A programming model for evaluating changes in resource use in the Bitterroot Valley of Montana

by Charles Thomas Hash

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Agricultural Economics
Montana State University

Abstract:
The rapid movement of land and water resources from agricultural to recreation-residential use in Montana's mountain valleys presents both opportunities and problems to the residents of those areas—-opportunities in the form of increased return to the resources of the area—-problems in providing for a growing population without substantial increases in local tax rates and without creating the kinds of urban problems that so many come here to avoid.

A multivariate regression model was used to analyze data on sales of unimproved tracts of land in the Bitterroot Valley area to determine the contribution to value of various amenities and detriments.

A linear programming model of the resource economy of the Bitterroot Valley was used to evaluate the impact on local community well-being of certain policies to internalize some of the external costs of recreation-residential development. It was estimated that an annual benefit of approximately $63,000 could be realized by forcing developers and recreation-residential occupiers to consider and react to such externalities as the costs of road maintenance, cost of school transportation, and the cost of incompatible uses on adjacent lands.

The present institutions and works for the distribution of irrigation water do not allow the waters available to Bitterroot Valley lands to be fully utilized in agriculture. The same linear programming model was used to estimate the impact of the agricultural economy of improvements in the irrigation water distribution system.

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ABSTRACT

The rapid movement of land and water resources from agricultural to recreation-residential use in Montana's mountain valleys presents both opportunities and problems to the residents of those areas--opportunities in the form of increased return to the resources of the area--problems in providing for a growing population without substantial increases in local tax rates and without creating the kinds of urban problems that so many come here to avoid.

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CHAPTER I

INTRODUCTION

Long-time residents of Montana's mountain valleys must feel the same sense of foreboding as their native American predecessors felt a century ago. A mounting wave of migrants into the mountain valleys present the current natives with a perplexing combination of problems and opportunities. In all of this one thing is certain--the face of the landscape will experience dramatic, and likely irreversible, change.

Much of the land on the high terraces of Montana's mountain valleys has been used in the production of forage and timber since the coming of the white man to these areas. In recent years there has been an increasing level of seasonal usage of these lands by recreationists--hunters and fishermen in pursuit of their quarry, picnickers and hikers in search of renewal, and snowmobilers pursuing the thrill of speeding over the snow covered landscape. These recreational uses apparently have not seriously conflicted with the utilization of the land in forage and timber growing. Recent developments in the land use area have led some observers to suspect that coming uses of such areas will not be nearly so compatible with the traditional western activities of forestry and grazing.

The last three decades have witnessed a massive exodus of people from rural to the urban areas of the United States. For a variety of reasons, some perhaps relating to the quality of life in the cities, the urbanites of the 1970's may attempt to counter this migration in substantial numbers. Many rural communities are ill equipped to handle this influx of people if it should occur. The demand for public services is likely to be immediate while the means of providing and financing these services will respond more slowly. A continuing sense of crisis is likely to well up among those concerned about the provision of services to such a rapidly expanding population. Although the migrant group may be somewhat disaffected with city life, one author has described them as "wishing to enjoy the rural life with all the comforts of the city" [19,p.679].

There are a variety of ways in which one can perceive the magnitude of the problem posed to local communities. One way is to examine the number of rural subdivisions. In the preliminary phases of this investigation, the records of several courthouses were examined to get some feeling for the magnitude of rural subdivision activity in recent years. A tabulation of subdivision filings was made. Some of the information obtained is presented in Table I-I. With the exception of Missoula County, there appears to be a substantial increase in filings of subdivisions in the later years of the period.

Another indicator is the reports of county assessors of the quantity of rural subdivision lands in their counties from year-to-year. The inclusion of orchards in the suburban lands in the report of the State Board of Equalization tends to cloud the data for total acreage

TABLE I-1. RURAL SUBDIVISIONS, SELECTED COUNTIES, WESTERN AND CENTRAL MONTANA, JANUARY 1965 TO MARCH 1970.

County	Estimated Number of Rural Subdivisions					
	1965	1966	1967	1968	1969	1970
Carbon	0	0	2	4	3	0*
Flathead	5	5	8	14	10	0
Lake	3	3	2	2	5	0
Park	0	0	1	1	14	7
Missoula	17	20	14	14	11	0
Ravalli	2	3	5	6	5	0

*During 1970 some eight subdivisions were filed after March 30 in Carbon County.

in Flathead and Lake Counties at least. The rather consistent increase in acreage reportedly devoted to suburban tracts, villa's and orchards in the other three counties identified in Table I-2 is likely to be principally in the tract and villa lands. The precipitous one-year change in Missoula County for 1968 is likely due to some interruption of normal reporting or is in error. 1/ (It is inconceivable that this large an acreage would have been annexed to the cities and towns during the one-year period from 1968 to 1969. An increase of some 7,850 acres in the period 1967-68 is equally unlikely.)

These indicators of impending problems and opportunities for local communities are also indicative of an increasing level of activity in the real estate business generally and in real estate development in particular. The expression "real estate development" is used here in the conventional sense of the process of acquisition, subdivision and resale of land.

Some Experiences of Other Areas Undergoing Rapid Real Estate Development

The pristine mountain valleys of the west are being recognized as an attractive place to live for many reasons. Modern communication and transportation have made possible a life style in the regions

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1/ This phenomena was discussed with the staff of the Missoula County classification office but no further explanation could be advanced.

TABLE I-2. ACREAGE ASSESSED AS SUBURBAN TRACTS, VILLA SITES, ORCHARDS ETC., SELECTED COUNTIES [39,40,41], 1965 TO 1970.

County	Acreage Assessed					
	1965	1966	1967	1968	1969	1970
Carbon	963	1,052	1,142	1,183	1,475	1,758
Flathead	16,265	16,664	17,717	19,130	48,331	58,433
Lake	12,688	13,446	12,649	12,912	13,547	14,694
Missoula	5,324	7,747	10,709	18,556	13,065	14,807
Ravalli	2,675	2,612	3,351	4,454	6,575	7,906

similar to the possibilities in or near our nation's population centers. Meanwhile, these once remote regions offer privacy, varied outdoor recreation opportunities, a relatively clean physical environment, and relative freedom from the problems of congestion, crime, etc., that now characterize some of our nation's cities.

Regardless of the causes, the mountain valley areas appear to be on the verge of, if not already in the midst of, a real estate boom. Tales of the real estate development practices that have been permitted elsewhere under somewhat similar circumstances cause responsible citizens to recoil. A description of these practices appeared in a recent issue of Saturday Review [45]. The author, a newspaper editor and publisher from Troy, Ohio, was preparing a series of articles on out-of-state land companies that were "peddling" land in Ohio. He relates stories of the successful selling of 300,000 acres of Florida land which lies under the waters of the Big Cypress Swamp; of 55,000 acres of Arizona desert sold, "like patent medicine, to buyers who, with a few exceptions, are conspicuously not from Arizona" [45,p.48]; of a proposed development scheme for settling a population approximating that of the city of Tucson in a remote desert area, on land unsuitable to the planned individual sewage disposal systems and with sufficient water for only a fraction of the anticipated population [45,pp.49-50]. A former salesman described the way his old company responded to the land fever in Florida [45,p.51]:

> At first we sold Cape Coral in Florida as a legitimate community, and today it is a community. Then we sold Golden Gate with roads, then River Ranch with nothing, and finally Remuda Ranch under water. Everything worked. One of the bosses said one time that 'eventually we'll reach the point where we'll just mail contracts and the people will send them in and we'll tell them where we'll put them.'"

He further described a variety of devious selling practices based on misinformation [46,pp.50-51] if not downright deceit.

Descriptions of rapid selling of land in areas closer to home have made many citizens wonder if they can continue to rely on good fortune alone to prevent Montana lands from becoming involved in some predatory promotion scheme. It does appear that so far fortune has been generally kind in the current land rush and few, if any, misleading practices are current here [27,p.2]. One official was quoted (in [27]) as feeling that the purpose of some purchasers was "to gain the exclusive control of trout streams"; a purpose which many Montana sportsmen would find disturbing.

Large scale developers have begun to show an interest in Montana lands. In addition to the so-called Big Sky development, several fairly large ranches have been purchased with the expressed purpose of subdividing them into 5 to 40 acre tracts for sale on a nationwide scale. These developments range up to seven sections in size and are spread from the Bird Tail Hills near Great Falls to the Rosebud Canyon near Red Lodge; from Hamilton in western Montana to Roundup in the central portion of the state.

One development along the Dearborn River west of Great Falls was the subject, recently, of a feature article in the city's daily paper [67]. The article described the process used by the Colorado based firm in platting, developing, and merchandising rugged, mountainous land in the Bird Tail Hills area and along the Dearborn. One technique described (which was observed in several other areas, too) was the mechanism of "communal parks" to guarantee any landowner in the development access to the river even if he himself did not own any frontage outright. The developers set aside an area of some 5 to 15 acres of river frontage land as communal park (sometimes a public park is used also). The developer, characteristically expressed an expectation of being able to sell the land as fast as access roads and survey work could be completed. It was estimated that the entire 5,500 acres in the project could be sold by early 1972.

Concern over the extent and direction of such changing land use patterns are observable over most of the western part of the state and in several central Montana localities. In late 1970 a group of state and federal officials concerned with the rural situation in Montana reported:

> A recent review of existing legislation by the State Department of Planning and Economic Development makes it increasingly clear that Montana's planning laws are inadequate for meeting the needs of local communities. Local units of government find it almost impossible to deal with problems brought on by change, whether suburban, industrial, or recreational. Undesirable patterns of land use are developing in the countryside due to lack of controls. [60,p.6]

Many of the concerns expressed reflect fears that the benefits and costs of change will fall rather unevenly upon present and future citizens and outside developers. Measurement of these distributional effects would likely reduce anxiety about the future.

History of Public Intervention in the Use and Development of Private Lands

The call for controls (government intervention) is frequently met by challenges of the legitimacy of such actions. A review of the background of public intervention may serve to clarify its respectability.

The term "real estate" 2/ as a synonym for land and improvements reflects the ancient Anglo-Saxon theory that the ultimate ownership of land was vested in the Sovereign. Those who held the land (the lords in medieval Europe) did so as a direct grant and had an obligation to the Sovereign both for personal service and for a share of the product of the land [34,p.187]. The lands could be taken by the Sovereign for public use with compensation (since the signing of the Magna Charta in 1215, anyway). Further, even in ancient times a man's neighbors had legal recourse from the antisocial uses of his lands under the common law of nuisance [34,p.188]. Another historical root is the

2/ Literally "royal property".

police power of the Sovereign. 3/ Modern taxes, zoning regulations, building codes, and other government imposed restrictions of the free use of property possess this ancient lineage.

In this country, zoning was practiced even before the nation was formed. The Commonwealth of Massachusetts in 1692 passed laws authorizing the major towns to assign offensive activities (e.g., slaughter houses and distilleries) to certain places in the towns where the activities would be the least offensive [50,p.2]. Mills for the production of gunpowder were forced to locate on the very outskirts of many colonial communities to reduce the risks to the community of fires and explosions that so frequently ravaged these mills and associated storehouses.

Risk of fire was the factor which led early American cities and towns to continue to regulate the type of construction permissible in various districts. This practice (zoning) was recognized in legislation passed in Wisconsin in 1889. Wisconsin led the way again in 1923 in extending zoning to areas outside the limits of cities and towns with general rural zoning authorized there in 1929 [50].

In the lake states, a very slow settlement rate on cutover lands resulted in an extremely scattered population on small farms. Rural zoning was initiated to return many of these areas to forestry and

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3/ Usually defined in terms of the powers of the state to control the individual's enjoyment of his liberty or property in the interest of public welfare.

recreation in an attempt to reduce the costs of providing public service in remote, scattered locations. Much of the privately owned cutover land in that area returned to public ownership through tax delinquency during the depression years [50,pp.33-34]. Most states using rural zoning do not permit further construction of year-round dwellings in the forest or recreation districts. Wisconsin also prohibits farming in such districts due to fire risks and the anticipated detraction from the recreation values of adjacent properties [50,p.35].

