed greatly to the declining real prices of other minerals until the mid-1960s (102)(194).

Capital, the other main input in the mineral production process, also has become much more intensively used over the past 70 years. This intensive use of capital has made possible the development of the energy required to extract the less concentrated, more distant nonrenewable resources. Thus, the substitution of energy for labor, made possible through science and technology, and more intensive use of capital, has enabled man to increase vastly the consumption of nonrenewable resources.

Recent trends in consumption of all materials and energy materials are shown in Figures 3 and 4. Figure 3 shows the doubling of per capita consumption of all materials in the last 70 years. Figure 4 shows that during the same period total energy consumption increased eight-fold, while per capita energy consumption was tripling.

Further evidence of the increasing importance of energy as a factor of production relative to other materials is seen by its steadily increasing share of all material consumed, from 44 percent in the period 1900-1904 to almost 60 percent during 1965-1969 (269).

The recent high rate of consumption of materials has several important ramifications. First, the U.S. search for minerals to satisfy requirements of industrial production has extended far beyond its national borders. Figure 5 shows that in 1974 over 80 percent of the United States' supply of each of 15 key minerals originated in foreign lands. Less than two-thirds of the supply of 14 additional important minerals came from domestic sources. This rising dependency on foreign sources for nonenergy minerals has raised the same questions about reducing the vulnerability to foreign embargoes that have arisen during discussions about petroleum supplies.

A second consequence of consumption is scarcity: exploitation of easily mineable high-grade mineral and fossil fuel reserves appears to have nearly exhausted low-cost sources of materials. The increasing cost of units of energy and capital, with the growing requirements in general for these two factors of production, has meant that it is simply more costly to explore for, process, and transport the nonrenewable resources that have become so vital to our economic system and standard of living.

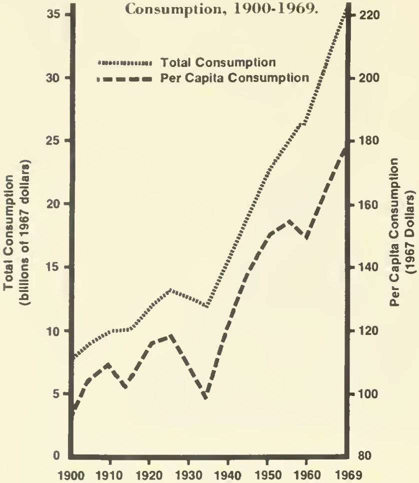
A FUTURE OF RESOURCE SCARCITY

Rising costs of resources and vulnerability of supply characterize the present with regard to energy and nonenergy mineral resources. Most knowledgeable physical scientists and geologists predict that resource scarcity will prevail. National and international conflicts over resource use and allocation also are thought likely.

We are all familiar with the limitations of U.S. fossil fuel energy supplies. Since the Arab oil export embargo of

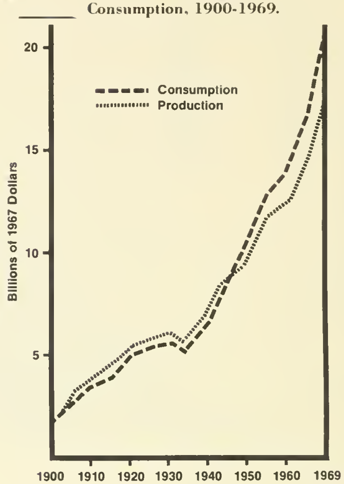
[7]"Real price" refers to a price adjusted for inflation for purposes of comparison.

Figure 3 Total and Per Capita U.S. Materials Consumption, 1900-1969.



Source: Reference 269.

Figure 4 U.S. Mineral Energy Production and Consumption, 1900-1969.



Source Reference 269.

1973 much attention and study has been devoted to future supplies of and demand for energy. Many unresolved questions remain, such as the potential impacts of a concerted national conservation program, the size of additional natural gas and petroleum reserves, the technical and economic feasibility of making coal a "clean" energy source, and the social acceptability of an expanded nuclear power program.

In the last 100 years, the nation has made two energy transitions. From wood to coal, and the second from coal to oil and gas. Now the nation is confronted with declining domestic supplies of oil and gas (an estimated 20- to 100-year supply at current consumption rates) (379). Global supplies are even shorter. Recoverable world reserves[8] of oil and gas at 1973 prices appear barely adequate to meet cumulative world demand through the year 2000. Of course, higher prices will result in additional reserves, but a doubling in reserves would supply only another 25-30 years global consumption at current rates (371).

The decline in oil and gas reserves means that increased reliance will be placed on coal and nuclear power. Although world coal reserves have been declared adequate to supply the current use for more than 2,500 years, it has been estimated that if coal consumption grows at a rate of 4.1 percent per year world reserves would be depleted in only 135 years (23). For comparison 1975 U.S. coal production increased 6 percent over 1974 levels, and the director of the U.S. Bureau of Mines recommended recently that coal production be doubled by 1985, which would require a production increase of over 7 percent a year.

Uranium, if it is to meet projected U.S. demands of about 1.4 million tons through the year 2000, also is in short supply. Known reserves now total approximately 780,000 tons—short by 40 percent of what would be required to meet the projected demand during the next 25 years (37). "Possible" uranium resources associated with currently productive areas and recoverable at $15 per pound may close the 40 percent gap, but no one can say from where U.S. uranium will come beyond the year 2000 (12). World uranium supply potentials appear not much different, in relation to world demand.

Nonenergy minerals are in equally short supply at today's prices. Of the 76 commonly used nonenergy minerals listed in Table 1, 20 have insufficient identified reserves to meet cumulative U.S. demand through the year 2000. Among them are chromium, tin, aluminum, mercury, platinum, nickel, silver, gold, and iron ore. When world reserves and needs are considered, almost one-half of the 76 minerals have recoverable reserves less than twice the amount needed to supply the next 25 years' cumulative demand. So if the demand remains constant over the next 50 years, then the world supply of 32 important minerals could be depleted before the year 2025.

Some cautions on this discussion of scarcity are needed. First, although the world is still supplying its needs (at high prices), notwithstanding the tremendous increase in usage of minerals, it should be recalled that past scientific

[8]Reserves are defined as economically recoverable resources with today's technology at current prices.

Figure 5 U.S. Mineral Imports, 1974.

Source: Reference 371.

Table 1 World Non-Energy Minerals Demand and Supply, 1973-2000.

Commodity	Units	Primary Mineral Demand 1973-2000			Mineral Reserves Recoverable at U.S. 1973 Prices			Ratio of Recoverable Reserves to Cumulative Demand		
		United States	Rest of World	World	United States	Rest of World	World	United States	Rest of World	World
Aluminum	Million S.T.	330	650	980	10	3,565	3,575	-	5.5	3.6
Antimony	Thousand S.T	908	1,920	2,828	120	4,465	4,585	0.1	2.3	1.6
Arsenic	Thousand S.T.	682	751	1,433	800	3,000	3,800	1.2	4.0	2.7
Barium	Million S.T.	36	88	124	35	65	100	1.0	.7	.8
Beryllium	Thousand S.T.	20	8	28	28	391	419	1.4	*	*
Bismuth	Million lb	112	217	329	10	105	115	.1	.5	.3
Boron	Million S.T.	6	10	16	40	70	110	6.7	7.0	6.9
Bromine	Billion lb	19	16	35	17	8	25	.9	.5	.7
Cadmium	Thousand S.T.	250	528	778	180	650	830	.7	1.2	1.1
Cesium	Thousand lb	1,760	2,220	3,980	-	A	A	-	*	*
Chlorine	Million S.T.	603	1,100	1,703	A	A	A	*	*	*
Chromium	Million S.T.	21	81	102	-	521	521	-	6.4	5.1
Cobalt	Million lb	804	1,690	2,494	-	5,391	5,391	-	3.2	2.2
Columbium	Million lb	347	1.039	1.386	-	13,000	13,000	-	*	9.4
Copper	Million S.T.	80	301	381	90	340	430	1.1	1.1	1.1
Fluorine	Million S.T.	40	98	138	3	36	39	.1	.4	.3
Gallium	Thousand Kg	364	261	625	1,000	A	A	2.7	*	*
Germanium	Thousand lb	1,650	4,090	5,740	900	3,100	4,000	.3	.8	.7
Gold	Million T.oz	277	895	1,172	120	1,200	1,320	.4	1.3	1.1
Hafnium	S.T.	1,500	1,200	2,700	A	A	A	*	*	*
Indium	Million T.oz	29	37	66	10	39	49	.3	1.1	.7
Iodine	Million lb	370	850	1,220	330	2,720	3,050	.9	3.2	2.5
Iron Ore	Billion S.T.	3	19	22	2	95	97	.7	5.0	4.4
Lead	Million S.T.	35	119	154	59	105	164	1.7	.9	1.1
Lithium	Thousand S.T.	285	208	493	312	637	949	1.1	3.1	1.9
Magnesium	Million S.T.	54	171	225	A	A	A	*	*	*
Manganese	Million S.T.	47	385	432	-	2,012	2,012	-	5.2	4.7
Mercury	Thousand Fl	1,400	5,240	6,640	170	7,015	7,185	.1	1.3	1.1
Molybdenum	Billion lb	3	6	9	6	7	13	2.0	1.2	1.4
Nickel	Million S.T.	8	23	31	(1)	50	50	-	2.2	1.6
Nitrogen	Million S.T.	890	2,410	3,300	A	A	A	*	*	*
Palladium	Million T.oz	28	68	96	1	194	195	-	2.9	2.0
Platinum	Million T.oz	21	70	91	1	297	298	-	4.2	3.3
Rare Earths & Yttrium	Thousand S.T.	663	629	1,292	5,054	2,715	7,769	7.6	4.3	6.0
Rhenium	Thousand lb	195	110	305	2,600	2,740	5,340	*	*	*
Rhodium	Million T.oz	2	3	5	(1)	17	17	-	5.7	3.4
Rubidium	Thousand lb	49	51	100	-	2,100	2,100	-	*	*
Scandium	Kg	370	330	700	A	A	A	*	*	*
Selenium	Million lb	51	80	131	77	293	370	1.5	3.7	2.8
Silicon	Million S.T.	23	58	81	A	A	A	*	*	*
Silver	Million T.oz	5,300	9,500	14,800	1,500	4,500	6,000	.3	.5	.4
Strontium	Thousand S.T.	694	1,310	2,004	-	2,730	2,730	-	2.1	1.4
Sulfur	Million L.T.	430	1,500	1,930	230	1,770	2,000	.5	1.2	1.0
Tantalum	Million lb	73	53	126	-	149	149	-	2.8	1.2
Tellurium	Million lb	11	6	17	18	69	87	1.6	*	5.1
Thallium	Thousand lb	79	540	619	150	490	640	1.9	.9	1.0
Thorium	Thousand S.T.	11	20	31	140	640	780	*	*	*
Tin	Thousand L.T.	1,590	6,320	7,910	42	9,936	9,978	-	1.6	1.3
Titanium	Million S.T.	27	63	90	29	264	293	1.1	4.2	3.3
Tungsten	Million lb	764	2,580	3,344	238	3,684	3,922	.3	1.4	1.2
Vanadium	Thousand S.T.	528	980	1,508	115	10,575	10,690	.2	*	7.1
Zinc	Million S.T.	62	191	253	30	119	149	.5	.6	.6
Zirconium	Million S.T.	4	8	12	6	16	22	1.5	2.0	1.8
Asbestos	Million S.T.	25	169	194	9	151	160	.4	.9	.8
Clays	Billion S.T.	3	19	22	A	A	A	*	*	*
Corundum	Thousand S.T.	23	407	430	-	500	500	-	1.2	1.2
Diatomite	Million S.T.	27	72	99	40	34	74	1.5	.5	.7
Feldspar	Million S.T.	35	95	130	600	390	990	*	4.1	7.6
Garnet	Thousand S.T.	859	443	1,302	700	1,540	2,240	.8	3.5	1.7
Graphite	Million S.T.	3	19	22	-	10	10	-	.5	.5
Gypsum	Million S.T.	738	1,914	2,652	350	1,700	2,050	.5	.9	.8
Kyanite	Million S.T.	8	16	24	30	70	100	3.8	4.4	4.2
Lime	Million S.T.	849	3,860	4,709	A	A	A	*	*	*
Mica-Scrap & Flake	Million S.T.	5	4	9	A	A	A	*	*	*
Mica-Sheet	Million lb	89	360	449	(1)	33	33	-	.1	.1
Perlite	Million S.T.	25	65	90	200	810	1,010	8.0	*	*
Phosphate Rock	Million S.T.	1,310	5,420	6,730	2,500	49,212	51,712	1.9	9.1	7.7
Potash	Million S.T.	250	890	1,140	200	10,800	11,000	.8	*	9.6
Pumice	Million S.T.	184	587	771	1,250	815	2,065	6.8	1.4	2.7
Salt	Billion S.T.	2	9	11	A	A	A	*	*	*
Sand & Gravel	Billion S.T.	40	272	312	A	A	A	*	*	*
Soda Ash	Million S.T.	299	793	1,092	A	A	A	*	*	*
Stone-Crushed	Billion S.T.	54	294	348		A	A	*	*	*
Stone-Dimension	Million S.T.	72	2,730	2,802	A	A	A	*	*	*
Talc	Million S.T.	41	196	237	150	180	330	3.7	.9	1.4
Vermiculite	Million S.T.	17	15	32	100	90	190	5.9	6.0	5.9

A - Adequate, * - Ratio, (1) - Less than one unit. *Source: Reference 371.*

and technological advances have been possible only with the help of cheap energy and capital. The only thing known with certainty about energy and capital is that they will be available in the future only at sharply higher prices.

The point also may be raised that science and technology will serve in the future no less adequately than the past, and that new breakthroughs will propel the production system to new heights of efficiency of minerals usage and allow substitution of readily available for less available resources. This might happen, but technology demands energy and time. As we have seen, energy is becoming more costly and its efficiency of use appears to be nearing limits dictated by materials themselves and the laws of thermodynamics (103). The real debate is whether sufficient time exists to move from dependence on nonrenewable minerals to an economic and production system based upon a reduced rate of use of minerals. No one knows whether technological innovation can meet even this reduced challenge.

For example, recent advances in technology have provided a sophisticated electronics capability through miniaturization of components. This process, although allowing construction of circuitry with a smaller gross materials requirement, is highly capital intensive and requires more *kinds* of material. The modern electronics industry therefore is dependent upon many kinds of minerals. Over 25 percent of the world's consumption of the following minerals is accounted for by electronics: silver, gold, cobalt, mercury, platinum group, tantalum, copper, germanium, beryllium, gallium, indium, and yttrium (42). Based on world reserves at 1973 prices, and assuming *constant* demands for minerals over 50 years, seven of these 12 minerals critical to the electronics industry could be exhausted before the year 2025 (Table 1).

Another caution. Advocates of an unfettered free market system declare that the price system, with perhaps some refinements to put prices on previously "free" resources,[9] will allocate efficiently the world's supply of natural resources. As prices of certain resources become prohibitively high, it is said the demand for these materials will decline due to the use of less expensive substitutes, or a reduction in final demand for the product made more costly by the higher prices of resources. In short, it is said the market will deal with scarcity before or as shortages appear. But faith in the adequacy of the free market is based upon two critical assumptions of traditional economic theory, both of which need clarification in light of current observable trends in free-market supplies of materials:

1. The price system will function efficiently only under conditions of perfect information regarding available supplies of goods and services. There are, however, fundamental uncertainties surrounding nonrenewable resource supplies and projected costs.

2. Prices set through free market forces assume that resources are privately owned. Because this is the case for the bulk of nonrenewable resources in the United States, it can be inferred that most resource exploitation decisions will be based on the objectives of private owners.

For a number of reasons private objectives are biased toward short-term goals. High discount rates, meaning that money is worth more today than in future, imply that resources exploited for private profit are more likely to be developed and marketed today, rather than tomorrow. Biases toward short-term use of resources are reinforced by the risk of holding resources for future development. Development of substitutes may make the resource less valuable. Increasing costs of extracting and processing may discourage future demand. Finally, corporate decisions toward natural resources are influenced heavily by the overriding objective of maintaining a high price on the corporation's publicly traded stock. This, by definition, is a short-term objective since stock prices principally reflect the projected corporate earnings of the next year or two. If projected earnings from resource development are equal over time, the tendency is toward rapid development of the resource rather than delay.

PLANNING FOR SCARCITY

Historically, cheap energy and a ready supply of capital have stimulated the consumption of vast quantities of nonrenewable resources at declining real prices. But fossil fuel energy now has become more costly while high quality, easily accessible sources of nonrenewable resources have become depleted. Rising costs of energy coupled with the increasing scarcity of nonenergy minerals has cloaked the future availability of nonrenewable resources in uncertainty. In confronting these ominous trends, economics and science are more likely than ever to run short of the miracles they have produced while bringing the industrial system to its present state (3)(103)(194). And as harsh realities come to the fore, disruptions in foreign and domestic systems are inevitable.

Many attribute the severe economic disruptions of the early 1970s, for example, to the scarcity of oil. In the U.S. and many other nations, severe inflation and high unemployment followed the scarcity. Growth of real income slowed and then actually declined (in the U.S.). The possibility of a world monetary collapse was aired in reaction to widely fluctuating international exchange rates. Economic forecasting was confounded. These economic disruptions could be a model for future events in response to real shortages as the world economic system and the raw materials on which it is based show their increasing interdependence.

In fact, upon close examination, the industrial economic system appears headed for some difficult times regardless of shortages. Best estimates are that $4.5 trillion in new capital will be needed in the next decade to replace and add to production capacity—almost *three times* that provided in the last decade (7). Uncertainty about the availability of raw materials at reasonable prices has led to increasing concern whether workers' wage increases can

[9] Free resources are resources historically without price in the market system, such as air and water.

keep pace with inevitable price increases (126). And workers unsure of their buying power tomorrow are reluctant to save today. This essentially psychological problem exacerbates the ever-present problem of raising enough capital for economic expansion. The fact that wages are trailing price increases inhibits spending for goods and services, thereby jeopardizing maintenance of historical growth in corporate revenues. This, by itself, may reduce corporate ability to generate needed capital.

There have been two responses so far to these seemingly intractable economic problems: a trend toward long-range, future-oriented economic planning and an acknowledgment by public and private institutions that the natural, social, and economic systems within which they operate are changing. Four basic hallmarks of a new world social and economic environment seem to be emerging:

1. Interdependence of world economic and resource systems.
2. Rapid and unexpected change in environment, natural resources, and economics, brought about by a combination of advances in information processing and technological innovation.
3. Increasing economic instability.
4. General uncertainty surrounding attempts to predict the future of the nation's economic, social and political systems.

There seems to be at least one certainty about resolution of complex natural resource and economic issues: every solution inevitably will involve conflict and trade-offs. There will be competition for resources, factors of production, and shares of the wealth emanating from the economic system. More than ever, conflict resolution will force politicization of the decision making process. Over the last 10 years the nation has experienced the beginning of this trend.

If we can assume that there are long-term conflicts inherent in a production and consumption system heavily dependent on nonrenewable resources, and if continued progress toward meeting the world's growing material needs is a proper objective of social policy, then a preliminary conclusion appears inescapable: *We must begin to reduce dependence on increasingly scarce resources by expanding the resource base through efficient use of nonrenewable resources, recycling and new methods of processing materials, and substitution of renewable resources, whenever possible, for nonrenewable resources.*

The suggested transition is from an industrial and economic system requiring large quantities of finite natural resources to one in which use of finite resources is minimized and augmented by intense, and in some cases advanced, uses of renewable resources.

It appears inevitable that renewable resources, eventually, will displace many nonrenewable resources as sources of materials. The only foreseeable countervailing forces are the development of an inexhaustible, inexpensive source of energy, and the development of ways to prevent the contamination of the biosphere by the effluents of expanding materials processing worldwide. Neither development is imminent.

If increased demands are to be placed on renewable resources it would be prudent to do everything possible to maintain their productivity. The knowledge to do so is available, but institutional changes will be necessary.

Dr. Sylvan G. Wittwer, chairman of the Board on Agriculture and Renewable Resources of the National Academy of Sciences, said as much in a recent article in *Science* magazine (408):

> The current avalanche of new knowledge coupled with problems of food, feed, and fiber supplies, and issues of availability, preservation, protection, renewability, and costs of resources should bring to the front the urgency of rapid information transfer and reassessment of information systems for agricultural and other renewable resources.

Wittwer's statement has particular relevance for Montana, a state blessed with abundant renewable resources with the indefinitely sustainable biological capacity to produce outputs in the form of agricultural products, fiber, and water. Montana contains 59.6 million acres of rangeland producing forage for livestock, 16.6 million acres producing crops, and 23.2 million acres of forestland producing fiber, recreational opportunities, and water. Taken together, these resources drive the state's economy today and provide a high-quality environment. Wise care of Montana's renewable resources would emphasize the need to maintain their self-regenerative capacities and biological productivity to provide for an endless source of wealth and natural beauty for tomorrow's Montanans.

Sound resource policy decisions made today can move us another step toward a secure future based on high-valued and productive renewable resources. Montanans have an opportunity whose payoff extends beyond their lifetimes. There is an opportunity to fulfill the constitutional responsibility as trustees of the environment for future generations. Private citizens and public officials alike should consider carefully the potential consequences of delay.

CHAPTER 3 MONTANA'S RENEWABLE RESOURCES: THEIR IMPORTANCE TODAY AND POTENTIAL FOR TOMORROW

Preservation and productive use of Montana's agricultural and forestlands can erect one small hedgerow against the conflicts, uncertainty and instability of a world anxious about resources, hunger and survival. But more importantly, these basic land resources can be the lasting foundation for a productive economy and way of life for Montanans: a way for a people blessed in resources to secure a decent future for their children while serving the needs of many million others in the nation and the world.

It bears repeating that these land resources, while not limitless, have the biological capacity to yield valuable products indefinitely. The outputs of these renewable resources include food for people and livestock, clean and abundant water from forested watersheds, wood fiber for housing and an array of industrial products, wildlife, places of wilderness, and unsurpassed recreational opportunities. World and national demand for these and other products of renewable resources is high and going higher.

Cereal grains are among Montana's most important products. If world population and per capita incomes continue to grow, world demand for grain could double by the year 2000 and double again by 2050 (110)(349). It is a foregone conclusion that grain exports from the United States and Canada, of which Montana provides a share, must and will help people in less developed countries whose own food production fails to keep pace with demand. Yet the task is ominously large. The potential demand for grain could require a five-fold increase in exports from the United States and Canada within 25 years. American grain producers already have been asked to plant fence-to-fence; even more effort will be asked.

Rising prices for food and livestock feed grains, caused by the ever rising demand for the actual products and by increasing costs of capital, land, water and energy needed to produce them, have important implications for Montana's range and pastureland. Forage on rangeland is a relatively inexpensive way to feed cattle. People in developed countries want meat. By the year 2000 the world may be demanding 30 percent more beef per capita. To meet the demand, beef producers will turn increasingly to forage as a way to avoid the high cost of feed grain. Estimates are that grazing will increase probably 50 percent and possibly 100 percent by the turn of the century (357).

Reliable supplies of unpolluted water are critically important for agricultural production and recreational opportunities. Water is demanded for energy and mineral development too. Conflicting claims on the available supply have made water a critical issue in Montana and the west (370). By the year 2010, water consumption is expected to increase 30 percent nationwide and more than 50 percent in the Columbia and Missouri river basins, where 60 to 90 percent of the available supply comes from forested watersheds (357). (Forecasted demand for water is based on assumptions about expanded irrigation and construction of new power plants which consume water for cooling.) Maintenance and enhancement of water quality—a goal inextricably tied to land use in each watershed—attains high priority through law and the desire of people to pursue recreation in a clean environment.

Timber—for wood pulp, lumber, plywood, poles and posts—historically has been considered the most important product of the nation's forests. Although timber production increased only 8 percent between 1952 and 1970, demand is expected to grow roughly 35 to 80 percent in the next 25 years (357). Wood always has been in demand as a structural raw material for housing. Recently, though, close investigation of the physical properties of wood has produced fresh ideas for its use: as a source of carbon for chemicals and synthetic fuels, and along with by-products of agriculture, as a direct fuel for energy production (2)(127)(297)(376).

Travel Promotion Unit, Mt. Dept. of Highways

Forested areas, particularly western forests, also supply increasingly scarce high quality recreational opportunities, wildlife habitat and wilderness. The belated, widespread public perception that the frontier is no more has kindled an awareness of the worth of unspoiled natural surroundings and given wilderness increased social value. Regional and national citizens' organizations have been formed to help preserve and expand scenic and natural areas. Political recognition of the increasing social value of wilderness is evident in wilderness study proposals in Congress and the rejection of development projects (the Hells Canyon dam, and the Kaiparowits Plateau power plant) that would detract from what are today essentially spiritual frontiers. Demand for wilderness is so great as to raise serious questions whether the wilderness that exists today will be sufficient to meet demands for its use without being destroyed through overuse. By the year 2010, in fact, camping is expected to increase by 40 to 80 percent; hunting and other uses of wildlife (an adjunct value of wilderness) is expected to increase 40 to 100 percent (357).

Even this limited description fails to account for the breadth and scope of future demand for the products of agricultural and forestlands. But even current demand, under today's conditions of public and private management, is straining the limits of renewable resources. For example, data on overall productivity of United States farms,[10] comparing output with input, show a slowing rate of increase, from 2.5 percent per year in the 1950s to 1.5 percent per year in the 1960s (8). Output per unit of capital, fertilizer, energy, and horsepower has declined since 1950 (271). Yields of corn, wheat, and soybeans have not returned to their highs of 1971 and 1972. Serious ecological problems may further inhibit increases in productivity.

In 1970 nearly three-fourths of the nation's rangeland was in fair or poor condition, and was producing less than 60 percent of its potential. Yet estimates are that the nation's rangeland has the potential to provide 50 percent more forage if economically justifiable investments were made. The changing worth of rangeland for other products has not been established but the fact that one-fourth of the range is in poor condition implies that its productivity for all outputs has been seriously impaired (357).

The nation's forestland is in a similar state. Although adequate data on the productivity of forestland for various outputs are sketchy, it is apparent that full productive potential is being blocked by managerial, economic, and political constraints. The only recent data available indicate that the potential supply of wood at economically reasonable prices is two to three times the current output. Economic potential for recreation is two to three times current output, for wilderness three to four times. Potential water and wildlife arising from forestland also are greater than today's level. Not all these outputs may be at maximum simultaneously of course. Some uses are incompatible with others. But there appears to be room for improvements in the productivity of forestland (44).

The conflicts that arise among multiple uses of renewable resources are not absolute. Some uses, such as rangeland for wildlife and production of red meat, and forests for timber production and wildlife, have some compatibility depending on the intensity and methods of the uses. Other uses, such as forestland for watershed and wildlife, are mostly compatible. Still other uses are mostly incompatible: crop production and wildlife habitat, and forestland for wilderness and timber production.

Conflicts among users of renewable resources are inevitable. The public at large has long been in direct conflict with private landowners over hunting and fishing access on private land, for example. Increasingly, there are new sources of friction: one example is the conflict between effects on water availability and quality and land use practices upstream. Dedication of public land, such as national forest, to the several possible uses has, until recently, been a question primarily of local concern. Now, national interest in wilderness areas, timber supply, wildlife, and the supply and costs of agricultural products has caused national debates concerning use of the forests for wilderness or timber harvesting, and use of public rangeland for wildlife or privately owned cattle. Dissension between parties desiring the various outputs is bound to increase. Ultimately there must be closer scrutiny of resource allocation decisions based on a professional measure of the compatibility among uses.

Public involvement in agriculture and forestry has a long history, and may serve best the need for arbitrating resource allocation. Promotion of agricultural education and research stemmed from an early recognition by the federal government that a productive agriculture is crucial to the welfare of the nation. Public ownership came to the national forests in the interests of promoting sound management principles for a vital base of resources.

It should be evident now that concern for the preservation and use of renewable resources, in a world milieu characterized by scarcity and a national disposition toward joint public and private ownership and management of resources, is a topic charged with complexity and full of potential for hope or despair, depending on how many critical questions one thinks can be resolved.

Although Montana has a vast endowment of renewable land resources—about 60 million acres of range and pasture, 16 million acres of cropland and 23 million acres of forested land[11]—they are not distributed evenly throughout the state. Eastern Montana, also known as

[10]The nation's agricultural land base can be divided into land used for the production of crops, about 385 million acres, and rangeland used for the production of forage, about 802 million acres (183). Forests total 754 million acres, about 500 million of which are classed as commercial (412). The data take into account a double counting of 198 million acres of forestland which was used for grazing part of the year and included in the 802 million acres of rangeland. Taken together the two land classes cover about three-fourths of the nation.

[11]Separate accounting of cropland, range and pasture add up to more than the state's total land area because of double counting of forested areas providing range and pastureland.

Great Plains Montana, contains 86 percent of the state's cropland and 70 percent of its range and pastureland. Western Montana, or Rocky Mountain Montana, contains 85 percent of the state's forestland.

These distinctions between eastern and western Montana's land resources represent fundamental differences in the natural environment and economic structure of the two areas. (See Map 1.) Great Plains Montana, land of distant horizons, is really Big Sky Country. "It is a vast expanse of plateaus and hills, plains and mountain outliers, grasslands and parklands, exotic[12] rivers and gallery forests, yellow grainfields and brown fallow strips, vast ranches and narrow, irrigated strips, flour mills and stockyards, oil wells and fuel refineries, coal mines and thermal-electric plants" (254).

Rocky Mountain Montana "is a land of high mountains and deep valleys, green forests and sparkling waters, dams and powerlines, sawmills, mines and smelters, irrigated farms and mountain ranches, spectacular scenery and outdoor recreation, heavily populated pockets and virtually uninhabited wildlands" (254).

The land resources of the two Montanas provide many goods and services of value to man. Montana's forestland provides timber for lumber, plywood, paper products, and particle board. Forested watersheds yield about two-thirds of the state's surface water and nearly all of the water in the state's largest rivers. Forestland provides the bulk of the state's 8.9 million acres of wildland and habitat for nearly all of the big game species found in Montana, such as elk, deer, moose, Bighorn sheep, Rocky Mountain goat, and bear. Much of Montana's most scenic recreation land is found in the forestland of western Montana.

Montana cropland and rangeland are used principally to produce food grains (wheat), feed grains (hay and barley), and forage to sustain the ruminant animal industry (mostly beef cattle). Range and pastureland also can provide living space and forage for deer and antelope and upland game birds, such as grouse, pheasant, partridge, and turkey. Waterfowl are plentiful in eastern Montana. Management practices on agricultural land can affect greatly the water quantity and quality in the Missouri and Yellowstone rivers which, together with their tributaries, provide water-based recreation and supply water for livestock irrigation, municipal uses and manufacturing throughout Great Plains Montana.

A conservative estimate of the economic value of agricultural and forestlands would include an assessment of the employment and income generated by the wood products industry, agricultural production, and recreation. These three sectors of the state's economy generate roughly three out of every five jobs statewide, and three out of five dollars of earnings throughout the state. This estimate is conservative because the accounting does not include the value of water provided by these lands. Historically water has been an undervalued resource; only recently have economic calculations of its worth been attempted. Water arising from national forests in Montana has been conservatively valued at 75 cents per acre-foot[13] in these areas (273). Water in agricultural areas is worth up to $100 per acre-foot for agricultural purposes and between $100 and $200 per acre-foot for energy development (97) (331).

The land base providing these goods and services is finite, but the outputs are biologically renewable and can sustain production indefinitely. How indefinite ultimately depends upon the healthy functioning the land's biological communities and the integrity of the abiotic environment which supports them. The continued production of derived outputs, those which combine products of renewable resources with energy, capital, and labor from the production system, depends upon the maintenance of a sound economic system in addition to a healthy environment.

When considering the importance of renewable resources it is instructive to view them in a national perspective. Montana has about 6 percent of the nation's supply of commercially valuable timber although generally of a lower potential productivity than that found in the states of the Pacific Northwest and Southeast (346). Montana produces 7 percent of the nation's winter wheat and 15 percent of its spring wheat and supplies about 5 percent of the nation's wheat exports (294).

Nationally, Montana's intrinsic resources (those produced irrespective of man's influence) are even more important. Almost one-fourth of the nation's designated wilderness and primitive acreage and one-fifth of all roadless acreage, excluding Alaska, is in Montana (49). Montana's 450 miles of "Class I" fishing streams are nationally famous. The state also has perhaps the greatest number of big game species of any state outside Alaska. Montana's high-quality, diverse recreational opportunities are of national importance. In 1975 the state ranked first in the nation in nonresident hunting licenses sold and third in fishing licenses (373).

Montana citizens have long acknowledged the importance of renewable land resources. Citizen groups have formed with the goal of protecting Montana's quality of life by emphasizing environmental integrity. Governor's conferences have examined the natural resource base and the relevance of land use to the management of these resources. The Legislature enacted the Montana Environmental Policy Act; laws regulating air and water pollution and water withdrawals; laws providing tax incentives for keeping land in agricultural use; and laws encouraging development of the state's renewable resources. A state forest practices act has been introduced in several legislative sessions and only narrowly defeated. Article IX of the Montana Constitution calls for protection

[12]Used in its geographic sense here to mean arising from humid areas upstream.

[13]Acre-foot: The volume of water that would cover one acre to a depth of one foot; equals 43,560 cubic feet.

of "environmental life support systems" and prevention of "unreasonable depletion and degradation of natural resources."

Montana state government acknowledges the importance of environmental and natural resources; there is equal concern for the state's economy. Concern focuses on providing higher levels of per capita income and increasing the rate of job formation, and has led to interest in promoting economic growth through resource development.

Today Montana's executive branch has clearly enunciated its number one priority: the creation of jobs. One element in attaining this objective has been implicit in recent state actions and pronouncements, that Montanans should put the state's natural resources to work by, for example, processing energy resources in-state, harvesting more timber, developing water supplies, and promoting exports of agricultural commodities.

The international energy and food crises have caused the federal government and national private organizations to take a fresh look at our resource base. Implicit in the policies enacted and decisions announced so far is a commitment to satisfying future demand for both finite and renewable resource outputs. Because of the magnitude of increasing demands for food, forage, fiber, water, wilderness, and recreation, it is therefore vital to plan the best way to satisfy demands for resources.

Federal policy appears to be promoting increased development and productivity of all the nation's natural resources. There has long been a call for increased funding to enable the Forest Service to increase harvest and management of national forests. In the west, much concern has been voiced over the poor condition of rangeland and the need to help the Bureau of Land Management improve range productivity. Pressure on the federal government to develop publicly owned western energy resources will continue as long as the nation depends on fossil fuels. And it is often said there is a need to develop Montana water resources before downstream states or the federal government appropriate them for other uses.

There exist two areas of potential conflict between the state and federal government. First, how can the state act to improve the productivity of land resources controlled by the federal government in the absence of a federal commitment to do the same? Second, how should Montanans respond when the federal government pursues objectives that may be contrary to state resource policy? Emerging federal initiatives in harvesting mature western forests in the absence of adequate timber management funds, encouraging maximum crop production, maintaining livestock grazing levels on already degraded rangeland, and promoting water and energy development throughout the west may run counter to one Montana objective of maintaining ecological integrity and productivity. It is important that Montanans recognize the inevitability of political conflict over resource issues and devise means to cope with it. The legacy of resources that Montanans will be able to leave for their children depends on it.

AN ENLIGHTENED POLICY FOR DEVELOPMENT.

Developing Montana's wealth of natural resources is an understandable response to projected increases in demand and the desire for economic development. The dilemma in any unrefined version of development policy is apparent when a crucial fact is appreciated: ultimately, the demand for the products of renewable resources can be met only by healthy and productive ecosystems. Enlightened management of the land base is the only way to overcome the apparent dilemma. In other words, what we do today will be felt tomorrow. Without certain changes, land management as practiced in Montana today may encourage environmental degradation and decrease the long-term productivity of the state's agricultural and forestland resources. The problem essentially is one of developing foresight. Modern western man has never fully developed a moral or spiritual concern for future generations. Political and economic institutions have likewise been built on the assumption that resources were practically infinite and, more recently, that the advancement of technology would forever forestall the need for programs and policies to protect the interests of unborn generations.

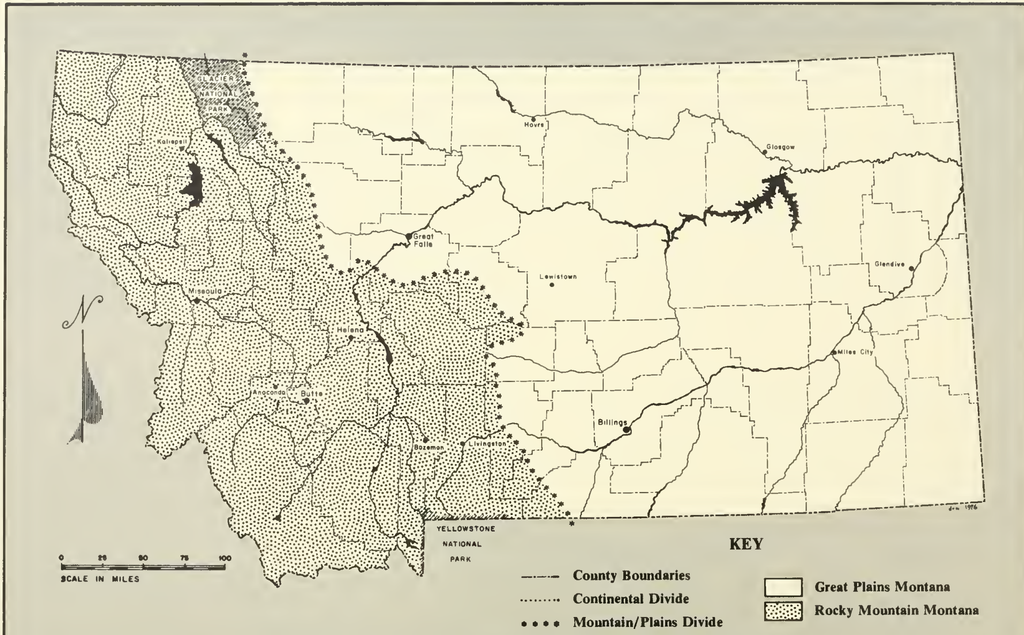
To say the least, the facts have brought historical assumptions into question. The base of nonrenewable resources has declined very significantly, even in Montana. Economic, social and environmental costs of forcing ever more-scarce resources to meet demand have given pause to all but the most jaded. Technology has given us an uncontrolled ability to make environmental changes on heretofore unknown scales.

Growth and development used to pose problems. Today they entail dilemmas, which arise unavoidably from the mutually interdependent nature of resource demands, resource management, and resource integrity. Appreciating the dilemmas and proposing realistic solutions to meet the need for resources requires knowledge of the interactions between productivity and use of renewable land resources. For as we have seen, decisions affecting the land are the first to influence all other (intrinsic and derived) resources which arise from the land.

Montana is rich in natural resources. Nonenergy minerals such as gold, silver, copper, lead and zinc have been mined for over a century. Montana has long produced oil and natural gas and may continue to do so given adequate economic incentives. Montana coal deposits are huge.

Montana's richness in renewable and nonrenewable natural resources can be an opportunity. The opportunity lies in recognizing that the resources Montana has in abundance are important to the resolution of the vital resource policy issues confronting the nation and the world. Energy, food and water are only the beginning. Ultimately there will have to be a transition from an economic and social system heavily dependent on finite resources to one which minimizes the use of nonrenewable resources and maximizes the utility of renewable resources.

Montana's public and private institutions should consider serious research into the potential benefits of the opportunity that is at hand. A detailed list of research proposals is presented elsewhere in the report. Many questions arise naturally: how much of each resource should be allocated toward what uses; how intensively should nonrenewable resources be used; how can renewable resources best be preserved; and how can the transition to a renewable resource economy be encouraged with the least disruption? *These are not merely biological and economic questions, of course, but social and political as well. How the world and the nation answers them will largely influence the future of civilization. With a serious commitment to its unavoidable responsibilities, Montana could do much to assist in resolving these complex and far-reaching questions.*



MAP 1 - MONTANA ENVIRONMENTAL REGIONS

PART II

MONTANA'S AGRICULTURAL AND FORESTLAND RESOURCES

CHAPTER 4 AGRICULTURAL LAND RESOURCES IN MONTANA

Currently there are about 76 million acres in Montana devoted in whole or in part to agricultural use. Almost 80 percent (59.6 million acres) is range and pasture, the remainder (16.6 million acres) is classed as cropland.

Tables 2 and 3 present the acreage according to ownership and general location. Of the total land area 80 percent is private. Practically all of the nonprivate ownership is range and pasture equaling about one-fourth of the total range and pasture. When viewed geographically, the vast majority of the agricultural land is in Great Plains Montana[14], which contains 85 percent of Montana's cropland and 80 percent of the rangeland. The total Great Plains Montana land resource also is much more intensively devoted to agricultural land use than Rocky Mountain Montana. Table 3 shows that about 99 percent of Great Plains Montana is used for agricultural production; the comparable figure for Rocky Mountain Montana is 47 percent.

Since 1920 privately owned acreage devoted to agricultural production has almost doubled. According to Table 4, land in farms appeared to peak in 1964 at 65.8 million acres and has since declined about 3.5 million acres to 62.4 million acres. Over the same period the number of farms declined by more than half; from 57,700 to 23,500 today. The average farm size has risen continuously: today it is 2,655 acres.

Except for a few areas, like Beaverhead, Meagher, and Powell counties, the average farm size in Rocky Mountain

Travel Promotion Unit, Mt. Dept. of Highways

[14]See p.20 for a map of Montana's environmental regions.

Table 2
Land in Agricultural Use in Montana.
(millions of acres)

	Rocky Mountain Montana	Great Plains Montana	Total
Cropland			
Private (incl. cropland for pasture)	2.3	13.8	16.1
Public (state)	.1	.4	.5
Total	2.4	14.2	16.6
Range and Pasture			
Private (excl. forestland used for grazing)	8.6	36.5	45.1
Public			
USFS* (incl. forestland used for grazing	1.3	.2	1.5
BLM (incl. forestland used for grazing)	1.4	7.6	9.0
State	1.0	3.0	4.0
Total	12.3	47.3	59.6
Total Land in Agricultural Use	14.7	61.5	76.2

*Estimated using 3 acres per reported animal unit per month.

Sources: References 100, 253, 364, and 374.

Montana is smaller than in Great Plains Montana. Many of the farms in northwestern Montana average less than 600 acres. (In the settlement of Montana's narrow mountain valleys, large contiguous farmland units were rare.) In contrast, ranches in Great Plains Montana have an average size of about 5,000 acres. Landholdings on the vast plains have been consolidated continually.

Table 3
Agricultural Land in Montana.
(millions of acres)

	Rocky Mountain Montana	Great Plains Montana	State
Total Land Area	31.4	61.7	93.1
Land in Agricultural Use	14.7	61.5	76.2
Percent of Total	47	99	82

Sources: References 100, 253, 262, 364, and 374.

As the average farm or ranch has increased so has its average value, from $8,400 in 1940 to about $160,000 in 1969. At the end of 1975 the average value per farm probably was close to $400,000, based upon an increase in the farm real estate value in Montana of 160 percent since 1967 (173).

The average market value per farm acre varies considerably throughout the state. Some representative figures for 1969 are shown in Table 5. Counting the latest farm real estate values, farms are now worth much more—about $180-$220 per acre in good wheat country; $75-$100 per acre in ranching country, and $260-$500 per acre for farmland in areas with high scenic value.

Table 4
Montana Land in Farms,
Number and Size of Farms.

Year	Million Acres	Thousand Farms	Average Farm Size (acres)
1975	62.4	23.5	2,655
1969	62.9	25.0	2,516
1964	65.8	27.0	2,437
1959	64.1	29.0	2,210
1954	61.5	33.1	1,858
1950	59.2	35.1	1,687
1940	47.5	41.8	1,136
1930	44.7	47.5	941
1920	25.1	57.7	608

Sources: References 227, 360, 362, and 364.

The most recent farm ownership information is for 1969. At that time, 43 percent of Montana's farm units were operated by full owners, 45 percent by part owners, and 12 percent by tenants. Since 1940 the share of units operated by full owners has remained fairly constant; part-ownership has increased about 50 percent at the expense of the tenants' operation whose share has decreased by more than half (360) (364).

Montana's rangeland supports cattle and sheep. Sheep once outnumbered cattle four to one, as indicated in Figure 6. During the 1940s, though, sheep declined precipitously while cattle and calves steadily increased. Total numbers of these ruminants reached a peak in the early 1950s at about 5.7 million, declined to 3.5 million in 1960 and today stand at 3.8 million head—3.2 million in beef stock and 635,000 sheep.

Between 1930 and 1975, Montana's harvested cropland varied between 4.4 and 9.7 million acres. Figure 7 shows that harvested cropland peaked in 1953. The figure declined until 1972 but since then has increased by 750,000 acres. The most recent increase represents the conversion of rangeland and previously uncultivated cropland.

Table 5
Average Value Per Acre, Montana Farms
in Selected Counties, 1969.
(dollars per acre)

County	Value
Garfield	30
Carter	35
Custer	36
Phillips	37
Toole	69
Liberty	74
Chouteau	84
Mineral	105
Gallatin	109
Missoula	119
Lincoln	122
Flathead	176
Ravalli	208

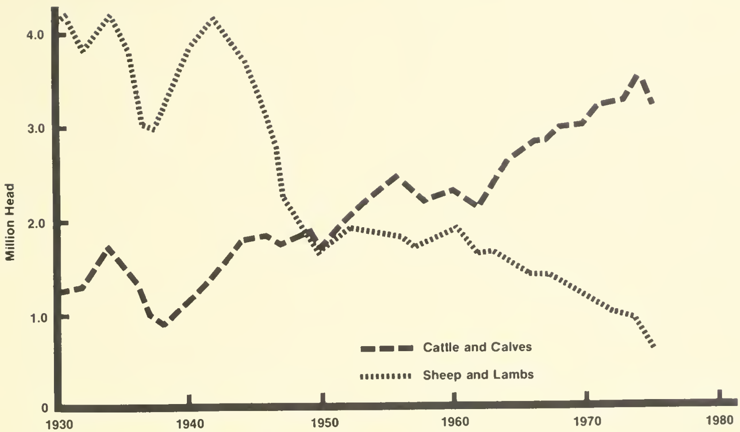
Source: Reference 364.

Crops of wheat and hay historically have accounted for 60 to 80 percent of the harvested acreage. Of the 9 million acres harvested in 1975, wheat and hay accounted for 82 percent and barley 13 percent (220).

Montana's hay is raised primarily as feed for cattle. Between 50 and 70 percent of Montana's barley is used for feed instate; almost all the rest is shipped west for the same purpose (212) (213) (224) (225).

The most widely used measures of the economic value of Montana's agricultural land are "cash receipts" and "value of production." The former measures actual monetary exchanges between individuals; the latter represents the value of the total harvest based on prevailing market price.

Figure 6 Cattle-Calves and Sheep-Lambs in Montana, 1930-1975.



Sources: References 208, 217, and 228.

Figure 7 Harvested Acreage of Montana Crops, 1930-1975.

Sources: References 208, 220, and 233.

Table 6 shows that Montana's agricultural cash receipts (livestock and crops) have increased more than 10-fold since 1940, from $96.5 million to $1,078.4 million in 1975. The separate values attributable to livestock products or crops have varied between 35 and 65 percent of each year's total. The table indicates that the widest such ranges were attained in two recent years, 1971 and 1974.

Table 7 provides a closer look at livestock and crops. Cattle and calves accounted for 81 percent of livestock receipts in 1975; wheat accounted for 60 percent of the value of all crops in 1975. Hay and barley production accounted for three-fourths of the value of remaining crops.

Montana's range livestock industry is dominated by cattle and calf operations; they account for 83 percent of animals being raised and 70 percent of the cash receipts for livestock. The dominant grain crop is wheat. It contributed 60 percent of the total value of the crops produced in 1975 and occupied nearly 60 percent of the total acreage cultivated. Hay and barley, needed for beef production, contributed three-fourths of the remaining value of crop production and, when combined with wheat, occupied nearly 90 percent of the acreage.

Cattle and calves, wheat, hay and barley—these are the principal economic outputs of Montana's agricultural land. A close look at how agricultural resource sectors operate and their future prospects follows, as essential first steps in analyzing Montana's renewable resource base, its role today and prospects for tomorrow.

MONTANA FOOD GRAIN PRODUCTION

Montana grain production can be divided into two parts: food grains (wheat) and feed grains (barley and hay). Because feed grains are used as part of the meat animal production process they will be included in the following section on Montana cattle and feed grain production.

More than 90 percent of Montana wheat production is of the hard red winter (67 percent), and hard red spring types (25 percent) with durum wheat representing most of the remainder (220).

Used primarily as flour for bread, winter wheat accounts for more than 40 percent of the total U.S. use of wheat for food (274). Between 1970 and 1974, 63 percent of the U.S. winter wheat crop was exported accounting for roughly the same percentage of total U.S. wheat exports (294). Winter wheat production is dispersed widely throughout the Great Plains states.

Table 6
Agricultural Production in Montana.
(millions of dollars)

Year	Total Receipts	All Livestock	All Crops
1975	1078.4	420.7	657.6
1974	1188.0	433.1 (36%)	754.9 (64%)
1973	1127.0	572.1	555.0
1972	823.7	495.4	328.5
1971	617.3	407.4 (66%)	209.0 (34%)
1970	603.2	357.1	246.1
1965	421.0	244.1	176.8
1960	401.0	222.1	185.3
1955	371.4	158.1	207.4
1940	96.5	52.2	44.3

Sources: References 208 and 358.

Spring wheat generally is higher in protein content than winter wheat. Spring wheat is a high quality wheat for bread because it contains much gluten,[15] so its consumption has grown with increases in commercial baking (274). Between 1970 and 1974, 54 percent of the U.S. spring wheat crop was exported; however, because of its small contribution to total wheat production it accounted for only about 20 percent of total U.S. wheat exports (294). Durum wheat has a specialty use: the manufacture of semolina used for pasta. Figures 8 through 10 show the history of Montana wheat production with spring and winter wheat shown separately.

Acreage devoted to wheat production in Montana peaked at 6 million in 1953 and since then, in response to government production controls and higher yields, declined to 3.4 million in 1970. There has been an associated decline

[15] Gluten gives cohesiveness to dough.

Table 7
Montana Livestock and Crop Production.
(millions of dollars)

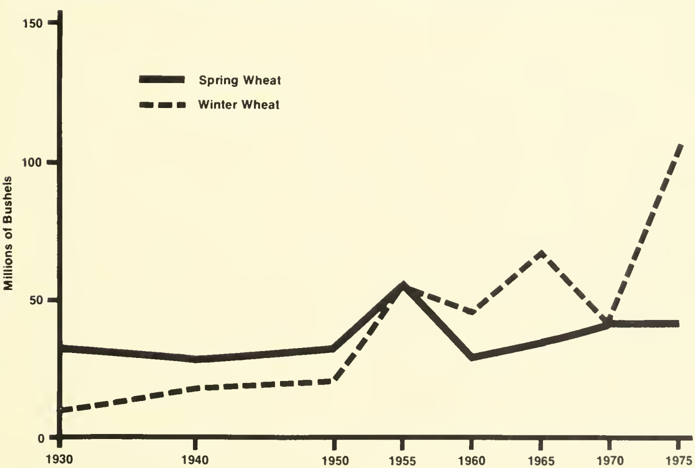
	Cash Receipts		Value of Production			
Year	All Livestock	Cattle & Calves	All Crops	Wheat	All Hay	Barley
1975	420.7	339.9 (81%)	900.8	541.7 (60%)	187.4 (21%)	11.5 (12%)
1974	433.1	348.1	946.2	509.2	193.9	96.9
1973	572.1	483.2	844.2	415.8	233.7	132.0
1972	495.4	431.2 (87%)	439.0	186.2 (42%)	139.6 (32%)	75.1 (18%)

Sources: References 76, 77, 208, 216, 220, 223, and 358.

Figure 8 Montana Wheat Harvested, 1930-1975.

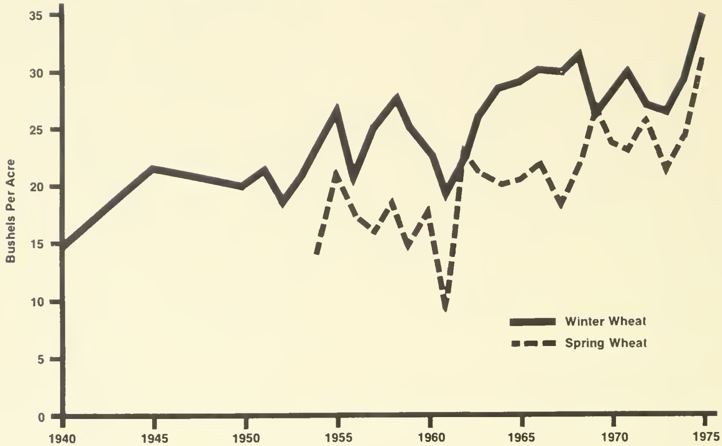
Sources: References 208, 216, 232, 234, and 363.

Figure 9 Spring and Winter Wheat Production in Montana, 1930-1975.



Sources: References 208, 216, 234, and 364.

Figure 10 Spring and Winter Wheat Yields in Montana, 1940-1975.



Sources: References 208, 211, 220, 234 and 360.

in number of wheat farms from 25,200 in 1950 to 13,300 in 1969 (364). Until 1974, production surpassed the 1953 level in three years only. Wheat production reached a high of 156 million bushels in 1975.

Until the late 1950s spring wheat out-produced winter wheat in Montana. Since then winter wheat harvests generally have exceeded those of spring wheat for several reasons: because winter wheat yields more and because winter wheat is the more marketable, especially at west coast markets. In 1975 over 50 percent more acreage was devoted to winter than spring wheat.

Yields of both varieties generally have increased since 1950; however yields have remained relatively stable since the early 1960s with the exception of 1975, an unusually wet year. Since 1963 spring and winter wheat yields have begun to move, on a year-to-year basis, in opposite directions. In fact, they have done this as often as they have moved in the same direction, perhaps due to variable seasonal weather conditions.

Coincident with the increase in wheat yield has been a decline in protein content. Decreasing protein content is particularly unsettling since Montana wheat historically has been high in protein and has commanded a slightly higher market price, the added value commonly called a "protein premium" (293). According to Figures 11 and 12, the inverse relationship between yields and protein content has become most apparent since 1962. Protein content since 1962 has fallen about 0.5 percent for both types of wheat (318).

Table 8 shows Montana wheat and barley production compared with that of the United States. For the marketing years represented Montana produced 6 percent of all wheat, 7 percent of winter wheat, almost 15 percent of spring wheat, and 14 percent of barley. As noted, however, Montana's share of U.S. spring wheat has been decreasing while its relative share of winter wheat has been increasing.

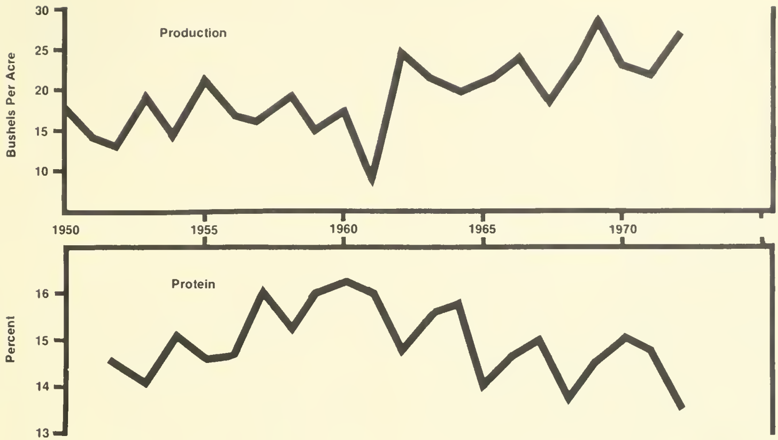
Table 9 shows the 13 counties that produce 70 percent of Montana's wheat. These counties cluster in two groups: the "Golden Triangle" comprising the northcentral area between Havre, Great Falls and Cut Bank, and the northeast corner mostly north of the Missouri River. The two distinct wheat producing areas also can be distinguished by the types of wheat in which they specialize: winter wheat in the Golden Triangle and spring wheat in the northeast area. Maps 2 and 3 show the relative concentrations.

Irrigation has played a minor role in Montana's wheat production: as of 1973 less than 2 percent of the acreage was irrigated. Approximately 50,000 acres previously irrigated were returned to nonirrigated status in the decade before 1973 (208).

Many of the typically large farms in these chief wheat producing areas also raise other crops such as barley and hay, and also have livestock operations. Generally such diversification reduces the risks of relying on only one commodity for income.

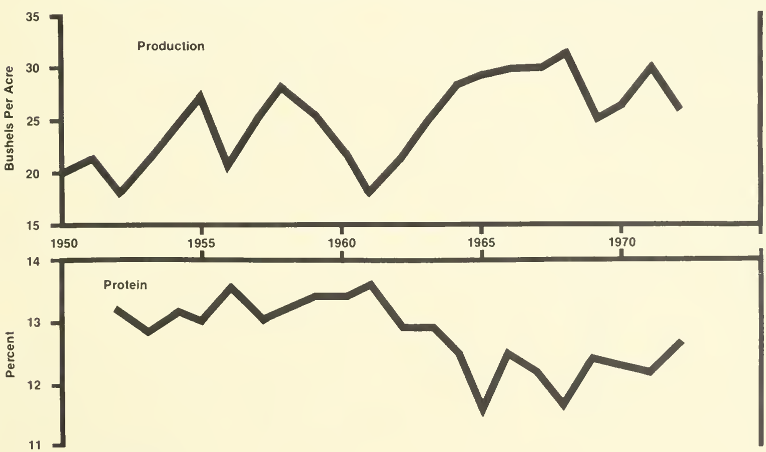
In an area suitable for both wheat and barley production, planting decisions are based on expectations regarding future prices and costs of the respective crops, in

Figure 11 Montana Spring Wheat Production and Protein Content, 1950-1972.



Source: Reference 318.

Figure 12 Montana Winter Wheat Production and Protein Content, 1950-1972.



Source: Reference 318.

Table 8
Montana and U.S. Production of Wheat and Barley.
(average for 1970/71-1974/75)

	Average annual production (million bushels)		Montana as a percentage of U.S. production (percent)	Annual average* increase (+) or decrease (−) (million bushels	
	Montana	U.S.		Montana	U.S.
All wheat	104	1,613	6.4	+7	+107
Hard red winter	56	822	6.8	+8	+ 45
Hard red spring	44	301	14.7	−2	+ 23
Barley	58	409	14.1	−5	− 21

*Simple average computed from least-squares trend.

Source: Reference 294.

conjunction with rough estimates of yields. Until 1974 government planting restrictions played a most important role in planting decisions. This could happen again if the federal government renews its involvement in agricultural production quotas. Climatic factors play a role in the planting of winter and spring wheat. Winters generally are comparatively mild in the Golden Triangle area. Mild winters are good for winter wheat, which is planted in the fall and harvested the following summer. On the other hand, the growing season is comparatively longer and the climate yields greater precipitation in the northeast corner of the state; these conditions are best for spring wheat, which is planted in the spring for fall harvest. If availability of moisture at planting time and other weather conditions permit, some acreage might be shifted from winter to spring wheat depending on forecasted yields, expected market prices, and costs of production. Apparently very little switching from spring to winter wheat takes place in the major spring wheat producing areas.

Table 9
Montana Wheat Production, 1973.

County	Total (acres)	Percent of Agricultural Land Harvested for Wheat
Hill	435,000	23
Chouteau	425,700	18
Roosevelt	314,000	22
Valley	274,000	14
Sheridan	268,000	24
Daniels	206,900	25
McCone	160,300	11
Liberty	159,500	18
Pondera	133,100	16
Cascade	129,000	9
Toole	128,200	11
Teton	117,800	10
Fergus	117,500	5

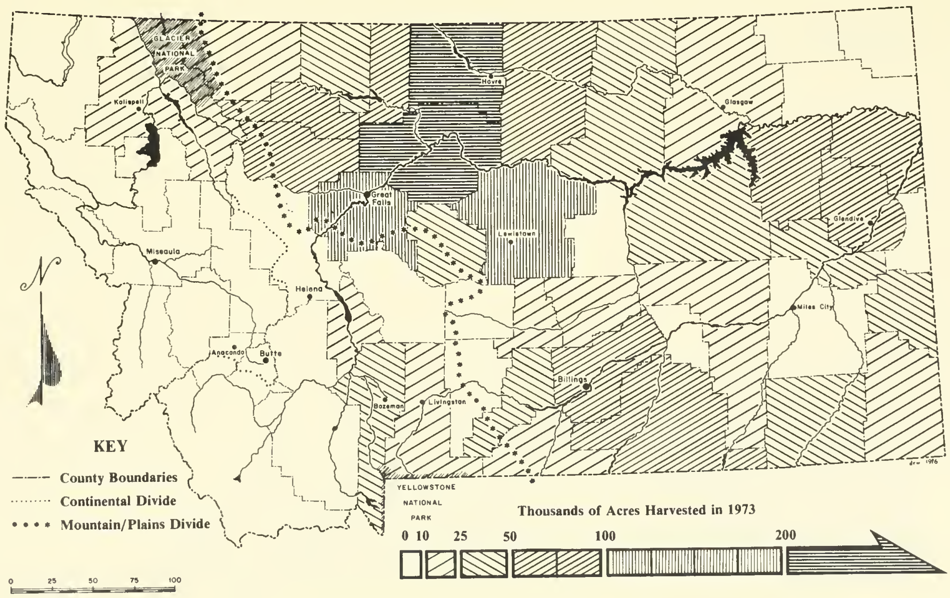
Source: Reference 208.

