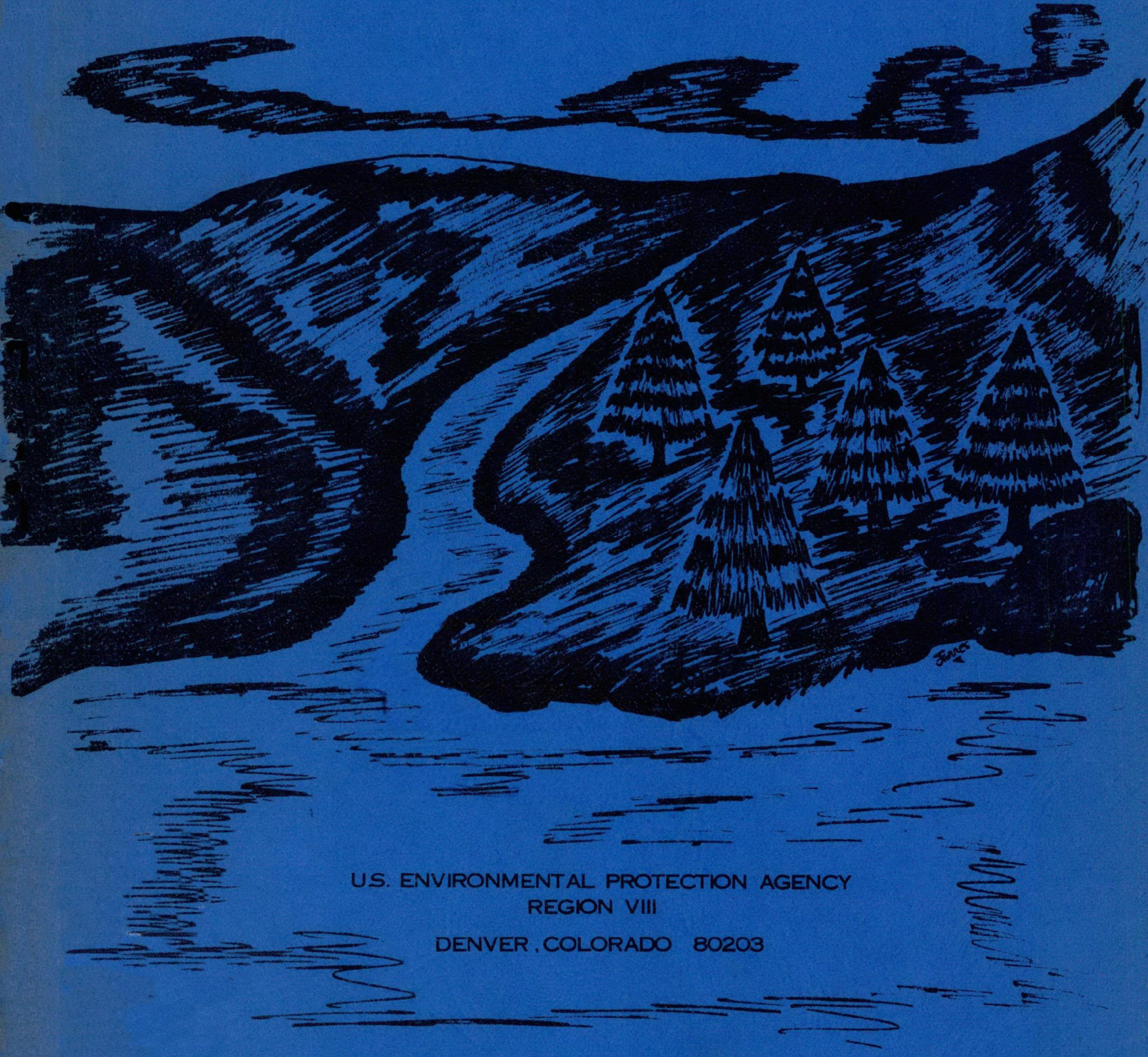
ENVIRONMENTAL CARRYING CAPACITY CASE STUDY OF GRAND COUNTY AREA, COLORADO



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ENVIRONMENTAL CARRYING CAPACITY

CASE STUDY OF GRAND COUNTY AREA, COLORADO

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PREFACE

Carrying capacity has for many years been a topic of discussion and analysis in resource management. It has also received attention via considerations of optimum population for cities and other geographical spaces. Recently, it has become a popular, but controversial, topic in regional planning for areas outside urban agglomerations. The study reported in this paper reflects this recent interest.

The study focused on evaluating a carrying capacity based planning process for its usefulness in regional planning. A case study area, Grand County, Colorado, was used for this evaluation and received the benefits of the project's data collection and analysis efforts. However, the study was of a process and the data supplied to the County were outputs of the test and do not represent a specific job done for the County. In fact, in this report the reader will find few data directly useful in the County's planning activities.

The research team which conducted this study is grateful for the cooperation and assistance it received from many individuals and governmental agencies. Among the many who provided considerable assistance were:

The Bureau of Land Management, the U.S. Forest Service, the Soil Conservation Service, and the National Park Service provided environmental data; the Colorado State Forest Service provided office space and transportation vehicles; Jerry Wolf of the Colorado Division of Wildlife gave the Team data, field study assistance, and access to living quarters.

Stan Broome, former Grand County Planner and Bob Chamberlain, Grand County Assistant County Planner gave us information, assistance, and the support of the Planning Office. Numerous County officials and residents not only provided us with needed data but also took the time to answer opinion questionnaires. We also thank the other members of the Regional Resource Planning Program who helped us during this project. Dr. Dennis Lynch was especially helpful during initial stages of the project. Vicki Traxler and Steve Long helped with the coding phase; Pat Kerschner produced graphics and provided assistance with survey research; Kate Chandler helped develop and administer the first questionnaire; Jim Kelly was always on hand to take part in daily operations; Sarah Crim participated in much of the map production; Jan Bergquist contributed to data collection efforts; Carole Travis did the typing of this manuscript and its many drafts.

Special thanks go to Gene Taylor, EPA project monitor from Region VIII. He had the patience, understanding, and flexibility to allow us to develop the project as it progressed.

INTRODUCTION

Many of the mountain communities of Colorado and neighboring states are illustrative of new trends in urbanization and development which have, to date, been given little attention by researchers and planners. While there has been growing concern for the plight of the large city and its suburbs, problems associated with rapid growth and development of small, relatively isolated towns and rural areas have not been adequately studied. The result is that we see (particularly in the mountain and intermountain states of the West) some extremely rapidly growing communities which are beginning to exhibit many of the problems of large urban areas. Deterioration of environmental quality, congested traffic, inadequate waste disposal, spatial and locational problems resulting from lack of adequate zoning, conflict among citizens with different attitudes toward expansion and economic growth, harmful alteration of environmental resources of the area, and many other problems are the result of inadequate planning and a lack of knowledge of the interrelationships between population increases in the community, economic expansion, and the total living environment. Because of the fragility of the environment in the mountain and intermountain states of the West, the consequences may be particularly bad.

These are the problems of such places as Aspen, Steamboat Springs, Winter Park, Dillon, Vail, Sun Valley, and Park City, as well as many other communities in the Mountain West. Because of the recreational and scenic attractiveness of these areas, they are drawing great numbers of seasonal residents (often as second home owners); yet uncontrolled growth is likely to destroy the very resource which has been the basis for the economic expansion of the area. In trying to solve these problems, what is needed is a dual effort of research and planning which will lead to a knowledge base plus a program for implementation which will permit orderly development and optimum use of the natural, capital, and human resources of an area, consistent with the public interest.

The rapidly growing mountain communities form a sub-set of a larger community growth phenomenon; that is, they are part of the general situation associated with rapid growth of heretofore rural areas caused by location of new manufacturing plants, relocation of existing firms, the creation of new towns, and the outward movement of the urban fringe. All of these phenomena have in common the rapid population growth of previously rural areas and the concomitant consequences of this population increase.

The potential problems of rapid growth are intensified by the fact that local planning decision makers (usually county commisioners or planning and zoning commissions) have not been exposed to critical environmental decisions in the past. They lack data on the existing community or regional situation, but more importantly they lack information on impacts of change which might result from various regulatory choices which fall within their province. The public decision makers often perceive community or regional change as an overwhelming force over which they have little control when, in fact, they may have the authority but not the information on which to plan the destiny of their community or region.

To gain understanding of the elements which drive these development situations, some organizing framework is needed. One possible framework is a carrying capacity based planning process. Because of the holistic nature of carrying capacity based planning, such a process is ideally suited to the problem of organizing for comprehensive analyses.

The planning problem is so complex that an intensive program is necessary to provide data and information as a basis for seeking answers which not only deal with the traditionally recognized role of spatial and architectural planning, but also deal with answers to questions from the fields of economics, political science, sociology, public health, ecology, business, and regional planning. What is needed is an interdisciplinary approach to solving community development problems.

This project has been built on the premise that sound planning decisions can only be made if reliable and comprehensive data on the existing conditions, on critical planning variables and constraints, and on the potential impacts of planning alternatives can be made available to a wide range of responsible decision makers. This requires, in turn, that information and data inputs be in a form intelligible to non-scientifically trained community leaders. A carrying capacity based planning process has the potential to be useful for such a task.

The central purpose of the project was to test a carrying capacity based planning process for its usefulness in comprehensive mountain land planning.

Probably the greatest shortcoming of planning and zoning decisions in most areas is that they are made in reaction to short-run crises and usually consider only immediate and direct impacts. In rapidly growing mountain communities that are being besieged by requests for planned unit developments, for condominiums, or development of new ski areas, short-run crisis decision making is far from adequate and, in fact, may be disastrous to the future quality of the living environment.

In attempting to develop a planning framework which would help avoid this kind of decision making, this project has examined the interaction of those planning variables, by way of designing alternative futures, which are the critical ones influencing the growth and environment of rapidly growing mountain communities. A systems approach, utilizing carrying capacity concepts, was aimed at identifying and quantifying these interactions.

To meet the problem of testing a carrying capacity based planning process for mountain land planning, the research has two specific objectives.

1. To employ a carrying capacity based planning process in an analysis of the future of Grand County, Colorado. This involved examing natural environmental capabilities, social and economic driving forces, and the institutional and infrastructure elements of the County. The future was forecast through derivation of several alternative futures, and these futures were utilized to provide a focus for the analysis.
2. To evaluate the employment of the carrying capacity based planning process utilized in (1) for its effectiveness and efficiency. To meet this objective required assessment of the concept's implementation including constraints and advantages. This involved study of environmental, social, economic, and institutional factors.

The following pages of this report describe the process utilized to meet these two objectives and the results of the case study investigation of Grand County, Colorado. An evaluation of the applicability of carrying capacity concepts to mountain land planning is provided.

PROCESS OVERVIEW

In focusing on evaluation of a carrying capacity based planning process, it is necessary to explain what is meant by such a process and of what it consists. After this explanation, the planning process utilized in the study is overviewed.

Planning

The planning orientation for this study is quite simple and is illustrated in figure 1. The system is in some "original state" at time period t. Through a "process" which occurs over time, the "probable state" at time t+1 has a high probability of emerging. Rather than accepting this probable state, the object of planning is to illustrate how to reach some "desired state" by t+1.

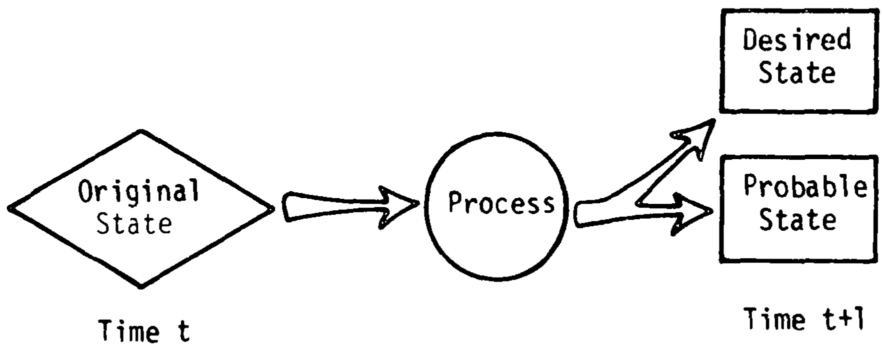


Figure 1. An abstraction of the planning problem.

While the objective of planning is quite easily articulated, specification of the original state, process, and probable and desired states is quite complicated. The basic components of the system are shown in Table 1. It is clear that for each of the three stages there are three primary components: Individual preferences and behavior, resource capabilities, and institutions. Comprehensive planning requires consideration of all dimensions shown in the table so that the probability of reaching the desired state is increased.

Table 1. Components of the planning situation.

System Characteristics	Original State	Process	Desired State
Preferences and behavior	Facilities and activities for meeting individual needs	Behavioral explanations of behaviors and changes in behavior	Individual aspirations
Resource capabilities and environmental impacts	Relationship of environment to facilities and activities	Resource capabilities	Environmental impacts
Institutions	Existing institutions and their characteristics	Institutions as a way government can intervene and redirect activity toward desirable state	Social goals translated into facilities and institutions

A critical element in this conceptualization of planning is the search for the desired state. The approach utilized in this study to find the desired state involved evaluating the impact of several alternative future states on the system components. Carrying capacity, as the quantification of an alternative future, fits within this general conceptual framework but the focus is the set of alternative futures to be evaluated.

Carrying Capacity

The carrying capacity concept, while used by many people, has essentially the same functional meaning in all cases. In the context of human systems its use begins with a decision maker being charged with defining "quality" of the environment (often only a portion of the environment). At his disposal he often has information about natural resources, peoples' desires, institutions, and the current situation. This information is filtered through his own screening mechanisms, and he articulates one or more definitions of quality--or what is desired. Each definition is an alternative future. Coupling these alternative states with different physical-geographic systems one can calculate carrying capacities. A capacity is the number of people and their distribution which can be accommodated by a future in a given physical-geographic system. Figure 2 shows the molar components of this calculation and shows the steps necessary in the planning process after carrying capacity calculation.

The planning framework discussed in this report is often considered "carrying capacity based planning." It derives this label from the opportunity afforded in the planning process to calculate a carrying capacity for a specific alternative future. One need not, however, consider the process as focusing on carrying capacity. There are other, more important components to the process.

Another way to view the process is to begin with alternative futures and treat them as driving forces changing an area. A central concern becomes the impact of each alternative future on subsystems of the total system. Possible subsystems to consider are: (1) demographic, (2) economic, (3) infrastructure, and (4) environmental. One output of this process is assessment of impact of changes on the four subsystems. These impacts are

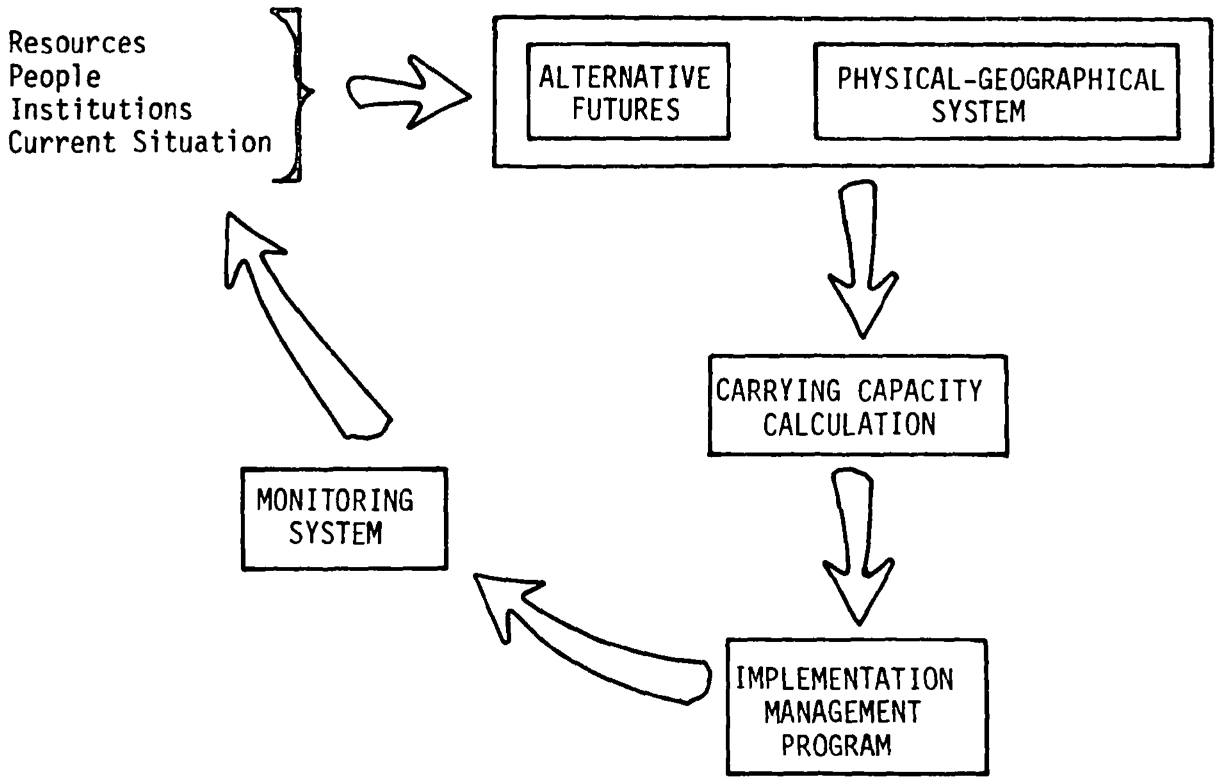


Figure 2. The carrying capacity based planning process from a decision-making perspective.

expressed as values attached to a set of system indicators which are common to all the alternative futures. Figure 3 illustrates this impact stage of the planning model.

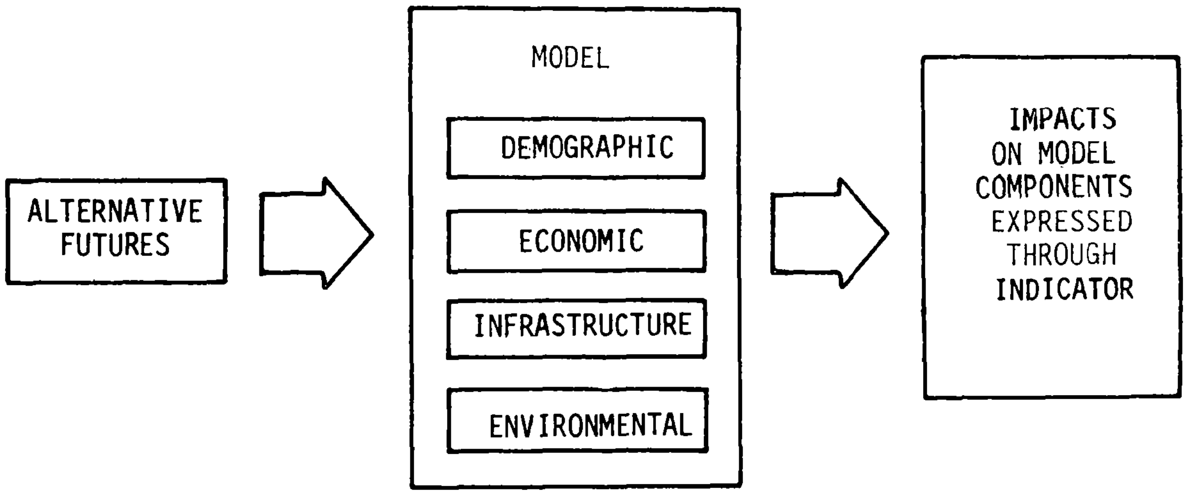


Figure 3. Impact generation process.

Once an alternative future is defined and the impact of its realization identified, a substantial amount of information is available to select a "desired" alternative future. In essence, one can choose which future, or combination of futures, is most likely to provide desired outputs. From this point, decision makers can select a "desired future" for which to strive. The task then is one of building the set of policies and programs to achieve the desired future, and change the "process" from paths that lead toward other futures. The final steps are implementing the policies and programs to reach the objective and monitoring and evaluating the effectiveness of the process.

Within this study, the alternative futures approach to carrying capacity based planning was utilized. Actual carrying capacity was viewed as only one indicator of the state of the total environmental system.

Study Process

The process used in the study followed the outline provided by figure 2. The most difficult stages in this process were identifying a relevant set of alternative futures and then settling on one future to follow through the remainder of the process.

The first objective in the process was to develop a set of relevant alternative futures. Figure 4 shows a broad outline of this stage of the process. To delineate alternative futures demanded considerable inventory work to identify the current situation and the forces actively shaping the future. Inventories were made of the economic situation, environmental resources, population structure and behavior, infrastructure elements (e.g., roads, schools, etc.), opinions of government officials, opinions of resident publics, and identifiable growth forces and development plans. In most cases secondary data were utilized, but where data did not exist, e.g., public desires, primary data were collected.

Once all inventories were completed, the information was examined for relevancy to construction of broad, "future" scenarios. Five scenarios were generated outlining future possibilities ranging from emphasis on preservation of unallocated land resources to active industrial development. The titles given these scenarios were: Preservation; Preservation/Tourism; High Development: Tourism; High Development: Extractive and Light Industry; Moderate Development: Tourism/Industry. In developing these scenarios, there is a degree of subjectivity in the synthesis of inventory data. The criteria utilized to delineate the scenarios were based upon the capability of the study area to support the scenarios and the likelihood that each scenario would be acceptable to an easily identifiable portion of the study area's resident population. All five scenarios are realistic for the study area in that they met these criteria.

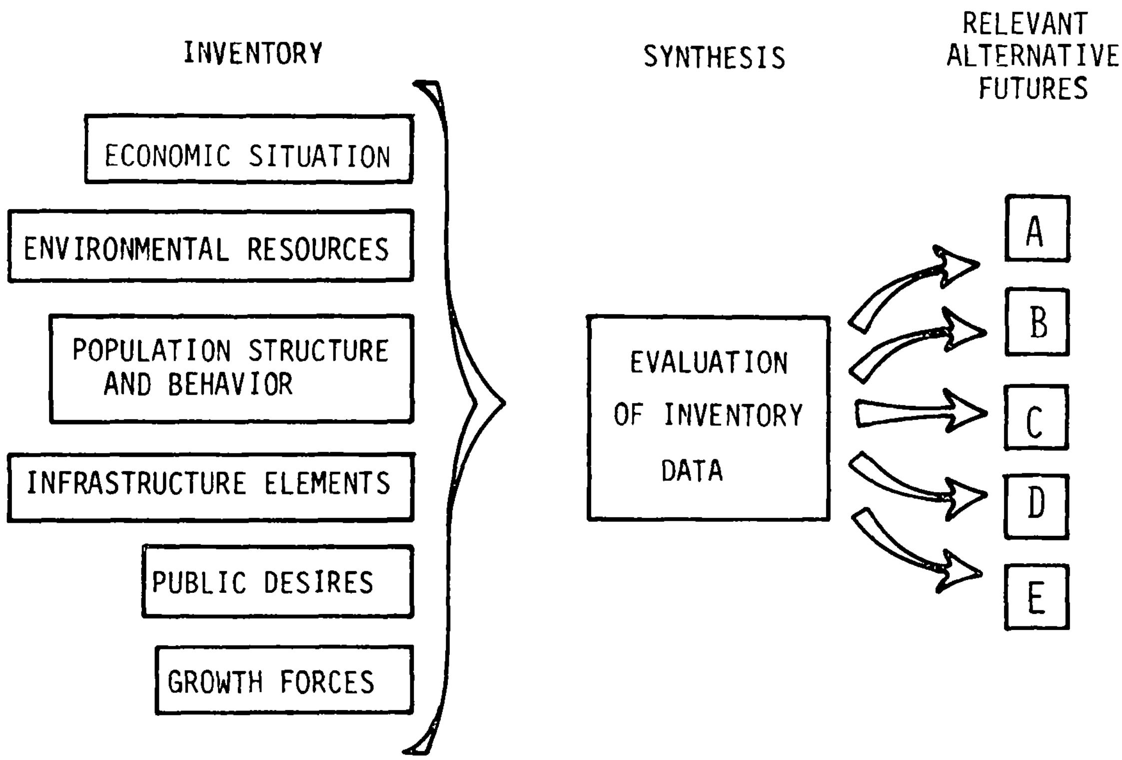


Figure 4. Deriving alternative futures.

After deriving the scenarios, they were transformed into more specific alternative futures by categorically and quantitatively specifying the meaning of the scenarios. A level of employment change and the type of employment was specified for each scenario. The result was a list of five alternative futures from which a desired future could be chosen. (Other alternatives are certainly possible but to test the process they were not necessary.)

The alternative futures were run against several sub-systems models as shown in figure 5. A model is simply a representation of some real situation. The purpose of this analysis was to determine the social and environmental impacts associated with each alternative. It was our belief that a necessary criterion against which to evaluate each alternative was its set of impacts, i.e., to preferentially choose between alternatives one needs to know the consequences of the choice.

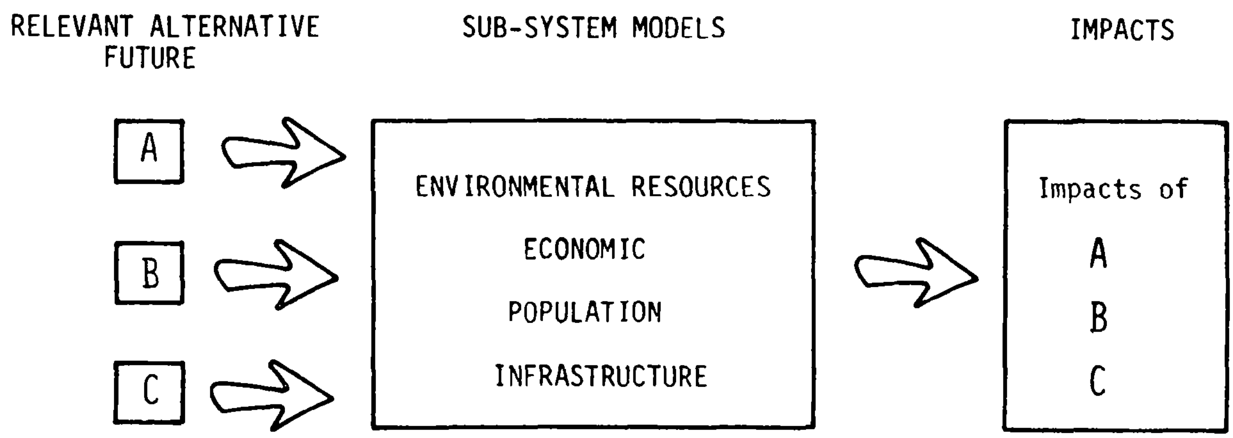


Figure 5. Evaluating impacts of alternative futures.

The models for this impact analysis were derived from the inventories which were conducted in phase one of the process. The kinds of models developed were as follows: Economic, economic base; population, cohort-survival; infrastructure, statistical-descriptive; environmental, map overlays. The economic, population, and infrastructure models were computer programmed and directly linked together so that they could be operated synergistically. Environmental resource modeling was done on map overlays, with one overlay representing constraints imposed by each scenario.

To assess impacts from alternatives, the employment change data were run through the economic, population, and infrastructure models to determine population levels and resource and infrastructure needs. Then, these needs were spatially located on the resource map overlays.

The final phase in selection of the desired future is shown in figure 6. Here, the alternatives and their consequences are subjected to evaluation by relevant publics. The approach utilized in this study was a survey of County residents giving them an opportunity to express a preference for each alternative. In the case of this study, the rank accorded each alternative was tallied and the alternative receiving the most acceptable scores was selected as the "desired future" for further analysis. A more sophisticated system of selection was not utilized because the "test" nature of this study made that unnecessary.

After selecting a desired future, one additional step in the planning process was necessary. Implementation schemes were discussed to show how the desired alternative future might be reached. Such schemes can be used to delineate the bounds on the kinds of land use activities deemed acceptable in location, design, and cost parameters. A final step in the study process was an evaluation of the process including estimates of workability, cost, and acceptability.

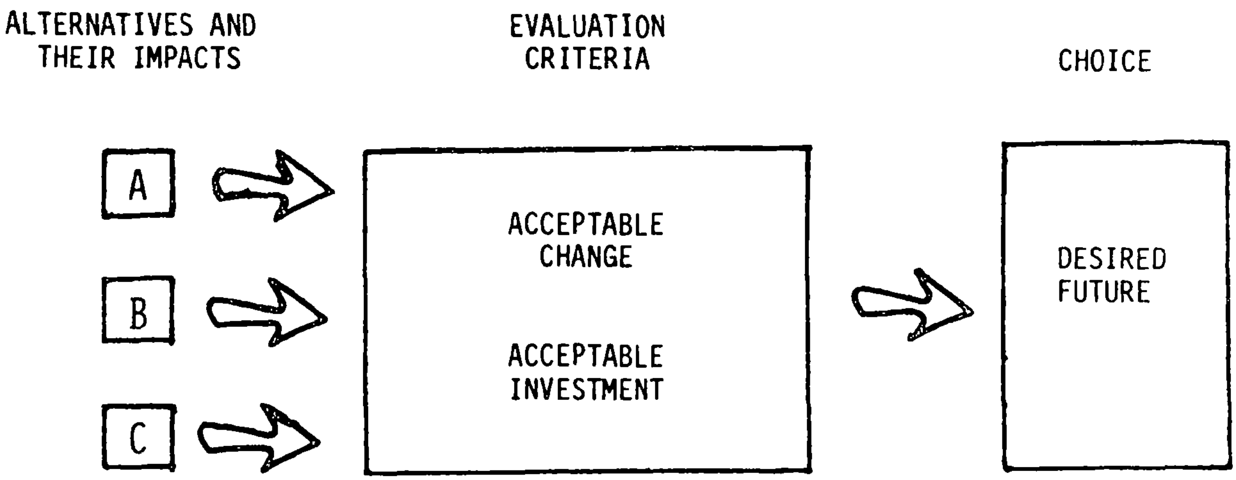


Figure 6. Selection of desired future.

Several conclusions emanate from the test of this process. First, the process is costly relative to many county planning budgets. But, given pooling of funds by several governmental agencies, the costs are not prohibitive. Second, while the process does meet the objectives of a good planning process, there are some problems in smoothness of operation. There are personnel, logistics, and cooperation problems which any user should consider before utilizing the process. Third, the process has potential to be highly acceptable to both users and publics. It is open, comprehensive, and provides a large data base for inputs to land use decisions.

In the following section of the report, each of the components of the study process is described via the case study of eastern Grand County, Colorado. The data needs for the study and data sources and analytical models used are described. A desired alternative future is selected and an implementation and management strategy is discussed.

CASE STUDY--EASTERN GRAND COUNTY

The planning process described in the preceding section of this report was applied in a case study of eastern Grand County, Colorado. Specific steps taken in using the process are described in the following paragraphs. Data sources, analytical techniques and models, data interpretation, decision making processes, and other aspects of the planning activity are identified.

Study Area

The study area shown in figure 7 was the eastern portion of Grand County, Colorado. The geographic boundaries of the area are R74W on the east and R77W on the west. The northern boundary was the northernmost private land in the Kawuneeche Valley adjoining Rocky Mountain National Park, and the southern boundary was the county line where Summit and Clear Creek counties abut Grand County. Seventeen USGS topographic map quadrangles cover the area. They are: Byers Peak, Fall River Pass, Isolation Peak, McHenrys Peak, Monarch Lake, Mt. Richthofen, Berthoud Pass, East Portal, Empire, Radial Mountain, Fraser, Granby, Grand Lake, Strawberry Lake, Trail Mountain, Shadow Mountain, and Bottle Pass. Only the latter seven maps contain private lands and were used in subsequent analyses.

Most of the private lands in the study area are in its central portion. These lands are encircled by U.S. Forest Service, Bureau of Land Management, National Park Service, and various state land holdings. The lowest elevation in the study area is approximately 2438 meters (8000 feet) while the highest is above timber line at over 4266 meters (14,000 feet).

Figure 7. Study area.

The study area contains several prominent recreational attractions and areas. Both Rocky Mountain National Park and Shadow Mountain National Recreation Area (composed primarily of three lakes--Grand, Shadow Mountain, and Granby) are important summer recreation areas. They also service some winter recreation demands. Winter Park Ski Area and some other winter recreation developments are also in the area. Dispersed recreation activity takes place on abundant forest and range land and along the river and stream courses feeding the upper Colorado River.

Within the study area are two primary highway routes and six communities. U.S. Highway 34 is the highway passing through Shadow Mountain Recreation Area and Rocky Mountain National Park. The community of Grand Lake is found along this route just before the route enters the southwest section of the Park. The other major highway is U.S. 40 which traverses the county from east to west. U.S. 40 is a major transcontinental highway route which, in the Rocky Mountain states, connects Denver, Colorado with Salt Lake City, Utah. The residents and visitors in Grand County utilize U.S. 40 to access the Denver Metropolitan Area as well as to travel between most of the County's communities. Winter Park, Hideaway Park, Fraser, Tabernash, and Granby are all located along U.S. 40.

Deriving Alternative Futures

In implementing the process as outlined previously, deriving a set of relevant alternative futures was the first major task. As was mentioned, this demanded a considerable amount of inventory in order to describe the current situation and to forecast information which might influence the future. Inventories of the environmental resources, population structure, economic situation, and public and governmental official opinions were made. These inventories are described in the following paragraphs beginning with those for environmental resources.

Resource Analysis

The inventory of environmental resource information was done utilzing secondary data (already collected) where available and combining this information with primary data collected by the resource team. Information was displayed for all resources utilizing a common format.

The United States Geological Survey 7½ minute topographic map series was chosen as the base for mapping the resource components. This map format was chosen because of its compatibility with mapping by other resource agencies (e.g., U.S. Soil Conservation Service, U.S. Bureau of Land Management, Colorado State Forest Service). Also this map scale is suggested for use in identifying hazard areas in compliance with Colorado Law (Chapter 106, Article 7, Colorado Revised Statutes, 1974) otherwise known as House Bill 1041.