Scope of Rural Zoning Legislation

Virtually every conceivable land use has come under regulation or outright proscription in some place or other in the United States since the beginnings sketched above. In addition to quite general objectives of protection of public health, safety and morals, and the promotion of the general welfare, the laws of some states have seen fit to include one or more of the following list of objectives which are grouped under several general headings.

Orderly Development:

To encourage the most appropriate use of land and water.
To guide a coordinated, adjusted, and harmonious development of the county.
To secure appropriate allotment of land area in new development for all requirements of community life.
To direct trends of building development.
To protect and guide development of rural areas.
To promote coordinated development of unbuilt areas.
To promote classification of land uses and distribution of land development and utilization.

To promote desirable living conditions and sustained stability of neighborhoods.
To protect against blight and depreciation.
To prevent tax delinquency.

Density of Population:

To prevent overcrowding of land or water.
To prevent wasteful scattering of population.
To reduce waste of physical, financial, or human resources due to congestion.
To encourage formation of neighborhood or community units.
To promote a wholesome home environment.
To promote desirable living conditions.

Health:

To preserve health and prevent spread of disease.
To prevent escape of obnoxious fumes or offensive odors.
To protect residential sections from traffic, noise, smoke, fumes, and other unwholesome conditions and influences.
To prevent development of unsanitary areas for housing purposes and relate housing density to practically available facilities for waste disposal.

Safety:

To secure safety from flood or windstorm.
To secure safety from fire, collapse, or explosion.
To reduce hazards to life and property.
To provide adequate police protection.

Highways:

To facilitate highway development and transportation.
To increase or preserve traffic-carrying capacity of highways.
To secure a well-articulated and adequate street system.
To reduce waste of excessive mileage of roads.
To prevent a close arrangement or construction of buildings upon streets.
To eliminate traffic hazards.
To lessen traffic congestion and accidents.
To promote convenience of access.
To provide reasonable access.

Soil and Water Conservation:

To conserve soil fertility.
To prevent soil erosion.
To facilitate soil conservation.
To facilitate adequate water flow, water supply, and drainage.
To make and adopt a development pattern for the physical and economic development of the county, including surface mining.

Esthetic Considerations:

To protect the scenic attractiveness of the landscape.
To promote conservation of exceptional natural physical features.
To conserve and restore natural beauty and other natural resources.
To preserve the natural and scenic beauty and attractiveness of roadsides.
To promote good civic design and arrangement.
To restrict unsightly development.
To increase amenities of the municipality.
To promote the reservation of common park and playground areas and conservation of natural physical features, trees, waters, stream courses, and other natural resources. [50,pp.10-11]

Although the outright prohibition of certain offensive activities in certain areas is the most obvious and likely the most common way of controlling such activities, it is not the only way. Within the framework of land use regulation, some states have required that minimum site areas be acquired by the potentially offensive or hazardous user to provide a buffer of land between him and his neighbors [50,p.33]. Where secondary uses (say grazing, cropping or recreation) are possible on the lands in the buffer area, this device might lessen somewhat the inequities and inefficiencies which result from outright prohibitions.

Relation of Zoning to Planning

Most zoning laws require that land use planning precede the actual formulation of the zoning districts in order to achieve the objectives of the legislation as described above. Perhaps the most obvious output of such a planning effort is a map delineating the uses permitted on the various subareas of the region to be zoned. The plan also establishes a sequence of events to be experienced by the region (and residents thereof) contemplating this sort of action (discussion, adoption, implementation and operation of the zoning district).

Montana's Recent Legislation on Land Use Planning

Local citizen concern over the impact of residential, part-time, and recreational use of rural lands probably came to a head with the announcement by Big Sky, Inc., of their planned recreation complex in the Lone Mountain area of Gallatin County. This project is to encompass some 10,000 acres of land and involve a total investment of some $18,000,000. Such a development is anticipated to have a profound impact on the basically agricultural community of Gallatin County and fear was expressed that considerable commercial activity might be undertaken on the narrow corridor of private lands in the forest area between Bozeman, the county seat, and the Lone Mountain area.

These several forces culminated in the passage of House Bill No. 79 [37] by the 1971 session of the Montana Legislative Assembly. This bill provided for building restrictions and zoning and subdivision regulations by cities, towns and counties; for boards of adjustment; and for city, county, and city-county planning boards. The bill further provided for a master plan and the establishment of the jurisdictional area of the boards to be formed under the provisions of the bill. Other provisions of the bill deal with definitions, the qualifications of board members, the authority of the boards, and the means of financing.

Montana's earlier laws [36] permitted the formation of city-county planning boards and provided that their jurisdiction might go to a maximum 12 miles beyond the limits of the city or town involved [36, Sec.11-3830]. The 1971 law allows the formation of a county planning board with jurisdiction over such area or areas of the county as the commissioners may see fit, including cities and towns should they wish to be included [36,Sec.11-3830.2].

The city, county, or city-county planning boards created under the provisions of the 1971 law are to have authority only to advise the board of county commissioners and city council (or city commission) [36]. The planning boards are to recommend boundaries and appropriate zoning regulations for each district within the planning district [35,Sec.16-4702]. These regulations are to be made in accordance with a comprehensive development plan [35,Sec.16-4704].

The purposes of the Montana planning and zoning laws are similar to those described for other areas and appear to have both a general and a more specific focus. At the general level, the purpose is stated

[35,Sec.16-4701] as ". . . promoting the health, safety, morals and general welfare of the people in cities and towns and counties. . . ." Later at a more specific level [35,Sec.16-4704] it is provided that zoning regulations made in accordance with a comprehensive development plan

> be designed to lessen congestion in the streets; to secure safety from fire, panic, and other dangers; promote health and general welfare; to provide adequate light and air; to prevent overcrowding of land; to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements.

Consideration in drafting regulations is to be given the character of the district and its suitability for various uses; the conservation of the value of existing improvements; the encouraging of the most appropriate use of land within the jurisdiction; and the municipalities within the jurisdiction of the planning district.

It appears that the legislation amply protects the individual citizen from high-handed action by the planning board. The citizen may protest the formation of the planning district, he may attend meetings of the planning board to express his views, he may express his dissatisfaction with a decision of that board when it takes its recommendation to the parent legislative body (Board of County Commissioners or City Council). If the decision of the legislative board is not to his liking, he still has access to the courts to seek redress [35,Sec.11-2707]. It would appear that the weak authority and protracted appeal features of the enabling laws might render ineffective any planning and zoning boards created under the provisions of the law. Despite these same weaknesses, the city-county planning boards created under the 1947 law appear to have been able to perform their intended functions fairly well. The instances where they have succumbed to industry pressure are probably no more prevalent than for regulatory agencies in general.

Whether local legislative bodies may, within the framework of Montana's land use planning legislation, develop truly unique and creative ordnances designed to meet the specific needs of their own areas will probably have to await the specification of the courts. The general welfare provisions seem quite broad in scope and would seemingly allow creative reaction to local need unless a strict construction of the law is pursured.

Problems of Rapidly Changing Patterns of Resource Use in the Bitterroot Valley Area

The resource development problems of Ravalli County were initially discussed with numerous local officials and community leaders. One, State Senator W. A. Groff, described the development situation later in a special report by a Missoula newspaper [16,p.2A]:

> 'When I was young, a high price for land was from $80 to $100 an acre. Now land is selling for around $400 to $500 an acre,' he said. 'Land values have been climbing ever since the war (WWII). Off hand, I'd say prices have increased in the neighborhood of 17 per cent from 1960 to 1970.'

The land in the valley formerly was devoted to orchards, sugar beet farming and cattle ranching. As more people discover the mild climate of the Bitterroot, agriculture is giving way to a different from of land use.

'The northern part of the county is becoming a "bedroom" for Missoula. Many people prefer country living, and are able to buy a small acreage and still work in the city,' Groff said.

The mobile home has become particularly important in the subdivision of the land. Young, middle-income families are able to purchase a small tract of land and set up residency in a matter of days.

Agriculture in the Bitterroot is declining for several reasons.

The closing of the sugar beet factory in Missoula, all but eliminated that crop from the valley. People either began growing other crops or sold out.

The permanent migration of youth away from the farm has hurt agriculture nationwide. Young people are finding higher wages and shorter working hours in the cities and urban areas.

Declining profits have caused farmers and ranchers to consider land sales. Most sources agree people in agriculture are making only a one to two per cent profit when the books are totaled up at the end of the year.

'Farmers and ranchers are making such a small return on their investment, land sales look inviting,' said Groff. 'But I wouldn't say there is a mad rush to sell land. Many of the agricultural properties being subdivided belong to older persons who are thinking of retiring.'

Senator Groff and most others expressed a desire to maintain a viable agriculture in the area in the face of growing demand by suburbanites for the resources currently employed in agriculture. Many have heard of the case of the Owens Valley in California, a formerly prosperous ranching area that currently produces water for Los Angeles, Tule Elk for sportsmen, and little else. The lands of the valley were purchased for their appurtenant water rights to meet some of the water needs of the burgeoning population of southern California. Many of the old "Bitterrooters" both on the land and in the towns recoil at such a prospect for their valley. They view Missoula, the valley's fast growing neighbors to the north, with some suspicion in this regard. Detailed analysis of the water resource potential of the entire Clark Fork-Bitterroot Basin in light of probable water needs should do much to quiet such fears.

The Bitterroot is, of course, in a situation quite dissimilar to the Owens Valley. It is not located in proximity to a rapidly growing municipality in a desert setting with few alternative sources of domestic and industrial water. Missoula is growing rather rapidly and may possess a potential for continuing an accelerated growth in the future but it has a host of alternative sources of water on which to base that growth. Upstream storage to provide timely availability of the 3.8 million acre-feet of average annual discharge of the Clark Fork [47,p.238] and development of the 8 million acre-feet of available ground water of the Missoula basin area [43,p.30] are two alternatives that would appear to be preferable to the expropriation of water being used in agriculture.

The characteristics of the Bitterroot Valley itself are such that means to lessen the impact of immigration on the agricultural base might be accomplished without great difficulty. The valley runs almost due north-south with a preponderance of the better agricultural land located on the valley floor and low terraces along the east side. The west side is a more picturesque than agriculturally viable area, frequently cut by the valleys of creeks draining the lofty Bitterroot mountains. These creek valleys support scattered stands of mixed coniferous and decidous trees and the terraces and ridges in between are dotted by open stands of Ponderosa Pine with some dense Lodgepole Pine stands intermingled. The steeper slopes and high terraces at the base of the Bitterroot Range are largely covered with mixed conifers and harvesting of these forests continues to support the local sawmills to a modest extent. The west-side lands are generally characterized by light, shallow soils overlying deep beds of gravelly or cobbled substrata. Small, scattered patches of land along the stream bottoms and fans lend themselves to crops, chiefly hay, while the preponderance of the west-side lands produce only a small quantity of forage for grazing livestock [59,p.6].

It is this agriculturally marginal area that seems to attract most of the immigrants rather than on the better quality land of the east side. This would appear to be a most fortunate circumstance as not only is the sacrifice of agricultural value very small as resources are transferred out but the land seems well suited to the support of roadways and home foundations and the operation of individual sewage disposal systems. Of course, not all the land on the west side is suitable or even attractive for residences [58,table 3]. Some areas that are attractive are certainly not suitable. The flood plains of the west-side streams in many cases contain several amenities which would make them attractive places to live were they not periodically inundated. Many very picturesque spots are in quite remote locations and/or may be accessible by automobile only in the absense of snow cover and thus are more suitable for seasonal, rather than year-round, residences. Along many of the creek bottoms the water table is so high as to seriously impair the operation of septic tank drain fields during some periods of the year and may pose a definite hazard to those who might use ground water for domestic purposes in those areas. Residential, commercial, industrial, and certain intensive agricultural activities are carried out on contiguous parcels of land when the best interest of all concerned might be achieved by not mixing such uses. A flood of runoff water runs down the west-side tributaries to the Bitterroot River early each summer but the lands irrigated by these same streams suffer chronic shortages of late season irrigation water.