One of the most important production factors is capital needed to finance farming until the wheat is harvested and sold. There has been a significant increase in the borrowing needs of Montana's farmers and ranchers over the last 15 years for many reasons. Inflation has affected the value of borrowed funds; real estate prices have increased 160 percent since 1967; farmer attitudes have changed about the use of credit and debt is accepted as a necessary part of managing a farm; more capital-intensive techniques such as sprinkler irrigation are being employed; prices of trucks, tractors, and combines have nearly doubled in the last three years alone (122).

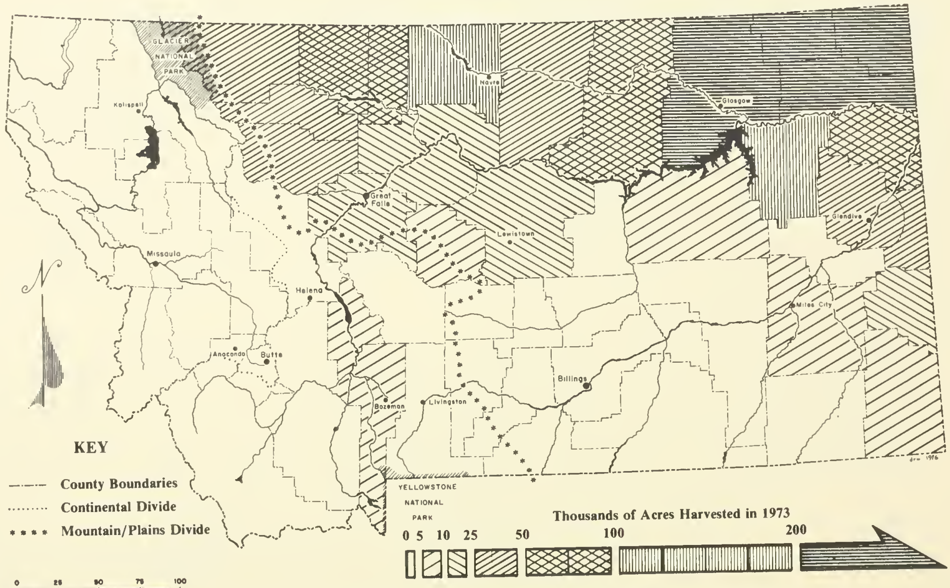
Estimates of the annual line of credit needed for farming 1,000 to 1,500 acres of wheat and other crops plus raising 150 to 250 head of cattle range between $40,000 and $180,000. The farmer typically will draw on the line of credit as needed, using up to the maximum at planting or harvesting time and paying back as the harvested crops are sold. Generally, nonreal estate items such as feed, forage, equipment and crops are put up as collateral. Generally, only well established farmers can borrow against the development value of a piece of farmland (96).

Montana farmers and ranchers have four major sources of credit: commercial banks, cooperative lending agencies owned by member-borrowers such as the Production Credit and Federal Land Bank associations, the Farmers Home Administration, and insurance companies. The Federal Land Bank will finance borrowing only for real estate; the Production Credit Association only for operating expenses. Life insurance companies usually avoid lending other than for real estate.

Nationally there has been a tremendous surge in farm borrowing. Over the last 25 years agricultural loans rose from $10 billion to over $80 billion. In Montana there has been a similar growth in farm debt. Real estate borrowings increased about five-fold between 1960 and 1974. The total was $976 million in 1974 (201). Farm borrowings for other than real estate have increased about four-fold since 1960, totaling $585 million in 1974 (202)(267).



MAP 2 - MONTANA WINTER WHEAT PRODUCING AREAS



MAP 3 - MONTANA SPRING WHEAT PRODUCING AREAS

Individuals hold 45 percent of the outstanding real estate loans; Federal Land Banks, 32 percent; insurance companies, 14 percent; Farmers Home Administration, 7 percent; and commercial banks, 2 percent. For loans other than real estate, commercial banks hold about 60 percent; Production Credit Associations, about 37 percent; and the Farmers Home Administration, the remainder (201)(267). Production Credit Associations have been responsible for supplying a large part of the increase in borrowings for farm operations. Their share of these loans has increased from 22 percent in 1950 to 37 percent today (201).

In Montana total farm debt has increased relative to the value in equity of farm real estate, from 15 percent in 1960 to 22 percent in 1975 (202)(267). This decline in secure real assets means there are greater risks in the year-to-year fluctuations in cash flow connected with farming in Montana.

In dryland wheat farming other purchases needed for operation include capital equipment, operating expenses (including fuel and oil), seed, fertilizer, lime, pesticides, insurance, utilities, and of course, labor. In 1968 a survey of northeast Montana wheat farms revealed three major costs: machinery operating expenses (15 percent of total cash costs); purchased energy (14 percent of total); and fertilizer and other purchased supplies (9 percent). Interest ranged between 10 and 12 percent of total cash costs (149).

Machinery is used principally to prepare the ground and seed, harvest, haul, and prepare for summer fallow. About two-thirds of machinery time is used for hauling and summer fallowing (149).

Some operating expenses are variable. Application of fertilizers and pesticides may be varied on a constant acreage depending on comparisons between expected future prices and yields and current costs of the chemicals. Table 10 shows how use of fertilizers has varied in Montana since 1950. The table shows that fertilizer consumption increased more than twenty-fold between 1950 and 1973. During the peak year (1973) an average 59 pounds were applied to each acre of cropland in Montana. Assuming that all the fertilizer went on land devoted to grain production only, the average rate in 1973 was about 130 pounds per acre. The 1968 survey of wheat farms reported fertilization rates of 60 to 80 pounds per acre. Ninety-one percent of the acreage had been sprayed with herbicides (149). By 1975 fertilizer use in Montana had declined 27 percent in response to the large increase in prices, estimated at close to 300 percent, and because yields increased more slowly with higher rates of application.

Labor also is important in wheat production. A typical wheat farm in 1968 required 1.5 man-year's labor. This included a half man-year of family or hired labor in addition to the farm operator. An average 1.5 hours of direct labor was required per acre of wheat produced. Hired labor represented between 10 and 30 percent of the total labor required (149).

When grain is harvested an important decision must be made regarding grain that has not already been sold. The farmer must accept the prevailing price or store the grain with the hope that the market price will go up. Key variables affecting this decision are available on-farm storage capacity, current price compared to expected future price, cost of storage, and the need for immediate income. Most Montana grain farmers have on-farm storage capacity of up to two years' production (62).

Wheat prices for Montana farmers are set in Minneapolis, Chicago and Portland grain exchanges by grain dealers and export houses. Until recently wheat prices were fairly stable because of production controls and grain surpluses.

Prices rose in 1973 because of harvest failures in other parts of the world, increased demand for U.S. grain for export, and smaller U.S. grain surpluses available to absorb the export demand. Since 1973 wheat prices have fluctuated widely due to uncertainty about international grain harvests, export demand, weather, and storage. Fluctuating prices complicate farmers' sales decisions.

If the price is adequate to cover expenses and return a profit, the farmer usually will sell grain. Generally, if the market is on an upswing, orderly sales will continue. If the market is on a downswing, sales will decline and grain storage will increase after harvest. These are general statements and, of course, an individual operator will act independently depending on his particular circumstances.

Table 10
Montana Commercial Fertilizer Consumption by Primary Nutrients and Fertilizer Materials, 1950-1975.
(tons)

PRIMARY NUTRIENTS

Year	1950	1955	1960	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Nitrogen	267	2201	6319	10932	17499	25002	30429	36507	36786	41207	43913	52840	45961	39024
Available P_2O_5	3950	7275	13537	22499	26609	37146	44188	48221	49775	56834	50154	62346	60786	43920
K_2O	50	52	98	413	449	1115	1688	1220	1572	1262	2504	2983	4225	3171
Total	4267	9528	19954	33854	44559	63253	76305	85948	88113	99304	96571	118169	110972	86114
*Total Materials**	10957	23686	44728	75082	102541	141160	167538	186361	186451	202947	203006	245929	229874	178973

*Includes primary materials plus inert ingredients.

Sources: References 77 and 208.

If the market price falls below the target price[16] for wheat established by the federal government (currently $2.28 per bushel), the government is committed to pay to the producer the difference between the target and market prices.

Some farmers are becoming increasingly sophisticated in grain sales. Some play the futures market through "hedging." The futures market for wheat is in the Chicago Board of Trade. It enables market participants to buy or sell a specified amount of wheat on a given future date at an agreed price. A farmer might hedge by promising to sell a certain amount of wheat at a given time and price, either to protect a growing crop against possible future decline in market prices or to protect a stored crop against future decline. If prices fall, profits from the futures market could offset the decline in the cash market; if prices rise the "loss" in the futures transaction is offset by the cash market gain. Apparently, the trend is toward more involvement by farmers in the futures market. Processors, exporters, and other commodity buyers also hedge the grain market in much the same way (95) (198) (256).

Figure 13 shows October grain storage data for selected years since 1960. The total amount stored has varied between 88 and 138 percent of that same year's production. On-farm storage as a percentage of the total stored has increased from 67 percent in 1960 to 80 percent in 1975, reflecting the desires of individual farmers to control better the timing of crop sales. In October 1975, off-farm storage was 50 percent of estimated elevator storage capacity in the state (221) (236).

The wheat farmer usually sells and ships by truck to one of Montana's 287 grain elevators, whose operators will in turn contract with processors or exporters through the Minneapolis or Portland markets. The local price to the farmer is determined by subtracting from the Minneapolis or Portland price the transportation and handling costs (elevator profit) for a particular weight and grade of grain. Because the prices between the two markets are very close, Montana wheat usually is sold by the elevator and shipped to the point with the lowest transportation costs.

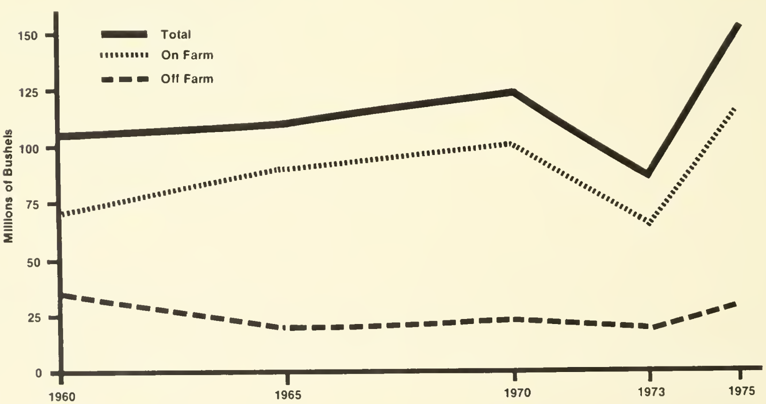
Table 11 shows that the trend in Montana has been toward fewer, larger elevators. The five largest elevators, those with a storage capacity of more than 750,000 bushels, would be classed as "terminal" elevators; the remainder are termed "country" or "subterminal" elevators. The five largest are in the Golden Triangle area: Great Falls (with two), Shelby (two), and Chinook (one) (236).

Grain elevators are valuable to the farmer for financing, assembling, storing, blending, cleaning and treating seeds, providing market information, and, of course, selling and shipping grain. It was estimated in 1968 that these services cost the nation's farmers an average of 10 cents per bushel (105). Inflation may have driven the cost to 20 cents by now.

Practically all Montana's wheat production (more than 150 million bushels) is shipped out of state. During the 1973

[16]Target price is established by the Secretary of Agriculture under provisions of the Agricultural and Consumer Protection Act of 1973.

Figure 13 Montana Wheat in Storage, 1960-1975.



Sources: References 208, 221, and 225.

Table 11
Number of Montana Grain Elevators by Size, 1930-1975.
(capacity in thousand bushels)

	Greater Than 750	250-750	100-250	Less than 100	Total
1930	1	2	9	516	528
1940	2	4	10	416	432
1950	2	8	29	386	425
1960	4	24	130	247	405
1970	4	32	131	165	332
1975	5	46	114	122	287

Sources: References 105 and 236.

marketing year (June 30, 1972-July 1, 1973) less than 10 percent of the available supply was used in Montana. Seven million two-hundred thousand bushels were milled into flour by Montana's three flour mills, Conagra and General Mills in Great Falls and Peavey in Billings. Four million eight-hundred thousand bushels were used for seed and less than a million bushels went for livestock feed (215).

More than 90 percent of the wheat exported out of state has been destined for west coast markets, principally Oregon and Washington. Table 12 shows that movement by truck has declined from 28 percent of the total in 1970 to 20 percent in 1974. It has been estimated that about half of the truck movement in is on a back-haul[17] basis (105). Most of the movement east is to Minnesota and Wisconsin (256).

Costs and structure of the grain transportation system heavily influence profitability of Montana grain farming operations. Transportation costs to west coast markets today are about 60 cents a bushel from the Golden Triangle and 78 cents from the northeast area. Transport costs, paid by the grain farmers, can in effect reduce their market price of wheat by 20 percent.

Shipping costs out of Montana's principal wheat producing areas do not correspond so much with differences in transportation distance as they do with Interstate Commerce Commission decisions on rates. It is cheaper, for example, to ship North Dakota's spring wheat to west coast markets than it is to ship Montana's. Rates for Montana wheat are thus said to be arbitrarily high. Lack of concerted public policy and ineffective competition in transportation are said to have discouraged pursuit of opportunities to have the rates reduced.

A port for river barges recently completed in Lewiston, Idaho may offer shipping savings to farmers in central and southwest Montana—up to 20 cents per bushel (less to those in northeast and northcentral Montana). In apparent response, Burlington Northern Railroad recently applied for a 13-cent per bushel decrease in rates for wheat destined for west coast markets from the central and northcentral areas of Montana.

Data in Table 13 show that Montana wheat shipped to the Pacific Northwest has increased from 63 percent of available supply in 1960 to 76 percent in 1973, responding to the increase in export demand for U.S. grain in the Near East. In 1973 about one-fourth of Montana's wheat shipped to the Pacific Northwest was milled into flour in the Pacific Northwest states; the remainder was exported. (During the 1973 marketing year, 62 million bushels of Montana wheat

[17] Back-haul—contracting for an unscheduled load on the return trip.

Table 12
Wheat Shipped Out-of-State by Mode and Destination, 1970-1974.
(million bushels)

	1970	1971	1972	1973	1974
Total Shipped	81.1	66.4	106.4	87.1	74.7
East	11.9	7.4	7.7	2.5	5.9
Truck	5.1		2.6		1.4
Rail	6.8		5.1		4.5
West	69.2	59.0	98.7	84.6	68.8
Truck	18.1		15.0		13.5
Rail	51.1		83.7		55.3
To Pacific Northwest (Oregon & Washington)	63.5	54.8	96.9	83.6	

Sources: References 208, 214, and 226.

Table 13
Montana Wheat Movement to Pacific Northwest, Use and Exports*
By Marketing Year 1968 (July 1-June 30, 1969) to 1973 (July 1-June 30, 1974).

ITEM	1968	1969	1970	1971	1972	1973
	(million bushels)					
Beginning Stocks, July 1	54.1	84.5	72.5	57.0	60.4	31.5
Production	125.9	99.8	85.2	112.0	98.8	96.7
Ending stocks, July 1	– 84.5	– 72.5	– 57.0	– 60.4	– 31.5	– 18.3
Available supply**	95.5	111.8	100.7	108.6	127.7	109.9
Recorded movement out of State***	81.1		81.1	66.4	106.4	87.1
Shipments of wheat into Pacific Northwest (adjusted for known incompleteness)	63.3	65.9	63.5	54.8	96.9	83.6
Total wheat used for flour in Pacific Northwest (includes bulgar)	36.6	32.0	34.2	29.8	31.8	30.6
Estimated Montana wheat milled for flour in Pacific Northwest (includes bulgar)****	22.9	18.2	20.8	17.9	21.5	21.6
Estimated Montana wheat exported from Pacific Northwest ports*****	40.4	47.7	42.7	36.9	75.4	62.0
Percent of available supply	42%	43%	42%	34%	59%	56%
Inspected exports of Hard Red Spring, Hard Red Winter and Durum from Pacific Northwest ports	96.3	101.4	108.9	75.3	133.4	183.8
Montana exports as percent of total HRS, HRW and Durum exports from Pacific N.W. ports	42%	47%	39%	49%	57%	34%

*Pacific Northwest - Oregon and Washington.

**Beginning stocks plus production minus ending stocks.

***Reported by elevators and licensed truckers - not adjusted for incompleteness.

****Total Pacific Northwest wheat millings minus estimated red wheat originating from Oregon, Washington or other States.

*****Recorded Montana wheat shipped to Pacific Northwest minus estimated Montana wheat milled in Pacific Northwest.

Sources: References 208 and 215.

were exported, 56 percent of the available supply.) Since 1970, about 60 percent of the exported wheat has been spring wheat. Estimates are that almost half of Montana wheat exports goes to Japan, divided evenly between the spring and winter varieties. Other large customers are South Korea, the Philippines and Hawaii (274). Montana wheat's share presently has ranged between 35 to 60 percent of Pacific Northwest wheat exports, although the percentage has been falling lately.

Montana wheat exports mirror a national trend. Between 1970 and 1974, wheat exports nationally increased by nearly 50 percent—to 1.2 billion bushels. According to Table 14 almost half of the total average supply was exported during these years. Winter and spring wheat both

Table 14
Average Annual U.S., West Coast, and Montana Wheat Exports, 1970-1974.

	Million Bushels	
U.S. Supply	2286	
U.S. Production	1555	
Winter		806
Spring		291
U.S. Exports	926	
Winter		508
Spring		157
West Coast Exports	251	
Winter		70
Spring		59
Pacific NW Exports	125	
Montana Exports	54	
Winter		20 (Excl. 1973/74)
Spring		32 (Excl. 1973/74)

Sources: References 208, 274, 294, and 359.

depend heavily on the export market; almost two-thirds of the winter wheat production was exported, over half of the spring wheat production. Pacific Northwest ports play a more prominent role in exporting spring wheat than winter wheat. Between 1970 and 1974, Pacific Northwest ports handled almost 40 percent of the nation's spring wheat exports but only 14 percent of the winter wheat. This situation reflects the concentration of production locations for spring wheat—along the northern plains states—as compared with the dispersal of winter wheat production, much of which is closer to the Mississippi River and Gulf Coast ports than to the Pacific Northwest.

The strength and stability of the Montana food grain production system is very dependent on costs to and profitability of the individual farmer. One rough estimate of the costs of grain production is obtained from the index of prices paid by Montana farmers and ranchers for commodities used in production. By 1974 the index had increased 136 percent from 1947-49 levels; 56 percent since 1970. The index of prices paid for all commodities including taxes, insurance, and interest rose 151 percent over 1947-49 levels. Obviously, farming is increasingly costly (337).

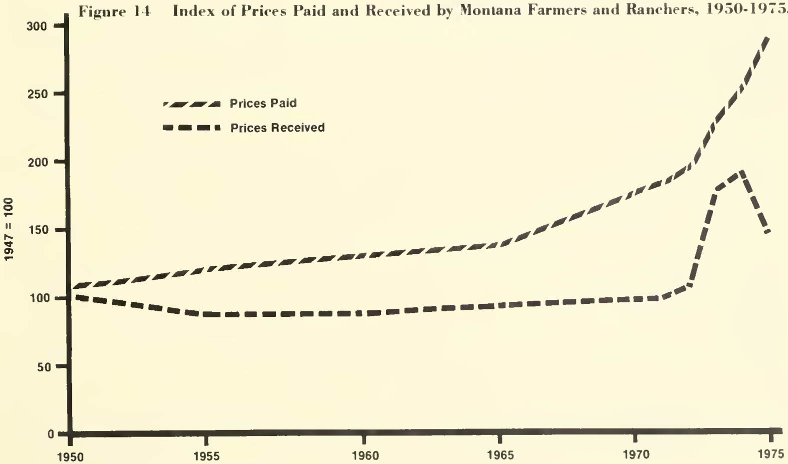
Rising costs of production, of course, are not as serious in times when market prices are rising as when they are stable, or falling. Figure 14 shows the trend in prices received and paid by Montana farmers and ranchers during the period 1950-1975. Until 1972 prices received remained remarkably stable while prices paid almost doubled. Since 1973 there has been an actual decline in all prices received, due to lower meat-animal prices, coupled with almost a 30 percent increase in all prices paid.

Cost of production increases in 1976 continued a trend that is driving farmers and ranchers in Montana toward increasing insolvency. Supporting evidence for this can be found by examining total Montana farm production expenses and cash receipts since 1950. Figure 15 shows that expenses, as a percentage of receipts, reached their low point (highest profitability) of 57 percent in 1959. Its highest point (low profitability) was in 1967 at 98 percent and then fell to 83 percent in 1975.

In 1974, the U.S. Department of Agriculture conducted a comprehensive national study of crop production costs. The winter and spring wheat areas covered in the report included portions of Montana. The Montana subregions reported production costs of $1.35 per bushel for winter wheat excluding costs of labor, management, and return on land. Labor and management charges added 38 cents per bushel and land allocation was 64 cents to as high as $1.09, depending on whether acquisition value or current land value was used. The total cost excluding land allocation was $1.73 per bushel. Including land, costs were $2.37 to $2.82 per bushel. The Montana costs of production compared favorably with the national winter wheat figure of $1.89 per bushel and between $2.80 and $3.17 including land (353).

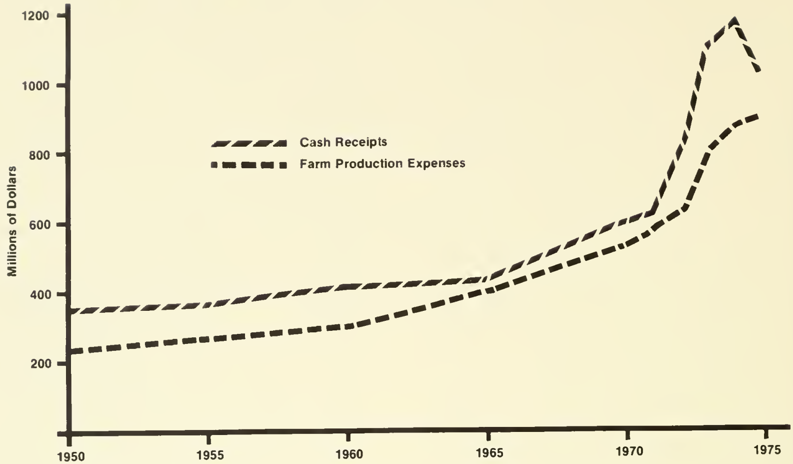
The spring wheat subregion reported production costs of $2.22 per bushel, 60 cents for labor and management, and 69 cents to $1.76 for land allocation. The total cost excluding land allocation was $2.82 per bushel and including land, rose to between $3.51 and $4.58. Hence Montana spring wheat production costs were higher than

Figure 14 Index of Prices Paid and Received by Montana Farmers and Ranchers, 1950-1975.



Sources: References 334, 335, and 337.

Figure 15 Montana Cash Receipts and Farm Production Expenses, 1950-1975.



Source: Reference 358.

the reported national figure of $2.42 per bushel or between $3.27 and $3.76 including land allocation (353).

In the Montana subregions, 90 percent of the winter wheat farms reported total costs, excluding land allocation, of less than $2.50 per bushel. For spring wheat, 90 percent reported similar costs of less than $2.75 per bushel (353).

Recent production cost studies at Montana State University for "representative" dryland farming operations in Hill, Sheridan, and Daniels counties, and the Beartooth area of southcentral Montana, report average total costs, excluding land, for winter and spring wheat of between $2.30 and $2.60 per bushel based on recent average yields for those areas. When a return on land of 9 percent was included the cost per bushel increased between $1.80 and $2.30. If a 7 percent return was used, the land cost fell by about 40 cents per bushel. At 5 percent the land cost fell another 35 cents per bushel. At 7 percent return on land, total costs are between $3.70 and $4.50 per bushel (298)(299)(300).

Analyses of production costs make it clear that the cost of land and the interest rate are critical in farm profitability. If the land is paid off, grain prices exceeding $2.50 a bushel will return a profit on the investment of labor and materials. Grain at $3.35 a bushel will return the same profit plus 5 percent on the investment in land. Montana farmers paying for land or those paying rent on farmland are faced with financial difficulties when grain prices fall below $3.50 to $4.00 a bushel.

MONTANA CATTLE AND FEED GRAIN PRODUCTION

Natural range and pastureland are the backbone of Montana's livestock industry. They also provide forage for wildlife and access to water based recreation. The livestock industry, in turn, creates demand for Montana hay for supplemental and winter feeding and for much of the state's barley (for use in feedlots).

Forty-five million acres, or 75 percent of Montana's rangeland, is privately owned. Nine million acres is administered by the Department of Interior's Bureau of Land Management; four million acres by the State of Montana, and roughly 1.5 million acres by the Department of Agriculture's Forest Service.

Although range is spread throughout the state, 80 percent is in Great Plains Montana[18] (see Table 2) and according to Table 15, 28.6 million of the 47.3 million acres of range in Great Plains Montana is found in 14 counties comprising the heart of a ranching belt running northwest to southeast through eastern Montana. These counties contain almost half of the range and pastureland in Montana.

Most of the remaining counties in Great Plains Montana have more than 60 percent of their land classed as range and pasture, with the exception of the wheat producing counties in the Golden Triangle and the

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[18] See p. 20 for a map of Montana's environmental regions.

Table 15
Range and Pastureland in
14 Eastern Montana Counties.

County	Acres (thousands)	Range and Pasture as Percent of County Land Area
Phillips	2,985	89
Rosebud	2,912	90
Garfield	2,711	92
Big Horn	2,670	83
Valley	2,420	76
Blaine	2,282	84
Custer	2,229	92
Carter	1,891	89
Powder River	1,757	84
Fergus	1,749	64
Yellowstone	1,258	75
McCone	1,166	70
Petroleum	977	93
Prairie	970	88

Source: Reference 261.

northeast corner. Two counties in Rocky Mountain Montana have about two-thirds of their land classed rangeland: Beaverhead with 2.3 million acres and Madison, with 1.5 million acres (261). Table 16 lists the 10 counties in the state with the most private range.

The differences in county acreages between Table 15 and 16 can be ascribed to public (BLM) land being included in Table 15 but not in Table 16. This is particularly evident for Phillips, Valley, Blaine and Carter counties. Beaverhead County also has large BLM holdings (374).

Three-fourths of Montana's ruminant animal population is cattle and calves (see Figure 6). Montana's cattle and calf population generally has increased with minor interruptions spaced 10 to 12 years apart. The general increase can be attributed to the development of water spreading systems providing for a greater winter feed base, the seeding of tame pastures, increasing knowledge and acceptance of basic range management techniques such as rest rotation, deferred grazing, and bush control, and the shift to cow-calf operations (34) (280).

The cyclical shifts in cattle and calf numbers in Montana parallel national trends which are referred to as the "cattle cycle." The cycle is characterized by a buildup in cattle until supply exceeds demand; then there is a decline in price leading to a reduction in animal inventories (58). Of course, cattle prices also are related to such variables as the price of feed.

The composition of Montana's cattle herds has been changing since 1940. Table 17 shows that cattle numbers have increased three-fold since 1940 while cows two years and older have increased four-fold. The trend toward cow-calf operations had been a response to the actual reduction, until 1972, in the real price of corn. Because corn is the principal feed grain in the United States it had thus become cheaper for cattle dealers to put weight on an animal in a feedlot than to buy the weight in the form of an older animal off the range. Ranchers responded to the demand by shifting their operations from raising more fully grown cattle to cow-calf operations. Today Montana ranches largely are cow-calf operations supplying young animals for fattening in feedlots out of state (34).

Not surprisingly, a steady increase in average herd size has accompanied the decline in number of ranches from 37,460 in 1930 to 17,851 in 1969 (360) (364). In 1969 the average herd size was 165 animals up substantially from 34 in 1930. Of the 17,851 ranching operations identified, almost 25 percent or 3,900 held permits to graze animals on BLM land.

Accurate and comparable data about the rangeland used for animal production are hard to find. Definitions vary among agricultural surveys and there have been many changes in the use of public and private land for grazing. Nevertheless, one survey shows that for the northern Great

Table 16
10 Montana Counties
With Most Private Range.

County	Acres (thousands)	Private Rangeland as Percent of County's Land Area
Rosebud	2,799	87
Bighorn	2,393	74
Garfield	2,174	74
Custer	2,166	90
Blaine	1,856	68
Powder River	1,518	72
Phillips	1,448	87
Fergus	1,434	53
Carter	1,407	66
Beaverhead	1,395	39

Source: Reference 262.

Table 17
Composition of Montana Cattle
and Calf Population
(Selected Years, 1920-1976)

	Operations Reporting Cattle Inventories	All Cattle and Calves	Cows 2-years old
1976	—	3,150,000	1,614,000
1973	—	3,197,000	1,685,000
1969	17,851	2,933,897	1,555,000
1960	—	2,245,000	1,114,000
1950	27,932	1,731,000	761,000
1940	—	1,148,000	386,000
1930	37,670	1,290,353	—
1920	45,475	1,268,516	—

Sources: References 34, 208, 217, 360, 362 and 364.

Plains area studied, including much of southeastern Montana, there was a decrease in the average number of acres per animal unit from 31 to 28 between 1958 and 1967. The report concluded that during the study years, the intensity of grazing increased uniformly across the entire ranch population (402).

The change in cattle and sheep numbers since 1950, the former increasing by 1.4 million, the latter declining by 1 million head, supports the contention that grazing pressure is growing. Map 4 shows that the largest concentration of range livestock is in the ranching strip of eastern Montana mentioned earlier. Nine of the 10 counties identified in Map 4 with the largest 1974 cattle populations are included in Table 15. The other is Beaverhead, which has the fifth largest range acreage of Montana's ranching counties. Forty-five percent of Montana's range cattle are in 13 counties: the 10 in Map 4 plus Garfield, Carter and Madison counties (208).

Table 18 shows the number of range acres per animal unit in selected Montana counties. This table combines two variables: the quality of the range measured by its ability to support animals, and the intensity of grazing on the range. Not surprisingly, those counties at the top of the table are in the drier areas of eastern Montana where slight precipitation limits the ability of the native range to support cattle. Lake and Ravalli counties, both with sizable cattle populations, are at the opposite end of the scale with an average of three acres per animal unit. Their position reflects their quality soils and ample precipitation.

Montana hay is vital to meat animal production. Hay contains much protein: between 15 and 20 percent. An acre of hay produces about twice the protein of an acre of soybeans and about four times the protein of an average acre of corn (131). It is uneconomical to transport hay long distances, so it can be assumed that practically all of Montana's hay production is consumed instate, primarily as a feed supplement for range cattle during the months of the year when range is unable to meet nutritional needs.

Table 19 shows that Montana hay production has kept

Table 18
Number of Range Acres Per Animal Unit
Selected Montana Counties, 1974*
(acres)

Garfield	30
Phillips	29
Rosebud	24
Valley	24
Custer	21
Bighorn	18
Madison	17
Beaverhead	14
Yellowstone	8
Cascade	5
Lake	3
Ravalli	3

*These figures are not adjusted for sheep and lamb grazing; the actual figure for beef animals would be slightly lower than shown above in those counties with large sheep populations.

Sources: References 208 and 261.

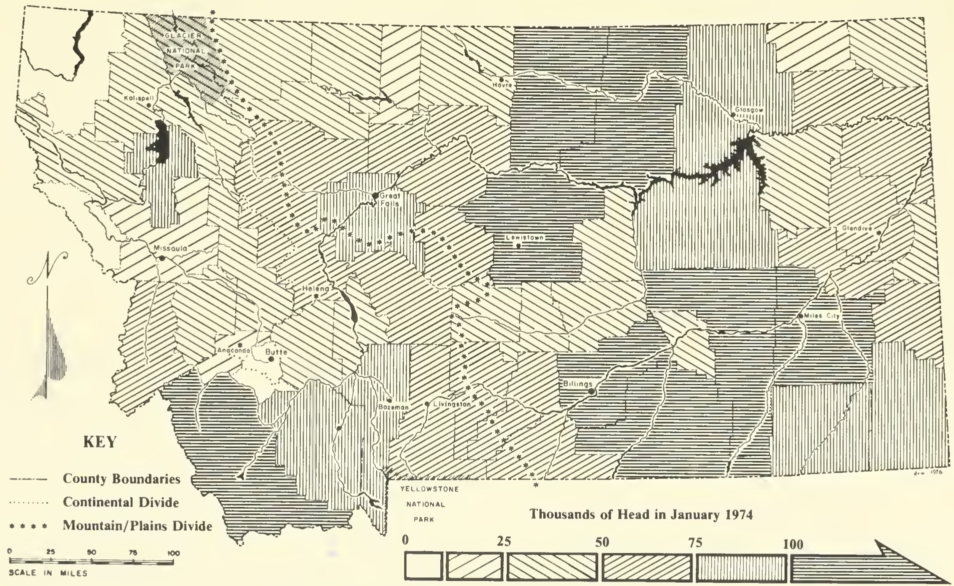
pace with the increase in cattle, growing 300 percent since 1940. Alfalfa hay has retained roughly a 65 percent share of production through the years. In 1975 slightly over a ton of hay was produced for each animal unit.

Acreage devoted to hay production increased by 700,000 between 1940 and 1950. Since 1950 the total acreage has remained constant, however, about 500,000 more acres have been devoted to alfalfa hay over the last 25 years. Since 1940, between 50 and 55 percent of the hay acreage has been irrigated. There has been a 400,000 acre increase in irrigated acreage since 1940. Most of the additional irrigation is for alfalfa hay, which alone has added 300,000 irrigated acres in the last 35 years. About 60 percent of all new alfalfa hay acreage since 1940 has been irrigated. Today about 62 percent of the alfalfa acreage is irrigated and about 49 percent of other hay land is irrigated (208).

Table 19
Montana Hay Production, 1930-1975.

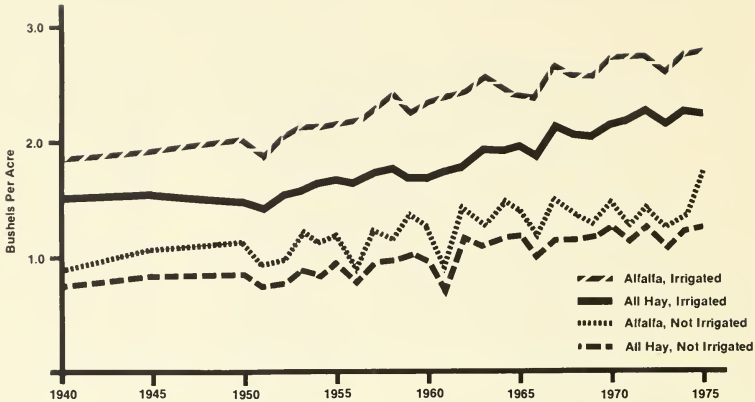
	All Hay			Alfalfa Hay		
Year	All Acres (thousands)	Irrigated Acres (thousands)	Production (thousand tons)	Acres (thousands)	Irrigated Acres (thousands)	Production (thousand tons)
1975	2,400		4,409	1,230		2,829
1973	2,450	1,368	4,100	1,220	760	2,562
1970	2,447	1,171	4,081	1,162	629	2,498
1965	2,490	1,171	3,823	1,100	608	2,145
1960	2,207	1,073	2,900	979	503	1,762
1950	2,432	1,146	2,730	753	447	1,242
1940	1,780	974	1,477	602	442	903
1930	2,193	967	1,326	733	477	1,100

Sources: References 208, 220, 229, 231, 233, 360, 362, and 364.



MAP 4 - MONTANA CATTLE AND CALVES

Figure 16 Montana Hay and Alfalfa, 1940-1975.



Sources: References 66, 208, 229, 230, and 233.

Figure 16 shows historical yields of irrigated and nonirrigated hay and alfalfa hay. Hay yields overall have increased by about 30 percent since 1940, although more slowly recently. Today's yields of irrigated and nonirrigated, around 2.2 and 1.1 tons per acre respectively, are not significantly higher than mid-1960 yields.

Alfalfa hay yields average about twice the tonnage per acre compared to wild hay and about 50 percent more tonnage per acre than other hay types. Nonirrigated hay yields have increased about 30 percent since 1940 while irrigated yields have increased about 40 percent. These yield increases appear to have slowed since the mid-to late 1960s.

Hay production is fairly evenly distributed throughout the state except for northwestern Montana, the two wheat producing areas, and east central Montana. In 1973, 10 Montana counties harvested more than 65,000 acres of hay. In order of decreasing production they were: Beaverhead, Fergus, Phillips, Madison, Cascade, Gallatin, Bighorn, Sweetgrass, Teton and Powell counties. As Map 5 shows, alfalfa hay is concentrated in many of the same counties. Alfalfa appears to be most intensively produced in these counties: Cascade, Lake, Powder River, Carter and Valley.

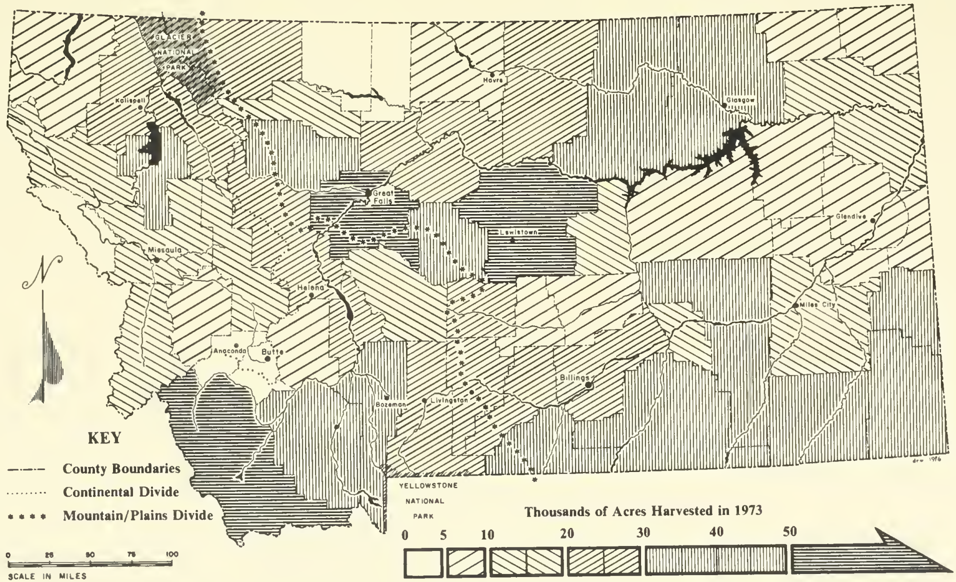
The availability of energy, in the form of hay forage and feed grain is, in general, the factor which limits the output of beef from the land (58). The general rule is particularly true in the cold northern regions of the United States, including Montana. Our cold season essentially dictates that greater amounts of forage and feed are needed here than in the southern areas of the country.

Broadly speaking, about 60 million acres of range and 2.5 million acres of hay land supports Montana's range livestock industry. Using the current figure of 3.8 million animal units, averages of 16 acres of range per animal and two-thirds of an acre of hay land are utilized for each animal. For beef animals the figures are 19 acres of range per animal and three-fourths acres of hay land per animal.

Another important resource used in the range livestock industry is water. It has been estimated that beef cattle require 10 gallons of water per head per day (248). Using 1976 Montana beef cattle population figures, the total requirement is 31.5 million gallons per day, or 36,000 acre-feet per year for cattle. More than half of the water consumption occurs in the Missouri River Basin; about one-third in the Yellowstone; and the rest in the Columbia. Water for livestock has been estimated to derive equally from surface and groundwater sources (248).

Water used for irrigated hay also is part of the livestock production process. In 1975 it was estimated that the amount of water withdrawn for irrigation use in Montana was 12.4 million acre-feet—95 percent of the state's total water withdrawal. The irrigation withdrawal results in actual consumption of 5.58 million acre-feet per year,[19] allocated to the three river basins in the proportions indicated earlier. Crop data show that 80 percent of Montana's irrigated acreage is devoted to hay production.

[19] Irrigation water withdrawal exceeds actual consumption because about half the withdrawal finds its way back to the stream from which it came.



MAP 5 - MONTANA ALFALFA HAY PRODUCING AREAS

On that basis, irrigated hay accounts for an estimated 9.9 million acre-feet of water withdrawal and 4.7 million acre-feet of consumption, or about 1.2 acre-feet of water for each livestock animal in Montana. Thus the livestock industry accounts for almost 80 percent of Montana's current water consumption, excluding evaporation from the reservoirs (248). Almost all of the water consumption goes to support beef cattle.

Range livestock operations also require capital. Financing plays a part in purchase of livestock, expenses for machinery, and in paying for land. One study concluded that capital requirements for machinery averaged $40 to $50 per animal unit in 1967 (402). Today that figure may be twice as high. It also has been estimated that cash expenditures range from $90 to $180 per head. The latter estimate includes, theoretically, all the cash costs of raising the animal (58).

The importance of interest payments on capital used for ranch and food grain operations can be approximated by comparing interest expenses with average cash operating expenses for both types of businesses. Interest expenses for food grain operations in 1968 averaged about 11 percent of total cash operating expenses (149). The comparable figure for ranch operations in 1967 was 18 percent (402). The interest share may include a reflection of investment decisions that are not really comparable. Yet it still appears that debt repayment is a relatively more important production expense in the range livestock industry than in the food grain business.

Ranching, however, appears to use hired labor less intensively than farming for food grain. The 1967 data indicate labor cost of 40 cents per animal unit for ranches of less than 200 animals; the figure for ranches over 200 animals jumped to $2.90 (402). If, on the average, $2.00 worth of labor was required to raise each animal, representing up to two hours' work at prevailing wages, then a 200-animal ranch would have to hire labor for up to 400 hours a year. Of course, the foregoing calculations do not take into account the labor expended by owner-operators nor do they include the labor associated with machine hire.

Purchases of prepared animal feeds represent a large cash expense for Montana livestock ranches. In 1967 purchases of feed accounted for 16 percent of the typical cash operating expense, or about $8.50 per animal (402). At today's prices this same figure would be between $20 and $25. In 1969 there were 339 dealers in prepared feeds in Montana, two-thirds of which were either cooperative associations or private grain elevators. Also in 1969, 63 dealers reported an average of 700 tons of feed sold annually (139). If the average were applied to all 339 dealers, it would mean that about 235,000 tons of feed were sold in Montana, that year or about 13 pounds per animal.

With today's choice feeder cattle prices of about 40 cents a pound the rancher who relies heavily on calf sales is finding it very difficult to break even, much less make a return on his labor. It has been estimated that cash operating costs, excluding a return on land or labor, range between $90 and $180 per head (58). With an average weaning weight of 400 pounds and a 90 percent calf crop this translates into a cost of 25 to 50 cents per pound of beef produced. Ranchers who can produce at a cost less than 40 cents, about midway in the cost range, will break even and perhaps return some money on labor. A rancher who has recently purchased land at the going rate of $1,200 to $2,000 per animal unit will suffer interest costs of up to $100 per year per animal unit—adding up to 25 cents per pound to the break-even cost. Ranchers who are paying interest or rent on land thus are much worse off than counterparts who already own the land.

About half the revenue of a typical Montana ranch is from the sale in the fall of calves born the previous spring (402). The calves are sold as "feeders," that is, they are purchased by feedlots for fattening and eventual resale for slaughter. Other revenue of a typical ranch is from the sale of wet and dry cull cows, heifers, and yearling steers. Unlike the calves, the latter are animals held over from previous years.

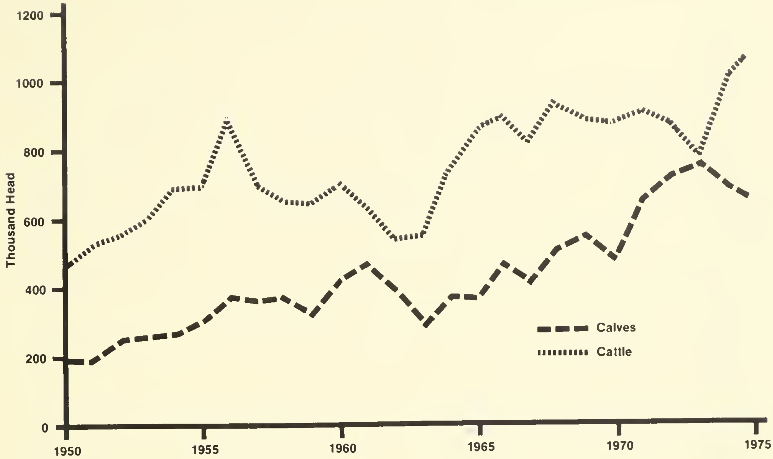
Rising prices for feed have caused a decline in demand for feeder calves. The rising cost of feed has affected prices for light animals, which require more time in the feedlot, compared with prices for those held over the winter and sold heavier. Thus some ranchers are encouraged to hold calves over the winter for sale later as yearlings. Such ranchers have found that the difference between yearling and calf prices is enough to absorb the additional feeding and other holding costs (58) (92). Nationally, 40 percent of the cattle slaughtered in 1975 were raised to maturity away from the feedlot (190).

Evidence of the fluctuating price spread between heavier and lighter animals can be seen in Figure 28 on p.102. In 1972, prices for calves were 37 percent higher than for cattle; by 1974 cattle prices were actually higher than calf prices. Both prices remained very close to each other through 1975.

Timing is the most important factor in livestock sales decisions. If the local market price is acceptable and if calves have gained sufficient weight, they are sold in October or November. If calf prices are unacceptable during the fall the rancher must decide whether it would be economically sensible to hold the animals over until next year, based on judgments about next year's yearling prices, availability and costs of the necessary feed, and general ability of the operation to carry the animal population. Ultimately, many such decisions are based on custom and habit (79).

Direct sales contracts with volume buyers are used by the larger ranches and some of the smaller. Local livestock auction markets handle the remainder. Figure 17 shows the historical trend in marketing Montana cattle and calves. If herd sizes are large and need to be reduced, sales actually may increase during a period of low prices. This happened in Montana during 1974-75.

Figure 17 Sales of Montana Cattle and Calves, 1950-1975.



Sources: References 208, 223, and 233.

There was little change in the number of cattle and calves marketed between the mid-1950s and 1960s. Between 1967 and 1975, though, there was about a 50 percent increase in total sales—the increase equally shared by cattle and calves.

Cattle sales were at least 50 percent higher than calf sales in every year between 1950 and 1968. About 1968 the ratio between slaughter steer prices and corn prices began increasing due to a continuing increase in demand for beef and an excess feed grain capacity. This situation resulted in a strong demand in the midwest for light feeders over heavier animals, encouraging the 50 percent increase in sale of calves between 1968 and 1972 and forcing a 30 percent decrease in cattle sales during the same years. By 1975, cattle sales had returned to a point 50 percent higher than for calves because of the need to reduce herd sizes and the increased prices of feed grain with its dampening effect on the demand for light feeders.

In 1970, the last year for which data are available, close to 70 percent of Montana calf shipments out of state went to the midwest, principally to Iowa, Nebraska, Minnesota, and Illinois in that order of importance. Other important destinations for calves were the Dakotas, 18 percent, and Wyoming, 8 percent (207).

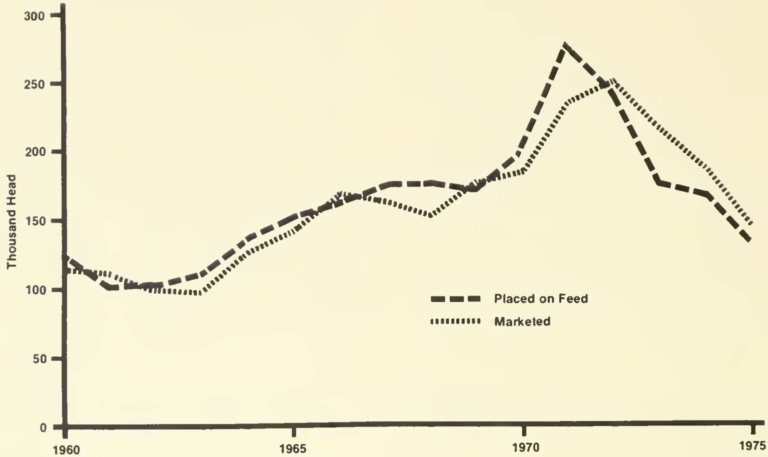
Unlike calf shipments, steers are sent more often to western destinations: 26 percent going to Idaho, Wyoming, Washington, and Colorado, compared with 14 percent for calves, and fifty-six percent went to the midwest (207). The trend probably reflects the range livestock industry's preference for Montana steers as seed stock (90).

An average of 1.35 million head of Montana cattle and calves were sold annually by Montana ranches between 1968 and 1975. During these same years the number of animals placed in Montana feedlots averaged 193,000 head, or about 15 percent of the state's sale of range livestock. Figure 18 shows historical data on the number of animals placed on feed, and the number of fed cattle marketed from the feedlots. Most of the fed cattle were exported to west coast and southwest markets (79).

The number of feedlots in Montana has declined since the early 1960s. On January 1, 1976 there were reportedly 152 feedlots in Montana, down from 305 in 1973 and about 600 in the early 1960s (219). The decline is accounted for mainly by a decline in lots with less than a 1,000 head capacity. Until 1973 there had been a gradual increase in the number of feedlots with a greater than 2,000-head capacity. One rough estimate is that there currently exists a capacity to feed about 300,000 animals in Montana feedlots (208). Almost half of the feedlot capacity is in 20 feedlots, each with a capacity exceeding 4,000 head.

Peak years for feedlot activity in Montana were 1971 and 1972. Since 1972 feedlot activity in Montana has declined by half. On January 1, 1976 there were 80,000 cattle in Montana feedlots (218). Eighty-thousand head represent about 25 percent of the current estimated capacity. Some reasons advanced to explain the low occupancy of feedlots include the effect of cold winters hindering turnover of animals, the seasonal nature of the feeder cattle supply, and the poor availability of credit

Figure 18 Montana Cattle Placed on Feed—Fed Cattle Marketed, 1960-1975.



Sources: References 208, 209, 210, 218, 219, and 234.

(336). As previously indicated, the number of cattle on feed also will be down during periods of marginal profitability brought on by high feed grain prices relative to prices for slaughter steers.

Montana feedlots rely heavily on Montana barley as a source of feed grain because it is high quality, low cost feed compared with principal substitutes, imported corn and other roughages. Montana barley retained for in-state consumption held close to 30 million bushels in the 1973 and 1974 marketing years (213) (224) (225). The 30 million bushels consumed in-state represented 60 percent of Montana's 1973 barley production, and 80 percent of the 1974 production. (The smaller 1974 production of barley came as farmers chose to plant wheat.) It is assumed that most of the 30 million bushels of barley consumed in-state is used for feed in the feedlots.

Montana barley moving out of state goes west—between 16 and 20 million bushels annually during the last two marketing years. It has been estimated that more than half of the shipments are exported from Pacific Northwest ports (294). If this is the case Montana barley accounts for between 10 and 20 percent of all U.S. barley exports (354).

Montana produces about 13 percent of the total U.S. barley crop. Barley production in Montana increased steadily between 1950 and the mid-1960s because more acres were planted and yields increased. Figure 19 shows that acreage planted in barley increased until 1974 when it declined in response to the move to plant wheat. Yields apparently have leveled off with the exception of 1975, a very wet year. Yield data are shown in Figure 20.

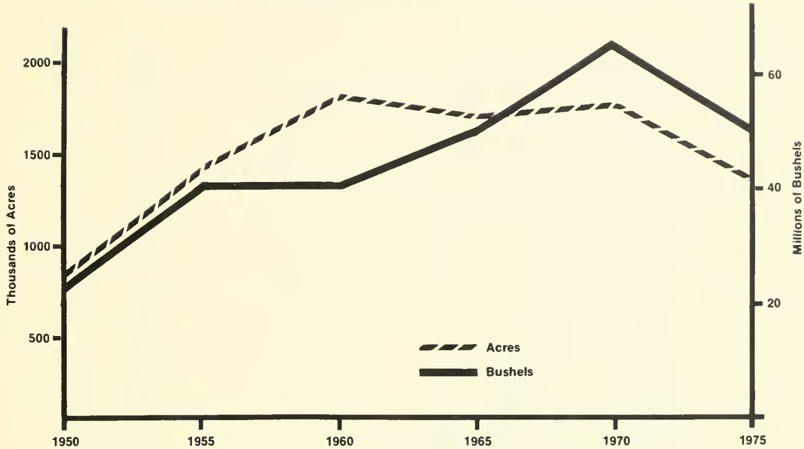
Map 6 shows Montana barley production by county for 1973. Production is strongly concentrated in the north central part of the state. The 10 leading counties accounted for half of Montana's 1973 barley production. If high wheat prices continue, barley production may become less concentrated in major wheat producing areas.

The fortunes of feedlots and slaughterhouses in Montana are closely related (79) (92). Today fewer than 5 percent of the fed cattle marketed in Montana are sold to Montana slaughterhouses (79). There appears to be a lack of instate competition for out-of-state purchasers of fed cattle. The most significant reasons advanced for the lack of slaughterhouse capacity are:

1. The difficulty in penetrating western markets due to high transportation costs and rate structures which discourage shipment of beef to eastern markets.
2. A reliable year-round supply of good fed cattle is lacking.
3. There is a lack of investment capital for slaughterhouses (58) (92) (136).

In addition, there are the usual economic forces acting on the demand for and price of beef at the national level. The constraints on Montana's ability to process beef are not related to a lack of feedlot capacity; it has been estimated that current capacity is sufficient to supply one additional large integrated slaughtering plant (92). Obviously, if an additional processing plant were to appear, feedlot activity

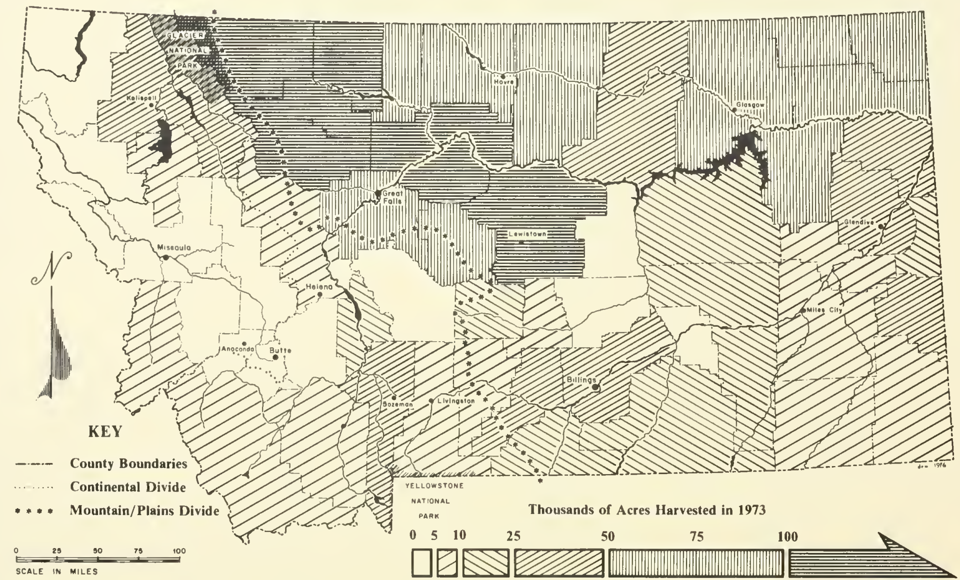
Figure 19 Montana Barley Acreage and Production, 1950-1975.



Sources: References 208, 211, 220, 231, and 234.

Figure 20 Montana Barley Yields, 1950-1975.

Sources: References 208, 211, 220, 230 and 233.



MAP 6 - MONTANA BARLEY PRODUCTION

Figure 21 Cattle and Calf Slaughtering in Montana, 1950-1975.

Sources: References 208 and 222.

would increase if feed grain and beef prices would permit profitable sale of fed cattle. The national market for beef and feed grain would be a controlling factor. If feedlot activity in Montana were to increase it would create additional demand for barley and perhaps help stabilize prices for Montana barley producers.

Figure 21 shows cattle and calf slaughtering in Montana between 1950 and 1975. Slaughter gradually increased until the mid-1960s when it rose dramatically. Slaughtering peaked in 1967; since then it has declined 35 percent. Since 1967 hogs and pigs increasingly have been slaughtered.

A recent survey identified 49 livestock slaughtering facilities in Montana. Only 14 of these were classified as commercial meat processing firms; the remainder do custom slaughtering. Of the 173 million pounds of red meat processed in 1974, slightly less than half, or 83 million pounds, was beef; the remainder was pork. Almost two-thirds of the beef that was processed was sold out of state. It was estimated that the amount sold instate accounted for roughly half of Montana's beef consumption (140). The three largest slaughterhouses accounted for 95 percent of the red meat (140). In 1974 these three firms were Midland Empire Packing, Pierce Packing and John R. Daily.

THE QUALITY OF AGRICULTURAL LAND

One way to describe the quality of Montana's agricultural land is to consider its capability to produce crops or forage given various limitations: erosion, moisture, soil and climate. Depending on the severeity of these limiting factors soils are ranked on a scale from one (I) to eight (VIII). Class I soil has few limitations that restrict its use; Class VIII soil has major limitations that preclude its use for commercial plant production. Class V is a relatively minor special case in Montana, consisting of land that is wet or frequently subject to flooding or ponding.

The distribution of irrigated and dry cropland among the eight capability classes in Montana's two environmental regions is given in Table 20. About 89 percent of Montana's cropland is in Great Plains Montana. The relative distribution of cropland among capability classes in each of the two regions is about the same, except that it is weighted much more heavily toward Class III than Class IV in Great Plains Montana. Thus Great Plains Montana not only has the bulk of the state's cropland, but has the cropland of generally better quality than Rocky Mountain Montana.

The distribution of irrigated and dry pasture and range among the eight capability classes in Montana's two

Table 20
Irrigated and Dry Cropland
by Environmental Region and Land Capability Class, 1967.

Class	Rocky Mountain Montana Acres	Rocky Mountain Montana Percent	Great Plains Montana Acres	Great Plains Montana Percent
I	1,875	0.1	306,393	2.3
II	362,483	22.8	2,711,152	20.3
III	632,604	39.8	7,999,507	59.8
IV	384,455	24.2	1,372,566	10.2
V	696	0.1	15,878	0.1
VI	208,070	13.1	945,357	7.1
VII	932	0.1	23,894	0.2
VIII	0	0	0	0
TOTALS	1,591,115	100.0	13,374,747	100.0

Source: Reference 262.

environmental regions is given in Table 21. As with cropland, the relative distribution of grazing land among the capability classes in the two regions is similar, except that it is weighted more heavily toward Class III than Class IV in Great Plains Montana. Thus Great Plains Montana has the bulk of the state's grazing land, land generally of better quality than grazing land in Rocky Mountain Montana.

A detailed description of land capability classes and subclasses, along with a county by county acreage tabulation is found in the *1970 Montana Soil and Water Conservation Needs Inventory* prepared by the U.S. Soil Conservation Service (SCS). Because classification of soil capability is based on information obtained from detailed soil surveys, the proportion of land in each class may change as modern county soil surveys are completed.

Another approach to the identification of quality farmland has been initiated by the SCS. According to *Land Inventory and Monitoring Memorandum - 3* (351):

> it is SCS policy to make and keep current an inventory of the prime farmland and unique farmland of the Nation. . .The objective of the inventory is to identify the extent and location of the important rural lands needed to produce food, feed, fiber, forage, and oilseed crops.

The SCS defines prime farmland as land best suited and available for producing the crops listed above. Prime farmland has the soil quality, growing season, and moisture to economically sustain production of high yield crops when treated and managed by modern methods. Unique farmland is land, other than prime farmland, used for the production of specific high-value food and fiber crops, for example, citrus fruits, olives, cranberries, and vegetables (351).

Table 21
Irrigated and Dry Pasture and Range
by Environmental Region and Land Capability Class, 1967.

Class	Rocky Mountain Montana Acres	Rocky Mountain Montana Percent	Great Plains Montana Acres	Great Plains Montana Percent
I	0	0	40,234	0.1
II	144,353	2.1	1,290,470	3.7
III	644,860	9.8	7,555,552	21.7
IV	1,415,942	20.9	4,811,972	13.9
V	27,857	0.4	76,792	0.2
VI	3,645,584	53.7	17,174,895	49.4
VII	885,249	13.1	3,833,849	11.0
VIII	0	0	0	0
TOTALS	6,763,845	100.0	34,783,764	100.0

Source: Reference 262.

In addition to the identification of prime and unique farmland, the *Land Inventory and Monitoring Memorandum* instructs each State Conservationist to list additional farmland of statewide importance and, if applicable, farmland of local importance. Farmland of statewide importance is land, other than prime and unique farmland, important for the production of food, feed, fiber, forage, and oilseed crops. Farmland of local importance is defined in a similar fashion. Criteria for defining and delineating lands in these various categories are to be determined by the State Conservationist in collaboration with agencies of state and local government.

To date, farmlands in only two counties—Carbon and Yellowstone—have been identified in response to the *Land Inventory and Monitoring Memorandum*. Copies of the study of these two counties were not retained by the state SCS office in Bozeman following submittal to the Washington SCS office and hence were unavailable to the EQC. Moreover, no other counties were scheduled in this program as of July 6, 1976 (87). Considering the importance of productive farmland to Montana's economy and the rate at which agricultural land is being coverted to other uses, the continuation and prompt conclusion of this program should be encouraged, particularly for farmland of statewide importance.

ENVIRONMENTAL VALUES PRESERVED IN MONTANA AGRICULTURE

A variety of wildlife range over the open agricultural land of Great Plains Montana and the broad mountain valleys of Rocky Mountain Montana. Provided they are not mismanaged, rangeland and pasture generally are more productive of wildlife than cropland; however, cultivated areas also can attract and support wildlife if cover is provided and application of chemicals is held to a minimum.

The three major big game species of Great Plains Montana are the mule and white-tailed deer and the pronghorn antelope. Both deer species have greatly extended their range in Montana since 1941: the mule deer is now practically ubiquitous throughout the state and the white-tailed deer is common in every major river drainage in Great Plains Montana plus most of Rocky Mountain Montana west of the Continental Divide (266). Although in balance with its food supply, the mule deer has a less significant population (155). In agricultural regions, white-tailed deer stay close to the gallery forest and thickets of river bottoms and do not seem to be affected by whatever is causing the population decline among the wider-ranging mule deer.