The proportional scale of the 7½ minute maps is 1:24,000 (one unit measured on the map is equal to 24,000 units measured on the ground). At this scale, 4.2 centimeters on the map is equal to 1 Kilometer on the ground (2 5/8 inches equals 1 mile). The mapping scale of 1:24,000 limits the size of the smallest land area which can be represented on the maps. Differences in resource components which occur in areas smaller than two hectares (approximately five acres) may not appear on the maps.

The accuracy with which specific natural resources have been mapped depends upon the nature of the resource and the precision of the initial survey. Features such as soil types and fault traces are variable in nature and may not conform precisely to the lines delineating them on the maps. The transfer of information from different mapping scales also affects map accuracy. The location of the vegetation, soils, and geologic hazard boundaries can generally be considered accurate to within ± 60 meters (200 feet) of their actual positions on the ground. The wildlife and visual vulnerability maps, because of the mobile and subjective nature of their respective components, may have considerably less accuracy. However, these boundaries are usually accurate to ± 400 meters (1200 feet).

These limitations of scale and accuracy should be considered in the use of resource information mapped at a scale of 1:24,000. This information is intended to indicate the locations and types of specific resource hazards or limitations. Field investigation and more detailed mapping at larger scales is necessary for intensive site planning on small areas.

Slope

Importance. The primary use of slope in the Grand County case has been as a land use constraint. The effect of slope in this role varies according to steepness of the gradient and the nature of soil and geological material on the site. On steeper slopes there exists a greater potential for erosion, slope failure, and landscape scarring. Where suitable fuels occur, any increase in slope causes an increase in the rate of spread for wildland fires. Also, in the higher mountains steep slopes are potential avalanche areas.

Four slope classes were selected: less than 10 percent, 10 to 29 percent, 30 to 44 percent, and slopes 45 percent or greater. These classes indicate ranges of relative severity of slope limitation for land development. Slope limitations, however, may be overcome if money and technology are invested, usually through engineering practices.

Data Source. Slope data were obtained from analysis of U.S.G.S. topographic quadrangles.

Situation Description. In the study area, most of the private land is described by the first and second slope classes; that is, relatively flat to gently sloping. This occurs since most of the private land lies in the river bottoms and valleys that compose Middle Park. Some private land is found on the steeper slopes, but the majority of the steeply sloped land in the study area is administered by the BLM or the U.S. Forest Service.

Interpretation. Slope limitations are relatively minor on land with slopes less than 10 percent. But, slope is still an important consideration on these lands because significant erosion, slope failure, and other phenomena can occur, particularly in areas where there are unstable soils and geologic materials.

The relative severity of limitations is moderate on lands with slopes from 10 to 29 percent. Considerable grading, cutting and filling, and other land alterations are necessary for construction of roads or buildings. Costly engineering measures may be required to stabilize the soil and provide adequate drainage. Construction may create visual scars that detract from the scenic quality of the landscape. These limitations become increasingly significant on slopes approaching 29 percent.

On slopes between 30 and 44 percent, limitations are relatively severe. The rate of spread for wildfires may be two to four times as fast as in similar vegetation on level ground. Slope stability and erosion problems make construction extremely expensive. Because of the limitations, the county has adopted regulations that prohibit buildings from being placed on slopes steeper than 30 percent (phone conversation with Stan Broome, Grand County Planner, October, 1974). It is also recommended that roads and other improvements requiring cutting and filling should not be constructed across slopes steeper than 45 percent without first making extensive engineering studies of stability problems. The visual scars created by construction on steep slopes should be considered in planning the location of improvements.

Slopes steeper than 45 percent are generally left in their natural state due to their inherent problems. When there is heavy snow accumulation and a suitable sliding surface, these slopes are potential snow avalanche areas. Construction limitations are extremely severe in these areas (Lautenbach, et al., 1974).

Slopes in the less than 10 percent class do not present any real problems for development. Slopes in the 10 to 29 percent class present moderate limitations for development. Land in these two classes is generally considered to be allowable for development. The other two classes, 30 to 44 percent and 45 percent and greater, have been recognized as presenting economic and safety problems for development by both the county commissioners and various state agencies. Problems include wildfire potential, avalanche potential, rockfall and landslide potentials, erosion, and economic problems in placing roads, water, and sewer systems. For these reasons slopes in these two classes are often classed as prohibitive to development.

In the study area, slope was used in the delineation of wildfire and avalanche potentials and in conjunction with soils and geologic analysis.

Vegetation

Importance. Because of its beauty and magnificent scenery, eastern Grand County attracts thousands of visitors every year. One of the reasons for this attraction is the abundance and variety of vegetation. However, vegetation does much more than increase the aesthetic quality of the area. It is also extremely important in cycling nutrients, maintaining water quality and quantity, providing wildlife habitat, reducing noise, screening man-made structures, and reducing the adverse effects of extreme weather conditions.

In this study vegetation was used to define and recognize ecosystems and as an indicator of less obvious components of these ecosystems. This was done because vegetation has several very useful classification attributes. These are:

1. Vegetation is easily seen and observed.

   Everywhere we look in the mountains we see a mosaic of vegetation--trees, shrubs, forbs, and grasses. This pattern of vegetation is stable enough to photograph for later comparison or analysis. An inventory of this easily observed component is much easier to make than an inventory of other components which are hidden, transient, or obscure.

2. Vegetation as an integrator.

   All factors of the environment interact to influence location, composition, and productivity of plant communities. Vegetation is representative of this integration, and this characteristic may be used to indicate environmental conditions which are important in establishing land uses.

3. Vegetation is a divisible factor.

   Broad classifications of plant communities can be subdivided into smaller and more precise units for detailed analysis. This feature allows the examination of ecosystems at increasing levels of intensity. Broad views of the environmental situation are possible and can be basic to further study, while detailed analysis can sort definite sub-systems out of a seemingly complex pattern.

4. Vegetation matures over time.

   Plant communities have a destiny as well as a beginning. Thus, the current structure and composition of a community of plants is a reflection of its history of development and can also give some idea to its future. Potential productivity is another part of future maturity. Therefore, vegetation can be utilized in making planning predictions and projections.

5. Vegetation responds to use.

   When areas are utilized or occupied by man's improvements, vegetation will respond to that use. Vegetation can be removed, reduced, or enhanced by use. Often the response of vegetation is somewhat predictable and adverse events can be avoided by proper planning.

By utilizing these characteristics of vegetation, we can begin a useful classification of natural mountain ecosystems for planning purposes. A true ecosystem does consist of more environmental factors than just vegetation. It is important, therefore, to look at these vegetative units as being representative of an integrated environment (Lynch, 1974).

Data Sources. Numerous sources are available for vegetation mapping. For instance, the U.S. Forest Service has timber type maps, the Bureau of Land Management (BLM) has vegetation keyed on its land, and the Soil Conservation Service (SCS) has range land vegetation mapped for private lands. Even U.S.G.S. topographical quadrangles type vegetation with forested lands differentiated from non-forested lands. In the study area, the Colorado State Forest Service had mapped the vegetation in the summer of 1973. The State Forest Service quadrangles that had been completed were available for use in the study. The vegetation in the areas that had not been previously mapped was interpreted from aerial photographs. All primary and secondary data were thoroughly field checked.

Situation Description. The area's vegetation occurs in three distinct ecological zones. These zones are differentiated by vegetation which occurs within them and they have fairly well-defined elevational limits based on length of growing season, rainfall, climate, and other environmental factors.

In Grand County, the montane ecological zone extends from the valley floor at an elevation of about 2,438 meters (8,000 feet) to approximately 2,894 meters (9,500 feet). Vegetation in this zone is characterized by riparian vegetation and irrigated haylands along river bottoms. Pure stands of lodgepole pine, Douglas fir, blue spruce, and aspen are found a little higher in this zone. Also in this zone are extensive areas of sagebrush and other mountain brush types. Summer brings forth fields of colorful flowers like golden banner, paintbrush, and columbine. This subalpine zone starts about 2,894 meters (9,500 feet) and extends to timberline. Stands of Engelmann spruce and subalpine fir dominate this region. Well-developed alpine tundra exists at elevations between 3,352 meters (11,000 feet) and 4,266 meters (14,000 feet). The tundra is characterized by many small, extremely fragile plants like bog birch, alpine phlox, moss campion, and fairy primrose. This ecological zone is climatically harsh, and the vegetation is the most sensitive to disturbance.

More specifically the study area is composed of nine major vegetation types. These types are defined as ecosystems. A mountain land ecosystem is a composite of living systems which contain both benefits and problems; hazards as well as opportunities. Such a viewpoint realizes that mountain lands are a complete integration of all environmental factors, both living and nonliving (Lynch, 1974). An example is an area where 50 percent of the tree cover is lodgepole pine and is called a lodgepole ecosystem.

The nine major ecosystems found in the study area are: 1) irrigated haylands which dominate the vegetation along the river bottoms; 2) riparian ecosystems which parallel the waterways; 3) bog ecosystems found along water routes; 4) sagebrush ecosystems which prevail on the hillsides and in the less desirable hayland areas; 5) 6) and 7) lodgepole pine, aspen, and juniper ecosystems which comprise the forests of the montane zone; 8) meadow ecosystems; and 9) spruce-fir ecosystems which exist in the sub-alpine zone.

Some of the forest lands in the area have been cut over or are presently being cut. In addition, Mountain Pine Beetle (D. monticolae) is presently attacking stands of lodgepole pine south of U.S. Highway 40 and can be expected to continue to spread. Much of what is now irrigated haylands was at one time areas of sagebrush, but due to the addition of irrigation water and chemical spraying, these areas have been converted to profitable agri-cultural lands.

Interpretation. Each ecosystem has its own natural uses as well as its own opportunities and constraints for man's development. The natural uses referred to are such things as the ecosystem's ability to provide wildlife habitat, protect water quality, provide aesthetic viewpoints, and protect watersheds. When development is anticipated, the value of an ecosystem must be weighted in two ways: First, one must consider the social and economic values placed upon the various natural products which an ecosystem produces, such as a bog ecosystem's ability to improve or maintain water quality. Each ecosystem has its own specific value in providing products. For instance:

1. The irrigated hayland ecosystems, in addition to providing economic value through hay products, provide scenic quality and open space;
2. The riparian ecosystem has visual and aesthetic value while also being a protector of water quality through its role as a buffer zone and filter between the water course and possible sources of pollution;
3. The bog ecosystem acts as a water filtering system in the maintenance of water quality;
4. The sagebrush ecosystem is mainly used for domestic grazing and wildlife habitat, but it may also be used as an indicator of soil fertility and water content;
5. The lodgepole pine ecosystem provides lumber and other wood products as well as having watershed values;
6. The aspen ecosystem has visual and aesthetic value;
7. The juniper ecosystem is used mainly for domestic grazing;
8. The mountain meadow ecosystem has high visual and aesthetic value and is usually associated with production of high quality water;
9. The spruce-fir ecosystem is valuable for wood products while also having high visual and watershed values.

Second, the economic value or cost of land development in each ecosystem provides basic opportunities and constraints to land development. On a relative economic scale, development within a lodgepole, sagebrush, juniper, or irrigated hayland ecosystem will be less expensive than development within a bog or other water related ecosystem simply because of the engineering problems that arise when building on wetlands. The aspen ecosystem would also be more expensive to develop because of engineering problems in soil stabilization. The spruce-fir ecosystem is characterized by a high water table and much above ground water flow in the spring and early summer making land development a problem.

Soils

Importance. The soil resource is an important element of the natural resource base and has a large influence upon urban and rural developments. Soil is the natural medium for the growth of plants, its physical properties and life forms serve to breakdown wastes and purify water, it serves as the foundation material for buildings, roads, and all other land based, man-made structures.

The soils which occur in an area are a result of complex interactions between physical and biologic processes. These soil resources are irreplaceable when considered in terms of the exceedingly long periods of time necessary to produce the soils in their present form.

Misuse of soil resources in the past has led to deterioration and in some cases destruction of the resource base itself. Very often this misuse is the result of a lack of knowledge and understanding of the relationships between the soil and proposed land uses. To avoid further misuse of this element of the natural resource base it is necessary to acquire definitive data about the soil resource, and then to use these data to guide the location and construction of proposed developments.

Data Sources. In 1973, the Grand County Board of Commissioners negotiated a cooperative agreement with the U.S. Department of Agriculture, Soil Conservation Service, for the completion of detailed soil surveys for the privately owned lands within the County. The work on the eastern portion of the County was completed in the summer of 1974 and the data were available for this resource analysis.

The field survey was mapped on aerial photographs, of 1:20,000 scale, and was compiled and transferred to 1:24,000 scale U.S. Geological Survey topographic quadrangle maps.

Situation Description. In the detailed soil survey, 31 individual soil series which occur in the study area were identified. A listing of the series names and their corresponding mapping unit designations are contained in Table 2. The field mapping units as shown on the soils maps also contain a slope class as designated by the letter following the map unit number. These slope classes were defined by the soil field mapping specialist and should not be confused with the slope classes which were defined for the separate slope analysis of the study area. The soils slope classes and their corresponding ranges are as follows:

B = 0- 3 percent slopes

C = 0- 6 percent slopes

D = 6-15 percent slopes

E = 6-25 percent slopes*

F = >15 percent slopes**

Exceptions:

* Soil unit 71E has slopes from 15-25 percent

** Soil units 70F and 71F have slopes >25 percent

Table 2. Soil series names and map symbols.*

Map Symbol	Soil Series Name
3 & 71	Clayburn loam
4	Cummulic Cryaquolls
12	Handran gravelly loam
15	Bearmouth sandy loam
19	Forelle loam
20	Leavitt loam
23	Aaberg clay loam
25	Hitchen clay loam
26	Binco clay loam
27	Cimarron loam
28	Mayoworth clay loam
33	Roxal loam
35	Woodhall loam
38	Gateway loam
39	Cebone loam
40	Anvik loam
43	Grenadier gravelly loam
46	Lake Creek loam
47	Leadville fine sandy loam
51	Cryoboralls-Rock Outcrop Complex
58	Rogert gravelly loam
59	Emerald gravelly sandy loam
60	Yovimpa clay loam
70 & 69	Frisco-Peeler Complex
72	Cowdrey loam
73	Hierro sandy loam
74	Youga loam
75 & 76	Quander cobbly loam
77 & 17	Scout cobbly sandy loam
79	Upson coarse sandy loam
W	Histic Cryaquolls

*Source: U.S. Soil Conservation Service, Kremmling, Colorado
Preliminary Data; subject to change

The soil series data have been grouped into soil associations, or sets of highly similar soil types. In the study area, these associations are closely related to geologic parent materials. These associations and their general land use suitability interpretations are shown in Table 3.

The following association descriptions have been condensed from the detailed association descriptions provided by the U.S. Soil Conservation Service in Kremmling, Colorado. These descriptions are of a preliminary nature and are subject to change prior to publication of the final soil survey report. They are:

1. Cimarron--Mayoworth--Hitchen. This association is composed of neutral to mildly alkaline, shallow to deep, fine-textured soils on mountain side-slopes and ridges. It occurs in approximately 25 percent of the study area, primarily over shale and Troublesome mudstone bedrock, in the sagebrush vegetation zones north and northwest of the town of Granby and west of Granby Reservoir. It is made up of about 40 percent Cimarron loam, 25 percent Mayoworth clay loam, and 20 percent Hitchen clay loam. The remaining 15 percent of this association consists of Binco clay loam, Aaberg clay loam, Cowdrey loam and Rocky Outcrop.

2. Youga--Woodhall--Quander. This association is composed of neutral to slightly acid, moderately deep and deep, medium-textured soils on mountain slopes and ridges. It occurs in about 10 percent of the study area on parent materials of glacial drift, sandstone, and basalt, in the sagebrush vegetation zones between the town of Granby and Granby Reservoir, and immediately north of Willow Creek Reservoir. It consists of 50 percent Youga loam, 25 percent Woodhall loam, and 15 percent Quander cobbly loam, with the remaining 10 percent made up of Cimarron, Clayburn, Anvik, Handran, and Rock Outcrop soils.

3. Frisco--Peeler--Hierro. This association is composed of slightly to strongly acid, deep, medium-textured soils on glacial drift. It occurs in approximately 15 percent of the study area and is located in small areas throughout the entire study area, in lodgepole pine, Engelmann spruce, subalpine fir, and aspen vegetation zones. It consists of about 45 percent Frisco gravelly sandy loam, 20 percent Peeler gravelly sandy loam, and 20 percent Hierro sandy loam, with the remaining 15 percent comprised of Cowdrey loam, Scout cobbly sandy loam, Cummulic Cryaquolls and Rock Outcrop soils.

Table 3. General soil association interpretation, eastern portion, Grand County, Colorado.

Soil Ass'n	Soil Series	Depth to Bedrock	Shrink-Swell Potential	Septic Tank Filter Field[b]	Sewage Lagoons[a]	Shallow Excavations[b]	Dwellings without Basements	Roads and Streets
1	Cimarron	40"	High	Sev.[1]	Slight	Sev.[2]	Sev.[3]	Sev.[3]
	Mayoworth	20-40"	High	Sev.[1,4]	Sev.[4]	Sev.[2,4]	Sev.[3]	Sev.[3]
	Hitchen	10-20"	High	Sev.[4]	Sev.[4,5]	Sev.[2,4]	Sev.[3,4]	Sev.[3,4]
2	Youga	40"	Moderate	Mod.[1]	Mod.[6]	Mod.[2]	Mod.[3]	Mod.[3]
	Woodhall	20-40"	Moderate	Sev.[4]	Sev.[5]	Sev.[4]	Mod.[3]	Mod.[4]
	Quander	40"	Low	Mod.[5]	Sev.[5]	Sev.[5]	Slight	Slight
3	Frisco	40"	Low	Mod.[5]	Sev.[5]	Sev.[5]	Slight	Slight
	Peeler	40"	Moderate	Mod.[1]	Mod.[6]	Mod.[5]	Mod.[3]	Mod.[3]
	Hierro	40"	Moderate	Mod.[1]	Mod.[6]	Mod.[5]	Mod.[3]	Mod.[3]
4	Scout	40"	Low	Slight	Sev.[6]	Sev.[5]	Slight	Slight
	Upson	20-40"	Low	Sev.[4]	Sev.[4,6]	Sev.[4]	Mod.[4]	Mod.[4]
	Grenadier	40"	Low	Slight	Sev.[5,6]	Sev.[5]	Slight	Slight
5	Gateway	20-40"	High	Sev.[4,1]	Sev.[4]	Sev.[2,4]	Sev.[3]	Sev.[3]
	Cowdrey	40"	High	Sev.[1]	Slight	Sev.[2]	Sev.[3]	Sev.[3]
6	Cryaquolls	40"	Low	Sev.[1]	Sev.[7]	Sev.[7]	Sev.[7]	Sev.[7]
	Handran	40"	Low	Slight	Sev.[5,6]	Sev.[5]	Slight	Slight

Source: U.S. Soil Conservation Service, Kremmling, Colorado   Preliminary Data: Subject to Change

[1] Slow permeability
[2] High clay content
[3] Shrink-swell potential
[4] Depth to bedrock
[5] Excess cobbles and stones
[6] Rapid permeability
[7] Flooding and depth to water table

Mod. = Moderate
Sev. = Severe

[a] Slopes not rated, use following as guide: 0-2% = Slight, 2-7% = Moderate; 7%+ = Severe
[b] Slopes not rated, use following as guide: 0-8% = Slight, 8-15% = Moderate; 15%+ = Severe

4. Scout--Upson--Grenadier. This association is composed of medium to strongly acid, moderately deep and deep, medium- and coarse-textured soils on mountain slopes and ridges. It occurs in about 20 percent of the survey area in the Fraser River Drainage northeast of Hideaway Park, north and west of Tabernash and in the Kawineeche Valley north of Shadow Mountain Reservoir. The association occurs on very steeply sloping mountainsides and ridges, over parent materials of glacial drift, highly weathered granitic rock and metamorphic gneisses, shists, and slate. The dominant vegetation consists of lodgepole pine, spruce, fir, and aspen. It is composed of 60 percent Scout gravelly sandy loam, 15 percent Upson sandy loam, and 10 percent Grenadier gravelly sandy loam. The remaining 15 percent of the association consists of Frisco-Peeler gravelly, sandy loam, Hierro sandy loam, and Rock Outcrop soils.

5. Gateway--Cowdrey. This association is composed of neutral to slightly acid, moderately deep and deep, fine-textured soils on mountain slopes, uplands and terraces. It occurs in approximately 20 percent of the study area on ridges and terraces over parent materials of Troublesome mudstone bedrock and glacial drift with dominant vegetation types of lodgepole pine and aspen. It is comprised of 45 percent Gateway loam and 35 percent Cowdrey loam with the remaining 20 percent consisting of the Frisco-Peeler soil complex.

6. Cryaquolls--Handran. This association is composed of neutral to slightly acid, shallow to deep, coarse- and fine-textured soils on alluvial terraces and floodplains. It occurs in about 10 percent of the study area along the major streams and rivers, on parent materials of alluvium and colluvium of mixed minerology. The dominant vegetation types are wheatgrass, bluegrass and other water tolerant grasses and sedges. About 60 percent of this association consists of Cummulic Cryaquolls, with 35 percent Handran gravelly loams. The remaining 5 percent of the association is comprised of Cimarron loam, Youga loam, and Quander cobbly loam soils.

Interpretation. Soils, like many other resource elements, display a continuum of attributes across the landscape. For this reason, the boundaries between soil mapping units may not represent an abrupt change in physical characteristics. The location of these boundaries is a somewhat subjective decision which is made by the soils field mapping specialist. These decisions are made based upon the scale of mapping, and generally reflect that the area contained within the boundaries of any mapped unit is at least 85 percent homogeneous and displays the described characteristics of that mapping unit.

Soils mapping, when displayed at a scale of 1:24,000 serves to delineate probable areas with general limitations and hazards as described by the detailed soil series interpretations. However, these series descriptions cannot, and should not, be used as the basis for decision-making for small areas of a hectare (2.471 acres) or less. The soil information should be used to indicate the occurrence and severity of limitations inherent to any soil unit. More detailed on-site investigations should be required based on the proposed land use to determine those limitations which have a direct bearing upon it.

Each of the 31 soil series which occur in the study area has certain inherent limitations. The list of these limitations is given in Table 4. These limitations have been grouped into two general categories: 1) health and safety limitations, and 2) economic and engineering limitations. The health and safety limitations are those which could have an effect upon surface and ground water quality in areas where individual wells and/or septic systems are used. The economic and engineering category includes the limitations which may cause structural damage to buildings and roads. Also included are those limitations which can be easily overcome through the use of special design and construction methods and increased financial investment. These soil limitations were incorporated into the study by including them in the typing for the soil classification and suitability matrix.

Table 4. Soil limitations incorporated in the use suitability matrix.

Subscript No.	Description of Limitation
	Health and Safety
5	Bedrock too close to the surface; may act as an impermeable barrier to effluent percolation.
6	Water erodes soil easily.
8	Soil temporarily flooded; septic systems inoperative during periods of flooding.
14	Water moves through soil too slowly; could allow surface ponding of effluent.
15	Water moves through soil too rapidly; ineffective filtration of effluent and possible ground water contamination.
17	Slope too great; percolating effluent may surface in short distance without proper filtration.
	Economic and Engineering
1	Borrow areas are difficult to reclaim
2	Decrease in soil volume is excessive under load.
3	Soil corrodes uncoated steel pipe.
4	Walls of cutbanks are not stable.
7	Excessive amounts of organic matter in soil.
9	Freeze-thaw actions can damage roads and structures.
10	Difficult to compact soil if removed.
11	Numerous rock fragments, 25.4 cm. (10 in.) or larger, in soil.
12	Soil has inadequate strength to support loads.
13	Too deep to ground water.
16	Soil expands when wet and shrinks when dry; may cause damage to structures.
18	Many rock fragments smaller than 25.4 cm. (10 in.) in soil.

Geologic Hazards and Mineral Resources

Importance. Geology is an important component of our environment. Since the overwhelming majority of man's activities are conducted upon the earth's surface, we are all affected by the existing geologic situation and geologic processes which are constantly changing our physical surroundings. These changes usually occur very slowly and imperceptibly, but sometimes they occur rapidly, and often with drastic and unpleasant results.

Man's activity and presence in an area transforms many natural geologic phenomena into geologic hazards which pose a threat to life and property. Consequently, a major concern in land use inventory is the identification of geologic hazards so that they can be avoided, controlled, or used in a manner which will not endanger human life and property. On the other hand, many geologic conditions and processes are highly beneficial to man, producing extensive mineral resources to meet his present and future needs. Thus, an additional concern in land use inventory is the identification of mineral resources so that they may be suitably and efficiently used.

Data Sources. Information for the identification of geologic hazards and mineral resources was obtained from: 1) published geologic literature; 2) published and open file geologic maps; 3) aerial photographs; 4) field investigations; and 5) personal consultation with geologists who have worked in the area.

Situation Description. Eastern Grand County has a wide variety of geologic hazards. Those hazards identified within the study area have been divided into two major categories: 1) existing hazards and 2) potential hazards.

"Existing" geologic hazards include those areas which show clear evidence of past failure, movement, or flooding, and which, due to natural geologic processes or disruption of the existing geology can be expected to change in the future. They include landslide and mudflow deposits, rockfall areas, zones of faulted and fractured rock, floodplains, and some alluvial fans.

"Potential" geologic hazards, on the other hand, include all other areas which do not show evidence of past failure, movement, or flooding, but which have the potential to change in the future, especially if the existing geologic situation or natural geologic processes are disturbed by man. Special emphasis in the study was placed upon potentially unstable slopes.

Many of these geologic hazards are found in great abundance. At least 80 landslides, over 30 individual rockfall areas, and numerous faults, mudflow deposits, and alluvial fans have been identified in the study area. Though floodplains and potentially unstable slopes cannot be counted individually, they run well into the thousands of hectares.

Though geologic hazards are found throughout the study area, most of them are concentrated in the mountains, where the terrain is steeper and more rugged. Floodplains and some alluvial fans are found in the lower elevations, but they are confined to the immediate area surrounding the Colorado and Fraser Rivers and some of their tributaries. On the other hand, many of the mountainous areas surrounding the study area are continually threatened by landslides, mudflows, and rockfalls. These hazards are not confined to any particular area, thus adding to the extent and severity of the problems encountered in mountainous areas.

The only known mineral resource of extractable quantities within the study area is naturally occurring aggregate, namely, sand and gravel. Mineral aggregate is an essential construction material. Great quantities are used in cement for foundations as well as in pavement for highways. Eastern Grand County has an abundant supply of excellent mineral aggregate. The meander plains of both the Colorado and Fraser Rivers and the valleys of many of their tributaries contain aggregate of varying amounts and quality in the form of alluvial and terrace deposits. These deposits are quite capable of meeting all of the present and likely future needs of the area.

Interpretation. Considering the number and extent of the geologic hazards in the study area, any development in mountainous areas should be limited and preceded by extensive geologic and engineering investigations. However, both the Granby and Fraser Basins are relatively free of geologic hazards, and based upon geologic criteria these areas encompass enough land to meet all of the development requirements of the county.

Most of the sources of mineral aggregate are located in the Granby and Fraser Basins, in close proximity to major transportation routes and in areas where extraction poses no major engineering problems. The supply of mineral aggregate is overwhelming, but many of the sources are located on prime developable land. It is therefore suggested that the majority of development in the basins be planned in those areas which are not also sources of mineral aggregate. However, since many companies are already extracting large quantities of sand and gravel from existing pits, sources of aggregate not yet mined may not be a limiting factor in land development. If development does occur in areas containing mineral aggregate of good to excellent quality, it is suggested that a portion of the area be designated as a source of aggregate to meet all of construction needs of the development.

Wildlife

Importance. Wildlife as a natural resource plays an important role in the east Grand County study area for three reasons. The most obvious is that it contributes to both aesthetics and recreation. The chance to view the wildlife that inhabit the area is a strong attractant for many summer tourists. Generally, glimpses of deer or elk or encounters with small animals such as birds and rodents greatly enhance a recreational experience.

A second reason why wildlife plays a significant role is that fall hunting expenditures are important in the economy of the County. Since equipment, food, and lodging payments bring supplementary income to residents of the County, the economic base is broadened by hunting activities. Nobe and Gilbert (1970) have estimated that hunting and fishing expenditures in 1968 for Grand County totalled $1,738,853. Deer hunting is nearly twice as important as all other big game hunting combined, while fishing expenditures account for over 60 percent of the total dollars spent (Nobe and Gilbert, 1970).

A third reason wildlife are valuable to the County stems from wildlife's role in ecological processes. Animal populations are organized in a vast system of environmental checks and balances. While man is most interested in big game and sport fishing species, predators, small mammals, and birds are also important if an ecological balance is to be maintained. Man's knowledge of ecological processes is still at an elementary stage. Linkages between segments of the system are often hidden, and an action that appears trivial may have far-reaching consequences to the ecological balance of the system.

While the inclusion of wildlife information in a resource inventory is clearly necessary and desirable, the accuracy of most wildlife data is highly suspect. Highway mortality figures for deer may be rather precise, but it is essentially impossible to count exactly the number of a species that exists in a large region. Beyond the problem of specific numbers is the problem of defining an area in which the population will always be found. It is possible to delineate general boundaries in which a herd may be found during the winter, but absolutes should be avoided if possible. Boundaries for a herd may change by as much as a mile depending on the prevailing winds during a heavy snowfall. Boundaries also change from year to year for no apparent reason (Wolfe, 1975).

However, since a map is the clearest way to demonstrate the area that is likely to be inhabited by a species such as deer or elk, boundaries have been drawn on the study area maps. A mapped area of general winter range is an area with a high statistical probability of having deer on it during the winter. It is an area where animals have been observed, and where required food, water, and cover are found.

Data Sources. Much of the data used in this project is the result of research that has been done during the last six years by the Colorado Division of Wildlife. The Division has been studying the deer and elk herds in the Middle Park area, a region that partially overlaps the study area. Division Researcher Laren Roper provided the general data for deer and elk. For deer, both general winter range and critical winter range were mapped, as were migration routes. These three factors are considered to be the limiting constraints on the deer population. General winter range is defined as that area used through all or most of the winter months. Critical winter range is defined as that area on which the herd will congregate during periods of heaviest snowfall. These areas generally have a southern exposure, are partially windswept, and have the necessary food, water, and cover. Deer typically use the same general path when they move down from their high country summer range to their winter range, and these paths have been identified and mapped as migration routes.

Only critical winter range was mapped for the elk populations. Elk are in general more free-ranging than deer and may not have definable general winter range. Laren Roper suggested that the elk stay in their summer range until the first major snow--only then do they head for their winter range. Depending on their location they may go to several different areas by various paths. Wildlife Conservation Officer Jerry Wolfe generally agreed with Roper's hypothesis, adding that only in circumstances where there are geographical or man-made barriers will elk develop an historical migration route. Therefore, neither general winter range nor migration routes were mapped for elk.

Data were also obtained from the U.S. Forest Service for the northern part of the study area. Several areas of general deer winter range were added, along with some areas that are thought to be used by elk as May-June calving grounds. These areas are typified as high south-facing benches with abundant water and cover being available.

The draft maps were prepared and then re-examined by Jerry Wolfe, and some boundary adjustments were made. The final maps are a product of consensus, and contain information on the location of the following features: elk critical winter range and calving areas, deer general and critical winter range, and deer migration routes.

Situation Description. The east Grand County study area is historically an area with an abundance of wildlife species. The construction of the Big Thompson Project in 1949 flooded large areas of land used both by area farmers and the resident wildlife, and since that time big game numbers have declined. Virtually all the wildlife in the study area are considered sub-climax species. They thrive in early and intermediate successionary vegetational complexes. Timber harvests on U.S. Forest Service lands have assured a moderate supply of early and intermediate vegetational stages, but other factors have begun to impinge on opportunities for wildlife. It is likely that only limited big game numbers will survive in the future. These animals will survive on the remnant winter range areas on public land.

The reason for this rather bleak projection is the large areas of land planned for development. Over 200 subdivisions are platted in the study area and more are anticipated as the recreation and second home industry enlarge. The developments themselves will result in an irretrievable and unavoidable loss of habitat, particularly of winter range. Summer range for most big game species is in high elevation areas and is predominantly federal land, so summer range will not be limiting. Winter range is in the lower elevations, and much of the suitable land is privately owned. Snowmobiles, high concentrations of people and automobiles, free running dogs, and a proliferation of roads will result in a significant reduction in both numbers and species of wildlife. Animals expected to remain are those that are tolerant to man and his activities, specifically rodents, birds, and coyotes.

At the present time there is a shrinking but still broad range of wildlife present. Table 5 lists the species of birds and large and small mammals the Division of Wildlife personnel have observed. Mountain lions have been reported, but not observed by Division personnel.

<u>Interpretation</u>. Sound land planning can do a great deal in reducing the impacts of man's activities on the wildlife in east Grand County. Generally stated, developments containing large numbers of people which

Table 5. Birds, small mammals, and large mammals observed in Grand County, Colorado.