The Bitterroot thus faces both problems and opportunities. Many have looked to planning at various levels to help solve some of the problems and capitalize on some of the opportunities.

The Role of the Economist in Planning

The community at large, it seems, tends to view the participation of economists in planning with suspicion in this country. This view perhaps reflects a perception of the rather indifferent success of the planned economies of the world and economists and planning are somehow associated with planned economies. Further, the members of the economics profession demonstrate a lack of unanimity in their prescriptions for treating the economic ills, past and present, of this country. It is not uncommon for the recommendation of the economist to appear, superficially at least, in conflict with some widely held values of society (those values are themselves sometimes conflicting).

The activities of economists in the resource development field have been somewhat overshadowed by their contribution at the national policy making level. Economists have participated in planning activities associated with public investments in the resource development field for some time. Typically, the economist served as a technical specialist assisting public officials and engineers in conducting a more complete and valid analysis of the economic consequences of a particular resource development project. The primary decisions of what shall be produced and for whom were largely left to that best of all planning agencies, the perfect market, which, unfortunately, does not exist.

Recent public awareness of the deteriorating environment has brought a sense of timeliness to a long recognized economic fact.

Economic processes frequently produce "bads" as well as goods and sometimes there is a fairly direct relationship between the quantity of goods produced and the quantity of "bads" generated--factory smoke is a classic example. Economists can help public planning agencies devise institutions to cause the costs of both goods and bads to be properly considered by market participants.

The Problem

The private development of mountain valley resources involves a variety of costs. Some of these costs are borne initially by the developer of the land (costs of plotting and surveying, service road construction, etc.). Some costs are borne by the occupier of the land (developing costs, construction and operation of water and sewage disposal facilities). Some costs are borne by the general public. The portion of the costs borne by the public are related to the institutional structure, the density and size of settlement and the distance to places where public services are provided.

The institutional structure will dictate the type of public services to be furnished and the necessary preconditions for such services. It will also largely determine the speed with which the local government can respond to real estate development from the revenue side. If there are few preconditions for service and the local government is relatively slow in increasing its revenue from the developing area, the public cost will be relatively high, other things being equal. The cost of several public services, e.g., road maintenance, snow removal, school bus transportation, appears to be related to distance.

Density of settlement in the developing areas is related to public costs through the general institutional setting. Services are provided upon request, as a rule, and usually are paid for indirectly through taxes. The excess of costs to local government to provide services to a developing (or distant) area over the tax revenue generated in that area is a direct public cost of the development during the period of development. Generally, the more densely settled an area, the more taxable value and the greater the tax revenue (city slums are an obvious exception). A sparsely settled area may require an extension of school bus routes to serve one family in a new development, for example. Assuming ample bus capacity, the additional cost of serving the second and succeeding families is far less than the addition to cost of serving the first family. Meanwhile as more families settle in the area the tax base expands and the margin between public outlay and revenue is reduced, until the point of break-even on direct public costs and revenues is reached. Excessively small, remote, and/or dispersed developments may never reach the point of providing sufficient revenue to cover the direct costs of service.

Efforts to reduce the external cost of settlement are a legitimate endeavor of public bodies concerned with planning. Efforts to protect and enhance existing values while providing for the needs of a growing population likewise should be of concern to such agencies. An awareness of the cost to be avoided or imposed; and of the values to be protected, created or destroyed, will hopefully improve the quality of decisions by individuals and groups charged with the responsibility for guiding the development of resources to meet expanding community needs.

Montana's mountain valleys, in general, and the Bitterroot Valley, in particular, are experiencing a fairly rapid transformation from resources out of agricultural employments into a kind of dispersed urban use. In many cases, the areas are occupied year-round and involve more acreage than the bare minimum necessary for housing alone. Upon observation that these rather sizeable tracts (1 to 40 acres) are not apparently used in agricultural use but more related to recreation, the term "recreation-residential" use was applied (with the sure knowledge that it is in some cases wholly inaccurate) to this type of resource employment. It was felt that this term was more descriptive than some of the more commonly used alternatives (rural residences, country estates, villas, etc.). While the conversion from agricultural to urban use proceeds there may remain a potential for water resources development in agriculture.

The Problem Defined

Recreation-residential use of land and associated resources provides a host of benefits and costs to the community in which it takes place. Increasing community concern about this use of resources and its impact on the community has resulted in provision for local government planning of land use. The success of these planning efforts will depend in large measure on the quality of the information on which planning decisions are to be based.

There is currently little information available on the costs and benefits of recreation-residential uses of land and associated resources.

This study will undertake:

1) To establish measures of the benefits to be enjoyed when land and associated resources are employed in recreation-residential use.

2) To estimate the benefits and costs of certain modifications in the institutional structure in which recreation-residential development may take place.

3) To estimate the potential for irrigation development.

Hypotheses

The major hypothesis of this study is that recreation-residential users of resources either do not consider or need not consider some significant costs of their activities. If a more complete reflection of the costs imposed were affected, a different resource allocation pattern would occur and the well being of the community in general would improve.

A secondary hypothesis is that total surface water does not impose an effective restraint on growth in the Bitterroot Valley but an inadequate distribution system prevents the realization of the economic potential of the land and water resources of the valley.

The Approach to be Followed

A brief review of previous studies related to resource development in the Bitterroot Valley area will be followed by a short discussion of the economic theory supporting the study in Chapter III. Measures of the values of certain agricultural and recreation-residential uses of land will be covered in Chapter IV. Chapter V will be devoted to the development of an aggregative linear programming model of the resource based industries of the valley followed by a discussion of several solutions to the linear programming model and some of the implications of those solutions. A summary of this study and recommendations for action will be found in Chapter VI.

CHAPTER II

A SURVEY OF RESOURCE STUDIES RELEVANT TO CURRENT RESOURCE PROBLEMS OF THE BITTERROOT VALLEY AREA

Studies Specific to the Area

The Bitterroot Valley area has been the locus of so many studies that someone recently suggested it be studied one more time to attempt to measure the return on public expenditure for research. Such a study will likely have to wait as there remain a plenty of real problems to be solved. A combination of low income, substantial political influence 1/ and fortuitous location combined to generate the plethora of studies.

The Bitterroot Valley of southwestern Montana is bounded on the west by the Bitterroot Mountains and on the east by the Sapphire Mountains. Except for a relatively small area of the northern end of the valley, its drainage corresponds to the boundaries of Ravalli County and thus most studies, including this one, treat the drainage and county as the same unit. The mountain barriers restrict its intercourse with its neighbors to the city and County of Missoula almost to the exclusion of all others. Relative isolation coupled with easy access for study has made the area an attractive one for field research,

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1/ One of Montana's U. S. Senators is from Stevensville, the other Senator and one Representative are residents of Missoula. In the State Legislature, the Chairman of House Appropriations Committee and the Chairman of the Senate Finance and Claims Committee are both from Ravalli County.

while an abundance of problems has led a responsive congressional delegation to press for funding of research.

Resource Inventories

One group of studies that has immediate application in any planning or evaluation is a set of studies that might be called resource inventories. These provide basic information on the physical and human resources of the area. A proper place to begin a discussion of this group is the Soil Survey [59]. The Soil Survey was issued in 1959 and contains a wealth of information on the capabilities of the soils, the extent and location of each soil type, etc. This information is presented in considerable detail in maps supported by tables and verbal descriptions and evaluations. Although the information and agricultural potential and farm management did not anticipate the rather widespread adoption of sprinkler irrigation in the valley, it can be of considerable aid to any person or group attempting an "on-the-ground" evaluation of the land resource. Discussion of drainage, flood hazard, and subsoil condition is included for all soils where relevant.

While the soil survey tends, characteristically, to focus on agricultural uses of land, the changing emphasis toward recreation-residential and suburban uses is recognized in a supplemental soil interpretation report [58] designed to complement the original soil survey. Information, coded to the soil descriptions and maps for the survey, on the suitability and limitations of each soil phase for urban development is presented in the supplement [58,pp.23-56]. Physical and chemical properties of each soil series are listed in considerable detail [58,pp.14-22]. Information on the estimated depth to the water table and depth to gravel or bedrock are also presented for each soil series. An estimate of the flooding hazard is presented for each soil series. Estimates of the limitations and suitability of each soil constitute a substantial portion of the report. Each soil phase, identified with its mapping symbol is rated for its suitability for suburban uses, recreation uses, and public service uses. Suitability for sewage disposal by septic tank and lagoon is also rated for each soil phase. Suburban uses rated are building sites, lawns and landscaping, roads and streets, and parking areas. In addition, several recreational uses are evaluated including playground, camping and picnic area uses.

The Water Resources Survey [45], originally published in 1958 and reprinted in 1965, contains a fairly comprehensive history of land and water use, water rights, decrees, ditch company origins and operation. In addition, it also contains detailed maps of the entire county showing the lands irrigated and identified by source of irrigation water. A foreword containing information about Montana's surface water laws and water right problems provides a useful introduction to these areas and should be sufficient to make planning agents aware of the limits imposed by these legal institutions. When questions of legal nuance come up, any lay person or group is well advised to seek legal counsel.

The listing of total appropriations by each source helps to dramatize the problems of overappropriation on many streams in the valley. For the valley, total appropriations are about seven times the normal August streamflow with considerable variation in the level of overappropriation on several streams. This phenomena (overappropriation) tends to indicate a considerable degree of scarcity of mid and late season irrigation water on some of these streams where it occurs. In the case of the Bitterroot mainstream, the overappropriation may be in large part due to the rediversion of such return flows but real scarcity does exist on many of the tributaries.

The brief but fascinating history of the settlement and development of the valley contained in the Water Resources Survey report reveals that both the first agricultural activity and the first appropriation of irrigation water [45,p.7] in the State of Montana occurred in the vicinity of Stevensville in the heart of the valley's modern agricultural area.

Irrigators, developers, and local agencies will find the Water Resources Survey a useful aid in tracing sources of water, locating diversions, and identifying others who have an interest in specific waters. Determining the priority of rights on a particular stream may require considerable searching of court records as the primary listing is of ditches and ditch companies and there is no cross-listing by source. The court decrees are cited and these should be consulted when questions of priority appear.

Still another basic resource inventory is the preliminary report on the Geology and Water Resources of the Bitterroot Valley, Montana [35]. This document concentrates on the ground water resource, analyzing the capacity and extent of water bearing materials and the quality of waters. The final report has (as of this writing) not been published although a review copy was available and provided a wealth of detailed information on streamflow, potential of ground water development, etc. It appears that domestic water from groundwater sources is not likely to be a significant restraint to recreation-residential development (except, perhaps, in certain areas along the higher slopes of the valley wall) [34,p.12].

Ground water is available in sufficient quantities in some areas along the flood plain and adjacent low terraces of the river to provide supplemental water for irrigation [34], but development of this water will likely have to await the resolution of certain institutional impediments to conjunctive use of ground and survace waters--particularly owner acceptance of water right transfer contracts. Evaluation of the impact of the integration of ground and surface waters for irrigation may be accomplished by developing a linear programming model along the pattern used by Young in the Gallatin Valley [69].