The pronghorn antelope was plentiful throughout the nonforested regions of Montana in pre-settlement times. As many as 2,500,000 of the animals may have inhabited the state at one time (266). With human disturbance, though, antelope populations dwindled to a low of 3,000 animals in 1924. Since the early 1930s antelope have staged a substantial comeback and have increased their range to include most of Great Plains Montana and a number of the broader valleys of Rocky Mountain Montana (see Map 7). The antelope has become a very popular big game animal in Montana over the past quarter-century; between 1970 and 1974 the annual kill by hunters averaged 18,743 animals. The Bureau of Land Management estimates there are 23,426 antelope on land under its jurisdiction in Montana (374).

Agricultural land in Montana supports a variety of upland game birds. The most important are the sharp-tailed grouse, sage grouse, ring-necked pheasant, Hungarian partridge and Merriam's turkey. The sharptail, pheasant and Hungarian partridge coexist fairly well with agriculture but only when feed and protective cover are available. Sage grouse are inseparately dependent on sagebrush grasslands; the wild turkey generally is restricted to open ponderosa pine forest in rugged terrain.

In addition to upland game birds, 33 species of migratory waterfowl have been recorded in Montana, including two swans, five geese, three mergansers and 23 ducks. Sportsmen value many of these birds, particularly the mallard duck and the Canada goose. Montana is on the edge of the best waterfowl breeding range in North America. Population densities on the northern glaciated prairies in Great Plains Montana compare favorably with the best on the continent (266). Waterfowl habitat generally is adequate and most populations are in no immediate danger.

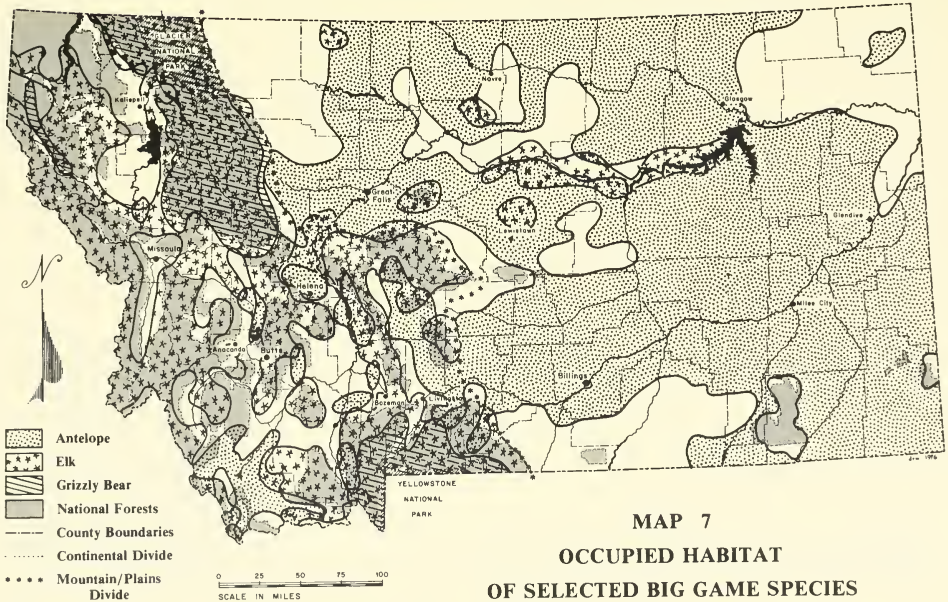
The Fish and Wildlife Service of the Department of the Interior manages an extensive system of wildlife refuges in Montana. Most are water-oriented and located in Great Plains Montana. A few are in the broad valleys of Rocky Mountain Montana (Map 8). The largest is the C.M. Russell National Wildlife Range, taking in the Missouri Breaks on both sides of Fort Peck Reservoir.

The eastern Montana prairie supports a variety of lesser game, furbearers, predators and nongame wildlife, collectively essential to the proper functioning of the grassland ecosystem. Three animals on the Fish and Wildlife Service's endangered species list have been known in Great Plains Montana: the peregrine falcon, whooping crane (a seasonal migrant) and black-footed ferret.

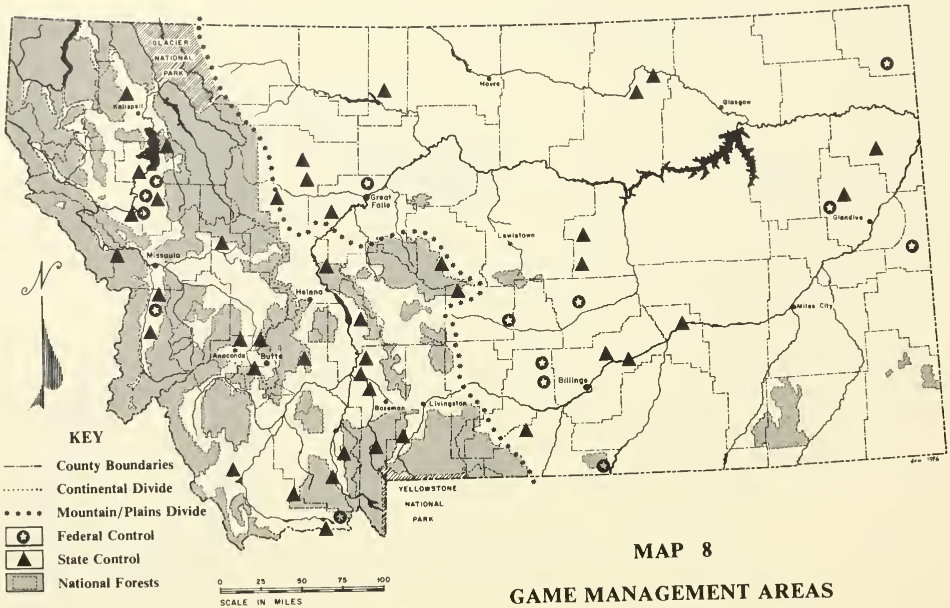
The most significant fisheries in Great Plains Montana are found in the exotic rivers and streams that spring from the Rocky Mountains or the Rocky Mountain outliers. With a few exceptions, most of these waters are important only to a local constituency for fishing purposes. Except at higher elevations in the foothills, the streams support warm water fish, including sturgeon, walleye, northern pike, sauger, channel catfish, paddlefish, bass and a variety of panfish.

WATER FROM AGRICULTURAL LAND

Nonforested land in Montana produces about one-third of the state's available surface water supply (304). Perhaps the only significant agricultural land sources of surface runoff are the foothill grasslands of Rocky Mountain Montana and the Rocky Mountain Foreland. Over most of the Great Plains Montana mean annual runoff amounts to less than an inch of water (see Map 9) (203). The Missouri and Yellowstone rivers, which drain 82 percent of the state's land area and about 90 percent of the state's range and cropland, contribute only 40 percent of the volume of surface water leaving Montana. Indeed, periodically there is a net deficit of usable moisture over much of this region. In areas of small grain production the application of modern farming technology—particularly summer fallow—has encouraged the infiltration and storage of water and reduced evapotranspiration and runoff, resulting in the damaging phenomenon of saline seep (17). Runoff from most agricultural land is probably important only following snowmelt or unusually heavy rain.

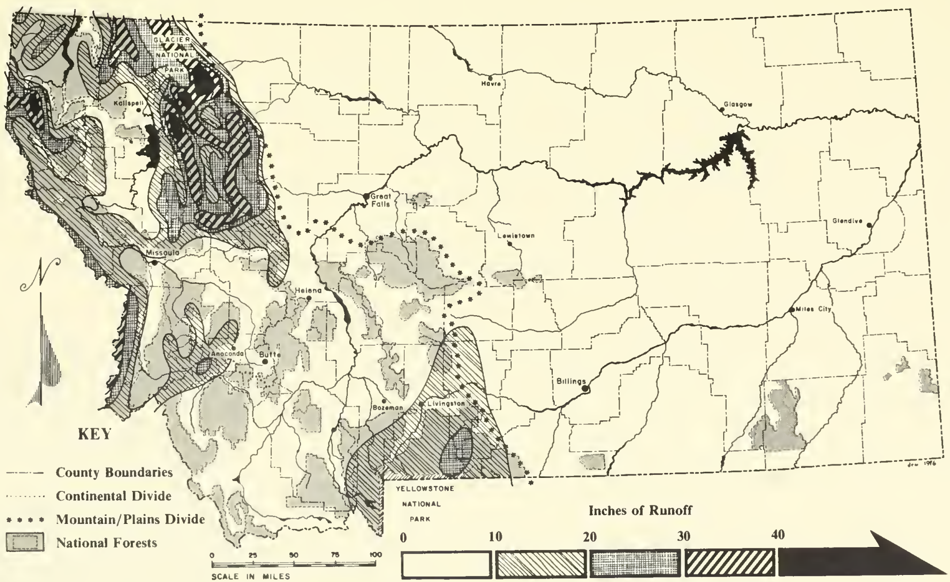


MAP 7
OCCUPIED HABITAT OF SELECTED BIG GAME SPECIES



MAP 8

GAME MANAGEMENT AREAS



MAP 9 - MEAN ANNUAL RUNOFF

CHAPTER 5 AGRICULTURE AND THE GRASSLAND ECOSYSTEM OF MONTANA

Approximately 82 percent of Montana's land area is devoted to farming and ranching including virtually all of the state's non-forested acreage except for urban and suburban tracts, highways, and other built-up areas. Montana agriculture is largely superimposed upon the remnants of the Northern Temperate Grassland Biome,[20] the largest cohesive natural ecological unit in North America (316). This huge biome extends 2,400 miles from Edmonton, Alberta, nearly to Mexico City, and from the Pacific Coast to western Indiana. Because ranching, and to some extent farming, rely on the grassland's natural endowment for their productivity, understanding grassland is essential for preserving the long-term health of Montana agriculture. This is because natural pastures and man-made pastures operate according to the same principles. The many checks and balances of the native grassland community and the degree to which these features are emulated in agricultural practice have a strong bearing on the environmental compatibility and long-term survival of farm and ranch operations.

THE CHARACTERISTICS OF NATURAL GRASSLAND

Montana lies mostly within the short grass grassland of the Northern Temperate Grassland Biome. This ecological unit originally was dominated by perennial grasses (producers) and grazing, predatory and burrowing animals (consumers).

The bison, which formerly occupied about 75 percent of the biome, was a major consumer. Very large herds of this grazing animal migrated 200 to 300 miles seasonally, north in early summer and south in early winter. They cropped and trampled vegetation in their path and their wallowing caused considerable soil disturbance. Among the checks on the bison population was the prairie wolf. Other important grazing animals included the pronghorn, jack rabbit, and prairie dog; natural predators like the coyote, fox, badger, skunk, and weasel; and ground squirrels, pocket gophers, mice, and a variety of birds, reptiles, and insects.

[20]Biome—An ecosystem or combination of ecosystems which contains a similar climate and shares a similar character and arrangement of vegetation.

The principal producers native to Montana's grassland may be inferred from studies of near-pristine vegetation in relict[21] areas (291). In undisturbed areas of high precipitation (15 to 19 inches), rough fescue grass *(Festuca scabrella)* is dominant. In low precipitation areas (10 to 14 inches), bluebunch wheatgrass *(Agropyron spicatum)* is dominant. All near-pristine sites have very low percentages of annuals and big sagebrush *(Artemisis tridentata)*. Generally over the Northern Plains, undisturbed sites are characterized by tall-growing grasses with small populations of short grasses, forbs and shrubs. While these latter groups contribute relatively little in weight of living matter to healthy grassland, they nevertheless provide for a diversity of plant species, which is prerequisite for biological stability in any ecosystem.

The vegetation of undisturbed sites is in what some ecologists call a climax condition; the stable, biological end point following an orderly, systematic process of soil development and plant and animal replacement known as biological succession. In the climax grassland, production and consumption are nearly in balance. Climax vegetation varies from site to site depending on climate, soils, seed sources, slope, exposure, and a variety of other factors.

[21]Relict—Containing persistent remnants of otherwise extinct vegetation.

Travel Promotion Unit, Mt. Dept. of Highways

Once soil and vegetation are disturbed, whether by mining, grazing, fire or cultivation, succession begins anew and, given time (20 to 40 years in the semi-arid West), the disturbed site evolves again toward its naturally ordained climax. Severely abused land will return to a less productive state than the climax. Initial stages of biological succession—the "pioneer" phases—often have simple vegetation with few species and a preponderance of opportunistic annual forbs or "weeds," which prepare the way for the more stable and diverse community that follows. A common pioneer plant characteristic of disturbed sites in Montana, particularly along roadsides, is the Russian thistle *(Salsola kali)*.

Grassland appears in places intermediate between forest and desert in terms of precipitation, in areas receiving between 10 and 30 inches annually, depending on the distribution of rainfall in the seasons, temperature, and evaporation potential. Most of the grasses of the Northern Great Plains, including wheatgrass, needle and thread grass, and blue-grass, are cool season varieties. These grasses renew growth early in spring, reach maximum development in late spring or early summer (when seeds are produced), become semi-dormant in hot weather and resume growth in autumn until arrival of heavy frosts. Other grasses grow continuously from late spring through early autumn with little growth early or late in the year. Productivity of the whole ecosystem may benefit from a mixture of cool and warm season grasses, particularly because rainfall may be most abundant in spring or fall in some years and in midsummer in other years (275). In Montana, June usually is the month of greatest precipitation.

Drought is a normal, recurring phenomenon on the Northern Plains and has helped shape the character of the grassland community over several thousand years of evolution. Drought results from periodic substitution of moist maritime Gulf air by the dry continental westerlies (47). A mixture of plants adapted to varying moisture has enabled the grassland community to withstand prolonged drought and to respond equally well to periods of unusual wetness. Such flexibility is assured only by the diversity inherent in the healthy native grassland ecosystem.

One of the many adaptations exhibited by prairie plants to prolonged drought on the Great Plains is the depth and layering of root systems. Roots of most grass species reach a depth of 6 feet and spread laterally between plants to form a subterranean web that assures maximum use of moisture. Other plants, notably coarse herbs and shrubs, have even deeper root systems to intercept moisture not used by the grasses. Moreoever, root systems of perennial plants, unlike those of annual crops, are already well established at snowmelt or when early summer rains arrive and are also capable of intercepting post-harvest precipitation. Seasonal consumption of moisture generally equals about 90 percent of annual precipitation (330).

Another key moisture-conserving feature of Montana's native grassland is the high humus content of the soil. Unlike forest plants (trees), which are long-lived and rapidly mineralized once they die, grasses are relatively short-lived and only very slowly mineralized, i.e., gradually returned to their inorganic components. Thus, the grassland soil accumulates a considerable quantity of decayed organic matter (humus), averaging about 600 tons per acre (275). Humus also contributes significantly to soil structure and moisture-holding capacity. The grassland soil soaks up water like a sponge and retains it in surface layers where it can be utilized and not lost at depth. For these reasons water infiltration on native prairie sod is often equal to or greater than that on planted fields or fallow ground, but deep percolation is much less (200). Thus are runoff and erosion on grassland minimized and efficient use of moisture encouraged. Runoff from grassland is very low, averaging about 1 inch for the Great Plains (330).

Plants are capable of converting solar energy (light) into chemical energy (carbohydrates) by the process of photosynthesis. Under natural conditions, only about 1 percent of the sunlight reaching plants is used to produce plant tissue. About 10 percent of the energy fixed by plants is available to grazing animals. Because of a chronic shortage of soil moisture grassland is not very productive when compared with contrived ecosystems, such as cropland. On the other hand, unlike cropland, grassland requires no additional inputs of fossilized energy (fuels and fertilizer) to sustain its productivity. Fertility is maintained naturally through nutrient recycling. Soil rich in humus harbors a multitude of microbes and very small animals (decomposers), which collectively contribute to soil fertility. Production can be maintained indefinitely as long as natural grazing is balanced with photosynthesis and nutrients are redistributed in the form of plant and animal wastes and decaying carcasses. For all practical purposes, energy and nutrient inputs into natural grassland are free. A schematic illustration of energy flow and nutrient cycling pathways in a terrestrial ecosystem is presented in Figure 22.

One important characteristic of the soil of grassland, particularly in the northern Great Plains, is salinity. Derived in part from marine shales, many Montana soils possess an excess of soluble salts, including sodium salts (320). Under most natural conditions, however, salts are leached by precipitation to a level usually below the root zone where they have little effect on plant growth. It is only where surface vegetation is disturbed and deep percolation is permitted for extended periods, such as under summer fallow agricultural systems, that salts can move downslope, surface, and ruin the vitality of the land, notably by the destructive process called saline seep. Saline seep currently is endemic in large regions of Montana where summer fallow agriculture is used.

One additional factor affecting grassland in Montana is fire. Fire was thought to be important in prehistoric times to keep grasses competitive against invading trees or shrubs where grassland borders with forest or shrubland. Native Americans at one time purposefully set fire to grassland. The practice is common in other areas of the world today. Natural lightning-caused fires always have occurred. Fire selectively disfavors slow-growing woody plants; its suppression may be a factor encouraging invasions of brush on some ranges in Montana.

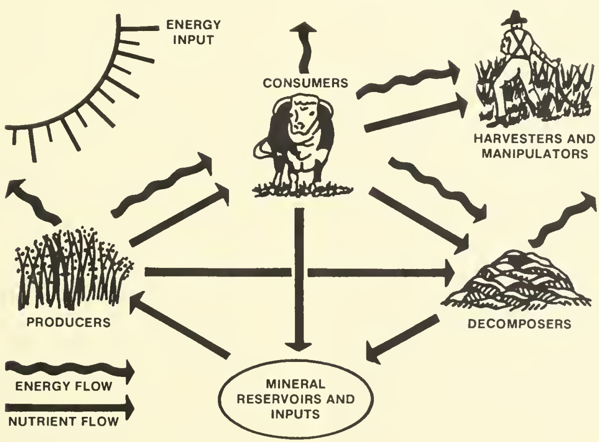
If there is a single significant theme of vital importance to an understanding of natural grassland, it is diversity—diversity in the kinds of plants and animals themselves and in their function, requirements and interrelationships. Although bought at some expense in terms of net production, diversity contributes much to stability and permanence in any ecosystem, natural or contrived. Diversity allows for more efficient resource exploitation because each different plant and animal uses a slightly different portion of the natural endowment of a place. On the other hand, in agricultural contrived ecosystems, a certain amount of diversity is forfeited in favor of increased production of specific plants and/or animals useful to man. The ecosystem is manipulated to maximize the flow of nutrients and energy to man from key producers and consumers, which have narrow and specific resource requirements (Figure 22). On rangeland this forfeiture of diversity may be slight; on cropland, particularly the wheat and barley monocultures, it is carried to the maximum possible extreme—cultivation of none but a single species and often a single variety. Natural grassland is balanced and self-contained, a living whole that in fact has achieved a degree of immortality. To give only the desired species a competitive advantage, agricultural systems, whose products are regularly harvested and carried off, require constant surveillance and often need additional inputs of nutrients and energy. What follows is a description of the extent to which agricultural systems have diverged from the original grassland ecosystem, but of course not from the ecological rules that govern it.

RANGE MANAGEMENT AND THE GRASSLAND ECOSYSTEM

The textbook goal of range management "is not conservation alone but maximum sustained production of forage, the backbone of the livestock industry, an industry that is second in importance to none in the West" (329). Range management first became a preoccupation of Montana ranchers about 100 years ago when bison were annihilated and replaced by cattle and sheep as the principal grazers on Montana grassland. Particularly after the devastating winter of 1886-87, rangeland was recognized as a finite resource dependent on careful stewardship. Since those early days much of the range has been in continuous use; some has been converted permanently to cropland, some to cropland and back to range, and some has been lost to production by other, non-agricultural uses. Rangeland therefore can have a history of uses that may have contributed to its present condition.

Ten years ago only about half of Montana's nearly 60 million acres of pasture and range were in satisfactory condition, presumably because of overgrazing. Odum lists two paramount considerations in determining the carrying capacity for grazing animals on any given range: 1) primary productivity (growth per year) and 2) the percentage of the

Figure 22 Agricultural Ecosystem Nutrient and Energy Flows.



Source: Reference 386.

annual production that can be cropped and still leave the grass reserve enough to continue the same production the following season. Range productivity in the Great Plains is low, between 150 and 500 grams of dry matter per square meter per year, depending on rainfall. Only about half of the annual production should be consumed by cattle if continued productivity is to be assured (106).

There is a step by step decline in a natural grassland when it is persistently overgrazed (396). Repeated grazing of the most palatable species of grass undermines their vitality. If grazed too early, too closely and too often, these species will disappear. The decline of what are to cattle preferred plants, known as "decreasers," serves as a reliable indicator of a deteriorating range. Meanwhile, other less preferred plants are selectively allocated a greater share of light, water, and nutrients, and subsequently exhibit more vigorous growth. These less palatable plants, including sagebrush, are called "increasers" and are similarly used as indicators of range condition and trend.

At first, overgrazing results in a shift in plant populations of species entirely within the normal variations of a native prairie. With continued grazing, however, many small bare places appear that invite the invasion of exotic annual weeds, which are better adapted to close grazing and trampling. These species are called "invaders" and are characteristic of ranges in a late stage of deterioration. They are less productive and less palatable than most native plants.

Soil and soil moisture also are highly susceptible to modification under most range practices (164). With increased grazing and trampling, soil may become compacted, soil moisture-holding capacity decreased, and runoff increased. Range condition has more influence over infiltration than does soil type. Range in good or excellent condition generally can accommodate an average rainstorm without producing much runoff (409). Under heavy grazing, increased runoff, particularly from bare areas not protected by vegetation, may accelerate soil erosion. Wind erosion also can be aggravated by overgrazing. With less capacity for absorbing and holding water, severely trampled soil can support only those species with low water requirements. Hence a plant community and ecosystem develop that are characteristic of arid, low-productivity areas. Growth of plants that do survive may be hampered by poor soil aeration. All this confirms that effective range management must concern itself with the total ecosystem and not just with forage plants.

The range manager has many techniques for preventing or reversing range deterioration. Among these are herding, fencing, strategic placement of water and salt to even out the grazing pressure, brush control, mechanical treatment of soil to increase infiltration and aeration, and fertilization. However, many of the available techniques are expensive and most are directed at treating only symptoms of overgrazing, which are secondary to the root cause: too many livestock on too little pasture for too long a time. With reduction of livestock to numbers that the range can support, ecologically compatible and inexpensive grazing systems can be applied based on rest and rotation (394). To a hopeful degree, such systems mimic naturally intermittent and seasonal use of grasslands by the once numerous migratory bison and are also deferential to the cycles governing flowering and seed-maturing in preferred forage plants.

Brush control, predator control and rodent control: all are activities aimed at local simplification of natural grassland (or grassland set into unbalance by man) with the goal of reducing competition with, and enhancing production of, those plants or animals useful to man. In some cases brush may be abundant not because of overgrazing but because of fire suppression. (Fire, incidentally, is an alternative to chemicals or mechanical methods as a way to control sagebrush.) Regardless, shrubs are important in the water budget of prairie soil, complementing the role of grass. Shrubs serve as food and cover for certain wildlife species, including pronghorn and sage grouse, and they provide important nutrients to livestock in fall, winter and early spring (280).

Rodents eat range plants both above and below ground but their burrowing activities help mix and aerate soil. Wild predators help keep in check populations of natural plant eating animals, preventing them from overpopulating their range. They also are known to eat cattle and sheep. Effective local predator control programs in the past sometimes resulted in troublesome populations of rodents because rodents' natural enemies were eradicated. Brush, rodent and predator control programs aimed at short-term results almost always short-circuit complex food webs and plant-animal interrelationships, and magnify ecological instability. No short-term measure will improve range condition or output effectively unless the basic problem of overgrazing is eliminated.

As wild predators still share grasslands with domestic livestock, so do wild plant-eating animals. Elk, bighorn sheep, deer and pronghorn occupy the same public and private ranges as domestic cattle and sheep. Elk and bighorn sheep have food habits approximating those of livestock; however because elk and the wild sheep are relatively rare, competition between these two groups, although at times locally intense, is generally insignificant. Pronghorn subsist mainly on sagebrush and weeds (266), hence, they offer little competition to cattle. Mule deer offer some competition for green grass and forbs in early spring, but tender shoots, twigs and leaves are their preferred food most of the year. In the absence of natural predators and with light or restricted hunting, big game populations have been known to expand to the point of range deterioration. Such effects may be superimposed on those caused by livestock.

Seeded pastures and range fertilization both have been used to increase output of forage in Montana. The ecological effects of these practices are more closely akin to those of cropping, which will be discussed in the following section.

A stable grassland ecosystem can be maintained on cattle ranges that are stocked sensibly and operated with some awareness of the facts. However, it requires familiarity with the range, knowledge of natural cycles, patience, close supervision, and a willingness to accept a reduction in short-term yields for the sake of maintaining healthy rangeland and ensuring long-term security of production.

FARMING AND THE GRASSLAND ECOSYSTEM

Farming is a miraculous contrivance with tremendous effect on ecosystems. Intensive agriculture especially is based on the fact that, by replacing native communities of plants and animals with introduced communities, the harvest of goods available and suitable to man may be multiplied dramatically. What is involved, technically speaking, is contriving to increase the quantity of stored solar energy that can be transferred intact to livestock or people (125). This principle is invoked both in seeding pastures, where a mixture of plants is involved, and in tilling cropland, where often a single variety of plant is sown. As might be expected, along with the advantages extracted by simplification and increased energy utilization, there come disadvantageous side effects of varying seriousness.

The greater the degree of simplification from a natural to a seeded grass or crop situation, the more complex and numerous the activities of the farmer have to be to control what is happening (324). The loss of diversity and stability unavoidable in artificial agricultural ecosystems must be compensated for by activities that replace the missing functions, such as artificial fertilization and pest control. Such activities may require the expensive use of capital, labor and energy. By its nature, raising a single variety of plant requires increasing these control activities the longer it is pursued. The recent trend toward intensification and specialization in agriculture was characterized by a bias toward sites with potential for high yields and an adaptability toward the necessary controls (15).

In the farmer's efforts to manipulate his part of the ecosystem, concentrate productivity into particular species and maximize the yield of these species, one common denominator is energy. For ranching on native grassland, relatively little additional energy beyond that supplied by the sun is required. Contrastingly, the plowing, seeding, cultivating and harvesting required to maintain a single variety of crop require much additional energy from sources outside the agricultural ecosystem. Energy needs for food production have increased dramatically since the turn of the century. The trend is toward higher fuel cost per unit of food obtained by the farmer from the field, hence a greater increase in energy cost to society per unit consumed (154).

The fact that the agricultural plant community is usually a single variety means that agriculture loses what nature has provided for natural communities—the ability to adjust to recurrent climatic crises, disease and pest attacks. There are many reasons why replacement of native plant communities with introduced communities has adverse effects on the structure and function of the ecosystem. Under the impact of the change, soil usually declines in nitrogen, becomes less porous and permeable, increases in density and resistance to root growth and has slower water infiltration rates compared with soil under perennial grass. Under row cropping, large spaces are left bare to wind and water erosion. Cultivation also decreases the diversity of insect, bird and mammal communities but initially stimulates the growth of soil bacteria, presumably because of the greater amount of plant residue that is available. Finally, cultivation can have a profound effect on evapotranspiration and the local climate, especially humidity (125). An additional consequence of cultivation on the northern Great Plains has been to stimulate excess subsurface moisture and movement of underground salt.

Under natural conditions grassland soil releases and replenishes its store of nitrogen very slowly. When the prairie sod is broken for the first time, the soil is suddenly so well aerated that bacteria have much better chance to break down the organic matter of the humus into its principal inorganic components, including nitrogen. Following the disturbance soil nitrogen in excess of immediate plant needs drifts below the root zone where it is no longer available for plant production. The total effect is seriously troublesome in two ways: 1) there is a loss of nitrogen in the root zone and hence a decrease in natural soil fertility, particularly following years of intensive cropping; and 2) there is a buildup of toxic nitrates in groundwater. Indirect documentation of both these problems has been provided in Montana (114)(318). In the midwest, the first 25 years of cultivation destroyed about 25 percent of the nitrogen originally present in the prairie soil (326). Consequently, it can be expected that conversion of rangeland to marginal cropland (one trend resulting from profitable wheat farming) will be accompanied by a decline in natural fertility and pollution of underground water supplies.

Compared with native grass communities, planted crops have relatively simple, uniform root systems which have been shown to be incapable of tapping all available moisture, particularly in wet years. Summer fallowing further compounds this inefficiency, in use of available moisture, to the point that some water percolates deep below the root zone. On the way the water carries off dissolved salts and may deposit them downslope where the water discharges at the surface as a saline seep (16). To slow down the rate of saline seep development, minimum tillage, crop rotation, and the inclusion of deep rooted perennials like alfalfa into the cropping system are recommended. The control proposals have elements in common with natural semi-arid grassland ecosystems: a minimum of surface disturbance, plant diversity, and root systems capable of tapping moisture at depth.

Wind erosion has accelerated with the move toward summer fallowing and block farming in Montana (345). Geographically large areas of bare soil are unknown in nature. To control wind erosion, farmers need to employ minimum tillage, alternate strip cropping, stubble mulching, windbreaks, grass barriers, and cover crops.

Some of the same controls are effective against water erosion.

Intensification of agriculture in the midwest and in Montana has been accompanied by continued difficulties in soil and water conservation, despite a decline in total acreage tilled between 1934 to 1965. The problems stem mainly from the severe specialization in single varieties of plants over large areas. Now there are signs of a new trend toward alternative crops, including oats, sunflowers, safflower, millet, corn, alfalfa, peas and beans. Because many of the additional acres cropped in recent years have been planted in wheat, even a tentative move toward diversification in crops is encouraging. Diversification in crops respects at least some of the natural limits of the grassland ecosystem, particularly if it is coupled with crop rotation and minimum tillage. For similar reasons, further encouragement can be taken from the revival of commercial organic farming in Montana (28).

The basic differences between the natural grassland ecosystems and agricultural ecosystem clearly are a function of diversity and useful production. Diversity is a mechanism that provides for community stability and efficient use of resources but it also limits the production of materials useful to man. Intensive farming that allows single varieties to dominate provides for maximum productivity of products useful to man, but it sacrifices stability and efficiency in use of resources. The degree to which these and other ecological characteristics are affected by grassland, range and cropland systems is summarized in Table 22.

In light of the energy requirements and environmental problems associated with intensive agriculture here and abroad, some scientists (15)(109) encourage movement as far as possible toward farming systems that retain natural mechanisms of fertility, productivity and regulation. Soil banking, game cropping and ranching, and forest farming are cited as means to this end. Intensive grain farming currently is enjoying unprecedented yields on a relatively small land area thanks to equally unprecedented energy expenditures and the use of hybrid crops. Unfortunately, this system of food production also is highly unstable and energy intensive. Cattle ranching can be far more ecologically comptaible and naturally resilient as a food production system, particularly under the semi-arid conditions prevailing over most of Montana's grassland ecosystem.

Table 22
Effects on Ecological Characteristics of Land Ecosystems Under Grassland and Cropland Management.

Characteristic	Native Grassland	Grazed Rangeland	Cropland
Diversity	Very High	Medium-High	Low
Stability	Very High	Medium-High	Low
Resource Use Efficiency	Very High	High	Low
Multiple-Use Potential	High	High	Low
Extra-Solar Energy Required	None	Low	High
"Useful" Energy Output	Low	Medium	High
Surveillance Required	None	Medium	High
Erosion Potential	Low	Low-Medium	Medium-High
Environmental Pollution Potential	Low	Low-Medium	High

CHAPTER 6 FORESTLAND RESOURCES IN MONTANA

Among major land uses—for crops, range and forests—forestland can support the broadest spectrum of activities. Although timber is one obvious product of the forests, they are equally valuable as habitat for wildlife, sources of atmospheric oxygen, and as huge storage basins for snow and water. Forestland also is useful and valuable for recreation, education and some cattle grazing. Despite the validity of these competing values, public and private management practices on most forestland give priority to propagation, growth and harvest of trees as timber. Hence this section analyzes Montana's forestland from the timberman's viewpoint: where are the stands, who owns them, what is made from them?

COMMERCIAL FORESTLAND (CFL)[22]

About 23 million acres, or one-fourth of Montana's land area, is forested. In 1970, 15,850,000 acres or about three-fourths of Montana forestland was classed as commercial (138). Economic, administrative and technical factors have entered into determining how much forest is commercially valuable. Before the turn of the century, only the most valuable species were considered because of the long distances to principal markets. The commercial base was greatly expanded after World War II with increased demands for housing and improvements in transportation. This trend continued until about 1962 when 17.3 million acres of Montana forestland was classified commercial (403). Thereafter, growing recognition of competing forest values and environmental impacts associated with timber growing and harvesting resulted in reduction in the CFL base. By 1970, 1,390,000 acres of productive Montana forestland had been reserved for non-timber uses, 641,100 acres were deferred for possible withdrawal in favor of non-timber use, including wilderness, and 132,000 acres CFL were placed in an "unregulated" category to preclude a timber harvest commitment in the face of increasing demands for non-timber use and desire to prevent unnecessary environmental degradation (138).

The most recent data showing forestland and commercial forestland ownership in Montana are in Table 23. The data are not strictly comparable because definitions, particularly of "commercial forestland," vary from owner to owner. Another problem is that, in the past, acreage figures for commercial and total forestland have been used interchangeably, notably by owners in the "other public" category. The least reliable data are probably those for "small private" ownership. Despite these drawbacks, some generalizations can be made about the data. Total forestland as commercial is greater in the private sector (73 percent) than in the public sector (58 percent). Acres of public forest outnumber private by nearly three to one but for commercial forest acreage the ratio is not quite two to one. About one-third of all private commercial forestland is owned by the three large industrial firms.

It is also important to note that forestland holdings among small private landowners are very concentrated. Of the 14,465 non-industrial landowners, 190, or 1.3 percent, own 32 percent of the acreage. At the other extreme 6,244, or 43 percent, own less than 40 acres each, or a total of only 3 percent of the acreage (54).

Travel Promotion Unit, Mt. Dept. of Highways

[22]A standard definition of commercial forestland (CFL) is land producing or capable of producing crops of industrially useful wood and not withdrawn from timber use; it must be able to produce at least 20 cubic feet of wood per acre per year under management.

Table 23
Ownership of Total Commercial Forestland in Montana.

Owner	Acres Forestland	Acres CFL
Small Private	4,844,410 (1967)	3,150,000 (1970)
Large Industrial (1975)	1,720,000 +	1,590,000
Burlington Northern	850,000	750,000
U.S. Plywood	670,000	640,000
St. Regis	200,000 +	200,000
Total Private	6,564,410 +	4,740,000
State	491,265 (1974)	421,000 (1975)
Forest Service	14,555,400 (1970)	7,944,700 (1974)
Other Public (1970)*	1,577,800 +	1,324,700 +
Total Public	16,624,465	9,690,400
STATE TOTALS	23,188,875 +	14,430,400 +

*Includes BLM, Indian (BIA), county and municipal, and miscellaneous federal.

Sources: References 50, 60, 61, 75, 83, 91, 138, 253, 262, 347, and 374.

Since 1970, 2.8 million acres of high elevation, inaccessible, marginally productive Forest Service land was removed from the CFL classification. More than half of the reductions occurred in three national forests: Lolo, Lewis and Clark, and Beaverhead (64). The large industrial forest holders, though, apparently have increased their commercial acreage by about one-half since 1970 when 1,055,400 acres of CFL were attributed to the forest industry. A contrary trend is seen in the private, non-industrial forest sector, where a reluctance to harvest and conversions to non-timber uses following harvest have effectively reduced this part of Montana's CFL base (347).

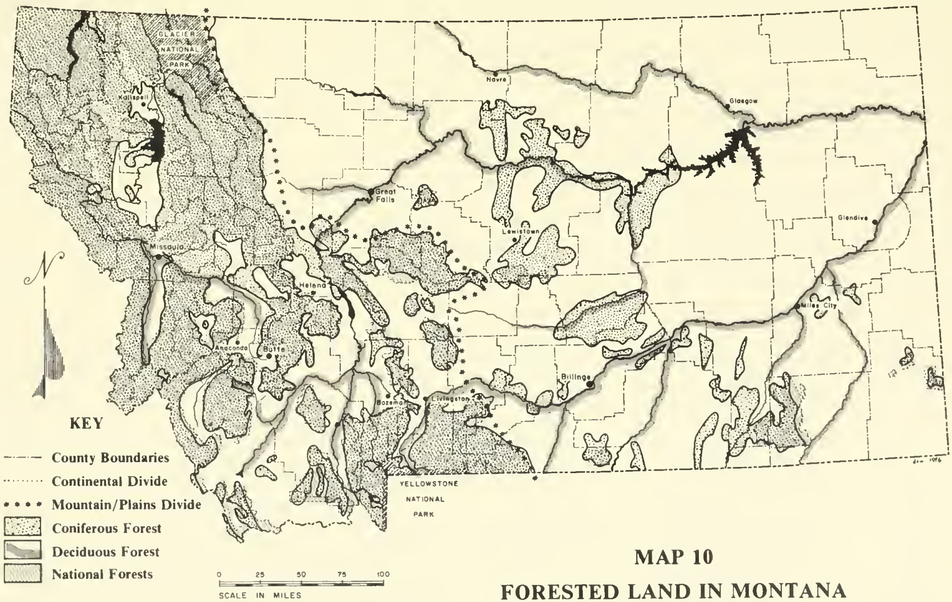
Every county in Montana has some forestland and all but two counties have some CFL (262). But the overwhelming majority of the state's commercial forestland is located in Rocky Mountain Montana (see Map 10). Table 24 shows forestland by owner in Rocky Mountain Montana and Great Plains Montana; about 85 percent of the total and commercial forestland is in Rocky Mountain Montana. Table 24 also shows that a much larger percentage of Rocky Mountain Montana is forested than Great Plains Montana: over 60 percent of the former is forestland, about 6 percent of the latter. And with only 17 percent of the state's total land area, Montana west of the Continental Divide contains

Table 24
Montana Land Devoted to Forest
by Environmental Region and Ownership Group
(millions of acres)

	Rocky Mountain Montana	Great Plains Montana	State
Total Land Area	31.4	61.7	93.1
Total Forestland	19.7	3.4	23.1
State and Private (1967)	4.9	2.1	7.0
U.S. Forest Service (1970)	13.7	.9	14.6
BLM (1975)*	.8	.2	1.0
BIA (1974)*	.3	.3	.6
Commercial Forestland	12.8 +	1.9 +	14.7 +
State and Private	4.6	1.5	6.1
U.S. Forest Service (Nonreserved)	7.6	.3	7.9
BLM*	.6	.1	.7
BIA*	---	---	---

*Estimated

Sources: References 64, 81, 262, 347, and 374.



MAP 10
FORESTED LAND IN MONTANA

Table 25
Net Volume of Softwood Growing Stock and Sawtimber on CFL in Montana, 1952, 1962 and 1970.

	1952	1962	1970
Growing stock (million cubic feet)	26,290	29,044	28,376
Sawtimber (million board feet)	100,237	106,702	100,925

Source: Reference 347.

61 percent of the state's CFL, 68 percent of the growing stock[23] and 71 percent of the sawtimber[24] (138).

Seven western Montana counties are over 70 percent forested; Mineral and Lincoln (over 90 percent), Flathead, Missoula, Ravalli, Sanders, and Granite, in decreasing order (333). At least 60 percent of the forestland in these counties, with the exception of Missoula, is public land managed by the U.S. Forest Service. In three of the counties—Mineral, Lincoln and Ravalli—almost 75 percent of the total land area is owned and managed by the Forest Service (313).

Forestland in Great Plains Montana is associated principally with the Rocky Mountain outliers, the eastern ponderosa pine woodlands, and with the hardwood—mostly cottonwood—gallery forests along the major waterways. The distribution of the principal softwood forest types in Montana is shown in Map 10.

In 1970, Montana forests contained 33 billion cubic feet[25] of salable timber, mostly growing stock, and about half in sawlog-size materials (304). Growing stock and sawtimber volumes have remained relatively stable over the last two decades (see Table 25). To put these figures in a national perspective, in 1970 Montana timber accounted for about 6.5 percent and 5.3 percent respectively of the nation's growing stock and sawtimber (347).

In 1970 about 65 percent of the sawtimber and growing stock was in national forests, about 17 percent in small private holdings, and about 10 percent on forest industry land. Comparing these figures with the share of CFL owned by the three classes of owners shows that, in general, Forest Service land has a proportionately larger share of timber volume than timber acreage. Hence it can be assumed that mature stands are more concentrated on Forest Service land than on small private and forest industry land.

Table 26 shows that Montana's forests are dominated by lodgepole pine and Douglas-fir which between them account for 60 percent of the volume of growing stock.

Data on net annual timber growth and removals for growing stock and sawtimber are in Table 27. Apparently there was substantial increase in net annual growth of growing stock and sawtimber between 1962 and 1970; more than a doubling for the former and about a 50 percent increase in growth for the latter. In 1962 reported removals exceeded annual growth for both growing stock and sawtimber. Private landowners were responsible for all of the excess removal of growing stock. Sawtimber removal exceeded growth on both public and private land in 1962. Between 1962 and 1970 removal of growing stock increased about 50 percent and sawtimber removal increased by about a third. The increase in growing stock growth has more than offset the increase in removals so that in 1970 growth exceeded removal for growing stock, the reverse of the 1962 case.

In mature sawtimber stands, removals continued to exceed growth in 1970. (Mature and over-mature stands generally have higher mortality and lower growth rates than younger, more vigorous stands.) This occurred primarily on

Table 26
Net Volume of Growing Stock and Sawtimber in Montana by Major Species.

	Growing Stock (percent)	Sawtimber (percent)
Lodgepole pine	34	22
Douglas-fir	27	32
Engelmann and other spruce	9	12
Western larch	9	12
Ponderosa and Jeffrey pine	8	11
True firs	8	7

Source: Reference 347.

Table 27
Net Annual Growth and Removals of Growing Stock and Sawtimber on Commercial Forestland in Montana, 1962-1970.

	Growing Stock		Sawtimber	
	Growth	Removal	Growth	Removal
	(million cubic feet)		(million board feet)	
1962	198	230	892	1381
1966	---	271	---	1571
1970	433	324	1486	1815

Sources: References 310, 347 and 403.

[23]Growing stock—stands of living trees of commercial species meeting specified standards of quality and vigor, not necessarily ready to harvest.

[24]Sawtimber—In the intermountain states, trees exceeding nine inches in diameter at breast height.

[25]For comparison, an average single-family, wood-frame dwelling contains about 900 cubic feet of wood, or about 11,000 board feet (each board foot equals a volume of 12 by 12 by 1 inches).

forest industry land; on public land sawtimber growth and removals were about equal (304).

Tree mortalitality from all causes—insects, disease, fire and wind—resulted in an estimated loss of 164 million cubic feet of growing stock and 586 million board feet of sawtimber in 1970—more than a third of the annual Montana growth (138). Very few dead trees are salvaged.

The quality of Montana's commercial forestland may be discerned from three perspectives: tree species, site productivity, and acreage non-stocked or, conversely, in need of thinning. Site productivity may be measured in three ways: stand-volume class (standing crop per acre in board feet), stand-size class (acreage in sawtimber, poletimber, or sapling and seedling) and site class (production capacity expressed in cubic feet per acre year). Tables 28 through 31 show Montana commercial forestland acreage in the various species and site productivity classes in 1970.

Table 28
Acres of Commercial Forestland in Montana by Species, 1970.

Species	Thousands of Acres
Douglas-fir	4,566.8
Hemlock	86.5
Ponderosa pine	2,620.2
White pine	55.1
Lodgepole pine	4,893.4
Larch	1,241.6
True firs	1,195.5
Spruce-fir	755.6
Other softwoods	243.3
Hardwoods	192.6
All Forest Types	15,850.6

Source: Reference 138.

Table 29
Acres of Commercial Forestland in Montana by Stand-volume Class, 1970.

Stand-volume Class	Thousands of Acres
Less than 1,500 board feet	3,750.2
1,500 to 4,999 board feet	4,767.9
Greater than 5,000 board feet	7,332.5
All classes	15,850.6

Source: Reference 138.

Douglas-fir and lodgepole pine each cover more commercial forest acreage than all other forest types combined, excluding ponderosa pine. A "typical" forest tract in Montana is either a sawtimber stand of Douglas-fir or a pole timber stand of lodgepole pine. In 1974, Douglas-fir and western larch accounted for half of the timber harvested in Montana. Ponderosa pine and lodgepole pine

Table 30
Commercial Forestland in Montana by Stand-size class, 1970.

Stand-size Class	Thousands of Acres
Sawtimber	9,186.2
Poletimber	4,466.7
Sapling and seedling	1,817.0
Non-stocked	380.7
All Classes	15,850.6

Source: Reference 138.

Table 31
Commercial Forestland in Montana by Site Class, 1970.

Site Class (cubic feet/acre/year)	Class #	Thousands of Acres
20-49	(V)	5,365.7
50-84	(IV)	4,801.9
85-119	(III)	3,962.9
120-164	(II)	1,496.0
165 +	(I)	224.1

Source: Reference 138.

each contributed about 15 percent of the harvest (401). Surprisingly, lodgepole pine was the leading tree specie harvested in 1975 in national forests.

Most of the volume of the principal species, except lodgepole pine, is in sawtimber-size trees. Montana has an abundance of mature forests: about 60 percent of Montana CFL acreage is in sawtimber-size trees. This is high when compared with the rest of the country, where about 40 percent of CFL acreage is sawtimber (347). However, Montana's sawtimber tends to be small diameter (about one-third is under 13 inches diameter at breast height), smaller than on the west coast but larger than in the central and southern Rocky Mountains. Also, Montana forests have a relatively poor age distribution for sustained timber harvest: much mature forest acreage and many youthful stands but little middle-aged growth (23).

Table 32 takes a closer look at the CFL base as of 1970, showing distribution of site classes (see Table 31) for each of the principal owner-classes. National forests in 1970 contained more than 90 percent of the state's Site Class III land and better. Slightly over half of the CFL in national forests was in these better classes. Surprisingly, in 1970 only 14 percent of forest industry land was in Site Class III or better. Recent data from two of the forest industry firms, though, indicate that this figure may be low. Champion International, formerly U.S. Plywood, indicated that 12 percent of its holdings were in Class I and II and that at least an equivalent amount was in Class III (61). St. Regis has

Table 32
Commercial Forestland in Montana
by Site Class and Ownership Group, 1970.
(thousand acres)

Site Class (cubic feet/acre/year)	National Forest	Other Public	Forest Industry	Farm & Miscellaneous Private
20-49 (V)	1559	1059	433	2313
50-84 (IV)	2733	522	473	1031
85-119 (III)	3632	81	122	126
120-164 (II)	1435	15	18	26
165 + (I)	197	6	8	11
	9732	1685	1055	3510

Source: Reference 347.

stated that the average productivity on its land was about 120 cubic feet per acre per year, meaning that almost half its acreage would fall in Classes I and II (163).

Commercial forestland acreage is not spread evenly throughout western Montana. Listings by national forest (see Map 11) give a better idea of the location of commercial forestland in relation to the total forestland resource. Table 32 presents data on total acres, nonreserved forestland (land legally and administratively available for timber harvest), and CFL acreage by forest. The two nonreserved CFL columns indicate by forest the magnitude of reductions in the CFL base occurring between 1970 and 1974. The last column in Table 33 shows the proportion of nonreserved land in each national forest classified as CFL.

The location of forestland most suitable for timber production in Montana may be ascertained by examining available site productivity data for the various national forests (see Table 34). Forests containing high percentages of CFL are not necessarily the most suitable for timber production; one must look also at the distribution of site classes within each forest. On five forests—Deer Lodge, Flathead, Helena, Kootenai, and Lolo—well over half the CFL is Site Class III or better. The Flathead, Kootenai and Lolo forests, all entirely west of the Continental Divide, contain 46 percent of national forest CFL and in 1975 accounted for about 70 percent of the potential yield on Forest Service land (64).

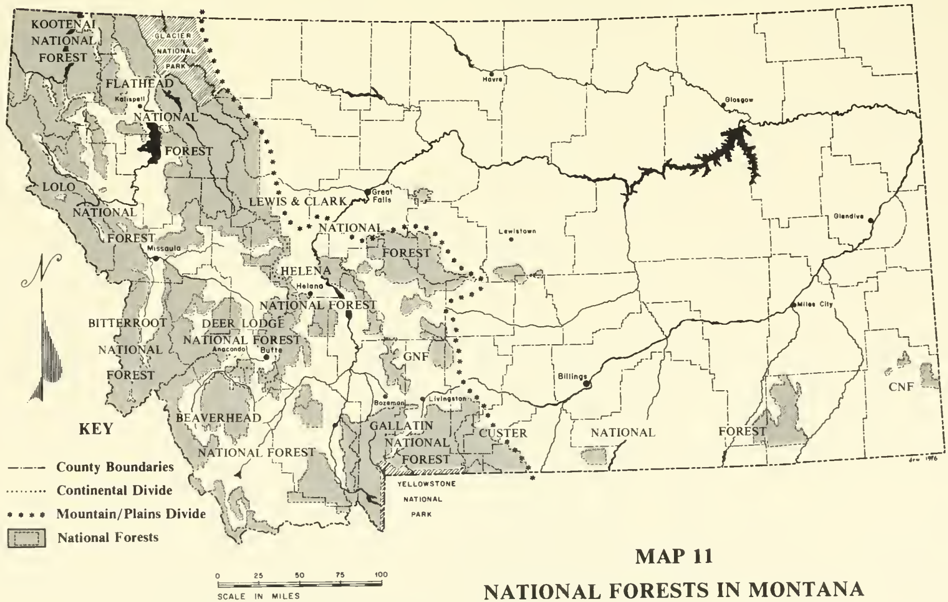
Two forests, the Bitterroot and Gallatin, are intermediate in productivity: about half of their commercial forestland is in Site Class II or better. More than half of the commercial forestland in the three remaining forests—Lewis and Clark, Beaverhead and Custer—is in Site Classes IV and V. To summarize, the potentially most productive national forests in Montana lie west of the Continental Divide, forests of intermediate productivity straddle the divide, and those of lower productivity lie entirely east of the divide (see Map 11).

About 380,000 acres of Montana CFL were classed non-stocked (in need of replanting) by the U.S. Forest Service in 1970. Most of this area was in private,

Table 33
Montana Forestland Classifications by National Forest.
(thousand acres)

Forest	Total Acres (1970)	Nonreserved Acres (1970)	Nonreserved Forestland (1970)	Nonreserved CFL (1970)	Nonreserved CFL (1974)	CFL as Percent of Nonreserved Acres (1974)
Beaverhead	2111.1	2036.2	1465.2	999.4	632.3	31
Bitterroot	1113.8	828.5	796.4	724.6	601.1	73
Custer	1113.7	944.9	477.4	380.4	218.0	23
Deer Lodge	1176.4	1132.8	940.5	761.6	761.6	67
Flathead	2355.1	1574.5	1532.4	1035.6	907.6	58
Gallatin	1701.1	1528.6	1151.2	650.9	441.3	29
Helena	965.0	936.5	808.0	695.8	569.1	61
Kootenai	2212.7	2105.5	2089.0	1514.6	1831.5	85
Lewis & Clark	1912.4	1669.1	1338.4	1040.0	615.5	37
Lolo	2077.1	2077.1	2048.9	1797.0	1366.7	66
	16738.4	14833.8	12650.8		7944.7	

Sources. References 64, 81, and 100.



MAP 11

NATIONAL FORESTS IN MONTANA

Table 34
Montana National Forests Ranked by Timber Production Potential and Percent Distribution of Commercial Forestland (CFL) within National Forests, 1970.

Forest*	Percent of Montana CFL in Site Classes I-III	20-49 (V)**	50-84 (IV)	85-119 (III)	120 + (I&II)
Lolo	23	12	23	56	9
Kootenai	20	11	23	30	36
Flathead	15	6	18	51	25
Deer Lodge	11	2	22	68	8
Helena	8	9	28	57	5
Bitterroot	7	17	33	37	13
Gallatin	6	10	40	45	5
Lewis & Clark	6	36	34	24	6
Beaverhead	2	20	70	9	1
Custer	0.4	40	54	6	0

*Listed in descending order of potential productivity for timber; based on acreage of nonreserved CFL in site class I-III

**Numbers preceding site class are in cubic feet per acre per year.

Source: Reference 100.

nonindustrial ownership. A more recent estimate considers 485,000 acres of small private CFL in need of replanting. An earlier survey in 1967 showed that 618,000 acres of private and state CFL were inadequately planted. However, these estimates probably do not reflect recent conversions of private commercial forestland, which would render the nonstocked classification economically irrelevant for land where the intended use is other than for growing commercial timber. Because of greater accountability and consolidation, non-stocked acreages on federal (Forest Service), state and large-industrial CFL are known with more confidence (see Table 35). Nonstocked acreage figures for other public holdings are not available. On land that has been surveyed for stocking, the relatively low nonstocked percentages reflect the intensity of timber management. The trend appears to be toward increased stocking and intensive management. Considerably larger acreages are in need of thinning (see Table 36) in order to release crowded stands for maximum growth.

Table 35
Acreage and Percentage of CFL Holdings in Montana Non-Stocked, by Ownership Group.

Ownership Group	Acres Non-Stocked	Percent Non-Stocked of CFL Holdings
Small Private (1975)	485,000	13.8
Large Industrial (1975)	53,500	3.4
Burlington Northern	10,000	1.3
U.S. Plywood	42,500	6.6
St. Regis	1,000	0.5
State (1975)	15,000	3.6
Forest Service (1970)	320,400	3.0
Forest Service (1974)	79,600	1.0
Total (1974-1975)	633,100	4.7

Sources: References 50, 60, 75, 81, 83, and 91.

Table 36
Acreage and Percentage of CFL Holdings in Montana in Need of Thinning, by Ownership Group.

Ownership Group	Acres Needing Thinning	Percent Needing Thinning of CFL Holdings
Private and State (1967)	3,614,744	59.0
State (1975)	76,000	18.1
Forest Service (1975)	1,877,828	23.6

Sources: References 91, 100, and 262.

TIMBER MANAGEMENT AND HARVEST FROM COMMERCIAL FORESTLAND

The three-fourths of Montana's forestland classified as commercially valuable is managed for timber production with varying intensity depending on ownership and the ability of the land to grow trees (site class productivity). Forestland's many potential values beyond timber production have been noted: as a haven for wildlife and recreationists, as an educational theater, as a storage basin for water. Ownership will determine the extent to which a forest's value beyond timber production will be recognized and respected. Public forests tend to be managed for a greater diversity of uses than private forests, where management is aimed primarily toward timber on large industrial holdings and toward timber, grazing, and recreation on small private holdings. By law, national forests are supposed to be managed to protect their multiple values.

Site productivity, an expression of the land's ability to grow trees, is especially important to large industrial holders of forestland. This factor sets the potential for return on investment in the form of increased wood fiber yield from management activities. Of the three forest industry firms operating in Montana—Burlington Northern, Champion International, and St. Regis—Burlington Northern and Champion acknowledge using some form of land use classification for their timberland. Champion uses three designations: intensive-culture areas, marginal production areas, and special impact areas. Harvesting in the latter is reportedly kept to a minimum (308).

Burlington Northern uses seven major land use classifications based on available resources, topography, soil, location, and environmental considerations. The classes are: 1. Multiple-use class, which provides a base for timber production activities (about 75 percent of BN's Montana forestland is in this category). 2. Limited use class, consisting of nonforestland whose principal use is grazing, wildlife, or recreation (about 20 percent of BN's Montana land). 3. Scenic area class, in which selective cutting techniques are used (accounts for 2.5 percent on BN's Montana land). 4. Water resource class of lands abutting bodies of water (2 percent of BN's land). And 5., 6., and 7.: prescribed use, quarry mining, and existing development classes (about 0.5 percent of BN's Montana land (84) (197).

The three forest industry firms operating in Montana can be assumed to view management investments in timber essentially no differently than other corporate investments. Rates of return will be computed for proposed investments based on assumptions about future market prices and project costs. Generally, those investments offering the highest rates of return will be favored. Of course, it isn't as simple as this: other factors are considered including overall corporate objectives, risks, and competitive factors. Other concerns entering into the decision making process may include legal and environmental requirements and social concerns. However, it is fair to assume that the profit motive plays a most important role in how corporate land is managed—more than it plays in decisions concerning public land or even other (noncorporate) private land.

The big three generally limit their forestland investments to restocking and thinning. Natural regeneration of cutover areas is the preferred stocking method. Up to five years can be allowed for this to take place (84) (163). St. Regis, for one, indicates that it desires to plant or seed nonstocked areas within five years of cutting. Burlington Northern relies principally on natural regeneration and indicates that it will not harvest unless "satisfactory regeneration" of the site can be assured within a "suitable" period of time (84). Long range plans by Burlington Northern now provide for restocking[26] to supplement natural regeneration when needed (197).

St. Regis estimates that about 30 percent of its forestland currently is regenerated or pre-commercially thinned.[27] The paper company also hopes to continue thinning up to 20,000 acres of its land each year, until its backlog of thinning needs is met (163).

Champion International indicates that its current policy is to reforest or plant up to 2,000 acres of its land each year and thin up to 5,500 acres (61). The industry emphasis on thinning points up the fact that Montana has much overstocked forestland where thinning to achieve proper spacing can enhance total annual growth. Wholesale price increases of about 50 percent for lumber and almost 100 percent for plywood since 1969 have encouraged intensive timber management[28] on highly productive forestland (292).

Decisions to harvest timber on industry land are, similarly, based on many factors, the most important of which are market price and demand for wood products and availability of timber from national forests. When demand is strong and prices are high, mills operating at full capacity will require much timber to maintain sufficient inventory. Mill operators try to obtain it at the most favorable price, of course, considering costs of transportation, access, and logging. Integrated mills, which own or control an assured timber supply, obviously are in the best competitive position compared to mills which do not. Yet an integrated mill's capacity may exceed its timber supply. Champion International, for example, currently is buying timber from national forests to supplement timber supply for its plywood mills (61). Mills without their own timber supplies are even more dependent on public land and also may purchase from small private landowners or from large forest industry competitors. Such mills purchased about 5 percent of Champion International's 1975 harvest.

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[26]Restocking a cutover forest plot usually involves hand planting of sprouts or may involve aerial distribution of seeds.

[27]Pre-commercial thinning is selectively cutting trees from a stand to enhance the potential for growth of the remaining trees.

[28]"Intensive management" implies careful use of growth-inducing techniques to encourage maximum production of timber with available funds.

Other important factors in the level of timber harvest on industry land are yield calculations coupled with the need to liquidate mature growth. Champion International found that it had purchased from the Anaconda Company many acres of old forest where net annual growth was minimal. To increase annual growth the company decided to increase harvest of mature trees and currently it is cutting all trees over 250 years old to more quickly establish vigorous, young stands (73) (308).

Timber production remains the primary focus of federal management of national forests, even though other values of forestland are acknowledged in the "multiple use" policy established by law. Because the U.S. Forest Service must compete for funds within the Department of Agriculture and against the rest of the federal bureaucracy, the Forest Service generally hasn't had enough money to manage its timber producing lands intensively.

As with the forest industry, timber management on national forests generally means site preparation, restocking, and thinning. Acres of public commercial forestland needing restocking were estimated at about 80,000 with an additional 1.9 million acres needing precommercial thinning (100). Practically all of the land needing thinning is in three forests: Kootenai, Lolo and Flathead (in that order of need, according to the Forest Service).

Some preliminary calculations made recently at the Forest Service Region 1 office, based on western larch and 1972 timber prices, seem to question the economic worth of public investments in intensive management. This limited analysis indicated that no treatment made more economic sense than either regeneration or thinning (346). This fact coupled with the federal government's reluctance to increase expenditures and the emphasis on economically sound decisions implies that very selective decisions will be made regarding intensive management of timber in Region 1 national forests.

Because publicly owned timber is cut for private use, harvest levels are subject to timber prices and other market forces. The amount of timber made available for sale is based on "sustained yield"[29] and has traditionally been referred to as the "annual allowable harvest." Annual allowable harvest, though, gave insufficient weight to the kinds of timber management actually practiced, so it is now giving way to a new concept, "potential yield." Potential yield is designed to incorporate several variables through the Timber Resources Allocation Method (RAM), including management levels and access, intensity and timing of harvest, and environmental and silvicultural requirements. The goal, according to the Forest Service, is to keep 10-year program harvest levels from dropping more than 0.1 percent from the preceding 10-year harvest level (65) (152).

Table 37 shows recent allowable harvest and potential yield levels in Montana national forests. The annual allowable harvest is shown as of Jan. 1, 1973, as is the new potential yield for July 1, 1974. The potential yield shows the Forest Service's estimate of what can be harvested at current management levels. The program harvest is the amount of timber planned for sale during the current year.

Timber included in the potential yield category but not scheduled for sale is usually found in the special and marginal categories. The special category includes land having constraints due to conflicting uses which will modify

[29]Sustained yield—the yield that a forest produces continuously at a given intensity of management.

Table 37
Comparison of Annual Allowable Harvest and Potential Yield for National Forests in Montana.
(million board feet)

Forest Working Circle*	Annual Allowable Harvest (1/1/73)	Potential Yield (7/1/74) Standard	Special	Marginal	Total	Program Harvest (FY '75)
Beaverhead	65.4	32.7	6.1	20.1	58.9	30.0
Bitterroot	53.2	39.1	5.5	19.1	63.7	46.0
Custer	10.4	4.9	5.5	0	10.4	4.0
Deerlodge	49.0	40.6	4.6	18.8	64.0	21.0
Flathead	181.6	111.2	8.2	26.9	146.3	135.0
Gallatin	48.0	22.8	10.6	11.3	44.7	28.0
Helena	32.7	23.7	6.0	.2	29.9	13.7
Kootenai	200.4	250.4	10.0	68.4	328.8	250.8
Lewis & Clark	40.4	4.6	1.2	17.4	23.2	15.2
Lolo	191.7	151.8	8.6	28.4	188.8	150.0
TOTAL	872.8	681.8	66.3	210.6	958.7	693.7

*An imaginary boundary encircling a particular forest for management purposes.