BIRD SPECIES

Common Name	Scientific Name	Abundance
Vesper sparrow	Pooecetes gramineus	A*
Brewer's sparrow	Spizella breweri	C
Cassieus sparrow	Aimophila cassinii	R
Chipping sparrow	Spizella passerina	C
White-crowned sparrow	Zonotrichia leucophrys	O
Raven	Corvus corax	C
Common crow	Corvus brachyrynchos	C
Black-billed magpie	Pica pica	A
Bank swallow	Riparia riparia	C
Barn swallow	Hirundo rustica	C
Cliff swallow	Petrochelidon pyrrhonota	C
Rough-winged swallow	Stelgidopteryx ruficollis	C
Mountain bluebird	Sialia curricoides	C
Red-tailed hawk	Buteo jamaicensis	C
Swainson's hawk	Buteo swainsoni	O
Marsh hawk	Circus cyaneus	O
Goshawk	Accipiter gentilis	O
Sparrow hawk	Falco sparverius	C
Peregrine falcon	Falco peregrinus	R
Prairie falcon	Falco mexicanus	O
Common nighthawk	Chordeiles minor	C
Golden eagle	Aquila chrysaetos	C
Bald eagle	Haliaeetus leucocephalus	R
Horned lark	Eremophila alpestris	A
Red-winged blackbird	Agelaius phoeniceus	A
Yellow-headed blackbird	Xanthocephalus xanthocephalus	C
Green-tailed towhee	Chlorura chlorura	A
Red-shafted flicker	Colaptes cafer	C
Grey-headed junco	Junco caniceps	C
Western meadowlark	Sturnella neglecta	C
Mourning dove	Zenaidura macroura	C
Violet green swallow	Tachycineta thalassina	C
Robin	Turdus migratorius	C
Sage grouse	Centrocercus urophasianus	C
Blue grouse	Dendragapus obscurus	C
Brewer's blackbird	Euphagus cyanocephalus	A
Audubon's warbler	Dendroica auduboni	C
Hairy woodpecker	Dendrocopos villosus	C
Loggerhead shrike	Lanius ludovicianus	O
Wilson's phalarope	Steganopus tricolor	O
Killdeer	Charadrius vociferus	C
Common snipe	Capella gallinago	C
Dusky flycatcher	Empidonax oberholseri	O
Black-capped chickadee	Parus atricapillus	C
Common bushtit	Psaltriparus minimus	O

*R = rare; O = occasional; C = common; A = abundant

Table 5--cont.

BIRD SPECIES (cont.)

Common Name	Scientific Name	Abundance
Belted kingfisher	Megaceryle alcyon	O
Western tanager	Piranga ludoviciana	O
Yellow warbler	Dendroica petechia	O
Wilson's warbler	Wilsonia pusilla	R
Rock wren	Salpinctes obsoletus	C
Band-tailed pigeon	Columba fasciata	R
Mountain chickadee	Parus sclateri	C
Brown-headed cowbird	Molothrus ater	C
Poorwill	Phalaenoptilus nuttallii	C
Broad-tailed hummingbird	Selasphorus platycercus	C
Rufous hummingbird	Selasphorus rufus	C
Sage thrusher	Oreoscoptes montanus	C
Great blue heron	Ardea herodias	O
Clark's nutcracker	Nucifraga columbiana	C
Spotted sandpiper	Actitis macularia	O
Bullock's oriole	Icterus bullockii	R
MacGillivray's warbler	Oporornis tolmiei	R
House wren	Troglodytes aedon	C
Ruby-crowned kinglet	Regulus calendula	R
Traill's flycatcher	Empidonax traillii	R
Townsend's solitaire	Myadestes townsendi	O
Gray-crowned rosy finch	Leucosticte tephrocotis	C
Stellar's jay	Cyanocitta stelleri	C
Pine grosbeak	Pinicola enucleator	C
American goldfinch	Spinus tristis	O
Cassin's finch	Carpodacus cassinii	C
Western kingbird	Tyrannus verticalis	O
Eastern kingbird	Tyrannus tyrannus	R
Gray jay	Perisoreus canadensis	C
Pinon jay	Gymnorhinus cyanocephala	O
Downy woodpecker	Dendrocopos pubescens	C
Lark bunting	Calamospiza melanocorys	O
Great horned owl	Bubo virginianus	O
Screech owl	Otus asio	O
Burrowing owl	Speotyto cunicularia	R
Short-eared owl	Asio flammeus	O
Common grackle	Quiscalus quiscula	C
Mallard	Anas platyrhynchos	C
Green-winged teal	Anas carolinensis	C
Shoveler	Spatula clypeata	C
Coot	Fulica americana	C
Canada goose	Branta canadensis	R
Gadwall	Anas strepera	
Pintail	Anas acuta	

*R = rare; O = occasional; C = common; A = abundant

Table 5--cont.

SMALL MAMMALS

Common Name	Scientific Name	Abundance*
Mountain cottontail	Sylvilagus nuttallii	O
Richardson's ground squirrel	Spermophilus richardsonii	A
Golden-mantled ground squirrel	Spermophilus lateralis	C
Badger	Taxidea taxus	C
Colorado chipmunk	Eutamias quadrivittatus	A
Snowshoe hare	Lepus americanus	C
Meadow vole	Microtus pennsylvanicus	C
Coyote	Canis latrans	C
Red squirrel	Tamiasciurus hudsonicus	C
Muskrat	Ondatra zibethicus	O
Porcupine	Erethizon dorsatum	C
Spotted ground squirrel	Spermophilus spilosoma	R
Mountain vole	Microtus montanus	C
Beaver	Castor canadensis	O
Yellow-bellied marmot	Marmota flaviventris	C
Bobcat	Lynx rufus	O
White-tailed jackrabbit	Lepus townsendii	C
Red fox	Vulpes fulva	C
Gray wolf	Canis lupus	R
Longtail weasel	Mustela frenata	C
Striped skunk	Mephitis mephitis	A
Raccoon	Procyon lotor	C
Mink	Mustela vison	C
Bushytail woodrat	Neotoma cinerea	C
Deer mouse	Peromyscus maniculatus	A

*R = rare; O = occasional; C = common; A = abundant

LARGE MAMMALS

Common Name	Scientific Name	Abundance*
Black bear	Euarctos americanus	C
Mule deer	Odocoileus hemionus hemionus	A
Rocky Mountain elk	Cervus canadensis	A
Pronghorn	Antilocapra americana	R

* R = rare; O = occasional; C = common; A = abundant

destroy or alter large quantities of wildlife habitat, particularly critical areas, inflict the most damage to wildlife population. As development intensity increases, the damage to wildlife also increases. However, concentration of human populations will have less effect on wildlife if that concentration is placed in areas that have little or no value to wildlife.

Since the most critical areas to the big game species have been mapped, we know where development should be avoided. In the land allocation phase of this project no land necessary for wildlife was consumed by developments under any of the scenarios. Theoretically, there would be no impact on the wildlife populations. Even if areas of critical winter range have been consumed, the absolute effect on a herd using that range is not well known. For example, if 20 percent of the critical winter range for a deer herd is used by man, it is not clear that the herd will decrease by 20 percent. The effect of the habitat loss may not become apparent until a particularly severe winter occurs. Usually even if the herd decreases by 20 percent, we do not know if the animals have actually died or if they have selected a new habitat area that fulfills their requirements. However, it may be generally stated that as critical areas are consumed, greater pressure may result in a lowering of forage quality in the suitable area. The lowered quality will then affect the entire herd, reducing the herd's visibility and survival potential during periods of increased stress.

Habitat destruction has a negative primary effect, but there are also secondary or peripheral effects around the primary impact area. In areas with rather low density development the basic wildlife requirements may be provided, but the site may no longer be suitable for a variety of reasons. A lack of accessibility into and through the area due to roads, fences, or buildings is one reason. Dogs and cats roaming the area will also discourage wildlife. Noise, a by-product of almost all human land use activities, is likely to have a significant negative impact on wildlife. Chemicals are also commonly used in many land use activities. Herbicides, fertilizers, and pesticides all impact on wildlife, but often in ways that do not become apparent for years.

Reallocation of water and the draining of wet meadows and marshes are also extremely damaging to wildlife. Clearing and grading of land areas have similar impacts by completely removing large areas of habitat from wildlife use. If the animal populations are to be protected, the above land uses need to be carefully regulated.

Wildfire

Importance. Fire hazard in wildland areas is becoming more intense because developments in adjacent areas are occurring without proper consideration of dangerous wildfire situations and without provision for adequate fire protection. Fires are increasingly a threat not only to valuable natural resources but also to human lives and facilities adjacent to wildland areas.

When human activities are combined with flammable vegetation, rugged terrain, and seasonal dry spells, dangerous fire situations are created. Fire is a potential hazard in the total study area, but the severity of the hazard can be increased or reduced depending upon the decisions that are made regarding location of development and the protective measures to be provided. There are varying degrees of fire hazard in different areas, necessitating varying levels of safety and preventive measures.

Hazard severity increases on steep slopes and in dense plant growth. Dense stands of coniferous forest and brush lands are most hazardous, particularly in rugged terrain. A fire burning in such fuels can spread rapidly through the tree crowns, destroying everything in its path. Fields of dense, dry grass are hazardous since fire can spread extremely fast through these fine fuels. But because grass fires are usually less difficult to control due to lower fuel volume, the hazard is not as severe as in densely forested areas. Fire danger in stands of deciduous trees is not as critical because they are generally more fire resistant.

A fire spreads much faster on sloping terrain than on level ground. Any increase in slope steepness results in a proportionately greater increase in the rate of fire spread. Therefore, fire hazard in any type of vegetation is much greater on steeper slopes. Fire danger is especially severe in narrow valleys and steeper draws or ravines with dense vegetation. Because of strong winds which may be funneled through these areas, they can act as "fire chimneys" and draw a fire upslope at an extremely rapid rate.

When a fire burns a home or other facility in a rural area, the structure is likely to be destroyed unless the landowner can extinguish the blaze himself. In rural counties, volunteer fire departments usually have a longer response time due to personnel dispersion and poor access to remote tracts of land.

Improved fire fighting forces alone will not assure protection. Development must incorporate precautionary measures that will alleviate serious fire hazard conditions. Once hazardous situations are allowed to develop, they may be beyond practical correction.

Data Source. The primary source for wildfire hazard data in Colorado is the Colorado State Forest Service. The C.S.F.S. is responsible for identifying and mapping wildfire hazard areas in Colorado. Wildfire mapping in eastern Grand County had been completed by the C.S.F.S., except in the

Bottle Pass area. For the Bottle Pass area, the Guidelines and Criteria for Wildfire Hazard Areas were followed and a wildfire hazard map was generated.

Situation Description. Land ownership patterns in the study area are a cause of some concern to fire fighting officials. Large amounts of publicly owned lands, intermingled with privately owned lands and numerous small communities, form a complicated land ownership pattern in many parts of the County. In many areas, these privately owned lands are being subdivided. These intermingled private lands and communities constitute sources of fire risk, with the subsequent potential for serious loss of life and property.

Mountain pine beetles are a new cause of concern for fire fighting officials. Large areas of lodgepole pine are being attacked leaving pockets of standing dead trees. As the attack continues, the numbers of these fire prone trees will increase, thus heightening chances of wildfire.

In the past wildfires have been small and few. Fire history of the area shows the average number of fires to be two per year. Man-caused fires account for three out of four fires and are usually less than one acre in size. These occur mostly along roads or in campgrounds. Sixty percent of these fires are caused by transients passing through the area. Although history shows that the majority of fires are small, potential exists in many remote and heavily fueled areas for severe wildfire problems (Hot Sulphur District Management Plan, Arapahoe National Forest, 1974).

Interpretation. The potential for destruction of natural resources by fires burning in a developed area can be kept to an acceptable level. By examining the factors which determine fire behavior, areas can be identified and classified according to the varying severity of wildfire hazard. Conditions can be specified under which land areas in each hazard class may be safely developed and used. Hazard can be reduced by implementation of fire safety precautions with regard to site design, building density, construction of streets and roads, provision of adequate water supplies, and fuel reduction measures (Lautenbach, et al., 1974).

Ecosystems were given fire danger ratings by examining fuel composition, density, and the percent slope upon which they occur. Five ratings, 0, A, B, C, and X, were applied to the area during the study. 0 standing for No Hazard, A for Low, B for Medium, C and X for Severe Burning Ability. C and X are differentiated by the types of fuels composing each group. Based on these ratings the mountain dry (irrigated hayland), bog, aspen, riparian, and wet meadows were classed as low severity. Sagebrush and juniper were classified as moderate fire danger and spruce-fir and lodgepole were classified as severe.

Avalanche

Importance. Each year thousands of avalanches occur in the high mountains of Colorado. Most of these avalanches are unseen and unheard simply because they occur in areas which are remote and uninhabited. Each year development pushes further into these remote areas which may eventually result in loss of life and property by avalanches. In high mountain counties like Grand County, identification and mapping of avalanche paths is a necessity in land use planning.

Avalanche paths are not always obvious to an untrained observer. If an avalanche has not run in many years, it is probable that vegetation will have moved back into the slide area. However, a trained observer is usually able to spot these areas by recognizing such clues as a significant change in vegetation type and age as compared with the vegetation found on adjacent undisturbed slopes.

In Grand County large avalanches occur only occasionally at elevations below 8,500 feet. Due to less snowfall and higher temperatures, the danger in these lower elevations is from small snowslides and sluffs during periods of heavy snow accumulation. At these lower elevations, potential slide areas are mainly found on slopes with north and east aspects where the snow accumulates faster and stays longer because of reduced solar exposure. Potential avalanche areas can also exist in areas of steep cliffs or densely forested slopes.

A potential avalanche hazard exists when several conditions are present. First, the mountain slopes must be steep enough to cause the snow to slide under the force of gravity (greater than 45 percent). A relatively smooth sliding surface must also exist between two snow layers or under the snow cover. In addition, the snow must have been deposited on the slope in a manner and to a depth which will result in sliding. The snowfall intensity, the density of the snow, the settlement of the snow, the temperature, and the presence of wind all influence avalanches. Lastly, some event must trigger or release the mass of snow from its resting place. This can be a sudden rise in temperature, snow falling from overhanging rocks or trees, or by the presence of a person in the avalanche area (Lynch, 1974). A complete identification procedure for potential avalanches may be found in the Colorado State Geological Survey Special Publication No. 6, 1974.

Data Source. Avalanche study is a relatively new field in the United States. The best records are to be found in areas where avalanches have occurred along highly traveled routes or in populated areas where life or property has been lost. Data sources on other avalanche areas is almost nonexistent. The best source of avalanche information for the more remote areas are the people who live or work in the area of concern. These people may include local residents, the U.S. Forest Service snow rangers, and local highway departments. These sources combined with potential areas identified by slope were used to delineate avalanche hazards.

Situation Description. There are no existing avalanche paths affecting private land within the study area and all slopes over 45 percent were classified as potential avalanche areas. The steep slope areas are mostly high in the mountains and away from private lands.

Avalanches are always possible when the conditions are right. In our definition of potential avalanches we stated that the slopes had to be greater than 45 percent. All such areas were excluded from development when compositing resources under different developmental scenarios. If there had been any known avalanches affecting private land in the county, these areas would also have been excluded from development.

Interpretation. Most of the private lands in the study area are in valley bottoms and free of avalanche potential. Where slopes were found over 45 percent, avalanche hazard was judged high and the lands classified as unsuitable for development.

Visual Vulnerability

Importance. The visual resource is one of the primary tourist attractants of eastern Grand County. Management of the scenic resources is important since the mountain scenery is important both as a tourist attractant and as an intrinsic attribute of the community. The visual quality creates an immediate impression on any person entering the area and is an important factor contributing to the region's quality of life.

U.S. Forest Service and National Park Service lands form the backdrops for many of the scenic vistas. The county also has several large bodies of water. Unplanned and unregulated developments are presently strewn along the shores of the lakes, degrading the visual environment. This degradation could threaten the economic base of the study area, since the scenic opportunities are a major factor that attract both visitors and residents.

While it is difficult to measure the exact visual and aesthetic quality of a view or an area, it is possible to measure the disruption potential that exists. Some areas, such as flat shorelines, ridgetops, or steeply sloping areas with low vegetation, are highly vulnerable, visually, to any type of structural development. Almost any land use change in such areas is likely to damage the visual experience as perceived by a viewer.

The primary purpose of this section is to delineate areas where land use changes have a high, moderate, or low effect on the visual resource. By delineating these areas, it is easier to judge the impacts that development may have in different areas of the County. The role of the land planner is then one of guiding developments away from high impact areas whenever possible.

Visual vulnerability is defined as the ability of a site or landscape to visually absorb or screen structures, land use modifications, or alterations of the vegetation (Lautenbach, et al., 1974). Private lands within the study area have been classified into three vulnerability categories--high, moderate, and low.

Data Source. Several methods are available for classifying the landscape into visual vulnerability categories. The method used in this project is easy to implement being based solely on slope and vegetation type. Six vegetation complexes were identified in this project as ecosystem indicators, and three slope classes were combined with the vegetation types in a decision matrix. An example of a decision matrix is presented on the following page.

Table 6. A visual vulnerability matrix.

Slope	Vegetation					
	Sage-brush	Dry Meadow	Water-courses	Conifers	Deciduous	Bog/Wet Meadows
30% and above	High	High	High	High	High	N/A
10 to 30%	High	High	High	Moderate	Moderate	N/A
0 to 10%	Moderate	High	High	Low	Low	High

This particular matrix was used when the visual resource received a high weighting under a particular land use scenario. For scenarios in which the visual resource received a lower weight the matrix was constructed under less rigid constraints. Only the watercourses maintained their High rating in all scenarios. This emphasis on the preservation of riparian vegetation and associated visual opportunities is supported by Litton's findings that any recreational opportunity is enhanced by the presence of water (Litton, 1971).

When the matrix was constructed with less rigid constraints, the matrix shifted toward more of the cells being Low or Moderate in their rating. Theoretically, if the visual resource received a weight of one, the decision matrix would assign Low Visual Vulnerability ratings to all slope and vegetation combinations.

Situation Description. The private lands in the study area are generally those that would be considered the most valuable for agricultural or residential use. The BLM and the Forest Service own much of the steeply sloping sagebrush or forested areas. Private holdings include both the bottom lands where irrigated agriculture is possible and the grazing lands up the hillsides from the valley bottoms. In addition, much of the land adjacent to the west side of the Three Lakes area is privately owned.

The visual vulnerability analysis places most agricultural land in the High Vulnerability category. The irrigated hay meadows and the sagebrush-covered hillsides have very poor vegetational screening. Hence, on the basis of a visual intrusion criterion, development would be steered away from these lands. The forested private lands higher on the hillsides or in areas with flatter contours and greater moisture would generally receive lower vulnerability ratings.

Interpretation. High Visual Vulnerability applies to lands with a low visual absorption capacity. Development of these lands will cause changes that are highly visual to the viewer. An example of such an area would be either a meadow or a steep slope (greater than 30 percent) covered with low vegetation such as sagebrush. Both areas lack the capacity to screen any changes that occur. Flat areas with low vegetation are often pleasing visually, but are highly sensitive. A viewer's eye will be drawn to any object or structure that breaks the floor-like lack of contour. Similarly, any object or structure on a steep slope or ridgetop will also attract a viewer's attention. Building a road or structure on a steep slope requires extensive site modification, and large amounts of vegetation are necessarily removed in the process. The problem is accentuated by the long time periods required to revegetate steep slopes in semi-arid mountain areas. The visual scars caused by erosion before revegetation is complete are also a problem. Therefore, lands in the High Visual Vulnerability category probably should be prohibited from land uses requiring structural development. They are suitable, however, for activities such as low intensity recreational use.

Moderate Visual Vulnerability includes those lands that are capable of absorbing structures, land use changes, and vegetation alterations without excessive visual change. These areas still require careful visual management. Examples of such areas include an aspen or a conifer stand on a moderate slope. Both areas have the ability to partially screen structures or land use changes if the vegetation is carefully preserved. If site designs make the best use of the screening vegetation, low density structures can be constructed with only a minimal impact on viewers. The Moderate Visual Vulnerability category is restrictive to land uses requiring intense structural development. It is best suited for low intensity development such as large-lot residences or second homes. In these areas, visual regulations and review procedures might limit the use of bright colors, excessive height, or high contrasts to the surrounding visual environment.

Low Visual Vulnerability includes the remaining lands which can visually accommodate more intensive levels of development and modification. Height, contrast, and color of the structures are still important if the landscape qualities are to be maintained. An example of this category is a conifer stand in an area of zero to ten percent slope. Conifers are excellent screening vegetation, so this area could absorb large numbers of structures with few of them being visible either to other residents in the development or to a viewer from a road or hiking trail. Only simple review procedures are necessary for this visual vulnerability category.

On the basis of these descriptions of the three Visual Vulnerability classes, it should be possible to judge the visual impact that proposed developments might have on different areas of the county. When the visual environment is important to the welfare of an area's citizens, as it is in

Grand County, visual vulnerability ratings may be useful to identify areas where restriction needs to be placed on development. Both maintenance of the existing visual environment and means to mitigate visual intrusion are important in such areas.

Hydrology

Importance. Consideration of the effects or urbanization or other development upon the hydrology of an area is especially important in mountainous regions. Of particular concern are those factors which produce changes in peak flow characteristics, changes in total runoff, and changes in the quality of water (Leopold, 1968). In addition, surface and ground water availability can become constraints upon future developments. Consideration of hydrologic changes is considered in a later section of this report which deals with impacts. Surface and ground water availability is considered here.

Data Source. Data for assessing the surface and ground water availability were obtained from the Office of the Colorado State Engineer.

Situation Description. There are presently large amounts of original and supplemental appropriations of agricultural water rights (surface) within the study area. A total of 17.08 cubic meters per second (603 cubic feet per second) is allocated from the Fraser River, 12.6 c.m.s. (445 c.f.s.) from the Colorado River, and 2.77 c.m.s. (98 c.f.s.) from Willow Creek (Colorado State Engineer, 1969).

Colorado's system of water law presently allows the purchase, transfer, and in some cases condemnation of agricultural water rights for domestic and municipal purposes. Depending upon demand, certain portions of these rights could thus be converted for human uses. These allocated flow rights are equivalent to 2.8 billion liters per day (740.6 million gallons per day). Assuming a consumptive demand of 140 liters (37 gallons) per capita per day (Stoltenberg, 1970), this amount is sufficient to support a population in excess of 20 million persons. Clearly, water supply is not presently a limiting factor to development of the study area.

In 1965 a ground water resource reconnaissance study was completed in the Grand County area by the U.S. Geological Survey (Voegeli, 1965). This survey concluded that the main sources of ground water supply were from the glacial and alluvial sediments which occurred in the Middle Park area. Voegeli also concluded that the geologic conditions necessary for water production from large capacity wells do not generally exist in Grand County, but that doubling or tripling the number of small wells in the alluvial aquifers should have no adverse effect upon the wells already in use.

A survey of the well log records contained in the Voegeli report, and more recent records from the Colorado State Engineer's office, indicate that bedrock aquifers which may exist have not been identified or evaluated for potential water yields.

Interpretation. Analysis of the hydrologic resource did not suggest significant quantity limitations in the Grand County area. However, the critical water sources which must be protected were not identified. Nevertheless, the usual methods of well construction and development density controls should be sufficient to protect the wells located in alluvial sediments from contamination.

Air Quality

Importance. Airshed resources are important in terms of their ability to assimilate residuals. Residuals resulting from industrial, recreational, and residential activities within the region are managed by infrastructure elements such as air emission controls. The characteristics of the environmental media and state and federal standards determine the extent to which the airsheds may be relied upon to absorb these residuals. Grand County is an area where clean air is of major concern to its important tourist industry. The influence of air quality on tourist activities and the influence of the activities themselves on air quality, may ultimately determine the region's carrying capacity.

Data Source. Both topography and meteorology are important considerations for air pollution potential; air circulation follows the topography of watersheds. Conditions of temperature inversions and wind direction and magnitude are of particular concern; shallow mixing depths and light winds present the highest air pollution potential. Such meteorological data are limited for Grand County, as conventional analysis procedures used in the evaluation of potential air quality and air pollution carrying capacity of airsheds requires intensive field studies. The process followed for the incorporation of air quality into the carrying capacity model was to establish the ambient (background) air quality in the study area and then calculate the "carrying capacity" of the area using state standards as limiting criteria. Both state and federal air quality standards are listed in Table 7.

As previously noted, air quality data for the study area are essentially nonexistent. The Colorado Department of Health, charged with collecting air pollution data, did not have any for the study area. The only data gathered were obtained from the Colorado Division of Highways which studied the situation at Fraser for preparation of an Environmental Impact Statement undertaken in 1974. Air samples were taken at seven locations along U.S. 40; pollution was well below current Colorado State Standards.

Table 7. Federal and Colorado air quality standards.

Pollutant	Type of Standard	Time Interval	Effective Year	Concentration ug/m³	Concentration PPM
Carbon Monoxide	Federal Primary & Secondary	1 hour	1977	40,000	35
		8 hour	1977	10,000	9
Hydrocarbons (non-methane)	Federal Primary & Secondary	3 hour (6-9 a.m. only)	(see ozone)	160	0.24
Nitrogen Dioxide	Federal Primary & Secondary	1 year (arith.)	(undetermined)	100	0.05
Ozone (Oxidants)	Federal Primary & Secondary	1 hour	1977	160	0.08
Sulfur Dioxide	Federal Primary	24 hour	1975	365	0.14
		1 year (arith.)	1975	80	0.03
	Secondary	3 hour	1975	1,300	0.5
	State Non-Designated areas	24 hour	1970	15	0.005
	Designated	1 hour	1973	800	0.28
			1976	300	0.10
		24 hour	1973	300	0.10
			1976	150	0.05
			1980	55	0.02
		1 year (arith.)	1973	60	0.02
			1976	25	0.009
			1980	10	0.004
Particulates	Federal Primary	24 hour	1975	260	--
		1 year (geo.)	1975	75	--
	Secondary	24 hour	1975	150	--
		1 year (geo.)	1975	60	--
	State Non-Designated areas	24 hour	1970	150	--
		1 year (arith.)	1970	45	--
	Designated	24 hour	1973	200	--
			1976	180	--
			1980	150	--
		1 year (arith.)	1973	70	--
			1976	55	--
			1980	45	--

The lack of data prompts the use of modeling to determine air pollution potential. Such models have been developed at the Rocky Mountain Forest and Range Experiment Station (Marlatt, 1974). Using hypothetical pollution sources, at "worst case" levels a Gaussian dispersion model is used to map generalized air pollution potential. These maps provide an estimate of the carrying capacity of the study area for air pollution. This model, because of its inherent limitations, should only be used to flag areas which have a high likelihood of air pollution. Lack of accurate mountain wind field and temperature gradient data forces assumptions to be made for these variables in the model.

Situation Description. Areas of Grand County have the following air pollution potentials for south and north wind conditions: Grand Lake--severe and high; Granby--moderate and high; Tabernash--high and severe; Fraser--low and high; Hideaway Park--low and low; Winter Park--low and low; Berthoud Pass--low and low. In calculating specific pollution levels for these areas, data on automobile emission levels need to be adjusted for high altitude. Table 8 shows comparative data for automobile emissions at high and low altitudes. Emissions from wigwam-tepee burners are also important in Grand County. Emission factors for these burners are in Table 9.

Interpretation. With information on air pollution potential, decisions. regarding the safe location (within established standards) of developments can be made. In addition to the constraint of established standards, air-shed carrying capacity may be constrained by both health and social criteria. The spectrum of health responses to pollution exposure are shown in Figure 8. Also, one must realize that before health effects are obvious or air quality standards are violated, people may complain about air pollution.

Table 8. Carbon monoxide, hydrocarbon, and nitrogen oxide emission factors for light-duty vehicles at low and high altitude.

EMISSION FACTOR RATING: A

Location and pollutant	Exhaust emission factors at low mileage per model year[a]								
	Pre 1968	1968	1969	1970	1971	1972[b]	1973 through 1974[b]	1975	Post 1975
Low altitude (excluding Calif.)									
Carbon monoxide									
g/mi	87	46	39	36	34	19	19	1.8	1.8
g/km	54	29	24	22	21	12	12	1.1	1.1
Exhaust hydrocarbons									
g/mi	8.8	4.5	4.4	3.6	2.9	2.7	2.7	0.23	0.23
g/km	5.5	2.8	2.7	2.2	1.8	1.7	1.7	0.14	0.14
Nitrogen oxides									
g/mi	3.6	4.3	5.5	5.1	4.8	4.8	2.3	2.3	0.31
g/km	2.2	2.7	3.4	3.2	3.0	3.0	1.4	1.4	0.19
High altitude (excluding Calif.)									
Carbon monoxide									
g/mi	130	74	48	72	75	42	42	1.8	1.8
g/km	81	46	30	45	47	26	26	1.1	1.1
Exhaust hydrocarbons									
g/mi	10	6.0	5.4	6.1	5.3	4.9	4.9	0.23	0.23
g/km	6.2	3.7	3.4	3.8	3.3	3.0	3.0	0.14	0.14
Nitrogen oxides									
g/mi	1.9	2.2	2.6	2.8	3.1	3.1	1.4	1.4	0.31
g/km	1.2	1.4	1.6	1.7	1.9	1.9	0.87	0.87	0.19

[a]Pre-1968 results are not at low mileage but are arithmetic means of tests of a random sample of vehicles. There is no reason to present low mileage emission rates for pre-1968 vehicles because they are not subject to exhaust control device deterioration.

[b]Estimates based on the relationship of low mileage emissions to standards for 1971 and earlier controlled vehicles.

Source: Environmental Protection Agency. Air Pollutant Emission Factors.

Table 9. Emission factors for wood and bark waste combustion in boilers.

EMISSION FACTOR RATING: B		
Pollutant	Emissions lb/ton	Emissions kg/MT
Particulates		
Bark		
With fly-ash reinjection	75 (15)	37.5 (8.5)
Without fly-ash reinjection	50	25
Wood/bark mixture		
With fly-ash reinjection	45 (9)	22.5 (4.5)
Without fly-ash reinjection	30	15
Wood	5-15	2.5-7.5
Sulfur oxides (SO_2)	1.5	0.75
Carbon monoxide	2-60	1-30
Hydrocarbons	2-70	1-35
Nitrogen oxides (NO_2)	10	5

Source: Environmental Protection Agency. Air Pollutant Emission Factors.

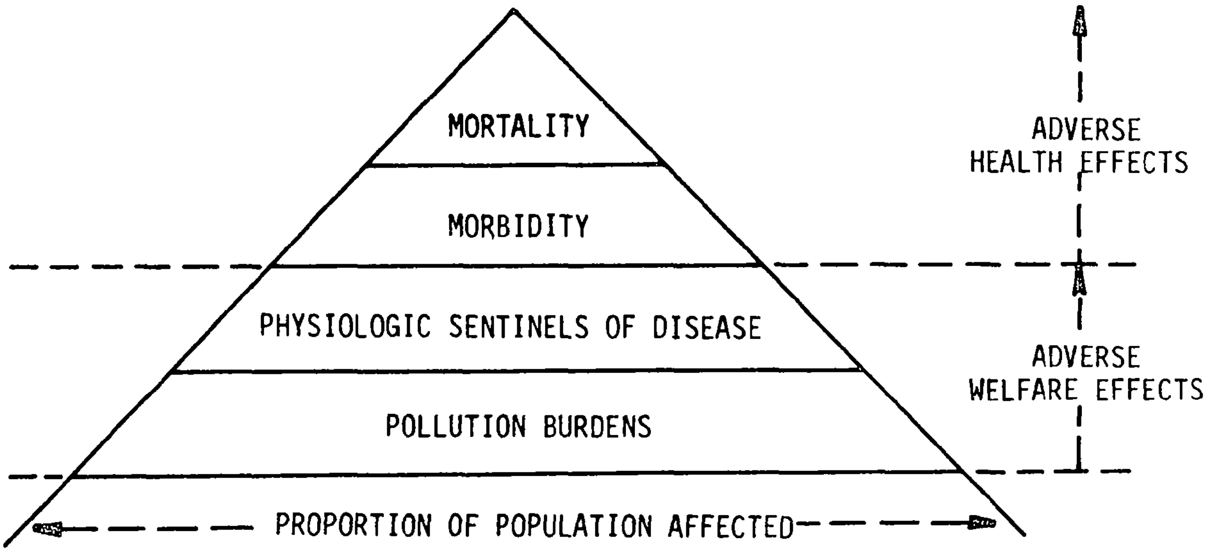


Figure 8. Spectrum of responses to pollutant exposure.

Source: Berry, 1974

Water Quality

Importance. Water, like air, is important in terms of its absorptive capacity for residuals. Residuals from human activities which are deposited in waters are dealt with by infrastructure elements. The characteristics of the environmental media, state and federal standards, and laws and ordinances determine the extent to which the waters of Grand County may be relied upon to absorb these residuals. Colorado has a non-degradation clause in its water quality standards and, therefore, maintenance of present water quality levels is important. Additionally, Grand County is an area where clean water is of major concern to its tourist industry. The influence of water quality on tourist activities, and the influence of the activities themselves on water quality, may ultimately determine the area's carrying capacity.

Data Sources. The procedure was to collect data on existing water quality in the study area and contrast this with the Colorado Water Quality Standards to determine if surplus assimilative capacity exists. These standards may be found in Table 10. Data for the study area were collected using EPA's water quality information storage and retrieval system STORET and published reports on the waters of Grand County.

Situation Description. Intensive water quality studies have been undertaken by the EPA to develop additional information for use in a water quality management strategy proposed by the Three Lakes Sanitation District. Grand Lake, Shadow Mountain Lake and Lake Granby are all classified A_1 waters according to Colorado's Water Quality Control Commission Standards. This classification suggests that there may be considerable room for residual absorption in this area.

For other areas of the County, water quality data are insufficient to estimate absorption potential.

Table 10. Colorado water quality standards summary.