Analysis of combining ground and surface water in the Bitterroot-Clark Fork basin is apparently being contemplated by the Montana Water Resources Board. What is apparently a preliminary report of a computer-simulation of this liaison [43] was published in April of 1971. Using a computer simulation approach the Board's planning staff is attempting to evaluate the irrigation water needs of this larger area and several subareas which they have defined. From this study, estimates of water demand on existing and potentially irrigable land will be made [43, p.16]. In discussing the potential uses of the simulation model, reference is made incorporating ground water development and surface storage proposals into their model and including an optimizing routine (probably a linear program) to evaluate the development of ground and surface water.

One of the earlier efforts to examine the resources of the Bitterroot Valley was that of W. E. Pollinger who undertook to "briefly analyze the social and economic problems of Ravalli County" [47,p.1] for a hearing of the Congressional Joint Committee on Forestry at Portland, Oregon in 1939. Pollinger's report emphasized the magnitude of social problems of an area whose population had only begun to recover from a major economic depression and whose forests had been ravished by an insect infestation which killed approximately 450 million board feet of pine timber [47]. This timber could not be salvaged due to lack of funds for forest roads. He pleaded for the committee to fund a vigorous timber land and watershed management program including protection of the forests watershed capabilities. He requested that funds be made available for the Forest Service to acquire marginal forest land and cutover lands that had reverted to county ownership so that these lands might be integrated into the National Forest system and managed in the best interests of the nation. He expressed a feeling that the Forest Service, as the largest landowner in Ravalli County, had an obligation to manage the resources under its dominion in such a way as to relive the distress of the local people, also. He sought to hire persons who were unemployed and on relief to re-establish timber "on the thousands of cutover acres located on the most productive forest soils" to provide for the timber needs of future generations. He demonstrated that some 12 percent of the local population at that time was dependent on forest industry while some 16 percent was dependent on public relief agencies and asked that funds be appropriated to accomplish a renewal of these dependency figures. In retrospect, Pollinger has to be recognized as a man of vision who was not afraid to suggest bold answers to pressing resource questions.

More recently, questions about the Forest Service's management practices and its relation to the local community prompted two investigations; one by a task force of Northern Region and Intermountain Forest and Range Experiment Station personnel [57] and another by a select committee of the University of Montana (at the request of Senator Metcalf) [67]. The principal matters of concern seem to be multiple use management and methods of timber harvest and regeneration. These matters are, as yet, unresolved and the implications for resource use on private lands of the valley must await their resolution.

J. Wayne McArthur, then of the Natural Resource Economics Division of the Economic Research Service, conducted what was essentially an inventory of the human and agricultural resources of the area during the mid-nineteen sixties. His work [54] appears to have been principally an analysis of U. S. Census and Montana Agricultural Statistics data with a discussion of the potential for more effective farm management to dramatically change the income picture in the valley. Unfortunately, most of the acreage and yield information terminates with the 1959 Census of Agriculture. Much of the information summarized in the report should be of interest to local community action and planning groups and should be up-dated for their use.

Studies of Real and Hypothetical Adjustment in Resource Use

McArthur's first study was followed very quickly by a second one [55] upon the announcement of the closure of the American Crystal Sugar Company's refining facility in Missoula. This plant had been a major outlet for Bitterroot Valley sugar beet growers for many years. The closure had probably been anticipated as the plant experienced increasing difficulty in contracting sufficient acreage in the last few years of its operation, and a general infestation of sugar beet nematodes in the better beet lands of the valley reduced both the yield and quality of the crop. His study, although born of trepedation, came to a fairly optimistic conclusion based on hope of a potatoe processing facility reportedly being contemplated for the area at that time. This venture was never launched, probably due to a pessimistic outlook for supplies of raw product for processing and finished product markets.

Another study involving processing of farm products was released at about the same time. This was an evaluation of the feasibility of vegetable processing in the Bitterroot Valley area [20]. It too, reflected some concern about supplies of raw products but, from a survey of local farmer costs and returns and attitudes toward vegetable production, it was fairly well established that acreage sufficient to supply a small plant could be contracted at then current prices. The factor of frost danger to certain tender crops in this mountainous environment and the nematode infestation narrowed the possibilities to one crop--green peas. The heavy investment in specialized equipment, high frieght costs on finished goods and the short processing season resulted in a quite low level feasibility estimate and no processors expressed any active interest in establishing a pea freezer in the Bitterroot area.

Water Resource Development Proposals

In 1946 the Bureau of Reclamation included a proposal for major modification of the water storage and distribution system of the Bitterroot Valley in its comprehensive plan of development of the Columbia Basin. The magnitude of the project can be grasped from the following exerpt from the Regional Director's letter of transmittal of the 1950 supplemental report [65].

> . . . The project is needed to stabilize the economy of Bitterroot Valley, which depends principally on irrigated agriculture. Nearly half of the 100,000 irrigated acres in the valley suffer frequently from water shortages. The principal purpose of the project is to alleviate these shortages.
>
> The plan of development recommended in the attached report contemplates the provision of an adequate storage system and the additional canals needed to supplement and interconnect the systems which now serve about 48,300 acres of irrigated land in the project area from several inadequate sources. In addition, about 700 acres of new land would be brought under irrigation.
>
> The water supply for the project would come from the Bitterroot River and its tributaries, which have an average

> annual run-off far in excess of the project requirements. Storage would be provided under the plan principally in two existing major reservoirs, one of which would be enlarged. Four very small existing reservoirs, to be rehabilitated, would complete the storage facilities. Five major canals would be constructed to convey the storage water and presently unused flows of the Bitterroot River to the project lands. These canals would be used in some instances to serve nonproject lands. In return, the canals now serving these nonproject lands would be used for the delivery of water to lands of the project. This would minimize the costs of new supply canals. About 26,000 acres of irrigated land not in the project area would thus be involved in the revised irrigation system. In addition, many exchanges of water would be essential to fulfillment of the purposes of the project. . . .

At the time the project was proposed, the evaluation indicated an excess of benefits over cost.

An earlier Bureau of Reclamation proposal for a major diversion and canal to serve some of the higher west-side lands was authorized in 1944 [65,p.318], and preconstruction surveys were undertaken. This development--known as the Woodside Unit--was halted by court action contesting the repayment scheme and no actual construction was ever initiated. The Bureau's Bitterroot Valley Project included the lands and works of the Woodside unit as a part of that project.

The Bitterroot Project was thus launched under the legal cloud that had prevented the fruition of the Woodside Unit and never got beyond the proposal stage. In view of the substantial increases in construction costs, the current feasibility of this project is certainly questionable. The engineering and basic resource information are of continuing usefulness and serve as some of the basic information for current studies. (The simulation study currently in progress by the Montana Water Resources Board [43] utilizes the reservoir capacity figures for the Lake Como enlargement [43,pp.12,52] and the irrigation diversion requirements [43,p.12].) Any future attempts to evaluate water resource development proposals in the valley should involve reference to this document.

In its summary of potential projects, the Montana Water Resources Board [44] lists a total of 29 projects on the Bitterroot drainage (of which all but four are in Ravalli County) a preponderance of which are for irrigation purposes. While this listing includes projects proposed by the Bureau of Reclamation, it fails to mention the Bitterroot Valley Project. Perhaps the feeling of those who compiled the list was that legal difficulties and cost increases have robbed the project of its potential.

Although a preponderance of the area needing supplemental irrigation water is on the west side of the valley [65,fig.2,p.330], one of the streams that seems to have received considerable attention is Burnt Fork Creek, on the east side, near Stevensville. In 1965, H. C. Holje [24] in a very concise descriptive report, discussed four proposals for development in this watershed that had been advanced by various agencies at various times. Three of these proposals involved storage facilities on Burnt Fork Creek and the fourth involved installation of some 24 irrigation wells and pumps along Burnt Fork Creek. Holje stated that an impasse had been reached with regard to the development of the Burnt Fork Watershed due to the plethora of proposals. He attempted to critically evaluate the several development schemes, pointing out the shortcomings of each. He concluded by calling for a comprehensive benefit-cost analysis of the watershed to determine the optimum level of development (the most ambitious proposal was limited to the statuatory maximum storage for soil conservation service pl. 566 projects--25,000 acre-feet). This watershed would seem to be idealy suited for the sort of analysis anticipated for the Water Board's simulation model.

These several studies of the resources of the valley, their changing use and development potential have tended to focus almost entirely upon agricultural use of resources. This information has provided a rich background for further studies of managing the resources of the area for their agricultural potential. The supplement to the soil survey which presents information directed at the interests of land developers, builders, engineers and planning agencies reflects a perception of the changing nature of resource use in the valley.

CHAPTER III

SOME ELEMENTARY THEORETICAL CONCEPTS RELEVANT TO PLANNING FOR RECREATION-RESIDENTIAL DEVELOPMENT

In our system, the preponderance of resource employment and development decisions are left to resource owners and entrepreneurs in what is called a market economy.

In theoretical analysis of this market economy, it is assumed that all consumers behave rationally; that is, their behavior consistently reflects their preferences. Further, consumers' preferences are such they prefer more of commodities rather than less, but their willingness to substitute one commodity for another in response to price changes, diminishes as increasing quantities are substituted. Still further, the preferences of consumers are independent in the sense that any consumption activities of one household have no influence on the level of satisfaction of other households. An individual consumer's preferences are based on the whole set of human needs ranging from physical to self-fulfillment.

For ease of presentation it is customary to begin by assuming a given consumer is faced with a choice between only two commodities. This permits one to illustrate graphically some principles that have general validity (Figure III-1). Let x and y represent these two commodities and curves, I, II, and III, be indifference curves. 1/

1/. This discussion of consumer behavior and markets is a standard treatment of the subject. More adequate descriptions can be found in most texts (e.g., [49,pp.29-81;22,pp.6-40]). Eckstein [13] is perhaps most strongly reflected here.

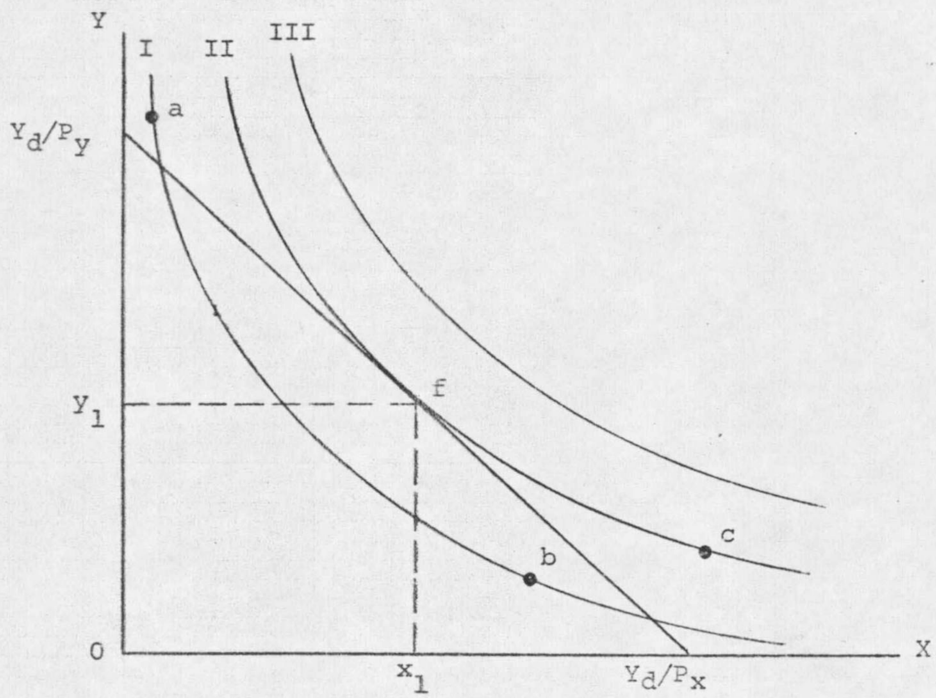

Figure III-1. Normal Indifference Map.