Source: Reference 50.

the harvesting technique. Marginal lands are generally sites that may be too costly to harvest due to poor access. The soils on marginal land also may not be good for harvesting using conventional techniques (65).

There are other reasons for the difference between program harvest and potential yield, such as the level of demand for timber from the particular forest which depends on the operations of local mills and the quality of the timber resource in that forest. Forest Service policy is to move eventually from current program harvest to the higher potential yield level (65).

There has been about a 20 percent reduction in the current timber sale levels in Montana's national forests. The reduction was distributed fairly evenly throughout the forests with the largest reductions, as a percentage of the previous harvest levels, occurring in Beaverhead, Deer Lodge, Helena, and Lewis and Clark forests. The largest reduction in total volume occurred in Flathead. The Kootenai is the only forest to show an increase in current timber sale levels.

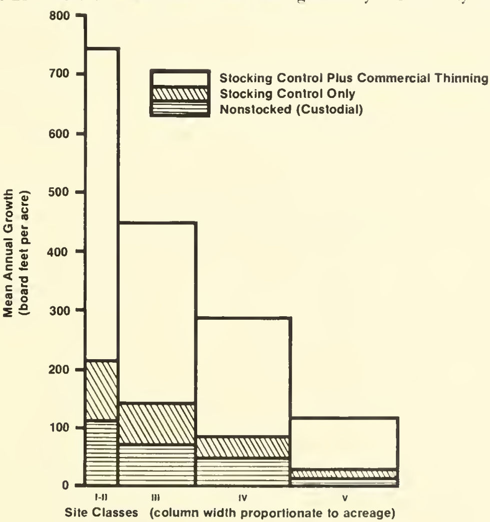
The potential yield, however, is about 10 percent higher than what was previously known as the allowable harvest. The major share of the net increase is in the Kootenai National Forest, with smaller increases in the Bitterroot and Deer Lodge forests. The remaining forests show net declines in potential yield levels.

The small private forestland owner controls about one-fourth of Montana's commercial forestland. Practically all of this acreage is in the poorest site productivity Classes IV and V (see Table 11). For a variety of reasons the small private forest owner practices the least intensive forestry management. Much of such acreage is held principally for recreational purposes which, in most cases, forecloses management for timber purposes. Harvest decisions usually are motivated by the need for quick income or to reduce the property tax on standing timber. Decisions to invest money in the timber base are necessarily rare because the payoff in increased yields normally doesn't occur until the next generation. Also many owners lack basic knowledge of sound forestry practices. The Montana Division of Forestry (DNR&C) currently is completing a survey of private forest owners to find out what their objectives are. Results are not yet available (53).

Various estimates have been made of potential increases in wood fiber yield resulting from intensive management. St. Regis believes that it can increase annual growth by 12 percent through pre-commercial thinning. Its experience with permanent growth plots indicates that over the next 20 years it may be able to increase annual growth by 80 percent at present management levels, including thinning and restocking when necessary (163).

Figure 23 shows potential gains in growth from restocking and thinning as calculated by the Forest Service Region 1 office. These figures appear to be more optimistic

Figure 23 Results of Montana Timber Management by Productivity Class.



Source: Reference 304.

than those developed by St. Regis. They indicate that stocking control could double growth rates and stocking control plus three commercial thinnings could triple annual timber production (304). It also has been estimated that the planting of genetically superior stock could increase growth rates by 15 percent in 30 or 40 years. (304).

A third estimate of potential timber growth based on an analysis of growth data by productivity class on 2.8 million acres of Montana commercial forestland shows that about a 40 percent increase in annual growth could be achieved by full and controlled stocking. Half of this annual increment could be achieved by managing intensively only the Class I and II land, less than a fifth of the 2.8 million acres. Viewed another way, 60 percent of the 2.8 million acres could, if intensively managed, eventually produce the same amount of timber annually as the total acreage is producing under current management levels (312).

Removals of growing stock and sawtimber from Montana CFL in 1970 are listed in Table 38. The most removals in 1970 were in the form of sawlogs. In 1969 the three leading tree species cut for sawlogs were Douglas-fir, ponderosa pine, and western larch. Veneer logs and logging residues (the unused portions of trees cut or killed by logging) also were removed from Montana forests in significant quantities. Other products were much less important. The availability of logging residues is directly proportional to the harvest of sawlogs. The amount of this material presently left behind in the woods as nonmerchantable far exceeds immediate demand. However, recent wood shortages, environmental concerns, and projected increases in demand for wood chip and pulp, have stimulated research and management activities to use more logging residues (304).

Historical trends in wood production in Montana forests are depicted in Figures 24 and 25. Figure 24 illustrates the dramatic increase in sawlog production over the past 20 years. During this same period the use of wood for fuel and miscellaneous products has declined but for plywood, pulp and paper, and particle board it has increased. Since 1952, total output of Montana roundwood products (all removals except logging residues) has more than doubled (304).

In recent years, total harvest from Montana forestlands has fluctuated between 1.1 and 1.3 billion board feet (see Figure 25). Most of the fluctuation has been on public land, primarily that managed by the Forest Service. Historically, national forestlands have contributed 85 to 90 percent of public land harvest and between half and two-thirds of the total harvest (304). In recent years national forests have contributed less than half the total harvest (see Table 40).

A breakdown of roundwood output by forest owner-managers in 1970 is given in Table 39. That year, public and private forests each contributed about half of the total harvest. The Forest Service with 54 percent of the state's commercial forestland, contributed 45 percent of the roundwood harvest. The large industrial forest owners, with only 11 percent of the commercial forestland, produced 34 percent of all roundwood output. This contrasts sharply with the situation on small private forests, where 24 percent of the commercial forestland produced only 15 percent of the total output. These figures indicate that public and small private forestland may be underutilized for wood production and that large industrial forests may be overutilized for wood production.

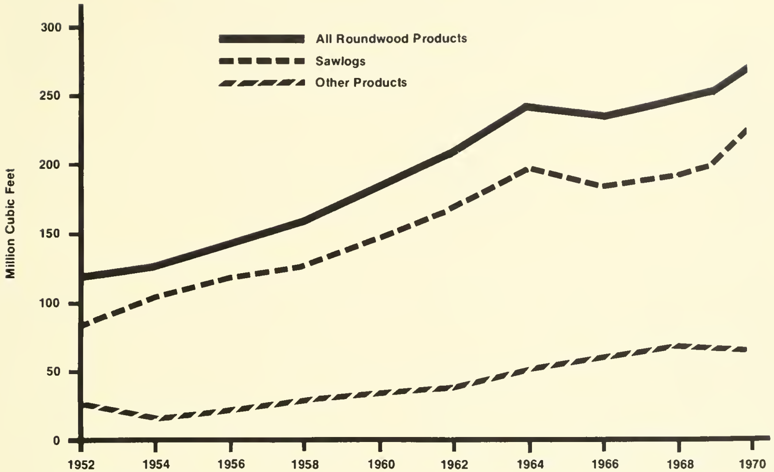
Since 1969, all private forests have contributed an increasingly larger share of total timber output while production on public forests has declined (see Table 40). It should be noted that removals from private forests do not include all small private forestland, but only that included on the state fire assessment rolls. Production is consequently underestimated by about 10 percent (54). Assuming harvests on state, BLM and BIA land were about the same in 1975 as in 1974, then 1975 may have been the first year in which timber removal from private forests almost equalled removal from public forests in Montana.

Table 38
Removals of Growing Stock and Sawtimber from Commercial Forestland in Montana, 1970.

Product	Growing Stock (thousand cubic feet)	Sawtimber (thousand board feet)
Sawlogs	237,026	1,425,519
Veneer logs	32,072	197,964
Pulpwood	1,642	8,016
Commercial poles	810	3,744
Mine timbers	1,844	5,057
Miscellaneous industrial wood	644	3,262
Posts, fuelwood, farm timbers	1,267	3,957
Logging residues	44,014	135,815
Other removals	5,085	30,815
Total removals	324,404	1,814,149

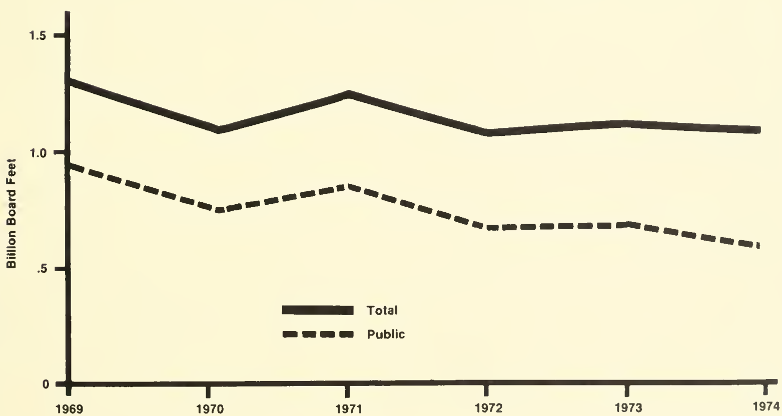
Source Reference 138.

Figure 24 Output of Montana Roundwood Products, 1952-1970.



Source: Reference 304.

Figure 25 Total Harvest and Public Timber Harvest in Montana, 1969-1974.



Source: Reference 304.

Table 39
Output of Roundwood Products and Percent Commercial Forestland in Montana by Ownership Group, 1970.

Ownership Group	Output: Thousand Cubic Feet	Output: Percent	Percent CFL
Forest Service	124,963	45	54
Other public	17,333	6	11
Large industrial	96,448	34	11
Small private	40,815	15	24
Totals	279,559	100	100

Source: Reference 138.

The three forest industry firms account for 60 to 70 percent of the total harvest from private land. Champion International's harvest has increased from 166 to 221 million board feet since 1973. In 1975 some form of harvesting occurred on about 40,000 acres of its land (61) (308). Burlington Northern's harvest has ranged from 70 to 90 million board feet since 1973 (84). St. Regis supplies about 40 million board feet of its annual 150 million board feet mill requirement from its own land (163).

In 1969 national forests provided 61 percent of Montana's timber harvest. By 1975 that figure had fallen to about 44 percent, the result of reduced sales from all the forests (with the exception of the Kootenai), reduced demand for timber, and lack of sufficient funding to carry on sales.

The data in Table 40 are disturbing because they show that nearly half of the total state timber cut is taken from private land, which is only a third of Montana's commercial forestland base, and which represents at most 10-15 percent of the land best able to produce timber. Historically, private land has had to sustain a disproportionate share of the cut. The serious question is whether private forestland in Montana will be able to maintain the high level of production being demanded of it. If total timber production is to be maintained, it seems probable that more and more timber will be demanded from public land (138) (410).

Timber production from Montana national forests since 1970 is given in Table 41. The order of forests is somewhat different than for potential productivity (see Table 34), perhaps due to the relatively short-term nature of

Table 40
Removals of Timber from Montana Forests, 1965-1975.
(million board feet)

Souce of Timber	1965	1969	1970	1971	1972	1973	1974	1975
Private	447.7	362.1	343.1	402.1	406.6	429.4	499.4	500.9
State**	28.7	46.7	28.2	21.8	31.8	23.3	7.6	----*
National Forest	774.6	800.0	654.4	738.6	558.0	564.1	495.3	453.1
Bureau of Land Management	15.0	15.0	12.0	5.0	4.3	2.6	3.3	----*
Bureau of Indian Affairs	30.0	78.8	55.6	76.0	82.8	98.0	82.7	----*
TOTAL	1296	1303	1093	1244	1084	1117	1088	

Percent Share of Timber Harvest

	1965	1969	1970	1971	1972	1973	1974
Public	66	72	69	68	62	62	54
Private	34	28	31	32	38	38	46

*Not available.

**State data underestimated by about 10 percent. See text, p.72.

Source Reference 72.

Table 41
Total Timber Sales and Volume of Timber Sold and Cut on Montana National Forests, FY 1970-75

Forest	No. Sales	Volume Sold (million board feet)	Volume Cut (million board feet)
Kootenai	2,009	1,108,801.10	1,077,149.60
Lolo	1,638	825,334.58	823,613.41
Flathead	1,317	807,239.49	816,905.50
Bitterroot	1,133	344,675.84	228,012.14
Deer Lodge	1,025	157,231.60	159,221.56
Gallatin	812	66,606.76	123,169.58
Beaverhead	908	80,310.02	116,755.83
Helena	959	58,426.17	107,616.55
Lewis & Clark	1,404	42,939.65	83,926.91
Custer	282	13,820.12	13,136.73
All Forests	11,487	3,595,485.00	3,551,507.81

Source: Reference 100.

the data; however, certain consistencies are noted. The Kootenai, Lolo and Flathead national forests produced far more wood than any of the other forests. Together they accounted for 77 percent of the timber volume cut and 79 percent of the timber volume sold on national forests for the period. The Custer National Forest was clearly the least productive forest in terms of timber harvest. The remaining six forests were intermediate in actual production.

A closer look at harvest activity by forest, presented in Table 42, reveals that harvest levels dropped since 1970 from 40 to 60 percent on most forests partially due to 1975 being a year of depressed activity in the wood products sector. The smallest decline in harvest, 20 percent, occurred on the Flathead, which most closely approached its 1975 program harvest level. An indication of future harvest activity on the forests is in the last column, the backlog of sold but unharvested timber. The supply of and demand for both Kootenai and Flathead timber has remained fairly steady since 1970 as shown by the stable backlogs of unharvested timber on these forests. All the other forests have had significant declines in backlogs of unharvested timber.

An indication of the type of harvests which take place can be found by looking at Forest Service Region 1 harvest data for the past several years. Region 1's total 1974 harvest of 978 million board feet came from 77,000 acres of forestland. Thirty-five percent of the area was clearcut, down from 57 percent in 1966. Activity on 28 percent of the

Table 42
Harvest and Backlog of Federal Timber in Montana By Forest, 1970 and 1975.

Forest	1970 Harvest	1970 Backlog	1975 Harvest	1975 Program Harvest	1975 Backlog
	(million board feet)		(million board feet)		
Beaverhead	24.4	104.7	12.4	30.0	28.7
Bitterroot	50.0	83.0	24.4	46.0	57.3
Custer	2.7	2.9	.7	4.0	1.1
Deer Lodge	26.6	143.2	15.6	21.0	60.2
Flathead	145.8	373.6	114.7	135.0	338.2
Gallatin	36.7	95.6	11.6	28.0	17.4
Helena	16.0	71.1	10.1	13.7	12.1
Kootenai	243.6	568.4	142.3	250.8	616.3
Lewis & Clark	19.0	80.2	11.2	15.2	28.7
Lolo	167.0	460.4	110.2	150.0	241.6

Source: Reference 100.

land consisted of removal of dead or dying trees, about the same for the past 10 years; and on 16 percent of the land (double the 1967 figure), trees were harvested under the seed shelterwood system in which up to one-third of the timber is left standing. Selective cutting and salvage of timber each accounted for about 10 percent of the 1974 harvest, both showing an increase in relative share over the past 10 years (81).

Forest industry firms generally do less clear-cutting than the Forest Service. In the last 10 years only about 8 percent was clearcut of Burlington Northern's 150,000 acres harvested in its Rocky Mountain District (eastern Washington, northern Idaho, and Montana) (197). Champion International reported that in 1975 it clearcut about 1 percent of its Montana land; about 2 percent was cut by shelterwood method. Other principal logging methods were the harvesting of dead or dying trees, and selective cutting. Fourteen percent of Champion International's harvest was salvage timber (61)(308).

The trend has been toward greater exploitation of standing wood. There are two reasons: generally increasing lumber values making the timber valuable, and technological innovation in the mills allowing the sawing of smaller logs. Many of Montana's lumber mills can now saw logs with a 3-inch diameter top and 5- to 6-inch diameter at breast height (306)(333).

More logging residues are being recovered too. A 20 percent increase in recovered residue volume was recorded between 1966 and 1970 (310)(347). Even so, it has been estimated that only about half of the available wood fiber is being recovered from timber harvest areas (146). Greater recovery is possible and may be achieved through innovation in sawmills or if the demand for sawmill residue chips for pulp or fiberboard exceeds local supplies.[30] Until there is an increase in pulp or manufactured board in Montana, the latter possibility seems rather remote.

Timber purchases from Montana forestland are based on objectives that depend on the purchaser. Lumber mills, which do most of the buying have certain requirements depending on mill design. Some tree species are better suited for production of a finished product than others: fir and larch for plywood, pine for low-grade studs and shop pieces, Douglas-fir, larch, hemlock, and lodgepole pine for large studs and dimension lumber, and cedar for shingles, posts, and poles. Mills sometimes specialize in products such as plywood, lumber, studs, and perhaps, by-products. They also may concentrate on large or small logs, depending upon their machinery (73).

Independent loggers also bid on timber, especially when the lumber market is strong and mills are anxious to purchase. Some of these loggers have been known to take advantage of the small private landowner's ignorance of the worth of standing timber (129).

The timber sale process differs significantly between public and private land. Members of the forest industry, in particular Burlington Northern and Champion International, generally will reserve a certain amount of their harvest for their own mills. When their timber exceeds needs, it may be sold to a predetermined buyer at an agreed price as a part of an existing contract, or to the highest bidder at the time of sale.

The Forest Service generally advertises its sales with greater than $2,000 "appraised stumpage value" for at least 30 days. Appraised stumpage value represents the public's direct monetary interest in the trees as timber. It is the difference between the estimated selling value of the timber, adjusted quarterly to reflect changing market prices, and the cost of harvesting, plus a margin for the logger's profit. Cost of harvesting includes field processing, and transporting the timber, including the costs of access road construction.

Some federal harvesting rules—specifications for road quality, slash disposal, and machinery—have been criticized as unnecessarily costly, preventing purchasers of public timber from receiving adequate profits from their winning bids. Estimated volume of timber and minimum acceptable stumpage rates are made public in the advertisement for bids. Closed bids are accepted and the sale is awarded to the highest bidder.

The trend in value of Montana's public land stumpage had been up until 1974, when there was a 50 percent decline. As Table 43 illustrates, stumpage values on public land were up even more sharply in neighboring Idaho. Overall, national forest stumpage values in the northwest increased about five-fold between 1965 and 1974.

The reasons for the substantial increase in stumpage values are connected with markets and buyers. The rise in lumber values upon which stumpage values hinge has been driven by the declining supply of old-growth sawtimber and increased demand for timber. In addition, mill ownership is becoming centralized. Fewer companies own progressively larger shares of mill capacity. In Montana in 1956 the five largest lumber mill operators produced 31 percent of the state's lumber. By 1974 the five largest operators doubled their share to 60 percent (73). The large firms are continuing to bid for a larger share of the stumpage and are better able to do so and simultaneously drive out smaller firms (51)(63)(74). Some of these, such as Hamilton Lumber Company in Missoula (recently closed), found themselves outbid on public timber. Other firms, such as Pack River Co. have closed down mills partly due to the high stumpage prices, coupled with a declining lumber market (63)(305).

Recent data show that timber costs, although rising appreciably between 1963 and 1972, did not increase much relative to total processing and manufacturing costs. In 1963, cost of logs represented 42.3 percent of average total lumber processing costs in Forest Service Region 1; in 1972 the comparable figure was 45.7 percent (160).

Logging on public land usually is controlled by the timber purchaser, who does the logging himself or engages a

[30] Increasing the demand for wood scraps in general would drive up their price and allow economical recovery of logging residues from the forest at harvest time.

Table 43
Stumpage Prices for Public Timber in the Pacific Northwest, 1960-1974.
($ per thousand board feet)

	All Public Lands			National Forests	
Year	Montana	Idaho	Washington & Oregon	Region 1*	Region 6**
1960	----	----	----	7.50	22.10
1965	----	----	----	9.00	27.50
1968	----	----	----	24.40	42.40
1969	----	----	----	26.20	58.80
1970	----	----	----	11.30	26.70
1971	18.30	9.69	32.02	12.00	30.10
1972	28.23	25.26	54.03	26.50	53.40
1973	53.34	62.43	109.20	53.30	102.80
1974	26.37	50.18	NA	44.70	128.70

*Includes Montana, Northeastern Washington, Northern Idaho, North and South Dakota.

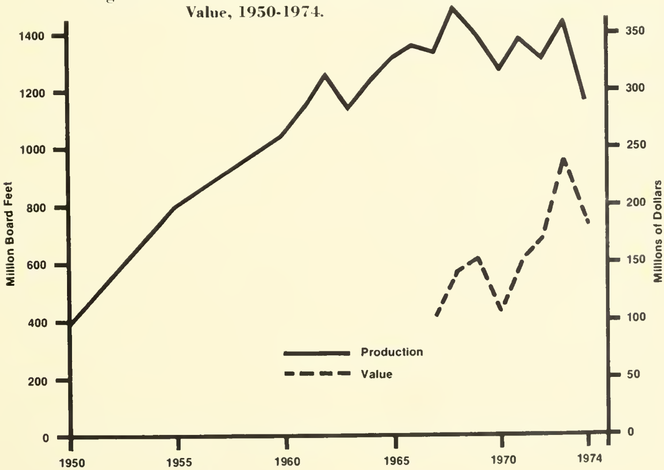
**Includes Oregon and Washington.

Source: Reference 292.

contract logger. For example, the Intermountain Company (subsidiary of Hoerner-Waldorf Corp.) contracts for about half its logging jobs. The smaller mills, though, may not have in-house logging capability; they must depend entirely on independent loggers. If access roads are needed the timber purchaser or his logging contractor is responsible for building them.

Logging procedures on forest industry land vary. Almost all logging on Burlington Northern land is done under contracts let and administered by company foresters. On BN's occasional 1- to 2-year term stumpage contracts to outsiders, the purchaser is responsible for the logging (84). About one-fourth of Champion International's 1975 harvest was done by company loggers, with the remainder

Figure 26 Montana Lumber Production and Estimated Wholesale Value, 1950-1974.



Sources: References 400 and 401.

performed under contract with independents (61). St. Regis does about 50 percent of its own logging (80).

Historically, contract loggers have had a tenuous relationship with mill owners, depending upon the strength of the lumber market and the particular mills they are dealing with. It is said that when the lumber market is strong and there is enough work to go around, mills pay fairly for the logs they receive. When the lumber market is weak, only the experienced logger in good standing with the mill will remain steadily employed. In a weak market, some say, loggers may not receive the full value for the logs they deliver. [A much more complete description of logger-mill relationships can be found in a series of newspaper articles in *The Missoulian* by Schwennesen and Walsh, which appeared in August 1975 (305) (306).]

Most of the timber harvested in Montana national forests is processed in Montana. In 1971 only 10 percent of the timber so harvested went out-of-state for processing, mostly to Idaho (73) (304). No comparable information exists on processing of timber harvested from private land in Montana.

In-state purchasers of timber include lumber and plywood mills. The number of lumber and lumber planing mills has been on the decline for the last 20 years. Estimates are that the total number of mills declined from about 330 in 1956 to about 125 in 1973. The decline has been in small mills, those producing less than 10 million board feet per year. During the same period the number of large mills, those producing over 10 million board feet, increased slightly from 26 to 29. Meanwhile, the average annual production of all mills has increased substantially (304).

Montana's lumber production and its wholesale value are shown in Figure 26. Between 1950 and 1960 lumber production doubled, reflecting the postwar boom in demand for housing and the "discovery" of Montana's largely virgin timber supply. After 1960 lumber production continued upward. Peak production was in 1968, responding to the high level of general economic activity, particularly in housing starts and the availability of easy credit. By 1974, output had declined by almost a fourth due to the generally depressed lumber market.

Table 44 lists the principal lumber producers in Montana. The seven firms, each producing more than 50 million board feet in 1974, accounted for three-fourths of Montana's lumber production that year. All of the firms are owned by corporations with headquarters outside Montana. Table 45 compares statistics for these firms.

The major timber sources for Montana sawmills are national forests. In 1972, two-thirds of the 1- to 1.2 million board feet purchased by Montana sawmills came from national forests; only 20 percent came from company owned land (BN, St. Regis, and Champion). The remainder came from other public and private sources (401).

Mills can produce volumes of lumber greater than the measured volumes of timber used to produce that lumber. This is called "overrun." Using an overrun of 25 percent, it can be estimated that for the years 1972 to 1974 the top three forest industry firms harvested as timber roughly one-half of what they later processed into lumber. St. Regis supplied about one-fourth its mill needs; Champion about three times its sawmill needs. Most of the remaining Champion production was for its plywood operation.

Three-fourths of Montana's 1974 lumber production occurred in six western Montana counties: Lincoln, Missoula, Flathead, Lake, Mineral, and Sanders. The principal production centers are Troy-Libby, Columbia Falls, and Missoula-Bonner. (401).

Montana's lumber production is still nationally and regionally small; Montana produces between 3.5 and 4 percent of the nation's total lumber supply and roughly 6 to 6.5 percent of the northwest states' production (California, Oregon, Idaho, Washington, and Montana) (171) (292).

Lumber basically is a standard commodity, like wheat or cattle. Its price is set by transactions of large volume buyers and sellers. This price, of course, is relayed to the lumber mill owners and determines, in large part, their short term operation. The small, nonintegrated lumber mills, of which there are fewer and fewer, generally market their products through brokers in Portland, Minneapolis, or Chicago. These brokers bring markets and suppliers together and receive a commission for doing so. Sometimes they will actually take title to the goods in order to increase sale flexibility. Sometime small-volume lumber mills will sell lumber to independent truckers for resale to markets at the trucker's eventual destinations or along the route. The large integrated mills have the advantage of their own in-house marketing operations and previously established markets. They are in a much better position to plan needs and output because of their developed marketing channels and long term supply contracts.

The transportation system which distributes Montana's lumber production plays a big role in determining markets. This is due to Montana's distance from major markets and the rising costs of transportation. Transporation costs can account for up to 40 percent of the delivered price of Montana lumber products and thus heavily influence the potential market (74) (159).

Most Montana lumber products move interstate by rail, although total rail volume has declined from about 90 percent in 1962 to 65-70 percent in 1973. The decline has been a result of the narrowing margin between costs of rail and truck movement. Today rail movement is still cheaper than truck for long hauls on rail routes (to the upper Midwest, for example) provided the shipment exceeds 40,000 board feet and qualifies for a special "incentive" rate (74).

Montana's most developed rail routes run east and west, which dictates the primary market for Montana lumber, the midwest, where about half the 1972 output was shipped. Other destinations, in order of importance, were the southern Rocky Mountain states (Denver area), the southeast and northeast (401). The southern Rocky Mountain market has become more important to western Montana as its population has grown. Because of the lack of

Table 44
Firms Producing More Than 50 Million Board Feet of Lumber in Montana, 1963-1974.
(thousand board feet)

Firm (corporate owner if different)	Corporate Headquarters	1963 No. Mills	1963 Volume	1965 No. Mills	1965 Volume	1967 No. Mills	1967 Volume	1968 No. Mills	1968 Volume	1969 No. Mills	1969 Volume
Diamond International	Cal.	1	50,720	1	54,000	1	54,000	1	55,000	1	55,000
St. Regis Paper Co.	New York	2	138,500	2	103,139	2	209,678	2	229,081	2	207,430
Intermountain Lumber Co. (Hoerner-Waldorf)	Minn.	3	74,100	3	83,000	3	102,476	3	124,000	3	119,226
Plum Creek Lumber Co. (Burlington Northern)	Minn.	2	83,658	2	83,417	2	141,262	2	147,658	3	141,822
Anaconda Forest Prod.		1	77,221	1	116,920	1	114,605	1	116,923	1	119,438
Pack River Co.	Wash.	-	...	-	...	2	87,000	3	144,266	4	148,577
Summit Lumber Co.		-	...	-	...	3	55,142	3	59,040	3	57,889
Evans Products (also Van-Evan)	Oregon	-	...	-	...	-	...	2	64,000	Less than 50,000 MBF	
F. H. Stoltze Land & Lumber Co.	Minn.	-	...	-	...	-	...	-	...	-	...
Louisiana-Pacific	Oregon	-	...	-	...	-	...	-	...	-	...
Champion International (U.S. Plywood)	New York	-	...	-	...	-	...	-	...	-	...
Totals		9	424,199	9	440,476	14	764,163	17	939,968	17	849,382

Firm (corporate owner if different)	Corporate Headquarters	1970 No. Mills	1970 Volume	1971 No. Mills	1971 Volume	1972 No. Mills	1972 Volume	1973 No. Mills	1973 Volume	1974 No. Mills	1974 Volume
Diamond International	Cal.	1	52,000	1	48,811	1	61,000	1	61,000	1	57,969
St. Regis Paper Co.	New York	2	193,168	2	216,400	2	207,069	2	192,930	2	126,849
Intermountain Lumber Co. (Hoerner-Waldorf)	Minn.	3	109,538	2	120,973	2	114,885	2	111,512	2	101,447
Plum Creek Lumber Co. (Burlington Northern)	Minn.	3	153,625	3	187,119	4	190,390	4	195,234	4	198,047
Anaconda Forest Prod.		1	99,176	1	116,817	To U.S. Plywood					
Pack River Co.	Wash.	4	114,622	4	144,989	4	158,550	4	173,814	4	129,064
Summit Lumber Co.		3	64,453	3	76,392	Not Available		To L-P			
Evans Products (also Van-Evan)	Oregon	Less than 50,000 MBF				2	66,000	2	62,755	Less than 50,000 MBF	
F. H. Stoltze Land & Lumber Co.	Minn.	-	...	2	52,330	2	38,491	2	52,926	Less than 50,000 MBF	
Louisiana-Pacific	Oregon	-	...	-	...	Not Available		4	135,000	4	147,000
Champion International (U.S. Plywood)	New York	-	...	-	...	3	54,396	3	171,375	2	100,608
Totals		17	786,582	18	963,831	20	890,781	24	1,156,546	19	860,984

Source: Reference 73 from Forest Industries *magazines.*

Table 45
Selected Characteristics of Montana's Major Lumber Producers.

Firm	Montana Lumber Production (million board feet)		Percent of Company's U.S. Production	Percent of Company's World Production	1974 Rank All U.S. and Canadian Lumber Producers
	1973	1974	1973	1974	
Plum Creek Lumber Co. (Burlington Northern)	195	198	100	91	31
Louisiana-Pacific	135	147	6	6	1
Pack River Co.	174	129	29	25	8
St. Regis Paper Co.	193	127	52	32	18
Intermountain Co. (Hoerner - Waldorf)	112	101	84	86	58
Champion International (U.S. Plywood)	171	101	26	23	11
Diamond International	61	58	17	17	21

Sources: References 10, 73, and 304.

direct rail transportation south from Montana much of the shipment in that direction has been by truck.

A case can be made that western Montana has been discriminated against in Interstate Commerce Commission rate-setting procedures for interstate rail traffic. For example, 1971 tariff data show that rail transportation incentive rates between Missoula and Chicago are only 4 percent less, on a weight basis, than the same shipment would cost between Olympia, Wash., and Chicago. This is hardly equitable on a cost per unit distance basis; Missoula is about 25 percent closer to Chicago than Olympia.

The national market east of western Michigan is also weighted in favor of the Pacific Northwest. Another anomaly can be found in the rates from the southwestern supply region, northern New Mexico and Arizona, to the midwest and northeastern markets. It is from 20-30 percent cheaper, on a weight basis, to ship from the southeast to these markets than from western Montana (159).

A recent analysis of Montana lumber producers provides some insight into their approximate costs of production and profitability (160). The benchmark against which costs were analyzed is net price received by the lumber seller. It was found that stumpage prices as a percentage of lumber selling price remained fairly constant between 1963-72. It was concluded that this may reflect the high degree of accuracy shown in estimates by timber purchasers of future lumber market prices.

Total manufacturing costs, as a percent of selling price, declined slightly from 43 percent in the 1963-67 period to 40 percent in the 1968-72, indicating improved profitability. Total sawmill costs as a percentage of sales price showed a slight downward trend over the 10-year period with the exception of 1970, a year of depressed lumber prices. Overall, it was concluded that on the basis of the years studied, future selling prices will increase more than all costs, implying that the profitability of Montana operations that survive the currently depressed market could improve. Of course, it must be kept in mind that when corporate profitability is being discussed, an individual operation is judged relative to other divisions of the corporation and not necessarily by itself.

Plywood production is relatively new to Montana; between 1960 and 1966 the number of plants increased from one to six. Today there are five plywood and veneer mills (see Table 46). The newest of these, the Champion International plant at Bonner, is reported to have the largest production capacity of any plywood plant in the U.S.: 300 million square feet annually (3/8-inch basis) (191). The Bonner plant represents 40 percent of Montana's current plywood capacity. Plywood production in Montana remained fairly constant between 1966 and 1973, between 400 and 450 million square feet annually. With the addition of the Bonner mill capacity, the total should increase to about 750 million square feet.

The production of plywood consists of heating a log, peeling it into veneer, drying the veneer, composing the veneer core, and finally heat pressing the sheets of veneer

Table 46
Montana Plywood and Veneer Mills, 1975.

Firm	Location	Approx. Capacity (million square feet - 3/8 inch basis)
Champion International	Bonner	300
Evans Products Co.	Missoula	165
Plum Creek Lumber (BN)	Columbia Falls	110
C & C Plywood Co.	Kalispell	96
St. Regis Paper Co.	Libby	80

and core together. The process is much more energy intensive than that of a sawmill; however, much of the energy can be and is supplied by generating steam from burning of mill waste (73) (191). Although detailed data on natural gas requirements is unavailable, three plywood plants in the Montana Power Company service area consumed 500 million cubic feet in 1974, or 2 percent of MPC's 1974 sales of industrial natural gas (55).

All of Montana's plywood mills, with the exception of C & C Plywood in Kalispell, have an associated sawmill capacity too. This allows efficient use of the purchased logs since the plywood process must use logs larger than eight or nine inches at the small end and generally needs even larger ones (73), while the newer sawmills can saw logs down to three to four inches. Thus by combining operations a greater percentage of the purchased wood fiber can be used at the plant.

Montana's plywood operations produce roughly 2.5 million square feet of board for every 1 million board-feet of logs put in (73). The total log requirement for Montana's mills, then, is roughtly 300 million board-feet annually, 40 percent of which is needed at the large Bonner facility. Three hundred million board-feet represent about one-fifth of the annual log requirement for Montana saw and plywood and veneer mills, given an annual sawmill requirement of roughly 1.1 to 1.2 billion board-feet (using a 25 percent overrun and the highest recent annual lumber production, 1968).

The remainder of the Montana wood processing industry, pulp and paper mills and facilities producing medium density board (particle board and fiberboard), relies almost entirely for raw material on the plant residues produced in the sawmill and plywood operations. In 1969, these residues totaled 156 million cubic feet, or about one cubic foot of residue for every eight board-feet of lumber processed (311). About 80 percent of the residue is generated from sawmills; 20 percent from the plywood and veneer mills.

The Hoerner-Waldorf Corp. paper mill in Missoula produces kraft pulp, paper, and linerboard for boxes out of residues from sawmills and plywood mills in roughly the following proportion: one ton of output for each 200 cubic feet of residues (304). The pulping process requires the wet, coarse residues suitable for chipping, such as slash and edgings from sawmills and green veneer trim from plywood mills. These coarse residues accounted for about 40 percent, or 61 million cubic feet, of the 1969 total residue output. In that year 87 percent of the coarse residues were used (311). It can be assumed that the Hoerner-Waldorf plant was responsible for most of the consumption of wood residue because its supply area is the entire length of western Montana. The emergence of a local market for wood residues has brought added revenues for small and medium-size mill operators.

With the decline in sawmill operations in 1974, Hoerner-Waldorf's chip supply was reduced. It purchased some chipping machines to work on dead and dying roundwood. However, the level of sawmill activity recently has improved sufficiently to supply the needed chips and Hoerner-Waldorf no longer is seeking roundwood to supply its current pulp capacity. In fact, there reportedly is an excess of wood residue which is being sold to paper mills in the Pacific Northwest and Great Lakes areas (73). Whether an excess will persist depends on the proposed expansion of Hoerner-Waldorf's pulp capacity. They have already initiated discussions with the Region 1 office for a long-term supply of wasted and dead wood from federal forestland (307).

The pulp and paper making process is the most energy intensive of all Montana's wood processing activities, using about six times the energy per ton of output as is used in lumber production. In Missoula the required energy is supplied by natural gas. In 1974 Hoerner-Waldorf purchased 4.5 billion cubic feet of natural gas, or one-fifth of MPC's total interruptible industrial supply (55). Other energy needs are met through the use of fuel oil, purchased electrical power, and hogged fuel.[31]

Particle board is a newcomer to western Montana's wood products industry. The first plant opened in 1970 in Missoula. It is now owned by Louisiana-Pacific which also operates sawmills in western Montana. In 1974 a plant manufacturing medium density fiberboard opened in Columbia Falls and is owned by Plum Creek, a subsidiary of Burlington Northern. Plum Creek operates sawmills and a plywood mill in western Montana.

The particle board is manufactured through heat and pressure bonding of dry wood particles such as chips and splinters. Medium density fiberboard is merely a more refined particle board using smaller, more flexible fiber (fine residues) and requiring a greater degree of processing than particle board. It is generally a superior product with better edges and a smoother finish and is used when a good quality board is required, such as in furniture. The major uses for particle board are floors, some furniture, and industrial uses.

The particle board industry basically grew as a result of the tremendous supply of shavings and sawdust from sawmills. The basic fibrous raw material used in the process previously was an inexpensive waste material. Early particle board plants originally opened in the South and Pacific Northwest. Only recently have particle board plants opened in the northern Rocky Mountains. Currently there are four: two each in Montana and Idaho (407).

Montana's two plants use shavings and sawdust in the manufacturing process at the approximate rate of one ton per 650 square feet of board (30) (333). At that rate, annual capacities of 108 million square feet for Evans Products and 70 million square feet for Plum Creek require about 275,000 tons of residues. This compares with Hoerner-Waldorf's annual requirement of roughly 800,000 tons (240).

Montana's supply of fine residues needed in particle

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[31]Hogged fuel—mill residue used to fire boilers and energize plant processes.

board manufacture was, in 1969, about 57 million cubic feet (311). It can be assumed that perhaps three-fourths of the available fine residue currently is used. In 1969, before operations of the particle board plants, only about 60 percent of the available fine residue was used (311).

Louisiana-Pacific's Missoula plant purchases residues from mills within an 80-mile radius of Missoula (170). The Columbia Falls plant uses residues from all the Plum Creek mills and six independent operations in a 60-mile radius. It is one of only 10 medium density fiberboard plants in the country and is the first to use western pines and spruce as well as Douglas-fir (30).

The manufacture of particle and fiberboards is more energy intensive than for lumber milling but less so than pulp and paper production. Natural gas is used in both kinds of plants in roughly the same amount as in plywood plants (55). Information on other energy inputs is unavailable at this time.

Montana forests support other less intensive commercial wood products operations. These include the harvesting of pulpwood for export out-of-state; cutting of transmission poles, mine timbers, posts and corral posts, house logs, and Christmas trees (plantation grown and natural stands); and manufacture of partitions, shelving, and wood furniture. It has been estimated that approximately six million cubic feet of roundwood is harvested annually for use in these products. Total activity is small in relation to the major processing activities already discussed; however, these small operations are locally important in rural communities. The number of commercial establishments engaged in the foregoing activities is 60 to 80 located throughout the state, but, of course, concentrated in western Montana.

BEYOND TIMBER: THE MANY VALUES OF FORESTLAND IN MONTANA

Beyond timber, Montana's forestland contains designated wilderness and primitive areas for recreation and education, and habitat for a wide variety of large and small animals. The forest also is a storage basin feeding snowmelt to Montana's major streams and rivers, which in turn support much water-based recreational activity, wildlife and irrigation for agriculture.

Most of the foregoing outputs are intrinsic to the natural system—that is, they are products of a self-sustaining biophysical system that can exist independent of man's influence. They are of value to man by themselves, requiring little in the way of additional factors of production. Persuasive arguments have been constructed that these outputs are part of a natural process which is valuable beyond mere utility—worthwhile in addition to being the life support of the earth. To support a prescription for action, though, the argument would require an exposition that is beyond the essentially descriptive and analytical scope of this report.

Montana has a significant share of the nation's roadless and undeveloped land in public ownership; most of Montana's share lies in the timbered portion of Rocky Mountain Montana. Montana has 22 percent of the designated wilderness and primitive acreage in the nation and 9.5 percent of all roadless acreage—18 percent excluding Alaska (49). About 95 percent of this land is located in the Rocky Mountain Montana environmental region.

Montana has 8,869,696 acres of wildland; the figure does not include roadless and undeveloped areas in private ownership or the Montana portion of backcountry in Yellowstone National Park (99)(100). Most public wildland in Montana—85 percent—is managed by the U.S. Forest Service (see Table 47). Of this land, more than 2 million acres in 10 management units have been officially designated as wilderness or primitive under the National Wilderness Preservation System,[32] and an additional 1.5 million acres in 38 units have been identified (called New Study Areas) through the Forest Service's Roadless Area Review and Evaluation system (RARE) as possible future additions to the system (see Map 12). About 640,000 acres of the new study areas already have been proposed for wilderness status. The Montana Wilderness Study Bill of 1975 (S.393) identified an additional 994,000 acres in 10 units for possible inclusion in the system.

Of the 5.25 million acres of nondesignated roadless areas under Forest Service management, nearly 2.9 million acres grow commercial timber, and of the 1.5 million acres of new study areas, 537,771 acres support commercial timber (see Table 48) (100). Timber harvest in new study areas has been deferred pending final disposition of the land. The timber growing potential is very low in most of the proposed study areas identified in S.393 (393).

[32]Under provisions of the Wilderness Act of 1964.

Table 47
Montana Wildland Under Jurisdiction of the U.S. Forest Service, 1975.

Category	Acreage	
Wilderness	1,795,167	
Primitive*	340,098	
Roadless and Undeveloped	5,246,785	
Proposed Wilderness**		640,861
New Study Areas***		1,541,809
Proposed New Study Areas****		971,000
Total Forest Service Wildlands	7,382,050	

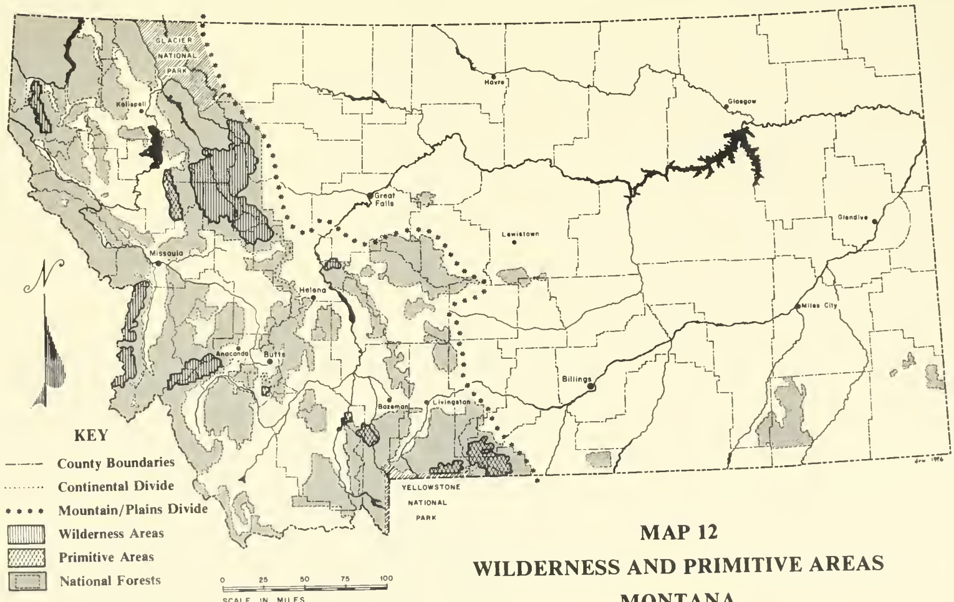
*All of this acreage has been proposed for wilderness status.

**Exclusive of existing primitive acreage proposed for wilderness status.

***Includes proposed wilderness.

****Montana Wilderness Study Bill of 1975 (S.393). Does not include 23,624 acre Mt. Henry area recently restored to the Bill.

Sources: References 99 and 100.



MAP 12
WILDERNESS AND PRIMITIVE AREAS
MONTANA

Table 48
Total and Commercial Forest Acreage in Roadless and Undeveloped Areas in Montana National Forests, 1975.

National Forest	All Areas* Total Acres	All Areas* Commercial Forest Acres	New Study Areas Total Acres	New Study Areas Commercial Forest Acres
Beaverhead	748,203	448,722	184,194	71,020
Bitterroot	479,200	395,577	---	---
Custer	166,629	8,400	130,109	4,200
Deer Lodge	199,080	126,775	39,848	16,346
Flathead	691,310	315,970	399,560	149,312
Gallatin	634,929	167,365	416,063	122,300
Helena	276,277	140,376	25,100	13,970
Kaniksu**	69,758	47,215	16,580	6,825
Kootenai	400,917	305,283	9,280	6,030
Lewis & Clark	807,952	505,095	137,100	56,304
Lolo	772,530	479,675	183,975	91,464
Totals	5,246,785	2,940,453	1,541,809	537,771

*Includes all roadless and undeveloped areas and new study areas selected by the U.S. Forest Service; excludes designated primitive and wilderness areas.

**Montana portion only.

Source: Reference 100.

An additional 1.5 million acres of wildland are managed by the National Park Service (NPS), the Fish and Wildlife Service (FWS) and the Bureau of Land Management (BLM) in Montana (see Table 49). Nearly a million acres of this wildland comprise proposed wilderness in Glacier National Park. Bureau of Land Management and FWS wilderness holdings are scattered throughout the state and, along with a few small Forest Service roadless tracts in the Rocky Mountain outliers, constitute the only public wildland in Great Plains Montana. Unlike the Forest Service, NPS and FWS, BLM has no enabling wilderness legislation; its land is not eligible for inclusion in the National Wilderness Preservation System. However, the agency has placed sizable acreages under roadless management.

A critical forestland resource, but small in terms of acreage, is the natural area. Designed to preserve representative segments of natural ecosystems for education, research, benchmark environmental monitoring, maintenance of genetic diversity or protection of endangered species, natural areas are "area of land or water representing significant natural features or processes, which are designated for their scientific and educational values." Although designated wildland, parks and refuges serve many of the same purposes, natural areas generally impose greater restrictions on recreational and commercial activities.

Two systems of natural areas—one federal and one state—have been initiated in Montana in recent years. Five Research Natural Areas have been formally designated on

Table 49
Montana Wildland Under the Jurisdiction of the Bureau of Land Management (BLM), National Park Service (NPS) and Fish and Wildlife Service (FWS), 1975.

Category and Manager	Acreage
Primitive*	
BLM	10,680
Proposed Wilderness	
FWS** BLM	176,140
FWS	63,409
NPS***	927,550
Proposed Primitive	
BLM	102,850
Roadless	
BLM	207,017
Total	1,487,646

*A BLM roadless management category; not a part of the National Wilderness Preservation System.

**The C.M. Russell National Wildlife Range is managed jointly by BLM and FWS.

***Glacier National Park only; does not include Montana portion of Yellowstone National Park.

Source: Reference 99.

federal land in Montana (see Table 50). All of these units are in timbered areas of Rocky Mountain Montana. The Montana Natural Areas Act of 1974 authorizes the state Board of Land Commissioners[33] to designate or acquire natural areas and to issue rules governing their use. The Owen Sowerwine State Natural Area, a forested island between the Stillwater and Flathead rivers east of Kalispell, has been proposed as the first natural area under the state act (287). Several other parcels on state and federal land have been identified as potential natural areas.

All of Montana's big game species save one—the pronghorn antelope—are fruits of the forested slopes of Rocky Mountain Montana (266). These are the elk, the mule and white-tailed deer, Shiras moose, bighorn sheep, Rocky Mountain goat, mountain lion, the black bear and the grizzly bear. Of these, only the mule deer and white-tail are widely distributed elsewhere in Montana and not confined to conifer forests and associated habitats. Population estimates of big game animals on federal forestland in Montana are given in Table 51.

The elk is Montana's most prized big game animal from the standpoint of hunter interest. With a large and stable population and broad distribution (see Map 7), Montana is one of the most important elk hunting states in the country. The grizzly bear has been declared a threatened species in Montana by the U.S. Fish and Wildlife Service under the Endangered Species Act of 1973. The bear's last major stronghold in Montana is in the wild country north of Missoula and west of Great Falls, commonly referred to as the Bob Marshall ecosystem (see Map 7). Given the bear's formidable nature, its rarity and synonymity with wildlands, and its sufferance of continued sport hunting and dwindling habitat, the grizzly unquestionably has become Montana's most controversial wild animal.

[33]Composed of the Governor, Attorney General, State Superintendent of Public Instruction, Secretary of State, and State Auditor.

Table 50
Research Natural Areas on Federal Lands in Montana, 1975.

Name/Location	Acres
Coram	635
Flathead National Forest	
Cliff Lake	2,301
Beaverhead National Forest	
Cottonwood Creek	128
Beaverhead National Forest	
Poker Jim	363
Custer National Forest	
Sheep Mountain	85
Red Rock Lakes National Wildlife Refuge	
Total Acreage	3,512

Source: Reference 304.

Table 51
Population Estimates of Big Game Animals on Federal Forest Lands in Montana, 1975.
(thousands)

Animal	Forest Service	Bureau of Land Management	
		Schweitzer*	U.S.D.I.
Elk	54.1	35.7	3.6
Moose	5.1	0.2	0.1
Whitetail deer	51.3	31.4	41.0
Mule deer	172.5	93.3	88.0
Grizzly bear	0.5	- -	- -
Black bear	12.9	0.7	0.5
Mountain goat	4.8	0.3	0.1
Bighorn sheep	2.2	0.4	0.4

*Reference 304.

Sources: References 304 and 374.

Montana's conifer forests also produce huntable populations of three forest grouse—blue grouse, ruffed grouse and spruce (Franklin) grouse—and economically and ecologically important populations of furbearers, predators and other nongame wildlife. Among these is the Northern Rocky Mountain wolf, which has been placed on the Fish and Wildlife Service's endangered list.

Most, if not all, of the suitable winter habitat for big game animals in Rocky Mountain Montana is now filled to capacity. Encroachment by man of the available winter range and habitat is limiting populations of these species. Except for deer, these animals cannot increase appreciably in numbers. For reasons generally unknown, mule deer numbers are now down compared to the bumper crops of the 1950s. However deer are now more nearly in balance with their food supply than they were two decades ago. The outlook for the forest grouse generally is good because its preferred habitat probably will continue to be available.

From 1940 to 1970 the Game Management Division of the Montana Department of Fish and Game bought or leased 152,978 acres in western Montana, primarily for enhancement of big game winter range (see Table 52). These game management areas are shown in Map 8. They have served to alleviate damage by game to vegetation, to reduce competition by livestock and to encourage populations of game in previously inhospitable areas or where winter range was limited. State wildlife ranges support more than 5,000 elk and numerous other big game and nongame species. The department in 1976 acquired 55,000 acres of the Mount Haggin Ranch, a game-rich forested area near Anaconda.

A unique and valuable characteristic of high, forested watersheds in Rocky Mountain Montana is the salmonid fishery. Salmonids are the trout family and thrive only in cold water that is relatively free of silt. Recreationally important native salmonids in Montana are the mountain whitefish, the Yellowstone and West Slope cutthroat, Dolly

Table 52
Montana State Game Ranges and Land* Administered By the Department of Fish and Game, 1970.

		Big Game Ranges (Acres)			Small Game Ranges (Acres)			
NAME	County	Owned	Leased	Total	Owned	Leased	Total	Total Acres
Alberton Game Range	Mineral	--	666	666	--	--	--	666
Augusta Check Station	Lewis & Clark	1 lot	--	--	--	--	--	--
Beartooth Game Range	Lewis & Clark and Cascade	27,000	5,318	32,318	--	--	--	32,318
Big Creek	Park	--	1,920	1,920	--	--	--	1,920
Bitterroot Game Range	Ravalli	2,289	160	2,449	--	--	--	2,449
Black Bluff	Yellowstone	--	--	--	--	52	52	52
Blackfoot-Clearwater Game Range	Missoula and Powell	11,420	37,951	49,371	--	--	--	49,371
Bowdoin	Phillips	--	--	--	--	156	156	156
Bowser Lake	Flathead	353	79	432	--	--	--	432
Bull Mountain	Jefferson	1,993	1,559	3,552	--	--	--	3,552
Canyon Ferry	Broadwater	--	--	--	--	5,000	5,000	5,000
Clark Canyon	Beaverhead	--	--	--	--	1,200	1,200	1,200
Flathead Lake	Lake	--	--	--	136	--	136	136
Fleecer Mountain	Silver Bow	6,425	877	7,302	--	--	--	7,302
Fox Lake	Richland	--	--	--	1,202	160	1,362	1,362
Freezout Lake	Teton	--	--	--	4,872	6,477	11,349	11,349
Gallatin Game Range	Gallatin	7,258	3,200	10,458	--	--	--	10,458
Garrity Mountain	Deer Lodge	--	1,760	1,760	--	--	--	1,760
Haymaker Game Range	Wheatland	1,360	150	1,510	--	--	--	1,510
Isaac Homestead	Treasure	--	--	--	535	--	535	535
Johnson Reservoir	Dawson	--	--	--	--	68	68	68
Judith River Game Range	Judith Basin	4,639	234	4,873	--	--	--	4,873
Madison-Bear Creek	Madison	3,455	960	4,415	--	--	--	4,415
Madison-Wall Creek	Madison	5,548	918	6,466	--	--	--	6,466
Milk River	Phillips	--	--	--	379	1,668	2,047	2,047
Moiese Bird Farm	Lake	--	--	--	80	--	80	80
Muddy Creek	Cascade	--	--	--	680	--	680	680
Ninepipe	Lake	--	--	--	2,755	--	2,755	2,755
Pablo	Lake	--	--	--	387	--	387	387
Pompeys Tower	Yellowstone	--	--	--	--	94	94	94
Red Rock Lake	Beaverhead	--	--	--	27	--	27	27
Sun River Game Range	Lewis & Clark	12,173	7,555	19,728	--	--	--	19,728
Threemile Game Range	Ravalli	5,739	--	5,739	--	--	--	5,739
Tiber Reservoir	Toole and Liberty	--	--	--	--	19,485	19,485	19,485
War Horse Reservoir	Petroleum	--	--	--	--	1,629	1,629	1,629
Warm Springs Bird Farm	Deer Lodge	--	--	--	--	15	15	15
Warm Spring Game Area	Deer Lodge	--	--	--	--	4,335	4,335	4,335
Willow Creek Camp	Lewis & Clark	19	--	19	--	--	--	19
Yellow Water Reservoir	Petroleum	--	--	--	--	1,500	1,500	1,500
	Total	**89,671**	**63,307**	**152,979**	**11,053**	**41,839**	**52,892**	**205,871**

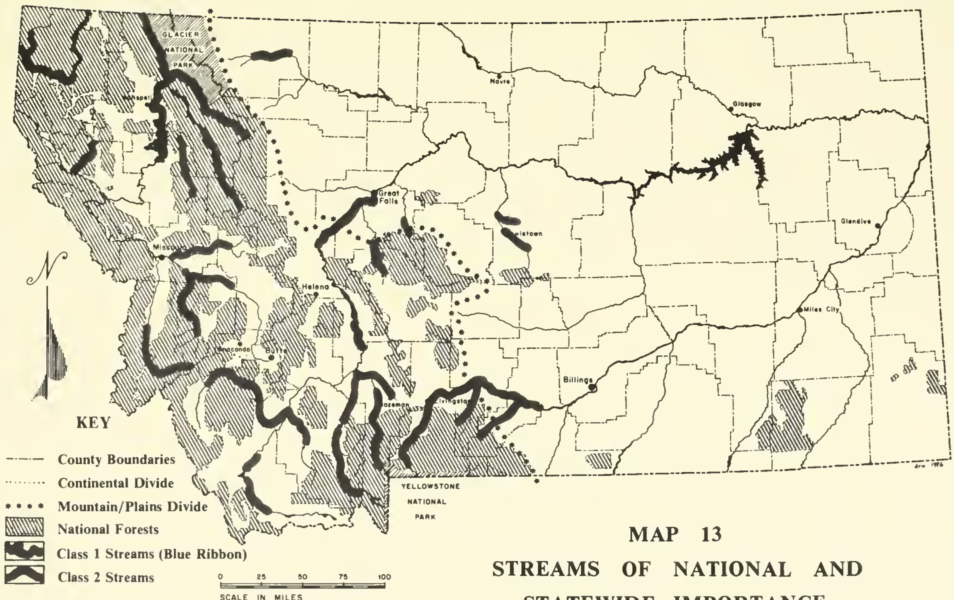
*Owned or leased by the Montana Fish and Game Commission.

Varden, and Arctic grayling. Important species introduced by man include the kokanee salmon, and rainbow, brown and brook trout (32). Montana has 452 miles of Class 1 salmonid fishing streams (31). These waters, commonly called "Blue Ribbon Streams," are of national as well as statewide value and located entirely within Rocky Mountain Montana (see Map 13).

The state has an additional 989 miles of Class 2 streams considered to be of statewide value (see Map 13). All of Montana's Class 1 and 2 streams derive from forested watershed. Although fishing pressure on most of these streams is increasing, destruction of habitat and water pollution have reduced their value in many instances. National forest land in Montana includes 13,032 miles of fish habitat—7,135 miles of it fishable—and 1,300 lakes and reservoirs covering 128,400 acres (304).

In Montana, only the forested mountain ranges of Rocky Mountain Montana produce significant water in excess of evaporation and the needs of native vegetation. Mean annual runoff in Rocky Mountain Montana ranges from less than 5 to over 50 inches on some of the high slopes (see Map 9) (278). In contrast, mean annual runoff amounts to less than an inch of water over most of Great Plains Montana (203).

A total of 43,899,580 acre-feet of water per year (afy) leaves Montana as surface flow; 28,465,950 afy originate here, the remainder having entered the state from adjacent states and provinces (248). If it is assumed that all of the



MAP 13
STREAMS OF NATIONAL AND STATEWIDE IMPORTANCE

6,700,000 afy evaporated or consumed in Montana is also produced in-state, then the gross production of usable surface water in Montana equals 35,165,950 afy. Of this total, it is estimated that a total of 18,923,875 afy or 54 percent is produced on national forests alone (273). All forestland together (public and private) encompassing one-fourth of Montana's land area, yields about two-thirds of the state's water (304).

It should not be surprising, then, that all large rivers in Montana have their headwaters in the Rocky Mountains and receive nearly all of their water from forested mountain slopes (112). Water from forestland may be used many times for many uses after it leaves the forest and before it leaves the state. Irrigated agriculture in the Broad Valley Rockies and Great Plains Montana is critically dependent on forest-generated water carried by the Missouri and Yellowstone river systems.

Montana's surface water resources, like the others which have intrinsic value, are of significant importance to outdoor recreation. Outdoor recreation can take many forms. The 1973 Montana Fish and Game Department Statewide Comprehensive Outdoor Recreation Plan identified 24 separate activities in a 1971 statewide recreation survey of Montana residents (259). The 10 most preferred activities are listed in Table 53. These 10 accounted for three-fourths of the total time the respondents devoted to recreation. It should be noted that the activity preference in Table 53 may understate the desire for strenuous activities because the survey was restricted to individuals on the income tax rolls, thereby excluding many young people.

Most of the selected activities depend on access by automobile. Access is important, but it can degrade and reduce the value associated with any of the 10 activities. In some cases—hunting and fishing—overuse made possible by automobile access can destroy the resources upon which the activities depend.

The desire by Montanans for recreational activity in largely undeveloped areas is supported by additional survey responses. Table 54 shows preferences for types of recreational areas. Forty-two percent of the respondents desired largely undeveloped or primitive areas, 22 percent wanted developed areas, and 16 percent wanted natural areas developed to provide access and some "viewer comforts."

Table 53
Outdoor Recreation Preferences of Montanans.

Rank	Activity
1	Driving for pleasure
2	Fishing
3	Walking for pleasure
4	Sightseeing
5	Hunting
6	Backcountry touring (auto)
7	Camping
8	Motor bike riding
9	Picnicking
10	Horseback riding

Source: Reference 259.

Table 54
Preferences by Montanans for Selected Types of Recreation Areas, 1971.

Type of Recreation Area	Percentage of Total Responses
Natural undeveloped environmental areas*	27.0
General outdoor recreation areas**	22.4
Outstanding natural areas***	15.5
Primitive areas****	15.4
Historic and Cultural sites*****	12.6
Intensively developed recreation areas.******	7.1
Total	100.0

NOTE: Weights are based upon rankings by respondents for 1st, 2nd, and 3rd preferences.

*Largely undeveloped but various types of recreation, such as camping, fishing, or picnicking can take place.

**Includes rest and recreation areas where the natural environment is an important part of the recreation experience, such as state parks and forest campgrounds with developed camping, picnicking, boating facilities, etc.

***These areas have outstanding natural features; examples would include the L&C Caverns; Glacier and Yellowstone Parks, etc.

*** Roadless areas characterized by natural wild conditions; no developments are found in such places.

*****Places of historical significance in Montana, such as Custer Battlefield, ghost towns, etc.

******Includes sites of intensive development found in city parks, such as swimming pools, tennis courts, playfields, picnic areas, etc.

Source: Reference 179.

Hence it appears that Montanans generally prefer minimal development of their recreational resources. There do exist, however, many developed recreational sites in Montana which attract both in-state and out-of-state users. A recent Department of Fish and Game inventory of these sites is summarized in Table 55. The Department of Fish and Game listed 780 developed sites statewide, three-fourths of them managed by public agencies. More than 70 percent of the listed sites are in Rocky Mountain Montana. It can be assumed that most sites are associated with forestland or watercourses associated with forestland.