STANDARD	CLASS A_1	CLASS A_2	CLASS B_1	CLASS B_2
Settleable Solids	Essentially Free	Essentially Free	Essentially Free	Essentially Free
Floating Solids	Essentially Free	Essentially Free	Essentially Free	Essentially Free
Taste, Odor, Color	Essentially Free	Essentially Free	Essentially Free	Essentially Free
Toxic Materials	Essentially Free	Essentially Free	Essentially Free	Essentially Free
Oil and Grease	Maximum - 10 mg/l	Maximum - 10 mg/l	Maximum - 10 mg/l	Maximum - 10 mg/l
Radioactive Material	Drinking Water Standards	Drinking Water Standards	Drinking Water Standards	Drinking Water Standards
Salinity	At or below present levels.	At or below present levels.	At or below present levels.	At or below present levels.
Fecal Coliform Bacteria	Geometric Mean of <200/100ml from five samples in 30-day per.	Geometric Mean of <200/100ml from five samples in 30-day per.	Geometric Mean of <1000/100ml from five samples in 30-day per.	Geometric Mean of <1000/100ml from five samples in 30-day per.
Turbidity	No increase of more than 10 J.T.U.	No increase of more than 10 J.T.U.	No increase of more than 10 J.T.U.	No increase of more than 25 J.T.U.
Dissolved Oxygen	6 mg/l minimum	5 mg/l minumum	6 mg/l minimum	5 mg/l minimum
Total Dissolved Gas Pressure	Maximum of 110% of atmospheric pressure	---	Maximum of 110% of atmospheric pressure	---
pH	6.5 - 8.3	6.5 - 8.3	6.0 - 9.0	6.0 - 9.0
Temperature	Maximum 68°F. Maximum Change 2°F.	Maximum 90°F. Maximum Change: Streams - 5°F. Lakes - 3°F.	Maximum 68°F. Maximum Change 2°F.	Maximum 90°F. Maximum Change: Streams - 5°F. Lakes - 3°F.
Phosphorus as P	Streams - max. 100 ug/l Lakes - max. 50 ug/l	Streams - max. 100 ug/l Lakes - max. 50 ug/l	Streams - max. 100 ug/l Lakes - max. 50 ug/l	Streams - max. 100 ug/l Lakes - max. 50 ug/l

Interpretation. Because little is known about the water quality situation in Grand County, definitive statements about residuals absorptive capacity cannot be made. Therefore, it seems prudent to proceed with development cautiously. Colorado's non-degradation clause may limit the residual input into water bodies.

Public Opinion Analysis

The public opinion analysis was based on the idea that planning can not be done in a social vacuum. Two common reasons for the failure of land use plans are: 1) plans often are not founded upon the needs and desires of most citizens, and 2) they often do not adequately take account of political realities. Consequently, if plans are to be successful they cannot be merely idealistic notions of the planner in charge. They must instead personify the values and preferences of the planner's constituents. The Grand County planning team did not seek the approval of the public regarding a specific plan, but attempted to involve the residents as much as possible in the total planning process, beginning with the formulation of relevant alternative futures.

In this study, both systematic and relatively unsystematic approaches were utilized as a means of obtaining public opinion. Unsystematic assessment was obtained by reading local newspapers and various County reports, attending public meetings, and talking with County residents. Opinions were also solicited from nonresident land holders and federal land managers. The analytical portion of the study involved three major activities. A survey of government officials was conducted through personal interviews, and two questionnaire surveys were administered to the resident population. Through this involvement the public became an active participant in the planning process.

Government Official Survey

Method. Political realities and the identification of power structures within the planning boundaries have often been omitted in the planning process. In order to avert possible conflicts and disapproval in latter stages, government officials were interviewed as the first step in assessing public opinion. The government officials survey was done on a relatively informal basis. Officials were interviewed either at their office or in their home. The average interview lasted 45 minutes. In general, the purpose of the survey was to gather information about planning efforts, growth forces, and political issues within the County. There were a number of predetermined questions, but the officials were also encouraged to verbalize their own perceptions of major issues confronting the County. A few of the most consistently asked questions were:

1) Would you favor expansion of the industry?

2) Would you like to see more/less subdivision development?

3) Do you feel that growth will jeopardize the quality of the physical and/or social environment?

4) Do you favor such developments as Bowen Mountain Ski Area, Val Moritz Second Home Development, Rocky Mountain National Park Wilderness Area, Three Lakes Recreation District?

5) Do you want more mining and timbering in the County?

6) What do you think are appropriate measures of control the government should incorporate in land use plans (i.e., master plan, transferrable development rights, zoning, etc.)?

7) What is your reaction to HB 1041 (the Colorado land use act)?

8) How do you feel about the presence of different federal agencies in the County such as the Park Service, Environmental Protection Agency, Bureau of Land Management, and Forest Service?

9) What do you think are the major land use issues confronting the County?

Situation Description. The resource and economic analyses of the Grand County project only include the eastern portion of the County. However, it was believed that when dealing with social, especially political, factors, the entire County needed to be included in the analysis.

A comprehensive analysis is particularly necessary in an area such as Grand County, due to the different economic conditions which almost literally divide the County in half. In the eastern portion of the County, the residents are primarily dependent upon the tourist and recreation industry for their livelihood. In the western sector, agriculture, timbering, and mining form the economic base of the area. It was thus necessary to determine what policy conflicts, if any, would arise from this economic division. For instance, would the western government officials favor an increase in the lumber and mining industries in contrast to eastern officials who might view this expansion as a deterrent to the tourist industry? Or would the eastern officials want to establish a policy of zoning prime agriculture land as a means of retaining the aesthetic qualities of the County, and if so, would this policy conflict with western goals? Thus, the government officials survey focused on two questions: 1) what are the major land use and political issues before the County, and 2) what are the issues resulting in either conflict or agreement?

The following general-interest issues became apparent as the interviews progressed: 1) population growth and development, 2) land use controls, 3) government, and 4) aesthetics. Although these issues may be interrelated, for the purposes of analysis they are discussed separately.

The extent of population growth and development will depend largely on the role of tourism and business opportunities in the County. There was no distinct consensus concerning the extent to which tourism should be encouraged. However, in the west side of the County the officials agreed that they preferred to have tourist development in the east section. Specific issues presently before the County include: 1) Bowen Mountain Ski Area, 2) Rocky Mountain National Park Wilderness Area, 3) Metropolitan Recreation District (which would provide a golf course and swimming pool for Fraser residents), 4) Three Lakes Recreation District, and 5) development of recreation sites on private land.

Regarding business opportunities other than tourism, most people were in favor of expanding these opportunities. Except in Grand Lake, there was much concern for establishing a stable, year-round economy. Specifically, there was almost total agreement that County officials should encourage light industries to settle in the County (at this point not a very realistic option). Other possibilities being considered by the officials were increased mining and timbering activities. It is recognized that along with population growth there will be a need for more housing. However, there is a difference of opinion whether to expand existing communities or develop new ones. This difference was not a function of the official's location. There also appeared to be a general consensus for new subdivision construction, providing it is "controlled properly."

Related to the second major issue, land use controls, many officials voiced concern that legislation and controls are becoming too technical and too time-consuming. The present issues before the county are 1) a master plan and 2) zoning. With regard to zoning, mobile home restrictions are viewed as a burden upon many of the residents, especially low-income and the elderly. The opinions are divided concerning agricultural zoning. Some people feel that zoning is necessary for the preservation of agricultural land and the enhancement of the tourist industry. Others believe that it is in violation of the principle of private property rights. *A priori* it was hypothesized that eastern officials would favor zoning and westerners would be opposed to it, but the interviews did not yield this distinction. In fact, the officials of the east expressed even greater concern with the ranchers' property rights than was expressed by the ranchers' representatives. Finally, when discussing land use controls, a great number of government officials are interested in the concept of Transferable Development Rights as a possible means of solving the conflict between control and private rights.

The third major issue discussed by the officials was "government." In general, there is a strong, unanimous desire for local control, with opposition to any kind of state preemption. The federal government, especially the Environmental Protection Agency and National Park Service, is looked upon even less favorably than state officials. Those interviewed believed that these agencies are not sensitive to local issues and problems. The U.S. Forest Service is the only exception to this general feeling of mistrust. However, this exception could be due to the administrator himself, who plays an active role in local government. Governmental services which are of concern to some or all of the officials are: 1) low cost housing, 2) food stamps, and 3) increased sharing of services such as police protection and dog control. Towns with limited budgets, such as Fraser, are especially interested in shared services. Taxes presented the one issue that could be identified according to location. Officials from both the east and west think their side of the County is carrying the tax load, so they want to see the burden equalized.

The final issue articulated by the officials was concern for the aesthetic qualities of the County. They defined the small town characteristics and clean atmosphere of the County as important attributes. However, the majority of those interviewed did not believe the quality of the environment is presently being jeopardized or would be jeopardized by population growth. Officials generally responded that they do not want Grand County to become "another Vail," but their primary concern seemed to be increased job opportunities and the protection of property rights, and not the aesthetic and environmental issues.

The government officials survey was thus able to identify, from one perspective, the issues confronting the County. Although no clear distinctions between the responses of those from the two major sections of the County became apparent, differences between several factors within the County did become evident. For instance, Grand Lake officials, unlike the majority of County officials, were not concerned with establishing a year-round economy. They have visions of Grand Lake continuing to be a resort area for the wealthy. They believed that a stabilizing increase in winter activities would bring in the wrong types of people, and eventually jeopardize Grand Lake's attractiveness. A distinction which became particularly evident in Fraser was between the young and the old. The older officials do not want more tourists or development in their area. In contrast, the younger people who make their living from the tourist industry, would like to see it expanded. Thus, although the survey did not reveal the conflicts between the western and eastern sectors *per se*, it did yield some sociological differences that could become future points of contention.

First Public Opinion Questionnaire

Method. A sample of 54 year-round residents (3 percent of the total population) was chosen at random from the Grand County telephone directory.

Initially, voter registration lists were to be used on the assumption that voters would be the people most interested in current issues before the County. However, due to the fact that these lists did not include telephone numbers, they were replaced by the less satisfactory telephone directory. Since year-round residency data were available for Grand Lake, Hot Sulphur and Parshall, Kremmling, Fraser, Winter Park, Tabernash, and Granby, the survey was spatially stratified into five areas. Proportional samples were then drawn from each section of the County directory. It was apparent that all business either should be included or excluded from the sample, and the decision was made to exclude them. Finally, since it was impossible to determine how many eligible voters resided in each household, a coin was flipped as a means of determining whether to ask for the male or female head of the household. The questionnaire was administered at the residence of the respondent, and a team of five interviewers covered the County. The respondent generally took about 30-45 minutes to answer the questionnaire.

The survey was divided into six major sections: 1) an open-ended portion asking the resident to list the advantages and disadvantages of living in Grand County, 2) 35 assumed characteristics or attributes of the County which were to be rated on a scale from 'most strongly like' to 'most strongly dislike, 3) a list of possible future issues confronting the County which were a) to be judged 'very important' to 'not important' and b) a determination made by the citizen as to whether he wanted more, same, or less of the activity, 4) questions related to a person's attitude regarding land use control and County growth, 5) an open-ended question asking the respondents to identify the three most important issues facing the County, and

6) demographic questions. The overall purpose of the survey was to determine the attributes of the County as perceived by the residents and to define the major issues confronting the County.

Analysis and Results. The first step in analyzing the survey was to code the open-ended questions into as few categories as possible and make a frequency count. For instance, the advantages of living in Grand County were coded in the following thirteen classifications with corresponding values.

	Category	Number of Responses
1.	Small, cohesive population	26
2.	Mountain living, quiet clean	21
3.	Aesthetics, wildlife	21
4.	The people, friendly	15
5.	Location	10
6.	Recreation	8
7.	Job opportunities	7
8.	Government	4
9.	Schools	4
10.	Climate	2
11.	Ranching	2
12.	Lack of crime	1
13.	Other	4

From these data it can be concluded that the residents of Grand County believe that the advantage of their area lies in its aesthetic, pollution-free qualities and in its friendly, cohesive communities. Utilizing the same methodology, the major disadvantages of living in Grand County are the weather, high costs, and lack of services. Furthermore, seventeen percent of those interviewed stated that there had been too much growth and development in the County, while fifteen percent felt there had been too much planning (i.e., restrictions on mobile homes).

As a means of ordering and quantifying these advantages or attributes of the County, 35 specific questions had been included in the questionnaire. There were two statistical tests run on these data. First, means and standard deviations were calculated for each of the 35 responses (Table 11). In this manner, those attributes which people most like or dislike can be readily visualized. For instance, being in the mountains, living in a small community, and being able to see wildlife all yielded high averages. Conversely, lack of cultural activities and having few minorities in the County both resulted in relatively low scores.

The second analysis of these 35 questions was a factor analysis. These questions had been designed by establishing seven broad categories, and then writing five items pertaining to each category. These items were then intermixed, the hypothesis being that when the survey was analyzed, these 35 questions would factor back into the seven categories. Presumably a person would rate all the questions within a category relatively consistently. However, only five clusters emerged from the analysis: 1) mountain living, 2) diversity, 3) activities/location, 4) recreation, and 5) government. Actually 10 factors were derived in the analysis but only five of them were deemed significant based upon the amount of variation explained by the factors. The individual items included in each factor were generally those which had factor scores of 0.5 or greater. However, some variables having a value slightly less than 0.5 were included in the factor if further investigation established a reasonable relationship with the other factor variables. Furthermore, factors can be combined if they are mathematically

Table 11. Attributes of Grand County: Like/Dislike (Scale 1-9).

Variables	Mean	Std. Dev.
Being in the mountains	8.654	.745
Living in a small community	8.423	.809
Diversity of population	7.192	1.650
Close to Denver	6.808	1.721
Knowing government officials	7.423	1.138
Close to recreation areas	7.346	1.696
Diversity of jobs	6.269	2.164
Being in the mountains	8.615	.752
Historical area	6.385	1.267
Few minorities	5.692	1.668
Many public resources	6.385	2.041
Active local government	6.769	1.986
Winter recreation opportunities	7.692	1.289
Mix year-round and seasonal employment	6.346	2.190
Large open spaces	8.154	1.289
Identifying with a mountain community	7.846	1.690
Having young people in the community	6.615	1.899
Having towns spread out	6.500	2.404
Having government interested in land use	7.039	2.306
Good summer recreation	7.692	1.225
Having basic industries	7.385	1.416
Being able to see wildlife	8.577	.643
Living in a close knit community	6.926	2.049
Having tourists in County	5.846	2.525
Federal highways in County	6.615	2.351
Having newcomers in government	5.885	2.405
Having national park nearby	7.539	1.476
Having active tourist industry	6.346	2.497
Having little development	6.346	2.497
Living in a western community	7.846	1.515
Newcomers settling in County	6.154	2.310
Being away from the city	8.385	.898
Federal and state officials in County	6.500	1.839
Limited cultural activities	4.713	2.341
Lack of jobs	3.774	1.914

and theoretically consistent. In this analysis, two factors were combined into one called "Government." The final five factors and their components are listed below. The name of the factor is a construction which describes it as a totality.

Name of Factor	Variables
Diversity	Diversity of population Diversity of jobs Mix seasonal employment Young people Basic industry
Mountain living	Small community Being in the mountains Western community Being away from the city
Location/Activities	Close to Denver National Park Limited cultural activities Newcomers settling in County
Recreation	Close to recreation areas Towns spread out Winter recreation opportunities
Government	Active local government Federal and state officials in County Government interested in land use

These five factors thus became descriptors of Grand County as perceived by the residents. They are in all cases (except limited cultural activities) positive attributes which the planner might consider as desirable attributes of living in Grand County and, therefore, things to be enhanced or protected.

The next section encompassed 59 questions describing possible County issues. The respondent was asked to indicate how important or unimportant each issue would be in the future and if he would like to see more, less, or the same of the item in the future. The issues were grouped into the following categories: 1) resources, 2) jobs/business, 3) community, 4) government, 5) population, 6) development, and 7) aesthetics. Due to budgetary and time constraints, only 24 questions were analyzed in this section. The 24 were chosen on the basis of the government officials survey and the answers already analyzed in the questionnaire. For instance, any questions having to do with aesthetics would be included due to the high score of this item in the section on attributes of the County. A frequency count yielding total percent scores was utilized for this section. Table 12 summarizes the results of this analysis. An interesting point to note is that although people would like to see more opportunities for small businesses and more year-round jobs (70 percent and 76 percent, respectively), they also displayed a strong concern for the environment and its preservation. Consequently, 56 percent of those polled wanted to see more regulations to preserve agricultural land, and 78 percent desired greater preservation of open space. Surprisingly, only 15 percent proposed more tourist oriented businesses.

The three questions relating to land use specifically were: 1) how important do you feel land use planning will be in making Grand County the kind of place you want it to be in the future, 2) will growth jeopardize the quality of the physical environment, and 3) will growth jeopardize the quality of the social environment? These questions were first simply tabulated, and it was found that although 63 percent of those interviewed said that land use planning would be very important in making Grand County the kind of place they want it to be in the future, and 19 percent think it will be important, only 22 percent strongly agreed and 30 percent agreed that growth would jeopardize the quality of the physical environment. Moreover, only 13 percent strongly agreed and 22 percent agreed that growth would jeopardize the quality of the social environment. Further analysis was done with these data by cross tabulating these three questions with

Table 12. Grand County: Future issues.

Issue	Not Impt.	Impt.	Very Impt.	Want More	Want Same	Want Less
Ski areas	17	41	41	39	46	9
Transmountain water diversion	9	30	54	24	13	54
Tourist oriented businesses	9	59	30	15	52	26
Opportunity for small businesses	4	48	46	70	24	0
Year round jobs	2	44	52	76	17	2
Low income housing	17	30	48	60	19	6
Middle income housing	9	43	41	59	26	7
High income housing	37	44	9	6	46	39
Schools	0	22	76	57	35	0
Regulations to preserve ag. land	2	44	50	56	28	7
Air/water pollution controls	0	45	55	78	15	4
Regulations for residential areas	4	33	61	61	13	19
Regulations for no. units/acre	2	33	65	67	22	4
Planning on a county-wide basis	0	48	52	57	31	6
Tourists	13	44	41	39	41	15
More populations	30	37	28	22	37	37
Expansion of existing towns	22	54	20	37	39	17
Construction of new towns	50	26	20	11	20	61
Subdivisions away from towns	20	46	30	24	31	41
Preservation of open space	0	30	65	70	19	0
Development of Three Lakes	20	41	37	26	35	31
Development on highway	17	44	37	33	20	39
Commercial development	7	57	33	35	43	17
Subdivision development	20	46	30	22	35	39

each of the 24 future issue questions. It was hypothesized that there would be a significant relationship between the response to land use questions and the issue oriented questions. For instance, it was believed that those who wanted land use controls or those who believed growth would jeopardize the physical and/or social environments would also be the ones who might want less development around the Three Lakes or more preservation of open space. Questionnaires were also classified according to their location and cross-tabulated in the same manner. Although a few dependent relationships were found between the different variables, no consistent relationship was established. The people who were most concerned about the quality of the environment could not be identified according to their responses to the issue oriented questions or their place of residence. One explanation for this lack of correlation is that people assume if there is sufficient land use planning, then neither the social nor the physical environment will be degraded.

The final analysis involved coding the open-ended questions regarding future land use issues. (Although the demographic data were summarized, they were not utilized in this analysis.) The following categories evolved.

Issue	Number of Responses
Land use/Development	31
Government sources	16
Water diversion: supply	16
Environment: protection, aesthetics, wildlife	12
Population growth	11
More jobs	9
Better government	8

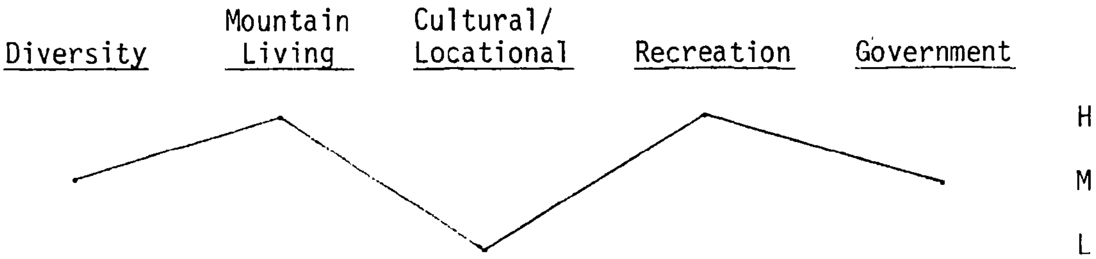
Schools	8
Taxes	4
Housing	4
Economy	4
Improved Recreation Areas	3
Transients	3
Tourism	3
More stores, businesses	2

These data can thus be combined with other survey results to provide planning parameters. For instance, by combining this analysis with responses pertaining to advantages and/or disadvantages of living in the County, a planner can readily ascertain at least some of the issues that might be addressed.

Interpretation and Use. One discrepancy which became apparent is that the citizens, unlike the government officials, are at least as concerned about environmental quality as they are about economic problems and job opportunities. These differences seem quite important and affect any interpretation which attempts to provide a statement of County goals and objectives for the study area. These differences, therefore, were incorporated into the subsequent task of developing land use scenarios.

The survey produced five county attribute clusters: diversity, mountain living, cultural/locational, recreation, and government. By utilizing the five clusters, a procedure was devised for 1) identifying particular groups within a community, and 2) determining which groups will be affected by different types of plans and/or developments.

Once the clusters were established, individual responses were analyzed in order to determine how each person rated each attribute on a scale of high, medium, or low. A high score constituted any score greater than 1 standard deviation away from the mean and a low score anything less than 1 standard deviation away from the mean. Once high, medium, and low scores were assigned to each person, an attribute 'signature' or 'profile' was drawn. An attribute signature for one individual might look like this:



The importance of these signatures is that they show some of the values about the County held by each individual. For instance, according to this profile, the person highly values attributes of the County related to mountain living or recreation while at the same time placing a low value on the cultural/recreational characteristics. After this type of signature was developed for each person, groupings were made of like signatures. However, at this stage instead of using high, medium, or low, the mean scores were translated back into the survey terminology so as to provide better descriptors. A partial example of this group matrix is shown below.

GRAND COUNTY RESIDENT TYPOLOGIES BASED UPON FIVE CLUSTERS

Type	Diversity	Mountain Living	Cultural/ Location	Recreation	Government
T1	Moderately Like	Most Strongly Like	Moderately Like	Moderately Like	Moderately Like
T2	Strongly Like	Moderately Like	Weakly Like	Moderately Like	Moderately Like
T3	Moderately Like	Strongly Like	Moderately Like	Strongly Like	Moderately Like

Now, the question is, of what use was this information?

Utilizing this procedure, each individual was assigned to a "values" group and each individual could be spatially located on a map according to his residence (Figure 9). In this way, it was possible to identify any clustering of groups and determine who was likely to be impacted upon by any plan or proposed development. From this analysis, it was evident that over 80 percent of the residents who strongly like or most strongly like the attributes associated with mountain living resided in the eastern portion of the County. Similarly, those most concerned with recreation opportunities are also located in the eastern portion of the County. Thus, there could be a conflict between public values and development of eastern Grand County. The people most valuing present attributes of the County reside in areas that may feel the greatest pressures for development.

The advantages of this type of technique are that not only were residents' values identified, but also groups having common value sets were determined. This information as well as that obtained from County officials and other parts of the survey was then used in the construction of a set of realistic land use scenarios.

Population Analysis

One component of an alternative future is the population size and composition given the other components of that future. The planner generally wants to know the population size, distribution, and composition both at the present and projected for some future time period. This information enables description of the current situation, description of some future situation, and an estimate of the impact of plan alternatives on the population and the population's potential impact on other resources. Therefore, it was necessary to develop a population model suitable for a rural area like Grand County and then apply this model to the County situation.

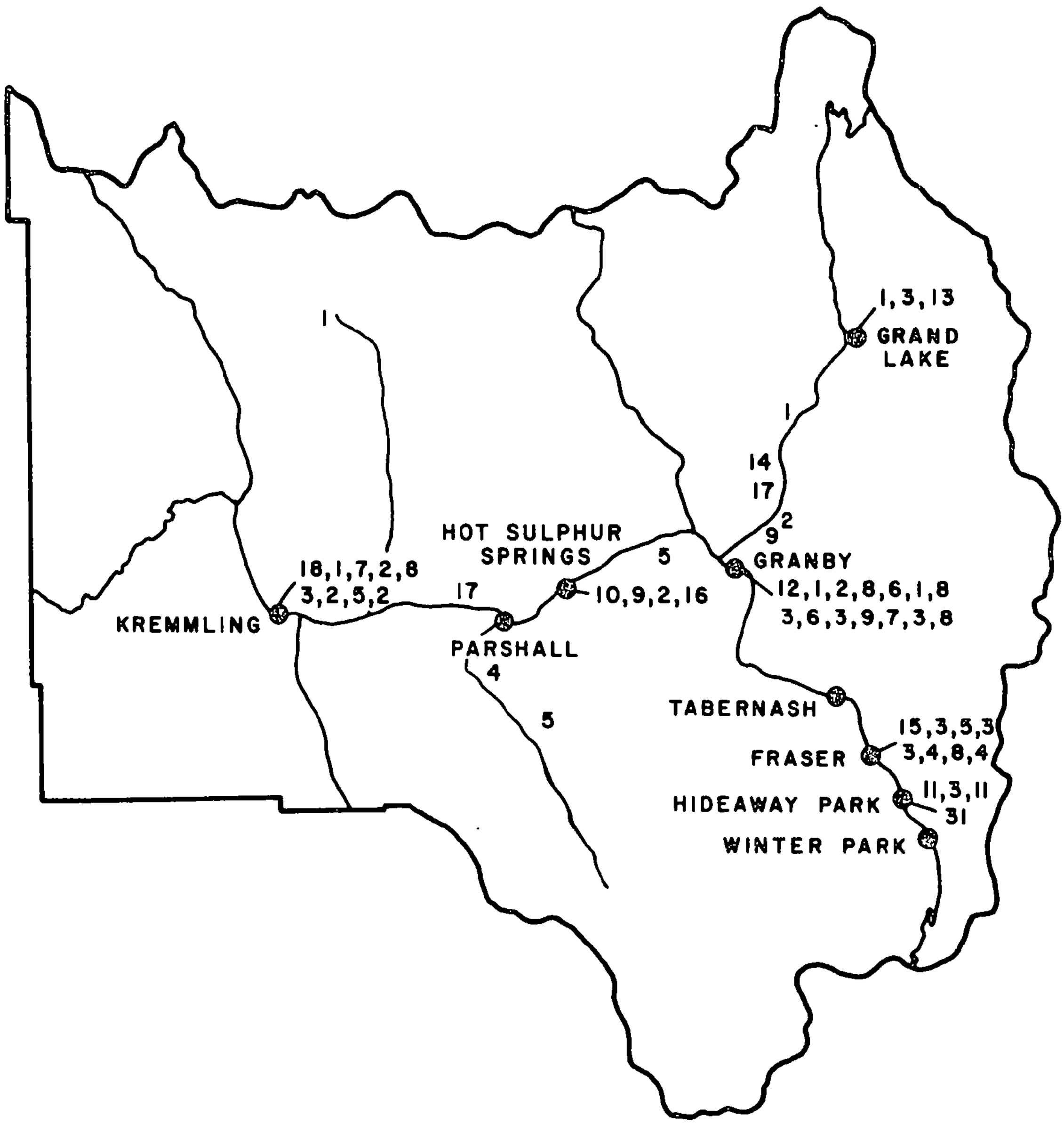


Figure 9. Spatial location of resident groups.

A population model is essentially a mechanistic device designed to replicate the processes of population change over time. A prime determinant of the procedure employed is the assumed causal relationships between the population system of the region and the level of economic activity. The model which was used for this study is based upon the assumption that regional migration is largely determined by available employment opportunities in the region. One of the major relationships between the population system and the economic system is illustrated in Figure 10. For any point in time there is a relationship which specifies that the resident population at that point is composed of a group which is not in the labor force (school children, retired, others not seeking work), while the remainder of the resident population is included and is available for employment. Of the group available for employment, some are unemployed and the remainder comprise the total regional employment for that time period. The purpose of the following section is to describe a model framework which includes the assumed causal relationships for the system and the process by which these changes occur through time. The current situation and use of population data are described.

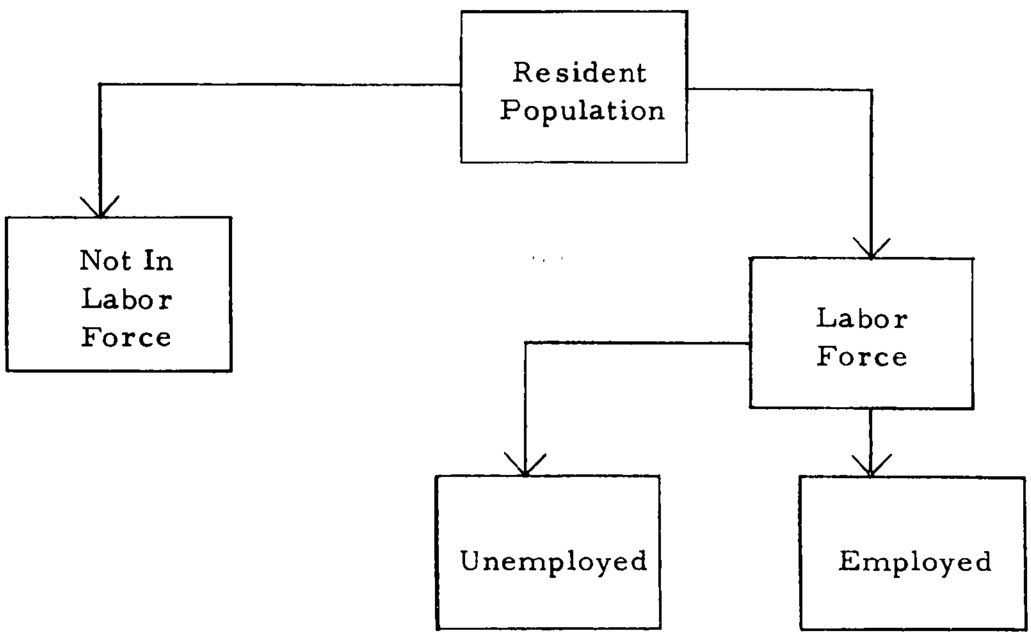


Figure 10. The population-employment relationship.

Inflow-Outflow Analysis

As illustrated in Figure 11, the population of an area open to migration may change as a result of births entering the system, deaths leaving the system, in-migrants of the system, or out-migrants from the system. This process can be described by the inflow-outflow technique outlined by Drake, et al. (1971) and Isard (1960). The total population of an area at some future time may be calculated as the total population in the previous period, plus the births which have occurred in the intervening period, minus the deaths, plus the net migration between periods. In order to use this type of analysis for projection purposes, some estimate of the in- and out-migration (or net migration) is necessary.

The inflow-outflow analysis may be expanded to yield estimates of individual age and sex components of the population. In its expanded form, the technique is generally known as a cohort-survival analysis (Keyfitz and Flieger, 1971).

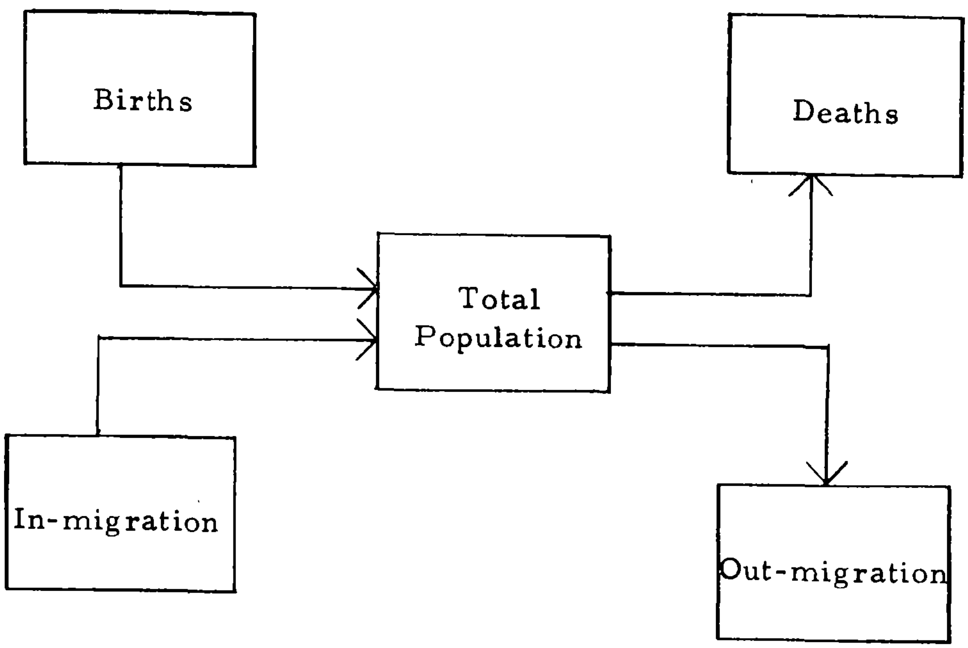


Figure 11. Inflow-outflow analysis.

A Cohort-Survival Model

A cohort-survival model may be viewed in much the same manner as the inflow-outflow model illustrated in Figure 11. Rather than a total population, the cohort-survival model is designed to monitor population change by age and sex. The analysis begins with a base year population separated into age and sex groups. Although any reasonable age grouping may be used, the most common practice considers five year age intervals (for example, age group 1 is age 0-4 years, group 2 is 5-9 years, group 3 is 10-14 years).

Births are calculated as a function of the female population in child bearing age groups and the birth rate for each female group. Deaths may be calculated as a function of the total population of each age, sex group and the death rate for that particular group. The process of aging is also included in the cohort-survival model. If each component of the original population survives, in a sense the group has already aged. However, since the size of each age group has changed through time, some calculations are necessary to determine the size of each new component.

The cohort-survival technique yields excellent results if there is no significant migration expected to occur into or out of the area. This no-migration assumption is clearly not applicable to most small areas. A basic limitation of the cohort-survival model for projecting population is that there is no mechanism within the model structure itself which relates the level or composition of migrants to the expected or projected economic activity. The usual practice when using this type of analysis is to extrapolate age and sex specific migration rates from a previous time into the future. For example, a net migration rate may be calculated from a previous time period and applied to a base year population to arrive at some future migration estimate.

To some extent, this approach does relate projected migration to changes in the area's economic activity. However, it implicitly assumes that changes in the level and structure of economic activity in a previous time period are similar to the economic changes expected in the projected period. Thus the problem of projecting migration is central to the problem of population projection for most areas. This problem was solved by setting the estimated total population consistent with the projected total employment and the projected unemployment. It is assumed that in- and out-migrants move on the very last day of the time period, then the total population estimate is completely consistent with the projected employment and unemployment. Applying this condition, the projected labor supply is now exactly equal to the projected labor demand for the area. Utilizing this procedure, approximations can be made of the changes that occur in a regional population system as a result of natural increases and decreases, and the migration which occurs as a result of the interaction between the natural population forces and changes in the levels of economic activity in the region.