These curves have the quality that the consumer is equally satisfied by any combination represented by a point on the curve. Any other combination represented by some other point on a given curve would do as well. As the consumer is equally satisfied with any combination along the curve he has, he does not prefer one combination over another and is said to be indifferent between combinations represented by points on the curve. Hence the name, indifference curves. All points on curve I yield equal satisfaction to the consumer. Curve II represents a higher level of satisfaction and curve III a level still higher. Combination a, involving very little x and much y, is no better or worse than combination b with much x and little y. Combination c is preferred to both a and b. The shape of these curves derives from the assumption about willingness to substitute.

The amounts of the two commodities which a consumer, as described here, will choose depends on his income and the prices of the two commodities. Let his income be represented by Y_d, and P_x and P_y be the prices of the two commodities. If he allocated all his income to the purchasing of X, he could purchase Y_d/P_x units; if all to Y, he could purchase Y_d/P_y. Any combination represented by a point on the line connecting these two quantities are also available to him. Of this infinity of possibilities he will select that combination that allows him the highest level of satisfaction. Geometrically, that point is defined as the one where the income constraint or budget line, just drawn, is just tangent to an indifference curve. This will be the highest level of satisfaction attained with the consumer's given income and he will choose the combination f here which allows him satisfaction at level II by consuming x_1 of X and y_1 of Y. If either of the prices change, or if the consumer's preferences on income changes, he will seek a different combination. For the moment, though, f remains his best choice as all preferred combinations are unavailable to him as well as all points as good as f. At point f the rate at which he is willing to substitute X for Y, as shown by the slope of curve II at point f, is precisely equal to the ratio of their prices as shown by the slope of the income constraint line.

In production, the firm is assumed to employ resources in the combination that will maximize profits; given the technological limits. Technology determines the rates at which certain resources may be substituted for others in the production of a given commodity. The firm will select the combination of resources that is the least costly and will hire resources in such a combination that the contribution to output of the marginal units of input will be in the same proportion as their prices. Firms are assumed to operate under conditions of decreasing returns and assumed to be independent of all other firms--that is, the operations of one firm have no influence on the productivity of other firms or the well-being of individuals except as reflected in resource or product market prices. The optimum level of output for a firm will depend on the prices of its products, the prices of inputs and the techniques of production.

One may represent the firm's resource employment decision on a diagram similar to that used for the consumer. Again, for ease of presentation, assume only two variables--resources in this case. Assume that the firm is interested in maximizing profits from the production and sale of commodity X. It may produce X by using various quantities of resources A and B (all other resources held constant). Let Q_1, Q_2, and Q_3 be three possible levels of output of commodity X. The curves so labeled in Figure III-2 represent all combinations of A and B that yield the specified level of output. These curves are called isoquants and are the counterpart of the consumer's indifference curve. All combinations of inputs represented by a point on a given isoquant will result in the level of output specified for that curve. As one proceeds upward and to the right, one encounters increasing levels of output (in the relevant range). Thus, Q_3 represents a higher level of output than Q_2, which is, in turn, a higher level of output than Q_1. If the firm has K dollars of working capital to spend on resources A and B during the ensuing planning period, it can purchase K/P_a units of A and K/P_b of B or any combination of these resources as represented by the line connecting these two points on Figure III-2. This line is called an isocost line and is one of a

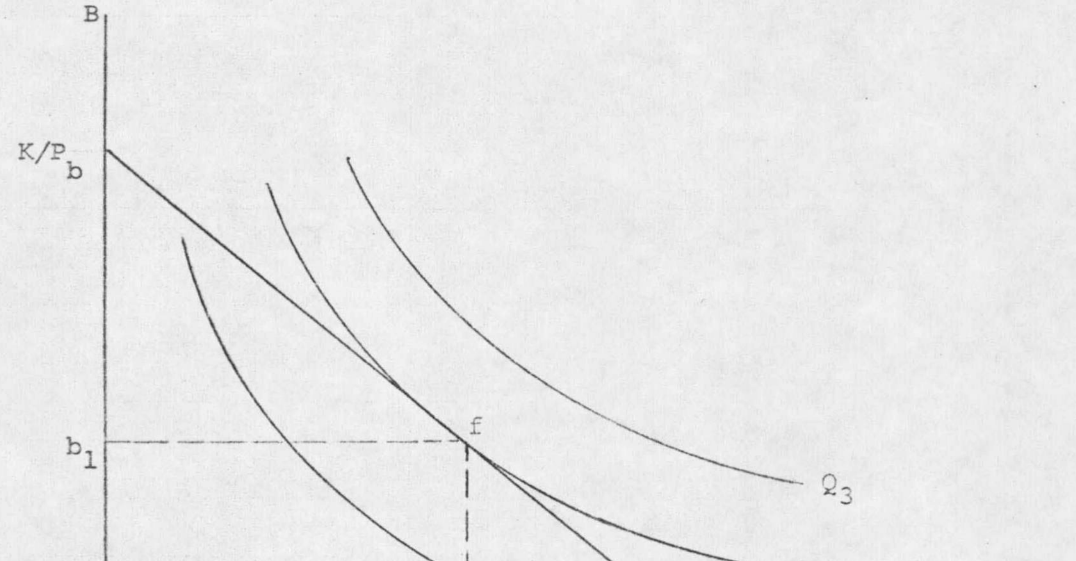

Figure III-2. Normal Production Surface.

family of such lines--one for every level of working capital. The firm will find its optimum combination of inputs at point f. This combination represents the highest level of output attainable with K dollars of working capital and will use a, units of A and B, of B.

A firm wishes to go beyond producing the maximum output possible with available inputs. Neither is it satisfied by producing a given output at minimum cost. It wishes to maximize profits! In so doing it will employ a given resource until the value of the production generated by the use of the last unit of the resource is just equal to the cost of that unit (marginal value product equals marginal factor cost). If the price of a resource is reduced (say in response to the discovery of new supplies) the firm will employ still more of that resource until its marginal contribution to revenue just equals the cost at the margin.

It is in the equating of marginal value productivity and marginal resource costs that firms operating in a competitive market bring together the preferences of consumers and the technical possibilities of the production sector. A competitive market, in order to provide all the wonders that are ascribed to it, must meet several very stringent conditions. In addition to the assumptions already imposed on consumers and firms operating in this market (independence and rational maximizing behavior), the markets themselves must be "perfect". By "perfect" it is meant that all buyers and sellers have perfect knowledge about commodity supplies and prices and the supplies and prices of substitutes; each buyer and seller must be so small with regard to his market activities that none can influence the supply of, demand for, or price of any commodity.

Because of its importance in subsequent discussions, the assumption of independence should be clarified at this point. If a firm is independent of others, its level of activity does not influence the cost, revenues or decisions of other firms or of consumers, except as reflected through product and factor markets. If one firm's activities influence the cost or revenues (and thus the level of output) of another firm an externality or a lack of independence is said to exist and the quantities of goods provided by reliance on the market will not reflect people's preferences. Consider an example of two firms. The first firm operates a gravel quarry and produces gravel which it sells at prevailing prices in an otherwise perfect market. It also produces some dust which it allows air current to carry away at no cost to the gravel quarry. The second firm in our example produces housing and associated services which it provides at prevailing prices (rental, if you prefer) to consumers (tenants). If the quarry firm increases its output of gravel, more dust is produced, too. Assume that the dust, among other things, soils the windows on the apartments rented out by the second firm and that firm's costs for window washing are increased. It is now clear that the level of the second firm's window washing activities and costs are influenced by (dependent upon) the level of activity of the first. If gravel quarries supplying the market are forced to recognize the costs imposed on all receptors of dust and this increase in cost is reflected in market prices, users of gravel will demand less gravel and the level of activity (output of gravel and dust) in quarries will be reduced. In the absence of some mechanism to cause the quarries to consider the costs imposed by their dust, too much gravel, too much dust, and too much window washing service will be produced.

If all the conditions of consumer behavior, market conditions, and independence are met and a resource allocation and product distribution is made by such a perfect market, the condition of economic efficiency will obtain [49,pp.55-60]. Economic efficiency is defined [49,p.55] as a condition in an economic system such that any adjustment that would result in someone's being made better off will result in someone else being made worse off. In any situation where someone may be made better off without anyone else being made worse off, a more efficient allocation can be made. In general, changes in the institutional framework for economic activity which result only in increased economic efficiency are less controversial than those that have an influence in the area of equity or social justice (where some are made better off but others worse off).

It is safe to observe that the conditions necessary for a perfectly competitive market to exist are not present in any area of the American economy. This should not discourage policy makers from using this ideal and supporting policies which would allow economic activity to be guided by a closer approximation of the competitive model than some other alternative policies might.

In areas of equity, the economist is much less sure of his ground than in the area of efficiency. Consider the classic case of a contemplated change in public policy which would, in effect, transfer the control and benefits of a set of resources from one group to another. It is not sufficient to show that the gains of the gainers (in dollar terms) exceed the losses of the losers; of even that an acceptable mechanism exists for compensating (with dollars) the losers with part of the gains from the new employment. Such a scheme involves the impossible task of comparing people's preferences for gains and losses which are probably not symmetrical for a given person in the first case and are certainly different from individual to individual. Bostwick [5] discusses a case where such a change was contemplated and monetary gains exceeded monetary losses and costs by three and one-half times and the losers were to receive substantial compensation. Yet, the project was not undertaken due, apparently, to consideration of the non-monetary losses and disruption of patterns of life to be imposed on the losers. Questions of equity are more in the realm of the politician and the parson than of the economist.

Some Problems in Actual Markets

In a market economy, certain goods and services must still be provided which, when provided to one person, unavoidably become available to others [6,p.380]. National defense, flood control, and some forms of pollution abatement are examples. The provision of such public goods through market processes is usually not possible and it is generally left to government, at various levels, or eleemosynary organizations, to provide a host of services of this nature. Some goods and services traditionally provided by government may furnish benefits that accrue, in part, to specific individuals; public roads, and education, for example. In this context, the opening of a public road into an area previously not directly served will provide substantial benefits to some resource owners and entrepreneurs in the area. These benefits are quite likely to be quickly reflected in the market value of the resources (see Chapter IV for a discussion of this process). The well-being of an individual student, and in some cases, his anticipated lifetime earnings, is enchanced by his attendance at a university. At the same time his efforts work for the benefit of all (or most) of society by reason of his becoming a more productive and informed citizen. His increase in productivity (and earnings if such occurs) are shared by many participants in the economic system. Further, our form of democracy would probably not work very well without an effective system of public education.

It is for these (and perhaps others) reasons that our forebearers chose to provide access to public education to all. In a sparsely settled area, providing schools of a reasonable size involved an even sparser distribution of schools. In order to overcome the resistance to sending children a considerable distance to school, a scheme of subsidizing remote settlers was incorporated to defray somewhat the private costs of transporting children to schools. In recent times this is most obviously manifest in publically operated (or contracted) school bus services in rural areas. In areas not served by school bus routes, persons dwelling more than 3 miles from school are still entitled to the cost of transportation subsidy in Montana [36,Sec.75-3401].

It can be argued that if a subsidy is to be provided parents of rural school children, the cash subsidy is more efficient than providing transportation at an artificially low (near zero) price. Consider a normal consumer's indifference map as described earlier. Let the horizontal axis represent school bus transportation and the vertical axis represent all other things which such a consumer might desire (Figure III-3). Suppose that the price of bus transportation services is such that with his given income Y, he could purchase quantity a of school bus transportation service.