A more recent National Association of Conservation Districts inventory of private sector recreation enterprises identified 1,070 such facilities statewide (52). This figure is understandably higher than the Fish and Game result because the Conservation District survey included urban sites and used a liberal definition of recreation: including golfing, field sports, rodeos, zoos, and amusement parks. Even with these qualifications though, it appears that the 179 private developed facilities in Table 55 may be an understatement.

The Department of Fish and Game also conducted, in the summer of 1971, a survey of users of publicly developed recreation sites in Montana. One of the results of this survey shows that about 60 percent of the users of these facilities were Montana residents (259). Nonresident users appeared most numerous in western Montana, particularly around the national parks and Flathead Lake, indicating the attractiveness of this area for tourists.

Outdoor recreationists in Montana want and use undeveloped and developed sites. The undeveloped recreational resources of Montana are huge, including practically all scenic public forestland and other wildland accessible by vehicle or foot. It also includes many of the watercourses, lakes and reservoirs accessible by vehicle, foot, or boat.

The data on land and water resources available for outdoor recreation are sparse and poorly organized. There is only a vague notion of what these resources are or should be. Information is sorely lacking on quality of the resources, trends in forestland and wildland related opportunities, and value to Montanans of an unspoiled natural heritage.

The lack of information is due to the unique nature of outdoor recreation. Unlike timber, recreational activities relying on Montana's forestland, wildlife, and watercourses take place for the most part outside the market system. Hence values placed on outdoor recreation are for the most part personal and immeasurable. The diffuse nature of recreational opportunities compounds the difficuulties. It is extremely difficult, if not impossible, to monitor wildlife movements accurately. Qualifying the many subjective variables affecting an individual's satisfaction or nonsatisfaction in a recreational experience is a Herculean task. Measuring and monitoring biophysical changes in land and water resources are costly and time consuming. Finally, an understanding of the ecological web surrounding these resources is really just emerging.

Table 55

Montana's Non-Urban Developed Recreation Sites*

(number of sites)

Counties**	Ownership: Federal	State	Local	Private, Non-Profit	Total
Phillips, Valley, Daniels, Sheridan, Roosevelt	16	4	1	2	23
Garfield, McCone, Prairie, Dawson, Richland, Wibaux	4	8	2	3	17
Treasure, Richland, Powder River, Carter, Fallon, Custer	10	10	0	4	24
Liberty, Hill, Blaine	1	4	2	2	9
Chouteau, Cascade, Teton, Pondera, Glacier, Toole	16	15	1	10	42
Judith Basin, Fergus, Petroleum, Musselshell, Golden Valley, Wheatland	4	11	0	7	22
Sweetgrass, Stillwater, Carbon,Bighorn, Yellowstone	30	34	2	17	83
Meagher, Gallatin, Park	37	13	0	15	65
Lewis & Clark, Jefferson, Broadwater	40	24	0	22	86
Lincoln, Flathead, Lake, Sanders	88	43	1	44	176
Mineral, Missoula, Ravalli	44	19	2	28	93
Powell, Silver Bow, Granite, Deer Lodge, Beaverhead, Madison	86	28	1	25	140
Total	**376**	**213**	**12**	**179**	**780**

*Examples include campgrounds, picnic areas, organization sites, resorts, commercial public service sites, recreation residences, winter and water sport sites, and observation and interpretive sites.

**Counties correspond to the 12 sub-state planning districts

Source: Reference 238.

One thing is fairly clear, based on results of the 1971 Fish and Game survey: Montanans prefer outdoor recreation to other leisure activities. For each month of the year outdoor recreation was consistently preferred over indoor spectator and home-related activities (259). Its ranking even may have been understated when it is recalled that the survey was limited to income taxpayers.

The preferred ranking of outdoor recreation as an activity supports the assumption that Montanans are extremely aware of the natural beauty of the state, and indeed may have decided to live here, or move here, because of that appreciation. There is little doubt that many residents do take this into consideration and in staying, perhaps, forgo higher paying jobs elsewhere. Although data are lacking to support this contention it does seem plausible.

It appears that use of Montana's outdoor recreation opportunities has been growing. Four sources of data allow an analysis of the trend: sale of hunting and fishing licenses (compiled by the Montana Department of Fish and Game); estimated numbers of out-of-state visitors (recorded by the Montana Department of Highways); annual travel reports for Yellowstone and Glacier national parks; and estimated visitor days of recreation use in Montana's national forests, wilderness, and primitive areas. The Highway Department estimates are derived from yearly updated sample counts applied to a base of travel data developed in 1963-64. The Forest Service estimates are based solely on random trail counts and observations.

Table 56 presents the data. Use trends have been on the upswing for all four measured activities, indicating a steady growth in demand for these particular elements of Montana's outdoor recreation scene. According to the state Highway Department, out-of-state visitation has increased at the rate of about 7 percent per year. Since 1954 there has been a similar 7 percent per year increase in visits to Glacier National Park; Yellowstone Park has had only a 3 percent

Table 56
Trends in Use: Montana Recreation.

(000's)

Activity Being Measured	Year 1954	1964	1968	1974	1975
Out-of-State Visitors*		2292		3949	
National Park Visitors**					
Glacier	608				1571
Yellowstone	1329				2246
Visitor Days of Recreation Use***					
National Forests			5244.6	7505.4	
Wilderness Areas****			269.0	349.2	
Primitive Areas			65.8	110.4	
License Sales*****					
Fishing					
Residents			123	161	
Non-residents			64	170	
Hunting					
Residents			178	243	
Non-residents			15	36	

*Data supplied by Montana Highway Department.

**Data supplied by National Park Service.

***Data supplied by Forest Service

****Excludes Scapegoat Wilderness areas since not in existence prior to 1973.

*****Data supplied by Montana Department of Fish and Game

Sources: References 57, 88, 93, 98, 100, 237, and 260.

per year increase over the same period. Visitor days of recreation use on Montana's national forests has increased at a rate of 7 percent per year since 1968; 4 percent per year for wilderness areas and 10 percent per year for primitive areas. Resident hunting and fishing license sales have been increasing at 4 to 5 percent per year since 1968; nonresident sales at much higher rate, about 20 percent per year. In 1975 Montana ranked first and third respectively in the nation in nonresident hunting and fishing licenses sold (373).

Some qualification of the data is needed. The first three measures focus on visitors without distinguishing who the user is and the purpose of the visit. The fourth measure is specific in these regards but by necessity is also a very limited view of the recreationist. In addition, the fourth activity—hunting and fishing licenses—is the only one specifically measuring absolute levels of use of a particular segment of Montana's recreational opportunities.

Additional difficulties exist in applying the data to yield a meaningful picture of the recreationist in Montana today because of deficiencies already cited and because there is no consensus on who the recreationist it. Should all travelers be counted or only tourists with Montana as a primary destination? How extensive is resident use of Montana recreational opportunities and what has the trend been relative to nonresident use and absolute population levels? Some information bearing on the last question was developed during the Fish and Game survey which noted that 60 percent of the use of public recreation sites in Montana was by residents (259).

How does the resident and nonresident use of Montana's recreational resources compare with other states and the nation? Why do nonresidents visit? The 1963-1964 highway travel survey revealed that 73 percent of the nonresident motorists were in Montana for pleasure, 4 percent for a combination of business and pleasure and 31 percent of those here for pleasure were passing through (260). Are they satisfied with their experience? What is the level of repeat visitations? Has the average length of stay increased with increased development of so-called second homes?

CHAPTER 7 THE FORESTLAND ECOSYSTEM OF MONTANA[34]

MONTANA FOREST TYPES

Approximately a fourth of Montana's land area is forested, much of it commercially valuable and most of it in the western mountains on tracts publicly owned and managed. But the state's forestland varies from scattered gallery forests of cottonwood along rivers and streams to large, dense stands of pine, fir and other coniferous species on the mountain slopes. Forests, particularly mountain forests, change dramatically with elevation. Groups of species reach climax through biological succession within the constraints of available soil, sunlight, temperature, wind and water supply all partly influenced by elevation. The climax zones for forests in Montana are as follows (304):

Ponderosa pine climax zone

Confined to comparatively low elevation, ponderosa pine border grassland as scattered individual trees or sparse stands which grow slowly and do not hold much snowpack. Understory growth is either grass or shrubs, depending on moisture. Particularly suitable for recreation; good producer of forage and wildlife.

Douglas-fir climax zone

Commercially important, dense stands of Douglas-fir are often mixed with ponderosa pine, western larch, or lodgepole pine. Covers much of the forested parts of Rocky Mountain Montana environmental region.

Grand fir and cedar-hemlock climax zone

Highly productive, restricted to the moist northwest corner of Montana. Shelters many other moisture-seeking plant species. Where disturbed by wild fire, is occupied by western larch, western white pine, and spruce.

Temperate spruce-fir climax zone

Relatively productive and successful conifers; the spruce especially so in stream bottomland and poorly drained benches at moderate elevations; subalpine fir is climax species elsewhere in the zone even when dominated by taller lodgepole pine and western larch.

Subalpine climax zone

Extensive but slow-growing stands of subalpine fir, spruce and lodgepole pine in this zone abutting the timberline. Generally cold and snowy environment productive of water, wildlife and recreational opportunities.

FORESTS AND WATER

The soil and vegetation of the forest ecosystem have a determining impact on variations in the quantity and quality of the water leaving the forested watershed. In Montana, such watersheds are important to agriculture, industry, municipalities and of course fishermen and hunters—anyone who uses or withdraws the water arising from forested areas. As a general rule, reduction of forest

Travel Promotion Unit, Mt. Dept. of Highways

[34]Adapted from "Management and Forest Ecosystems," School of Forestry, University of Montana, Montana Forest and Conservation Experiment Station, in Montana Environmental Quality Council *First Annual Report* (October, 1972), pp. 31-40.

cover increases streamflow while establishment of forest vegetation on nonforested sites reduces it. The increased runoff feeding the streamflow also moves forest soil; the most drastic soil losses occur where much of the vegetation has been destroyed. Mass erosion hazards are greatest on steep slopes with deep soils and moist conditions. Subtle but very important effects on the soil's dissolved nutrients also result from forest disturbance. As the medium in which water moves and is stored and in which vegetation is anchored and grows, soil is a basic value of critical importance. The soil and vegetation together give the forest ecosystem whatever resilience it has against the effects of change or manipulation. The limits to the forest's tolerance vary among forests and are difficult to predict. Even the most basic question of whether removal of vegetation and subsequent loss of nutrients from the ecosystem may cause long-term reduction of forest productivity remains scientifically controversial (377).

FORESTS AND WILDLIFE

Many animals make their homes in and obtain food from the forest, and thereby alter the forest environment. Plant species preferred by animals may be browsed into obscurity. Deer, elk and moose damage seedlings; bears strip the bark from trees; rodents girdle both seedlings and mature trees. Seed-eating rodents and birds also influence forest composition. Rodents that consume seed either in trees or on the ground usually obtain great quantities from large species such as ponderosa pine and Douglas-fir. Animals in turn reflect changes in vegetation caused by their own and other activities, by changes in numbers, productivity and general welfare.

The forest's many niches—unique habitat combinations that fulfill the needs of resident animal populations—are the chief influence on the diversity and abundance of wildlife in the forest. Vertical forest niches depend on the air space around trees and their surfaces, branches and trunks, and the ground layer of shrubs and debris that surrounds them. Hawks and other aerial predators feed on prey produced in the forest and inhabiting the airspace around it. Other animals feed on the buds, flowers, fruits and leaves of trees. Large branches and trunks provide homes for many birds and mammals and refuge and food for others. Trees, of course, serve to protect many creatures from sun, wind and rain.

The shrub layer offers nesting sites for birds as well as cover and nutritious food for these and for a wide variety of other animals ranging from mice to moose. Wildlife forage on the ground is augmented by fallen fruits and insects from the air, tree and shrub zones. Underground is home for numerous burrowing animals, and it is here that predators such as foxes and coyotes make their dens. The worms and insects that live in the ground and the many microbes that occupy forest litter and soil also are essential to the forest's functioning.

Horizontal forest niches depend on the borders between groups of trees and open areas both within and at the perimeter of the forest. The perimeter allows a greateer diversity of shrubs and herbs than the forest interior, so this zone provides nutritious feeding and useful cover for the animals. Open areas created by rockslides, streams, fires, blowdown, and rock outcrops provide similar opportunities for wildlife, as do man-made openings such as roads.

Forest density varies considerably with topography, soil moisture and past history. At a given time and place, a tree population reaches a certain maximum density with a representative population of animals. As the stand degenerates with age or use, the forest canopy is opened and resident animals respond to the vegetational change with changes in their own abundance and diversity. Disturbances in the forest ecosystem accelerate changes in the vegetation and animal components. The composition and well being of the forest community also is influenced by the nature of plant replacement, whether it is by chance (natural seed crops, root sprouting), or by design (prescribed fire, reforestation).

THE ROLE OF NATURAL PROCESSES

Natural disturbances play a major ecological role in the forest. Change, sometimes gradual and sometimes abrupt, is normal. Many factors including wind, fire, disease, insects, and vertebrate animals affect natural regeneration processes, genetic selection, and plant succession, and are in turn affected by the alterations so caused.

Wind often is a sudden and dramatic disturbance, especially to weak or old stands. In Montana, western larch is the most windfirm species and Engelmann-spruce the least. Wind may level large stands. Even among stands in naturally windy areas changes wrought naturally or artificially may increase the probability of windthrow damage. Wind disturbance often initiates natural regeneration by opening the stand, permitting more light to enter, and exposing mineral soil where trees have been uprooted. At the same time, a fire hazard may be created by adding to the accumulation of debris.

Fire has played a major role in shaping Montana's forests, credited by some (116) as equal in importance to soil, water, temperature and other fundamental ecological factors governing plant succession. In some national parks and forests, some fires are allowed to burn themselves out so as to take advantage of their natural role in the forest. Numerous Montana tree species such as western larch, Engelmann-spruce, and lodgepole, ponderosa, and western white pine, which would otherwise have been replaced by climax species, have been perpetuated by the repeated incidence of fire. Their regeneration habits are adapted to fire-created conditions. For example, the thick bark of western larch protects mature trees against the heat of the fire. The seeds cast by surviving trees fall on a favorable bed of fire-exposed mineral soil, often giving rise to overly dense stands of young trees. Seed cones of the lodgepole pine survive in the crowns of burned trees and open to release seeds over the fire-prepared seedbed, a process similar to that for larch. Single burns tend to maintain tree cover, but repeated burns on steep south slopes on granitic soil have caused accelerated erosion and critical soil loss (399).

Eventually, the plant community may change from one dominated by trees to one dominated by shrubs. This has happened in extensive areas of Montana and Idaho. Light, repeated ground fire in the mature stands of ponderosa pine have a thinning effect (395). Such fires produce the clean, picturesque, park-like stands that were so prevalent among the ponderosa before organized fire protection. These light fires reduce the accumulation of debris and limit the growth of succeeding species such as Douglas-fir and grand fir.

Infestations of insects are another powerful ecological disturbance that greatly influences the competition, structure and succession of Rocky Mountain forests (289). The destruction of many trees by insects may hasten succession by eliminating the overstory and releasing understory tree species for proper growth. Insect-killed trees also may increase the intensity of wildfire which can set back succession by establishing another seral stand (390). Mature and overmature stands are sometimes destroyed by disease-causing organisms such as dwarfmistletoe, rust, and needle-blighting and canker-forming fungi. All of these diseases affect Montana forests to some degree. Mistletoe infection is a major problem. It afflicts all Montana species, except for ponderosa pine growing east of the Bitterroot Mountains. Seral species such as larch and lodgepole pine appear to be especially vulnerable to dwarfmistletoe. Douglas-fir, a climax species in some parts of the ecosystem, also is highly vulnerable (178). Pollutants released from power generation and industrial facilities also can affect the growth of trees and biological succession. There is fear, for example, that sulfur dioxide pollution will stunt the growth and weaken the disease resistance of ponderosa pine forests downwind of the coal-fired generating complex at Colstrip. Emissions of airborne fluorides from the Anaconda Aluminum Co.'s reduction plant near Glacier National Park killed many trees near the plant and caused further losses in timber growth amounting to 404,695 board-feet during the period 1968-73 (40).

How closely forest uses and forestry management resemble natural disturbances and processes in both degree and kind has a great influence on the ability of the forest ecosystem to survive and prosper. A primary problem of forest management is determining the amount of disturbance the ecosystem can sustain from human uses, errors, and economic exploitation without suffering irreversible damage. Only through careful planning and management can the multiple values of the forest—Montana's forests—be restored and preserved. Management that understands and respects the limits of the forest ecosystem and gives primary consideration to the basic natural values that spring from it will be able to conserve the forest and benefit all its users.

IMPACT OF FOREST MANAGEMENT PRACTICES

Growth and harvest of commercial timber are major factors affecting the forest ecosystem in Montana. Timber management considerations such as the desired product, species to favor, economics, and impact on environmental and other values often determine the silvicultural framework that must govern management. In many cases it is possible to select from alternative management systems to minimize effects on wildlife, water and the vegetational complex. Economic considerations especially affect the methods of cutting and provisions for regeneration unless it fails, after which seeds or seedlings may be cast aerially or planted by hand.

Basic cutting methods include clear-cutting (removing all trees in blocks, patches or strips), seed tree cutting (essentially a clearcut, with seed trees reserved in groups or strips), shelterwood cutting (removal in two or more cuts spaced 10 or more years apart), group selection (one to five-acre openings cut and allowed to regenerate before cutting of the residual), and single stem selection (cutting of selected, mature trees periodically within a given area). Clear-cutting, seed tree, and shelterwood cutting are most applicable to trees intolerant of shade; regrowth will produce even-age, plantation-like stands. Group and single stem selection cutting are best applicable to shade tolerant species and will result in multiple-age stands. Based on the biological response of species to methods of cutting, foresters have developed recommendations for cutting methods. Table 57 presents a summary of recommended cutting methods.

If timber production is the management objective, mature stands that have been destroyed by insects, disease, or early cutting frequently require "sanitation" or improvement cuttings and overstory removal to help establish new stands. New stands, established either by favoring advanced reproduction or starting a completely new crop, are necessary in this case to achieve the potential timber growth on the site (165).

Each cutting method has particular impacts on other values and uses of the land. The wildlife component, for example, can suffer drastic alteration by timber growing and harvesting practices. Complete clear-cutting generally will be accompanied by complete loss of deep-forest wildlife on the site and replacement by animals that can live in the clearing. Partial clearing usually increases forest perimeter dwellers, but species dependent on the deep forest habitat, including elk and bear, will diminish or disappear. Changes in the forest ecosystem wrought by timber harvesting can directly affect snow depth, timing of snowmelt, and other factors that also affect wildlife, including aquatic life in the streams draining the forested watershed. Forage and niches produced by even-age or single-species timber growth management may increase the abundance of a few species (some inimical for forest regeneration) at the expense of animal diversity.

The extensive road systems that usually accompany logging also cause severe and sudden disruptions of the forest ecosystems. Roads may help distribute hunting pressure or may facilitate excessive hunting. Roads into hitherto undeveloped forestland constitute loss of habitat for species such as grizzly bear and eliminate options for wilderness or other natural area designations that could benefit animals and the values associated with their presence. Animals adapt, move or die when their environment is radically altered. Because wild species have evolved over many millenia, they cannot be expected to adapt successfully to sudden changes; nor do they have the unrestricted opportunity to move elsewhere; others of the same species may already occupy suitable habitat. Logging that removes shelter and scarification that reduces grass, shrub, and forb competition can hardly be said to benefit wildlife. Because intensive forest management for timber production is seldom compatible with preservation of wildlife, wildlife benefits that do occur are almost always by accident, not design.

Other forest values are affected by timber management too. The effects on soil and water resources of the forest watershed can be deleterious and long-lasting, especially the effects of road construction. Recreational opportunities vary as to their compatibility with timber production. Timber management can be modified to enhance recreational and aesthetic resources of forestland, for example by selective cutting near and in campgrounds and picnic areas. Carefully planned and executed cuttings can open up scenic vistas along roads and trails. Cutting and subsequent regeneration can add variety to the monotony of even-age stands. But in some scenic and recreational areas, clear-cutting is obviously undesirable. In others it may be a suitable method if small cuts are used and if cutting boundaries blend with natural features of the landscape. In general, sophistication and sensitivity in choosing cutting methods is needed and necessary to ensure minimum conflict between timber production and preservation of other forest values.

This may mean, in fact, prohibition of timber harvest in selected areas, such as in protected wilderness, natural areas and land adjacent to population centers and transportation corridors around which scenic values are especially important. Thus timber management cannot be described as categorically good or bad for recreational, aesthetic and other values of the forest ecosystem. Alternative cutting methods have been ranked as to the desirability of each method relative to its effect on other forest uses. Table 58 presents this comparison.

A review of current timber management suggests that disruptive practices occur all too frequently. Revised methods are essential if demands for forest products are to be met without intolerable disruption of the forest environment. Logging methods that disturb the ground surface very little are especially worthwhile in sites of high productivity, where frequently the soil is most vulnerable to erosion. Growing species that do not require harvest by clearcutting also would be helpful in reducing the potential for conflict among forest uses and destruction of forest values. Smaller, more mobile harvesting equipment is needed so that damage to forest vegetation can be minimized. Road construction should more often conform to topography and fewer roads should be constructed.

As general rules, such recommendations fail to account for the wide variation in environmental capacities and conditions of the forest ecosystem. Hence systematic resource management is needed to allow for natural variations. Detailed inventories of resources are needed, including physical, biological, social and economic factors. Multiple use plans are important to guide decisions based on field investigations. Within the limits of the forest ecosystem, careful planning and management can increase some of the forest's multiple values. Other values, equally important, cannot be increased but only restored or preserved, and only then with effort.

Table 57

Timber Cutting Methods Recommended and Practiced in Montana.

Method of cutting	Western larch	Lodgepole pine	Douglas-fir	Ponderosa pine	Engelmann spruce and subalpine fir	Western white pine and associated species
Clearcutting	†1	†1	†2	3	††2	†††1
Seed tree	2	2	1	2	2	2
Shelterwood	2	2	2	1	2	2
Group selection	3	3	2	1	1	3
Stem selection	4	4	3	4	3	4

Legend: 1 most desirable; 2 good alternative; 3 least desirable; 4 not applicable.

†Sanitation requires clearcutting to remove infection sources in stands with heavy dwarfmistletoe infection.

††Shade, preferably that cast by dead material, is required for successful germination and seedling survival.

†††Special measures are required to control the alternate host for white pine blister rust, *Ribes* species, in stands containing western white pine. Often the best alternative is to favor one or more of the associated species over white pine because of the extreme difficulty in controlling blister rust.

Source: *Montana Environmental Quality Council*, First Annual Report. *(October 1972), pp. 31-40.*

Table 58

Cutting Methods and Their Impact on Non-Timber Uses in Forests of Western Larch.

	Desirability (Least) 1	2	3	4	(Most) 5
Multiple use considerations					
1 Esthetic attraction	CC	ST	SW	GS	SS,NC
2 Forage, livestock:					
Quantity and use	NC	SS	GS	SW	CC,ST
3 Forage, big game:					
Quantity	NC	SS	SW	GS	CC,ST
Use	NC	SS	CC,ST	SW	GS
4 Timber production	NC	SS	GS	SW	CC,ST
5 Water production:					
Yield	NC	SS	GS	SW	CC,ST
Quality	CC	ST	GS	SW	NC,SS
6 Soil protection	CC	ST	SW,GS	SS	NC

LEGEND:
NC=No cutting
CC=Clearcutting
ST=Scattered seed tree cutting
SW=Shelterwood cutting
GS=Group selection cutting (groups one acre or less)
SS=Single-stem selection cutting

Source: Reference 290.

CHAPTER 8 ECONOMIC CHARACTERISTICS OF MONTANA AGRICULTURAL AND FORESTLAND RESOURCES

ECONOMIC IMPACT OF AGRICULTURE

Most of the income and employment derived from the use of agricultural land resources in Montana is a result of agricultural practices on the land, for example the raising of food and feed grains and livestock. In-state processing and transportation of those products also provide employment. Additional income and employment are derived from the recreational resources associated with agricultural land, for example from hunting and fishing in agricultural areas.

The foregoing economic activities, except for recreation, are considered as "primary" ones; that is, their existence depends on markets outside the state or region. Recreation has not been considered a primary activity because it is assumed that most users of the recreational resources are Montana residents.

Additional local economic activities, for example wholesale and retail trade and service industries, occur as a result of agriculture. These are considered "derivative" economic sectors. Essentially they depend upon the primary sectors for their existence. For example, owners and employees of local businesses in rural eastern Montana communities are directly dependent on farmers and ranchers; but indirectly, they are as dependent on the land resource base for a livelihood as are those who derive income from the land directly.

Another derivative effect of the primary economic activities is the revenue they provide to the state through income taxes and the revenue the land resources provides to local taxing jurisdictions through property taxes. The revenue provides employment for government workers and distributes income through government nonwage expenditures.

Table 59 shows Montana's direct agricultural employment, total primary employment, and total state employment. It also shows other primary manufacturing employment dependent on direct agricultural employment, such as meat packing and grain mill products. It is also assumed that a large portion of railroad employment depends on the transportation needs of basic agriculture, so half of the total railroad employment in Montana has been included for the selected years.

Total agricultural employment declined by a third between 1950 and 1975, reflecting its decreasing labor intensity. Agriculture remains the single largest employer among Montana's primary industries, accounting for 47 percent of Montana's primary employment in 1975.

Table 59

Montana Employment—Agriculture, Primary and Total, 1950-1975. (thousand jobs)

	Agriculture (direct)	Agriculture (related)*	Total Agriculture	Total Primary**	Total Employment
1975	34.3	4.5	38.8	83.9	303.1
1970	36.1	4.9	41.0	85.1	262.7
1965	35.2	5.1	40.3	84.5	246.5
1960	39.2	5.8	45.0	86.6	236.9
1950	52.8	8.4	40.3	103.3	228.5

*Includes meat packing and grain mill products plus half of railroad transportation.

**Includes agriculture, mining, manufacturing, railroads, and federal government.

Sources: References 67, 172, and 246.

Roughly two-thirds of the direct agricultural employment is composed of farm proprietors (365).

A complete picture of agricultural employment also must account for the derivative employment dependent on agriculture. In 1975 there were 2.6 jobs statewide in derivative industries for each job in a primary industry (246). Because the figure represents urbanized western Montana as well as rural eastern Montana and because there is a tendency for derivative jobs to increase in proportion to primary jobs as an area becomes populated and developed, a more conservative 1.5:1 ratio was presumed to prevail between derivative jobs in Montana and agriculturally related primary jobs on which they depend. If this assumption is accurate, then Montana's 38,800 primary agricultural jobs in 1975 generated an additional 58,200 derivative jobs in local industries for a total of about 97,000 agriculturally related jobs statewide. Thus agriculture accounted for a third of the state's total employment in 1975. It may be concluded then, that about 30 to 35 percent of Montana's jobs are dependent on agriculture.

Because the principal concern here is with wheat and beef production, it is instructive to compute how much employment wheat and beef production activities contribute to Montana's agricultural economy. The acreage devoted to wheat and range livestock as well as for other inputs, such as hay and barley, is known. When acres devoted to range and pasture are added to wheat, hay, and half of the barley acreage, the total is 67.6 million acres, or 88 percent of the total agricultural acreage in the state. Acreage is not necessarily proportional to employment. Nevertheless, it is probable that nearly 9 out of 10 agriculturally related jobs in Montana are related to wheat and beef production.

Table 60 shows agricultural employment and total employment in Montana for the state's two environmental regions. Almost three out of four agricultural jobs are in Great Plains Montana. This is understandable because 80 percent of the agricultural acreage is in the eastern two-thirds of the state. Twenty-six percent of all the jobs in Great Plains Montana are directly agricultural, when Cascade and Yellowstone counties are excluded. Using the earlier assumption of 1.5 derivative jobs for each primary job this means that for eastern Montana areas outside Cascade and Yellowstone counties, almost two out of every three jobs is dependent on agriculture. In Rocky Mountain Montana, agriculture is directly responsible for 7 percent of the jobs; nearly 17 percent when indirect employment is considered.

A discussion of the employment impact of agriculture would be incomplete without mentioning its seasonal nature. Peak direct employment is in midsummer and since 1970 has averaged 50,000 jobs. This is twice the average of 24,000 jobs held in agriculture during the midwinter months, and 30 percent higher than the annual average of 35,000 jobs.

Income is derived from the production and exchange of agricultural products and, until 1973, from large government payments. Figure 27 shows total cash receipts along with cash receipts from cattle and calves, wheat, hay, and barley (one-half) for the years 1950 through 1975.

Travel Promotion Unit, Mt. Dept. of Highways

Table 60
Agricultural and Total Employment in Great Plains and Rocky Mountain Montana, 1974.

(thousand jobs)

	Agriculture (direct)	Percent of Total	Total
Great Plains Montana*	22.4	26	86.0
Great Plains Montana**	25.7	16	160.0
Rocky Mountain Montana***	9.7	7	141.0

*Includes the following labor market areas: Glendive, Miles City, Glasgow, Lewistown, Hardin-Red Lodge, Shelby and Havre.

**Includes Billings and Great Falls in addition to those mentioned in footnote (*).

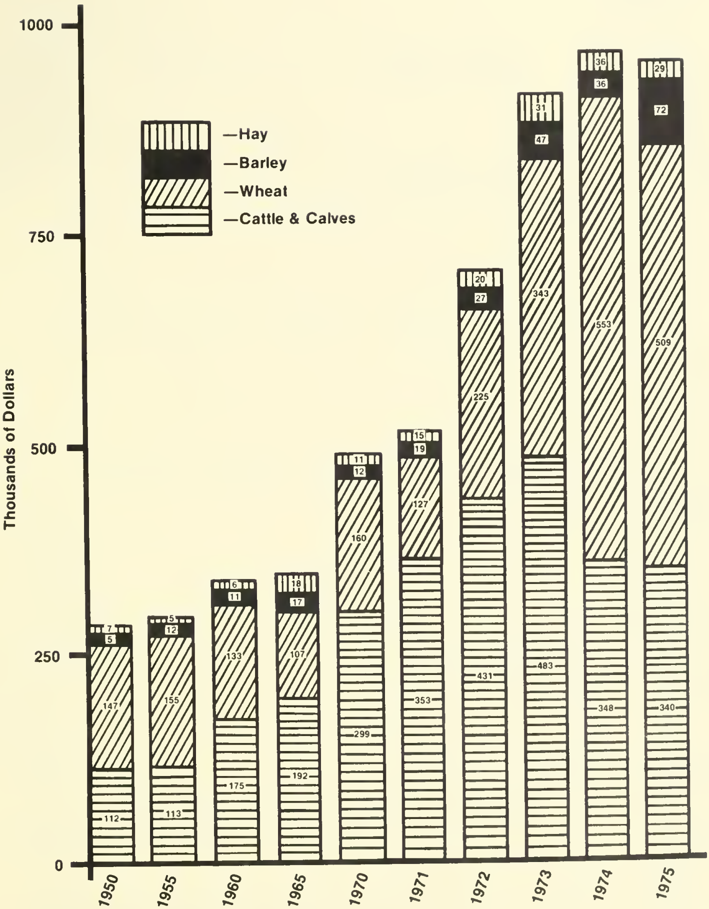
***Includes the following labor market areas: Bozeman, Anaconda-Butte, Helena, Kalispell and Missoula.

Source: Reference 86.

Receipts from the agricultural commodities shown in Figure 27 have remained remarkably stable at about 80 percent of total agricultural receipts. Even though substantial swings in prices in the individual crops are evident, grain and animal prices generally run in a counter-cyclical pattern: when grain prices are high, animal prices are depressed, and vice-versa. Data on receipts and production values are given for wheat, hay, barley, and cattle and calves in Figures 28 through 31.

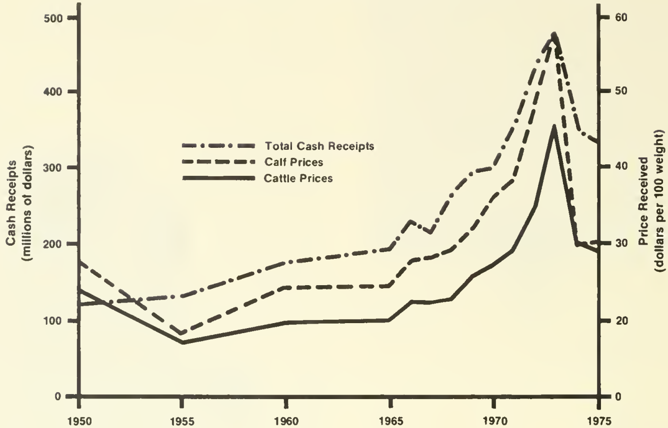
The relationships between cash receipts, realized net farm income, and personal income (earnings) directly attributable to Montana agriculture are described in Figure 32. For the years shown, earnings in the agricultural sector ranged between 43 and 59 percent of total farm cash

Figure 27 Montana Agricultural Cash Receipts, 1950-1975.



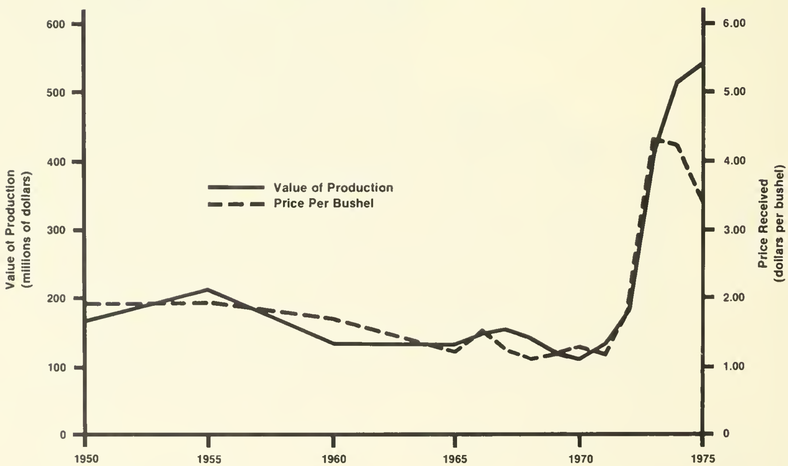
Sources: References 208, 211, 220, 223, 231, 232 and 358.

Figure 28 Montana Cattle and Calf Prices and Cash Receipts, 1950-1975.



Sources: References 208, 223, 231 and 232.

Figure 29 Montana Wheat Prices and Value of Production, 1950-1975.

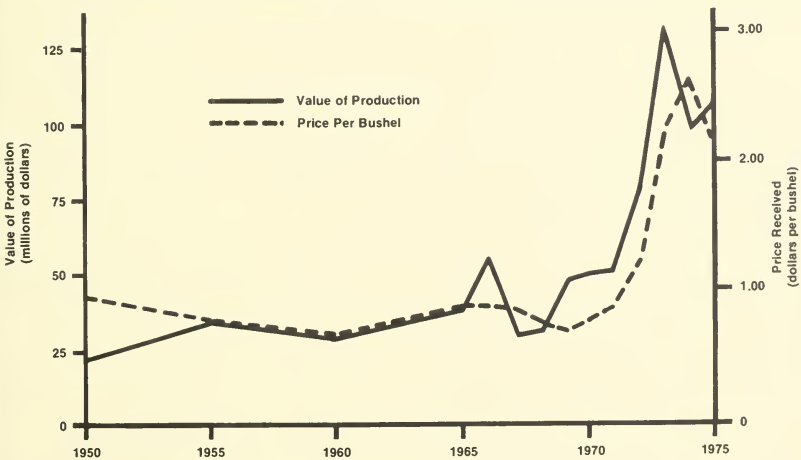


Sources: References 208, 220, 231 and 232.

Figure 30 Montana Hay Prices and Value of Production, 1950-1975.

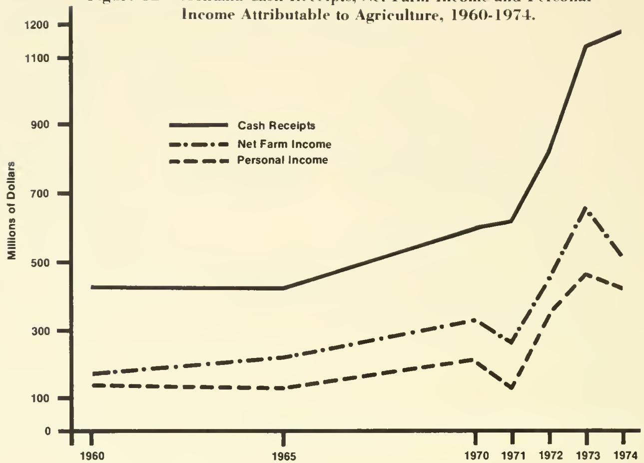
Sources: References 208, 220, 231 and 232.

Figure 31 Montana Barley Prices and Value of Production, 1950-1975.



Sources: References 208, 220, 231, and 232.

Figure 32 Montana Cash Receipts, Net Farm Income and Personal Income Attributable to Agriculture, 1960-1974.



Sources: References 358 and 361.

receipts. The variance is due to the relationship between receipts and costs of production for each year and changes in farm inventories.

Table 61 shows total earnings for Montana and total earnings resulting from farm activities for selected years since 1960. Estimates of earnings derived from the other primary economic activities associated with agricultural production (manufacturing, food and kindred products,

Table 61

Total Montana and Agricultural Sector Personal Income (Earnings), 1960-1974.

(millions of dollars)

Year	Montana	Agriculture (direct)	Agriculture (related)	Agriculture (total primary)	Percent of Montana
1974	2819	514	59	573	20
1973	2746	664	56	720	26
1972	2287	448	51	499	22
1971	1939	269	45	314	16
1970	1883	323	44	367	19
1965	1374	208	36*	244	18
1960	1110	183	30*	213	19

*Railroad share estimated because data are withheld under government regulation.

Sources: References 67, 86, 246, and 304.

and railroad transportation) have been added to the data. It has been assumed that the same proportions for employment hold for earnings attributable to agriculture in these additional sectors.

Total earnings derived from agriculturally related activity ranged between 16 and 26 percent of total Montana earnings for the years shown since 1960. In 1974, the last year for which data are available, agriculturally derived earnings were 20 percent of the state's total. At the same time they represented 44 percent of the state's total earnings derived from primary economic activities (361). This is very close to agriculture's 47 percent share of employment derived from primary activities and reinforces its position as the most important primary economic activity in Montana.

In 1974 there was $1.20 of derivative personal income for each dollar arising from primary activities. Because the income effect of the agricultural sector is more direct than its employment effect, it has been assumed that the relationship between agriculture and its derivative income will be close to that between primary and derivative income prevailing for the state as a whole. Using a 1:1 relationship, the $573 million derived from Montana's agriculturally related activities in 1974 generated a total of $1,146 million dollars in earnings statewide or about 40 percent of the state total. This is a greater share than agriculture's direct and indirect contribution to Montana's employment and is understandable due to agriculture's pronounced impact on incomes.

This strong income effect is also recognizable when regional income relationships are studied. Table 62 shows total and agricultural income for Montana's two major environmental regions. The difference in agriculture's share of income between Montana's two regions is striking. Agriculture directly contributed 56 percent of Great Plains Montana income (35 percent when Yellowstone and Cascade counties were included). In Rocky Mountain Montana agriculture's share was only 8 percent.

Another manifestation of the importance and strength of agricultural income is its direct relationship to state per capita income. Real earnings per employe (adjusted for inflation) in the agricultural sector increased 140 percent between 1968 and 1973 (from $5,000 to over $12,000). The substantial increase was the principal factor in Montana's 12 percent increase in real per capita income during those same years.[35]

Again, because the focus is on wheat and beef, it is of interest to know how much wheat and beef production activities contribute to Montana's agricultural income. The most logical computation using existing data would assume cash receipts are directly proportional to income. In this case, wheat and beef account for 80 percent of total farm cash receipts. It seems fair, then, to assume that 80 percent of Montana's agricultural income is based on wheat and beef production.

Agriculture also directly contributes to state government revenue. If agriculturally related earnings are 40 percent of the state total and earnings constitute three-fourths of Montana's personal income, then about 30 percent of Montana's personal income taxes can be attributed to agriculture. The Governor's Office of Budget and Program Planning has estimated that personal income taxes will total $146 million in the 1977 biennium. If its share were indeed 30 percent, or $44 million, agriculture would account for about 13 percent of the total general fund account revenues for the biennium, estimated at $336 million (276).

Montana's range, pasture and cropland also yield property tax revenues for local taxing jurisdictions. A rough idea of the importance of agricultural land to local authorities can be gained by studying the assessed valuation in the two major environmental regions of the state. Table 63 shows that about 18 percent of the total assessed

[35]The Montana Environmental Quality Council's *Fourth Annual Report* (1975) summarizes many facts on statewide employment and income as part of a general system of environmental indicators.

Table 62

Agriculture and Total Personal Income (Earnings) in Rocky Mountain Montana and Great Plains Montana, 1973.

(thousand dollars)

	Agriculture (direct)	Percent of Total	Total
Great Plains Montana	529.8	56	954.2
Great Plains	571.9	35	1629.7
Rocky Mountain Montana	85.4	8	1068.8

Source: Reference 365.

Table 63

Total Assessed Valuations and Assessed Values of Montana Agricultural Land Resources, 1974. (millions of dollars)

	Rocky Mountain Montana	Great Plains Montana	Great Plains* Montana
Total	1697.9	2307.2	1620
Cropland			
Irrigated	18.5	27.0	24
Nonirrigated	25.0	169.4	160
Range and Pasture (inc. wild hay)	39.0	104.0	99
Total Agricultural Land	82.5 (5%)	304.4 (13%)	283 (17%)

*Excluding Yellowstone and Cascade counties.

Source: Reference 250.

valuation of Great Plains Montana, including Yellowstone and Cascade counties, is due to cropland, range and pastureland; the figure for Rocky Mountain Montana is 5 percent. Unlike most other property taxes, which are levied against market values, assessments against agricultural land are based on the value of the production potential of the land. Revenue to local authorities would be higher if agricultural land were assessed at the current value of potential production: assessments have remained unchanged since 1962 (82).

ECONOMIC IMPACT OF FORESTLAND USES

Montana's forestland has five major outputs which provide economic value to the state and its citizens: timber, water, wildlife and associated recreational amenities, forage for grazing, and minerals. All are renewable except minerals, which for that reason will be excluded from further analysis here.

As with agriculture, the traditional, accepted method of measuring the value of the foregoing outputs is in terms of employment and income. Timber and perhaps grazing are the only outputs which lend themselves easily to this type of analysis. Difficulties in concept and definition abound when one attempts to apply this same type of analysis to recreational opportunities. And water does not lend itself easily to market analysis due to its diffuse ownership and varied uses, some of which are difficult to quantify economically. Hence, water has traditionally been discussed from the perspective of its social value, which makes it hard to deal with in economic analysis that works for some of the other outputs.

Like the agricultural products industry which produces for export out-of-state, Montana's wood products industry is known in economics as a "primary" economic sector. It likewise serves as a driving force for "derivative" economic sectors which provide goods and services for the wood products industry and its employees.

Receipts from timber harvesting in national forests in Montana also provide the bulk of the so-called "25 Percent Fund"[36] revenues that flow to the counties within which the forests stand. Additional money from timber sales is earmarked under the Knutson-Vandenburg Act for stand regeneration and management. Access roads in the public forests are financed by reducing public timber prices to purchasers. Purchasers promise in the bid to be responsible for road construction.

Table 64 shows employment in Montana's wood products industry and additional employment in related primary sectors. It was assumed that half of the U.S. Forest Service's Montana employees manage and market timber from national forests. It was also assumed that, like agriculture, the wood products industry generates demand for railroad transportation—in this case, one-eighth of the state's railroad movements.

Employment in the wood products industry has been a bright spot in Montana's recent economic history. Between 1950 and 1974 direct employment nearly doubled, with the increases occurring mainly in counties lying west of the divide. In 1974 there were an estimated 9,800 people employed directly in the wood products industry statewide

[36]See p.109 for a discussion of the 25 Percent Fund.

Table 64

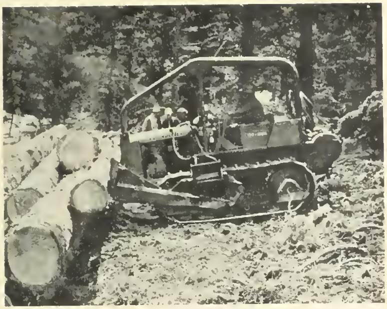
Montana Employment—Wood Products, Primary and Total, 1950-1975. (thousand jobs)

	Wood Products (direct)*	Wood Products (related)**	Total Wood Products	Total Primary	Total Employment
1975 (est.)	9.1	2.6	11.7	83.9	303.1
1974	9.8	2.6	12.4	86.4	301.0
1970	8.6	2.4	11.0	85.1	262.7
1965	8.9	n.a.	n.a.	84.5	246.5
1960	7.4	n.a.	n.a.	86.6	236.9
1950	5.4	n.a.	n.a.	103.3	228.5

*Includes logging, sawmill and planing mills, plywood and millwork, particle board, pulp and paper mills, and miscellaneous wood products.

**Includes one-half of Forest Service employment and one-eighth of railroad transportation.

Sources: References 67, 100, 171, and 246.



USDA Forest Service photo by Phil Schlamp

and an additional 2,600 employed in other primary sectors heavily dependent on the timber industry. Employment related to wood products is estimated at 12,400 or 14 percent of Montana's total primary employment. This figure also represents 4 percent of Montana's total employment. The distribution of direct employment in 1974 was as follows: sawmills, 60 percent; logging, 18 percent; plywood and millwork, 12 percent; the remainder largely being the two particle board plants and a pulp and paper mill.

The increasing diversification of the wood products industry has led naturally to a reduced relative importance of logging and sawmill operations. Growth in employment since 1960 has occurred largely because of new plywood, paper, and particle board plants. There also has been an increasingly strong but localized demand for post and pole operations, house logs, and custom wood products.

Estimates of the contribution of the wood products industry to Montana's employment also must include the derivative employment that depends on the continued operation of the timber industry. Statewide, in 1975, there were 2.6 jobs in derivative industries for each primary industry job. This figure prevails in western Montana and will be used to estimate the derivative employment associated with the wood products industry. This means the 12,400 primary jobs were responsible for an additional 32,200 derivative positions, or a total of about 47,700 jobs statewide. This is 16 percent of the state's 1975 employment.

Table 65 shows wood products industry employment by geographical area. Almost all of the jobs are in Rocky Mountain Montana. Of these a substantial portion, about three-fourths, are in three northwestern Montana counties; Missoula with over 3,000, Flathead with about 1,900, and Lincoln with close to 1,600 (304). In the last decade the wood products industry has become even more centralized in these counties with the closing of economically weak, small mills in outlying areas and the large investments by major corporations in expanded (sawmill, pulp and paper) and new operations (particle board, plywood) in these areas.

While 8.5 percent of jobs in Rocky Mountain Montana are directly attributable to the wood products industry, about 30 percent of jobs are dependent on direct and derivative employment. The figures are much higher for the several counties in which the timber industry is concentrated. For example, in 1971 there were seven western Montana counties in which over 10 percent of the employment was attributable directly to the wood products industry: Lincoln, 23 percent; Mineral, 22 percent; Sanders, 17 percent; Meagher, 14 percent; Flathead and Missoula, 12 percent; and Granite, 10 percent (304)(365).

The figures would be higher still for Missoula, Flathead and Lincoln counties with the inclusion of Forest Service employees. Although estimates of derivative employment in small geographical regions are subject to error, it is probably fair to assume that the wood products industry is ultimately responsible for up to twice as many jobs in these western Montana counties than the figures indicate.

Like agricultural employment, wood products related employment is seasonal. Peak employment is July through October when roads are dry and the woods accessible. Low employment is in late spring. On average, since 1970 1,800 more persons were employed during the peak period than the low period.

Personal income in the wood products sector is derived from the sale and harvesting of timber and sale of the raw materials and manufactured products, such as rough and finished lumber, plywood, particle board, pulp and paper, and other products.

Although the available data are very sketchy, there has been a steady upward trend in the value of Montana's timber products. This is most evident in the stumpage (timber minus cost of harvest and profit) price data presented earlier in Table 43, because stumpage prices represent a fairly accurate gauge of the future prices of the

Table 65

Wood Products and Total Employment in Rocky Mountain Montana and Great Plains Montana, 1974

(thousand jobs)

	Wood Products (direct & related)*	Percent of Total	Total Employment
Great Plains Montana	.4	.3	160.0
Rocky Mountain Montana	12.0	8.5	141.0

*Derived by applying geographical ratios prevailing in 1971 to 1974 total employment data.

Sources: References 67, 86, 246, and 304.

products manufactured from raw timber. Between 1965 and 1974, stumpage prices on public land in Montana increased about three-fold; six-fold, if 1973 prices are used. The increased stumpage prices were closely paralleled by the increasing value of Montana's lumber output. The average wholesale value of 1,000 board-feet doubled between 1967 and 1974 (400) (401). Wholesale prices of plywood products also approximately doubled between the same years (292). Price increases of close to 100 percent for pulp, paper products and particle board also have occurred in the last several years.

Increases in the price and value of industrial output do not necessarily indicate earnings gains for Montanans working in the forest industry, but they do mean that the industry retains the ability to pay higher wages to its employees.

Table 66 presents data on personal earnings in Montana and in the wood products industry for recent years. The wood products sector, including related income, in 1974 accounted for 5 percent of the state's total earnings; 12 percent of the state's earnings derived from primary economic activities (361).

In 1974 there was $1.20 in derivative earnings for each dollar of earnings generated in the primary sectors. Using this figure to discern the total income effect of wood products industry yields a net income contribution in 1974 of roughly $330 million or 12 percent of Montana's total personal income. Thus slightly more than one dollar in 10 of Montana personal earnings was attributable to the wood products industry in 1974.

Current regional earnings data are not available for the wood products industry but a recent study (171) estimated that close to 90 percent of wood products related earnings in 1969 originated in eight western Montana counties: Missoula, Flathead, Lincoln, Sanders, Ravalli, Lake, Mineral, and Granite. In these counties about 20 percent of the total earnings was from the forest industry. When five other Rocky Mountain Montana counties are included (Meagher, Powell, Broadwater, Gallatin, and Park), the portion of total earnings derived from this sector still remains high, about 15 percent.

Assuming that the 1969 estimate of wood products earnings closely approximates conditions prevailing today and assuming that each dollar of direct earnings contributes 1.2 additional dollars of earnings, then the wood products industry can be said to contribute about one-third of the earnings in these counties, and a somewhat larger share in the eight-county area.

Table 66

Total Montana and Wood Products Sector Personal Income (Earnings), 1960-1974.

(millions of dollars)

Year	Montana	Wood Products (direct)*	Wood Products (related)**	Wood Products (total primary)	Percent of Montana
1974	2819	107	43	150	5.3
1973	2746	100	40	140	5.1
1972	2287	86	36	122	5.3
1971	1939	82	33	115	5.9
1970	1883	72	31	103	5.5
1965	1374	57	21***	78	5.7
1960	1110	38	16***	54	4.9

*Pulp and paper figures estimated due to data withheld for years prior to 1973.

**Income of federal employees allocated on basis of forestry related share of total employees.

***Railroad share estimated because data are withheld under government regulations.

Sources: References 361 and 366.

National forests provide revenue to Montana counties in the form of the so-called "25 Percent Fund." The fund is federal government revenue from the sale of timber, grazing permits, user fees, minerals, and other sources. One-quarter of the fund, or 25 percent, is returned to the counties within which the forests stand. The revenue is distributed in proportion to the area of national forest in the county. Forest revenue changes with use. For example, recently nearly 100 percent of the revenue arising from the Lolo National Forest was derived from timber sales. About three-fourths of the revenue from the Helena National Forest for 1974 was associated with sale of timber. For the same year 40 percent of the revenue derived from the Beaverhead National Forest was from timber sales. The principal source of nontimber revenues in the forests is grazing permits (313).

Receipts from timber sales will, of course, depend on the amount of timber cut as well as its quality. Comparison of Beaverhead and Lolo national forests in 1974 shows this variation. In the former, net revenue per 1,000 board feet averaged $5.46; for the latter the same figure was $38.98 (313).

Table 67 shows federal payments to Montana counties for three selected years. Three of the counties, Flathead, Lincoln and Sanders, received 60 percent of all such payments in Montana in 1974. Although the trend in federal payments has been generally upward (a two-to four-fold increase for most of the counties shown since 1967), significant annual variations in payments can and do occur (313).

Montana law currently requires that two-thirds of a county's receipts from the 25 Percent Fund be allocated to the county road fund and the remaining one-third to the county elementary school district. The road fund money can be very significant. During the period 1961-74, road fund receipts for the counties listed in Table 67 ranged from 5 percent of total county highway expenditures (Park County) to 150 percent (Lincoln and Mineral) (313).

In most counties the portion accruing to the school fund represents a smaller percentage of total elementary school expenditures than the road fund share, ranging from about 1 percent in some western Montana counties (including Missoula County), to an average of about 15 percent in Mineral and Sanders counties (313).

In 1975, about $3.5 million was allocated from timber sales under the Knutson-Vandenburg Act for timber management in Montana's national forests. The major shares went to Lolo National Forest, 31 percent; Kootenai, 21 percent; and Flathead, 16 percent. Timber sales also financed 37 percent of the road construction in the same forests in 1975, or about $6.3 million of total expenditures of $16 million (100).

About 90 percent of the money from timber sales administered by the Bureau of Indian Affairs is returned to the respective reservations, as are matching funds for forest improvement work. In 1973, $3.9 million was distributed in this way, 96 percent of which went to western Montana's Flathead Reservation (304).

Montana's forestland base and the wood products industry account for about 12 percent of the state's total

Table 67

"25 Percent Fund" Payments to Selected Montana Counties, 1961, 1967, and 1974.

County	1961 Fund Payments	1961 Percent of total	1967 Fund Payments	1967 Percent of total	1974 Fund Payments	1974 Percent of total
Beaverhead	$ 19,848	3.88	$ 20,875	1.49	$ 47,786	1.13
Flathead	92,354	18.06	279,725	19.97	888,559	20.97
Granite	16,148	3.16	42,468	3.03	154,112	3.64
Jefferson	5,716	1.12	10,492	0.75	38,059	0.90
Lake	7,901	1.54	23,736	1.69	80,152	1.89
Lewis & Clark	17,232	3.37	33,020	2.36	104,427	2.46
Lincoln	114,918	22.47	209,375	29.23	1,018,189	24.03
Meagher	5,302	1.04	5,621	0.40	14,248	0.34
Mineral	32,222	6.30	97,566	6.97	374,372	8.20
Missoula	33,676	6.58	102,259	7.30	351,428	8.29
Park	9,996	1.95	7,621	0.54	21,273	0.50
Powell	23,105	4.52	65,104	4.65	221,082	5.22
Ravalli	9,932	1.94	63,584	4.54	158,756	3.75
Sanders	57,489	11.24	166,233	11.87	619,979	14.63
All other Counties	65,588	12.82	72,817	5.20	171,313	4.04
	$511,427	100.00	$1,400,476	100.00	$4,236,735	100.00

Source: Reference 313.

earnings. Because earnings constitute roughly three-fourths of Montana's total personal income, approximately 9 percent of the state's personal income taxes may be due to the wood products industry. Nine percent of the personal income tax receipts estimated for the 1977 biennium is about $13 million, which in turn is about 4 percent of the total general fund account revenues expected during the biennium.

The state's private timberland is taxed to provide local property tax revenues. Timberland is taxed based on the quality of timber and the stand volume. Value of the timberland for grazing is also involved in the tax calculation (82).

In 1975, 23 Montana counties included timberland on their assessment rolls. Assessed values ranged from $2.17 per acre (Deer Lodge) to $10.96 (Lincoln) (59). It is estimated that the assessed values represent about 5 to 10 percent of current market values (82).

In 1975 timberland in five western Montana counties contributed more than 3 percent of each county's total assessed valuation: Lincoln, 6.6 percent; Mineral, 5.6 percent; Powell, 5.3 percent; Granite, 3.4 percent; and Sanders, 3.3 percent (250). However, in the same year only 3 million acres of Montana were classed as timberland: a significantly smaller amount than 5.1 million acres of private commercial forestland identified earlier.

FORESTLAND AND ITS VALUE FOR RECREATION

As difficult as it is to define "recreation," it should be no surprise that it is nearly impossible to ascribe an economic value to its existence and use. This value takes many forms. Some of it is in the spiritual enjoyment derived from living amidst natural beauty. Although a satisfied spirit is not subject to economic analysis, it has economic value nonetheless. More concretely, the value placed on recreational pursuits is viewed in terms of expenditures by recreationists, in-state employment arising from the expenditures, and income to Montanans from the expenditures and employment. Three major sets of questions need to be answered before a quantitative economic valuation of recreation can be determined:

1. Who are recreationists? Are they all who spend dollars in Montana in recreational pursuits, including residents, or only nonresidents who travel to or through Montana? What recreational activities should be included? How should people who combine business with pleasure be treated? Should seasonal residents be considered tourists?
2. Where do the identified recreationists spend their money? What share of the residents' expenditures should be ascribed to Montana's recreational opportunities?
3. What does the economic activity in recreation mean for employment and income? How much of the business of the recreation establishment depends on recreationists? What does this mean in terms of employment? How can recreation revenue be related to profits and wages, and hence to earnings of proprietors and employees? Can secondary employment be estimated? Does it depend on the definition of recreationists used at the outset? These issues serve to indicate the many conceptual difficulties inherent in the economic valuation of recreation. However, some initial work in this area has been done and may serve as a starting point.

Only one source estimating employment dependent directly on the recreation business has been identified in this study (157). The procedure was to allocate percent shares of employment in the basic economic sectors connected with recreation. Allocations were based on the employment difference during months of low and high activity. Subjective assumptions were necessary regarding the share of the difference attributable to recreation. The assumptions and 1975 employment figures in recreation are given in Table 68. This shows that about 32,000 jobs, or 11 percent of Montana's employment is derived from recreation. A more conservative estimate can be made using the same basic approach and assuming smaller percentage shares due to recreation: contract construction, 2 percent; transportation and public utilities, 2 percent; wholesale and retail trades, 15 percent; services, 10 percent; government, 5 percent; and other, 5 percent. The latter assumptions yield an estimated employment of about 18,800, or about 6 percent of the state total. Applying these conservative estimates of recreation reveals that earnings accruing to Montanans from use of recreation are $142 million, or 5 percent of the state's total.

Another method of estimating recreation revenues uses tourist expenditure data developed by the Montana Highway Department. The calculation is based on three important assumptions. First, that today's tourist count can be approximated by updating 1963-64 surveys, based on annual sampling. Second, that 1963-64 data showing persons per party and length of stay approximate that prevailing today. Third, that expenditures per party per day estimated in 1963-64 can be adjusted upward by the rate of inflation.

Using these assumptions, the Montana Highway Department estimated that resident and nonresident tourists spent $274 million in Montana in 1974. It has also been estimated that in 1967, 22 cents of each dollar of tourist expenditures accrued to Montanans as earnings (283). The $274 million would then result in about $60 million in earnings for Montanans. This is less than half that yielded by the more conservative earlier calculation and is about 2 percent of total earnings in Montana.

It might be fair to assume that the actual income effect of Montana recreation resources today is somewhere between the two estimates. The low estimate, based on 22 cents in earnings per $1 of expenditures, has been acknowledged as underestimating the true earnings by tourists for other than trade and services. Correcting for expenditures in other sectors (utilities and manufacturing, for example) would result in an average figure slightly higher than 22 cents per dollar receipts. The low estimate also is conservative in that it failed to take into account the effects of spending by Montanans that followed the tourist spending. Another omission was the exclusion of revenue from hunting and fishing licenses, which support Montana Fish and Game Department programs and employees. At any rate, the estimates show that income accruing to Montanans from recreational resources may have been from $60 million to $140 million or perhaps as high as $250 million in 1974, or 2 to 8 percent of the state's total income.

Table 68

Montana Employment and Estimated Employment Ascribed to the Recreation Industry, 1975.

Sector	Employment	Percent Due to Recreation*	Employment due to Recreation
Manufacturing	22,200	1	200
Mining	6,700	0	0
Contract Construction	12,400	5	600
Transportation & Public Utilities	19,200	5	900
Wholesale & Retail Trade	59,900	20	11,900
Finance, Insurance, Real Estate	10,200	5	500
Services	44,900	25	11,200
Government	64,900	5	3,200
Agriculture	34,300	2	700
Other	30,900	10	3,100
Total	303,100	10.7	32,300

*Dr. Horvath's assumptions.

Source: Reference 157.

PART III

TRENDS AND PROSPECTS: IMPLICATIONS FOR THE FUTURE OF MONTANA'S RENEWABLE RESOURCES

CHAPTER 9 NATIONAL TRENDS IN THE USE OF AGRICULTURAL LAND

WORLD POPULATION AND FOOD DEMAND

The seemingly inexorable growth in world population and generally rising levels of affluence have led to a continually increasing demand for food and animal feed grains worldwide. World population grew from 2.8 to 4.1 billion during the last 15 years and is now increasing at the rate of 2.2 percent annually, or about 70 million persons per year (349). Grain is a basic need of each of them. Spreading affluence increases the demand for animal feed grain too by advancing per capita demand for meat. Table 69 shows that per capita grain demand has been increasing in the developed western economies (including the U.S.) at 1.4 percent per year since the early 1960s. The rate has been almost 3 percent per year in the Soviet Union and Eastern Europe.

Table 70 shows that growth in world per capita food production has kept pace with population over the past two decades. However, there has been a slight decline in the rate of growth in per capita food production. Growth in per capita food production has lagged in the developing countries; during the period 1962-1972, it averaged 0.3 percent per year compared with 1.7 percent per year in the developed countries. Population increases in the developing countries have remained constant over the past 20 years, averaging 2.4 percent per year. Population increases in the developed countries have been below that average throughout the period and have recently declined even farther.