The Population Model--Overview and Summary

As illustrated in Figure 12, the population model is essentially an accounting framework which monitors and projects: (1) births, (2) deaths, (3) net non-employment related migration, and (4) net employment-related migration. As illustrated, births, which enter a population system, are determined by birth rates and the population to which these rates are applied. Similarly, deaths, which leave the system, are determined by death rates and the population to which these rates are applied. Non-employment related migration may add to or remove population from the system. In the framework

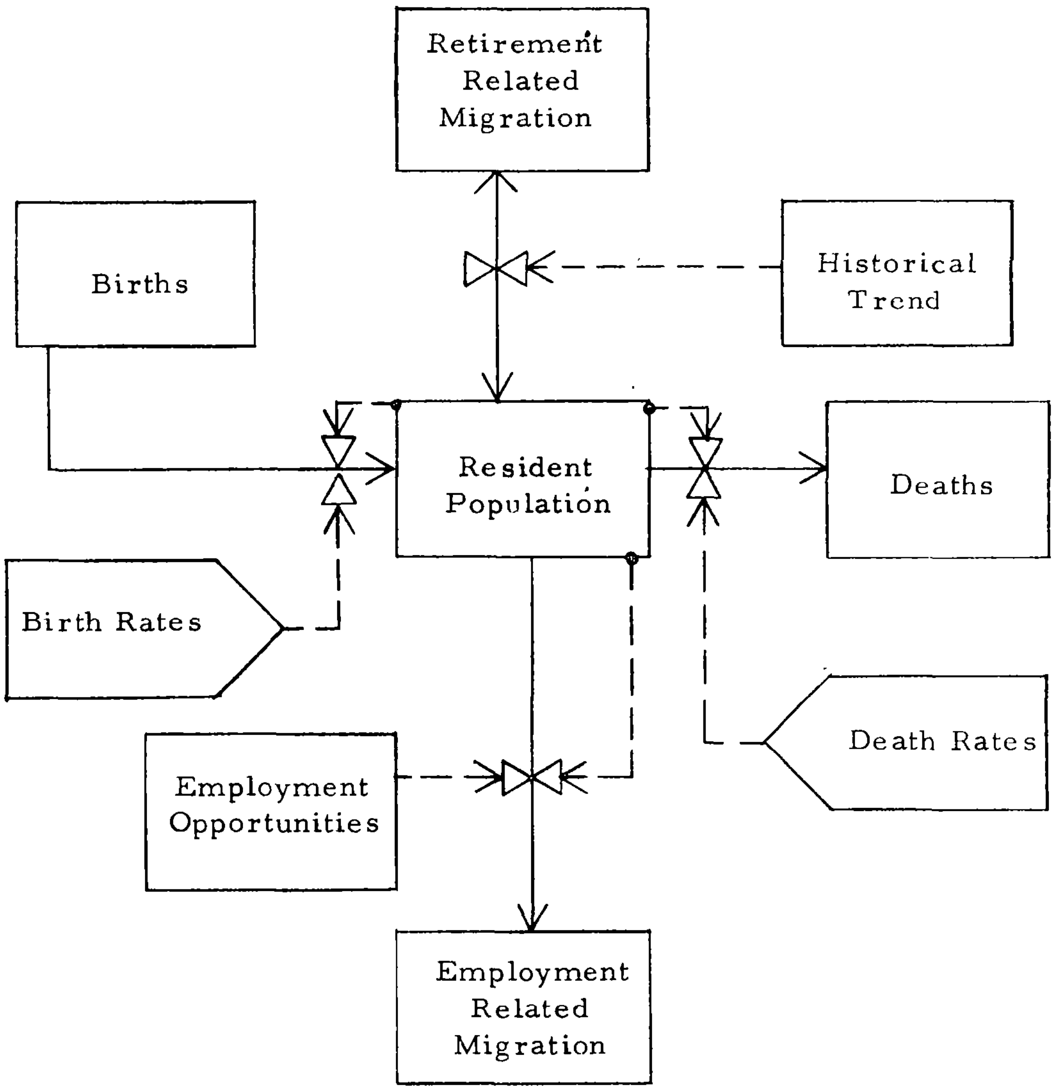


Figure 12. Population model-summary.

developed, this component of net migration is exogenous and its quantity is not determined by a rate application. Employment related migration may also add to or remove population from the system. The number of employment-related migrants is determined by employment opportunities and by the number of workers available from the resident population. Thus, given some estimate of the level of economic activity for an area for some future time period, the model can be used to generate a population forecast for the area under study.

Data Sources

All basic data for the population model were obtained from currently available federal or state sources. The model requires eight separate data inputs. These are:

(1) base year population by age and sex,

(2) birth rates which are age-specific by mother's age, proportion of births which are male,

(3) age and sex specific death rates,

(4) age and sex specific labor force participation rates,

(5) annual retirement-related migration,

(6) projected unemployment rate,

(7) age and sex distribution for employment-related migrants, and

(8) projected total regional employment.

A brief description of each, along with the corresponding data sources is provided below.

Data Set 1 - 1970 population by age and sex was taken from the 1970 Census of Population.

Source: U.S. Bureau of the Census (1970a).

Data Set 2 - Age-specific birth rates for mothers were estimated from 1970 County births and 1970 age-specific birth rates for the state. These base year rates were then adjusted for each time period until convergence with the Census Bureau. Series E birth rate projections were achieved in 1990. Male births were assumed to be 51 percent of the total.

Sources: County and state births - Colorado Department of Health (1971).
Series E projections - U.S. Bureau of the Census.

Data Set 3 - Base year death rates were estimated from 1970 County deaths and 1970 death rates for the state. These rates were also converged with the Series E 1990 Census Bureau projections.

Sources: County and state births - Colorado Department of Health (1971).
Series E projections - U.S. Bureau of the Census (1972).

Data Set 4 - 1970 labor force participation rates were taken from 1970 Census. Adjustments through 1980 were based upon Department of Labor national estimates for 1980.

Sources: County rates - U.S. Bureau of the Census (1970b).
National projections - Cooper and Johnston (1965).

Data Set 5 - Retirement-related migration was based upon 1960-1970 net migration estimates for age groups 55 and over.

Source: Estimates were based upon the results of census survival migration analysis (forward procedure) for 1960-1970 for County.

Data Set 6 - Average annual unemployment for 1970-1973 was taken from state estimates. Full employment (4.5 percent unemployment) was assumed for all projections.

Source: Colorado Division of Employment (1974).

Data Set 7 - Migrant distribution was based upon net migration estimates by age and sex for Colorado for period 1960-1970.

Source: Monarchi and Rahe (1974).

Data Set 8 - Total projected employment for each time period was estimated on the basis of alternative futures and the employment model.

Source: Employment model

Situation Description

The 1970 Census recorded a total population of 4,107 for Grand County, an increase of 21 percent over the 1960 estimate of 3,395. The 1970 total was, however, only about 4 percent greater than the 1950 population of 3,963. Declining employment opportunities between 1950 and 1960 apparently contributed greatly to this decline. Substantial net out-migration occurred between 1950 and 1960 (net out-migration of 1,180), while some net in-migration took place between 1960 and 1970 (net in-migration of 174). With an expanding economic base for the area, this in-migration trend can be expected to increase sharply. Population size and composition for 1970 and estimated 1975 totals are shown in Tables 13 and 14.

Table 13. Grand County population - 1970 Census

Age	Male		Female
0 - 4	137		180
5 - 9	201		156
10 - 14	237		204
15 - 19	191		221
20 - 24	121		145
25 - 29	153		130
30 - 34	99		96
35 - 39	132		158
40 - 44	181		136
45 - 49	118		134
50 - 54	132		122
55 - 59	102		95
60 - 64	120		113
65 - 69	76		61
70 Over	77		79
Total	2,077		2,030
Total		4,107	

Table 14. Grand County population - 1975 estimated

Age	Male		Female
0 - 4	230		240
5 - 9	230		232
10 - 14	295		268
15 - 19	313		301
20 - 24	339		352
25 - 29	283		328
30 - 34	251		262
35 - 39	220		220
40 - 44	213		206
45 - 49	189		182
50 - 54	167		157
55 - 59	126		128
60 - 64	118		119
65 - 69	87		83
70 Over	101		110
Total	3,161		3,186
Total		6,347	

Interpretation and Use

The estimated Grand County population for 1975 has an unusually low number of dependents. That is, there are relatively few people dependent (those less than 15 years and those older than 65 years) upon the productive age (15-64 years) population. For the mountain states the ratio is about 60 dependents for each one hundred non-dependents, for the nation the ratio is about 62 to 100, and for Grand County the ratio is only 42 to 100. From these data it appears that there are many unmarried workers in Grand County. One could also expect that a substantial portion of the population is quite mobile and would move if economic conditions deteriorate.

These population data were useful in understanding the current situation in Grand County and in deriving the alternative futures. Projections of them were the basis for the population estimates in the alternative futures. Additionally, the impact of alternatives on infrastructure needs can be estimated from projections of the population.

Economic Analysis

The economic system existing in an area and its change over time is of concern in the planning process. Planners, politicians, and citizens are all interested in economic well-being and how that well-being is affected by land use and other plans. For Grand County it was necessary to develop a region specific economic model to be used in current situation description and projection of future economic activity. The output of the model was useful both in deriving alternative futures and in assessing the impact of any future on the area's economy.

The most frequently used form of regional employment projection model is export base analysis. Several excellent summaries of the approach are available including Isard (1960), Pfouts, ed. (1960), Tiebout (1962), Land (1966), and Hirsch (1973). Isard (pp. 199-205 and 327-43), Tiebout (Chapter 6), and Hirsch (Chapter 8) have discussed forecasting problems associated with this type of analysis.

Richardson (1969) has summarized the export base theory as:

$$Y = (E - M) + X$$

$$E = eY$$

$$M = mY$$

$$X = X\bar{i} \text{ (exogenous)}$$

where

Y is regional income
E is that part of the regional income spent locally
M is imported income
X is income for exports
e and m are the marginal propensities to spend locally and to import respectively.

By substitution

$$Y = eY - mY + \bar{X}$$

$$Yi = \frac{\bar{X}}{1 - e + m} \quad \text{or} \quad \frac{Y}{\bar{X}} = \frac{1}{1 - e + m}$$

Regional income is therefore some multiple of exports and the ratio of total income to export income ($Y/\bar{X}$) is the multiplier. Most of the applications of this framework have used employment rather than income.

Critics of this procedure have frequently cited a lack of theory and the instability of the parameters estimated from past data. Among the numerous critics, Lewis (1972) has presented perhaps the strongest case for discarding the approach. Williamson (1975), however, has recently suggested that empirical verification of the theory is often overlooked by its critics and has presented several examples of past research which indicate that the predictive power of the technique is quite good.

Figure 13 summarizes the operation of the regional employment model. As illustrated, the levels for basic industry employment, the export component of business-serving employment, and the export component of population-serving employment are determined by external market demands. The export oriented employment in basic industries and in population-serving industries then determines the levels for parts of the locally oriented business-serving employment. The population levels associated with this employment then determine a locally oriented population-serving employment which in turn feeds back into the population system and the local business-serving employment until some equilibrium level is achieved. The sum of all the various employment levels then becomes the total required employment which is used to drive the population model through time.

Situation Description

Census employment estimates for Grand County for 1975 are displayed in Table 15. These employment totals identify the number of employees by industrial sector and represent employment by place of residence rather than

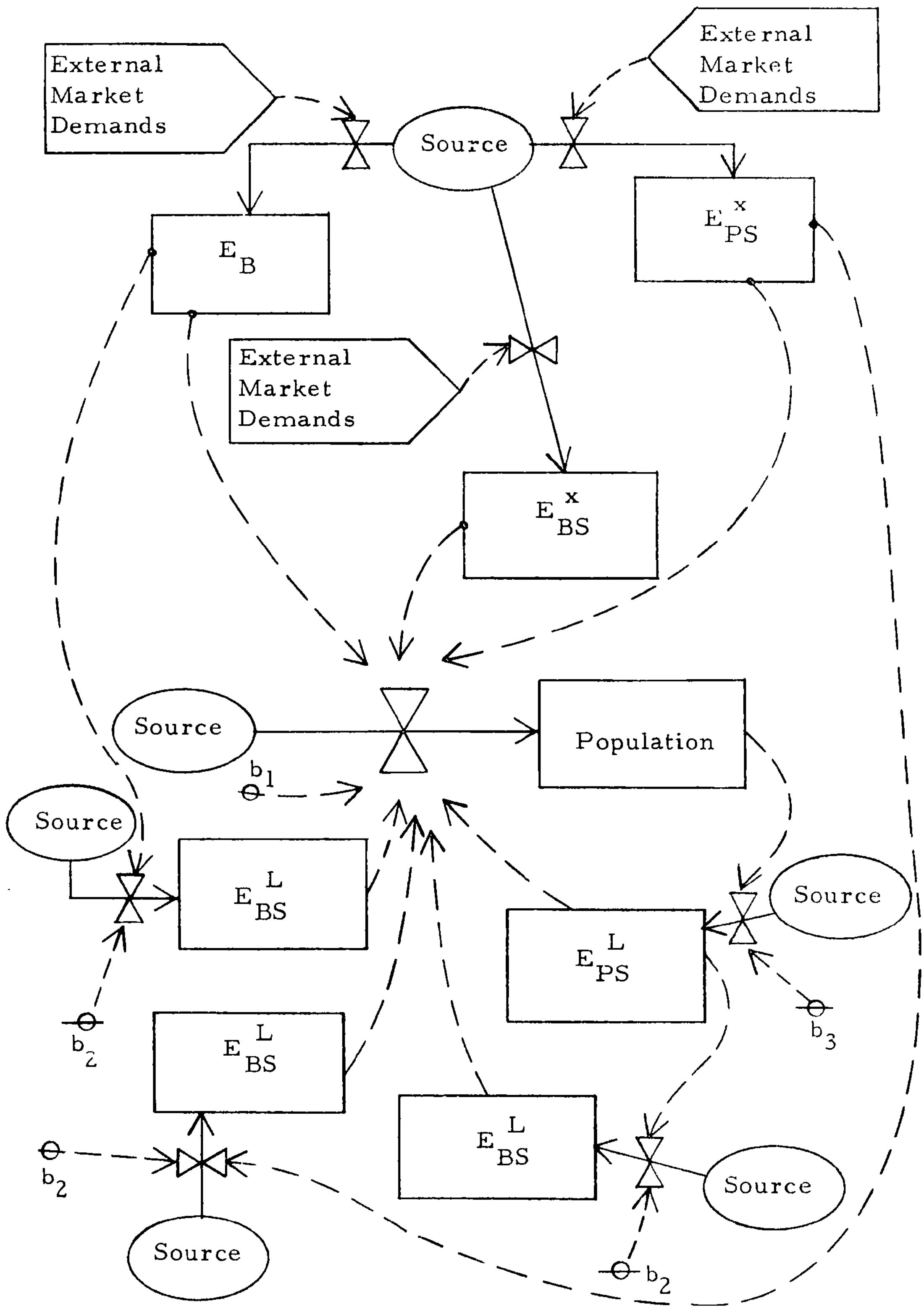


Figure 13. Employment model-summary.

Table 15. Grand County employment by industry - 1970 Census.

Industry	Employment	Estimated Non-local Employment
Agriculture	185	185
Mining	85	85
Furniture, lumber, wood products	102	102
Metal industries	-	-
Machinery, ex. electrical	-	-
Electrical machinery	-	-
Transportation equipment	-	-
Other durable goods	-	-
Food and kindred products	-	-
Textiles and textile products	-	-
Chemical and allied products	-	-
Other non-durable goods	-	-
Federal government	43	43
Construction	177	59
Printing and publishing	6	-
Transportation	57	-
Communications	40	12
Utilities and sanitary services	47	14
Wholesale trade	12	-
Finance, insurance, real estate	22	-
Business and repair services	34	-
Legal and misc. professional services	36	-
Food, bakery, dairy stores	12	-
Eating and drinking places	227	180
General merchandising retailing	34	-
Motor vehicles and service stations	46	12
Other retail trade	153	67
Households and personal services	249	177
Entertainment and recreation services	71	58
Hospitals and health services	45	-
All education	70	-
Welfare, religious, non-profit	22	-
Public administration, ex. federal	58	-
Total	1,834	994

place of work. In addition, Table 15 also shows the estimated non-local or export employment by sector. The level of export employment for each sector was estimated based upon the procedures outlined above. Of the 1,834 employees in the County, 54 percent are estimated to be engaged in export oriented employment. The most striking feature of the 1970 data is the almost complete absence of manufacturing activity and the high degree of export activity in the service sectors.

Interpretation and Use

The employment structure for Grand County shows the dominant economic activities in the area: Agriculture, tourism, timbering, and personal services are the export industries most responsible for economic health of the area. A rapid decline in any of these industries could cause economic disruption in the area.

Employment information was utilized in describing the current situation, estimating possibilities for economic growth or contraction, and deriving alternative futures. Employment estimates are a key element of the alternative futures and are related to projecting infrastructure needs.

Deriving Scenarios

Importance

A key element in the derivation of alternative futures was the construction of a set of broad scenarios, or future histories, for the study area. These scenarios were the general structure on which the alternative futures were built.

Scenarios can range, in structure, from very restrictive and conservative views of change to unrestricted growth or decline. However, if scenarios are to be viable in the construction of alternative futures relevant for planning, the more realistic they are, the better. In other words, they should be achievable within resource, institutional, and social capabilities of an area. It does little service to decision makers to produce unattainable scenarios which can be dismissed without consideration.

Process

The process utilized to construct the set of scenarios for the study area was based upon the extensive inventories of the environmental resources, economic situation, population structure and behavior, public desires, and growth forces which have been described earlier. Various alternatives were considered based upon known growth forces and public desires. These were then checked against the other data to insure that they were possible. The following five scenarios were then written to be reflective of the possible futures which eastern Grand County might experience, given different levels of governmental intervention and different economic thrusts.

SCENARIO I

It is proposed in this scenario that the qualities inherent in "mountain living" have the highest priority for residents of Grand County. Therefore, emphasis in planning will be placed on preservation of the environment. The goal will be to preserve to the greatest degree possible, wildlife, open space and the aesthetics of the area. This scenario will require strong governmental controls with development and economic opportunities being sacrificed.

Developments which occur because of population growth will primarily be concentrated in existing communities. New developments will be controlled so that impacts on scenery, wildlife, and unique features will be minimized. Roadless areas will remain roadless. Water and air pollution control will be of prime concern to government agencies. Agricultural land will be maintained for agriculture because of its open space characteristics. Developments which rapidly expand population or change the basic, present character of the area will be discouraged.

SCENARIO II

Due to increased demand for recreational opportunities, Grand County will develop its tourist industry, but only to the extent that the development is compatible with preservation values. Thus, the increased recreation activities will only take place in areas that will not cause stress to the environment and aesthetic characteristics of the area. The government will have to exercise strong controls in order to achieve these goals.

This scenario calls for dual emphasis on tourism and preservation. To accomplish this, tourist facilities and developments should not infringe upon the prime scenic, wildlife and wilderness (roadless) areas of the

County. Tourism and preservation should complement each other. Tourist facilities will be designed primarily for transients and located in areas already having some tourist development--primarily highway corridors, Three Lakes area, and existing communities. Open space will not be intruded upon if the intrusion is visually degrading. Location of tourist facilities should take advantage of scenic views, proximity to recreation facilities and activities, and clustering opportunities. Full year recreation opportunities would be encouraged to even out employment opportunities. The only industry encouraged under this scenario is light and clean. Its location will not infringe upon tourist or preservation opportunities.

SCENARIO III

As a result of the expanding tourist industry in the state, Grand County will develop its tourist industry as much as possible in order to gain part of this market. Consequently, all areas will be developed in light of their economic potential as tourist "attractors" and preservation and aesthetics will only be considered to the extent that they can make Grand County more appealing to tourists. Government control will only be moderate and second home builders (middle to high income) will be encouraged.

Under this scenario emphasis is given to facilities and developments which encourage people to visit Grand County for a day or a month. Ski area expansion and new areas, condominium development, second homes, trails, snowmobile areas, campgrounds, boating areas, and all kinds of facilities will be encouraged. Diversity within and between seasons is emphasized in order to stabilize the tourist based economy. Industry is okay as long as it does not infringe upon tourism opportunities--same location, scenically, etc. Low income housing for seasonal workers is needed. Highways will be improved and new roads cut into new areas. Maintenance of air and water quality plus some open space is important so that natural tourist attractors are not destroyed. However, most areas near to transportation corridors will be developed. The Three Lakes will be a high density, activity oriented area.

SCENARIO IV

One of the primary goals of Grand County residents is to expand their economy and stabilize the job market. Therefore, government officials will do all they possibly can to encourage both extractive and light industries into the area. In order to attract such industries, the policy of the government will be one of "laissez faire," with only minimum amount of control as necessitated by state and national regulations. The government will also attempt to expand its services and concentrate on the availability of low income housing for the influx of new residents.

Traditional urban development, except for heavy manufacturing, is visualized under this scenario. Natural amenities are of low value. Economic geology, timbering, and some processing are the primary activities. Tourism is still encouraged, particularly around the Three Lakes and the Winter Park area. Granby, Hot Sulphur Springs, and Kremmling will become "mini" industrial centers. Primary homes will be needed for workers. New businesses will come into the towns. Mills and refineries must be located. Roads must be improved or built, water systems expanded, and energy systems developed. People moving between Denver and the coal producing areas of Routt and Jackson counties will increase. Services to meet their travel needs must be located. Health, safety, and economic constraints provide the only restrictions on land use.

SCENARIO V

Because of the need to develop a stronger economic base for the region, and because of the "overflow" of demands on the County which will result from energy development in neighboring Routt County, the government will attempt to increase both their tourist and industrial base. This plan will involve fairly strong governmental controls in order to preserve the tourist qualities of the area. The government will attempt to provide for both the increased lower income and secondary housing demand, but only in such a way that the aesthetic qualities of the areas will not be lost.

Without a doubt, this scenario is the most difficult for planning. It calls for growth in two sectors which are often conflicting. It calls for a balanced economic base rather than one sector dependency. Moderate development of ski facilities and other winter sports opportunities is visualized. Controlled growth of the summer recreation opportunities, particularly in the Three Lakes and Fraser River areas, is necessary. Both transient and second home type developments are warranted as long as they don't destroy the tourist/scenic environment. Industry is also encouraged but not to the extent that it degrades most tourist opportunities. Therefore, air and water pollution control are important. Open space, scenic, and transportation controls are also important. The interaction between people on highway corridors and mines is of consideration, for instance.

Use

The scenarios, ranging from maintenance of the current environment with a low emphasis on growth to an aggressive emphasis on industrialization and growth, formed the basic guidance for development of alternative futures and for compositing of environmental resource factors into suitability maps. The scenarios provide an indication of the kinds of employment opportunities, land needs, governmental policies, and other elements of interest in forecasting the future. They also provide an indication of alternative goals which might be pursued.

The next steps in the process were to translate the scenarios into specific, quantitative alternative futures and to develop resource stability maps to fit each scenario. These steps are discussed in the next few sections of this report.

Alternative Futures

The five scenarios identified for the study area represent general directions and changing emphasis for the economic base of the area. In order to change these into alternative futures and to estimate the population and employment impacts of these changes, each of the five scenarios was associated with a different employment pattern for the area. As outlined earlier, the level of export, or non-local employment, is used as the primary driving force for the population and employment models. Given various employment patterns for each scenario, the models were then used to estimate the total population and employment levels. The assumptions and procedures which were used to develop the employment patterns for each future are described below.

Data Input Requirements

The primary data inputs for the employment component of the model include base year total employment and base year estimates of local and non-local employment. As is the case with the population component, all data bases were developed at the County level and were drawn from currently available federal or state sources. The model required six separate data inputs. These were:

(1) industry classification scheme,

(2) base year values for County employment by industry,

(3) base year values for national employment by industry,

(4) base year estimates for CBS values, CPS values, DBS values and DPS values,

(5) base year values for local and non-local employment by industry, and

(6) projected levels for non-local employment for each industry.

A brief description of each, along with the corresponding data source is given below.

Data Set 1 - Industries were defined by Standard Industrial Classification and were assigned to basic, business-serving, or population-serving group.

Source: All assignments were judgmental

Data Sets 2 and 3 - 1970 County and national employment by industry was by place of residence.

Sources: U.S. Bureau of the Census (1970b) and U.S. Bureau of the Census (1971).

Data Set 4 - These coefficients were derived from the employment data above. The population-employment ratio (b_1) used for each time period was the actual ratio calculated from the model results of the preceding time period.

Source: Data Sets 2 and 3.

Data Set 5 - 1970 export and local employment estimates were calculated based upon the coefficients from Data Set 4.

Source: Data Set 4.

Data Set 6 - Projected growth in export employment was based upon assumed average annual rate of growth for export employment developed on the basis of alternative futures.

Source: All growth rates were judgmental and were derived from scenarios.

Given these data inputs and sources of data, each scenario had an inherent set of assumptions which directed its quantification and thus change into an alternative future. The projections for all scenarios from the 1970 base data are given below along with projections for 1975 to 1990. The product of this quantification and projection process is a set of alternative futures.

Assumptions

The estimated employment patterns for all scenarios for 1970-75 were identical. The average annual rate of change for all export employment (with the exception of agriculture) was estimated to be 12 percent (i.e., 12 percent increase per year). The level for agricultural employment was assumed to remain constant at the 1970 level. Trade patterns were assumed to remain constant over this period also.

Scenario 1: Preservation/Tourism. Under the assumptions of this scenario, the study area would continue to develop its tourist-oriented industries but only to the extent that the development is compatible with the protection of the surrounding environment. As a result of this protective orientation, growth in the export employment levels would be considerably slower than under a "business as usual" approach. While total employment would continue to increase, the rate of change would be much lower than that experienced during the early 1970's. Agricultural employment would decline at an average annual rate of 1 percent while mining and lumber and wood products employment would remain stable at 1975 levels. All other export employment would increase at a rate of 3 percent per year. Relative trading patterns would remain constant at the base year levels.

Scenario 2: Extractive and Light Industry--High Development. The assumptions of this scenario dictate an expanding economic base for the study area. Traditional urban type development, except for heavy manufacturing, would be encouraged along with more intensive development of the extractive industries. A "year-round" economy which is not heavily dependent upon services imported from outside the area is visualized for this scenario. Agricultural employment is expected to decline by 1 percent per year while mining and forestry related activities will increase at an average annual rate of 5 percent per year. Industries which are presently export oriented will continue to grow at 3 percent per year. Several light industrial operations are expected to locate in the area between 1976 and 1980 and these can be expected to expand somewhat over time. In addition, those business-serving and population-serving industries which are presently under-represented in the area are expected to expand to a point of self-sufficiency by 1980.

Scenario 3: Tourism--High Development. The principal assumption of this scenario involves the increased development of tourist recreation related activities in the study area. For this alternative, agricultural employment is projected to decline at an average annual rate of 1 percent with mining and forestry related activities remaining constant at 1975 levels. Those industries which are presently export-oriented are, for the most part, related to the tourist-recreation market and are expected to grow at a rate of 5 percent per year. No new light industry is projected for this scenario and trading patterns are held constant at base year levels.

Scenario 4: Preservation. For this scenario, emphasis will be placed upon the natural environment. The goal will be to maintain and enhance, where possible, wildlife, open space and the aesthetic qualities of the area. Developments which rapidly expand population or change the present character of the region will be discouraged. Although agricultural land would be maintained under the assumptions of this scenario, agricultural employment would continue to decline at 1 percent per year. Mining and forest product industries which are already established would continue in operation; however, no significant employment growth would occur in these industries. All other export industries would increase at an average annual rate of 2 percent per year. No new industries are expected under this scenario. Total employment would continue to increase under these assumptions, but at a rate far below that of recent years.

Scenario 5: Tourism/Industry--Moderate Development. This scenario emphasizes the development of both the tourist and light industry potentials of the area. The tourist-recreation based activities would be encouraged, and at the same time, some light industry would be encouraged to expand and stabilize the economic base. Under the assumptions of this scenario, agricultural employment would decline at 1 percent per year, mining and forestry related activities would increase at 3 percent per year, while all other export employment would grow at 4 percent per year. Several light industrial operations are projected to locate in the area between 1976 and 1980; however, future growth for these industries is expected to be minimal. In addition, those business-serving and population-serving industries which are presently under-represented in the area are expected to reach self-sufficiency by 1990.

The Futures

FUTURE 1: PRESERVATION/TOURISM

Grand County will continue to develop its tourist industry, but only to the extent that the development is compatible with protecting the environment. Tourist facilities will not be allowed to harm the best scenic, wildlife and backcountry areas of the County. Developments will mostly be for transients and located in areas already having tourist development like along highway corridors, the Three Lakes area and existing communities. Year-round recreation opportunities would be encouraged in order to stabilize the job market. Local government will have to exercise strong controls in order to accomplish goals.

With this future, by 1990 there would be 1,016 new jobs in the County. But not much real economic growth would happen in the County. The population would increase by about 500 residents by 1980 and by another 1,500 by 1990. The land needed for these developments would be less than 1 percent of the total available, with about 188 acres needed in Grand Lake, 268 in Granby, 35 in Fraser, 145 in Hot Sulphur Springs, and 163 in Kremmling.

FUTURE 2: EXTRACTIVE AND LIGHT INDUSTRY--HIGH DEVELOPMENT

In order to stablize the economy, local government officials will do all they possibly can to encourage both extractive (i.e., mining, lumber) and light industries in the County. There will be little government control except that necessitated by state and national regulations. Natural amenities will be protected, but not at the expense of industry. Tourism will still be encouraged, particularly around the Three Lakes and Winter Park areas.

This future indicates that the economy will be greatly accelerated by an additional 4,500 jobs by 1990. The total population for the County will reach 15,400 by 1990, an increase from 1975 of 9,100 residents. The land for this development would be about 795 acres in Grand Lake, 1,279 in Granby, 190 in Fraser, 614 in Hot Sulphur Springs, and 810 in Kremmling.

FUTURE 3. TOURISM--HIGH DEVELOPMENT

Areas of the County are to be developed giving greatest consideration to their economic potential as tourist "attractors." The natural environment will be maintained to the extent that it makes Grand County more appealing to tourists. Local government control will be moderate. Second home developments (middle to high income) will be encouraged, campgrounds and boating areas will also be developed. Tourists will be encouraged to visit Grand County for a day or a month. The Three Lakes area will be developed as a high density, activity oriented area.

If this future is pursued, an additional 2,016 jobs would be created by 1990. The population of the County will increase by 1,000 residents by 1980 and 4,100 by 1990. These people and their developments would need about 544 acres in Granby, 407 in Grand Lake, 59 in Fraser, 347 in Hot Sulphur Springs, and 307 in Kremmling.

FUTURE 4: PRESERVATION

Emphasis in planning will be placed on the natural environment. The goal is to maintain and enhance, where possible, to the greatest degree possible, wildlife, open space, and aesthetic qualities of the County. Developments which rapidly expand population or change the present character of the area will be discouraged. Agricultural land would be maintained for agriculture and open space. Strong local governmental controls are necessary to reach this future, with development and economic opportunities being sacrificed to maintain the natural environment.

The results of such a policy would be slow growth of the County. In 1990 there would be about 600 more jobs than there are today. The total population would increase from 6,347 in 1975 to 6,646 in 1980 and 7,586 in 1990. The land needs for development would be 103 acres in Grand Lake, 144 in Granby, 13 in Fraser, 98 in Hot Sulphur Springs, and 68 in Kremmling.

FUTURE 5: TOURISM/INDUSTRY--MODERATE DEVELOPMENT

This future emphasizes both the County's tourist and industrial bases. Fairly strong local governmental controls would be needed to preserve the tourist qualities of the area while still providing for industrial opportunities. Therefore, air and water pollution, open space, scenic and transportation controls would all be important. This future would be difficult to reach because it calls for growth in sectors which are often conflicting. Moderate development of ski facilities and other winter sports would be encouraged. There would be controlled growth of summer recreation opportunities, particularly in the Three Lakes and Fraser River areas.

With this future, total employment in the County would reach 6,875 by 1990, an increase from 1975 of 3,926 jobs. In 1990, the County population would have increased by 7,923. The acreage needed for these people and developments would be 803 in Grand Lake, 1,106 in Granby, 140 in Fraser, 601 in Hot Sulphur Springs, and 660 in Kremmling.

Estimating Impacts of Futures

The process as described earlier calls for the estimation of impacts which would occur if an alternative future was realized. Impacts need to be estimated so that those persons charged with selecting a desired future know the consequences of their decision.

For the eastern Grand County study area, impacts of each alternative future were established for four components of the total environment: demographic, economic, infrastructure, and environmental. Following is a discussion of the process utilized and the impacts.

Resource Weighting and Compositing

Weighting and compositing the individual resource data into a single map was necessary for estimating impacts on the environmental resource sector. The product of this process is often called a land suitability composite, since it identifies parcels of land that are the most suitable for specific uses given a set of assumptions and constraints.

One problem that must be dealt with is the relative importance of the individual resource factors. Often one or two resource factors are considered to be more important than the others. However, one must be able to demonstrate that he is neither injecting his own biases nor being arbitrary in the weighting scheme proposed. Having a statement of goals and objectives for the planning region, on which to base resource weighting, permits objective weighting.

In this project, the five scenario descriptions provided the goals and objectives that were needed. Through careful study of the scenario descriptions, concurrence on what resource weights were implied by each scenario was reached by the resource specialists.

This exercise reflected the interdisciplinary nature of the resource phase of this project. It was obvious that each specialist valued his resource highly, and desired to have it play a major role in all the scenarios. However, by having the group examine the weighting proposed by each specialist, the decision-making logic used by each was made explicit. Biases for or against particular resource factors were thereby exposed and corrected.