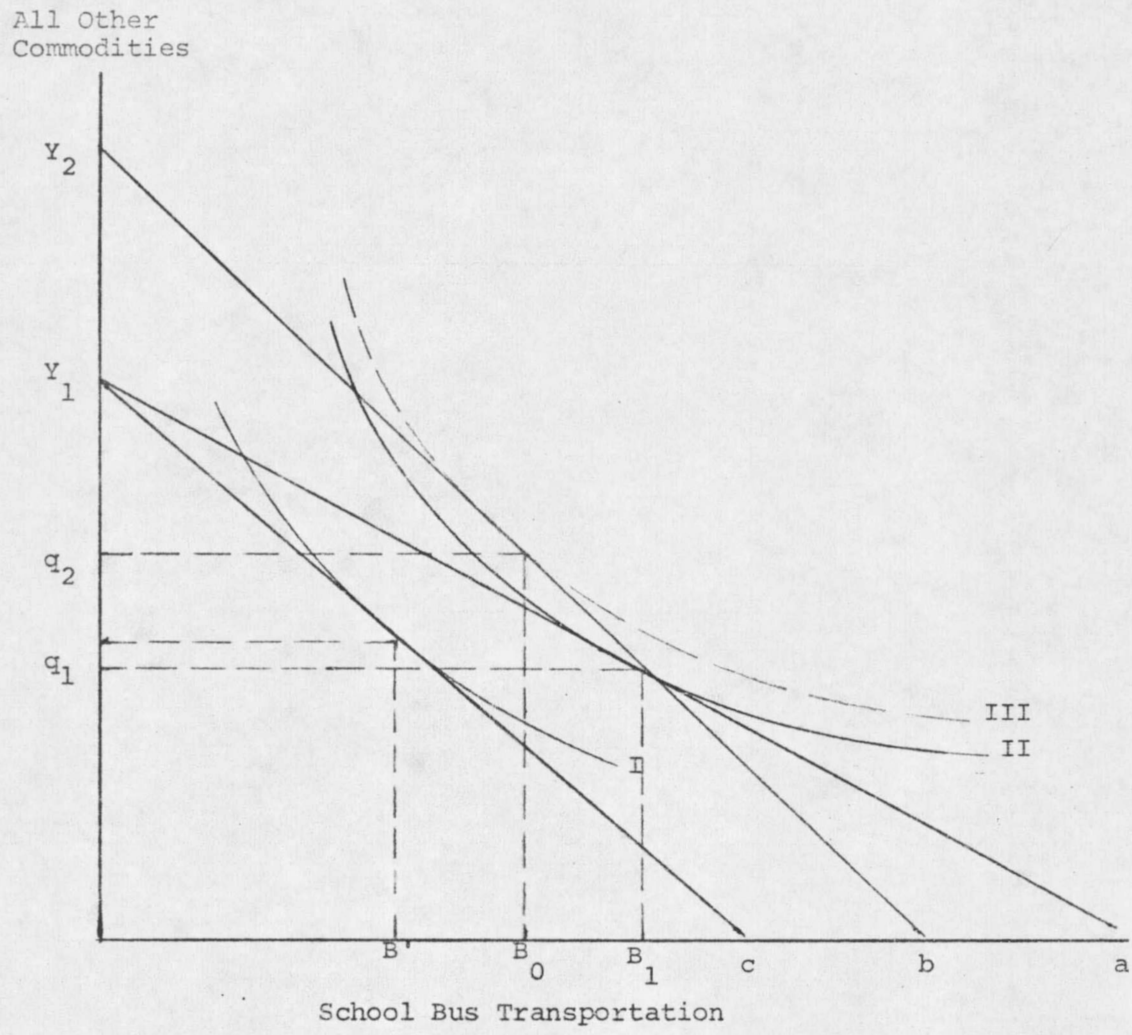

Figure III-3. Indifference Map of Influence of Subsidies.

The consumer behavior model described earlier would suggest that the individual would choose to take B_1 of bus service and q_1 of other things. If the in-kind subsidy were removed, this would be tantamount to raising the price to the user of the service and with his constant money income he could purchase only C of the service. He would then choose quantity B' represented by the point of tangency of his new budget line and an indifference curve--here the one labeled I. If the public felt a subsidy was in order and chose to award parents in rural areas a cash subsidy sufficient to enable them to buy at the unsubsidized price the quantity of the service preferred when the commodity price subsidy was in effect, a cash subsidy of Y_1Y_2 would be required. This would appear as a new budget line reflecting the unsubsidized or market price but containing the point of original intersection of indifference curve II and the budget line under the subsidized price arrangement. It will be noticed that a portion of this budget line lies above indifference curve II. This allows the consumer to achieve a higher level of satisfaction, represented by indifference curve III. If permitted to do so, the consumer would not take the original combination of B_1 units of bus service and q_1 of other things but would adjust his consumption pattern to B_0 of bus service and q_2 of other things and enjoy a higher level of satisfaction.

Two features of consequence can be deduced from the foregoing analysis. First, the consumer of bus services is better off (on a higher indifference curve) with a cash subsidy than in the case of the subsidy administered by reducing the price of the service. Second, the consumer will choose to consume less if he must pay the market price even if his income is subsidized enough to permit him to purchase the original quantity at the new price.

Under the present scheme of providing the service at a price near zero, the individual household has no reason to consider the cost of bus transportation in making their location decision. They are perhaps aware that if bus routes have to be extended to serve them it will increase the cost of school operations and taxes, but the portion of the cost which they will have to bear themselves is imperceptibly small. Either a cash subsidy or the elimination of the subsidy altogether would provide an incentive for the household to consider school transportation costs in their location decisions. The cash subsidy is more efficient in the sense that households with school children are made better off and other taxpayers are no worse off than under the present system. The question of elimination of the subsidy is in the realm of equity--as was the decision to initiate the subsidy. (The above assumes a subsidy of fixed amount, a subsidy computed as an increasing function of distance would be little different from the present price subsidy.)

Where some aspects of education itself may be definable as a public good and properly be supported by public funds, it seems clear that provision of school bus transportation at a near zero price is not the best use of public funds even if some school transportation subsidy is deemed proper. Its close relationship to education somewhat clouds the case for the elimination of the subsidy. The original provision of the transportation subsidy was an interference in market processes and a more satisfactory situation is likely to result from greater reliance on free market forces.

The proximity of school bus transportation and the current subsidy to education as a public good is made no more palatable from an efficiency standpoint by reason of its resulting in a type of real life violation of competitive assumptions. Specifically, the occupation of a rural residence by a family with school children may impose an external cost upon other citizens in the area.

It has been pointed out that the potential tax increase resulting from an extension of routes to serve a rural family is probably not felt strongly enough by that family to discourage them from selecting a location requiring such an extension. What has not been pointed out is that other residents will find their tax bill increased just as much as the family requiring the increased service. This is a clear case of lack of independence (one economic unit's action influencing the well-being of other economic units) or external costs.

Interest by economists in externalities has experienced a lively awakening associated with recent general interest in the quality of the environment. The current economic literature on the subject harks back to a 1960 article by Coase [9] wherein he suggests remedies ranging from bargaining between the parties to the use of a merger to internalize the externality, to the outright prohibition of the activity which generates the externality. If costless bargaining is possible, no intervention by government is necessary in order to achieve the optimum level of the activity involving the externality (only rarely would one expect the optimum level to be zero in the case where the activity resulted in production of goods or services).

In a later review article, Turvey [52] asserts that the economist has little to say where bargaining is made difficult or too costly by either the number of or geographical distribution of the parties involved. He further argues that the case for intervention when bargaining is possible, must be made on the basis of equity. It is probably correct to say that the participants in the case at hand are scattered enough to make bargaining difficult. The existence of district school boards as a body representing the taxpayers in the district may make some meaningful exchange possible. Previous generations of public officials have seen fit to intervene, no doubt on the basis of equity, and the result can, in some instances, result in significant externalities.

To the extent that the children of rural families whose occupation requires them to live in remote areas enjoy a more complete and higher quality education than they otherwise might, usual concepts of justice may seem to be served. To the extent that workers, tradesmen and retired people living in the towns pay higher taxes that the children of high income people in the environs may ride the bus to school, our sense of justice is violated. It is not, however, the question of whether to subsidize or not that is being examined here for that is purely a question of equity and properly in the province of politics. What is being brought to question is the manner of administration of the subsidy which magnifies the distortion resulting from the intervention.

The case of provision of maintenance service on county roads is similar to the case just discussed in the sense that it does result in an external cost associated with dispersed settlement pattern. The more widely dispersed, the greater the total cost of providing the service and the greater the externality. At the theoretical level the developer can be made to economize on this service by making him responsible for perpetual maintenance of the roads as well as their initial construction to specifications. The institutional mechanism for accomplishing the task is not so obvious.

Still another case of externalities can be demonstrated in the area of land settlement and development. This is the problem that occurs when adjacent properties are employed in what are usually called conflicting or nonconforming uses as the gravel quarry example discussed previously. The simple presence of such a conflicting or nonconforming use may involve some decrease in the satisfaction of other "normal" users and there may be additional discomforts or costs imposed which vary depending upon the level of activity of the offensive occupant. This may be represented graphically as an expression of the damage inflicted by the offensive user as a discontinuous function of operating level. Once the decision is made to carry on a certain offensive activity in a location where the welfare of others will be adversely influenced, an initial damage of say, oa is inflicted upon others. The additional damages which vary with output may take on a relationship such as the line ac in Figure III-4. For existing operations, Coase [9] shows the optimum level of activity to be that level at which the cost of controlling damage just equals the damage imposed by the last unit of output.

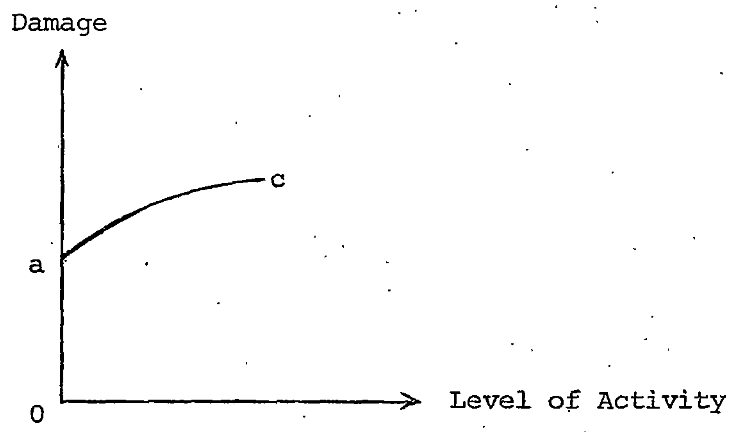

Figure III-4. Hypothetical Damage Function.

CHAPTER IV

ESTIMATING BENEFITS FROM RESOURCE USE

On the Valuation of Assets

The value of any productive resource is, in theory, equal to the present value of benefits to be enjoyed from the use of that resource throughout its productive life. For a productive asset such as agricultural land, the measure of benefit is the annual net income from agricultural operations accruing to the land resource. This residual, after payments for labor, capital and management have been subtracted, is called economic rent.

If we let a represent the annual amount of such economic rent and r represent the appropriate rate of interest for weighting the amounts to be received as economic rent in future years, we may express the value (V) of a piece of land earning this economic rent as:

$$V = \frac{a}{(1 + r)} \quad \frac{a}{(1 + r)^2} \quad \frac{a}{(1 + r)^3} + \ldots + \frac{a}{(1 + r)^n}$$

As n--the number of years over which the rent is to be enjoyed--becomes quite large, the above expression reduces to:

$$V = \frac{a}{r}$$

Thus, a piece of land earning an economic rent of $1,200 per year would, at a rate of 6 percent for discounting, be valued at $1,200/.06 = $20,000. Such a value is frequently referred to as the capitalized value and the process is called capitalization. 1/ We would thus expect that a rational operator would be indifferent between renting land at this price and paying the capitalized value for it.