The disproportionate growth in per capita food production between developed and developing countries has produced significant increases in world food trade. In the 1960-61 marketing year, 70 million metric tons[37] of major grains were traded. By 1973-74 the figure had more than doubled to 151 million metric tons.

Much of the increase was due to grain imports by developing countries. In the mid-1950s these countries were net grain exporters; by 1973 they imported more than 30 million metric tons. Imports by the Soviet Union and

[37] Metric Ton: Equivalent to 1.1 U.S. tons.

Table 69
Per Capita Use Of Grain in Developed Market Economies, the United States, Eastern Europe and the Soviet Union, Selected Years
(kilograms per year)

Years	Developed Market Economies*	United States	Eastern Europe and Soviet Union
1960-62	465**	757	534
1964-66	482	743	601
1969-71	530	723	680
1971-73	543	852	732

*Includes the United States
**Each of the figures is an average of three years. For example, those for 1960-62 are based on 1960/61, 1961/62, and 1962/63.

Source: Derived from Reference 169 based on consumption data (from Economic Research Service, World Agricultural Situation. *WAS-4, December 1973; WAS-5, September 1974; and WAS-6, December 1974), and population data (from Food and Agriculture Organization.* Production Yearbook, *various issues).*

USDA Forest Service photo by Phil Schlamp

Table 70

Growth Rate of Food Production in Relation to Population in World and Main Regions, 1952-62 and 1962-72.

(percent per year)*

Type of Economy	Food Production 1952-62 Population	Total	Per Capita	1962-72 Population	Total	Per capita
Developed market economies**	1.2	2.5	1.3	1.0	2.4	1.4
Western Europe	.8	2.9	2.1	.8	2.2	1.4
North America	1.8	1.9	.1	1.2	2.4	1.2
Oceania	2.2	3.1	.9	2.0	2.7	.7
Eastern Europe and USSR	1.5	4.5	3.0	1.0	3.5	2.5
Total developed countries	1.3	3.1	1.8	1.0	2.7	1.7
Developing market economies**	2.4	3.1	.7	2.5	2.7	.2
Africa	2.2	2.2	---	2.5	2.7	.2
Far East	2.3	3.1	.8	2.5	2.7	.2
Latin America	2.8	3.2	.4	2.9	3.1	.2
Near East	2.6	3.4	.8	2.8	3.0	.2
Asian centrally planned economies	1.8	3.2	1.4	1.9	2.6	.7
Total developing countries	2.4	3.1	.7	2.4	2.7	.3
World	2.0	3.1	1.1	1.9	2.7	.8

*Trend rate of growth of food production, compound interest.
**Including countries in other regions not specified.
Source: Reference 169.

China also influenced the increase in trade. Crop failures in those two countries forced them to purchase over 30 million metric tons of grain in 1973 (392).

Stocks of world grain remained fairly steady throughout the 1960s and by 1969 had reached record levels. In response, the world's major grain exporting countries—the U.S., Canada, and Australia—began to cut back grain production, principally wheat, in order to reduce the costs of maintaining reserves and to raise wheat prices. The policy worked. By the 1973-74 marketing year, wheat and coarse grain stocks in these three countries had been halved, from 111 to 58 million metric tons (Table 71). Reduced stocks of grain in the exporting countries, combined with increasing demand, caused a sharp reduction in world grain stocks, from 191 million metric tons in 1969-70 to 108 million metric tons in 1973-74. U.S. export prices of grains rose accordingly over the same period in response to the increased demand and reduced supply. Soybean prices rose 350 percent; wheat 300 percent; and corn 150 percent (296).

The increase in overseas demand and prices for U.S. food and feed grains had a number of impacts on agricultural land resources. First, farmers responded by increasing production. Nationally, there was a 60 percent increase in harvested wheat acreage, from 44 to 70 million acres between 1970 and 1975. Acreage devoted to corn, a leading indicator for all feed grain activity, increased 22 percent from 55 to 67 million acres. Increasing prices had the effect of reducing domestic demand for these grains for use as feed for livestock which had the net effect of slightly reducing total domestic demand for wheat and holding domestic demand for corn steady through the period. A 200 percent increase in exports of corn and a 100 percent increase in wheat exports kept reducing U.S. stocks of food and grains and maintaining high prices until the 1974-75 marketing year (354) (359).

A secondary effect of high grain prices was to force economic hardship on livestock producers. Until 1971 livestock producers had taken advantage of low grain prices by increasing the number of livestock on feed grain. As long as feed grain prices remained low and total slaughter held fairly constant, livestock producers enjoyed steadily rising returns. Fed cattle (those sold from the feedlot) prices increased 50 percent between 1967 and 1972, from about $22 per hundredweight to $33 per hundredweight (349).

A combination of events in 1973 changed the livestock

Table 71

Wheat and Coarse Grains Area Production, Net Exports, and Beginning Stocks of Major Exporting Countries, 1962-1975.

	United States				U.S., Canada, Argentina			
Year	Area (millions of Hectares)	Production (millions of metric tons)	Net exports (millions of metric tons)	Beginning stocks (millions of metric tons)	Area (millions of Hectares)	Production (millions of metric tons)	Net exports (millions of metric tons)	Beginning stocks (millions of metric tons)
1962-63	58.9	158.3	32.5	101.5	85.7	197.1	48.4	115.4
1963-64	60.9	170.8	39.9	91.0	87.9	215.0	64.4	109.4
1964-65	59.4	156.6	39.1	87.4	87.2	196.4	58.6	106.1
1965-66	58.9	179.2	49.8	71.9	86.6	219.2	71.7	90.9
1966-67	59.8	179.8	40.1	52.8	90.2	233.4	64.1	69.2
1967-68	64.6	203.3	41.5	45.3	95.5	241.4	56.9	68.5
1968-69	61.7	197.1	31.3	58.7	95.0	248.4	46.7	83.0
1969-70	58.0	200.1	35.4	67.8	88.5	248.5	54.9	106.2
1970-71	57.7	182.1	38.6	68.1	81.1	222.0	66.4	111.3
1971-72	62.3	232.4	41.6	50.0	91.2	283.3	70.6	80.7
1972-73	57.2	223.3	71.0	67.4	85.7	266.7	95.3	92.1
1973-74	63.3	232.3	71.1	41.1	94.2	284.0	93.7	57.9
1974-75	67.3	198.6	60.0	26.7	98.0	245.2	85.0	45.7

Source: Reference 296.

picture drastically. High feed grain prices put a severe pinch in the profitability of feedlots, causing a reduction in the demand for feeder cattle (those sold off the range to the feed lot). At the same time feeder cattle supplies were still increasing. The situation caused a sharp reduction in feeder cattle prices beginning in mid-1973. Over the next 18 months feeder cattle prices fell from over $60 per hundredweight to less than $30 (350). Many ranchers faced with potential losses on their cattle elected to retain their animals longer on range forage and sold only heavier animals to the feedlots—requiring less feedlot feeding of expensive feed grains. Fed cattle prices didn't increase enough to offset rising grain prices because domestic per capita meat consumption actually declined between 1971-75 in response to the declining growth of per capita income. So feedlot operators preferred to feed animals less grain (350). Hence, as feed grain prices increased, grass and hay from range and pastureland increased in value to ranchers, who began to depend more on it for livestock feed.

The energy crisis also has contributed to the increasing pressure for production on agricultural land in the United States. Increases in prices of foreign oil in 1973 resulted in a sharply deteriorated balance of payments. Because balance of payments and the stability of the dollar are overriding goals of U.S. international economic policy, maintaining a favorable balance of trade became a major policy objective. Federal officials recognized that agriculture was the only hope to retain a favorable trade balance. With an eye toward increased foreign trade, acreage restrictions were lifted on major grains in 1973. Total agricultural exports rose from $8 billion in 1972 to $22 billion in 1975. The strategy increased the agricultural trade balance, from $2 billion to $12 billion (see Figure 33) (355). Wheat and feed grains currently are contributing in equal shares about half of the nation's total agricultural exports and are therefore critical commodities in maintaining the nation's strong international economic position (350).

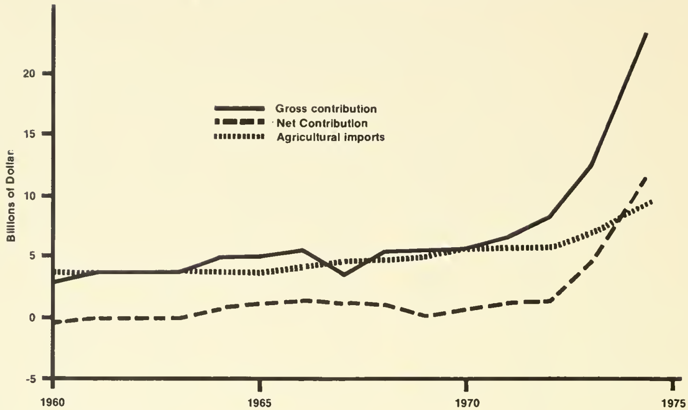
In a space of only five years, then, U.S. grain producers profited from reduction of grain reserves, climatic instabilities and crop failures elsewhere, and burgeoning demand for food. In contrast, U.S. beef producers suddenly saw feed grain prices rise, demand for cattle fall and profitability disappear.

Changing economic forces, though, are once again at work, reversing the economic climate for farmers and ranchers. Recent increases in food and feed grain supplies worldwide apparently have begun to offset demand; the result has been falling prices since early 1974. Wheat prices fell from around $5 per bushel to slightly over $3; corn prices from $3.50 per bushel to $2.50 (354) (359). Feeder cattle prices have begun to rise.

Much has been written about these unstable trends in demand. The recent decline in grain prices had been widely expected as the inevitable outcome of the transient conditions occurring in 1973. Prices should remain at or near current levels for a time, according to market analysts.

Perhaps the most important contributing factor to economic instability faced by American agricultural

Figure 33 Agriculture's Contribution to the Balance of Payments, 1960-1975.



Source: Reference 350.

producers is the steadily rising costs of production, largely forgotten in face of the sudden recent price increases of agricultural products. It is important to remember that prices farmers pay for all goods have been steadily rising. The index of all prices paid by farmers doubled between 1963 and 1975. Over the same period the index of all prices received by farmers and ranchers increased only 50 percent (350). The divergent long-term trend promises to be increasingly troublesome. All indications are that the prices of principal agricultural inputs, such as energy, machinery, and chemicals, will continue rising. Capital shortages and the continuing demands on agricultural land for nonagricultural purposes mean that land prices may continue rising as well. Water also is increasingly scarce, particularly in the west where multiple demands are being placed on it.

Whether international food demand will cause price increases offsetting the advancing costs of production is a question receiving much attention because of its importance to U.S. monetary strength, agricultural policy, foreign policy and environmental protection. The question is essentially two-part, one dealing with growth in demand for grain worldwide, the second concerning the potential for increased food supply in the world.

Estimates of growth in world demand for cereal grains range from 2.3 to 3 percent per year. The developing countries are expected to cause the most grain demand—3 to 4 percent per year through 1985—due primarily to population growth. The developed countries are expected to demand 1.7 to 2.8 percent per year more grain, mostly for conversion to meat and dairy products. Projected increases in per capita income in the developed countries will contribute to the increased demand for animal feed grain although the rate of expansion of world trade in meat is expected to slow somewhat. Meat prices are not expected to keep pace with grain price increases (349).

Predictions concerning food supply are contingent on more complex, less predictable variables than for food demand. It is generally agreed that the developed countries have some capacity to increase food production, barring unforeseen climatic changes and assuming the availability of required land, water, energy, and capital. Widely debated is the extent to which the environmental impacts of intensive food production will impair the self-regenerative capacity of agricultural land and whether societies will accept environmental degradation in the interest of raising food for others (110).

Also generally acknowledged is that population in developing countries will outpace food production. It has been estimated that the potential deficit in grain production in these countries may approach 71 million metric tons by 1985 and 155 million metric tons by the year 2000 (110) (349). Because the total grain import requirements of these countries was about 30 million metric tons in 1973, the increasing deficit would cause a 200 percent increase in grain import requirements by 1985 and a 500 percent increase by the year 2000. At least half of the imports would have to be supplied from U.S. production because the United States has been the world's leading exporter of grains and soybeans, accounting for two-thirds of the world's grain exports and 90 percent of the soybean exports in 1975 (110).

The extent of the grain deficit will depend on five factors: availability of natural resource inputs, ecosystem stability, technological advances, institutional constraints, and climatic patterns. Expansion of cultivated acreage in the developing countries is limited to only a few areas where fertile land remains uncultivated. Conversion to agriculture of land not already considered "fertile" would be more costly than increasing yields on land already under cultivation (33) (169) (392). Hence future food production increases will come more from increasing yields than bringing new land under cultivation (111).

Increasing yields will depend on availability and cost of energy, water, chemicals, and capital, and the ability to maintain the land's productivity under increasingly intensive cultivation. Also important are institutions which provide incentives for and make available technological innovations. The ability of the developing countries to fulfill the needed conditions is in serious question. Water, energy, fertilizer, and capital are not abundant today and the prospects for tomorrow are, at best, uncertain (33). Even less assured are the tremendous investments required to provide the inputs and disseminate the necessary technological know-how to farmers in developing countries. There is simply no foreseeable way that the developing countries could raise this capital internally and prospects for transfers of the required money are dim.

In an article entitled, "Institutional Obstacles to Expansion of World Food Production," Pierre Crosson examined in depth the situation in developing countries and concluded (111):

> Development of new technology, the fundamental condition for continued long-term growth, is basically a public responsibility because the gains from [its] adoption usually cannot be sufficiently captured by private institutions to justify their assuming the cost... The lack of a well-defined mechanism that would link responses of public institutions to the large social payoffs to increased public investment in irrigation, new technology, and technical abilities of farmers may prove in the long run to be the most important single obstacle to adequate growth of food production in the LDC's [Developing countries].

The final contributing factor to the increasing uncertainty surrounding increased food yields in the developing countries is the trend toward deteriorating ecosystems. In an as yet unpublished book *Losing Ground: Environmental Stress and World Food Prospects*, Erik Eckholm raises the possibility that already existing indications of environmental stress, such as overgrazing, deforestation, expansion of deserts, soil erosion, silting of irrigation reservoirs, and increased flooding may be precursors to even more serious environmental problems resulting from future population pressures and intensive agriculture (33).

Thus there is great uncertainty whether developing countries can increase food output. The United States will be one source for food supplies if food production is inadequate in developing countries. It is also likely that United States policy will continue to encourage food exports for two reasons: to maintain grain prices adequate to offset production costs and to improve the balance of trade and the strength of the dollar. These international economic policies could even act to deter United States efforts to assist developing countries to increase food production because successful efforts would be counterproductive of U.S. food exports (62).

World dependence on North American grain production will continue to increase. Food grains will be needed by the developing countries. Feed grains will be demanded by the developed countries as they consume more meat. Whether and how this sustained demand for United States food exports will affect American farmers and ranchers and their use of land will depend on two additional factors: future United States agricultural policies and agricultural productivity. Much attention has been given to United States agricultural policy (1) (46) (119) (169) (286). Implicit in most analyses has been the assumption that meeting export demands is desirable. Although the eventual level of the export demand is debatable, the evidence points toward an increasing demand for grain exports. But for much of the grain, cash sales are unlikely.

Clearly the developing countries will be unable to finance all purchases of needed grain. The U.S. may be faced with carrying out concession-type sales, or an international fund may be set up to assist in financing grain trade. It is likely that one of the courses of action will be pursued. Also likely are programs to stabilize grain prices and build up grain reserves (1) (46) (169) (296).

Such policies might reduce international instability in trade and prices but might not stabilize grain prices for the American farmer. A full discussion of grain prices is beyond the scope of this report, but a few observations should be made. Indications are that for the next five to 10 years, food grain prices, including wheat, are likely to fluctuate more widely than prices for animal feed grains. In addition, it is highly probable that feed grain prices will remain close to or exceed current levels. Food grain prices may decline slightly (119) (286) (288). Actual price changes will depend on many interrelated variables—productivity, export demand, and domestic agricultural policy.

In the long run, costs of producing food and animal feed grains inevitably will be higher than they are today simply because water, energy, and land will be increasingly scarce and expensive. Owners of rangeland should see the importance of this trend. Per capita demands for beef are expected to increase between 15 and 30 percent by the year 2000, depending on assumptions about population and growth in income (357). The extent to which beef is produced by the feeding of feed grains, concentrates, or forage, or a combination of all three depends, essentially, on the relative costs of the alternative feeds. Evidence of this can be found in the recent shift, during a period of high feed grain prices, from intensive feeding of cattle in feedlots to a greater reliance on forage from range.

The foreign demand for feed grains implies a continuation of high feed grain prices. This suggests in the future there will be increasing demand for forage from range and pastureland as a relatively low-cost source of animal feed. Range grazing is expected to increase between 15 and 100 percent by the year 2000, with a median level 50 percent higher than that prevailing in 1970 (357).

Meanwhile, economic instability and uncertainty will continue to plague U.S. farmers and ranchers. In fact the next five to 10 years may be more unpredictable because of rising production costs, increased price instability and a growing world interdependence between grain producing and consuming countries (48)(161). In addition, grain exports from Canada, Australia and Argentina may affect export demand for U.S. grains (175)(176). In the short run, the federal government may be forced to increase price supports for grain.

Policies to support prices and maintain production levels sufficient to meet export demands may not be needed in the long run. If world population and per capita income continue upward, demand for cereal grains could double by the year 2000 and double again by the year 2050 (6).

Today the U.S. and Canada supply 80 percent of the world's export grain. By the year 2000, some agricultural experts feel the U.S. and Canada may be the only countries in the world producing grain for export (406). In that case demand for export grain certainly would exceed productive capacities. Serious reservations have been expressed about the ability of agricultural technology to continuously increase production (271). The social desirability of certain technological advances also is questioned today. Adverse environmental impacts already in evidence from current management practices have raised the possibility of future environmental constraints inhibiting increased U.S. agricultural production (110). In the long run, the ability of American grain production to keep up with world demand may be inhibited by the diminishing returns of technological and environmental factors. These possibilities have important implications for U.S. agriculture.

PROSPECTS FOR INCREASED U.S. PRODUCTION

Recognizing that the trends in crop yields in the U.S. could largely determine whether the world's food supply will be abundant or scarce, the National Academy of Sciences recently published *Agricultural Production Efficiency*, which examined trends and prospects for U.S. crop yields. The principal conclusion was that the rate of increase in yields of most crops may slow down based on four considerations (8)(271):

1) technology in current use may be encountering diminishing returns

2) no economically attractive alternative technologies will become widely available in the next decade

3) desire to reduce environmental degradation will cause environmental constraints to be placed on the uses of technology

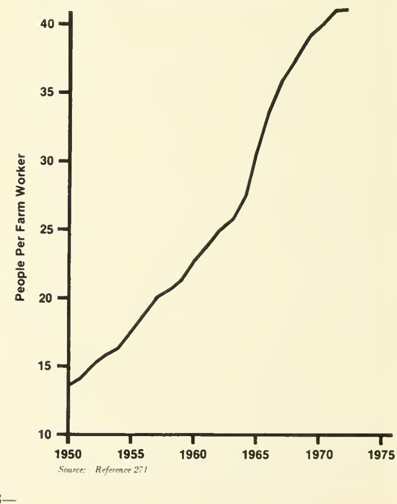
4) factors of production are becoming scarcer and more costly and will, in the future, have to be husbanded carefully

Two figures are presented to indicate trends in general productivity of the agricultural land base. Figure 34 shows a tapering off in the ability of the farmer to feed increasing numbers of people. Figure 35 shows a decline in the ability of the land to feed increasing numbers of people.

More specific indication of diminishing returns from current technology can be found in Table 72. Recent technological advances in agriculture have substituted capital, energy, and chemicals for labor and land. These substitutions have meant significant increases in labor productivity (output per unit of labor input)—250 percent since 1950. Crop production per acre of land has increased 61 percent since 1950. At the same time though, output per unit of fertilizer has declined by 81 percent, output per unit of tractor horsepower has declined 31 percent.

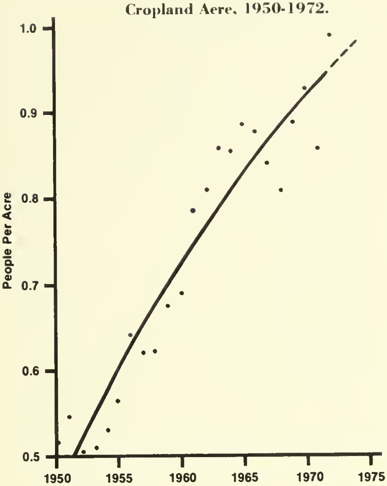
As U.S. crop production increased by 32 percent between 1950 and 1970, farm energy consumption increased 73 percent (328)(350). Declining utility of farm capital also is evident. While crop production per acre was increasing 61 percent between 1950 and 1970, the average investment per farm acre doubled during roughly the same years, 1947-49 to 1967-69 (378). A further perspective on energy consumption in U.S. agriculture can be gained by

Figure 34 People Supplied with Farm Products Per Farmer, 1950-1972.



Source: Reference 271

Figure 35 People Supplied with Food Per Cropland Acre, 1950-1972.



Source Reference 271.

comparing the relationship between protein and caloric output for various crops and animal production processes with the amount of total energy required to produce the agricultural commodities. Figures 36 and 37 show that animal feed and food grain crops today are the most energy efficient products of the agricultural system. However, the U.S. production system for these crops compares poorly with similar crops produced elsewhere in the world. For example, corn production in Mexico requires one-tenth the amount of energy to produce protein than does corn production in the U.S. By the same measure rice production in the Philippines is 30 times more energy efficient than in the United States (282). Of course these other production systems are based on extensive use of land, and thus are much less land efficient than that of the United States. The continuation of U.S. energy use trends would be disquieting, if only because energy is so expensive. Research is needed to insure a supply of food protein and calories at reasonable energy costs.

A comprehensive measure of agricultural production efficiency can be found by inspecting the last column of Table 72. While steadily rising since 1950, there has been a slowing rate of increase in the index measuring output per unit of all inputs, from 2.5 percent per year during 1950-60, to 1.5 percent per year between 1960 and 1970. Figure 38 supports this declining trend by showing farm production efficiency indexes. Although the three indexes are different and reflect successive revisions in the way they were

Table 72

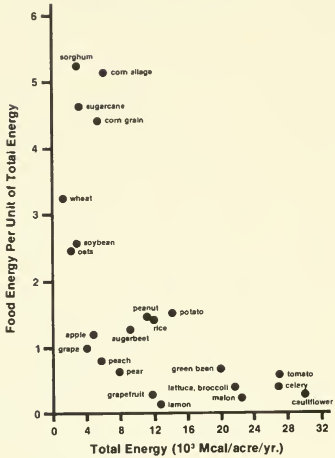
Measures of U.S. Farm Productivity, 1950-1971.

Year	Crop production per acre of cropland	Farm output per hour of labor	Farm output per unit of non-purchased inputs	Crop output per unit of nitrogen	Crop output per unit of total farm nutrients	Crop output per horsepower of tractors	Farm output per unit of mechanical power and machinery	Farm output per unit of purchased inputs	Farm output per unit of all inputs
1950	100	100	100	100	100	100	100	100	100
1955	107	134	116	58	69	83	97	90	111
1960	128	191	155	45	60	75	104	91	128
1965	145	260	182	29	43	70	105	100	137
1970	148	323	201	19	30	64	107	95	139
1971*	161	357	210	19	31	69	117	103	151

*preliminary

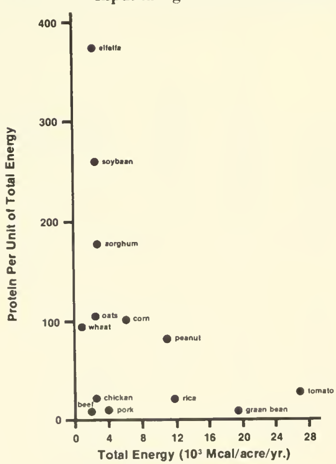
Source: Reference 271.

Figure 36 Caloric Yield (Energy Efficiency) in Agricultural Production.



Source: Reference 148

Figure 37 Protein Output Per Unit of Energy Input in Agricultural Production.



Source: Reference 148

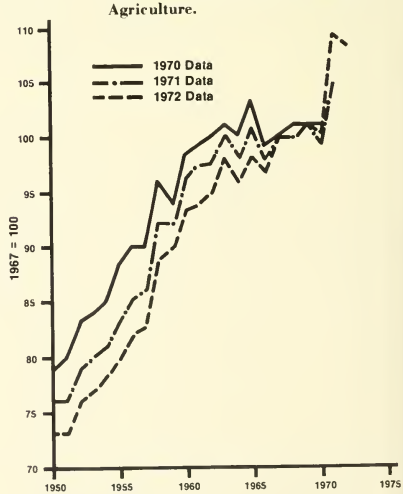
constructed, it is instructive that all three depict a flattening in the rate of increase in farm output per unit of input.

Recent yields of all three major U.S. crops, although not necessarily indicative of a trend, appear to be a sobering affirmation that farm successes of the past 20 years may not be repeated easily. Yields through 1975 actually declined from 1971-72 highs for corn, wheat, and soybeans (8).

Other constraints may hurt agriculture's ability to respond to world food demands. It seems inevitable that prices of production inputs will continue to rise. Natural resources such as water and land are scarcer and the farmers must compete for them with other sectors of the economy. Energy industries and land developers historically have been able to offer high prices for water and land. Costs of energy seem bound to go higher. The demand for capital will act against any decline in interest rates. Rising costs of production will accelerate the need for farm financing. By 1979 it is estimated that credit needs will be double those of 1969 (271). Already some farmers are finding it difficult to raise money.

In addition to economic uncertainties, tomorrow's agricultural producer will be faced with national and local conflicts in competing uses of natural resources. Demand for water is likely by the year 2000 to exceed supply in many river basins in the western U.S., including the Missouri, Arkansas-White-Red, Texas-Gulf, Rio Grande, Lower

Figure 38 Farm Production Efficiency Indexes as Published by the U.S. Department of Agriculture.



Source: Reference 271

Colorado, Great Basin, Columbia, and California (357). Concerns have been expressed that productive cropland may continue to be lost to other uses (26). Between 1949 and 1975, cropland acreage decreased by 23 million acres; by the year 2000 it is estimated that, under a continuation of past economic trends, an additional 20 to 40 million acres will be required for special uses, such as urban areas, highways and parks, thus precluding agricultural use (20) (183). The point is important because extensive agricultural land use, rather than intensive, may be what is required to sustain future agricultural production increases. These potential conflicts have been a major factor in the public debates over land use planning on the federal and state level. Land use and the allocation of critical land and water resources are topics which will only increase in importance (270).

Competition for resources can also take the form of environmental resource degradation caused by agriculture. Some of these public costs, or "externalities," resulting from agricultural practices have been acknowledged for many years. They include soil erosion from wind and water, loss of wildlife habitats, and noxious odors creating a public nuisance. Lately, new classes of environmental deterioration have been identified as a result of the more intensive agricultural management made possible by modern technology. Irrigation, a highly energy intensive technology, contributes to the buildup of salts in irrigated soils and water receiving irrigation runoff. Widespread application of fertilizers containing nitrogen and phosphorous lead to nutrient enrichment of water bodies, contributing to the declining usefulness of waterways for fishery habitat or further human use. Human health is endangered if nitrate levels become excessive. Use of pesticides has generated a concern for potential damage to plant and animal life and for the human health (110) (270).

"FOOD CRISIS" RESEARCH NEEDS

Assuming that U.S. agricultural policy places a high priority on continued exports and that the American farmer is urged to respond, the negative ecological trends already evident may gain momentum. It is safe to assume that agricultural practices in the future will be greatly influenced by actions taken to reduce environmental degradation.

Since 1970 climate has been important to those interested in agricultural production. It is generally acknowledged that extremely favorable weather patterns persisted between 1890 and 1970. A cooling trend in the middle latitudes over the last 20 to 40 years has been noted. Drought conditions recently in the Soviet Union, Africa, India, and the U.S. have adversely affected the world's production of cereal grains. Because of the documented relationships between climate and agricultural yields, it has been increasingly suggested that more research be directed toward weather variability and climatic change (143) (339).

There also is renewed interest in the many complex questions raised by structural changes in U.S. agriculture such as increased mechanization, increased farm size, greater reliance on agribusiness firms in marketing arrangements and purchases of farm inputs, and the increased need for technical management expertise (391). These changes have, of course, greatly affected the social and economic climate surrounding the agricultural producer and his rural community. Concern has been expressed that a continuation of these trends will act to further shift control of agriculture away from the agricultural producer. Some research has been directed toward analyzing relationships between agricultural policy and alternative farm structures (288) (322).

Agriculture is living in a world much changed in the last five to 10 years. This world is characterized by increasing interdependence, scarcities and high prices of resources critical to agriculture, U.S. policy of encouraging maximum food production, unsettling productivity trends, economic uncertainty, changing social and economic structure, and increasing social costs of agricultural production in the form of environmental degradation.

Because the production of food and fiber is a renewable activity in a world of increasingly scarce resources and because food is a basic need of mankind and vitally important to the U.S. economy, these changing trends have not gone unnoticed. The food "crisis," with its high prices and starving people, has sparked much international interest.

National research institutions such as the National Academy of Sciences, the Committee for Economic Development (48), the American Enterprise Institute for Public Policy Research (169), and the National Planning Association (46) have examined the role of the U.S. in the world food picture. The executive and legislative branches of the federal government have produced many publications on the world food situation, the operation of the agricultural system, and agricultural policies.

Much of the research is a result of the fundamental recognition that recent events show there needs to be a deeper understanding of and concern for the nation's base of renewable resources. The principal conclusions emerging from research to date are:

1. World demand for grains will continue to grow.

2. Future world production of grains likely will fall short of demands, resulting in higher relative prices for food derived from grain. A number of uncertainties surround food production forecasts: technological innovation, biological limitations, weather patterns, resource availability, input costs, and ecosystem productivity. We have been particularly fortunate in the past regarding these important factors; in the future we may be less fortunate.

3. A grain reserve storage system is needed to reduce fluctuations in grain prices. Eventually, international financial arrangements will be needed to finance grain sales to less developed countries.

4. Increased pressure will be placed on the U.S. agricultural land base to produce food and animal feed grains. High feed grain costs and increased use of grain for human consumption will encourage intensive use of range and pastureland to produce animal protein.

Responses to these basic trends have included recommendations for a renewed emphasis on basic agricultural research and a reorganization of the agricultural research establishment in the U.S. The latter point was explicit in a recent report on *Enhancement of Food Production for the United States* by the Board on Agriculture and Renewable Resources (BARR) of the National Academy of Sciences. Several criticisms of the current research system were made (272):

1. Basic research by the Agricultural Research Service and state agricultural experiment stations has "virtually disappeared."
2. Central coordination and review is lacking.
3. American agricultural researchers have been slow to initiate new projects in needed areas such as energy, environment, and social considerations affecting agriculture.

The BARR report also called for a National Agricultural Research Policy Council which would be responsible for establishing national agricultural research policies and goals. Its membership would be broad to include food scientists and representatives of major interest groups concerned with the availability of food.

New research initiatives should encourage enhancement of agricultural productivity and efficiency but also should recognize that additional objectives must play a major role. The overriding objective of many proposals is increasing the production of renewable resources while minimizing the use of increasingly scarce nonrenewable inputs (272) (408).

The BARR report goes on to state that stability of yields at "high" levels is important. The importance of maintaining ecosystem productivity to ensure long-term dependability is acknowledged. Though by no means exhaustive, what follow are some of the major needs for research listed in many recent publications reviewed as part of the research for this report.

Resource Base

—A reassessment of the productivity of the nation's land and water resources regarding their ability to supply long-term food and fiber needs. Public policies to prevent the irreversible transfer of productive land to non-agricultural use should be explored.

—Evaluation of alternative technologies for reducing the inputs of water and energy per unit of agricultural output, such as new cropping or irrigation techniques.

—Information about relationships between usage of chemical inputs and environmental degradation. Goal would be to improve application practices or a reduction in use of those whose public costs exceed the public benefits.

—Research in carrying capacity response of the nation's rangeland and forage system to alternative management practices.

—An evaluation of the potentially complex relationships between air and water pollution and food and fiber production.

—Compatibility between use of range for increased forage production and maintenance of range productivity.

Crops

—Expand research on photosynthesis with the objective of increasing efficiency of plant growth.

—Increasing understanding of biological nitrogen fixation with the objective of decreasing the dependence on chemical nitrogen inputs and increasing the supply of biologically fixed nitrogen by major grain and forage systems.

—Development of biologically based weed and pest control systems.

—Research into new genetic varieties to improve grain nutritive values and yields.

Livestock

—Increase production of domestic livestock by improving fertility and reducing disease.

—Increase the efficiency of conversion of forage protein and energy to animal protein and energy.

Other Suggestions

Conspicuously absent are suggestions for social and economic research. Initiatives in this area are particularly timely in view of the large public role in agricultural policy today and the potential for a larger role in the future arising from the international ramifications of food policy as well as increasing conflicts over use of natural resources. Such research topics include:

—Determination of the proper mix of agricultural inputs to minimize environmental and economic costs of production.

—American farm size and its relation to agricultural production.

—Agribusiness and the relationship of structural changes in agriculture to the rising costs and increasing financial instability facing the American agricultural producer.

—Alternative agricultural structures and their potential impact on rural development.

CHAPTER 10 NATIONAL TRENDS IN THE USE OF FORESTLAND

Like crops and forage, the renewable goods and services arising from the nation's forests face a future of increasing demand. Increasing population and per capita incomes mean growing demands for wood fiber, water, recreational opportunities, wildlife, and wilderness.

However, trends and prospects for forestland are being shaped by several factors differing from those acting on agricultural land. First, almost 30 percent of the nation's commercial forestland is publicly owned; the figure is much higher in the west, about 76 percent for the Rocky Mountain region (347). Second, forestland provides a multiplicity of goods and services, some of which are consumed and valued through the market system such as timber, and others which have no price in the market system, such as water, wildlife, wilderness, and recreation. Valid concern often arises over the sometimes conflicting nature of these resource uses. Third, timber, historically the most highly valued output of the forest, is the major renewable material used in the U.S. economy, contributing 98 percent of the organic renewable raw materials utilized in 1972 and over 6 percent of all the raw materials[38] (269).

MANAGEMENT CONFLICTS ON NATIONAL FORESTS

The national forests, which make up 85 percent of the nation's public forestland, are managed in accordance with several laws, the most important of which are the Organic Administration Act (1897), Multiple Use-Sustained Yield Act (1960), the Wilderness Act (1964), National Environmental Policy Act (1969), and the Forest and Rangeland Renewable Resources Planning Act (1974). A recent analysis of management goals and objectives in the U.S. Forest Service, and their relation to congressional intent, concluded that the principal direction of Forest Service policy was to maximize total value of the national forests subject to two overriding constraints. First, that no activity be undertaken which diminishes that land's productivity, and second, that all resources be managed on a sustained yield[39] basis. Most importantly, Congress has nowhere specifically indicated priorities among the various forestland outputs (4). The most recent legislation requires resource planning with a long-range perspective.

The Forest Service thus has a mandate to maximize the total value of all forest outputs, but no clear direction regarding how to resolve the conflicts inherent in "multiple use" resource management. For example, at any given time the same general area cannot be used for timber harvesting and remain valuable for a backpacking experience. Managing a forest primarily as watershed may limit what can be done to encourage growth of trees. Obviously, the same area of forestland cannot be managed intensively for all uses at the same time. Questions arise, then, on the choices to be made about relative intensities of management for the various goods and services produced by forestland. When uses are incompatible, such as timber harvesting and wilderness, the question is how the dominant use is to be determined.

Until the last 10 to 20 years, the supply of the various outputs of the nation's forestland was abundant in relation to the demands placed upon them. Attention to the adequacy of forestland resources was diverted by many factors: the migration of population from rural to urban areas, generally increasing affluence, a socio-cultural milieu encouraging the acquisition of material wealth, and a ready acceptance of technological innovation. Recreational

USDA Forest Service photo by Phil Schlamp

[38]Raw materials are natural resources intended to be used for the production of goods, with the exclusion of food.

[39]See page 70.

use of forestland distant from urban areas probably decreased until widespread use of the automobile and rising income levels enabled individuals to visit. Rural wildlife populations generally seemed adequate to meet local demands until growth in national population combined with increased mobility and affluence to put pressure on wildlife habitat throughout the country. Technological innovation, federal support, and social attitudes in favor of dams and diversions made water accessible nationwide. Generally, water was considered abundant, or at least available through sufficient investment.

The industrial revolution and relatively cheap energy combined to drastically decrease per capita lumber consumption during the first third of this century. Rising real prices[40] of lumber relative to other building materials and mineral products was a major factor contributing to the extensive substitution of other materials for wood. After 1935 per capita lumber consumption was stable, while unfavorable price trends relative to other building materials continued (388). It was not until after World War II and a greatly increased demand for housing appeared that the timber industry recognized the limits of conventional timber producing areas and finally moved into the last uncut, original growth forests, the Rocky Mountains.

Until the last decade, social and economic conditions encouraged little public debate or attention to questions of forestland resources. With the reawakening in America called the environmental movement, recognition came of the limits of natural resources in providing the various goods and services demanded by increasing populations, industrial growth, and affluence. The latter conditions encouraged demand for forestland products. For example, recreation experienced a tremendous growth. Between 1960 and 1973 the number of camping households tripled, from 4.3 million to 14.3 million; visits to national parks increased almost sevenfold since 1950, from 33 to 217 million; visitor days of recreation on dispersed sites in national forests increased 30 percent between 1968 and 1974. Consumptive uses of wildlife have continued to increase: days spent hunting and fishing increased 37 percent between 1960 and 1970 (357). Non-consumptive uses of wildlife achieved considerable importance. In 1970, 12 million persons were involved in wildlife observation and photography, as compared with 21 million hunters (107).

Although not as spectacular as the demand for recreational opportunities, demand for water and timber has continued to grow. Timber consumption in 1970 was 14 billion cubic feet, up almost 25 percent from 1962 (347). In the 11 western states, where over 90 percent of the usable water originates on typically forested, high altitude watersheds, water withdrawals increased 7 percent between 1970 and 1975 (357)(370). This figure does not reflect growth of in-stream uses, such as fishing.

[40]Real prices are prices adjusted for the effects of inflation.

Three trends promise to push demand for major forestland outputs even higher. First, costs of energy will continue to rise, creating incentives for processes and products requiring less energy. Second, widespread public acceptance of the need to maintain and improve environmental quality means closer scrutiny of public and private decisions affecting the environment and an increasing regard for natural environments. Third, continued growth in international demands for cereal grain will be met by the American agricultural producer who may have incentives to use more irrigation to increase the productivity of farms and ranches.

All three trends point to increases in demand for water, particularly in those western states, such as Montana, with available energy and agricultural resources. By the year 2010 water consumption is expected to increase nationally by 600 percent for steam-electric energy production, 30 percent for livestock, and 100 percent for irrigation. In the Missouri River Basin the same figures are 1,426 percent, 60 percent, and 45 percent respectively. For the Columbia River Basin, the other major watershed containing Montana forestland, the figures are 2,984 percent, 46 percent, and 46 percent respectively. In the next 35 years total water consumption is expected to increase by 56 percent and 51 percent in the Columbia River and Missouri river basins respectively (see Table 73). In the two basins between 60 and 90 percent of the surface water typically originates on forested high altitude watershed.

Water quality also will become increasingly important to continued water-based recreation opportunities, in-stream flows sufficient to sustain aquatic habitat, and irrigation needs. The foregoing needs will serve to emphasize the already acknowledged national mandate to clean up and maintain quality of water. Water quality is, of course, initially determined in the forested watershed.

The importance of environmental quality to the nation also is evident in the renewed emphasis and social value being placed on the remaining high-quality natural environments. This regard has been legislatively recognized through the passage of National Environmental Policy Act, the Wilderness Act, and strong water and air quality acts. As of July, 1975, 12.3 million acres of public land had been designated wilderness under the Wilderness Act, and 112 additional areas totaling 26.1 million acres had been submitted to Congress for its approval. Recreational and non-recreational uses of wilderness, such as the value to non-recreationists of "knowing it's there" and the preservation of pristine ecosystems (184), have been projected to grow significantly in the years ahead, almost 6 percent annually (357).

Forecasts of demand are up for all types of outdoor recreation, based on assumptions regarding income, age distribution in the population, and the costs of travel (see Table 74). The largest projected increase is for water-based

Table 73

Projected Water Consumption in the Columbia River and Missouri River Basins, 1975-2010.

(million gallons/day)

River Basin	Use	1975	2010	Percent Increase
Missouri	Steam electric cooling	49.0	748.7	1528
	Livestock	408.2	653.7	60
	Irrigation	13,243.4	19,292.5	46
	Manufacturing	136.2	226.9	67
	Domestic	247.8	295.6	19
	Minerals processing	106.5	151.5	42
	Public lands	185.6	345.8	86
	Total	14,376.7	21,714.7	51
Columbia	Steam electric cooling	13.0	400.8	3085
	Livestock	71.5	104.0	44
	Irrigation	12,880.0	18,758.1	46
	Manufacturing	332.4	1,509.1	454
	Domestic	224.7	271.1	20
	Minerals processing	17.4	25.9	49
	Public lands	244.6	449.2	83
	Total	13,773.6	21,518.2	56

Source: Derived from Reference 357.

recreation, again implying a continued emphasis on water quality. By the year 2010 the demand for dispersed camping is expected to be 41 to 77 percent higher than today's. For developed camping the comparable figures are 40 and 62 percent.

Forecasts of increased demand for wildlife related outdoor recreation activities show similar trends, between 41 and 69 percent for big game hunting in the next 35 years, 64 to 103 percent for fresh water fishing and 50 to 80 percent for non-consumptive uses of wildlife, such as photography and sightseeing.

The renewed national interest in outdoor recreation has encouraged innovative attempts to determine the value of natural environments. Economists, such as John V. Krutilla and Anthony C. Fisher in *The Economics of Natural Environments* (1975), have begun to develop criteria for natural resource decision making computing trade-offs between preservation of natural environments for the enjoyment of future generations and development of those same environments, where the development would have irreversible consequences. In the first application of the technique, preservation of the Hells Canyon area of the Snake River was seen to surpass its development value for hydroelectric power, primarily because the value of preservation was expected to increase due to the lack of substitutes while the value of development might decrease because additions to the regional energy supply could be made in other ways. Also, preservation was seen as retaining the "option value" of future development, while damming would have been irreversible (184).

Indexes* of Demand for Selected Outdoor Recreation Activities in the U.S., 1975-2010.

Activity		Year 1975	1980	1990	2000	2010
	High	100	111	128	146	169
Big game hunting	Medium	100	111	127	139	152
	Low	100	111	126	134	141
	High	100	111	135	167	203
Fresh water fishing	Medium	100	111	133	156	180
	Low	100	111	131	148	164
	High	100	106	117	143	177
Remote camping	Medium	100	106	116	133	156
	Low	100	106	114	126	141
	High	100	106	116	138	162
Developed camping	Medium	100	106	114	129	143
	Low	100	106	113	122	130

*1975 = 100

Source: Reference 357.

PRESSURES ON TIMBER RESOURCES

Like other forestland outputs such as recreation opportunities and water, timber is a commodity whose value may increase more than the value of substitutes (43). In a world increasingly concerned with availability and cost of energy, wood is seen as having several distinct advantages over those commodities which were widely substituted for it during the last 60 years. Table 75 shows the energy advantages of wood over its common substitutes. The recent article in *Science* magazine discussing this table concluded that "not only are the gross energy requirements for many wood products substantially lower than alternative products based on nonrenewable materials, but the degree of energy self-sufficiency of many wood products is striking" (167). It might be added that the energy costs of extracting non-renewable materials will continue to increase relative to those for wood, given that in the future nonrenewable raw materials will be available only in less accessible locations and in less concentrated forms.

Structural wood products for use in residential and light industrial buildings can perform the same functions as other commonly used substitutes at significant energy savings. Studies show that wood requires only one-fifth to one-fiftieth the energy of steel floor joists, aluminum framing, aluminum and steel rafters, and brick siding. Wood also is acknowledged to have superior insulating characteristics (167).

The use of wood for the production of energy and chemicals will become more feasible as fossil fuels become scarcer and more costly. Preliminary indications are that even today fossil fuels could be conserved by the economically feasible generation of energy from wood wastes locally and the use of wood for chemical feedstocks. Because supplies of wood are renewable, wood can only increase its relative advantage over nonrenewable materials currently being used for energy and chemicals (297).

These changing circumstances in combination with projected increases in population and economic activity mean that timber consumption in the United States is bound to increase substantially in the years ahead. Projections of the Forest Service, based on assumptions regarding population and income levels, construction, manufacturing, shipping, and timber prices, indicate that demand for timber will be between 16 and 21 billion cubic feet in the year 2000 (Table 76). This figure represents a 34 to 82 percent increase over the 1970 level of timber production from the nation's forestlands (325). By the year 2020 projected demands range between 19 to 29 billion cubic feet, or a 62 to 148 percent increase over 1970 production. The magnitude of the projections is underscored by the recent history of timber production, which recorded an 8 percent increase between 1952 and 1970 (357).

The future is likely to be characterized by increasing demands for all of the various renewable resources of forestland. Although not discussed here, it is obvious that future requirements for minerals, a nonrenewable output available from the same forestland, also will be up. The

Table 75

Energy Requirements for Selected Wood-Based Commodities and Commodities Not Based on Wood

	Energy (10^6 Btu/oven-dry ton)				
	Extraction	Manufacture	Total	Available from processing residual fuel	Supplementary requirements for manufacture*
	Wood-based				
Softwood lumber	0.943	4.846	5.789	8.313	0(3.467)
Oak flooring	1.073	5.691	6.764	11.388	0(5.697)
Lumber laminated from veneer	0.740	6.587	7.327	3.540	3.047
Softwood sheathing plywood	0.747	6.871	7.618	3.697	3.174
Structural flakeboard	0.956	7.511	8.467	8.616	0(1.105)
Medium-density fiberboard	0.783	9.303	10.086	2.741	6.562
Insulation board	0.622	10.539	11.161	0.667	9.872
Hardwood plywood	1.041	10.242	11.283	10.629	0(0.387)
Underlayment particleboard	4.617	8.101	12.718	1.529	6.572
Wet-formed hardboard	0.743	19.662	20.405	0.797	18.865
	Not wood-based				
Gypsum board	0.14	2.73	2.87		
Asphalt shingles	0.03	5.70	5.73		
Concrete	0.52	7.60	8.12		
Concrete block	0.52	7.60	8.12		
Clay brick	0.57	7.73	8.30		
Carpet and pad	6.60	28.69	35.29		
Steel wall studs	2.45	46.20	48.65		
Steel floor joists	2.45	46.20	48.65		
Aluminum siding	26.80	172.00	198.80		

*In calculations of supplementary requirements, it is assumed that energy from processing residual fuel can be used only in the manufacturing process and not in extraction. Values in parentheses are for energy from processing residual fuel in excess of that required for manufacture which could be available for other uses.

Source: Reference 167.

major working assumption of many publications reviewed in preparation of this report is this: meeting the needs of tomorrow through forest products, from wood fiber to wilderness, is socially and politically desirable public policy. Many of the reasons have been cited here.

Trouble with defining "multiple use" is symptomatic of the lack of concise and specific national legislative and administrative direction that has produced intense public debate over the use of the nation's forests. One result has been lawsuits by groups seeking judicial remedy in instances where it is believed one proposed use of the forest, wildlife habitat for example, would be detrimental to another proposed use, such as recreational development. The Monongahela decision[41] temporarily prohibiting cutting of unmarked mature trees in certain eastern national forests is but a specific example of such a lawsuit. Parties to the decision sought to resolve seemingly incompatible forest uses, in this case a form of timber harvesting known as clear-cutting, and recreation in a popular old forest.

Those involved in forest policy know that the trend of increasing demands for the goods and services of the nation's forests carries with it the seeds of continued controversy over forestland use. Contributing to the controversy is that national forests today are being managed at less than full productive potential, thus increasing the opportunity for scarcity and conflict among uses. Marion Clawson has aptly summarized the problem in his article "The National Forests" (44):

[41]522 F.2d 945 (4th Cir. Aug. 21, 1975).

Table 76

Summary of Roundwood Consumption, Exports, Imports, and Production from U.S. Forests with Medium Level* Projections, 1952, 1962, and 1970.

(billion cubic feet, roundwood equivalent)

ALL SPECIES

Year	U.S. consumption	Exports	Imports	Production from U.S. forests**
1952	11.9	0.2	1.4	10.8
1962	11.6	.5	1.9	10.2
1970	12.7	1.4	2.4	11.7

1970 RELATIVE PRICES

Year	U.S. demand	Exports	Imports	Demand on U.S. forests
1980	16.6	2.3	2.8	16.1
1990	19.2	2.4	3.0	18.6
2000	22.0	2.4	3.1	21.3
2010	25.1	2.6	3.1	24.6
2020	27.8	2.6	3.1	27.3

RISING RELATIVE PRICES****

1980	15.2	2.3	3.7	13.8
1990	16.6	2.4	4.4	14.6
2000	18.2	2.5	5.0	15.7
2010	20.1	2.6	5.2	17.5
2020	22.1	2.6	5.4	19.3

RELATIVE PRICES ABOVE 1970 AVERAGES*****

1980	14.6	2.3	3.9	13.0
1990	17.2	2.4	4.4	15.2
2000	19.6	2.5	4.5	17.6
2010	22.6	2.6	4.5	20.7
2020	25.4	2.6	4.5	23.5

SOFTWOODS

Year	U.S. consumption	Exports	Imports	Production from U.S. forests**
1952	8.4	0.2	1.3	7.3
1962	8.5	0.4	1.7	7.2
1970	9.7	1.2	2.1	8.8

1970 RELATIVE PRICES

Year	U.S. demand	Exports		Demand on U.S forests
1980	12.3	2.0	2.4	11.9
1990	13.8	2.1	2.5	13.4
2000	15.4	2.1	2.6	14.9
2010	17.2	2.2	2.6	16.8
2020	18.8	2.2	2.6	18.4

RISING RELATIVE PRICES****

1980	11.3	2.0	3.2	10.1
1990	12.1	2.1	3.9	10.3
2000	12.8	2.2	4.3	10.7
2010	13.9	2.2	4.4	11.7
2020	14.8	2.2	4.6	12.4

RELATIVE PRICES ABOVE 1970 AVERAGES*****

1980	10.7	2.0	3.3	9.4
1990	12.4	2.1	3.8	10.7
2000	13.7	2.2	3.9	12.0
2010	15.6	2.2	3.9	13.9
2020	17.2	2.2	3.9	15.5

HARDWOODS

Year	U.S. consumption	Exports	Imports	Production from U.S. forests**
1952	3.5	--***	0.1	3.5
1962	3.1	0.1	0.2	3.0
1970	3.0	0.2	0.3	2.9

1970 RELATIVE PRICES

Year	U.S. demand	Exports	Imports	Demand on U.S. forests
1980	4.3	0.3	0.4	4.2
1990	5.4	0.3	0.5	5.2
2000	6.6	0.3	0.5	6.4
2010	7.9	0.4	0.5	7.8
2020	9.0	0.4	0.5	8.9

RISING RELATIVE PRICES****

1980	3.9	0.3	0.5	3.7
1990	4.5	0.3	0.5	4.3
2000	5.4	0.3	0.7	5.0
2010	6.2	0.4	0.8	5.8
2020	7.3	0.4	0.8	6.9

RELATIVE PRICES ABOVE 1970 AVERAGES****

1980	3.9	0.3	0.6	3.6
1990	4.8	0.3	0.6	4.5
2000	5.9	0.3	0.6	5.6
2010	7.0	0.4	0.6	6.8
2020	8.2	0.4	0.6	8.0

Footnotes:

*Based on the medium projections of growth in population and economic activity shown in the section on basic assumptions.

**The data for 1952, 1962, and 1970 are estimates of actual harvests.

***Less than 50 million cubic feet.

****Relative prices rising from 1970 trend level as follows: Lumber—1.5 percent per year; plywood, miscellaneous products, and fuelwood—1.0 percent per year; paper and board—0.5 percent per year.

*****Relative prices of lumber and plywood—30 percent, miscellaneous products and fuelwood—15 percent, and paper and board—10 percent above the 1970 averages.

Note: Columns may not add to totals because of rounding.

Projections: U.S. Department of Agriculture, Forest Service.

Source: Reference 357.

The output of every kind of good and service from national forests could be increased [Table 77]. In considering potential, at least two questions arise: (i) whether the potential is purely biological or whether it is also economic, and (ii) whether the potential for each kind of output should be considered separately, without regard for competing outputs, or whether all outputs should be considered at the same time. Table [77] shows a combination of the extremes of these considerations; that is, biological output of each good and service managed for its maximum output with other outputs in a subordinate but often significant role; and an economically defensible output with the use of each kind of good or service adjusted to the demands for the other services. While these estimates are approximate, they demonstrate the potential for substantially increased output of each major kind of good or service.

The second type of potential output (economic) in Table [77] could be achieved only by the application of new technology and usually only by greater investment of capital, or greater expenditures for current operations, or both.

The national forest's full productive potential for all outputs cannot be met because some uses interfere with others. Trade-offs among uses are necessary and so is acceptance of less than full production for any one output because of social and economic considerations.

It is also worth noting that, with the possible exception of some forest industry land managed for timber growth, little of the nation's non-federal forestland is managed near full potential timber productivity either. Three deficiencies are often noted to explain the existing public and private forest management situation:

1. Management objectives are being hindered for reasons that differ depending on ownership.
2. Investment in forestland is inhibited by economic factors.
3. More information is needed about the forestland economic system.

Management constraints on federal land have been discussed already. In addition to the conflicting goals pursued by the Forest Service itself, authority for management of the nation's forests is dispersed within the federal government, spread over several agencies including the Office of Management and Budget, Department of Agriculture, the Forest Service, the Congress, and the many Forest Service regional offices. All compete with one another in pursuing specific goals. Each has its own particular constituencies with sometimes conflicting perspectives on the overriding objectives for management of the nation's forestland (4) (44).

The small, private, non-forest industry ownership group, accounting for almost 60 percent of the nation's commercial timberland, is poorly equipped to apply intensive forestry methods. In most cases, long-term management decisions on such forestland are economically unfeasible. Recent estimates are that only about 5 percent of the small private forestland is intensively and continuously managed (347). Close to half of the acreage is on small farms, where the forestland is incidental to the farming business. In recent years much of the land has been purchased for recreational purposes, precluding management for timber. Speculation on land, with the

Table 77

Current and Potential Outputs of National Forests.*

Kind of output	Present output**	Potential Output***	
		Biological basis	Economic basis
Wood grown annually (billion cubic feet)	2.6	10.5	6 to 7
Wilderness area**** (million acres)	11.6	55	40
Outdoor recreation (million visitor days)	188	1000	400
Water yield (volume)	Not measured	25 percent more	10 percent more
Wildlife, all kinds	not measured	Many more	Slightly more

*Potential output is given on a biological basis with each use considered dominant, other uses subordinate, and no concern for economic efficiency, and on an economic basis with each use adjusted to other uses.

**1970 for wood, some more recent year or average of years for others.

***See Reference 44 for derivation.

****Formally designated wilderness areas, excluding de facto wilderness. Assumes no major relaxtion in definition of wilderness with regard to size of tracts or degree of nonwilderness use tolerated.

Source: Reference 44.

intent to sell later, makes unlikely the kind of investment that is required for timber.

Forest industry land, comprising only one-seventh of national commercial forestland acreage, is, of course, managed with some intensity for timber production. Table 78 shows that timber growth on forest industry land in 1970 was estimated at 59 percent of its productive potential; the comparable figure was 39 percent for national forests and 49 percent for the small private owner. Because of the continuity of ownership, forest industry land has the potential for intensive management for other outputs as well. However, corporate profit objectives will inhibit management for non-timber purposes.

Essential to enlightened management of national forests is a full understanding of the compatibilities of forest uses. Trade-offs currently being made among resource uses are too often the result of inadequate information (43) (357).

EMERGING FOREST MANAGEMENT OPTIONS

A useful framework for analyzing forest uses is suggested by Marion Clawson (see Table 79). It is evident that the various uses of the forests differ greatly in compatibility. Some uses, such as wilderness and wildlife, are highly compatible. Developed recreation and timber harvesting may have limited compatibility depending upon harvest timing and intensity. It is possible, for example, that timbering could open up a scenic area for greater public use. Some uses, such as wilderness and high intensity recreation, are highly incompatible. The point is that compatibility is relative. Some forest outputs can be taken from the same general area simultaneously or perhaps successively. Where uses are totally incompatible, full consideration must be given to social and economic considerations. Where uses are fully compatible and no outright conflict exists, the problem is deciding relative intensities of management for one output or the other. In cases of limited compatibility the need for full information is greatest (43).

Although there is rough information on the amount of commercial forestland in various timber productivity classes there is very little information regarding the usefulness of commercial forestland for non-timber purposes—wildlife, wilderness, recreation, and water storage. This lack of information seriously limits the ability to make judgments regarding intensities of management for the various outputs no matter what their compatibility. Other unknowns are the objectives and desires of the small private landowners who control 60 percent of the commercial forestland. Little is known about how their land is being managed. Trends in forestland management toward dominant use, such as recreation, will affect greatly assumptions about the productive potential of forests.

Much work also needs to be done in developing a consistent and acceptable procedure to assign values to the goods and services yielded by forestland. Typical is the problem of putting a value on the presence of wildlife and comparing it somehow with the value of timber, which unlike wildlife is easily expressed in monetary terms. Economists and other social scientists currently are

Table 78

Productivity and Growth of Wood by Ownership Class, 1970.

	Estimated productive capacity* (cubic ft./acre)		Growth achieved in 1970 on sites I-V	
Ownership class	Land in site classes I-V	Land in site classes I-IV	Total (cubic ft./acre)	As percent of productive capacity of sites I-V
National forests	76	93	30	39
Other public	72	92	39	54
Forest industry	88	98	52	59
Other private	74	88	36	49
All ownerships	76	91	38	49

*Productive capacity estimated by multiplying acreage in the specified site classes (as reported in "Forest Statistics for the United States, by State and Region, 1970," Forest Service, U.S. Department of Agriculure, 1972), by the midpoint of each site class interval (taking 180 as the value for class I). Data include both hardwood and softwood forests.

Source: Reference 43, adapted from Reference 284.

Table 79
Degree of Physical Compatibility of Secondary and Primary Forest Uses

Primary Use	Secondary Use: Attractive environment	Recreation opportunity	Wilderness	Wildlife	Natural watershed	General conservation	Wood production and harvest
Maintain attractive environment		Moderately compatible; may limit intensity of use	Not inimical to wilderness but does not insure	Compatible to most wildlife, less so to a few	Fully compatible	Fully compatible	Limited compatibility; often affects amount of harvest
Provide recreation opportunity	Moderately compatible unless use intensity excessive		Incompatible would destroy wilderness character	Incompatible for some kinds; others can tolerate	Moderately compatible; depends on intensity of recreation use	Moderately compatible; incompatible if use too heavy	Limited compatibility depends on harvest timing and intensity; roads provide access
Wilderness	Fully compatible	Completely incompatible, can't tolerate heavy use		Highly compatible to much wildlife, less so to others	Fully compatible	Fully compatible	Completely incompatible, precludes all harvest
Wildlife	Generally compatible	Limited compatibility; use intensity must be limited	Mostly compatible though some wildlife require vegetative manipulation		Generally fully compatible	Generally fully compatible	Generally compatible but may require limiting volume or conditions of harvest
Natural watershed	Fully compatible	Moderate compatibility; may require limitation on intensity	Not inimical to wilderness but does not insure	Generally compatible		Fully compatible	Moderate compatibility; restricts harvest methods but does not prevent timber harvest
General conservation	Fully compatible	Moderately compatible; if use not excessive	Not inimical to wilderness but does not insure	Generally compatible	Fully compatible		Compatible but requires modifications in methods of timber harvest
Wood production and harvest	Compatible if harvest methods strictly controlled	Moderately compatible	Completely incompatible; would destroy wilderness	Compatible if harvest methods fully controlled	Compatible if harvest methods fully controlled	Compatible if harvest methods fully controlled	

Source: Reference 43.

investigating ways of solving such problems but the problem is difficult. Reasonable people probably always will disagree over relative values of the various outputs, making the setting of priorities for forestland uses extremely difficult.

The economic climate also can hinder achieving full productivity on forestland. In an analysis viewing forestry as "a process of long-term capital investment and disinvestment," John Zivnuska reiterates six propositions first offered by S.V. Ciriacy-Wantrup about general conservation programs, including forestry (411):

1. Low interest rates favor investment in forestry, while high interest rates favor early liquidation of assets.

2. Uncertainties about future costs and profits are adverse to forestry investment; a reduction in uncertainty favors forestry investments.

3. Replacing property taxes by income and yield taxes favors forestry investments because it leads to the distribution of costs over time, consistent with yields.

4. Stability in public policies is favorable to investments because it reduces uncertainty.

5. High incomes favor investments while low incomes favor liquidation.

6. Rising relative values for forestland goods and services generally favor investment; falling relative prices work against investment.

The present, characterized by high interest rates, factual uncertainties and mounting controversies over forest policy, is basically unfavorable to increased investments in our forestland base. Although rising values of forest outputs and generally higher incomes eventually may favor forestry investment, a reversal of the current economic climate is not in sight (398) (411).

It is difficult enough to justify investments in the timber growing potential on forestland, let alone investments in non-timber outputs. Calculations on the profitability of reforestation, shown in Table 80, indicate that many such investments would return less than 8 percent without a doubling of softwood lumber prices over those prevailing in 1967. Current federal requirements call for returns of 6.9 to 10 percent annually on federal investments (398). The same calculations show that poor quality timberland fails to justify any investment, given current timber prices, even though all the land involved in the calculation is classified "commercial." Other research efforts came to similar conclusions (325). The central problem appears to be justifying forestry investments during periods of high interest rates. But if capital shortages persist, high interest rates are inevitable. Justifying investments in national forests to enhance non-timber values, values which have so successfully resisted quantification (what is wildlife worth?), is even more difficult for a cost-conscious government.