The product of the interaction was a scenario-specific resource weight matrix. Of the six resource factors listed, it was later decided that the soils and hydrologic information would not be included in the general compositing process. The highly detailed and site specific data on soil would have been blurred in the compositing process. Additionally, the key hydrologic information was of much less detail than the other resource data. Therefore, it was decided that soils and hydrologic information would be utilized during the land allocation phase to help select the best (least-cost) site for a particular land use from the possible sites as delineated by the resource composite maps.

A one-to-five resource weighting scheme was chosen. A weight of five implied that a resource was a major constraint on land development. As a resource weight decreased to four and then three, larger areas of developable land occurred on the land suitability maps. An example would be the rating that a deer migration route would receive under different resource weights for different scenarios. A weight of five was set for wildlife in Scenario I, and land crossed by migration route was classed as prohibitive to development. The prohibitive category implied that unacceptable resource damage was likely to occur if development took place. In Scenario II, a weight of four was set, and in this case the land crossed by a migration route was classed as restrictive to development. The restrictive category implied that while development should be placed elsewhere if possible, limited development was feasible if there was not another viable alternative tract of land. For Scenario III and a weight of three, the migration route was classed as allowed. This weight implied that the wildlife resource was not important enough to impede development where the migration route was not vital to the wildlife population.

A weight of two implied that the resource was important enough to be included in the compositing process, but only on the basis of public health and safety. The geologic hazard was an example of this category in Scenario IV. Geologic features such as rockfall areas must be considered even in the high development scenario insofar as the hazards are a threat to human health and safety.

Finally, a weight of one denoted that a resource was so unimportant, on a relative basis, that it was not even included in the composite process. As examples, wildlife and visual vulnerability received a weight of one in the high development Scenario IV, and were therefore not even considered as limiting factors.

It should be made clear that the resource weights used in this project are not absolutes. If different goals were expressed in the scenarios, it is likely that different resource weights should be applied. The flexibiity of this procedure is one of its greatest strengths, since it is the weighting process rather than the actual weights that is important. The ability to change weighting schemes to reflect different locations, policies, and public preferences is vital if the procedure is to be broadly applied as an analytical tool.

Once the resource weighting process was completed, resource maps delineating allowed, restrictive, and prohibitive areas were constructed for each scenario. During the compositing phase, for each scenario, the individual resource maps were overlaid to produce a composite land suitability map. Since there were five scenarios, seven quads and usually four resource maps for each scenario, a total of 126 resource maps was overlaid to produce 35 scenario composite maps.

The compositing process was based on a technique made popular by Ian McHarg (1969). McHarg developed an overlay process using shades of gray. His composite maps displayed light and dark areas, with the dark areas usually denoting areas that had high hazards to development. This process was modified to retain larger amounts of information in the composites, and to allow differential weighting of individual resources, as noted above. Rather than shades of gray, a three-level suitability index, allowed, restrictive, and prohibitive was employed. In utilizing these categories it is important to note that many inherent limitations can be overcome if costly engineering techniques are employed. However, the process was based on natural limitations and assumed that developers would use the usual engineering and building practices employed in the area.

The process of producing an individual composite entails many steps and considerable cartographic expertise. A composite map is initially nothing more than a simple base map. It only becomes a true composite when two or more resources have been transferred onto it. The first step is to remove from the composite (base map) all lands classed as prohibitive on any resource map--these lands were outlined and colored red. The next step is to go back through each of the resource maps again, drawing lines on the composite and labeling areas either allowed or restrictive. Allowed areas were allowed for all resources, while restrictive areas were indexed with a letter to specify which resources were limiting. For examples, Rwvx means that a parcel is allowed for geology, but is restrictive for wildlife, vegetation, and visual vulnerability.

When all four resource factors had been composited, a final comparison (overlay) was then made with the slope and wildfire maps. Any allowed or restrictive areas that had slopes in excess of 30 percent were classed as prohibitive, reflecting current County building codes. Similarly, the comparison process was carried out to rate as restrictive any areas with wildfire potential.

Since the completed composites were regarded as the available supply of land for development under each scenario, the next step was to remove all land that was already developed. By overlaying the present land use maps these areas were netted out. The remaining areas of allowed and restrictive land were then measured utilizing a dot grid counting technique. The final product was a tally of hectares of allowed and restrictive land for each of the thirty-five composite maps. The hectares tallied became allocation constraints in the partitioning model described in a following section.

Generating Resource Needs

Human activities are distributed over the regional landscape in patterns and arrangements that result neither from arbitrariness nor chance. They result from the interdependencies that give form to economic and social space. These spatial patterns change with shifts in the structure of demand and production, in the level of technology, and with changes in a region's political and social organization. The economic and social development of a region is reflected in its patterns of settlement, its systems of flows and exchanges of commodities, money, information and resources, its patterns of commuting and migration, and its distribution of areas of urban influence (Friedmann and Alonso, 1964).

Public policy is an expression of the various goals and objectives relating in general to economic and social activities within a region. Public policy has thus become concerned with the manner and pace of development in subregional areas. Accordingly, space and distance are increasingly considered explicitly in the determination of these policies. Thus, the means for ascertaining the most suitable public policy is concerned with requisite information about the spatial attributes of the region and its subregions.

In order to analyze various aspects of alternative futures, information regarding the spatial arrangement of populations, activities and facilities is necessary. Once the location of activities associated with a future have been estimated, the interactions between human and natural environments can be examined in an impact analysis mode. Similarly, the state of the community system can be subjected to evaluation by normative criteria.

As a part of the study process, a mathematical process was designed to decompose the estimates of total growth for the study region. This partitioning enabled the examination of location specific impacts, including those associated with natural resources and infrastructural facilities. Within the carrying capacity system, the allocation subsystems function as linkages between the various resource models and the set of perturbations which initiate a set of impacts. Figure 14 provides a graphic illustration of this relationship.

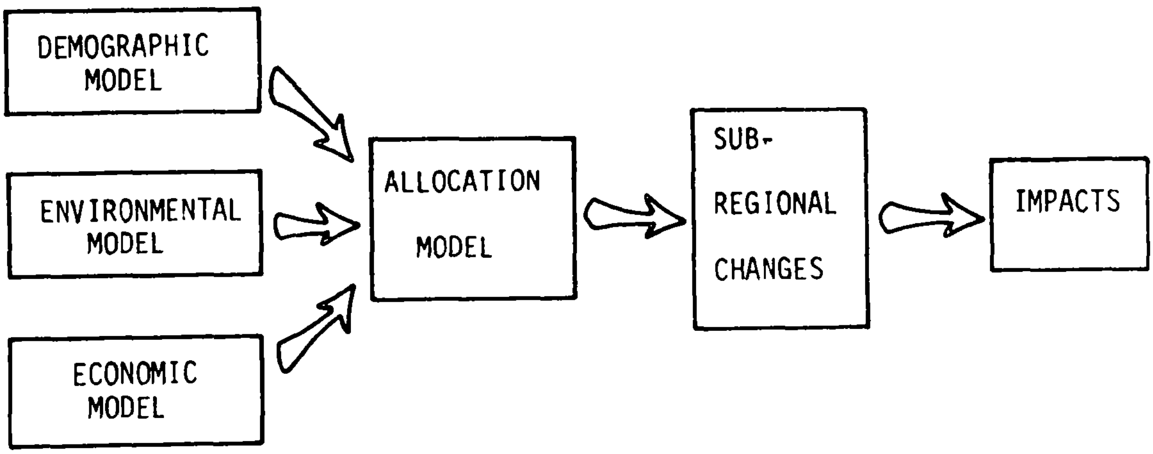


Figure 14. Position of spatial allocation in the planning process.

The analysis of interactions between components of the community system provides the opportunity to estimate future arrangements in space. Figure 15 illustrates a simplified community structure and its component interactions. From information concerning current and historical levels of interaction, estimates can be made regarding the probable future arrangement of these components as a result of change in population or economic activity.

The central focus of the allocation model rests on the relationship between employment and population. The model is designed to allocate activities associated with both resident and nonresident populations. This attribute stems from characteristics common to many rural mountain areas, including Grand County, Colorado. Local growth forces may be the result of normal community expansion and additionally as a response to specialized demand for

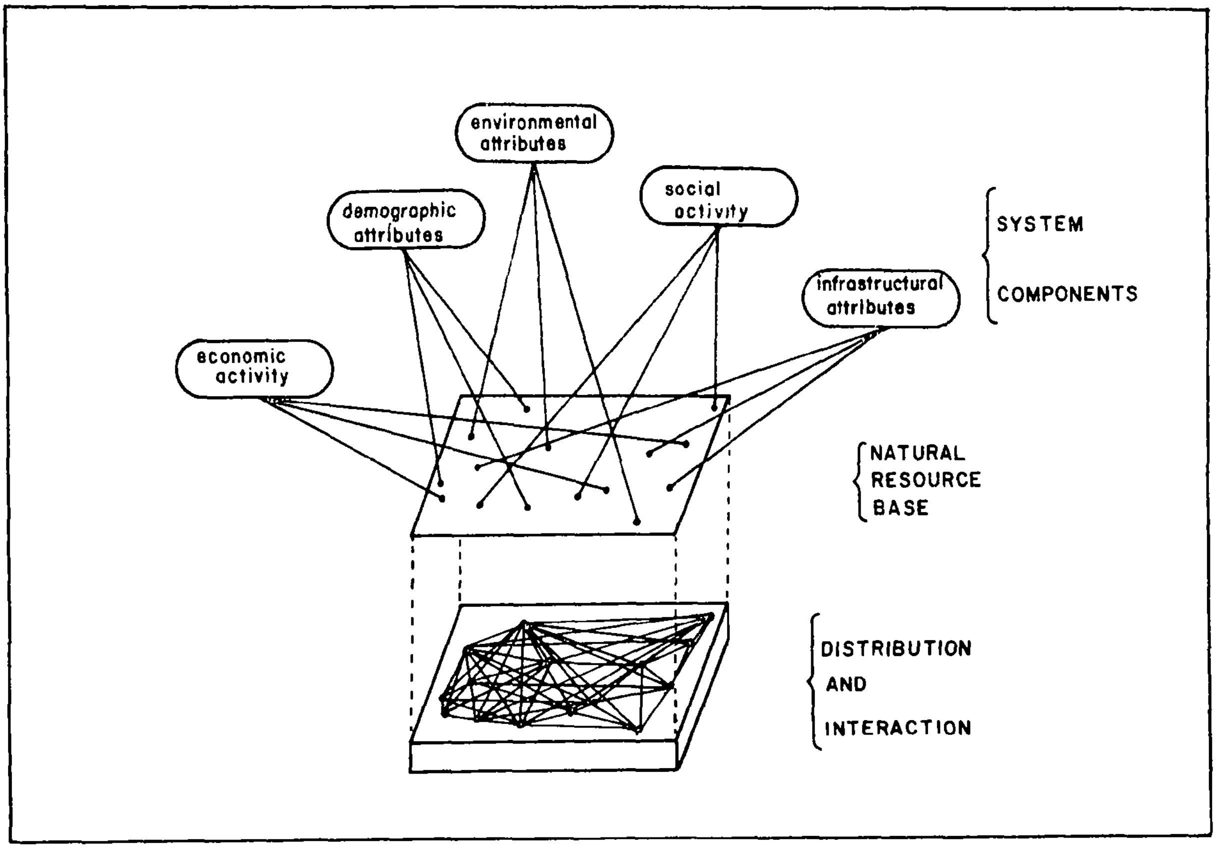


Figure 15. A community structure and its component interactions.

such products as recreation or energy resources. In this manner, the model is responsive not only to the direct effects of population and economic growth resulting from resident activity, but it is likewise responsive to the induced effects of temporary influxes of nonresident populations.

In the aggregate form of the model, activities which occupy space are classified into three taxonomic groups:

1) The basic sector includes those industries which are subject to factors other than local influences. These factors might be unique site features, interindustry linkages, agglomeration economies, resource availabilities, and interregional transportation routes (Goldner, 1971). These "export" industries are largely unconstrained in local site selection and are treated as

exogenously supplied decisions. In other words, a change in the level of basic employment is an input to the model which is derived from the alternative future assumption set.

2) The service and retail sector is linked to the distribution of the resident population. In this manner, the market area for a service center, consisting of business, commercial, administrative, and similar establishments, is tied directly to the population and its purchasing power. Although the individual service centers may compete differentially for customers within a bounded region, the region of study itself is treated as a closed system, thereby defining the term "local." The location and level of employment associated with this sector are treated as endogenous variables and are determined by the model.

The nomenclature used here is similar to that developed for the economic base concept (Tiebout, 1962). It should be pointed out, however, that this economic dichotomy does not necessarily follow that of the economic base mechanism. The above definitions are based more stringently upon location features rather than strict interindustry and interregional marketing criteria. As Lowery (1964) suggests, better descriptions might be "site-oriented" for basic and "residence-oriented" for service.

3) The population sector consists of both resident and transient populations. It is assumed that the level of employment in the service and retail sector is directly related to the number of resident households and the level of temporary population within the region

at a given time. The resident population is in turn dependent upon the number of job opportunities in the basic and service sectors. The distribution of households is assumed to be largely influenced by the location of the resident's workplace and his value structure regarding the natural environment. The number and location of households (and population) is endogenously determined by the model.

The model distributes activities throughout a bounded region. These activities are located in subregions or zones within the region. This distribution is possible because non-homogeneity is characteristic of geographical areas. Further, the subregional concept is an aid in the description and understanding of the impact of spatial friction and differentiation on human activity (Tiertz, 1962). The purpose of partitioning a region into zones is to reduce the non-homogeneity of the constituent set with which the analysis is concerned to some acceptable level of homogeneity. Reflecting a concern for interaction between members of the constituent set, homogeneity was an overriding criterion in the determination of the zones. Thus, the region was partitioned into zones corresponding to nodes, those areas capable of reflecting a great diversity of elements bound together in a systematic way by interconnections, interactions or flows. Each nodal zone expressed an internal uniformity of organization with regard to information flow, economic activity, and infrastructural facilities.

The partitioning sequence begins with either a change in employment or a change in non-resident opulation. To analyze distribution changes associated with resident population, exogenously determined levels and location of basic employment serve as the driving variables. This input is obtained from the population and employment models previously described. Through the use of allocation functions of the gravity type, workers employed in these new jobs are allocated to zones of residence. In turn, the generated service demand is distributed by the use of a similar allocation function. Multipliers are used to calculate total subregional population, number of households, service demand, land consumption, and employment. To analyze the impact of non-residents upon the system, the initial input consists of the projected change in the number of transients. This triggers a demand for services. The remaining changes are determined in a manner similar to that outlined above, although the parameters differ. Since control totals for employment and population are provided by other models, the allocation process is solved repeatedly in an iterative manner until convergence with these totals is attained.

Land consumption rates are determined exogenously for each land use, usually by examining local historical ratios. As subtotals of population are allocated to zones in an iterative manner, the consumption rates are applied and the results compared to the available amounts of land as determined by the resource analysis model. If the allocated portion of the total population increase exceeds the holding capacity of the zones, the excess is reallocated to the remaining zone.

A common nemesis of mathematical models is their insatiable appetite for data. Fortunately for planning analysts, data requirements for this model are relatively small. Most are available during normal data gathering undertaken in the planning process. Baseline data on employment, population, travel times and land use are included in this category. Attractiveness indices can be obtained from the analysis of properly implemented surveys. Alternative futures are expressions of public policy.

Infrastructure

Importance

Infrastructure is one of four subsystems in the carrying capacity model. It has been defined as the "underlying capital of a society embodied in roads and other transportation and communications systems, as well as water supplies, electric power, and other public services. ....the term is also often widened to include the health, skills, education and other qualities of the population" (Bannock, et al., 1972). It is the foundation that underlies a community's economy and determines the degree of its economic activity. This infrastructure resource links the composite of community activities such as education, recreation, commerce, and personal services to a range of physical products, often termed regional outputs. Public services and distribution networks are typical infrastructure linkages. Such linkages or infrastructure components may be in the form of waste water and water treatment, transportation, solid waste disposal, hospitals, schools, and fire and police protection. The current capabilities of the infrastructure and the products they distribute to sustain activity are key aspects of the carrying capacity of a community. As such, infrastructure represents short- and medium-run constraints on an area's growth potential, both in terms of quality and quantity. Infrastructure resources in the long-run may be expanded or reduced to meet a region's demand by modifying capital investment of those resources.

Process

In order to examine whether or not growth forces in the study area would effect change in the infrastructure base, it was necessary to first determine the adequacy of the area's existing infrastructure resources.

The adequacy of infrastructure components was determined in two ways. The first method was to review historical ratios between population and infrastructure requirements; for example, per capita waste water discharge and treatment plant capacity. Most historic infrastructure ratios are typically derived from urban studies. The second approach was to determine if the infrastructure output was provided at a level sufficient to meet accepted standards, either in terms of performance or convenience. Performance standards provide criteria for testing the degree of hazards or nuisances to human life which may be present. Criteria are usually developed from health, safety, or amenity elements which are in the public interest. Convenience standards are less closely defined, but are used as guidelines in determining infrastructure resource adequacy. Standards of these types were found, for the study area, for such components as schools, police and fire protection, and air and water quality.

Two levels of service must be considered in the examination; this is dependent on the level of government at which the service is provided. Certain components were examined at the County level; police protection, solid waste disposal, and hospitals were of this category. Others, such as schools, waste water and water treatment, and fire protection were handled on a district basis for the service is only provided to people residing in that district. Specifically, for this study inventory, an analysis was conducted on the following infrastructure resources:

Sewage Disposal	Police Protection
Water Supply	Hospitals
Transportation	Recreation Areas
Education	Solid Waste Disposal
Fire Protection	

Quasi-public utilities such as electric and natural gas and telephone services were not considered in the same manner as public services. Due to the nature in which these services are supplied by the quasi-public utility companies, it was found that any increase in demand would be met by these utility companies. Therefore, it was concluded that services of this type would not constrain the forecasted population growth for the study area.

The resources of concern were both mapped and described using secondary data obtained from field interviews and site checks. Following is a discussion on data sources and situation descriptions for each infrastructure component. Then, interpretation and uses of the infrastructure subsystem in the carrying capacity model are discussed.

Water Supply and Waste Water Treatment

Both individual and central systems are included in this infrastructure component. Individual systems are those which service only one household whereas central systems service many. There are currently eleven water and sanitation districts which provide central system service in the study area. Five of these districts have established water supply and waste water treatment systems. The data source for these districts was primarily an engineering study entitled "Water & Sewer Facility Plan - 1972" for Grand County prepared by Oblinger-Smith Corp. County, District, or EPA sponsored Area Wide Water Quality Plans and engineering studies are potential secondary data sources. The Facility Plan was updated with field interviews to more accurately determine existing conditions. A synopsis of water supply and waste water treatment plant carrying capacity for the five districts is shown in Table 16. The water supply standard typically used for engineering design is 140 liters (37 gallons) per capita per day. However, maximum water usage is also significant when peak daily demands or fire demands are considered. It has been found that the maximum instantaneous demand will not exceed 2.5 lpm (.67 gpm) per capita. Based on a maximum use of

Table 16. Capacity of the water and sanitation districts within the study area.

District Name	Service Area Description	Capacity Description	
		Water Supply	Waste Water Treatment
Fraser Sanitation District	The Incorporated town of Fraser (sewer also Winter Park West Sanitation District)	Deficit for peak fire flow demands	Excess capacity--will handle 1750 more people
Granby Sanitation District	The Incorporated town of Granby	No excess or under capacity	No excess or under capacity
Grand Lake Water and Sanitation District	The Incorporated town of Grand Lake and Columbine Lake Water and Sanitation District	Deficit for large peak fire flow demands and large peak tourism demands	Deficit for large peak tourism demands
Winter Park West Water and Sanitation District	The Winter Park area of the Fraser Valley	Will handle an excess of 300 more people	Excess included in the 1750 people of Fraser
Grand County Water and Sanitation District #1	Hideaway Park Area of the Fraser Valley	Considerable excess capacity--will handle 4,000 more people	Deficit of approximately 100 permanent resident capacity, and large deficit during peak tourist season

eight hours, this demand would amount to 1212 liters (320 gallons) per capita per day (Stoltenberg, D. H., 1970). Water systems are being designed to meet this standard of 1212 liters (320 gallons) per capita per day and, therefore, it was used as the standard in this analysis.

Individual systems, such as wells or septic tanks, were not analyzed in terms of their adequacy to supply water or dispose of waste water. Data are lacking in this area. Wells and septic tanks are both heavily site dependent and a primary data survey is needed to determine their adequacy. Individual systems, however, do play a significant role in water supply and waste water treatment for people in the study area who reside outside of water and sanitation district service areas.

Transportation

Major highways in the study area are U.S. Routes 40, 34, and 125. Total distance for federal highways in the study area is 111.5 kilometers (69.4 miles). Roads maintained by the County total 369 kilometers (229.5 miles), 196 km (122 miles) of which are primary gravel roads and 173 km (107.5 miles) of secondary gravel roads. Road data were obtained from the Colorado State Highway Department and the Grand County Surveyor.

The capacity of a roadway is a measure of its ability to accommodate traffic at an acceptable level of service. The prevailing conditions such as traffic composition, roadway alignment, and number and width of lanes usually determine the capacity. Specifically, there are two groups of prevailing conditions. One group is the prevailing roadway conditions which are established by the physical features of the roadway. These may change only with construction or reconstruction of the roadway. Another group is the prevailing traffic conditions. These conditions depend on the nature of the traffic on the roadway and may change hour to hour or during various periods of the day. Ambient conditions such as rain, fog, and snow also affect capacity; however, data of this nature are limited and not used to quantify effects on capacity (Highway Research Board, 1965).

Having considered prevailing and ambient conditions, a service volume can be established. This volume is the maximum number of vehicles that can pass over a given section of land or roadway in one direction during a specified time period, while operating conditions are maintained which correspond to the selected or specified level of service. The measurement used in analyzing roadway capacity is Annual Average Daily Traffic (AADT). This is the total yearly volume divided by the number of days in the year. Actually, samples are taken and adjusted to obtain a yearly total.

Although the methodology exists to determine roadway capacity, it is usually extremely site specific. Intersections, traffic lights, cross streets, speed, grades and corners could easily be considered in the analysis. Typically, however, the capacity of a two-lane, two-way roadway under ideal conditions is 1500-2000 passenger vehicles per hour total, regardless of distribution by direction; this estimate assumes the current 88 kmph (55 mph) speed limit. Analysis of the present use rates on these roads indicates that there is considerable excess capacity. For example, the 1974 AADT figures for the intersection of U.S. 34 and 40, the busiest roadway in the study area, was 4250 (Colorado Division of Highways, 1974). Clearly, there is much excess capacity for the state roads in the County. Also, as the speed limit decreases, the capacity of a highway increases. Thus, near the towns where the speed limits are 65 kmph (40 mph) the capacity will actually be higher than 1500-2000 vehicles per hour. One must remember that these figures are average daily figures, and that these use rates do not accurately reflect peak demand loads, especially near high tourism and recreation areas.

To determine whether the roadway is sufficient near these areas requires a detailed, on-site study. County roads will also exhibit different capacities. Because of the lack of traffic usually found on county roads, criteria have not as yet been developed to test their sufficiency.

Education

The entire study area is served by East Grand School District No. 2. There are no institutions of higher learning in the district. All classes for children in the area are held in Granby with the exception of grades 1-6 in Fraser where children attend Fraser Valley Elementary School. The 1973-74 enrollment for the district was as follows: Middle Park Junior-Senior High School--450, Granby Elementary--380, Fraser Valley Elementary--100, for a total of 930 students. According to the Superintendent of Schools, the system has a capacity of 1000 students; this leaves excess space for 70 additional students. However, based upon floor space area standards of 42 square meters (150 ft.^{2}) per high school pupil and 11 square meters (120 ft.^{2}) per elementary school pupil (Nations Schools, 1973), there is currently overcrowding in the school system: The high school by 127 pupils, Fraser Elementary by 55 pupils, and Granby Elementary by 147 pupils. It is not clear that the carrying capacity of the school system has been exceeded; a more detailed analysis would have to be undertaken to determine if this is the case. However, for the purposes of this study, it is concluded that the school system is just adequate to handle present needs and does not have any excess capacity.

Fire Protection

The study area lies within three volunteer fire districts. The fire stations are located in the towns of Granby, Hideaway Park, and Grand Lake. Distance and response time are the usual constraints in providing adequate fire protection in the study area. A definitive adequacy test in the form of performance indices may be achieved utilizing the Grading Schedule for Municipal Fire Protection (Insurance Services Office). This schedule is a means for classifying municipalities according to their fire defenses and physical conditions and is used by insurance agencies as an indicator of fire risks. Ten classes are used to describe the conditions based on deficiencies of the fire department in four areas; these are water supply, the department itself (personnel, etc.), fire service communications, and fire safety control. Nearly 80 percent of the rating is based on the two categories of personnel and available water supply. A class one rating indicates little or no deficiency, i.e., very little fire risk; a class ten rating indicates large deficiency and/or no fire department or water supply. Ratings in the study area are typically class eight within corporate limits, class nine up to one mile outside of corporate limits, and class ten elsewhere within the district. These low ratings are due to the fact that the departments are all volunteer, that there are usually no fire hydrants outside of town, and because distances may be great to a fire.

Police Protection

There are presently 20 officers in the Grand County Sheriff's Department, headquartered in Hot Sulphur Springs. Resident Town Marshals are located in Granby, Grand Lake, and Kremmling; and the Colorado State Patrol also has headquarters at Hot Sulphur Springs for an addition of approximately 10 officers.

As of this time there are no standards for police protection for rural mountain communities. Historic ratio studies have been conducted in metropolitan areas where the recommended number of officers is one per 1000 people (National Advisory Commission on Criminal Justice, 1973). Three other important criteria used to determine this standard include case load, geographical considerations, and ability to respond with backup officers within a reasonable amount of time. Of paramount importance is response time for emergency calls. Because of distance and geography, it is suggested that one officer per 500 people more accurately reflects requirements for rural mountain communities (Henderson, 1974). If one used the 1/500 figure and the total of 30 officers, it could be said that there is sufficient enforcement for 15,000 people, an excess of approximately 8,500 people or 17 officers. However, this conclusion of excess capacity may or may not be correct; as with many infrastructure components, peak demand loads are no exception when considering police protection. Although 85 percent of law enforcement activity may be adequately covered, 15 percent may be peak or "worst case" loads and the department may not have the manpower to adequately protect the community. High levels of transient populations, such as those Grand County experiences in the summer months, or serious crimes, are often the cause of peak demand loads. Also, where cases must be investigated great distances from the police headquarters, investigative officers must stay at the scene for long periods of time. Clearly, this reduces the efficiency of protection for the remainder of the County.

It is concluded that present police protection is adequate to meet present needs. However, the exact excess capacity, if there is any, cannot be found using existing standards or historic ratio criteria.

Hospitals

A 20-bed hospital is located in Kremmling, Colorado, which is approximately 30 miles from most points in the study area. Ambulances are located throughout the County, one each in Hot Sulphur Springs, Grand Lake, and

Granby. The hospital in Kremmling does not service the entire study area. Many residents prefer to travel to Denver Metropolitan hospitals for their health needs. The exact number is not known, but variables which account for large percentages of variations in geographical dispersion of patients include: the required time to reach the hospital providing the type and quality of services that the individual is seeking; the size of the hospital complex; and the number of services provided by that complex (Ault, 1973).

The disutility of distance and uncertainty as to the quality and type of services offered are the considerations people include in making their choice as to which hospital to choose. Distance does not seem to be the single appropriate criterion whereby one can measure hospital adequacy for an individual will travel great distances to receive medical services essential to his survival.

Gravity type models have been developed using distance and attractivity indices (determined by size or services offered) to estimate hospital service areas. Once the service area is known, the population that the facility will serve can be approximated and the hospital's adequacy determined (Ault, 1973). Although tested primarily in metropolitan areas, gravity models could also predict accurately for rural areas.

Because the exact service area of the Kremmling and Denver Metro hospitals are not known, it is impossible at this time to derive a quantitative description of the sufficiency of present health care facilities. Local interviews do not suggest that they are inadequate. Therefore, we can conclude that the carrying capacity for this infrastructure component has not been exceeded.

Recreation

The recreational resource inventory revealed that town recreational areas in Granby and Grand Lake and the district provide the recreational opportunities in the Grand Lake Metropolitan Recreation District. Granby has approximately five acres of land on which are located two tennis courts, two basketball courts, two swingsets, one baseball diamond, and one picnic shelter. Grand Lake has approximately three acres of land on which two tennis courts are located. The Grand Lake Metropolitan Recreation District charged with providing recreational activities to its service area, currently provides a 9-hole golf course with plans for expansion to 18-holes in the near future. The generally accepted standard for recreation space is one acre of land for each 100 persons in the community (Rodney, 1974). Further breakdowns of standards by activity may be found in Rodney (Rodney, 1974); however, these standards are for urbanized areas and cannot be applied to the study area because population figures needed to support each activity are above those of both the towns of Granby and Grand Lake. Suggested space standards are also found in Moeller (Moeller, 1965); however, the same problem exists--standards in Moeller are figured to service a population of 100,000. Adjustment to the study area's populations produces absurd results in terms of facilities and space needed.

The only standard that seems reasonable is for golf courses. Using a stand of one 18-hole golf course per 20,000 population (Moeller, 1965), it is found that there is much excess capacity for this activity.

An abnormality also affects the inventory of the recreational capacity in the study area because approximately 2/3 of the area is federally managed by the Forest Service, National Park Service, or BLM. Any established standards will tend to overestimate the area needed in municipal and district areas because the federal lands provide many recreational needs. Local government is, therefore, not obliged to supply the recreational space suggested by the known standards. It is concluded that there is much excess recreational capacity; however, this capacity may not be in the form of established facilities. Standards do not yet exist to determine capacity for recreational facilities in rural areas where opportunities exist for recreation on vast amounts of federal land.

Solid Waste Disposal

Solid waste disposal sites are supplied by the County government. The data source was the Grand County Sanitarian for present description and situation and the Colorado Department of Health for standards and regulations. Two sanitary landfill operations are working in the County, one in the Fraser area and one near Granby. Adequacy was determined by using present state and County regulations (i.e., performance standards). If these regulations are not being met, then capacity has been exceeded. Minimum standards that must be met are: control of obnoxious odors, prohibition of radioactive materials, nuisance minimization such as windblown debris, insect and rodent control, adequate fencing, absence of burning, and covering of the landfill with soil at the end of each working day (Colorado Department of Health). The County is currently under a cease and desist order from the State of Colorado Department of Health to stop operations at the Granby dump. There is no more room both in volume and area at the present time to support any more solid waste for residents in the Granby area.

A fair average allowance of landfill space is three cubic meters (4 cubic yards) per capita for a 20-year period (Colonna, R. A., and C. McLaren, 1974). However, it is difficult to determine the amount needed in terms of volume required for a mountain community. The volume of space required is "....primarily dependent upon the character and quantity of the solid wastes, the efficiency of compaction of the wastes, the depth of fill, and the desired life of the landfill" (Colonna, R. A., and C. McClaren, 1974). The volume requirement then should be determined on the basis of specific data and information. Although efforts are underway to obtain a new landfill site, it must be concluded that because present operations do not meet state standards, they are not adequate and the carrying capacity in the Granby area has been exceeded.

Interpretation

Each infrastructure component must be interpreted individually when determining the capacity status of that component. Standards, regulations, and historic ratios have been used to determine if existing infrastructure systems are sufficient to meet projected demands. This procedure has been used in the urban setting (Isard, 1957), and conceptually the procedure seems quite adequate for the mountain environment. There may, however, be some inherent problems associated with using urban standards as criteria for evaluating infrastructure adequacy in a rural mountain setting. The mountain setting is typically quite variable in terms of topography, climate, and physiography, and it is to be expected that standards should also vary. Requirements for public service facilities must be typically determined on the basis of on-site studies in order to meet the individual needs of each facility. Also, some standards for infrastructure components are as yet imperfectly developed, some being more highly developed than others (Chapin, 1965). For example, the analysis for fire protection was much more exact than for hospitals. Also, many historic ratios of per capita water use and waste water generation are usually from urban areas. Chapin suggests that where there are variations in the circumstances of infrastructure components, variable standards may be warranted (Chapin, 1965).

Definitions of desirable standards are often only subjective in nature, and performance standards are presently focused on minimum rather than "desirable" standards (Isard, 1957). Isard suggests that space requirements for public service facilities should be determined on the basis of special studies of the individual needs of each facility and that the site size and/or capacity should be dictated by these needs (Isard, 1957). In a study conducted on residential and second home uses, a conclusion is drawn regarding the inadequate data sources for infrastructure resources. It says:

> A review of available literature indicates that some research has been done and methodological appraoches are available. However, the research emphasis in this area is usually on the demands for goods and services from the private sector and the objective is primarily to determine the multiplier effect. Data about the effects of vacation home developments and industrial based "new towns" on the demand for, and the supply of, public goods and services are almost completely lacking. (Williams, Anne S., et al., 1974).

Of special concern is the inadequacy of the infrastructure subsystem to handle individual systems, such as septic tanks and wells. These systems are ignored in the final determination of a specific region's carrying capacity. Although proxies such as water quality may be used to analyze these systems, these data are also often lacking.

It is concluded that in many cases, individuals in rural settings have made a tradeoff in their consumption of public services and choose less of those services for a "country lifestyle." This decision presumes that a greater risk has been undertaken in terms of health care or police and fire protection. Standards and regulations developed for urban centers may not adequately reflect the value Grand County residents put on those services. The assumption has been made, through this procedure, that both urban and rural residents place the same value on public services as the same criteria used to evaluate urban infrastructure were used to evaluate rural infrastructure. Clearly, in terms of health facilities and fire protection the same criteria do not hold and when interpreting an individual infrastructure component for adequacy, the method used must be considered.