Estimate of Benefits of Agricultural Uses

To the extent that farmers hold land to be used as an input in agricultural production; and, to the extent that they maximize their money incomes from agricultural operations; the present value of rent incomes from agricultural production will be reflected in the market prices of lands to be used in agriculture. The accuracy of this reflection is diminished due to factors other than rental earnings having a fairly sizable influences on market prices. Such factors as the marginal demand price effect [29] on "add on" purchase; the influence of speculation, tax shelter, etc., while not dominating the farm real estate market, do have their influence on prices [53,pp.39-45]. Such influences certainly are acceptable if the criterion of general income maximization is allowed. Accepting the premise that agricultural producers are indeed maximizers would allow the use of market prices for land as a proxy for the present value of anticipated earnings from all sources. The market could be surveyed and the prices (present value) of various categories of agricultural resources ascertained.

1/ See Barlowe [4] page 169 for a more thorough discussion.

In view of the costs of such a survey and the difficulties in obtaining sufficient information to allow reliable conclusions, another alternative measure for the present value of resources used in agricultural pursuits was selected. All agricultural lands in Montana have been classified on a productivity basis for real estate tax purposes under the Montana Land classification law. The records of such classification are available in the courthouse in each county in the state. Further, the State Board of Equalization has established values for each class and grade of land (see Appendix A) on the basis of capitalized net earnings of such lands in agriculture [31,p.6].

The State Board of Equalization establishes assessed values per acre for each class and grade of agricultural land. Assessed value is established by board policy as 40 percent of full and true value. Full and true value is normally interpreted as market value or, in the case of agricultural land, capitalized earnings. Capitalized earnings value of agricultural lands is approximately one-half current market value for such lands.

If one were then to attempt to use the State Board assessed values to work back to current market values for say Class 2--medium rotation, grade 1A irrigated land with water cost under $1.50--the assessed value set by the board is $97.25 per acre. As assessed value (A) is 40 percent of full and true value ($\bar{t}$),

$\$97.26 = .4\bar{t}$

$\bar{t} = 243.15$

observing that "full and true value" is approximately half current market value (M):

$\bar{t} = .5M$

$\$243.15 = .5M$

$M = \$486.30$

The current (1970) market value estimated by this method is thus \$486.30 for Class 2 (medium rotation); grade 1A land assuming a water cost of under \$1.50 per acre. (A recent enterprise cost analysis on similar lands in the study area [18] use a current market value of \$495.00 in estimating real estate opportunity costs.)

The thrust of this study is to examine the allocation of resources between agricultural and recreation-residential uses (interindustry) rather than the allocation within the farm section (intraindustry). It was felt that attempting to examine the intraindustry allocation with each grade of land considered separately would add little of substance to understanding of the interindustry allocation, but would substantially complicate the appearance of the analysis. An aggregation of the agricultural lands was made by weighting assessed value of each grade of land by the acreage in that grade to determine a weighted average assessed value for irrigated land and nonirrigated land. The resulting assessed values were then inflated to current market values using the approach just outlined.

Benefits from Recreation-Residential Use

In the context of recreation-residential assets, the counterpart of the economic rent is the net benefit to the occupier. Value is the present value of the benefits to be enjoyed by the occupier of the recreation-residential tract. As it is impossible to isolate and measure each of the benefits accruing to the occupier of the residential-recreation tract we seek a proxy measure of these benefits. The purchase price of the tract is such a measure, to the extent that both parties to the sale exhibit maximizing behavior in a competitive situation.

The benefits to the occupiers of such tracts tend to differ both quantitatively and qualitatively from those of town lots. Beyond space on which to construct a house, the occupier is able to provide space and even some forage for horses, carry on rather extensive home gardening, provide habitat for wildlife, practice forestry on a limited scale, or various combinations of these and other activities. He is further able to enjoy and sense roominess or absence of crowding or the relative isolation such a sparse settlement pattern provides. He enjoys as well, a less obstructed view and all the other amenities--including perhaps a free flowing stream--provided by his rustic setting.

The occupier, of course, gives up certain conveniences too. He will likely have to travel further to obtain certain services; medical and dental services, for example; than he would had he chosen to live in town. He will have to provide his own domestic water supply and sewage disposal system and be responsible for the maintenance of these facilities. He will have to make his own arrangements for disposal of trash or at a minimum, select a portion of his property for its accumulation at some inconvenience to himself and his neighbors.

The recreation-residential tract then provides its owner with a collection or "shopping bag" of services. The components of such a bag might include: (a) open skies above with air relatively free of dust, industrial and automotive pollutants, and certain irritating pollens; (b) a surface cover to be utilized by the occupier to satisfy his needs for fuel, shade and seclusion, or to supply forage for his livestock or cover for wildlife or to be removed at some cost to encourage one type of use over another; (c) the surface for space for buildings, paddocks, and gardens; (d) a soil mantle in which certain horticultural crops may be grown and into which certain domestic wastes may safely be passed. Streams may flow over the surface of his land and subject to his also acquiring water right, 2/ the occupier

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2/ For a layman's discussion of how water rights are established and transferred, see Bowman and Lessley [7,p.17]. A more technical analysis is that of Hutchins [25].

may, subject to superior rights, divert a portion of the water from the stream onto his land to irrigate his horticultural and/or forage crops. Such streams have, and in some areas continue to serve as receptacles for various forms of animal and human waste--liquid and solid. Increasing awareness of the true cost of such a use of streams will likely cause this practice to disappear. At some level below the soil mantle in most cases the occupier acquires a segment of a ground water acquifer from which he may pump water for his domestic needs, for livestock water, and/or irrigation or various combinations of these.

Estimating the Benefits of Recreation-Residential Use

In an effort to determine the benefits to the occupier of recreation-residential tracts and the contribution to benefits of at least some of the components of the package, a study of sales of small (less than 40 acres) unimproved tracts 3/ was undertaken. Finding a centralized source of information on land sales proved to be a difficulty of some importance. As many sales involve deferred payment terms and the deeds are not recorded until final payment is made, the official records at the courthouse could not serve as a source of information on recent sales. Further, the actual sales price of a

3/ Unimproved in the sense of an absence of buildings, interior streets, alleys, municipal sewer and water facilities.

piece of real estate is only rarely disclosed in the terms of the deed and the seller is no longer required to affix revenue stamps to the deed upon filing it.

Rather than trying to contact the purchaser of the tracts--many of whom live elsewhere and hold their tracts for seasonal or future use--it was decided that the seller or his agent should be contacted. On inquiring at the county tax equalization offices it was found that a preponderance of the recreation-residential tracts were being developed by a few dealers who tended to specialize in this sort of real estate. Attempts were made to contact each of these specialists and solicit his cooperation in supplying sales data from his records. Five of a total of nine such dealers contacted agreed to provide such information. An additional sample of five dealers not identified as small tract specialists agreed to supply similar information on such of their sales as might be of interest.

Information on a total of 203 sales of unimproved land was collected. Such factors as date of sale, size of tract, purchase price, stream frontage, etc., (see description of variables X_1 through X_{19} on page 69), were taken from the dealer's copy of the purchase agreement. In addition, the agricultural productivity and timber classifications, where appropriate, were taken from the records of the Ravalli County Tax Equalization Office. All agricultural productivity levels were converted to equivalent animal unit months of forage using the technique of Remer [48]. Virtually all the tracts included in the sample were classified on a forage base. Tracts containing 40 acres or more were arbitrarily excluded on the basis of their being large enough to rather easily move back into agriculture. Elimination of tracts 40 acres and larger; tracts to be re-subdivided; tracts moving into commercial uses; and tracts outside the study area or otherwise not conforming to the population under study, reduced the size of the usable sample to 134 sales of which 42 "fronted" on streams. Some of the characteristics of the sample are presented in Table IV-1.

Land value analyses have long been used to measure the expected benefits in connection with public projects involving natural resource development [8,p.143]. Such an approach assumes participants in the land market are able to perceive the contributions to land value of recreation-residential amenities and adequately reflect these in the purchase prices of lands possessing such amenities. Use of the technique of regression analysis, although not completely satisfactory, to separate the myriad of determinants of market value has also been widely used. A number of the early attempts are discussed by Remer [48,pp.11-21] and Remer used the technique to evaluate the contributions of some eight factors (productivity, size, mileage to town, etc.) on the values of agricultural lands in Montana. Alonso [1] lists

TABLE IV-1. DESCRIPTIVE CHARACTERISTICS OF SAMPLE OF SMALL TRACT LAND SALES.

Characteristic	Number of tracts possessing this characteristic (134 total)	
Stream frontage		42
Irrigating water		66
Trees:		
Commercial timber	46	
Non-commercial	30	
Total		76
View:		
Bench view, east side	10	
Bench view, west side	31	
Hill view	32	
Bottom view	56	
Total		129
Special feature		11
Detriment		5
Sold by small tract specialists	132	
Sold by other dealers	11	
Total		143

several applications of regression analysis [1,pp.5-15] in his analysis of locational and zoning influences on urban land values. David [10] uses regression to evaluate certain characteristics of recreation land in Wisconsin and their contributions to land value.

In an attempt to evaluate the contribution of various qualities of a recreation-residential tract to the value of that tract, a single equation regression model was developed. In the interest of simplicity, a preponderance of the relationships were specified as linear, with nonlinear relations being used where sound theory justified such a relationship. In general, the value per acre of a tract of recreation-residential land was conceived as a function of the several readily identifiable features of that tract plus some others, not so obvious and assumed to be random. Symbolically:

$$Y_i = f(X_1, \ldots, X_n) + U_i$$

In this analysis:

Y_i = sales value per acre of the i^{th} tract;
X_1 = year of sale (1960 = 1);
X_2 = month of sale (January, 1960 = 1);
X_3 = size of tract in acres;
X_4 = total sales value of tract ($ of year of sale);
X_5 = stream frontage in feet;
X_6 = road mileage to town;
X_7 = identification of town;
X_8 = straight-line mileage from tract to National Forest boundary;

X_9 = road distance to Missoula;

X_{10} = miners' inches of irrigation water rights;

X_{11} = agricultural productivity per acre in AUM's;

X_{12} = commercial timber dummy;

X_{13} = noncommercial timber dummy;

X_{14} = bench view, east side, dummy;

X_{15} = bench view, west side, dummy;

X_{16} = special feature, dummy;

X_{17} = detriment dummy;

X_{18} = hill view dummy;

X_{19} = bottom view dummy;

X_{20} = stream frontage dummy;

$X_{22} = X_4/X_3$ = price per acre;

$X_{23} = X_8 \cdot X_9$ = distance to National Forest boundary times distance to Missoula;

$X_{24} = X_5 + 1$ stream frontage plus 1 foot;

$X_{25} = X_4/X_{24}$ frontage price (X_4/X_5);

$X_{26} = X_{10} \cdot X_{11}$ irrigation water times productivity;

$X_{27} = X_{10}/X_3$ irrigation water per acre;

$X_{28} = 1/X_{24}$ inverse frontage $(1/X_5)$;

$X_{29} = X_6 \cdot 2$ twice distance to town;

$X_{30} = X_{29} + X_8$ twice distance to town plus distance to National Forest boundary;

$X_{31} = X_{30}/3$ weighted average location;

$X_{32} = X_{15} + X_{19}$ bench view W plus bottom view;

$X_{33} = X_8 + .001$ distance to National Forest boundary plus .001 miles;

$X_{34} = 1/X_{33}$ inverse distance to National Forest boundary;

$X_{35} = 1/X_3$ inverse of size;

$X_{36} = X_{27} \cdot 2$ two times water per acre;

$X_{37} = X_{36} + X_{11}$ two times water per acre plus productivity per acre; and

$X_{38} = X_{37}/3$ weighted average productivity.

U_i is unexplained variation in sales price presumably due to things not included in the model and to random error.

The analysis of the data was conducted at two levels. First, the regression of price per acre (X_{22}) on all acceptable sales was run on a selection of the other variables using feet of stream frontage as a continuous variable with the second regression run using only a dummy variable to indicate whether or not a tract fronted on a stream.