The role of timber as a renewable resource was given special emphasis in the 1973 final report of the National Commission on Materials Policy (45). In that same year the President's Advisory Panel on Timber and the Environment produced a report addressing the problems of timber supply to meet the nation's housing needs while maintaining environmental quality (284). In 1974,

Table 80

Rates of Return to Given Investments in Forest Improvement Under Various Price Assumptions, by Type and Site Class of Forest.

(percentage rates of return)

Type of investment and softwood lumber price index (1967 = 100)

Forest type and site class*	Forestation**				Stapling stand improvement				Management intensification			
	Price index at harvest:				Price index at harvest:				Price change during rotation:			
	115	144	180	225	115	144	180	225	None	155-144	115-180	115-225
Hemlock-spruce												
I or II	5.8	6.6	7.5	8.4	10.2	11.5	12.2	14.1	14.4	18.0	23.5	31.7
III	3.8	4.6	5.2	5.6	6.7	7.7	8.7	9.7	7.0	8.8	11.3	15.3
IV	3.0	3.6	4.2	4.8	5.2	6.0	6.8	7.6	5.0	6.3	8.1	10.9
Douglas-fir and fir-spruce												
I or II	6.0	6.9	7.7	8.6	10.6	11.3	11.3	14.5	16.2	20.3	26.3	35.5
III	4.4	5.1	5.8	6.5	7.5	8.5	8.5	10.4	9.6	12.0	15.6	21.0
IV	3.4	4.0	4.6	5.2	5.7	6.5	6.5	8.1	6.4	8.0	10.4	14.0
Ponderosa and lodgepole pines												
I or II	4.8	5.6	6.5	7.4	9.0	10.3	11.6	12.9	9.0	11.2	14.7	19.8
III	3.4	4.1	4.8	5.5	6.2	7.2	8.1	9.1	5.5	6.9	8.9	12.0
IV	2.5	3.1	3.7	4.3	4.5	5.3	6.0	6.8	3.5	4.4	5.7	7.6
Southern, red, and white pines												
I or II	6.5	7.4	8.2	9.1	11.6	12.9	14.2	15.6	8.0	22.6	29.2	39.4
III	4.8	5.5	6.2	6.9	7.7	8.7	9.7	10.6	10.4	13.0	16.9	22.7
IV	3.7	4.3	5.0	5.6	6.1	6.9	7.7	8.5	7.2	9.0	11.7	15.7

*Site classes I and II include those forests capable of producing 120 cubic feet or more of timber per acre per year; site class III includes those producing 85-120 cubic feet; site class IV includes those producing 50-85 cubic feet.

**For derivation of these figures, see original source.

Source: Reference 43, adapted from Reference 284.

Resources for the Future devoted an entire publication to forest policy considerations (411). And in 1974, Congress passed the Forest and Rangeland Renewable Resources Planning Act calling for long-range assessments of demand and supply of related forest outputs. The Monongahela decision has resulted in two dissimilar proposals currently pending in Congress. Both propose changes in legislative mandates for managing timber resources. The National Academy of Sciences Committee on Renewable Resources for Industrial Materials is focusing on wood fiber in recognition of its tremendous potential to substitute for nonrenewable materials (24).

Proposals for revitalizing forest management have been offered (44)(284)(357). A new forest policy board at the presidential level made up of citizen members with diverse interests, was advocated first in 1973. The need still exists for thorough, innovative, and conscientious policy development at the national level by a wide range of interests (43).

Historically the Forest Service has been in a position to manage an abundant forest resource and hence has not fully developed the decision-making tools required, including funds for research and management, that might realize the fullest potential of public forestland. A number of interrelated suggestions for improving the existing federal management framework have been offered:

1. The Forest Service needs people knowledgeable about and responsive to today's forestry issues. Before this can happen, the Department of Agriculture must cultivate a serious, intensive effort to resolve forest management problems.

2. Through research, information needs to be developed on resource compatibility, productivity of land for various outputs (including the response of land at different intensities of management for the various outputs), and the valuation of non-timber outputs.

3. Adequate plans for the first two objectives might enable the Forest Service to justify much needed increases in funding required to meet reforestation needs and improve maintenance of recreation facilities.

Increased funding also is needed to maintain adequate levels of investment to stimulate forest productivity. Timber and wilderness—forest uses least compatible with others and subject to the most emotional debate today—are the focus of the remaining emerging national policy toward tomorrow's management of the nation's forestland.

The recommended Renewable Resources Program, designed to respond to the planning requirements of the 1974 Congressional act, has called formally for placing future management emphasis on dispersed recreation and "moderate" increases in wilderness area. A 50 percent increase in dispersed recreation visitor days by 2015 would be planned for, and a doubling of wilderness (to 25 or 30 million acres) by the same year (357). Although at this point the recommendations are subject to many management and appropriation decisions, the plans indicate that the recognized demand for non-timber forest outputs probably will result in more forestland devoted to non-timber uses in the future. It is implied that this land would, for the most part, be unsuited in any case for timber harvesting or intensive timber management.

FOREST RESOURCE RESEARCH NEEDS

Most of the attention of forest management has, of course, emphasized wood. The significant increases in future demands for wood fiber already have been discussed. Not considered in the estimates is that potential for increased demands for wood fiber caused by the new interest in research aimed at substituting renewable for nonrenewable materials (24)(297). It has been pointed out that during the past 20 years there has been a decline in research devoted to renewable materials. Needs in this area have been summarized as follows (24):

> What is needed is a framework that incorporates the diverse information on the technical, economic, energy, and environmental aspects of the materials system and thus facilitates the study of the future role of the renewables as a source of materials and more specifically addresses the substitutions of renewable materials for nonrenewable in particular end uses.

Rising timber prices are said to be a potential threat to encouraging greater use of wood fiber, especially as a substitute for existing uses or for new materials (301)(325). Increasing the supply of timber could act to dampen the upward trend in prices. For this reason, and to meet future demand, increasing wood fiber production from national forestland is viewed almost unanimously as a priority.

A consensus further appears regarding a framework for achieving the goal of increased wood fiber production: that intensive timber management should be undertaken on the most productive classes of forestland. A study assessing how the goal might actually be reached on national forestland indicates that about 40 percent of national forest commercial acreage could, under intensive management, economically produce more wood annually than is produced currently from all forests (43). A similar analysis in California showed that intensive management on 60 percent of the commercial forest acreage could achieve fiber output adequate to meet future demand (389).

Concentrating timber investments on the three most productive classes of forestland (Site Classes I, II, III) may be sufficient to yield timber to meet the nation's needs. There would be difficulty in encouraging the small private owner of forestland to intensively manage his land for timber production. Environmental degradation might accompany intensive management. Conflicts might arise if especially scenic or otherwise valuable land was reserved for timber alone. The fact that high and low-productivity timberland is intermingled would cause problems. Yet concentrating timber investments on specific land parcels would free other land for maximum production of non-timber forest outputs.

The small private forestland owner is a special problem. Existing timber management incentive programs administered by the Forest Service should be continued, according to forestry experts, who also call for greater effort in analyzing the effectiveness and efficiency of the programs (319). Others suggest limiting the incentive programs to high productivity lands and large parcels (43). Innovative approaches include federally assisted leasing of small private forestland to form large management units for timber production by professionals for the benefit of the landowner (43).

Public tax policy also is mentioned as a potentially fruitful approach to encourage better timber management on small private land holdings. It is generally acknowledged that annually assessed property taxes on standing timber are unfair in that they confront the owner with the need to make annual cash payments on a production process that requires many years before revenue is produced. Upward trends in property taxes on timber compound the problem. Severance taxes would be more consistent with the long-term nature of timber production (44).

Research also is needed on increasing the utilization of wood fiber. Estimates are that in 1970 an additional 4.7 billion cubic feet, or more than a third of the timber harvest in that year, could have been secured by using innovative logging techniques, wood processing practices, and more efficient manufacturing and construction methods (45) (167).

An issue directly related to intensifying timber management on high productivity forestland concerns the rate of harvest in mature national forests in the western United States. Harvest levels have remained relatively stable on mature forests, and even declined in some cases, but increasing harvest levels on industry forestland means that pressure to harvest public timber will increase.

Some studies suggest that timber harvest on public timberland should be increased for silvicultural and economic reasons (284). It is suggested that substantial increases in the growth of timber could be obtained by planting young vigorous trees in place of the mature trees, which grow more slowly. The increased income from harvesting old trees also could be plowed back into intensive timber management by government, thereby assisting in achieving substantial growth in wood fiber output. Three crucial elements in the proposal need clarification. First, funding must be adequate to ensure that harvesting of mature trees is followed by successful reforestation and other timber management techniques. This implies that harvesting of mature stands might be limited to high-productivity forestland. Second, because up to 100 years may be required for new growth, care must be taken not to overcut. John Zivnuska believes that the problem is finding (411)

> the optimum balance between a rate of cutting which would help meet the expanding demands of the next 30 to 40 years and accelerate the process of bringing the forests into a substantial net growth condition and the need to contain that rate of cutting in order to ensure a reasonable continuity in the level of cutting over time.

The third consideration is that environmental ramifications of the proposal might inhibit the productivity of the land for non-timber forest outputs. Scenic areas and valuable watersheds may be subject to degradation without careful harvesting.

CHAPTER 11 EMERGING FEDERAL POLITICAL AND INSTITUTIONAL POLICIES AFFECTING THE USE OF LAND

FEDERAL PLANNING ASSISTANCE

In the early 1970s, Sen. Henry Jackson (D-Wash.) began to press for Congressional approval of comprehensive federal land planning. These efforts finally failed in 1975 when the House Interior Committee defeated the latest version by four votes. The defeated bill would have provided grants to states to establish land planning programs. Participating states would have been required to inventory and control development within areas of critical environmental concern and to consider environmental and economic problems raised by subdivisions and developments of regional impact. No land use legislation was introduced in 1976.

Individuals and groups supporting federal land planning legislation are now concentrating on encouraging enforcement of a number of federal programs which require land use planning. The Ford administration has taken a fiscally conservative approach on all land use matters, asking for large cuts in land management and grant programs.

Section 701 of the Housing and Community Development Act of 1974 provides grants to cities and counties for comprehensive land use planning. Participating government agencies are required to include in their planning the same kinds of considerations as were required under the unsuccessful land use planning bills. The 701 money has been essential to city and county planning efforts throughout Montana; currently there are 21 programs with full time staffs. The $150 million originally appropriated by Congress for the program has been cut drastically and state officials predict that the federal program will be eliminated within two years. State coal tax funds have assisted some Montana counties in continuing their planning programs, although counties located in non-coal areas, especially those with small populations, have been hurt.

The National Flood Insurance Act of 1968 requires that structures built on floodplains and financed by federal programs—Veterans Administration loans, FHA loans, or conventional lending insured by the federal government—be covered by flood insurance. Federal flood insurance costs a fraction of private insurance. It is available only in communities which regulate construction practices on hundred-year floodplains.[42]

FEDERAL POLLUTION PROGRAMS

Federal and state water pollution abatement programs now emphasize indirect (so-called non-point) sources, including pollution caused by agricultural, forestry, and mining activities. Since Congress passed the Water Pollution Control Act (FWPCA) Amendments in 1972, state and federal programs have concentrated on a permit system to reduce or eliminate water pollution from a single pipe (point sources). The change in program emphasis will have especially significant effects in Montana. The state

[42]The hundred-year floodplain is that portion of a riverbed that could be expected to flood once every hundred years. In any given year the chances of a hundred year flood average 1 in 100.

Travel Promotion Unit, Mt. Dept. of Highways

Water Quality Bureau estimates that 3,800 miles of Montana's streams are degraded by non-point pollution, compared to 200 miles which are polluted by municipal and industrial point sources (243). In Montana, the source of non-point water pollution is runoff from agricultural land which carries sediments, pesticides, herbicides, and chemical fertilizers into streams and rivers.

To reduce non-point pollution, Montana officials must implement Section 208 of the FWPCA, which provides for planning grants to the state and to designated area planning organizations. Section 208 requires that the planning process include methods for reducing or eliminating non-point pollution with sanctions imposed for failure to do so.

State Water Quality Bureau officials will involve conservation districts through the state in its program to reduce pollution from agricultural, mining, and forestry activities. The conservation districts would be responsible for issuing land use regulations to eliminate excessive erosion from agricultural and timber cutting practices.

The program to eliminate water pollution caused by sediments is in its early stages. It is impossible to predict its success or eventual impact on agricultural and timberlands. However, if federal requirements do not change, programs to control non-point water pollution and the necessary land use regulations to go with them are likely to have a significant impact on land use in Montana.

In 1972 the District of Columbia District Court prohibited states from allowing significant deterioration of air quality where it was already cleaner than required by national standards. Critics of the decision say the ruling in effect is a prohibition of new industrial development. Advocates argue that any other position allowing further air quality degradation would defeat the intent of the Clean Air Act.

The U.S. Environmental Protection Agency's (EPA) regulations designed to enforce the court decision set up a classification system which allows individual states much flexibility in preventing deterioration of clean air. Several environmental groups have challenged the validity of the EPA regulations in federal court, claiming that they will not protect clean air.

Congress currently is debating amendments to the Clean Air Act which address the significant deterioration issue. The House and Senate versions give the federal government sole authority to protect air quality within large wilderness areas, international parks and national parks (Class I areas). Virtually no air quality deterioration would be allowed in Class I areas, which include large areas of western Montana. Class II "discretionary" areas, those the state could classify as either Class I or II, would include small national parks and wilderness areas. The Senate bill automatically would classify remaining land as Class II; the House bill would give states discretion to classify them as Class II or Class III. Class III would allow the greatest amount of deterioration, but in no case in excess of legal limits. The Senate bill would permit air quality degradation for industrial expansion in clean-air areas only if certain criteria were met. The Ford administration proposed a number of amendments, including abandoning the court's restriction against "significant deterioration."

In May 1976, the Northern Cheyenne Tribe, whose reservation overlies the Fort Union coal formation near the Colstrip energy development area, requested that the reservation be reclassified as Class I under the EPA regulations. (Currently the area is Class II.) If the request were granted, the Class I designation could limit construction of power plants in eastern Montana and northern Wyoming. The Northern Cheyenne request is an example of how the Clean Air Act might be used to effect land use decisions. How Montana chooses to enforce requirements to keep clean air clean could influence significantly development decisions throughout the state.

FEDERAL ACTIONS AFFECTING MONTANA FORESTLANDS

Montana Senator Lee Metcalf has introduced legislation to maintain the free flowing character of a 149-mile segment of the Missouri River (known as the Missouri Breaks) between Fort Benton and the Robinson Bridge. The Bureau of Reclamation and the U.S. Corps of Engineers each have proposed dams for this part of the river.

Under the Wild and Scenic Rivers Act, which the bill would amend to include the Missouri River segment, a river may be designated wild, scenic, or recreational. Each designation requires different water and land regulations; a "wild" designation is the most restrictive of human uses. Sen. Metcalf's bill would apply a combination of wild, scenic, and recreation designations to various portions of the Missouri. Its provisions guarantee that present uses of the river and adjacent land, which include grazing, farming, fishing and hunting, would not be restricted. Boundaries of the designated segments would exclude all adjacent land except significant historic sites, camping areas and access points.

Montana's 1.5 million acres of wilderness could be expanded by as many as 1,032,321 acres under the Montana Wilderness Act of 1975 (S.1506). The bill would require the Forest Service to study 10 areas in the state for possible designation as wilderness:

1. West Pioneer Wilderness Study Area, Beaverhead National Forest (151,000 acres);

2. Taylor-Hilgard Wilderness Study Area, Beaverhead and Gallatin national forests (289,000 acres);

3. Bluejoint Wilderness Study Area, Bitterroot National Forest (61,000 acres);

4. Sapphire Wilderness Study Area, Bitterroot and Deerlodge national forests (77,000 acres);

5. Elkhorn Wilderness Study Area, Helena and Deerlodge national forests (77,000 acres);

6. Middle Fork Judith Wilderness Study Area, Lewis and Clark National Forest (81,000 acres).

7. Ten Lakes Wilderness Study Area, Kootenai National Forest (91,000 acres);

8. Big Snowies Wilderness Study Area, Lewis and Clark National Forest (91,000 acres);

9. Hyalite-Porcupine-Buffalo Horn Wilderness Study Area, Gallatin National Forest (150,000 acres); and

10. Mt. Henry Wilderness Study Area, Kootenai National Forest (21,000 acres)

The 10 areas have been identified by the Forest Service as among those in its inventory of all roadless areas, and, except for portions of three, were not selected as wilderness study areas in a nationwide review process.

When an area has been designated for study under the Wilderness Act, the Forest Service must protect its wilderness character while it determines the area's suitability for wilderness designation. The Forest Service recommends to the President whether the area should be designated within five years after passage of the bill; the President may recommend wilderness designation to the Congress.

The proposed Endangered American Wilderness Act of 1976 (S.3630) would designate the Mt. Henry (Study Area No. 10) and the McGregor-Thompson area in the Kootenai and Lolo national forests (89,000 acres) as areas to be studied for possible wilderness designation.

The Multiple Use-Sustained Yield Act of 1960 states: "it is the policy of the Congress that the national forests are established and shall be administered for outdoor research, range, timber, watershed, and wildlife and fish purposes." At best the policy suggests harmonious ecological management of the varied national resources entrusted to the care of the Forest Service. However, critics of the multiple use concept feel that in theory and in practice it is so vague as to be meaningless or worse yet, to allow conflicting interpretations. Because the statute lists no priorities among uses, critics feel that the concept can be used to justify whatever management practices the Forest Service chooses to adopt.

Closely related to the multiple use debate is the controversy over clear-cutting, the practice of cutting all trees of all ages within a defined area. Critics maintain that clear-cutting violates the spirit of the multiple use concept because through it timber production precludes all other possible uses. The controversy is not new but it has received renewed attention in light of a recent federal court ruling referred to as the Monongahela decision, which held that clear-cutting violates the National Forest Organic Act of 1897. The court commented that Congress might wish to review the Organic Act in light of modern timber practices. Senator Hubert Humphrey responded to the court's suggestion by introducing a bill (S.3091) relaxing restriction on clear-cutting. Those opposed to clear-cutting and other Forest Service timber management programs submitted a bill which supplements existing laws by more specifically defining acceptable management practices, including limits on clear-cutting.

Recreational land development on Forest Service land and on private land adjacent to national forests is becoming an increasingly important issue. Montanans became familiar with many of the pertinent questions when the Forest Service approved the development of Big Sky of Montana, Inc., a large real estate development in southwest Montana that uses public and private land as a recreation area to attract buyers. Ski Yellowstone, a similar real estate development, currently is under consideration by the Forest Service.

In its Recommended Renewable Resources Program, a planning document required by the Forest and Rangeland Renewable Resources Act of 1974, the Forest Service proposed that demands for outdoor recreation be met by "dispersed recreation" requiring little development of Forest Service land. It suggested that fully developed recreation facilities be provided through private means. The program fails to suggest a policy to limit environmental degradation of national forestland when private developments on land adjacent to national forests put pressure on wildlife. Nor does the program consider the potential for secondary developments stimulated by Forest Service assistance to private developments through land exchanges and special use permits, as occurred in the case of Big Sky.

Under the General Exchange Act of 1922 the Forest Service may exchange public land for private land of equal value. Through land exchanges, private developers are able to consolidate their holding within or adjacent to national forests, thereby making possible large scale real estate developments.

The special use permit provides an alternative means for private development. Under its permit system, the Forest Service can authorize private developers to build recreational facilities on national forestland. The Ski Yellowstone development would use this alternative to construct ski lifts, a restaurant and roads in the Gallatin National Forest.

Wildlife experts point out that depending on the pattern of land ownership and wildlife needs, real estate developments near Forest Service land may have a more significant adverse impact on wildlife habitat than might be suggested by the total land area being developed. In typical national forest areas, because the federal government disposed of most of the more productive areas at lower elevations and retained the less productive mountain land, a significant portion of land available for development is vital winter range for wildlife which uses national forest land for summer forage.

FEDERAL, STATE, INDIAN WATER ISSUES

In 1973 Montana changed its water appropriations laws by enacting the Water Use Act. Just before the new law went into effect, a number of individuals and corporations filed for appropriations rights under the old law. Intake Water Company, a subsidiary of Tenneco, Inc., filed a notice of appropriation for approximately 80,500 acre feet of water from the Yellowstone River. Tenneco has large coal interests in Montana; it intends to use the water for industrial and agricultural purposes.

The state Department of Natural Resources and Conservation (DNR&C), the state agency responsible for determining water rights, challenged Intake's notice of appropriation in state district court, claiming that the company had no water rights because it had not begun construction of water diversion structures within 40 days as the law required. DNR&C also argued that a ruling against it could infringe on existing water rights and destroy the state's ability to promote orderly use of its water. Intake claimed that it had adequately demonstrated the diligence required by the law by conducting extensive aerial and ground surveys and environmental studies. The district court ruled in favor of Intake and the case is now before the Montana Supreme Court. The outcome of the case will affect over a half million acre feet of water appropriations from the Yellowstone and also will determine the water rights on other rivers where numerous claims were filed before the effective date of the 1973 law.

In a related lawsuit, Intake has challenged a state law prohibiting diversion of state water out of Montana without the Legislature's permission and also has challenged the constitutionality of a provision in the Yellowstone Interstate Compact prohibiting diversion of the river's water to areas outside the river basin without permission of the legislatures of Montana, North Dakota and Wyoming, which are parties to the compact. Intake hopes to build a dam on the Powder River, a tributary of the Yellowstone. Water from the impoundment would be piped to coal development areas in North Dakota and near Gillette, Wyoming, both outside the Yellowstone Basin.

In 1975 three lawsuits filed by the Northern Cheyenne and the Crow Indian tribes and the federal government claimed large amounts of water from the Tongue River and its tributary, Rosebud Creek, and the Bighorn River under several Indian treaties and the federal reserved water doctrine. The suits were prompted by possible water shortages and the Montana Water Use Act of 1973. Under the act, Montana planned to adjudicate in state courts all water rights on state rivers. The Indians believe state courts traditionally have been unsympathetic to their claims; therefore they sought by their suit to move adjudication of their water rights to federal court. The state, which was named a defendant along with approximately 5,000 ranchers, coal development companies, and other corporations, is resisting.

In their suit, the tribes are asserting for the first time that their rights to water include water sufficient for industrial, recreation, and wildlife as well as for domestic and irrigation use. Cases decided in the past have been limited to determining Indians' rights to water for irrigation and domestic uses. Final resolution of the cases could take 10 years. Whatever the outcome, the decision could affect significantly the scale and terms of coal development in eastern Montana. Montana lawyers expect the Indians to be granted rights to very large amounts of water.

USDA POLICY CHANGES

During the past several years the Department of Agriculture has pursued aggressively a policy of eliminating many of the direct subsidies and restrictions which formerly had been important to the nation's farm policy. The policy now is to encourage farmers to produce at capacity and, in the words of Earl Butz, Agriculture Secretary, "to compete in the open market for the consumer's dollars" (380). All crop acreage limitations have been removed.

To assure a market for American farmers, the department has emphasized marketing U.S. farm products abroad. In calendar year 1974, farm exports reached $21 billion, compared to $9.4 billion in 1972. The Food for Peace Program enabled the department to ship $1 billion in agricultural commodities to other countries. Terms under the program vary from sale of commodities at current market prices to outright donations as part of the nation's program fails to suggest a policy to limit environmental $252 million in wheat and wheat products and $101 million in animal feed grains. The program has been credited with being a successful tool of market development; frequently, gifts of American products have led to full cash transactions.

The effort to reduce direct subsidies and increase imports was influenced significantly by the Nixon and Ford administrations' policy to reduce the federal budget and to improve the United States balance of payments status with other nations. Official policy was to encourage demand for American agricultural products to deal with potential and actual food shortages in other countries.

The numerous research and cooperative programs administered by the Department of Agriculture have reflected its policies of increased production and aggressive export marketing. In his statement before the Senate Appropriations Committee in April 1975, Robert Long, USDA Assistant Secretary for Conservation, Research and Education, requested money for "an all-out research effort aimed at significantly increasing food production, while at the same time reducing energy consumption and improving environmental quality."

EPA REGULATION OF TOXIC SUBSTANCES

The Environmental Protection Agency (EPA) has, since 1975, emphasized regulating pesticides under the Federal Environmental Pesticide Control Act of 1972 (still referred to as the Federal Insecticide, Fungicide and Rodenticide Act [FIFRA]). Approximately 60 percent of all chemicals regulated under the act are applied to commercial agricultural land. Despite intense political pressure, including threats to reduce EPA's funding if pesticides regulation were too aggressive, in the past two years EPA Administrator Russell Train has suspended use of four widely used pesticides and has taken steps to eliminate chloroform and mercury as pesticide ingredients. EPA's recent moves against pesticides and toxic substances arise in part from the pressure of groups and citizens who point to evidence that cancer in humans may be due largely to strange chemicals loose in the environment. The World Health Organization and the National Cancer Institute attribute 90 percent of cancer in humans to environmental pollutants.

A major issue yet to be resolved is this: should government limit or forbid the sale of chemicals only when there is very substantial proof that they are dangerous or should chemical manufacturers be required to prove their products are safe before offering them for sale? Until recently, EPA and federal judges hearing cases concerning potentially harmful chemicals have been reluctant to accept scientific evidence, showing various chemicals to be harmful to laboratory animals, as a basis for inferring that they were harmful to humans and therefore to be limited or banned. However, EPA Administrator Train, in his recent suspension of chlordane and heptachlor, based his decision on the conclusion that the chemicals are *likely* (not proven) to result in an unreasonable risk to human health and the environment. Train also said that manufacturers carry the burden of proving the safety of the pesticides they want to sell. The Food and Drug Administration has taken a similar position on the sale of some food coloring.

Proving that a chemical is dangerous is especially difficult with carcinogenic (cancer-causing) chemicals since there is typically a long period of incubation between exposure and the appearance of cancer. In addition, environmental factors may combine (so-called synergism) in their cancer-causing effects; a chemical may be carcinogenic only in combination with other chemicals or environmental conditions.

If enacted, the federal Toxic Substances Control Act, variations of which have been pending in the Congress for five years, would give EPA very broad authority to regulate chemicals and would specifically require the agency to test new chemicals for harmful effects before allowing them on the market.

Farming interests have been a major factor in pesticide regulation. Efforts to give the U.S. Department of Agriculture veto power over EPA's pesticide classification decisions failed in early 1976. However, agricultural interests successfully prevented EPA from regulating private applicators (farmers) who apply hazardous pesticides.

BLM MANAGEMENT OF PUBLIC LAND

Unlike the Forest Service, the Bureau of Land Management has neither an Organic Act nor any legislative authority comparable to the Multiple Use-Sustained Yield Act of 1960. Because BLM land, for reasons of law and geography, can be used by only a limited number of ranches, a close working relationship develops between the BLM and private landowners, which, of course affects BLM's management practices. Environmental activists have considered this combination of interests potentially a barrier to maintaining productivity of public rangeland. Legislation to give BLM an Organic Act is now pending in Congress. Senate Bill 507 (passed in early 1976) generally is supported by environmental organizations; it would place limits on mining claims on BLM land, repeal various desert land entry and public land disposal laws, require BLM to review its land for possible wilderness designation, transfer enforcement responsibilities from local officials to BLM personnel, and mandate a multiple use-sustained yield management policy to replace BLM's present emphasis on grazing under the Taylor Grazing Act. The House version of the BLM Organic Act favors grazing and mining interests by mandating low grazing fees; limits the discretion of the Secretary of Interior to withdraw lands from mining claims; increases the life of grazing permits; requires that regional grazing district advisory boards heavily represent grazing interests; and limits the Interior Secretary's discretion to enlarge the National Wildlife Refuge System with BLM land without congressional approval.

Grazing fees have been a subject of controversy for years. Historically the fees have been below market value of the grazing rights in part because the Taylor Grazing Act aims to subsidize the livestock industry, and in part because of the aforementioned relationship between BLM and ranchers who hold BLM permits.

In 1969 the Departments of Agriculture and Interior began a program of increasing fees to make comparable the fees for public and private lands by 1980. Those supporting fees below their market value point to the Taylor Grazing Act and to the often marginal economic position of livestock producers as justification for continuing to lease public grazing land on terms favorable to ranchers. Critics of bargain grazing fees say that the practice has contributed to serious overgrazing because permit holders have little economic incentive to maintain high quality rangeland. The Public Land Law Review Commission recommended that "fair market value, taking into consideration factors in each area of the lands involved should be established by law as a basis for grazing fees."

In late 1975, two federal courts agreed with a group of non-profit environmental organizations that the BLM was required to prepare "geographically individualized" environmental impact statements for its grazing permit program. The judge noted that the serious overgrazing of many BLM administered lands (estimated at one-half million acres in Montana and 126,000,000 acres nationwide) supported the environmental organizations' position that BLM had neglected environmental considerations in its program. BLM plans to prepare environmental impact statements (EISs) for each of its 212 management districts. All of the statements must be completed by July 1988. The first EIS covering Montana land will consider the area surrounding the Charles M. Russell National Wildlife Refuge in BLM's Lewistown, Malta and Miles City districts. The EIS on the area, known as the Missouri River-Musselshell Breaks, must be completed by Oct. 1, 1978. The EIS on the Mountain Foothills in the Missoula and Dillon districts must be completed by 1979, and the Prairie Pothole EIS in the Malta district must be completed by 1981. Five additional EISs must be completed for the state by 1988. Current permits and leases will continue uninterrupted during the EIS preparation process. However, all lease renewals will be on an annual basis until the EIS for the allotment management plan is completed. The allotment management plan provides a specific scheme for managing individual grazing operations. Grazing allotment plans are based on a quantitative and qualitative listing of resources and criteria for maximum development of resources of which forage for grazing is but one.

FEDERAL COAL LEASING AND MINING ISSUES

Mining of coal and other minerals is certain to have a major impact on Montana's renewable resources because grazing and agricultural land overlies much of the large coal reserves in eastern Montana. The Bureau of Land Management is responsible for all minerals on federally owned land, including national forests. The Bureau also administers federally owned minerals underlying private land.

Project Independence, the federal policy to make the U.S. independent of foreign energy sources, has intensified pressure to mine western coal as quickly as possible. The desire for quick "independence" evidently overrides other conflicting federal policies, including the Department of Agriculture's program to increase agricultural and beef production in the face of expected worldwide food shortages and increased demand for American food products, BLM's mandate to conserve grazing land, and the Interior Department's responsibilities as trustee for Indian lands.

Department of Interior regulations published in May 1976, will govern mining practices for federally owned minerals. Under the regulations, BLM must approve mining and reclamation plans before mining can begin. The plans must assure restoration to original contours and revegetation of land with minimum interference with surface and underground water supplies.

Critics of the accelerated mining policy and the Interior Department regulations make the following arguments (155):

1. Coal mining companies can obtain variances from reclamation requirements if "unusual physical conditions" make reclamation "impractical" or "environmentally undesirable." Environmentalists feel that the variances could result in little or no reclamation, especially because, in their view, reclamation of semi-arid land might not be possible.

2. State laws more stringent than federal regulations, which will generally apply under the regulations, can be ignored if the Secretary of Interior decides that the "overriding national interest" requires mining. The State of Wyoming in a lawsuit filed June 9, 1975, in the Wyoming federal district court claims that this provision is illegal and unconstitutional. Wyoming has asked the court to declare the regulations invalid and to permanently enjoin any federal activity which ignores state regulation of mined land reclamation. Interior Secretary Thomas Kleppe stated that he will not allow states "to sit on their hands and attempt to block or lock up federal coal reserves that can be mined in an environmentally sound manner."

3. The regulations, which require companies to use "best practicable commercially available technology" to minimize degradation of water quality and flow, do not sufficiently protect groundwater supplies. Louise Dunlop, coal mining specialist for the Environmentally Policy Center, feels that the word "practicable" is simply a euphemism for "convenient," and offers scant protection for the region's water resources.

Coal mining interests have criticized the regulations as being "unduly restrictive." President Ford vetoed the most recent attempts to pass national strip mining and revised coal leasing laws.

THE 25 PERCENT FUND

A bill recently passed by Congress increases federal payments to counties which have Forest Service land within their boundaries. Under recent law, counties receive 25 percent of the income derived from Forest Service activities, primarily timber sales and grazing leases, to offset losses in property taxes which would go to the counties if the land were privately owned. H.R. 9719, written with the assistance of the University of Montana School of Forestry, would give counties 10 cents per acre in addition to 25 percent of total receipts, or a flat 75 cents per acre of Forest Service land. The 20 counties in Montana which contain most of the Forest Service land may receive substantially greater income from the newly enacted bill.

CHAPTER 12 DEVELOPMENT AND JOBS—THE ROLE OF RENEWABLE LAND RESOURCES

STATE CONCERN WITH "QUALITY OF LIFE"

Beginning in the late 1960s Montana state government began to respond to the growing national interest in, and concern for, environmental quality. In May 1968, the state Department of Health sponsored a conference entitled *A Montana Strategy for a Livable Environment* with the goal of discussing environmental pollution in Montana and proposing governmental initiatives to reduce it (239).

The publication of the *Montana Economic Study* in October 1970, properly focused attention on what some considered Montana's major economic problems: a slow rate of growth in job formation and a Montana per capita income below the national average. The Bureau of Business and Economic Research at the University of Montana, which did the study under contract with the state Department of Planning and Economic Development, concluded that a greater emphasis on the growth of job opportunities would be "a sensible general goal of state policy" (383).

By the end of 1970, then, two central planning themes for Montana state government had been put forth, environmental quality and economic growth. In December of that year a governor's conference was convened to examine goals and objectives for state government in the 1970s. The keynote speech by then-Governor Forrest Anderson established that improving the "quality of life" for the people of Montana was an appropriate principal focus of governmental planning and that "quality of life" was a function of both a high quality environment and a strong economy (263).

In 1972 the same themes again were explored by Montana government. In recognition of increasing demands on Montana's natural resources and the importance of those resources to Montana's environment, the governor sponsored a symposium on environmental and economic issues concerning the state's land and water resources (384). In late 1972 Montana State University sponsored a Public Affairs Forum devoted to the advantages and drawbacks of potential economic growth in Montana (264).

In early 1973 the state USDA Committee for Rural Development released a publication delineating what it considered the four major areas of concern surrounding "development" in Montana: human resource development, environmental and natural resource improvement, community development, and economic development (258). And in 1974, another governor's conference was convened to deliberate over the relevance of land use to state efforts at shaping Montana's future.

These public activities have important common themes: resources, the environment, the economy, and the future. Apparently a consensus has been reached at the highest levels of state government that there should be a close assessment of whether existing policies and programs are responding to the natural resource issues critical to Montana's future.

The state legislature also has acknowledged the need for more state involvement in land and resource decisions affecting the state's economy and environment. It enacted the Montana Environmental Policy Act, laws regulating the appropriation of water and the siting of major energy production facilities, laws providing tax incentives for keeping land in agricultural use and for regulating air and water pollution, and laws stimulating the development of alternative energy resources and the enhancement of the state's renewable resources. These legislative and executive initiatives are based on the assumption that state government has a valid role in directing, in the public interest and to the extent possible, the inevitable changes that will confront the state.

Travel Promotion Unit, Mt. Dept. of Highways

THE PUSH FOR JOBS

Today state government is promoting the formation of jobs. In fact the theme of economic growth and job formation appears to have surpassed in importance the objective of environmental quality. In August 1975, Governor Thomas L. Judge stated (156):

> The number one priority of this administration for the remainder of our term in office is simply stated. It is jobs. We must aggressively pursue the goal of creating an atmosphere which nurtures the expansion of job opportunities and encourages well planned economic growth. Effective today it is the role and function of state government to devise and implement programs and policies which will provide job opportunities for all Montanans in this year and in the years to come. There is no task more demanding of our best energies, there is no problem more pressing, there is no governmental activity of greater moment.

The emphasis on development and jobs reflect the wider national concern over the economy, an emphasis prevailing since the economic recession in 1974 and the high unemployment levels which followed.

The federal government has long had, of course, an active interest in the nation's economy. In the 1960s this interest was extended to include national policies promoting public welfare through regional development. Federal regional development initiatives today are carried out largely through programs funded by the Economic Development Administration (EDA) of the Department of Commerce and Title V regional commissions. Both the EDA and the regional commissions were established pursuant to the Public Works and Economic Development Act of 1965.

Because regional commissions (which number seven nationally and include at minimum two states or portions of them) take a wider geographical perspective in their work than the sub-state districts originally funded through EDA, the federal government has been favoring the regional commission approach to regional development. Recently the commissions have enjoyed increased funding and responsibilities through the efforts of lobbyists on behalf of the commissions, by member state governors, senators, representatives, and because it is federal policy to return decision making authority to local and regional bodies.

The Old West Regional Commission (OWRC), of which Montana, North and South Dakota, Wyoming and Nebraska are members, has joined with the regional EDA office to assist Montana state government in planning for economic development. This assistance includes money for a Governor's Office of Commerce, formed to promote development; the Montana International Trade Commission, formed with a similar intent; the Montana Futures Process, a state level model designed to simulate future economic and demographic conditions; and the Regional Economic Plan, a long-range plan for the region's economic development called for by the Public Works and Economic Development Act.

Although there is no specific state policy enunciating economic development goals or means to achieve them, it is assumed that the general direction implicit in all these efforts can be seen in the thrust of recent state actions and in publications emanating from the state's participation in the Regional Economic Plan formulated by the Old West Regional Commission.

First, primary economic development objectives are stated in terms of increasing employment opportunities, per capita income, and maintaining and achieving environmental quality implied in federal programs (245) (277). Secondary objectives, or methods of achieving the primary objectives, include the development and promotion of further agricultural and wood products processing, tourism and recreation, the promotion of export trade, the development of water resources, the stimulation of investment capital through public funding, and providing necessary educational, vocational and manpower training, health and housing services and facilities (245) (277).

State actions and public announcements support the emerging objective of putting Montana's natural, environmental and human resources to work. The Montana International Trade Commission has been working with the governor's office and the Coal Gasification Task Force to investigate the feasibility of building a coal gasification plant at Glasgow Air Force Base. The governor has long decried the lack of funding adequate to enable the Forest Service's regional office in Missoula to make the full allowable cut on Montana's national forests. The state Board of Natural Resources, whose members are appointed by the governor, has approved the construction of Colstrip Units 3 and 4, partly because of the jobs they will provide. The importance of tourism to the state's economy has been widely debated. The Travel Promotion Unit of the state Department of Highways has recommended more research on the question. State government has assisted in identifying potential markets and promoting the export of agricultural commodities. The major focus of the recently enacted Renewable Resources Development Act is to put available water supplies to agricultural use.

FACTORS LIMITING STATE ECONOMIC DEVELOPMENT SCHEMES

The assumption throughout these development initiatives is that promoting jobs is a valid public policy. If this is the case, it is important to discuss briefly the constraints that govern the role of public policy in achieving this objective.

Studies on why firms decide to locate in an area conclude that there are three principal factors involved: availability and cost of inputs (the most important of which are raw materials and labor), distance to markets, and transportation corridors from suppliers and to markets outside the region (193). As the *Montana Economic Study* pointed out, the state's role in positively affecting these three important variable is "sharply limited" (383). Another suggests that two broad external conditions are the key factors in determining how and whether a region will develop: demand for the region's outputs, and supply of inputs (such as labor, capital, technology, knowledge) to the region's productive capacity (158). In addition state government efforts to stimulate demand are limited mainly to publicizing a region's goods and services and lobbying for more favorable transportation rates to outside markets. Secondary activities favorably affecting factors of production might include more support of educational research activities, increased investment in upgrading the productivity of the region's human and natural resources, the provision of local public services, and general promotion of the region's attractive features.

In addition to the economic constraints limiting the effectiveness of regional development initiatives, the fundamental economic uncertainties inherent in any kind of planning based on past experience may render singular development objectives, such as job formation, meaningless. For example the *Montana Economic Study* predicted that, during the 1970s the job gap[43] in Montana would continue to grow, out-migration would intensify, and per capita personal income would continue to slip relative to the national average. What it failed to foresee was the increasing economic attractiveness of Montana's agricultural, energy, and forest resources which have caused trends counter to predictions of the early 1970s. From 1970-74 Montana experienced a net in-migration of 20,000 persons caused in part by an increase in employment of 35,000—just about keeping pace with the increase of 44,000 in the civilian labor force. Per capita personal income has also improved relative to the national average, from a level 16 percent below average in 1968 to a level 9 percent below average in 1974 (254).

The status of Montana's economy obvioisly has improved since the *Montana Economic Study*. The point is that policies encouraging job formation need to be reevaluated carefully in light of changing economic forces. Upon close examination, for example, job formation may be too general an objective and not as workable as specific strategies to encourage employment of seasonally unemployed Montanans, or manpower training to ensure that as many Montanans as possible fill whatever new jobs appear. If changing conditions are characterized by increasing demands on Montana's renewable resources, future economic viability and strength may be achieved better through investments in resource productivity and changes in transportation rates.

Political and social limitations also counteract the achievement of singular economic growth goals. The social and political desirability of maintaining and enhancing environmental quality may limit directly specific development proposals. Evidence of such contradictions in public policies in Montana abounds. Environmental concern greatly influenced state review of Colstrip Units 3 and 4. Similar concerns govern timber harvest levels and planned increases in irrigation. More importantly, there may be basic conflicts between policies designed to alleviate loss of jobs due to an economic recession or technological innovation and policies to maintain the long term productivity of the resource base.

Dilemmas also present themselves in the matters of jobs, population and quality of life. Efforts to promote jobs inevitably will add to the potential for increasing population. There may be a point at which population levels in Montana will exceed a level that preserves the quality and value of Montana's natural and environmental resources.

RE-EXAMINING REGIONAL ECONOMIC DEVELOPMENT

Given the valid public objective of encouraging a strong, stable, and viable economy, a rephrasing of the issues involved would be helpful. Edgar M. Hoover's *An Introduction to Regional Economics* (1975), provides a basic framework (158):

1. Do we wish to emphasize prosperity of "place" or "people"?

2. Can we distinguish between alleviating "distress" symptoms (unemployment) and promoting investment toward long-term economic strength?

3. How important are diversification and specialization to Montana's economy?

4. How should we choose among the various means of promoting economic growth and stability available at the state level?

Some brief examples will focus these issues:

1. Encouraging industrialization in eastern Montana is emphasizing "place" prosperity. This is a questionable strategy when two central facts are examined. First, eastern Montana has the highest income level and lowest unemployment rate in the state (254). Second, how many Montanans actually will be employed at Colstrip Units 3 and 4, without large local or regional supplies of trained labor?

2. One researcher contends that efforts designed to alleviate the "job gap" by discouraging out-migration are merely responses to distress symptoms (145):

> Whatever may be the consequences of out-migration from lagging areas, it is clear that policies that merely try to check migration—even by attempting to subsidize the industrialization of rural areas—do little service to either the nation or the individuals concerned. . .The real problemof sagging regions is underinvestment in their human resources, rather than migration as such which is a symptom rather than a cause.

3. Assuming that the ultimate objective of diversification efforts is developing an inherent resilience in a region's economy, then cannot this objective be better served by other strategies such as improving the human or resource productivity of the region? Also, diversification achieved through large, specialized producing units may be counter-productive (158):

[43]The difference between the number of jobs created and the growth in the labor force.

> The inhibiting effects of high specialization are compounded if the region is specialized in activities characterized by large producing units, large firms, and absentee ownership.... The range of local external economies is underdeveloped and the whole climate for new and small businesses and new lines of activity is much less favorable than it is likely to be in a region of similar size where the firms and production units are smaller, more numerous, and less self-contained.

4. Are efforts at attracting outside industrial firms as important as expanded research and investment in resources? What role can public employment and manpower training play? What are the limits of effectiveness of promoting international trade and tourism?

These issues acknowledge the need for adequate employment opportunities for Montanans but they question standard responses to dilemmas about economic growth and development. Placing development proposals in a long-term, holistic perspective is imperative.

Need exists for long-range planning in the preservation and development of Montana's renewable resources given the importance of agriculture and forestry to the Montana economy, the seemingly endless national demand for the products of renewable resources, and the unresolved conflicts already apparent in their use.

Most Montanans depend on agricultural and forestlands for a living or depend on those who do. Some 180,000 jobs in the state are directly or indirectly related to agricultural or timber products—60 percent of Montana's total employment. Some communities in the state are totally dependent on either agriculture, wood products or recreation, or a combination of them. The production of water, perhaps the most important of the renewable resource outputs, depends on forestland almost exclusively.

Political and economic forces are working to increase future demands for the outputs Montana can supply: recreation, wilderness, range forage, feed grain (barley and hay), food grain (wheat), timber and water. But recent trends in the use and productivity of agricultural and forestland are cause for concern, particularly in light of the forecasted demand for the outputs of the land. Unsettling trends include management of forest and rangeland at less than full economic productivity, inadequate information about compatibilities among resource uses, and the potential for environmental degradation in some agriculture and forestry practices. Historically, demand for agricultural and wood products has been met through more intensive use of the land (application of chemicals, irrigation, increasing the number of animals on a given piece of range), and more extensive use of land (harvesting of timber in inaccessible areas, plowing under of rangeland).

Intensive and extensive uses both are becoming more expensive socially as the common environment is degraded and economically as land values rise and the costs of intensive use—labor, capital, energy—move ever higher. Combined with price instability, these trends have led production of agricultural and forest outputs to a condition of financial instability and economic uncertainty. Enlightened policies in the care and use of the land's renewable resources could reverse this trend toward instability and uncertainty. Production goals and methods in harmony with the land's ability to produce also could have the positive side effect of preventing otherwise inevitable environmental decline and ensuring the productivity of the land for future generations.

Throughout this report the implicit assumption by policy makers has not been challenged: that demand for the renewable and nonrenewable outputs of Montana's land resources will continue to grow. The point has been that the quality and productivity of Montana's two major land resource sectors, forestland and agricultural land, must be maintained. Montana's wealth is attributable largely to these land resources. It is imperative that an intensified effort be devoted to gathering and using knowledge about the economic and environmental systems surrounding the use and production of outputs from agricultural and forestland; only through this type of commitment can we hope to sustain the land's productivity.

Very little of the political discussion on "development" and "growth" concerns the land base itself. Because of the growing importance of renewable resources, because Montana's vast land resources provide renewable outputs, and because it is important to Montana's economy, equal attention should be devoted to the capability of the land to sustain the increasing demands that will be placed upon it as is devoted to developing and promoting those demands. It is this coequal emphasis that should begin today. In the long run the land's productivity will be the major determinant of Montana's quality of life.

CHAPTER 13 ECOLOGICAL ISSUES ARISING FROM THE USE OF MONTANA'S AGRICULTURAL AND FORESTLAND RESOURCES

The sustained production of renewable outputs from forest and agricultural lands in Montana depends on the healthy functioning of biological communities and the integrity of the environment that supports those communities. Four interrelated characteristics of biological systems have been identified as being crucial to regional planning and resource management (121). These characteristics are 1) ecosystem stability, 2) ecosystem assimilitative capacity,[44] 3) biological diversity, and 4) ecosystem productivity. To the extent that these features are disturbed either directly or as the result of damage to the physical environment, the long-term prospects for renewable resource production will be impaired. This observation applies equally to forest and agricultural systems (range or cropland).

The four cardinal features of renewable resource systems are difficult or impossible to measure in themselves. But when an ecosystem malfunctions, usually certain symptoms are physically measurable. Examples of symptoms are soil erosion, reduced yield, air and water pollution. It is principally on the measurements of these symptoms that we must rely for clues about the quality and trends of renewable resource systems.

In the following pages activities on forest and agricultural land in Montana will be identified that may interfere with important ecological processes and that may limit production or significantly add to the public and private costs of producing goods and services from the land on a sustained basis. In general, three types of sources are used to identify issues: 1) environmental condition and trend (indicator) data derived by measuring symptoms, 2) published and unpublished accounts by specialists identifying resource problems, and 3) data descriptive of actual physical impact upon ecosystems, for example acres of rangeland plowed and converted to marginal cropland.

The treatment of each issue will involve four separate elements. First, a brief description will be given of the pertinent ecological relationships operating within that segment of the resource system affected by the activity in question. Second, the extent and severity of the problem will be documented and the causative agents identified as accurately as possible. Third, institutional, legal, technical or management options for mitigating resource conflicts will be identified. And fourth, gaps in land use inventory and environmental monitoring information will be identified. Such data are necessary to form a clear picture of resource interactions and tradeoffs.

Not all resource conflicts can be documented scientifically; some may be just emerging and given scant attention to date; some will be expected to arise in the near future, given either past experiences in Montana or existing situations in other states. A complete tabulation of environmental problems and information needs for renewable resource management would be very long. Only the most significant issues and data gaps will be identified here.

FOREST PRACTICES AND THE PHYSICAL ENVIRONMENT

The steep slopes of Rocky Mountain Montana promote water erosion and movements of surface materials so that the soils tend to be thin and stony (117). Furthermore, the mean annual runoff from forested watersheds is often up to 50 times the runoff from non-forested watersheds in Montana (203)(278). The vegetation, soils and hydraulic components of Montana forests have evolved together to achieve a stable yet delicate balance, which can be disturbed

USDA Forest Service photo by Phil Schlamp

[44]Assimilitive capacity is the relative ability of a natural system to withstand disturbances and shocks, such as environmental pollution, and still remain viable.

by the physical alterations of the environment caused by logging (27).

Specific practices causing physical damage to forest ecosystems include: improper erosion control on roads, streambank cutting, skidding logs across streams, improper cleanup, failure to reforest, scarification, terracing, and cutting—particularly clear-cutting—on steep slopes. Some of these practices are no longer followed, at least not to the extent they were several years ago before the current era of environmental awareness. Others continue today and can be prevented only through closer supervision of logging activities and rigorous enforcement of guidelines. Problems resulting from these practices include: land slumping, increased runoff, untimely runoff, channel instability erosion and sedimentation, eutrophication, logging slash-caused fire hazards, blocking of streams, and visual pollution. The two most widespread, damaging and controversial practices are road building and clear-cutting.

At least concerning the Flathead National Forest, which is reasonably typical of Montana forestland, specialists feel that most of the environmental problems relating to timbering activities are caused by road building (385). The most serious problem resulting from road construction on steep slopes in forested watersheds is mass failure, which usually results in damaging landslides. Accelerated soil erosion and sedimentation have been documented from logging roads in the northern Rockies (196); erosion and sedimentation are greater the steeper the slope, and roads crossing drainageways cause greater sedimentation than roads on ridge tops (133). About 127 miles of streams in Rocky Mountain Montana have been degraded by sediments resulting from logging practices (244), primarily road building. But logging disturbances have other effects that are only slowly being recognized. Slope failure and sedimentation from roading and timber cutting in a drainage may act together to create a far more serious problem: watershed disequilibrium (113), a progressive wastage of trees, soil and water courses whose effects may last centuries even after a small disturbance. Criteria for designing and locating logging roads to control sediment are available (279). Environmental problems from logging roads could be substantially reduced by close supervision during construction and strict enforcement of design and location guidelines and water quality laws and regulations. Detailed and comprehensive soils capability mapping of unroaded commercial forest areas would help to alleviate the problem in the future. Alternative, "light handed" logging techniques such as helicopter or overhead cable systems would also help areas highly susceptible to erosion (27).

Clear-cutting involves the removal of all trees in a block, patch or strip. Among professional foresters it is the accepted method of harvesting 1) species that are intolerant of shade and whose regrowth will produce even-age stands, and 2) stands of trees that are infected with disease or insects (27). The primary impacts of clear-cutting are genetic, aesthetic and hydrologic. Clear-cutting is usually followed by the regeneration of an even-aged, single species, plantation-type stand of trees. Much of the resistance to clear-cutting by environmentalists has stemmed from the method's use in scenic and recreation areas. Clearcuts leave large volumes of residues following harvest. After logging some stands, there may be nearly as much logging debris as there is merchantable timber (147). Reports of recent studies on the hydrologic effects of clear-cutting in northern Idaho and Rocky Mountain Montana indicate an increase in streamflow and a change in water quality resulting from this practice (132) (321). Clear-cutting may also exacerbate erosion and slope problems triggered by poorly designed or located roads. Many of these problems can be mitigated by applying common sense management: avoid clearcutting in scenic and recreation areas, fit the size and shape of the clearcut to the landscape, clean up debris after logging, and refrain from cutting on overly steep slopes.

FOREST PRACTICES AND BIOLOGICAL RESOURCES

Two important biological outputs of forested watersheds in Rocky Mountain Montana are elk and trout. Elk require large blocks of undeveloped land, which in Montana are nearly all forested and in public ownership. Seventy-one percent of Montana's total elk habitat lies on national forestland (188). In mountainous areas elk migrate vertically with the seasons, taking to the timbered uplands and open parks in summer and descending to grassy winter ranges on lower slopes when snowfall accumulates at higher elevations. It is the lower ranges, which are often adjacent to private land, that are generally in short supply and limiting to elk populations. However, it is the timbered summer ranges that are most often affected by logging operations.

The naturally cool and almost chemically pure and silt-free streams draining timbered slopes in Montana provide spawning and nursery areas and contribute waters for the state's nationally known trout fisheries. Each stream reflects uses practiced on the forested land it drains, in terms of quality, quantity and timing of the runoff water it carries. Hydrologic stability, including channel integrity and adequate vegetative cover, are prerequisite to a self-sustaining trout fishery.

In recent years, it has become apparent that widespread modification of elk summer range by logging may produce complex and possibly detrimental effects on the animal. The lack of specific guidelines prompted the Montana Cooperative Elk-Logging Study, which was initiated in 1970 to determine "...the influences of logging and road construction, together and individually, on the behavior, movement, harvesting and survival of Rocky Mountain Elk in Montana." Various elements of the study are still underway. However two significant findings have been reported to date: 1) active logging effectively displaces elk and 2) elk summer range consists of five specific habitat types. These and other findings have resulted in the release of five interim management recommendations (189). The study has also raised further questions and needs, namely: 1) where are the key elk summering areas in Montana? 2) what are the behavioral and physiological responses of elk to stress brought on by logging? and 3) what is the economic value of the species? (188). Detailed vegetation mapping would be very useful generally and would help locate key elk habitat (187).

Improperly located roads and stream crossings, improper erosion control on roads, and poorly managed timber harvest operations, including streambank cutting, skidding logs across streams, leaving logging slash in streams, and cutting on steep unstable soils: all have detrimental impacts on trout habitat. The net effect of these practices on streams is to elevate water temperature and silt loads and reduce dissolved oxygen. In some cases the physical integrity of the stream may be threatened. About 127 miles of 10 streams in Rocky Mountain Montana—some of them significant trout fisheries—have been degraded by sediments from logging practices (244). Guidelines for stream protection in logging operations are available (186), although they are not always followed. The acceleration of road construction and timber harvest on steep terrain prompted the Montana Chapter of the American Fisheries Society to pass a resolution in 1975 requesting ". . .federal, state and county agencies and private industry to protect trout habitats in the utilization of Montana's forage and timber resources" and urging ". . .these agencies to seek consultation of fishery scientists to assist in the development and implementation of renewable resource planning. . ." (5).

FOREST PRACTICES AND SOIL NUTRIENT LOSS

The nutrients in forest soil that are required for timber production come primarily from the soil parent material or bedrock, and precipitation. Trees "tie up" certain soil nutrients, which are incorporated into trunks, branches, roots, and leaves. Some of these nutrients are recycled when needles fall. Forest litter decomposes slowly, releasing nutrients back into the soil. Nutrient losses can occur as the result of harvesting or fire, which in turn may promote overland runoff and leaching below the root zone. As long as nutrient inputs match or exceed nutrient export, forest soil can maintain tree growth indefinitely.

In addition to the physical soil losses due to erosion that may be accelerated by forest practices, several recent Montana studies have documented varying degrees of dissolved nutrient losses from forest soil following harvest or burning (36)(118)(132)(327). Forest soil nutrients carried away by surface water have the potential for compounding eutrophication problems in lakes downstream. Nutrients and sediment released by forest practices have been partially responsible for accelerated eutrophication in Lake Mary Ronan (241) and are contributing to the sediment and nutrient load of Flathead Lake (309). Nutrient losses usually subside within a few years following disturbance and after revegetation.

Montana forest soils are generally "young," with a biological life[45] approaching infinity, meaning there are potentially enough nutrients on the better sites to sustain timber production indefinitely under natural conditions (327). However, certain sites in Montana are chronically low in one or more nutrients, usually calcium, phosphorous and nitrogen, and on which it may be very difficult to reestablish a stand of trees once they are removed. Following harvest or burning, such sites may enter a state of "nutrient shock" during which nutrients are short for up to 1,000 years (95). Such sites need to be identified and managed according to their intrinsic nutrient limitations. Conversion to grazing land on either a permanent or a rotation basis may be more economically rewarding as suggested by Weaver (397). On sites studied by Stark (327) on the Lubrecht Experimental Forest, intense controlled burning of standing timber was calculated to reduce the theoretical biological life from infinity to 55,000 years, a time span long enough to be irrelevant to management. A companion study on the effects of harvest practices on nutrient loss is in progress. This study could help resolve the issue of whether the removal of vegetation and subsequent loss of nutrients from the ecosystem will cause long-term reduction in forest productivity. Undoubtedly the impacts of harvest and fire will vary, depending on how much material is removed and on the site's natural endowment of nutrients.

OLD GROWTH AND SUSTAINED YIELD

In Montana, most of the volume of all the principal species is in old growth, i.e., trees over 9 inches in diameter at breast height (304). These trees also comprise the bulk of timber harvested in the state. A considerable length of time—usually 60 to 120 years—is required for a tree to reach maturity under natural conditions. In overcrowded stands tree growth is suppressed and the time it takes to reach marketable size may be prolonged indefinitely. Elements of intensive timber management, including commercial thinning, pre-commercial thinning, restocking and control of disease, insects and fire, may be necessary to insure that growth of immature trees into the marketable category (5 to 9 inches or larger diameter at breast height) keeps pace with old growth harvest. Otherwise, stagnation and a growing backlog of non-stocked land will result eventually in a shortage of commercial timber. Aside from the possibility of a "timber bust" and its social and economic ramifications, overcutting old growth is now known to affect hydrologic balance and wildlife habitat.

Indeed, there is ample evidence that in many of the forests in the Northern Rockies (138), and in Montana the Flathead and Bitterroot national forests in particular (56)(344)(382)(385), the old growth is being overcut, based on a large restocking backlog and estimates that timber removal is exceeding net annual growth. The problem on national forests exists because forest administrators lack

[45]The biological life of a forest soil has been defined as the geologic time span during which any particular soil is chemically able to support trees of commercial size (327).

money for intensive management. The quicker the old growth is cut without intensive management, the more serious the problem will become (56). Nevertheless, much of the old growth is probably over-mature and should be harvested, while a switch to smaller trees and salvage of nongrowing stock should take some of the pressure off the old-growth timber.

On private land in Montana, industrial forests have been contributing an average of 58.6 percent of the timber cut while occupying only 22 percent of the total land (54). The level of intensive management on large private holdings varies considerably (56); however, it is evident that the industry cannot sustain this rate of cutting indefinitely. The implications of over-cutting some national and large private forests include greater reliance on other public and private timber in the future. Unfortunately, foresters have only incomplete knowledge of timber volume and production on private and even public land. More information is needed on inventory and growth of timber on private land and on actual acres of forestland in small private ownership (54). Should more funds be made available for intensive management, it would present a corollary problem: forest regeneration and thinning result in soil disturbance and impacts on hydrology, wildlife habitat, and ecosystem diversity (121).

FOREST INDUSTRIES, AIR QUALITY AND PUBLIC HEALTH

The climate and topography of Rocky Mountain Montana lend themselves to frequent episodes of inversion, a situation where masses of still air are trapped in pockets for hours or even days at a time. This relatively poor ventilation combines with heavy population and industry to cause air pollution problems in the mountainous areas of Montana. Seven of the nine state air pollution "hot spots" are located in Rocky Mountain Montana (254).

Death rates from 1969 to 1973 for asthma, emphysema and bronchitis were higher over all age groups for both sexes in Rocky Mountain Montana than in Great Plains Montana, and Lake County had the highest death rate in the state (69). Most of the population of Lake County is located in the Flathead Valley on the western side of the Mission Mountains. The Missions act as a barrier to the easterly flow of air, trapping in the valley whatever pollutants may be blown in from points north, west and south (69). Other counties with significantly high death rates were Lewis and Clark (ranking 12th) and Missoula (13th). Rates for Lincoln, Sanders and Mineral counties were extremely high but not significantly so because of the small sample size.

The primary antagonist responsible for aggravating respiratory problems is particulate matter or dust. The primary sources of dust in Lake and neighboring counties—Flathead, Missoula and Lewis and Clark—are unpaved roads, slash burning, and forest fires (see Table 81). Data for other neighboring counties are not available. In addition to area sources, Missoula and vicinity includes six major point sources—all associated with the forest products industry—emitting a total of 2,995 tons of particulates in 1975. In the Kalispell-Columbia Falls area there are eight major point sources affiliated with the wood products industry, together emitting a total of 478 tons of particulates in 1975 (135).

Although other sources may be involved, evidence suggests that particulates generated from logging roads, slash burning, natural and prescribed forest fires, and wood products plants in western Montana may aggravate respiratory problems significantly among the region's population. The Department of Health and Environmental Sciences has prepared and submitted to the U.S. Environmental Protection Agency a grant proposal for $135,000 to study the relationships between emissions and chronic respiratory diseases in several counties of Rocky Mountain Montana.

OTHER FOREST ISSUES

A number of forest practices aimed at increasing the

Table 81

Area Source Particulate Emissions, 1974.