With recognition of these data and methodological limitations, there are some conclusions warranted from the analysis. For the central water supply, central waste water treatment, solid waste, and fire protection components, there are existing deficits. Police and hospital services appear adequate to meet existing needs, but the amount of excess capacity in these components is not known. The educational system is operating at capacity. The only obvious areas that can handle growth (where excess capacity exists) without new investment are transportation and recreation. One might conclude from this analysis that there are presently significant infrastructure capacity constraints to the growth of eastern Grand County. Any alternative future for which growth is projected will demand expansion of the infrastructure of eastern Grand County.

Allocation of Development

The product of the population and economic modeling process was the generation of resource needs; in particular, hectares of land needed to satisfy the demand for residential housing, vacation housing, and business-commercial development. Since the scenario composites represent the supply of environmentally suitable land, the projected demand was sited directly on the composites. Once the demand was sited it was possible to estimate the impacts of the alternative futures for both the environmental factors and the infrastructure components.

In order to locate the resource demands on the scenario composites, it was necessary to formulate a set of guidelines. The guidelines were developed to make the allocation process as realistic as possible, but there are definite limitations inherent in the allocation process. While the composite maps identify private lands that are environmentally best suited for development, it is impossible to accurately reflect the actions of individual developers. In the real situation when a developer owns land and wants to develop it for second homes, he will often attempt to do so regardless of the environmental suitability of that land. Often, all he must do is comply with existing county regulations concerning plat sizes, services, road widths, and other requirements. He can ignore to a large degree the environmental factors on which the composites are based. However, in carrying out the study process, it was assumed that County regulations would support the use of our environmental composites. Based on that assumption, the following guidelines were developed:

1. Location of the demand was sited on areas of suitable land nearest to the existing population centers. If all the allowed parcels of land were consumed, or when they had severe soils and hydrologic constraints, demand was sited on the least restrictive parcels closest to the towns.

2. All existing County-approved and maintained roads were considered to be transportation corridors. Under the scenario descriptions, new roads were assumed permissible only in the high development Scenario IV. For the other scenarios the siting was based on a concept of least cost for the public, i.e., the County. Since new road construction, maintenance, and snow plowing are large public expenditures, this assumption seemed reasonable. Other utilities, such as electricity and telephones, are costs borne by the private developer, so access to these services was not considered.

3. In all the scenarios, business and commercial demands were sited first. This seemed reasonable due to the fact that access to the main highways, U.S. 34 and U.S. 40, is more important for businesses than for residences or vacation homes. Also, businesses are more likely to be able to afford the high-cost land adjacent to the present towns on the main highway corridors. No separate business-commercial sitings on areas smaller than

two hectares were made. If the demand was two hectares or less, it was assumed that there would be space available within the exiting town boundaries to absorb the projected demand. Residential demand was sited second, and vacation demand sited last.

4. Allocation of the total demand for each category was split into any size that seemed reasonable. However, allocations of less than two hectares were avoided for the residential and vacation categories. This decision was based on the premise that the infrastructure costs, such as water and sewer lines, should be maintained. Many small areas would be much more costly to service than several larger areas. Hence, the infrastructure costs are a response to location of the demand based on environmental hazards and the distance to the nearest population center.

5. If there were two towns in an area (e.g., Granby sector), the demand categories were generally split into two groups. The percentage of each of the three demand categories was roughly proportional to the size of the two towns. Thus, it was assumed that the towns in the areas would grow at an even rate, rather than allowing the size of one town to quadruple while the others stayed the same.

These guidelines were utilized to allocate the demand into three such areas of the study area. The allocation process was carried out by overlaying the soils maps on the composites. In this way the soils and hydrologic limitations of each environmentally suitable area of land could be ascertained. Usually there were enough allowed parcels of land adjacent to County roads with low to moderate soils and hydrologic limitations to site the projected demand on each scenario campsite. However, in some cases, and especially in Scenario I, there was no allowed land, or not enough to absorb the development. There were also cases in which the allowed land had severe soils and hydrologic limitations. In these special situations the demand was sited on restrictive areas. Parcels were selected that had the fewest number of limiting environmental factors, balanced with the soils and hydrologic limitations and the other guidelines.

Table 17 shows the allocation of land demand for each alternative future. Demand allocation for residential, vacation, and business-commercial development is given. The table shows land suitability class, area required, and the general location of allocation.

Once the allocation phase was complete, the environmental impacts and infrastructure demands could be calculated. This subject is treated in the following section.

Impact Estimation

Estimating the impacts from each of the alternative futures is necessary for full evaluation of each future. Impacts on the environmental system were estimated for each alternative future. Summary results of this impact assess ment are given below. The environmental impacts are only given for the Granby Quadrangle (USGS) as an illustration.

The lands likely to be utilized under each future for commercial/ business, permanent residential, and vacation residential are shown in figures 16 through 20 for the Granby Quadrangle. Allocation of uses to these lands came through the process outlined above. The allocation is to lands capable of producing the land use activity with the least environmental disturbance (given the goals of each scenario) and the most feasible opportunity.

Vegetation

Vegetation in the Granby region consists of five major ecosystems. The streamside ecosystem parallels the waterways, the mountain dry ecosystem

Table 17. Allocation of land demand giving suitability class, use, area, and general location.

Land Suitability Map (Scenario)	Granby				Fraser				Grand Lake			
	Land Class[a]	Use[b]	Area[c]	Location	Land Class[a]	Use[b]	Area[c]	Location	Land Class[a]	Use[b]	Area[c]	Location
I	R	BC	14.14	SE of Granby	R	BC	1.21	In Fraser	R	BC	8.08	W of Grand Lake
	R	BC	2.02	In Granby	R	R	.81	SW of Fraser	R	BC	5.66	E of Grand Lake
	R	R	14.54	S of Granby	R	V	3.64	SW of Fraser	R	R	10.10	NW of NRA Hdqts.
	R	R	6.06	NW of Granby					R	R	6.06	W of Grand Lake
	R	R	4.04	NW of Granby					R	V	19.80	W of Grand Lake
	R	V	4.04	N of Granby								
	R	V	18.18	S of Granby								
	R	V	13.74	SW of Granby								
II	R	BC	14.14	SE of Granby	R	BC	1.62	In Hideaway Park	R	BC	12.12	W of Grand Lake
	R	BC	6.46	NW of Granby	R	BC	1.62	In Fraser	R	BC	6.06	E of Grand Lake
	R	BC	2.02	In Granby	R	R	2.02	NE of Hideaway Park	R	BC	4.04	E of Grand Lake
	R	R	4.04	N of Granby	R	R	2.02	SW of Fraser	R	R	36.76	E of Grand Lake
	R	R	14.54	SE of Granby	R	V	3.23	NW of Hideaway Park	R	V	8.08	NE of Grand Lake
	R	R	10.10	S of Granby	R	V	3.23	NE of Fraser	R	V	6.46	NE of Grand Lake
	R	R	18.18	S of Granby								
	R	R	6.87	S of Granby								
	R	V	13.74	SW of Granby								
	R	V	14.95	SW of Rainbow Bay								
III	R	BC	14.14	S of Granby	A	BC	2.02	W of Hideaway Park	A	BC	10.10	E of Grand Lake
	A	BC	6.06	NW of Granby	A	BC	2.02	SW of Tabernash	A	BC	8.08	W of Grand Lake
	R	BC	22.22	W of Granby	R	BC	2.42	W of Fraser	A	BC	31.51	N of Granby Pump Stn.
	R	BC	5.66	NE of Granby	A	R	4.85	W of Hideaway Park	A	R	32.72	E of Grand Lake
	A	R	12.12	S of Granby	R	R	7.27	W of Fraser	A	R	77.51	N of Granby Pump Stn.
	A	R	20.20	S of Granby	A	R	2.42	W of Tabernash	A	V	4.44	N of Columbine Lake
	A	R	30.70	S of Granby	A	V	2.83	E of Fraser				
	A	R	62.62	S of Granby								
	A	R	16.16	SW of Granby								
	R	R	19.80	S of Granby								

The column headings Granby, Fraser and Grand Lake are printed under the spanning heading "Sub-Area".

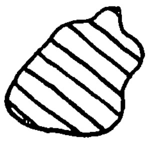
[a]R = Residential, A = Allowed
[b]BC = Business/Commercial
R = Residential
V = Vacation residential
[c]In Hectares

Table 17--Continued.

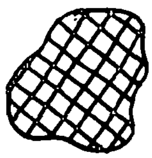
Land Suitability Map (Scenario)	Sub-Area: Granby				Fraser				Grand Lake			
	Land Class[a]	Use[b]	Area[c]	Location	Land Class[a]	Use[b]	Area[c]	Location	Land Class[a]	Use[b]	Area[c]	Location
IV	A	BC	107.87	NW of Granby	A	BC	4.04	SE of Tabernash	A	BC	67.87	E of Grand Lake
	A	BC	18.58	NE of Granby	A	BC	10.10	N of Fraser	A	BC	54.54	SW of Grand Lake
	A	R	170.89	N of Granby	A	BC	8.08	S of Hideaway Park	A	R	154.73	E of Grand Lake
	A	R	51.70	E of Granby	A	R	16.16	SW of Fraser	A	V	31.92	N of NRA Ranger Stn.
	A	R	35.15	S of Granby	A	R	10.10	W of Hideaway Park				
	A	R	66.26	N of 8-Mile School	A	R	4.04	NE of Fraser				
	A	V	16.16	NW of Granby	A	R	4.04	E of Fraser				
	A	V	50.50	SW of Granby	A	R	8.08	S of Tabernash				
					A	V	12.12	E of Tabernash				
V	R	BC	14.14	S of Granby	A	BC	10.10	N of Fraser	A	BC	8.08	W of Grand Lake
	A	BC	6.06	NW of Granby	A	BC	5.66	W of Hideaway Park	A	BC	42.02	SW of Grand Lake
	R	BC	22.22	W of Granby	A	BC	2.02	In Tabernash	A	BC	84.44	N of Granby Pump Stn.
	R	BC	5.60	NE of Granby	A	R	6.06	NE of Hideaway Park	A	R	32.72	E of Grand Lake
	R	BC	29.08	W of Granby	A	R	2.02	NW of Hideaway Park	A	R	121.60	W of Grand Lake
	R	BC	14.14	NE of Granby	A	R	6.06	SW of Tabernash	A	V	8.08	NW of Granby Pump Stn.
	R	BC	4.04	S of Granby	A	R	4.04	E of Fraser	A	V	6.06	NW of Grand Lake
	A	BC	18.18	S of Granby	A	R	10.10	SW of Fraser				
	A	R	12.12	S of Granby	A	V	6.06	SW of Fraser				
	A	R	50.90	S of Granby	A	V	4.44	NE of Fraser				
	A	R	62.62	S of Granby								
	A	R	16.16	SW of Granby								
	R	R	19.80	S of Granby								
	R	R	111.50	N of Granby								
	A	V	10.10	SE of Granby								
	A	V	50.10	W of Val Moritz								

[a] R = Residential, A = Allowed
[b] BC = Business/Commercial
R = Residential
V = Vacation residential
[c] In Hectares

KEY FOR RESOURCE COMPOSITE MAPS, FIGURES 16 to 20.



Existing Developed Areas, exclusive of towns.



Scenario Demand Allocation Areas.

P - Land Areas Prohibitive for Development

R - Land Areas Restrictive for Development for Reasons Indicated by Subscript.

v - vegetation restrictions
x - visual restrictions
w - wildlife restrictions
g - geologic restrictions

A - Land Areas Allowable for Development

B-C - Business-Commercial Development

Res - Year Round Residential Development

Vac - Vacation and Second Home Development

Figure 16. Land allocation for Scenario I resource composite.

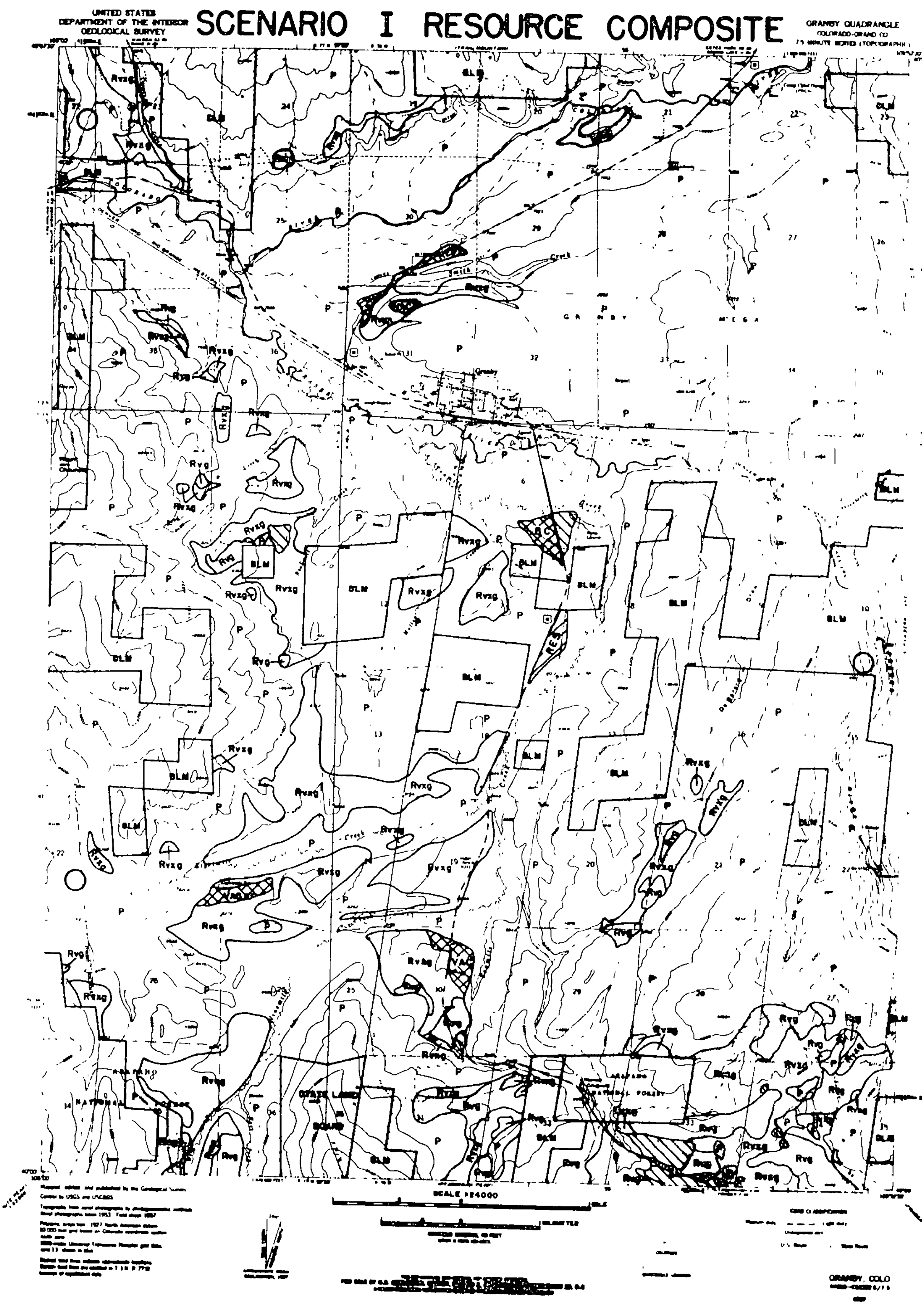

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SCENARIO I RESOURCE COMPOSITE
GRANBY QUADRANGLE
BLM
Rvxg
Rvg
P
GRANBY MESA
Granby
STATE LAND BOARD
SCALE 1:24000
GRANBY, COLO

Figure 17. Land allocation for Scenario II resource composite.

SCENARIO II RESOURCE COMPOSITE

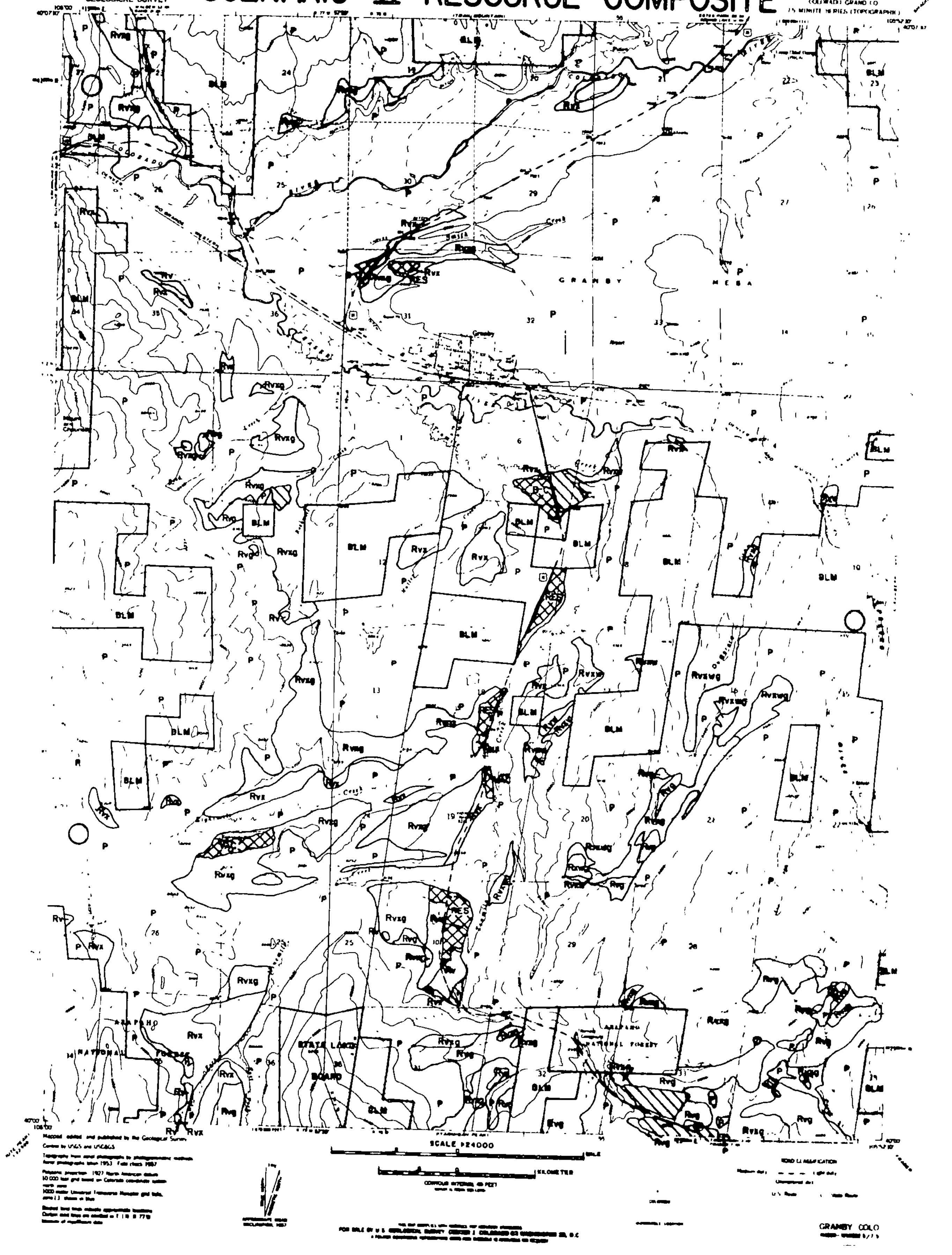


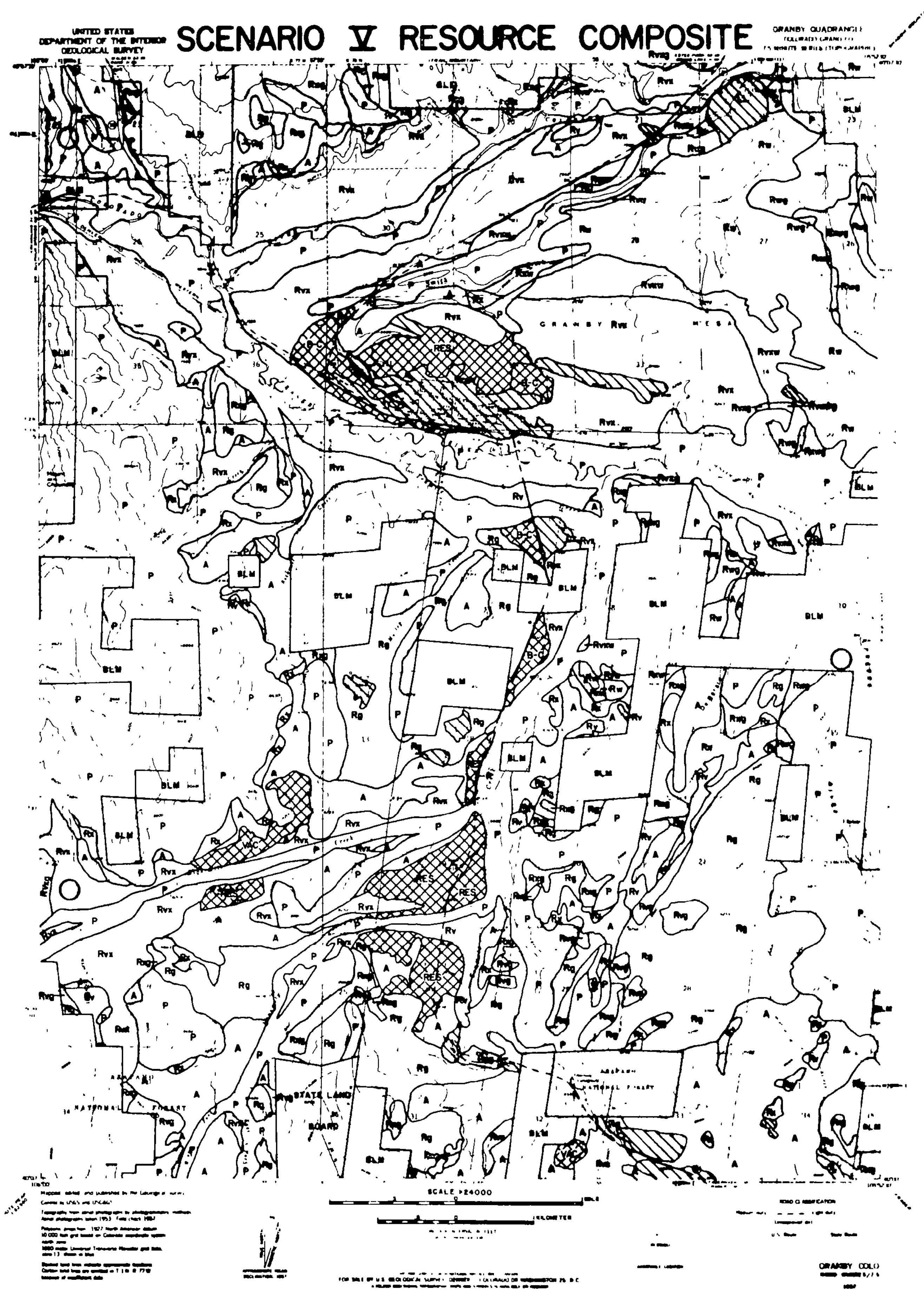
Figure 18. Land allocation for Scenario III resource composite.

SCENARIO III RESOURCE COMPOSITE

Figure 19. Land allocation for Scenario IV resource composite.

SCENARIO IV RESOURCE COMPOSITE

Figure 20. Land allocation for Scenario V resource composite.


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SCENARIO V RESOURCE COMPOSITE
GRANBY QUADRANGLE
GRANBY MESA
RES
BLM
STATE LAND
BOARD
ARAPAHO
NATIONAL FOREST
SCALE 1:24000
GRANBY, COLO.

occupies the flatter lands where haying operations are possible, and the sagebrush ecosystem is on the drier hillsides. The lodgepole pine ecosystem is the major forest type with small patches of the aspen ecosystem scattered within the area.

In allocating development within the Granby region, only three of the five ecosystems (sagebrush, mountain dry, and lodgepole pine) were used. This was because development was allocated under the various alternative futures in a manner meant to minimize the environmental and social impacts to the vegetative ecosystems and the other resource factors. Based on the relative resource weighting system, as reflected in the composite maps, the cost of allocating development to the streamside or aspen ecosystems was considered too high (restrictive or prohibitive).

As the hectares of development needed for the different alternative futures increased, the hectares of vegetation consumed increased with the result that more and more vegetation would be taken out of future production. In addition to the specific productive capacity that would be lost, other less quantifiable attributes, such as aesthetic and water quality standards, may be degraded by loss of hectares of vegetation.

Following is the list of hectares of vegetation consumed and their relative weighting by each alternative future.

Future 1

56.2 hectares (139 acres) sagebrush ecosystem - Restrictive

2.0 hectares (5 acres) lodgepole pine ecosystem - Restrictive

Future 2

106.6 hectares (264 acres) sagebrush ecosystem - Restrictive

Future 3

139.4 hectares (345 acres) sagebrush ecosystem - Allowable

59.8 hectares (148 acres) mountain dry ecosystem - Restrictive

20.6 hectares (51 acres) lodgepole pine ecosystem - Allowable

Future 4

305.5 hectares (756 acres) mountain dry ecosystem - Allowable

205.6 hectares (509 acres) sagebrush ecosystem - Allowable

Future 5

262.6 hectares (650 acres) mountain dry ecosystem - Restrictive

184.2 hectares (456 acres) sagebrush ecosystem - Allowable

As the demand for hectares increases, the supply of allowable land is more rapidly consumed. This leads to development being located on less desirable land (for development) and thus higher impacts on vegetation.

Soils

The soil resources of an area can impose certain limitations upon the types of developments which can occur. These limitations are related to soil type, and thus are site specific and dependent upon the proposed use. The development types and the locations of the affected soils can be seen by comparing the soil map, Figure 21, of the Granby Quadrangle with the scenario resource composite maps.

Geology

The same geologic impacts affecting the entire study area are the impacts which can be expected in the Granby Quadrangle. These include 1) increased potential for slope failure; and 2) removal of aggregate sources form production.

With continued development on gentle to moderate slopes throughout the quadrangle, an increase in potential for slope failure can be expected. However, since all suggested areas of development have been located in low and

Key to Soil Series Names and Map Symbols* for Figure 21

Map Symbol	Soil Series Names
3 & 71	Clayburn loam
4	Cumulic Cryaquolls
12	Handran gravelly loam
15	Bearmouth sandy loam
19	Forelle loam
20	Leavitt loam
23	Aaberg clay loam
25	Hitchen clay loam
26	Binco clay loam
27	Cimmaron loam
28	Mayoworth clay loam
33	Roxal loam
35	Woodhall loam
38	Gateway loam
39	Cebone loam
40	Anvik loam
43	Grenadier gravelly loam
46	Lake Creek loam
47	Leadville fine sandy loam
51	Cryoboralls-Rock Outcrop Complex
58	Rogert gravelly loam
59	Emerald gravelly sandy loam
60	Yovimpa clay loam
70 & 69	Frisco-peeler Complex
72	Cowdrey loam
73	Hierro sandy loam
74	Youga loam
75 & 76	Quander cobbly loam
77 & 17	Scout cobbly sandy loam
79	Upson coarse sandy loam
W	Histic Cryaquolls

General Slope Classes and Corresponding Ranges

B - 0- 3% slopes
C - 0- 6% slopes
D - 0-15% slopes
E - 6-25% slopes*
F - > 15% slopes**

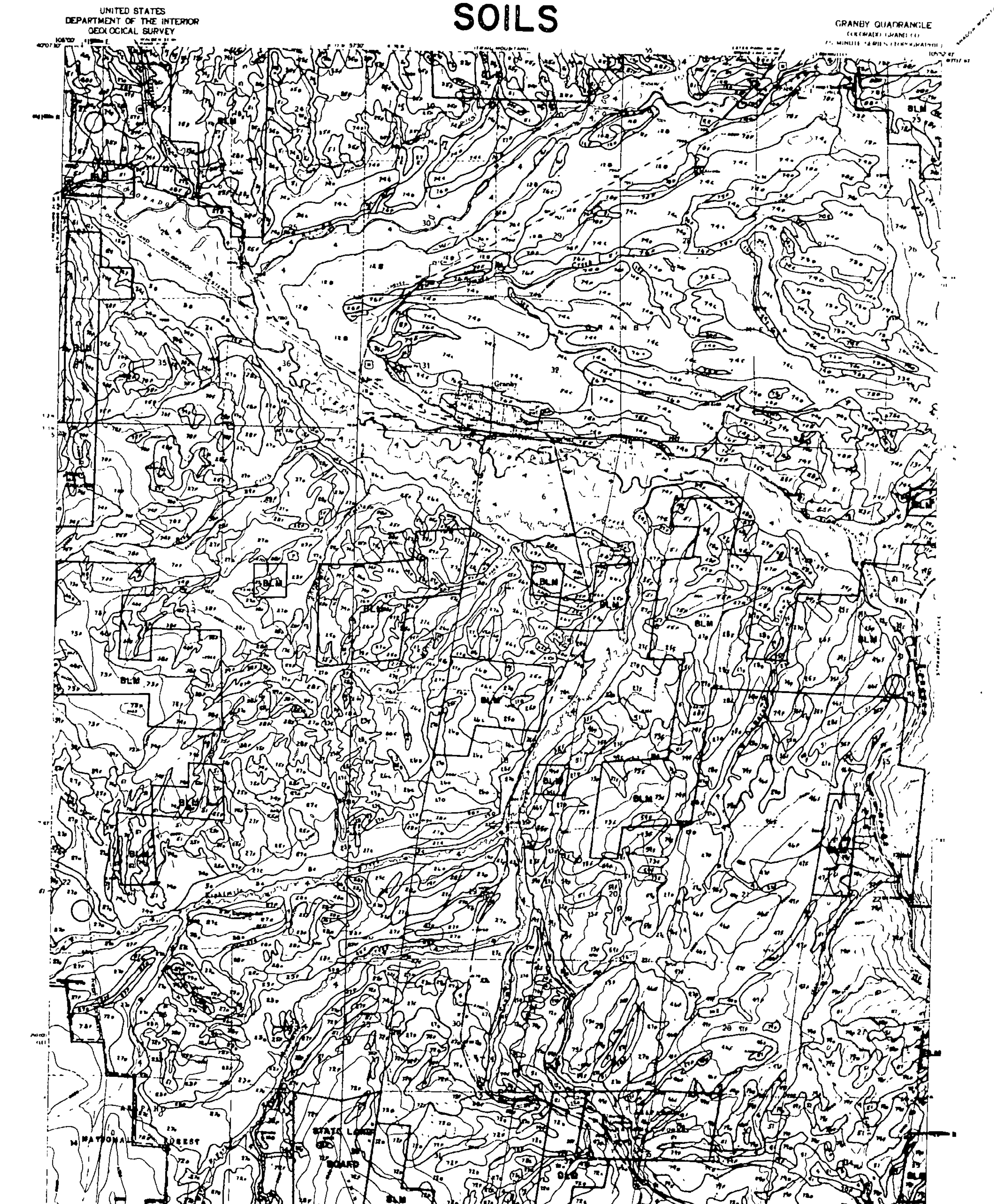
Exceptions:

* Soil unit 71E has slopes from 15-25%
** Soil units 70F & 71F have slopes >25%

*Source: U.S. Soil Conservation Service, Kremmling, Colo.
Preliminary Data; subject to change

Figure 21. Detailed soils map for the Granby quadrangle.

SOILS


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
GRANBY QUADRANGLE
Granby
BLM
NATIONAL FOREST
STATE LAND BOARD
SCALE 1:24000
GRANBY, COLO.

moderate hazard areas, the potential for slope failure is not great, and these areas should be considered as safe for development, provided that proper construction practices are followed.

In addition, the removal of aggregate sources from production can be expected to occur only in the immediate vicinity of Granby as development continues upon and adjacent to the terrace on which the town is located. Due to the fact that abundant sand and gravel are already being extracted from a portion of the terrace, moderate development in the area should not significantly affect the amount of available mineral aggregate.

Wildlife

While no critical wildlife areas were consumed or removed from use under the different alternative futures, it is likely that increasing the number of County occupants will have a generally negative impact on wildlife populations. This impact was minimized because under the allocation rules future developments were placed near existing towns or roads. If the development areas had been allocated under a more random system, there would have been considerably more impact on wildlife. For instance, deer and elk herds tend to avoid human settlements and uncontrolled and scattered development would impinge on a herd's freedom of movement and thus, available habitat.

Visual Resource

Visual vulnerability is defined as the potential of a parcel of land to absorb and screen land use changes. In this section areas of land classed restrictive because of the visual resource and used for development are tallied. Different quantities of land are consumed under each future, yet the difference does not necessarily imply that a future in which a large quantity of restrictive land is consumed is of a low visual quality. It does mean, however, that the change in visible amounts of development is great.

In contrast, if all the development in an alternative future was located in areas of low visual vulnerability, the visual quality of the area would remain essentially unchanged.

Utilizing carefully designed building standards, the impact of development problems in restrictive visual areas can be mitigated to a large degree. Careful location away from ridgetops, sensitive selection of building materials, and low building heights can reduce the visual impact of development in any area. The tally of lands in the Granby Quadrangle needing these special treatments is below. From these figures it is apparent that unless mitigating measures are taken, significant visual impacts would occur under all alternative futures except number 4.

Future 1

All but 2 hectares (5 acres) of the total demand were located in visually restrictive areas. In the Granby area, the restriction is primarily due to the lack of screening vegetation. In total, 77 hectares (190 acres) of restrictive area is consumed.

Future 2

Approximately 99 hectares (244 acres) of restrictive land are consumed. Only 2 hectares (5 acres) of demand are located in non-vulnerable areas.

Future 3

Development areas are located on 48 hectares (118 acres) of visually restrictive land. Twenty-eight of these hectares (69 acres) are used for business-commercial development while the remaining 20 hectares (49 acres) are classed residential.

Future 4

No visually restrictive areas were consumed.

Future 5

Over 206 hectares (511 acres) of visually restrictive land were consumed with Future 5. Business-commercial developments utilize over 75 hectares (186 acres) while residential developments utilize over 131 hectares (325 acres).