(tons/year)

County	Unpaved roads	Slash burning & forest fires*	Other	Total
Flathead	66,550	26,484	1304	94,338
Lake	46,069	2,572	611	49,252
Missoula	45,767	10,896	1585	58,248
Lewis & Clark	55,434	15,253	850	71,537

* Assumes an emission factor of 50 pounds of particulates per ton of slash burned.

Sources: References 69 and 281.

production of merchantable timber have the potential for undermining ecosystem stability, reducing assimilative capacity and decreasing biological diversity (121). Wood fiber production is often promoted at the expense of other plants and animals, which may compete with man for wood and be the target of control efforts, or may be destroyed unintentionally as the result of forestry practices. Each species serves a function in the coniferous forest ecosystem; however, the role of many biotic components remains poorly understood. The pervasiveness of man-caused changes in the forests of Rocky Mountain Montana underscores the need to establish and maintain a system of representative ecosystems or natural areas where man's influence is negligible and natural processes prevail (302). There, complex and balanced systems could be studied and compared to the more simplified systems created by intensive management.

Restocking efforts usually try to establish a single-species, even-age stands of trees. Along with selective thinning and site preparation, restocking may result in ecosystem simplification, as well as soil disturbance, changes in the hydrologic budget, reduced assimilative capacity and alteration of wildlife habitat (121).

Forest insects and diseases are ecological factors that play an important role in forest succession. They attack primarily overmature trees, which when killed or weakened, allow for release of understory trees or invite fire, which has a sanitizing effect and promotes natural regeneration by pioneer species (27). Insects and diseases also exact a staggering toll against timber. For example, 2,161,309 acres in Montana were defoliated by western spruce budworm in 1974 alone (142). In 1975 an estimated 939 million board feet of timber were destroyed by insects and diseases in the 13 forests of the Northern Region of the U.S. Forest Service, which includes all of Montana's national forests (14). Various natural and exotic biological enemies, along with such chemicals as DDT, Zectran, and Sevin, have been used to control forest pests on limited acreages in the Northern Region in recent years (142) (192). Where they are applied, such pesticides and exotic species may upset ecological relationships (121).

Natural fires often result in an immediate and severe economic loss. For this reason fire prevention and suppression have achieved a great sophistication in forested regions. However, forest fires are also essential for mass establishment of certain commercially valuable trees and shrubs that game animals use for browse (117). Fire control changes the frequency and intensity of fire from that under which the biotic community evolved and thus may change species and ecosystem diversity. Natural and man-influenced fire regimes may differentially affect the non-biological component of ecosystems (121). Fire retardants may also cause fish kills and enhance the potential for eutrophication (387). A "let burn" policy may be appropriate in some areas for enhancement of wildlife habitat (303).

Under pressures of increasing demands for wood fiber and predictions of a timber shortage, forest fertilization has received increased emphasis and is growing rapidly in some areas of the country (265). At least one private industrial forest operation in Montana is experimenting with application of nitrogen at seasonally critical growth periods (95). But fertilization may result in an increase in stream nutrient concentrations (195)(265). It may also lead to changes in competitive relationships among species and in ecosystem productivity (121).

Genetic improvement basically involves the development and propagation of commercial tree seeds and seedlings that are more vigorous, faster growing and more resistant to forest pests than are natural strains. On highly productive sites, natural regeneration is often more efficient than planting and tree improvement programs need not be applied. However, where restocking is required, planting of genetically "improved" trees must be undertaken with great caution. Tree improvement activities can reduce the genetic diversity that has resulted from millenia of natural selection and that is responsible for the intricate balancing mechanisms among competing biological systems (121). Gene combinations developed in foreign environments may be unsuitable for local conditions and can lead to serious problems with pests, growth, and mortality not present in native populations (162).

The current trend toward salvaging deadwood may have a significant effect on forest ecosystems. A number of wildlife species are dependent on dead or decaying wood, standing and fallen, for their lives. Deadwood also represents a significant reservoir of nutrients which when removed cannot replenish forest soil.

The Forest Service, and perhaps other forest managers as well, routinely apply a variety of herbicides for purposes of range management, roadside and recreation area maintenance, right-of-way maintenance, tree management and nursery management (348). Available data suggest that residues resulting from recommended rates of application should not cause concern as potential biological or health hazards, provided label restrictions and cautions are followed. However, ecosystem stability, assimilative capacity, biological diversity and ecosystem productivity may all be affected, just as with any other man-caused disturbances of forestland (121).

OTHER INFLUENCES ON THE FORESTLAND ENVIRONMENT

The sustained production of renewable resources from Montana forestland is threatened not only by improper timber production activities but also by activities of other forest users and enterprises. Ecosystem stability, assimilative capacity, biological diversity and ecosystem productivity may be affected by indiscriminate use of recreational vehicles and emissions from a copper smelter as much as by poorly designed roads or large clearcuts on steep slopes.

Large industrial plants frequently emit airborne chemicals that are toxic to plant life. Under the stable air conditions that are commonplace over the valleys of Rocky

Mountain Montana, industrial toxins—usually sulfur dioxide and fluoride—are dispersed only slowly and often are carried by prevailing air currents over forests which are, in effect, fumigated. Repeated and prolonged exposure of trees to such toxic fumes stunts growth and reduces resistance to insects and disease, even if it does not kill them outright. Many thousand acres containing several million board feet of timber have been afflicted in this manner by large industrial polluters in Montana.

From 1968 to 1973 fluoride emissions from the Anaconda Aluminum Co. plant at Columbia Falls were responsible for timber growth losses amounting to 404,695 board feet (40). With increased plant production in 1974, damage to vegetation increased to levels observed in 1970 and a cumulative total of 6 million board feet was reported lost in the form of stunted growth, not including mortality (142). In the area surrounding the Anaconda Co. copper smelter at Anaconda, estimates are that vegetation on more than 50,000 acres of national forest, state, and private land shows varying damage from sulfur dioxide (142). Sulfur also was the principal cause of serious needle damage to Douglas-fir over 5,200 acres of forested land during the winter of 1972-73 near the Hoerner-Waldorf pulp and paper mill west of Missoula. Potential impact—the volume of merchantable timber that may die if the situation persists—amounts to nearly 2.5 million board feet (39). Although damage was not as severe in 1974, vegetation on more than 2,000 acres of state, private and federal land showed symptoms of sulfur damage (142). Sulfur dioxide damage has also been documented on ponderosa pine and Douglas-fir near the American Smelting and Refining Co. lead smelter at East Helena. Damage was found on nearly 6,500 acres of private land within five miles of the smelter (142). Following negotiation of variances with the Montana Department of Health and Environmental Sciences, Anaconda Co., Anaconda Aluminum Co. and American Smelting and Refining Co. are under a schedule to comply with Montana air pollution standards within three to five years. Although damage to forest vegetation will not be eliminated completely even with compliance, some improvement can be expected (142).

The foregoing problems raise some very pertinent questions concerning the siting of major industrial plants. Gordon predicts that the combined pollution load from the Colstrip generating plants Units 1 through 4 will have a "severe" impact on the ponderosa pine of the Northern Cheyenne reservation and in the Custer National Forest, both within 60 miles of Colstrip. Because of such impacts on renewable resources, Gordon advocated an alternative site, namely Butte (137). Considering the recent approval of Colstrip Units 3 and 4, close attention to alternative sites would seem prudent in order to prevent a relatively ephemeral industrial pollution source from permanently affecting the renewable resource potential of large areas of productive agricultural and forestlands.

People using forestland for recreation also can have a significant effect on ecological systems, particularly if use is concentrated. Commonly cited impacts of recreational use of forestland include soil compaction and erosion, pollution from transportation to the recreation site, alteration of wildlife behavior patterns, changes in big game harvest levels, adjustments in biologic interrelationships, and exposure to man-caused wildfires (121). From observation it is evident that many parks and recreation areas in Montana, especially those near bodies of water, are overused and suffering physical abuse. Trail deterioration, even in wilderness areas, has been documented as a serious problem in Rocky Mountain Montana (115)(150). Two interrelated and critical research needs concerning the carrying capacity of recreational land have been identified: 1) determine the carrying capacity for specific areas and 2) determine which levels of management on developed recreation areas would provide not the minimum quality that users will tolerate, but conditions that guarantee ecological integrity of the area (19).

A separate but related recreational issue is the off-road vehicle (ORV). ORVs may cause noise, damage soils and vegetation, disturb wildlife, conflict with other forest recreationists, encourage vandalism, theft and trespass, and create safety problems. Some of the needs that have been identified relative to ORVs are comprehensive state legislation, effective law enforcement, vehicle use zoning and research on the effect of ORVs on fish and wildlife (18). The use of off-road vehicles on Montana forestland and conflicts with other forest users have been increasing.

A third set of recreational issues is associated with large recreational real estate developments in semi-primitive environments. The impacts of one such development—Big Sky of Montana—have been documented at length (332). Among the needs tentatively identified as the result of the Big Sky-Gallatin Canyon Study are for a methodology and authority to regulate siting of large recreational real estate developments and a policy to discourage other development within a prescribed radius of a major recreational complex (166). Another large real estate development—Ski Yellowstone—has been tentatively approved for the semi-wild country north of Hebgen Lake, an area known to include grizzly bear (405). Winter resorts such as Big Sky and Ski Yellowstone typically petition the Forest Service for land exchanges or special use permits, which are necessary for successful operation. There may be a need to reexamine the process by which these exchanges and permits are granted or denied, particularly where potentially extensive development and critical wildlife habitats are involved.

All of Rocky Mountain Montana west of the Continental Divide contributes water to the Columbia River drainage, which is a major hydropower producing area (112). Much of the potential power for hydroelectric facilities lower in the drainage depends on snowmelt from forested mountain slopes. A proposal has been made in recent years to seed winter clouds over western Montana in order to augment snowpack, thereby enhancing spring runoff and hydroelectric production potential (367). Although the proposal was later dropped because sufficient snow eventually came without seeding, the dry conditions prompting the proposal in 1973 will most certainly recur again and winter cloud seeding again will become an issue.

Although an extensive winter cloud seeding program has not been conducted in Montana, the range of ecological impacts can be estimated. Increased snowpack, altered moisture budgets and growing seasons could affect plant and animal community composition, productivity and diversity (121). The prospect of complex ecological interactions is one of the most important points to be considered in assessing the probable consequences of environmental change due to weather modification (104). Whatever the ecological changes, they will be slow and perhaps within the range of variation experienced under normal climatic fluctuations. However, any renewed proposal to seed winter clouds over Rocky Mountain Montana should be accompanied by an environmental monitoring program.

The general impacts of grazing on forested land are predictable: changes in ecosystem structure, increased competition with wildlife and potentially decreased diversity in vegetation (121). However, the quality of grazeable woodland in Montana and specific conflicts with other uses are poorly documented and understood. In 1967 about 47 percent of the total state and private forest acreage grazed in Montana was in need of improved forage or grazing reduction or elimination (262). Unfortunately, more recent data or comparable data for federal land does not appear to exist.

With increasing materials and energy shortages and dependence on foreign supplies for certain materials, Montana forests will come under increasing pressure to supply these commodities in the foreseeable future. In the past few years exploration and development activities have begun on the Custer National Forest (platinum and palladium), Kootenai National Forest (copper and silver) and Flathead National Forest (oil and gas). Exploration, road construction and vehicle travel associated with mining cause soil disturbance, change air and water quality, and disturb wildlife behavior patterns. Mining changes soil profiles, water quality and yield, topography, wildlife habitat, and ecosystem productivity (121). Research indicates there is need for further information on the environmental impacts of accelerated mining and energy development in Rocky Mountain Montana, criteria and goals for revegetation, and the effect on rare and endangered species of minerals and fossil fuel exploration, extraction and processing (121).

Conversion of forestland to other uses has significant implications for the long-range integrity of Montana's forestland resources. Conversions usually result in a shift in management emphasis, for example from logging and grazing to recreation. With different land uses, the forest ecosystem will be subjected to different degrees and patterns of pressure. The outputs of the land also will change in character and volume.

Subdivision of forestland into rural or second-home tracts effectively removes the land from any meaningful production of food, timber, or wildlife. Even where subdivisions remain undeveloped, management for timber and grazing on 5, 10 or even 20-acre tracts is inefficient and impractical. A large but undetermined amount of private forestland has been subdivided in Montana. As of 1974, there were at least 347,924 subdivided acres in 35 counties, predominately in Rocky Mountain Montana (29). It is not known how much of the land was private forest, but forested tracts frequently are involved in subdivision transactions reviewed by the Department of Health and Environmental Sciences. The rapid conversion of private forestland to recreational real estate is a potentially serious problem because that class of land is expected to play a progressively more important role in the timber harvest picture for Montana (54). Not only is a more accurate inventory needed of the private forestland in Montana, but also an analysis of its productive potential and the rate of conversion to other uses. In addition to the obvious conflict inherent in the conversion itself, recreation often interferes or conflicts with renewable resource management on adjacent land, whether it is managed for timber, water production, grazing or dispersed recreation, or all four.

Many public forest tracts in Montana already have been or are being proposed for conversion to wildland. The U.S. Forest Service recently estimated that 5,426,785 acres under its management in Montana are roadless and undeveloped, exclusive of designated primitive and wilderness areas. Of this land, 1,541,809 acres have been designated as "New Study Areas" for potential inclusion into the National Wilderness Preservation System. Of the 5.25 million acres of roadless and undeveloped area, 2,940,453 acres (56 percent) are classified as commercial forestland, and 537,771 acres (35 percent) of the 1.5 million acres of New Study Areas are commercial (100). An additional nine areas encompassing 971,000 acres have been proposed by Senator Lee Metcalf for study as wilderness in his Montana Wilderness Study Act of 1975 (S.393). Although passage of S.393 "would not have any serious impact on timber supplies in Montana. . .much of the land in question. . .should not be managed as formal wilderness but instead as unroaded back country," according to one forester (393). There are at least two needs regarding the conversion of forestland to wildland management. An intermediate unroaded back country category is needed, with management flexibility to allow a variety of uses such as dispersed recreation, wildlife preservation, watershed protection, and certain other nonconflicting uses such as cattle grazing and small reservoirs (393). There also should be a determination of the impact on timber supply and ecological systems of expanding the National Wilderness Preservation System.

New pipelines, transmission lines, telephone lines and highways all result in incremental decreases in the acreage of forestland that can be used effectively for production of renewable resource outputs. Twin 500-Kilovolt transmission lines were approved recently to carry power from Colstrip to Hot Springs, Montana. The forested acreage that will be removed from production by the lines is undetermined. There needs to be an accurate accounting of the total and commmercial forestland affected by utility, communication and transportation corridors and an evaluation of the environmental impacts of construction and post-construction activities associated with maintaining such systems.

WILDLIFE HABITAT AND MANAGEMENT

Two somewhat related forestland issues concern the factors affecting the survival of the grizzly bear as a species in Montana and the management and protection of non-game wildlife.

Rocky Mountain Montana contains this continent's last major population of grizzly bears south of the Canadian border. The bear requires large unbroken tracts of primitive land, basically wilderness. There are only three areas in Montana where the grizzly is self-sustaining: Yellowstone Park and environs, the Glacier National Park-Bob Marshall Wilderness area, and the Cabinet Mountains. In July 1975, the U.S. Fish and Wildlife Service listed the grizzly bear as a threatened species under the Endangered Species Act of 1973, which puts the bear under the protective custody of the Department of Interior. At the same time the Montana Department of Fish and Game reserved the option to manage the bear through special hunting regulations in the Bob Marshall Ecosystem.

Grizzly bear habitat is threatened by many activities, mainly logging, subdivisions, and energy exploration and development, but further research is needed (185). The most critical need for assisting in protection of the animal is identification of habitat. In the summer of 1976 the Montana Department of Fish and Game and the U.S. Forest Service independently submitted accountings of grizzly bear habitat to the Secretary of Interior, who must then legally define the habitat and instruct all federal agencies to protect it from encroachment (405).

Non-game wildlife are not restricted to the forested areas of Rocky Mountain Montana, but here as elsewhere they contribute many of the most important elements in the natural ecosystem. Non-game wildlife include endangered species—the Northern Rocky Mountain wolf and the peregrine falcon. Funding for non-game wildlife management and protection in Montana is small relative to the importance of these animals in biological systems. The present funding of $27,000 per year is less than 1 percent of the Department of Fish and Game's total budget and comes entirely from hunting and fishing license fees (131). In order of priority, there are two critical needs facing the non-game and endangered species programs in Montana: adequate funding and research into the status and habitat requirements of key species.

AGRICULTURE AND ITS ENVIRONMENTAL IMPACTS

Cropland and rangeland are actually contrived ecological systems with the same characteristics and requirements as forest ecosystems: some degree of stability, assimilative capacity, diversity and productivity. Cropland in particular has been managed to increase production for human consumption at the expense of the other three features. As agricultural production is intensified, natural checks and balances are weakened and the system becomes more dependent on human inputs—fuel energy, pesticides, fertilizers—in order to sustain production at accustomed levels.

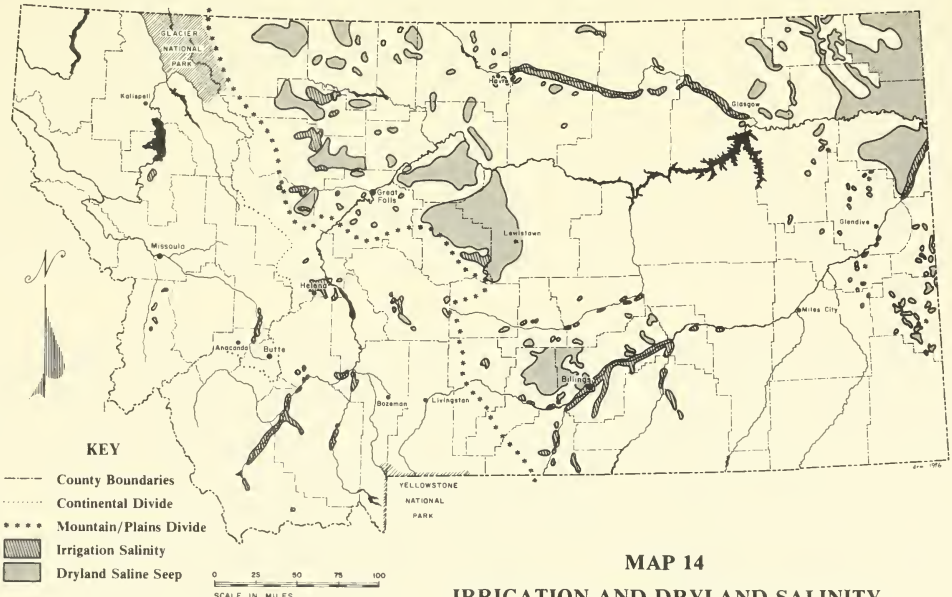
Symptoms of ecosystem instability and loss of assimilative capacity include degradation of the physical and chemical qualities of soils and water resources. Nearly a quarter of a million acres of agricultural land in Montana have been damaged by natural salts, exacerbated by irrigated or dryland farming practices (252). Many millions of additional acres of range and cropland have been damaged by overuse or erosion and are in need of conservation treatment (262)(343)(345)(369). Of the 4,000 miles of Montana streams that do not meet the 1983 goals of the Federal Water Pollution Control Act Amendments (PL 92-500), 1,296 miles are affected by "agricultural practices" or "overgrazing" (244).

The causes of the symptoms are many and varied. They stem basically from manipulation of soil and vegetation resources beyond their inherent assimilative capacity, which threatens to undermine the very renewable resource base on which the agricultural industry depends.

CROPPING PRACTICES AND THE PHYSICAL ENVIRONMENT

Saline seep has been the subject of extensive investigation in recent years (17). Basically it results from excess water in the soil profile brought on by modern dryland farming practices—mainly summer fallow—on salt-charged soils overlying a shallow impermeable or semi-permeable barrier. Conditions favorable for saline seep development are found over 228,000 square miles of the northern Great Plains. The area damaged by saline seep in Montana has been growing by more than 10 percent per year and in 1975 it totaled nearly 160,000 acres. The impact of dryland salinity on water resources has been noted by the state's Water Quality Bureau: "Salinity from agriculture is probably a significant factor in the salt loads of streams in Montana" (177). "Possibly the greatest potential for groundwater damage in Montana is due to saline seep. There is also a substantial potential for surface water pollution from saline seep" (242). The extent of active saline seep in Montana is shown by Map 14.

Saline seep control and prevention requires using up excess soil moisture before it has a chance to escape below the root zone. Ideally, control would involve reestablishing something resembling the native grassland community. Practically speaking, the best agricultural control system would involve intensive cropping coupled with the following modifications: 1) diversification with deeprooted, non-grain crops—preferably legumes—in crop rotation, 2) minimum tillage, and 3) flexibility as allowed by continued waiver of acreage allotments for wheat production. Coupled with the proposed system would have to be a recognition by



MAP 14
IRRIGATION AND DRYLAND SALINITY

farmers that per-acre yields under intensive farming often will not match those achieved under the fallow system, but that *total* yields will be greater because more land would be in production. Otherwise, perpetuation of the "high yield syndrome" under intensive farming would require additional inputs of inorganic fertilizer, often at the expense of natural soil fertility. This problem and the requirement for more chemical weed control under minimum tillage are the only significant ecological drawbacks to the flexible-intensive cropping systems proposed for saline seep control. Flexible-intensive cropping, properly managed, over the long term could increase diversity, moisture storage capacity and soil fertility while decreasing erosion, pest problems, and fertilizer and energy requirements (128) (205) (381). In environmental terms, this would be a healthy direction for agriculture to take. Further research and education in flexible-intensive cropping, therefore, should be encouraged. Specifically, more research is needed on the relative requirements for fertilizer, herbicides and energy of this sytem as opposed to tthe fallow system under Montana conditions.

Summer fallow was developed following the drought of the 1930s, mostly as a technique for storing moisture. Because virtually half of all the cultivated acreage is left unprotected every year under this system, it presents a substantial soil erosion problem. As a result, agriculturalists have advised that fallow land be alternated with cropped land in narrow strips, placed perpendicular to prevailing winds or following the contour of sloping land. As tractors got bigger and more powerful and implements got bigger and wider, some farmers found that in dispensing with the narrow strips and farming large blocks of land instead, they increased their efficiency. Although it has been practiced for decades, block farming has been increasing in the past few years (22).

Block farming coupled with summer fallow are two of the principal reasons why wind erosion has become a progressively more serious problem in Montana. Land damaged by wind in the 1975-76 "wind erosion season"[46] was nearly double that damaged the season before and over four times the land damaged during the 1972-73 season (Table 82). However, these data must be evaluated with care because the sample size (number of counties reporting) has varied from year to year. Other commonly cited factors influencing wind erosion damage include inadequate crop residue, alternate freezing and thawing, below normal moisture and higher than normal winds.

The Agricultural Stabilization and Conservation Service offers limited incentives to lay out the strips (22). Perhaps in the light of inflation, the incentive payment needs to be increased. Under more intensive farming, particularly with minimum tillage, soil erosion should not be so severe even on blocks.

Block farming is only one of many conservation problems on dryland farms. A 1967 Conservation Needs Inventory found 57 percent of Montana's dryland acreage was in need of some conservation treatment, including strips (262). A great deal has happened since the 1967 inventory and the figures are now hopelessly out of date, yet the Soil Conservation Service has "no definite plans for updating the Conservation Needs Inventory" (71). One of Montana's most critical needs for information on renewable resources is an update of the Conservation Needs Inventory.

[46]November 1, 1975 to May 31, 1976.

Table 82

Land Damaged by Wind Erosion in Selected Montana Counties, 1969-1976.

(acres)

Wind Erosion Season*	No. Counties Reporting	Total Land Damaged
1969-1970	?	259,670
1970-1971	15	224,450
1971-1972	15	241,510
1972-1973	15	210,075
1973-1974	19	550,300
1974-1975	20	455,175
1975-1976	20	903,454

*The wind erosion season runs from November 1 through May 31.

Source: Reference 345.

Soils over extensive areas of Montana are high in water soluble salts (323). When such soils are subjected to irrigation water, which itself may be high in dissolved solids, some of the salts are leached and enter the return flow. However, as this process is repeated and as more saline return flows are added to the receiving water, the receiving water becomes saltier and less desirable for irrigation, leaving greater residues of salt in the soil than it removes. Larger quantities of the now more saline irrigation water are required to flush the salts from the soil, which only wastes water and compounds the problem. Eventually, salt progressively builds up in the soil to the point where seed germination is inhibited, crop yields are reduced, salt intolerant crops are excluded and, ultimately, the land becomes worthless for agricultural production and is abandoned (124). A total of 120,814 irrigated acres in Montana have been damaged by salinity (252).

Salinity from agriculture is a significant factor in the salt pollution of Montana streams. About 1,400 miles of stream have been degraded by "natural salts aggravated by poor land use practices" (244). The Montana Department of Health and Environmental Sciences predicts that "future increases in cropland, particularly irrigated cropland, will further increase salinity problems in state waters, including groundwater" (177).

Land under irrigation in Montana increased by 2.4 percent from 1973 to 1975 and plans for irrigation in the next two years will increase the irrigated area by 118,601 acres or 5.3 percent (320). Some of the data needs associated with this growth are: 1) critical evaluation of salinity conditions on land proposed for irrigation; 2) development of techniques to minimize accumulation of salt in water from cropland; 3) evaluation of salt yields from irrigated cropland; 4) evaluation of salt balances in heavily irrigated drainages; 5) determination of the economic and environmental costs associated with the benefits of crop production; 6) establishment of a water quality monitoring network to determine trends in salinity; and 7) development of water management programs to measure water usage, provide minimum flows to streams affected by salt, encourage economical water use and minimize or eliminate saline return flows (177).

In 1967 only 11 percent of Montana's irrigated land was receiving adequate conservation treatment (262). Recent increases in irrigated land underscore the need for updating the Conservation Needs Inventory by the Soil Conservation Service.

Breaking sod for farmland causes a significant hydrologic impact. Salt and moisture balances are upset, which leads to leaching of salts to ground and surface waters. Thus, the rate at which grassland is plowed under has a direct bearing on the salinity problem (177). It is also believed that the cultivation of native sod may be responsible for groundwater nitrate problems under farmland (114). In addition, when new cropland is plowed it is often in large blocks rather than strips, thus enhancing the potential for wind erosion (22).

In the 1940s, farmers began returning much marginal cropland back to range and applying strip cropping on the remaining farmland. Now, with wheat prices relatively high and stable, farmers are reversing the trend. At least 250,000 acres have been converted from range to marginal cropland since 1967 (291). Current conversion may be as high as 500,000 acres annually. The Agricultural Stabilization and Conservation Service estimated 75,000 to 100,000 acres of cropland were added in 1975 (177). Many thousands of additional acres were converted in the spring of 1976, much of it in blocks (11) (134).

Most of the "new" cropland that Montana has acquired in the past nine years is marginal and best left to grass (11). Whatever land that is best for growing crops has long been in production. Shallow soils, unfavorable climate and other problems make the remainder a poor conservation risk. Continued conversion of range to marginal cropland underscores the need for soils capability mapping for the state, identification of those areas where dryland farming has a less than even chance of success or where environmental constraints would prohibit disturbing the native sod, and updating the 1967 Conservation Needs Inventory.

Another critical need is for completion of modern soil surveys in agricultural areas. Map 15 shows that basic detailed soil surveys have been produced for only a relatively small portion of the state. Completion of detailed soil surveys should allow for mitigation of many of the conservation problems discussed here through the identification of soils limitations and application of environmentally sensitive farming practices.

Grain harvest exacts a significant toll in soil nutrients. Recent increases in yields have resulted from improved grain varieties, more efficient summer-fallowing, and increased use of fertilizer. Yet, even with these innovations and inputs there has been a simultaneous decrease in protein content of spring and winter wheat (318). This may indicate that the natural soil fertility responsible for Montana's reputation as a producer of high-protein wheat is being depleted and that inorganic fertilizers are inadequate to maintain high yields and protein content simultaneously. Minimum tillage coupled with diversification and inclusion of legumes in rotation may help rebuild soil fertility. In any event, the "high-yield syndrome" may have to be scrapped in favor of somewhat reduced yields of more highly nutritious crops.

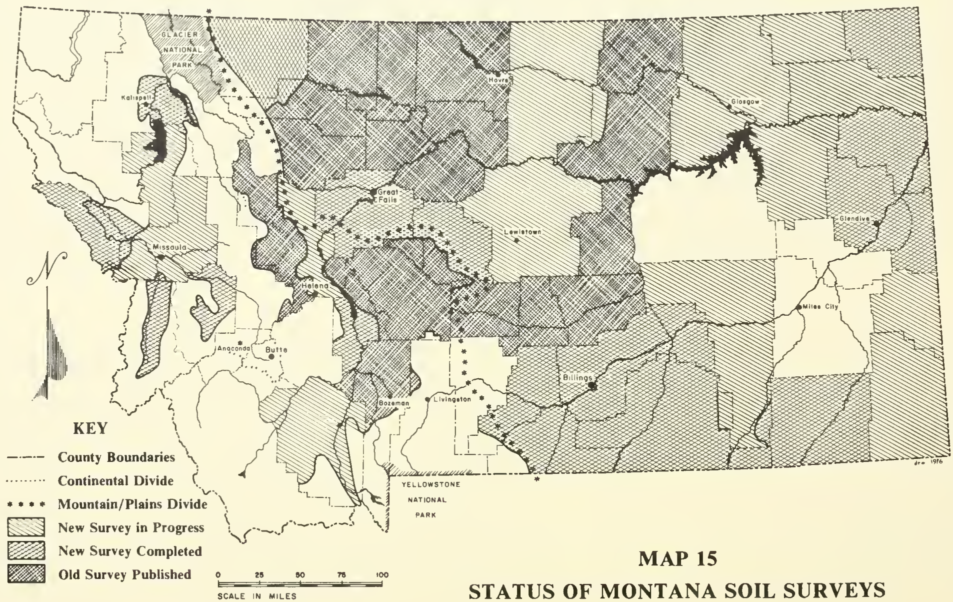
FARMING PRACTICES AND BIOLOGICAL RESOURCES

Land use practices on farmland are often reflected in the quality of surface water draining the land. Many Montana streams draining or passing through farmland contain populations of game fish. There are basically three ways in which farming can affect fish habitat: 1) dewatering (for irrigation); 2) stream channel alteration; and 3) water pollution.

Farming practices contribute sediment to streams at rates surpassing those expected under natural conditions. Although one of the functions of a stream is to move sediment, excessive sediment can smother fish eggs and fish food. Of the 4,000 miles of streams in Montana not meeting the 1983 national water quality goals, 2,512 miles are affected by sediment (244). Much of this sediment is of natural origin but aggravated by agricultural practices or poor land use practices.

Irrigation in Montana consumes 5,851,827 acre-feet per year, which together with reservoir evaporation, accounts for 98 percent of all water consumption and about 16 percent of the total annual supply in the state (248). Surface water is the source of 99 percent of the water used for irrigation in the state. While supplies are generally adequate, locally intense irrigation activity may cause locally severe depletions, stream dewatering and impacts on aquatic life and recreation. About 860 miles of streams in Montana are chronically dewatered and 630 miles suffer elevated temperatures, often associated with dewatering (244).

Perhaps the most critical impact of irrigation on fisheries is alteration of the stream channel itself, which is often done to install, maintain and protect water diversion facilities. A 1973 Department of Fish and Game study on sections of six streams—Beaver, Lolo and Rock creeks, and



MAP 15
STATUS OF MONTANA SOIL SURVEYS

the Big Hole, Jefferson and Ruby rivers—revealed that 24 of the 160 miles of stream studied had been altered with draglines or bulldozers. Forty-four additional miles of streambank were riprapped or altered in some other fashion (199). It should be pointed out that some bank stabilization in the form of riprap may be necessary to protect public and private property. But this and other forms of stream alterations are only temporary solutions at best; they often cause hydrologic disequilibrium upstream and downstrom and they skirt the major issue of appropriate use of the floodplain.

There is a great need for information on techniques to minimize these resource conflicts. Regarding stream alteration, one long-range alternative is non-structural: floodplain zoning and management. Another is for technology to allow water diversion without extensive streambank modifications (340). The sediment problem is being addressed by the Statewide Sediment Control Project and the four Section 208 Areawide Planning Organizations established under the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). Improved efficiency in management of irrigation water would help to conserve water and alleviate chronic dewatering problems.

Wildlife generally fare best where habitat consists of a mosaic of vegetation types, each supplying somewhat different food and cover requirements in response to seasonal changes. Intensively managed cropland is poor wildlife habitat. A few upland game birds and some small mammals are compatible with farming, provided some cover for security is left along fence rows, irrigation ditches, etc. But most game birds and animals do not do well on cropland, particularly where large contiguous blocks of land are devoted to the same crop variety and where efforts are made to keep weeds to a minimum.

Intensive agriculture has been cited as one factor thought to be responsible for the current decline in mule deer in several areas around the state (21). Perhaps an even more important factor is the current trend of converting range to marginal cropland. When this is done, habitat for most wildlife is destroyed. The wildlife does not simply move away; it dies, because most other habitat is already filled to capacity and the displaced animals are excluded by competition from using what is already occupied. Converting rangeland, supporting livestock and some wildlife, to marginal cropland is not only a poor soil conservation risk but it also forecloses a piece of ever-diminishing wildlife habitat. More flexible and diversified farming practices probably would enhance the potential for existing cropland areas to support wildlife.

In 1969, insecticides, herbicides, fungicides and other chemicals were applied to 3,226,697 acres of cropland and 86,872 acres of pasture in Montana (363). At least six of the 24 fish kills that have been documented since 1968 have been caused by pesticides and herbicides (244). Pesticides are one of many causes of degradation of water quality associated with irrigation and farming in Montana (177). Pesticide application may affect ecosystem stability, assimilative capacity, biological diversity and ecosystem productivity (121). Needs exist for screening, registration and rigid control of distribution and application of pesticides.

RANGE MANAGEMENT AND ENVIRONMENTAL QUALITY

The rangeland resource begins as a complex community of plants and animals that has evolved together for centuries under given geologic and soils conditions, climate and grazing pressure by native herbivores. On modern grasslands in Montana some or all of the natural grazing pressure has been replaced by livestock. Rangeland can support livestock up to a point without damage. Beyond that point, plant reproductive cycles are interrupted, the plant community is simplified as the more palatable and nutritious plants are replaced by a few less desirable "weedy" species, and, if grazed to extreme, much of the vegetative cover is lost altogether leaving the soil exposed to erosion by wind and water.

Less than half (42 percent) of Montana's 41.3 million acres of privately owned rangeland was adequately treated in 1967 (262). An almost equal quantity (40 percent) was in need of some protection from grazing to allow the vegetation a chance to recover. In the same year 38 percent of the state's 1.7 million acres of pasture was adequately treated while 22 percent needed protection and 32 percent needed improvement. A year later in 1968, 62 percent of range and pasture on public land (about 6.8 million acres) was in need of treatment to reduce soil erosion (343). Unfortunately there are not equivalent data from a more recent inventory, so a trend is impossible to establish. The Bureau of Land Management classified range condition and trend on the 9.3 million acres of grazing land under that agency's jurisdiction in 1963-64. The survey found 51 percent of Montana's BLM grazing land was in good or excellent condition, 42 percent was in fair condition and 7 percent was in poor condition (369). An updated survey is now in progress. The effects of poor land use practices including overgrazing are reflected in stream water quality: 1,773 miles of streams were affected by these activities in 1976, resulting mainly in increased sediment loads (244).

Recent studies indicate relatively little direct competition between cattle and mule deer for forage except at certain times of the year (180)(181). However, overgrazing and certain grazing management systems, depending on how they are applied, may operate to selectively reduce some of the more desirable wildlife forage species (120).

The most critical need for information regarding Montana's range resource is an update of the 1967 Conservation Needs Inventory on state and privately owned range and pasture. With that and the updated BLM range survey, there would be some objective information on trends in range conditions. Another need would be the broader application of BLM's Allotment Management Plans (AMPs), grazing systems that involve the sequential rotation of livestock through various pastures of a grazing allotment over a period of time, generally two to five years.

Since 1964, BLM has begun 244 AMPs on 3,056,597 acres, mostly in Montana and about one-third on private land (374). This represents about 6 percent of the total range and pasture in Montana. However, not all federally initiated grazing systems are adequately supervised or enforced. BLM Director Curt Berklund recently directed his agency to "take corrective action in managing its grazing lands to include more supervision of range use. . .adjustment of the number grazing to range capacity, a realistic apportionment of the forage requirements of wildlife. . .and consideration of environmental impacts of competing land uses" (108). On private land, responsible state and federal agencies should encourage and supervise the proper application of deferred and rest-rotation grazing systems.

For over 100 years, season-long grazing by domestic livestock within confined areas has drastically reduced the productivity of native grasslands in Montana and, together with fire control, has allowed certain shrubs to gain a competitive advantage over grasses and forbs more palatable to livestock (251) (295). The result has been that some ranges now support much denser and more extensive stands of brush—particularly sagebrush—than they did in the past. With reduced grazing pressure the balance between grasses and shrubs probably would return to normal; however it would take a very long time.

Desiring a more immediate increase in returns from shrub-infested rangelands, some land managers have turned to brush control, which may take the form of burning, mechanical treatment or more commonly, spraying with 2,4-D. Brush control is sometimes used as a substitute for rest-rotation grazing rather than being used in conjunction with comprehensive grazing management as it should be. Grazing systems sometimes are not given a chance or they are managed improperly in order to justify control (120). In 1975 about 2 percent of the public land under BLM jurisdiction was treated for brush control (374). Comparable figures for other public and private land are not available.

The importance of sagebrush to wildlife is well documented. Programs designed to control sagebrush often eliminate other wildland shrubs as well, including mountain mahogany and antelope bitterbrush, which are beneficial to wildlife (120). While substantially increasing livestock forage production, brush control also can alter soil moisture, contribute to erosion, and interfere with natural succession of the plant community (174) (251).

A number of other rangeland treatment techniques have been proposed for increasing water infiltration and enhancing growth and vigor of livestock forage. These include pitting, scalping, furrowing and fertilizing (85). These practices should be used with caution because of their potential for inducing ground nitrate and salinity problems (114) (295). Increases in yields with nitrogen fertilizer applications on some rangeland types are negligible, far short of justifying the expense and the risk (174).

Grazing pressure needs to be reduced or temporarily eliminated on much rangeland in Montana. Rest-rotation systems and allotment management plans should be encouraged as alternatives to brush control on infested land. Shrubs are a natural element of vegetation in semiarid country and range managers need to give more consideration to their value as forage, not only for wildlife but also for exotic but potentially domesticable herbivores that could convert shurbs to food and fiber (268).

Under natural conditions predators are necessary for keeping herbivores from overpopulating and destroying their habitat. Under livestock grazing systems, where an objective is to maximize returns from the range, predators are out of place. Predator control changes the relationships among species, particularly length and complexity of food webs, thus altering biological processes (121). An example of the consequences of predator control is that another predator may increase in numbers to fill the vacuum left by the target animal; or failing that, other herbivores such as rabbits and ground squirrels may increase to compete with domestic livestock for forage.

OTHER ENVIRONMENTAL IMPACTS ON AGRICULTURAL LAND

The issue of conversion of agricultural land has been treated at length by Brandes (29):

> U.S. Department of Agriculture data released in January 1974 indicate that there has been a 4.7 million acre decrease in acreage in its "land in farms" category during the last decade in Montana. State Department of Revenue figures suggest that 1,613,412 acres of land were removed from agricultural use during the same period. Land is taken from agriculture for a number of uses: conversion to residential or second home use, annexed by cities or towns, conversion to industrial or commercial uses, mining, for reservoirs and highways. Land removed from agriculture for these uses usually is taken forever.

At the present rate of conversion there will be 4.5 million fewer agricuultural acres in 1990 than in 1973. Not only is the acreage available to agriculture being reduced but the land taken out of production tends to be of better than average productivity (29). This trend makes it important to identify the most valuable and productive farm and rangeland and develop some process to keep it in agricultural production.

ENERGY AND MINERALS PRODUCTION AND AGRICULTURE

Airborne by-products from existing or proposed coal-fired electrical generating stations threaten ageicultural production at scattered locations over Great Plains Montana, particularly near Billings (13), Colstrip (137) (247) and Scobey (182). Water requirements for these and other proposed industrial operations in eastern Montana will conflict with potential irrigation water requirements in the future (249). Another perennial issue concerning energy and agriculture is the feasibility of reclaiming strip mine spoils to withstand the test of agricultural use and maintain a diverse and stable vegetative cover (168)(255). These problems point to a need for carefully locating large pollution-emitting, water-consuming industrial facilities and for considering agricultural surface productivity in proposed mining plans.

WEATHER MODIFICATION

Summer cloud seeding has long been considered a means to increase agricultural yields on the Great Plains. Initial phases of a cloud seeding research program began recently near Miles City (123). Designed "to develop an effective technology, scientifically and socially acceptable, for precipitation management in the High Plains," the Miles City program is part of the High Plains Cooperative Project (HIPLEX). With other study sites in Kansas and Texas, HIPLEX is part of a much larger atmospheric water resources program called "Project Skywater" (368)(375). The expected impacts of HIPLEX research in Montana are believed to be slight. However, the impacts from additional rainfall induced by a full scale operational cloud seeding program are expected to be significant: increased growth of livestock, increased food and cover for wildlife, increased streamflow, increased agricultural income and increased secondary income (204). There remain many unanswered questions regarding cloud seeding and its legal, social, political and ecological implications. For example, what will be the effect of induced rainfall on land subject to saline seep? There is a need to monitor the changes produced by any weather modification project, experimental or operational. Some of the topics that need monitoring or additional research in connection with cloud seeding are: silver toxicity, weeds, soil water, plant communities, animal communities, rainfall variability, crop and forage production variability, erosion and siltation, economics, public understanding and acceptance, plant diseases and insects (204).

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APPENDIX A

Biographies

MEMBERS OF ENVIRONMENTAL QUALITY COUNCIL AND EXECUTIVE DIRECTOR

Thomas O. Hager, chairman of the Environmental Quality Council (EQC), was born in Minneapolis, Minnesota. He attended public schools in Billings, Montana and was graduated with a degree in accounting from Montana State University. Hager, an egg rancher in Billings, is a Republican state representative and served in the 1973-74 session as a member of the Agriculture, Livestock and Irrigation and the Fish and Game Committees. In the 1975 session, he represented District 60 in the Montana House and served on the Judiciary and Taxation Committees. He is a member of the Montana Egg Council, President of Northwest Egg Producers, and Secretary of United Egg Producers.

Margaret S. Warden, vice chairman of the EQC, was born in Glasgow, Montana. Sen. Warden is a graduate of Great Falls High School and attended Great Falls Commercial College. She was a delegate to the Montana Constitutional Convention in 1971-72. She has long been active in library affairs throughout the state and, among other activities, currently serves on an advisory committee planning a White House Conference on Libraries. Sen. Warden, a Democrat, represents District 18 in the Montana Senate.

L.M. (Larry) Aber was born in Colgate, North Dakota. He has lived in Montana since 1926. Aber was graduated from Reed Point (Mt.) High School and Eastern Montana Normal College. He has done graduate work at Greeley, Colorado and Rocky Mountain College and Eastern Montana College in Billings. Aber taught school for twelve years, eleven of which he served as principal. He was in the automobile and farm machinery business for 27 years. Aber resides in Columbus, where he is active in community affairs. He is a Republican and represents District 35 in the Montana Senate.

G. Steven Brown, the Governor's designated representative on the EQC, was born in Corvallis, Montana. He was graduated from the University of Montana and received his law degree (with honors) from George Washington University. Brown was awarded an Environmental Law Fellowship at George Washington University in 1972. He served two years as a legislative assistant to Senator Mike Mansfield. Brown was legal counsel on the governor's staff before becoming chief legal counsel for the Department of Health and Environmental Sciences in May, 1975.

William M. Day is a rancher-farmer in Glendive, Montana. He was born in Hendrix, Oklahoma and has lived in Montana since 1951. Day is active in Glendive civic activities, serving as Chamber of Commerce president for 1975-76. He has a special interest in eastern Montana water issues and was a founder and first president of the Yellowstone Basin Water Use Association. A Democrat, Day represents District 54 in the Montana House.

G.W. (Por) Deschamps is a native and life-long resident of Missoula, Montana, where he ranches. Deschamps attended both Montana State University and the University of Montana. He served in the U.S. Marine Corps during World War II. Currently a citizen member of the EQC, Deschamps, a Republican, served in the Montana House in the 1963 session and in the Montana Senate from 1967 through 1974.

Charles W. Doheny was born in Twin Falls, Idaho and came to Montana two weeks later. He ranches near Dutton, Montana. Doheny served with the Army Air Corps from 1942 to 1945. He is active in the Montana Farmers Union. A citizen member of the EQC, Doheny is a Democrat.

Gary Niles Kimble was born at the Ft. Belknap Agency near Harlem, Montana. He resides in Missoula, where he practices law and teaches in the Native American Studies Program at the University of Montana. He received a B.A. degree in journalism from the University of Montana in 1966 and obtained his law degree from the University of Montana in 1972. From 1966 to 1968, Kimble was with the U.S. Army. He served in the Montana House in the 1973-74-75 sessions. A Democrat, he represents District 94.

Harriet Marble was born in Petersburg, Virginia. She has been in Montana since 1964 and lives in Chester. She earned her B.S. degree from Muskingum College and obtained a M.S. degree in wildlife management from the University of Montana. Ms. Marble is active in the League of Women Voters, the Wilderness Society, and the Montana Wilderness Association. Ms. Marble is a Democrat and has served as an EQC citizen member since 1971.

Terry Murphy was born in Butte, Montana. He attended schools in Gallatin County and farms near Cardwell, Montana. Murphy is active in the Montana Farmers Union and is currently serving as president. He was a member of the Montana House in the 1971-72 session. In the 1974 session, Murphy was a member of the Agriculture, Livestock and Irrigation Committee and vice chairman of the State Administration Committee. A Democrat, Murphy represents District 40 in the Montana Senate.

A. Thomas Rasmussen was born in Plentywood, Montana. He attended Montana State University and Pacific University, where he earned a doctorate in optometry. Rasmussen, a Helena optometrist, is past president of the Montana Optometric Association, and a member of the American Optometric Association, the Northern Plains Resource Council, and the Friends of the Earth. During the 1974-75 session, Rasmussen represented District 31 in the Montana House as a Republican.

Jack D. Rehberg is a native of Billings, Montana. A former executive director of the Montana Petroleum Association, he currently is vice president of a Billings savings and loan association. Rehberg was educated in Billings public schools and earned a B.S. degree in agriculture from Montana State University in 1951. Rehberg served as a Republican member of the Montana House in 1963-65 and of the Montana Senate in 1967, 1969, and 1971. He is a citizen member of the EQC.

Ed B. Smith was born in Dagmar, Montana, where he still lives and engages in farming and ranching. He has served as vice president of the National Wool Growers Association. Smith was the Republican candidate for Governor in 1972. He served in the Montana House in the 1967, 1969, and 1971 sessions. In 1975, he represented District 1 in the Montana Senate. Smith also serves on the Legislature's Interim Finance Committee and the Consumer Council.

John W. Reuss, EQC executive director, was born in San Bernardino, California, and holds B.A. and M.A. degrees in history from the University of California (Riverside), where he also worked toward a Ph.D. in political science. From 1968 to 1971 he was an instructor in the Science, Technology and Public Policy Program at Purdue University. In 1971, he came to Bozeman, Montana to become an assistant professor in the governmnent program at Montana State University, where he taught and conducted research in the areas of science and public policy, environmental politics, and public administration with emphasis on natural resources management. In 1972, Reuss was appointed principal investigator of the National Science Foundation-sponsored Gallatin Canyon Study. Reuss has been at the EQC since July, 1974. He is a member of the American Association for the Advancement of Science and the Policy Studies Organization.

APPENDIX B

Montana Environmental Policy Act

PUBLIC HEALTH AND SAFETY
CHAPTER 65 — MONTANA ENVIRONMENTAL POLICY ACT

69-6501. Short title. This act may be cited as the "Montana Environmental Policy Act."

History: En. Sec. 1, Ch. 238, L. 1971
Title of Act
An act to establish a state policy for the environment and to establish an environmental quality council and setting forth its powers and duties and providing an effective date.

69-6502. Purpose of act. The purpose of this act is to declare a state policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the state; and to establish an environmental quality council.

History: En. Sec. 2, Ch. 238, L. 1971.

69-6503. Declaration of state policy for the environment. The legislative assembly, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the state of Montana, in cooperation with the federal government and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can coexist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Montanans.

(a) In order to carry out the policy set forth in this act, it is the continuing responsibility of the state of Montana to use all practicable means, consistent with other essential considerations of state policy, to improve and coordinate state plans, functions, programs, and resources to the end that the state may —

(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(2) assure for all Montanans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our unique heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(b) The legislative assembly recognizes that each person shall be entitled to a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

History: En. Sec. 3, Ch. 238, L. 1971.

69-6504. General directions to the state agencies. The legislative assembly authorizes and directs that, to the fullest extent possible:

(a) The policies, regulations, and laws of the state shall be interpreted and administered in accordance with the policies set forth in this act, and

(b) all agencies of the state shall

(1) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment;

(2) identify and develop methods and procedures, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations;

(3) include in every recommendation or report on proposals for projects, programs, legislation and other major actions of state government significantly affecting the quality of the human environment, a detailed statement on —

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible state official shall consult with and obtain the comments of any state agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate state, federal, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the governor, the environmental quality council and to the public, and shall accompany the proposal through the existing agency review processes.

(4) study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(5) recognize the national and long-range character of environmental problems and, where consistent with the policies of the state, lend appropriate support to initiatives, resolutions, and programs designed to maximize national co-operation in anticipating and preventing a decline in the quality of mankind's world environment;

(6) make available to counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(7) initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(8) assist the environmental quality council established by section 8 (69-6508) of this act.

History: En. Sec. 4, Ch. 238, L. 1971.

69-6505. Review of statutory authority and administrative policies to determine deficiencies or inconsistencies. All agencies of the state shall review their present statutory authority, administrative regulations, and current policies and procedures for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this act and shall propose to the governor and the environmental quality council not later than July 1, 1972, such measures as may be necessary to bring their authority and policies into conformity with the intent, purposes, and procedures set forth in this act.

History: En. Sec. 5, Ch. 238, L. 1971.

69-6506. Specific statutory obligations unimpaired. Nothing in section 3 (69-6503) or 4 (69-6504) shall in any way affect the specific statutory obligations of any agency of the state

(a) to comply with criteria or standards of environmental quality,

(b) to co-ordinate or consult with any other state or federal agency, or

(c) to act, or refrain from acting contingent upon the recommendations or certification of any other state or federal agency.

History: En. Sec. 6, Ch. 238, L. 1971.

69-6507. Policies and goals supplementary. The policies and goals set forth in this act are supplementary to those set forth in existing authorizations of all boards, commissions, and agencies of the state.

History: En. Sec. 7, Ch. 238, L. 1971.

69-6508. Environmental quality council. The environmental quality council shall consist of thirteen (13) members to be as follows:

(a) The governor or his designated representative shall be an ex-officio member of the council and shall participate in council meetings as a nonvoting member.

(b) Four (4) members of the senate and four (4) members of the house of representatives appointed before the fiftieth legislative day in the same manner as standing committees of the respective houses are appointed. A vacancy on the council occurring when the legislature is not in session shall be filled by the selection of a member of the legislature by the remaining members of the council. No more than two (2) of the appointees of each house shall be members of the same political party.

(c) Four (4) members of the general public; two (2) public members shall be appointed by the speaker of the house with the consent of the house minority leader, and two (2) shall be appointed by the president of the senate with the consent of the senate minority leader.

In considering the appointments of (b) and (c) above, consideration shall be given to their qualifications to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the state government in the light of the policy set forth in section 69-6503 of this act; to be conscious and responsive to the scientific, economic, social, aesthetic, and cultural needs and interests of the state and to formulate and recommend state policies to promote the improvement of the quality of the environment.

History: Amd. Sec. 1, Ch. 492, L. 1975, eff. April 21, 1975.

69-6509. Term of Office. (1) The terms of office of all council members shall be two (2) years and shall terminate upon appointment of a new council before the fiftieth legislative day. Council members may be reappointed; however, in no case shall a member serve more than six (6) years.

(2) The council shall elect one of its members as chairman and such other officers as it deems necessary. Such officer shall be elected for a term of two (2) years.

History: Amd. Sec. 2, Ch. 492, L. 1975, eff. April 21, 1975.

69-6510. Meetings. The council may determine the time and place of its meetings but shall meet at least once each quarter. Each member of the council shall, unless he is a full-time salaried officer or employee of this state, be paid twenty-five dollars ($25) for each day in which he is actually and necessarily engaged in the performance of council duties, and shall also be reimbursed for actual and necessary expenses incurred while in the performance of council duties. Members who are full-time salaried officers or employees of this state may not be compensated for their service as members, but shall be reimbursed for their expenses.

History: En. Sec. 10, Ch. 238, L. 1971.

69-6511. Appointment and qualifications of an executive director. The council shall appoint the executive director and set his salary. The executive director shall hold a degree from an accredited college or university with a major in one of the several environmental sciences and shall have at least three (3) years of responsible experience in the field of environmental management.

He shall be a person who, as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the state government in the light of the policy set forth in section 3 (69-6503) of this act; to be conscious of and responsive to the scientific, economic, social, esthetic, and cultural needs and interests of the state; and to formulate and recommend state policies to promote the improvement of the quality of the environment.

History: En. Sec. 11, Ch. 238, L. 1971.

69-6512. Appointment of employees. The executive director, subject to the approval of the council, may appoint whatever employees are necessary to carry out the provisions of this act, within the limitations of legislative appropriations.

History: En. Sec. 12, Ch. 238, L. 1971.

69-6513. Term and removal of the executive director. The executive director is solely responsible to the environmental quality council. He shall hold office for a term of two (2) years beginning with July 1 of each odd-numbered year. The council may remove him for misfeasance, malfeasance or nonfeasance in office at any time after notice and hearing.

History: En. Sec. 13, Ch. 238, L. 1971.

69-6514. Duties of executive director and staff. It shall be the duty and function of the executive director and his staff

(a) to gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information for the purpose of determining whether such conditions and trends are interfering, or are likely to interfere, with the achievement of the policy set forth in section 3 (69-6503) of this act, and to compile and submit to the governor and the legislative assembly studies relating to such conditions and trends;

(b) to review and appraise the various programs and activities of the state agencies in the light of the policy set forth in section 3 (69-6503) of this act for the purpose of determining the extent to which such programs and activities are contributing to the achievement of such policy, and to make recommendations to the governor and the legislative assembly with respect thereto;

(c) to develop and recommend to the governor and the legislative assembly, state policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the state;

(d) to conduct investigations, studies, surveys, research, and analyses relating to ecological systems and environmental quality;

(e) to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;

(f) to make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as the legislative assembly requests;

(g) to analyze legislative proposals in clearly environmental areas and in other fields where legislation might have environmental consequences, and assist in preparation of reports for use by legislative committees, administrative agencies, and the public;

(h) to consult with, and assist legislators who are preparing environmental legislation, to clarify any deficiencies or potential conflicts with an overall ecologic plan;

(i) to review and evaluate operating programs in the environmental field in the several agencies to identify actual or potential conflicts, both among such activities, and with a general ecologic perspective, and to suggest legislation to remedy such situations;

(j) to transmit to the governor and the legislative assembly annually, and make available to the general public annually, beginning July 1, 1972, an environmental quality report concerning the state of the environment which shall contain

(1) the status and condition of the major natural, manmade, or altered environmental classes of the state, including, but not limited to, the air, the aquatic, including surface and ground water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban, and rural environment;

(2) the adequacy of available natural resources for fulfilling human and economic requirements of the state in the light of expected population pressures;

(3) current and foreseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the state in the light of expected population pressures;

(4) a review of the programs and activities (including regulatory activities) of the state and local governments, and nongovernmental entities or individuals, with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and

(5) a program for remedying the deficiencies of existing programs and activities, together with recommendations for legislation.

History: En. Sec. 14, Ch. 238, L. 1971.

69-6515. Examination of records of government agencies. The environmental quality council shall have the authority to investigate, examine and inspect all records, books and files of any department, agency, commission, board or institution of the state of Montana.

History: En. Sec. 15, Ch. 238, L. 1971.

69-6516. Hearings by council—enforcement of subpoenas. In the discharge of its duties the environmental quality council shall have authority to hold hearings, administer oaths, issue subpoenas, compel the attendance of witnesses, and the production of any papers, books, accounts, documents and testimony, and to cause depositions of witnesses to be taken in the manner prescribed by law for taking depositions in civil actions in the district court. In case of disobedience on the part of any person to comply with any subpoena issued on behalf of the council, or any committee thereof, or of the refusal of any witness to testify on any matters regarding which he may be lawfully interrogated, it shall be the duty of the district court of any county or the judge thereof, on application of the environmental quality council to compel obedience by proceedings for contempt as the case of disobedience of the requirements of a subpoena issued from such court on a refusal to testify therein.

History: En. Sec. 16, Ch. 238, L. 1971.

69-6517. Consultation with other groups—utilization of services. In exercising its powers, functions, and duties under this act, the council shall

(a) consult with such representatives of science, industry, agriculture, labor, conservation organizations, educational institutions, local governments and other groups, as it deems advisable; and

(b) utilize, to the fullest extent possible, the services, facilities, and information (including statistical information) of public and private agencies and organizations, and individuals, in order that duplication of effort and expense may be avoided, thus assuring that the commission's activities will not unnecessarily overlap or conflict with similar activities authorized by law and performed by established agencies.

History: En. Sec. 17, Ch. 238, L. 1971.

69-6518. Fee may be imposed. (1) Each agency of state government charged with the responsibility of issuing a lease, permit, contract, license or certificate under any provision of state law may adopt rules prescribing fees which shall be paid by a person, corporation, partnership, firm, association, or other private entity when an application for a lease, permit, contract, license, or certificate will require an agency to compile an environmental impact statement as prescribed by section 69-6504, R. C. M. 1947, of the Montana Environmental Policy Act. An agency must determine within thirty (30) days after a completed application is filed whether it will be necessary to compile an environmental impact statement and assess a fee as prescribed by this section. The fee assessed under this section shall only be used to gather data and information necessary to compile an environmental impact statement as defined in the Montana Environmental Policy Act. No fee may be assessed if an agency intends only to file a negative declaration stating that the proposed project will not have a significant impact on the human environment.

(2) In prescribing fees to be assessed against applicants for a lease, permit, contract, license, or certificate, as specified in subsection (1), an agency may adopt a fee schedule which may be adjusted depending upon the size and complexity of the proposed project. No fee may be assessed unless the application for a lease, permit, contract, license, or certificate will result in the agency incurring expenses in excess of two thousand five hundred dollars ($2,500) to compile an environmental impact statement. The maximum fee that may be imposed by an agency shall not exceed two per cent (2%) of any estimated cost up to one million dollars ($1,000,000); plus one per cent (1%) of any estimated cost over one million dollars ($1,000,000) and up to twenty million dollars($20,000,000); plus one-half of one per cent (½ of 1%) of any estimated cost over twenty million dollars ($20,000,000) and up to one hundred million dollars ($100,000,000); plus one-quarter of one per cent (¼ of 1%) of any estimated cost over one hundred million dollars ($100,000,000) and up to three hundred million dollars ($300,000,000); plus one-eighth of one per cent (⅛ of 1%) of any estimated cost in excess of three hundred million dollars ($300,000,000). If an application consists of two (2) or more facilities, the filing fee shall be based on the total estimated cost of the combined facilities. The estimated cost shall be determined by the agency and the applicant at the time the application is filed.

(3) No fee as prescribed by this section may be assessed against any person, corporation, partnership, firm, association, or other private entity filing an application for a certificate under the provisions of the Montana Utility Siting Act, Title 70, chapter 8, R. C. M. 1947.

(4) In adopting rules prescribing fees as authorized by this section, an agency shall comply with the provisions of the Montana Administrative Procedure Act, Title 82, chapter 42, R. C. M. 1947.

(5) All fees collected under this section shall be deposited in the state earmarked revenue fund as provided in section 79-410, R. C. M. 1947. All fees paid pursuant to this section shall be used as herein provided and each agency upon completion of the necessary work will make an accounting to the applicant of the funds expended and refund all unexpended funds without interest.

(6) In cases where a combined facility proposed by an applicant requires action by more than one (1) agency or multiple applications for the same facility, the governor shall designate a lead agency to collect one (1) fee pursuant to this section, to co-ordinate the preparation of information required for all environmental impact statements which may be required, and to allocate and disburse the funds necessary to the other agencies which require funds for the completion of the necessary work.

(7) Each agency shall review and revise its rules imposing fees as authorized by this section at least every two (2) years. Furthermore, each agency shall provide the legislature with a complete report on the fees collected prior to the time that a request for an appropriation is made to the legislature.

History: En. 66-6518 by Sec. 1, Ch. 329, L. 1975.

APPENDIX C

Documents Submitted in Compliance with MEPA

July 1, 1975 to June 30, 1976

Lead Agency	Environmental Impact Statements	Agency Impact Determinations
Department of Fish and Game	1	4
Department of Health and Environmental Sciences	1	49
Department of Highways	1	138
Department of State Lands	2	2
Department of Livestock	1	0
Department of Natural Resources and Conservation	4	0

APPENDIX D

Environmental Quality Council
Program Cost Summary

July 1, 1975 - June 30, 1976

General Fund:			
Salaries	86,317.22		
Other Compensation	1,000.00		
Employee Benefits	10,582.58		
		$ 97,899.80	
Contracted Services	23,231.34		
Supplies	705.09		
Postage & Telephone	2,716.52		
Travel	6,656.29		
Repair & Maintenance	235.60		
Other Expense	1,476.59		
Rental	6,661.32		
		$ 41,682.75	
Total General Fund Expense			$139,582.55

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Designed & Printed by
COLOR WORLD OF MONTANA, INC.
201 E. Mendenhall, Bozeman, MT 59715