Hydrology

The determination of the hydrologic impacts which result from developments in the Granby Quadrangle requires the application of an impact assessment process. Table 18 shows the comparative volumes of runoff from open space and developed lands by development type and scenario. Based on the volumes shown in Table 18, total runoff, sediment quantities, and pollutant loading estimates are given in Table 19. By using the size and type of development and the soil type which occurs at the location, the specific impacts of any of the developments shown on the resource composite maps can be estimated.

The volumes of runoff and the resultant sedimentation and pollutant loading will cause problems in stream channel modification, sediment deposition, and water quality degradation. The stream channels in the Granby Quadrangle can be expected to become deeper and wider in response to the increased volumes of water they will have to carry. Increased bank erosion will also occur with a resultant loss of streamside vegetation.

As the volume of storm runoff increases, the size of the flood peak will also increase. Runoff volume also affects the base flow because for any storm the larger the percentage of direct runoff, the smaller the amount of water available for soil moisture replacement and ground water storage (Leopold, 1968). As a result of increases in impervious areas, flood peaks will be higher during storms, while low flows will decrease during the

Table 18. Comparative runoff by development type and scenario for the Granby Case Study Area.

			Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Business-Commercial	Open Space	M^3 X 1000	4.0 to 12.3	5.3 to 15.5	11.7 to 30.3	32.8 to 78.4	28.8 to 71.1
		Acre feet	3.2 to 10.0	4.3 to 12.6	9.5 to 24.6	26.6 to 63.6	23.4 to 57.6
	Developed	M^3 X 1000	35.7 to 57.6	47.4 to 78.1	105.4 to 171.9	279.7 to 448.6	267.0 to 420.5
		Acre feet	29.9 to 46.7	38.5 to 63.3	85.5 to 139.3	226.7 to 363.7	216.4 to 340.9
Residential Housing	Open Space	M^3 X 1000	8.6 to 20.0	26.3 to 59.0	92.9 to 178.2	185.9 to 364.7	160.0 to 326.4
		Acre feet	7.0 to 16.2	21.3 to 47.8	74.6 to 144.5	150.7 to 295.6	129.7 to 264.6
	Developed	M^3 X 1000	25.0 to 41.6	62.6 to 106.8	185.1 to 315.5	429.5 to 666.3	344.0 to 569.7
		Acre feet	20.2 to 33.7	50.7 to 86.6	150.7 to 255.8	348.1 to 540.1	278.9 to 461.8
Vacation Housing	Open Space	M^3 X 1000	15.1 to 36.5	12.9 to 32.3	5.5 to 13.0	38.0 to 76.9	26.6 to 65.3
		Acre feet	12.2 to 29.6	10.4 to 26.1	4.5 to 10.5	30.8 to 62.3	21.6 to 53.0
	Developed	M^3 X 1000	25.9 to 51.7	23.6 to 43.3	9.3 to 18.1	55.7 to 100.8	45.3 to 91.2
		Acre feet	21.0 to 41.9	19.1 to 35.1	7.5 to 14.7	45.2 to 81.7	36.7 to 74.0

Table 19. Total volume, sediment, and pollutant loading from Granby Case Study Area.

		Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
Total Runoff		86.6 to 150.9 cubic meters 71.1 to 122.3 acre feet		133.6 to 282.2 cubic meters 108.3 to 185.0 acre feet		299.8 to 505.5 cubic meters 243.7 to 409.8 acre feet		764.9 to 1,215.7 cubic meters 620.0 to 985.4 acre feet		656.3 to 1,081.4 cubic meters 532.0 to 876.5 acre feet	
Area and Sediment Volume		.769 $km.^2$ 273 metric t/yr 301 short t/yr		1.052 $km.^2$ 374 metric t/yr 412 short t/yr		2.201 $km.^2$ 782 metric t/yr 862 short t/yr		5.180 $km.^2$ 1840 metric t/yr 2028 short t/yr		4.476 $km.^2$ 1590 metric t/yr 1752 short t/yr	
		Low	High	Low	High	Low	High	Low	High	Low	High
Pollutants from Storm Runoff	*BOD	2,018	3,516	3,113	5,317	6,985	11,778	17,822	28,325	15,291	25,196
	*COD	5,534	9,642	8,537	14,582	19,157	32,301	48,871	77,683	41,937	69,101
	*N	234	407	361	616	809	1,364	2,065	3,282	1,772	2,919
	*P	69	120	107	182	240	404	612	973	525	865
	*S.S.	86,600	150,900	133,600	228,200	299,800	505,500	764,900	1,215,700	656,300	1,081,400
	**FCB	105,306	183,494	162,457	277,491	364,557	614,688	930,118	1,478,291	798,060	1,314,982

*in kilograms per year

**in number of bacteria per year x 10^5

periods between storms. Also, since ground water storage will decrease, those areas which depend upon water supplies from surface alluvial sediments may be seriously affected.

The major effect of land use upon sedimentation results from exposure of the soil to rainfall and storm runoff. This sediment chokes streams and fills reservoirs, severely limiting their uses for recreation and aesthetic enjoyment, as well as reducing their capacities to accommodate peak flood flows.

Several methods are commonly used to handle the water quality problems attendant with increased runoff. Storm water can be collected through a storm sewer system and mixed with effluents from household sewer lines. The effluent mix is then processed through central treatment facilities before release into the natural water ways. However, treatment facilities with the capacities necessary to treat the effluents from peak storm flows are extremely expensive to construct and operate. In addition, the costs of the collection system alone can be prohibitive in rural areas. Another option is the separate collection of storm runoff and the direct, untreated discharge of the untreated water into large bodies of water.

The alternative approach is to neither collect nor treat storm runoff. This latter approach is the course of action most often used in mountainous situations. This approach can and does lead to decreased water quality and to the degradation of the natural conditions of streams, lakes, and reservoirs.

Choosing a Desired Future

The next step in the process was selection of a desired future. Articulation of a desired future is necessary so that a plan can be written to achieve a particular goal. In this study, the selection of a desired future was done through utilization of a second survey. The survey technique enabled the identification of a future which reflected community objectives and goals rather than the guesses about a planner's assumption about public desires.

Survey Purpose and Methodology

The primary purpose of the survey was to describe the five alternative futures and have the respondents indicate which ones they like or disliked. They were also to preferentially rank the futures. Following are the five composited futures.

FUTURE 1: PRESERVATION/TOURISM

Grand County will continue to develop its tourist industry, but only to the extent that the development is compatible with protecting the environment. Tourist facilities will not be allowed to harm the best scenic, wildlife, and backcountry areas of the County. Developments will mostly be for transients and located in areas already having tourist development like along highway corridors, the Three Lakes area and existing communities. Year-round recreation opportunities would be encouraged in order to stabilize the job market. Local government will have to exercise strong controls in order to accomplish these goals.

With this future, by 1990 there would be 1,016 new jobs in the County. But not much real economic growth would happen in the County. The population would increase by about 500 residents by 1980 and by another 1,500 by 1990. The land needed for these developments would be less than one percent of the total available, with about 188 acres needed in Grand Lake, 268 in Granby, 35 in Fraser, 145 in Hot Sulphur Springs, and 163 in Kremmling.

FUTURE 2: EXTRACTIVE AND LIGHT INDUSTRY--HIGH DEVELOPMENT

In order to stabilize the economy, local government officials will do all they possibly can to encourage both extractive (i.e., mining, lumber) and light industries in the County. There will be little government control except that necessitated by state and national regulations. Natural amenities will be protected, but not at the expense of industry. Tourism will still be encouraged, particularly around the Three Lakes and Winter Park areas.

This future indicates that the economy will be greatly accelerated by an additional 4,500 jobs by 1990. The total population for the County will reach 15,400 by 1990, an increase from 1975 of 9,100 residents. The land for this development would be about 795 acres in Grand Lake, 1,279 in Granby, 190 in Fraser, 614 in Hot Sulphur Springs, and 810 in Kremmling.

FUTURE 3: TOURISM--HIGH DEVELOPMENT

Areas of the County are to be developed giving greatest consideration to their economic potential as tourist "attractors." The natural environment will be maintained to the extent that it makes Grand County more appealing to tourists. Local government control will be moderate. Second home developments (middle to high income) will be encouraged, campgrounds and boating areas will also be developed. Tourists will be encouraged to visit Grand County for a day or a month. The Three Lakes area will be developed as a high density, activity-oriented area.

If this future is pursued, an additional 2,016 jobs would be created by 1990. The population of the County will increase by 1,000 residents by 1980 and 4,100 by 1990. These people and their developments would need about 544 acres in Granby, 407 in Grand Lake, 59 in Fraser, 347 in Hot Sulphur Springs, and 307 in Kremmling.

FUTURE 4: PRESERVATION

Emphasis in planning will be placed on the natural environment. The goal is to maintain and enhance, where possible, to the greatest degree possible, wildlife, open space, and aesthetic qualities of the County. Developments which rapidly expand population or change the present character of the area will be discouraged. Agricultural land would be maintained for agriculture and open space. Strong local governmental controls are necessary to reach this future, with development and economic opportunities being sacrificed to maintain the natural development.

The results of such a policy would be slow growth of the County. In 1990 there would be about 600 more jobs than there are today. The total population would increase from 6,347 in 1975 to 6,646 in 1980 and 7,586 in 1990. The land needs for development would be 103 acres in Grand Lake, 144 in Granby, 13 in Fraser, 98 in Hot Sulphur Springs, and 68 in Kremmling.

FUTURE 5: TOURISM/INDUSTRY--MODERATE DEVELOPMENT

This future emphasizes both the County's tourist and industrial bases. Fairly strong local governmental controls would be needed to preserve the tourist qualities of the area while still providing for industrial opportunities. Therefore, air and water pollution, open space, scenic and transporation controls would all be important. This future would be difficult to reach because it calls for growth in sectors which are often conflicting. Moderate development of ski facilities and other winter sports would be encouraged. There would be controlled growth of summer recreation opportunities, particularly in the Three Lakes and Fraser River areas.

With this future, total employment in the County would reach 6,875 by 1990, an increase from 1975 of 3,926 jobs. In 1990, the County population would have increased by 7,923. The acreage needed for these people and developments would be 803 in Grand Lake, 1,106 in Granby, 140 in Fraser, 601 in Hot Sulphur Springs, and 660 in Kremmling.

A second part of the survey included questions similar to the first survey in which attributes of the County were rated according to how they add to or detract from the desirability of living in the County. The second portion of the survey served as a reliability check and is not included in this analysis. The questionnaire concluded with a number of demographic questions.

The survey was sent to a sample of 300 residents chosen randomly from the latest voter registration lists. The questionnaires were coded numerically on the last page in order to identify the respondent. A letter accompanying the survey noted that grouped responses would be made public but that individual answers would be kept anonymous. A return envelope was provided. After a week and one-half, a letter requesting the return of the survey was sent. In approximately another week and one-half, another reminder, questionnaire and return envelope were sent to those people still not replying.

Results

A total of 184 persons or 67 percent of those sampled returned the questionnaire (26 questionnaires were undeliverable). Table 20 lists the number and percent of surveys returned by area.

Table 20. Survey response results.

Town	Number Sent	Number Returned	Percent
Grand Lake	40	29	73
Fraser	51	37	73
Granby	78	48	62
Kremmling	73	48	66
Hot Sulphur Springs	32	20	63

As mentioned previously, the primary purpose of the questionnaire was to have the respondents choose the future which could ultimately provide the basis or goal orientation for a land use plan. Table 21 summarizes the results of the first part of the survey in which the people were asked to check the words that best described their feelings about each particular future. It can be seen from these calculations that 75 percent of the respondents favored, in varying degrees, the Preservation/Tourism future. Similarly, 61 percent favored the Preservation future. Conversely, only 27 percent favored the High Development Industry alternative. The remaining two futures more closely resembled a normal distribution of responses.

In order to avoid inconclusive data, those surveyed were asked not only to describe how they felt about each individual future, but also to rank these same futures in relation to one another. Table 22 illustrates the results of this ranking procedure. In accordance with the results of the previous table, Preservation/Tourism was ranked either first or second 62 percent of the time. The Preservation alternative was the next most favored, with 47 percent of the respondents giving it a rank order of two or better. As would be expected, the High Development Industry future was ranked last by 40 percent and fourth by 23 percent. Again, the remaining two futures did not yield such skewed responses, although High Development Tourism was ranked lower slightly more often than Tourism/Industry.

One of the weaknesses of an alternative future approach is that there are bound to be certain aspects of a future which one will like and others that he will dislike. Consequently, five major components of the futures were extracted so that they too could be rank ordered. By utilizing such a procedure, it was then possible to abstract those components of the futures which were desired and plan for them accordingly, while at the same time eliminating those things which elicited negative responses. It should be

Table 21. Ratings of five alternative futures.

Response	Preservation/ Tourism #	%	High Development Industry #	%	High Development Tourism #	%	Preservation #	%	Tourism/ Industry #	%
Strongly Favor	39	21	15	8	18	10	46	25	17	9
Favor	58	32	19	10	24	13	42	23	30	16
Somewhat Favor	40	22	17	9	28	15	24	13	30	16
Neutral	6	3	9	5	13	7	20	11	21	11
Somewhat Oppose	15	8	15	8	20	11	13	7	25	14
Oppose	10	5	42	23	34	19	15	8	41	22
Strongly Oppose	14	8	65	36	45	25	23	13	19	11
Mean Rating Score	2.92		5.07		4.51		3.28		4.13	
Std. Dev.	1.81		2.09		2.10		2.08		1.90	

Table 22. Rankings of alternative futures.

Rank Order	Preservation/ Tourism #	Preservation/ Tourism %	High Development Industry #	High Development Industry %	High Development Tourism #	High Development Tourism %	Preservation #	Preservation %	Tourism/ Industry #	Tourism/ Industry %
1	52	32	22	14	22	14	50	31	15	9
2	48	30	19	12	30	19	25	16	39	24
3	19	12	19	12	36	22	36	22	50	31
4	24	15	37	23	38	24	20	12	42	26
5	18	12	64	40	35	22	30	19	14	9
Mean Rank	2.43		3.63		3.21		2.72		3.02	
Std. Dev.	1.37		1.45		1.34		1.48		1.13	

remembered, though, that these rank orders are not absolute indicators of a person's preferences, but only a comparative measure. For instance, as was the case in a number of surveys, a person could believe all the components to be important and rank them all one, or alternatively, they could all be given a five ranking. Consequently, the results provided in Table 23 should not be analyzed without giving consideration to other survey results. In this particular situation, however, the results do coincide with the other findings. Forty-seven percent of the respondents ranked the Environment first and 24 percent ranked it second. This is in line with the preference for the Preservation futures. A perhaps less consistent finding appears in the low rankings given the population increase category. A possible explanation for this inconsistency is that the residents are also concerned about the economy and have indicated in the previous survey and interviews that they are not opposed to population growth per se. What they do not want is uncontrolled growth that would adversely affect their environment.

Based upon the preceding results, Future 1, Preservation/Tourism, was selected to guide plan development. The following section identifies a strategy which could be employed to achieve this goal.

Control and Management of Land Use

Given the preservation/tourism goal which has been selected, the next decision is to arrive at a plan to achieve that goal. It is not the purpose of this section of the report to develop a land use plan with appropriate management tools, but rather to identify some possibilities for plan development within the overall carrying capacity based planning process. The actual tools and techniques utilized by the County in controlling and managing land use need to be selected by the County. Therefore, below are some strategies and specific tools which are available to the County.

Table 23. Rankings of alternative future components.

Rank Order	Population Increases #	Population Increases %	Economy #	Economy %	Land Needs #	Land Needs %	Environment #	Environment %	Local Government Control #	Local Government Control %
1	17	11	36	23	19	12	73	46	13	8
2	18	11	30	19	46	29	38	24	27	17
3	17	11	35	22	42	27	25	16	38	24
4	27	17	48	30	35	22	17	11	31	20
5	79	50	9	6	16	10	5	3	49	31
Mean Rank	3.84		2.77		2.89		2.00		3.48	
Std. Dev.	1.42		1.26		1.18		1.16		1.31	

Strategies

Property is defined in terms of the rights which are held relative to a property object. In land use terms, property refers to the rights held relative to the use of land, with land being the specific object of the rights. Given this concept of land, government (or society) has reserved to itself a portion of the rights attendant to any land. Society (in the U.S.) has reserved the right to condemn, police, and tax land. In doing this, society has stipulated that it is unlawful to take the rights held by someone else without compensating that individual for his loss. The fifth amendment to the U.S. Constitution affirms this compensation necessity. It does not, however, prohibit society from taking rights; it only demands that the loss be compensated.

While the government has the power to condemn, police, and tax land, it is unclear as to how much control the government can exert and still avoid compensation. This is a matter being debated in court, and it will not be substantively addressed here. However, since the establishment of zoning ordinances in the 1920's, it appears that government has more regulatory power than it has exerted. Zoning ordinances based upon density are well accepted and constitutional. These combined with building permit regulations and other regulatory permits have been accepted. Taxing land differentially under "green belt" legislation has been adopted in several states. And, condemnation is a form of public land acquisition that has been repeatedly upheld in the courts. Condemnation, of course, requires compensation, but the compensation is often to a highly reluctant seller.

The strategies which the County has for controlling and managing land uses are dependent upon the rights which the government has reserved to itself. There are basically three strategies possible and these can be operated simultaneously, though one is usually dominant.

Governmental Spending

The ultimate way to control land use is to own as much of the rights to a land area as possible. Purchase of property by government is one strategy for controlling land use. While it is simple to visualize the control possible through public purchase (through easement or fee simple), there are three major impediments to implementing this strategy. First, it is extremely costly and few governments have the resources to make but a few small purchases. Second, since many governments receive substantial revenues from property taxes, many purchases remove the financial base which supported purchases in the first place. Third, management and maintenance costs run high and governments must pay these costs like any other property owner.

There is one other kind of spending power which can be employed to regulate land use. This is spending on development of infrastructure elements like roads, police and hospital services. Within the generalized spending strategy, governments can indirectly control land use through development or non-development of governmental services.

Condemnation

A strategy closely related to market purchase of property is condemnation. Condemnation is essentially the taking of property by force, for the public good, and with compensation paid to the previous owner.

For good reasons, governments attempt to avoid condemnation. Often it precipitates ill-will among the citizenry and leads to political repercussions. Also, it is often somewhat costly while appraisals are made and courts evaluate what is just compensation. Like market purchases, however, condemnation does lead to governmental ownership and utlimate control of land use.

Police and Taxing Powers

The most common land use control strategy is to utilize police and taxing powers. For instance, zoning of land by governments is an affirmation of the governments' police powers. Within police powers there are several specific tools which can be utilized to control land use; some more publically palatable than others. Most of these, however, rest on some form of zoning.

Taxing power also enables the control of land use through variable land taxation and other incentive programs. In these instances, incentives are provided to either maintain land or put it to certain uses. Different forms of "green belt" taxation, usually to maintain agricultural and open space, are a good example of application of taxing powers for regulating land use.

Selection of a Strategy

While all three of these strategies for controlling land use are applicable to many governments, including Grand County, they are applied differentially among many governments. One needs to choose a strategy and develop it in recognition of legislative, financial, manpower, and temporal constraints. In most rural areas, like Grand County, some form of the use of police powers will most likely be the strategy chosen. This is because these areas have neither the financial resources nor the legal expertise to develop the other strategies to any but a minimal extent. Also, in recognition of the land ownership patterns in these rural areas (particularly in the West) local publics often see additional public ownership of land as detrimental to their welfare.

Control Tools

Within each of the strategies there are different tools which can be employed, and the selection of tools will often be situational. That is, some tools will fit one area while some fit other areas. It appears that there are few tools to regulate land use which are universally applicable. A discussion of some potential tools for land regulation is below.

Traditional Zoning

Zoning has been upheld by the Supreme Court since the 1920's as a legal extension of local governments' police powers. Traditional zoning is concerned with the intensity of use per parcel of land. Specifically, this technique mandates the number of dwelling units to be permitted in a specific area. Large lot zoning and open space zoning are means by which the densities of an area can be kept low. One of the more recent innovations in this category has been the Planned Unit Development. This type of zoning gives the developer flexibility in designing the site and the exact densities within the area as long as he meets overall density limits and other requirements.

Functional Zoning

Functional zoning until recently has generally been applied to such classifications as Residential, Industrial, and Commercial zones. More recently, however, and more applicable to nonurban areas, some states and counties have utilized this tool as a means of phasing or limiting growth and development in certain areas. For instance, in Buck County, Pennsylvania a classification scheme was devised that included: (1) Urban Areas where the development had already occurred; (2) Development Areas where intense growth pressures were present; (3) Rural Holding Areas composed primarily of agricultural land; (4) Resource Protection Areas where it was felt that development would jeopardize the natural, recreation and historic resources. A somewhat less restrictive scheme divides the area into development zones. The purpose of these zones is not to prevent development in general, but to avoid scattered development. In accordance with this technique, each zone is designated based upon its readiness for development.

Environmental Zoning

Environmental zoning is dependent on the particular resources of the area. Flood plains, stream banks, steep slopes, geologic hazards, and wildlife habitat are examples of the types of areas which come under the auspices of environmental zoning. Within these zones, development could be prohibited or merely restricted depending on the particular resource. A limitation of this technique is that it cannot be utilized without a reliable resource inventory. HB 1041 in Colorado enables the County to carry out this type of plan.

Transferrable Development Rights

Transferrable Development Rights is the newest zoning technique and one that has gained considerable attention in the past couple of years. The purpose of this management tool is to free certain areas from development pressures while at the same time protecting the individual landowner's property rights. In order to accomplish these dual objectives, each property owner is given a certain number of "development rights." Simultaneously, a master plan is developed which denotes the different zoning classifications and the number of development rights needed within each zone as a prerequisite for development. Before a developer can build on a piece of land, however, he must possess all the rights required for a designated use. Consequently, he must purchase rights from other land holders in order to obtain the necessary number. The logical owners to sell their rights are those in the agricultural or conservation zones who cannot themselves build on their land. This technique is thus viewed as a means of controlling growth while at the same time including all citizens in the prosperity that comes with growth. It is a way to compensate those who cannot, because of zoning, develop their land while controlled development takes place.

Permit Systems

As mandated by HB 1034 in Colorado, the counties are given the power to establish land use plans. Utilizing these powers, it is possible for the county to set up a permit system, whereby a developer must obtain a permit before he is allowed to build on a particular site. Permit requirements would vary according to the type of project and according to the land itself. For instance, one would have to meet more stringent requirements such as architectural design, lot size, etc. in a recreation area as compared to an urban area. Development codes could be established for different development or different zones if they are applicable. SB 35 already necessitates that certain regulations must be established by the counties regarding subdivision development. The permit system would be an extension of this enabling legislation. The advantage of such a system is that the developer is aware of his obligations at the outset of the project.

Utility and Service Control

Utilities and services are a tool for land use planning. Moritoriums on utility extensions can be established for an interim period giving a government additional time to adjust or implement its plan. A more permanent technique is to initiate an Urban Service Boundary or "blue line" as was done for the Salem, Oregon area. This line becomes a physical limit to the extension of public services and/or utilities. The boundary, however, must be rationalized according to discrete sociological, economic, and physical factors in order for it to be a legal extension of a government's police powers. Regulation of utilities extensions does not necessarily lead to no growth; rather it is used to control growth into desirable areas or at a manageable pace.

Market Purchase and Easements

The most direct means of land use control is simply to purchase the property. By acquiring the rights to use of the land, governments can control the land's development and also often influence the use of adjacent land. Boulder, Colorado has had a continuing program whereby the city purchases the land deemed necessary for parks and open space. Money for purchase is acquired through the city's sale tax. A more recent concept utilized by local governments is land banking. This concept calls for the establishment of land banks which in turn acquire and hold land as a means of controlling its future use. In order for the bank to be effective, it must 1) be granted public corporation status, 2) have the power to condemn land and purchase property, and 3) be financially able to pursue its goals. Purchase of easements (and leases) also leads to direct land use control. This method enables a government to purchase wanted rights while leaving some rights in private ownership. It is often far less costly than outright purchase. An advantage of this system is that possession remains with the landowner allowing him to reside on the land. For the granting of an easement, he may also receive a tax advantage. In the government's favor are the facts that the expense of maintaining the land remains with the landowner and the land remains on the tax rolls.

A Possible Program

Of the possible implementation controls previously described, only four of them are recommended for Grand County. These four controls can be utilized as the means to achive the desired goal of Preservation/Tourism.

The first step is to designate Functional Zones, i.e., preservation, commercial, tourist, residential. Within these zones, Environmental Preservation Areas could be established where especially sensitive or hazardous lands exist. In combination with this zoning scheme, a Permit System should be devised which would specify particular development requirements for each zone. Finally, the County could regulate the utility and service component, e.g., road extensions, in order to pace development or direct it into specific zones.

As noted previously, these implementation tools are not the only ones available to the County. Traditional or density zoning could become a part of the implementation plan. Market purchase and easements are also possibilities, but ones that would necessitate considerable capital investment. Transferrable development rights have gained considerable attention, but they are more applicable to goals other than Preservation/Tourism and to areas feeling greater development pressures. Considering the stated objective of Preservation/Tourism and the financial status of the County, Functional Zoning, Environmental Zoning, Utility and Service Control, and a Permit System could effectively be integrated into an implementation plan: A plan designed to achieve the specified goal.

EVALUATION OF THE PROCESS

The aim of this project was to test a carrying capacity based planning process for its usefulness in comprehensive mountain land planning. It is important to remember that this was the test of a process and not development of a plan. To test the process, two objectives were articulated for the project.

1. To employ a carrying capacity based process in an analysis of the future of Grand County, Colorado.
2. To evaluate the employment of the carrying capacity based planning process for its effectiveness and efficiency.

This final section of the project report deals with the second objective; the first objective having been met by the material presented in previous sections of the project report. Here the carrying capacity based process utilized is reviewed and its costs, workability, and acceptability is assessed.

Derivation of an area's carrying capacity rests on specification of an explicit "quality of life" objective and on the physical capability of the natural and man-made systems. Modifying either the objective or the physical systems means a change in carrying capacity. Hence, there is not one, absolute carrying capacity for an area. Rather, for one specific objective and physical system structure there is one carrying capacity.

The process utilized in this study recognized this variable condition of carrying capacity and thus emphasized delineating an objective for Grand County and identifying the natural and man-made system capacity constraints. Most of the study focused on these two elements of carrying capacity analysis.

Given the task of delineating an objective to be met by the implementation of a plan, the carrying capacity based planning process utilized in the Grand County study began with an inventory of several elements. The present economic situation, environmental resources, population structure and behavior, infrastructure elements, public desires, and exogenous growth forces were inventoried and evaluated for their effects on the future. Through a process of scenario development and subsequently scenario quantification, possible alternative futures for the County were developed. The impacts of these futures on the environmental resources, economic, population, and infrastructure sub-systems were assessed. These alternatives and their impacts were presented through a survey to the County's population and a majority preferred alternative was chosen as the County planning objective (for the purpose of this project). From this point, possible plan strategies and land use control tools were discussed and recommendations made for plan development. The project was not carried through either formal plan development or implementation phases as those aspects were beyond the project responsibilities and are direct functions of the County. An evaluation of the project process follows.

Cost

Two costs for the process as outlined in the preceding report sections are given. First, the actual cost of the process as undertaken by the Regional Resource Planning Program at Colorado State University is estimated. This cost reflects the utilization of graduate and undergraduate students working for stipends and low wages and utilization of capital facilities and equipment not wholly charged to the specific project. Second, an estimate of costs which would be incurred if the work was undertaken outside the University is made. These costs more completely recognize the real process implementation costs than do the first set of cost estimates.

Actual Study Costs

Professional Salary	$ 15,000	
Graduate Assistants*	25,600	
Labor*	3,850	
Secretarial Services	2,750	
Benefits (*no benefits)	1,900	
Overhead (64 percent)	30,200	
Subtotal		79,300
Materials and Supplies	1,500	
Computer	1,500	
Travel	3,200	
Printing - Duplicating	1,500	
Lodging and Office Space (on-site)	-0-	
Subtotal		7,700
Total		87,000

Estimated Outside University Cost

Professional Salary	15,000	
Technician Salary	51,200	
Labor	5,000	
Secretarial Services	3,000	
Benefits	7,200	
Overhead (64 percent)	47,500	
Subtotal		128,900
Materials and Supplies	1,500	
Computer	2,000	
Travel	3,200	
Printing - Duplicating	1,500	
Lodging and Office Space (on-site)	2,000	
Subtotal		10,200
Total		139,100

Both cost estimates indicate that implementation of the process (in about a 15-month time period) is costly relative to a county planning budget. The estimated cost for such a study produced by a county itself or through a consultant is 60 percent higher than the study cost produced through the University. The cost difference is primarily due to the cost of technician services provided in the University at low wages by graduate students and the benefit and overhead costs which automatically increase with these personnel costs.

In terms of the practicability of implementing this process in mountain counties in the West, one should be skeptical. The costs are excessive for most county planning budgets over a one to two year time frame. Extending the time would mean loss of data due to its becoming outdated resulting in the inability to integrate the components of the process.

From a cost standpoint, the process is not completely impractical, however. Key components of the process can be implemented and useful information for planning provided. For instance, both the economic system and population system components of the process are relatively inexpensive and can be utilized in a short time frame. If a county already has an environmental resources inventory, these components can be combined with the inventory to produce a much more complete data base for objective setting and plan development. Another approach to overcoming the cost limitations of the process is to combine funds from several sources. For instance, county planning funds, state planning funds (e.g., Colorado P.L. 1041), and federal planning funds (e.g., EPA Water Quality Planning) could be combined to cover the costs. These two solutions to the cost problem suggest that the process can be implemented at the county level under some joint funding arrangements.

Workability

Apart from cost considerations, is the process workable? Does it achieve the objectives of providing a comprehensive base of information to enable calculation of carrying capacity, selection of a planning objective, and development of a land use plan? Even if it achieves these objectives, is the process a good one to use? These are tough criteria for any planning process to meet.

A carrying capacity based process demands a holistic approach to information collection and analysis. A full information base is necessary to enable carrying capacity calculation. Therefore, the process must meet its objectives or else it is not truly carrying capacity based. As articulated, the process utilized in this study enables carrying capacity calculation, objective setting, and plan development.

In terms of its operation the process requires several specialists representing many different fields. Specialists are needed in numerous environmental resource fields, survey research, regional economics, demography, infrastructure analysis, and land use control. Many of these roles can be filled by some county planning staffs while other counties are void of most of these skills. What this suggests is the necessity to contract for much of the needed expertise.

Another workability problem is the logisitics of carrying out such a broadly based process. While the completion of this project indicates that the logistical problems can be overcome, they are quite extensive. The project involved moving people and equipment between Fort Collins, Grand County, and Denver (where many federal regional offices are located). The logistics problems would have been a much greater problem if the Division of Wildlife had not provided temporary living quarters and the State Forest Service had not provided office space in the town of Grand Lake.

Finally, the process utilized could not be carried out without intensive cooperation by federal, state, and local agencies as well as by the citizens of Grand County. Data must be obtained from all these sources and, at times, it is necessary to borrow personnel from the organizations to collect new data or interpret data for specific purposes.

To sum up the workability of the process tested in this project, it appears that the process meets its objectives but presents some problems in smoothness of operation. There are personnel, logistics, and cooperation problems which any user should consider before utilizing the process.

Acceptability

Acceptability of the process, to both users and the public, is difficult to evaluate since the process was carried out by an "outside" organization and not formally implemented by the County planning office. However, there are some attributes of the process which one can use to evaluate acceptability.

Some criteria for acceptability to its users might be ease of implementation, cost, generation of relevant information, and maintenance of decision making perogatives. To general publics the process would likely be acceptable if it allows substantive public input into planning decisions and is not deemed excessively costly.

Both ease of implementation and cost have been covered in previous sections. There can be little question that the process leads to generation of information relevant to land use decisions, if it is acknowledged that a comprehensive data base is desirable for land use decisions. The process has the attribute of requiring production of information on many factors which influence land use planning. The process, as implemented, also leaves decision making in the hands of responsible elected or appointed officials. In no way is the process a substitute for decision making, rather it is used to provide a comprehensive data base useful for land use decisions.

From a public standpoint the process has several desirable attributes. Most important of these is the heavy reliance on public involvement in the process. Whether one uses surveys or public meetings to obtain public desires, those desires are an integral part of the process. A second important attribute of the process is its transparency. That is, all steps in the process are open to view by interested publics. There is no "black box" decision making and all assumptions and analytical procedures of the process can be easily articulated; the process is open to public scrutiny.

While not all aspects of acceptability of the process are entirely favorable (e.g., cost may be a problem in some instances), as a general process of data collection and analysis for comprehensive land use planning, it has many desirable attributes. One would expect that if the process was carefully implemented, it would be highly acceptable to both the user and the general public.

Conclusion

A carrying capacity based planning process, as utilized in this study, is quite useful in land use planning. It has the desirable attribute of focusing on setting planning objectives and specification of natural and physical system capacities. Whether or not an actual capacity is calculated for any area is relatively unimportant, but collection of the data necessary to make such a calculation means the data necessary for comprehensive land use planning are available.

While the land use planning process described in this report is not new in its molar aspects, all of the parts are integrated into a comprehensive process. This integration is a primary output of the Grand County study. Linkages have been made between environmental resource, economic, population, infrastructure, and public preference analyses. This has enabled the use of the process as a comprehensive process, or use of its individual modules which can be linked with other modules.

A final conclusion about the land use planning process utilized in the Grand County study is that it can be used to identify planning data gaps, political issues, and cost factors. Because it is a relatively holistic process, implementation of the process can lead to identification of significant data gaps; where data are needed to fully implement this process and develop land use plans. The process also leads to identification of political issues by both soliciting public land use preferences and identifying the status of critical resources related to these preferences. Finally, the process leads to development of cost estimates for government services and is thus useful in estimating the impacts which a government would sustain by choosing a particular alternative.

The overall conclusion from this study of the utilization of a carrying capacity based land use planning process in Grand County, Colorado is that the process has a great deal of promise. It needs further refinement, but has proven to be a useful approach to the generation of land use planning information.

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