Several initial runs of the regression analysis program [32] were made using a completely linear relationship to aid in the detection of errors and to gain a familiarity with the program. These initial fits were, of course, not very revealing. The reciprocal transformations of the stream frontage, distance to National Forest boundary, and size variables were introduced. Further, the several flatland views were felt to be quite similar in their effects so were dropped leaving only the hillside view variable. Table IV-2 presents the description of the independent variables, partial correlation coefficients and computed t values for the final, condensed regression model. The estimated feet of stream frontage model is thus:

$$Y_i = 338.2 + 60.39X_1 + 1,465/X_3 - 121.6/X_5 - 47.92X_6 + -3.176X_9 + 116.5X_{12} + 331.7X_{16} - -304.6X_{17} + 184.5X_{18} + e_i$$

TABLE IV-2. ESTIMATED FEET AND STREAM FRONTAGE MODEL: Description of Variables, Means, Partial Correlations, Estimators and f Values; 134 Small, Unimproved Tracts, Bitterroot Valley Area, 1960-1970 (All regression coefficients significant at 90% level).

	Variable	Mean	Correlation X vs. Y	Regression Coefficient $\hat{B}_i$	t
X_1	Time (1960 = 1)	9.02	.226	60.39	2.834
$1/X_3$ 1/	Size (acres)	8.376 1/	.7572	1,465.00	13.05
$1/(X_5 + 1)$	1/feet of frontage	237.8 1/2/	-.1327	- 121.6	- 1.453
X_6	Distance, local	4.49	-.2071	- 47.92	- 3.498
X_9	Distance, commute	30.27	-.2149	- 3.176	- 1.564
X_{12}	Commercial timber	Dummy	.0722	116.5	1.424
X_{16}	Special feature	Dummy	.0319	331.7	2.592
X_{17}	Deteriment	Dummy	-.0555	- 304.6	- 1.711
X_{18}	View plot	Dummy	.1848	184.5	2.014

$R^2 = .6885$ $S_Y \cdot X = 383.2$ $\hat{B}_0 = 381.1$ $\bar{Y} = 1,110$

1/ Mean of variable rather than reciprocal of variable.

2/ Average for those 41 tracts with frontage was 758.6 feet per tract.

where Y_i is the price per acre in current dollars of small, unimproved tract lands and the X's are as described above.

The information in Table IV-3 indicates that the coefficients in this model do differ significantly from zero unless a sample event has occurred which would happen less than 1 in 100 times. Further some 69 percent (68.85%) of the variation in price per acre is explained by variation in the dependent variables in the model. This value corresponds to the R^2 on Table IV-2.

The estimated linear regression coefficients ($\hat{B}$'s) are interpreted as the impact upon price per acre of a unit change in the associated variable, all others remaining unchanged. For example, $\hat{B}_6$ tells us that for otherwise similar tracts as one moves away from a local service center the value per acre decreases at a rate of $47.92 per mile. The coefficients of the dummy variables indicate how much the presence or absence of that factor influences per acre selling price. A tract with some commercial timber sells, on the average, for $116.50 per acre more than one not possessing commercial timber; those having a detriment (adjacent on industrial site, feedlot, etc.) would sell for $304.60 per acre less, other things remaining the same.

In the case of the size variable, a reciprocal relationship was specified indicating that as acreage becomes larger the value per acre becomes less and less until a limit (something approximating the value of the land in agriculture or forestry or for subdivision purposes) is

TABLE IV-3. ANALYSIS OF VARIANCE: 134 SMALL, UNIMPROVED TRACTS, BITTERROOT VALLEY AREA, ESTIMATED FEET OF STREAM FRONTAGE.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Regression	9	40,238,000	4,470,890	30.449
Deviation from Regression	124	18,207,100	146,831	
TOTAL (N = 134)	133	58,445,000		

reached. If we may, consider an exaggerated, two dimensional representation of a reciprocal demand relationship for a commodity. Observe in Figure IV-1 how as the quantity taken increases from one to two units (a one unit increase) the price decreases from three to about one and three-quarters (a one and one-quarter unit decrease). The coefficient of the acreage variable ($1,465) may be viewed as a premium paid for smaller tracts possessing the necessary amenities for recreation-residential use. This premium decreases as the size of tract increases, _ceteris paribus_, until the value in a less intensive use or in speculation is approached. A tract 1 acre in size would thus enjoy a premium of the total $1,465.00 while a tract of 2 acres would show a premium of only $732.50, etc. As the data on acreage ranged between .67 acres and 39 acres it would be unsound to attempt to extend the interpretation of this coefficient beyond that range.

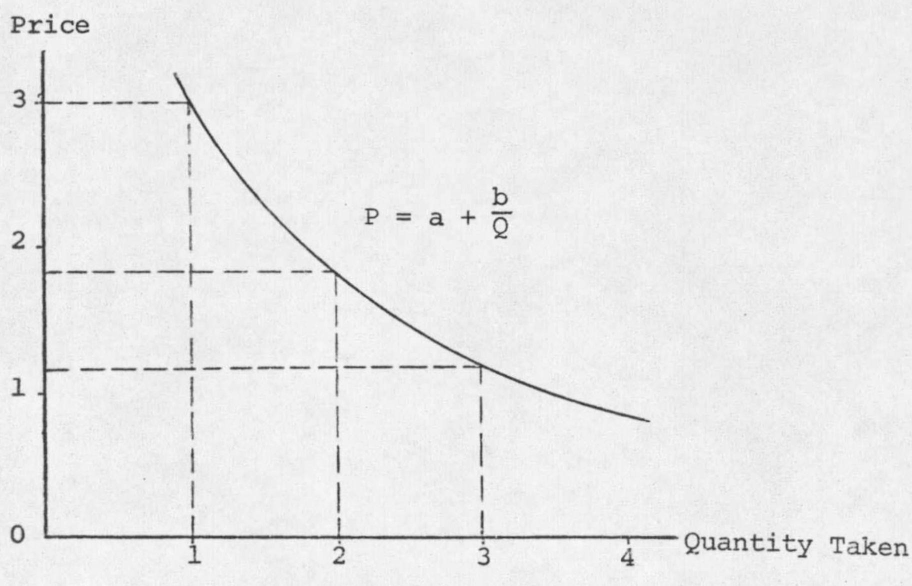

Figure IV-1. A Reciprocal Relationship.

One would expect a recreation-residential occupier to be willing to pay more per acre for a tract with stream frontage (X_5) than for a tract not affording such an amenity. Further one would expect such a person to be willing to pay a higher price per acre as the frontage increased, other things remaining the same, until he acquired enough frontage to allow for his reasonable access and enjoyment of the stream. The occupier may desire and even be willing to pay for more frontage but additional frontage would add less and less to value per acre as frontage is increased. Geometrically the relationship between value per acre and stream frontage may be represented as a curve which the rate of increase approaching zero as it moves upward and to the right as in Figure IV-2.

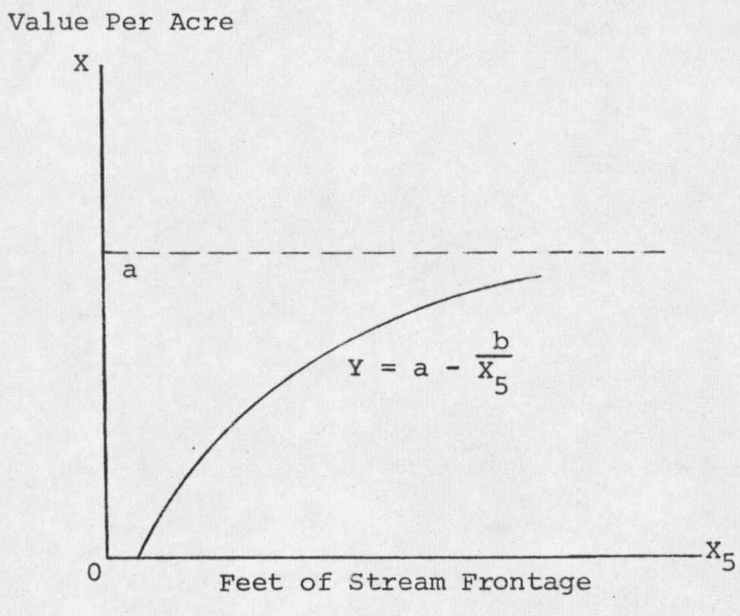

Figure IV-2. Relation of Price to Frontage.

To begin with it is convenient to think of this coefficient as a penalty for a property not having the ideal amount of frontage with this penalty decreasing as the quantity of frontage increases up to a limit of "ample" frontage and no penalty. In the feet of stream frontage model it was necessary for computational reasons to add a small amount (1 foot) of frontage to each tract, any inferences drawn from this coefficient must weight this adjustment. For example, a tract having, say 30 feet of frontage would be penalized by $121.6/30 + 1 = $39.23 per acre while one possessing 100 feet would be penalized about $1.22.

Since those tracts possessing frontage had, generally, rather substantial amounts (758.6 feet on the average or an average for the sample as a whole of 237.8) the average difference between riparian and non-riparian tracts is very close to the total penalty. The results of the stream frontage dummy model are presented in Tables IV-4 and IV-5 and indicate the average difference to be $121.50 while the feet of frontage model estimates the maximum difference at $121.60. Such a small difference can, no doubt, safely be ignored. The facts that there is no difference in the coefficients of determination of the two models and the t values of the stream variables are substantially the same to reinforce this feeling.

It was, perhaps, an unfortunate characteristic of this sample that the tracts possessing frontage had rather generous amounts and there were none showing less than 100 feet of frontage (frontage ranged from

TABLE IV-4. STREAM FRONTAGE DUMMY MODEL: Description of Variables, Means, Partial Correlation, Estimators and Student "t"; 134 Small, Unimproved Tracts, Bitterroot Valley Area. (All regression coefficients significant at 90% level).

	Variable	Mean	Correlation	B_i	t
X_1	Time (1960 = 1)	9.02	0.2260	60.39	2.834
$1/X_3$	Size (acres) 1/	8.376	0.7572	1,464.00	13.04
X_{20}	Stream frontage 2/	Dummy	0.1338	121.50	1.456
X_6	Distance local	4.49	-0.2071	- 47.92	- 3.499
X_9	Distance commute	30.27	-0.2149	- 3.173	- 1.562
X_{12}	Commercial trees	Dummy	0.0722	116.50	1.424
X_{16}	Special feature	Dummy	0.0319	331.60	2.571
X_{17}	Detriment	Dummy	-0.0555	- 304.70	- 1.711
X_{18}	View plot	Dummy	0.1848	184.7	2.015
Y	Price per acre	1,110			

$R^2 = .6885$ $S_{y \cdot x} = 383.2$ $\hat{B}_0 = 259.4$

1/ Mean of variable rather than reciprocal of variable.

2/ Mean frontage for those plots possessing frontage was 758.6 feet.

TABLE IV-5. ANALYSIS OF VARIANCE STREAM DUMMY MODEL, 134 SMALL, UNIMPROVED TRACTS, BITTERROOT VALLEY AREA.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Regression	9	40,239,500	4,447,105	30.4528
Deviation from Regression	124	18,205,600	146,819	
TOTAL (N = 134)	133	58,445,000		

3,400 to 100 feet). Apparently, about all that can be said on the basis of the observations is that for tracts of the size and other characteristics of those studied is that those having stream frontage sell for about $121 per acre more than similar tracts not having frontage.

A reciprocal relationship similar to that illustrated in Figure IV-1 was hypothesized for the distance from the tract to the forest boundary. The reasoning was that being located a short distance from the forest boundary might add considerably to the sales price per acre of a tract, but as distance increased, the influence on price would rather rapidly decrease and became inconsequential rather quickly. A small t ratio indicated that the coefficient was, in a probability sense, not significantly different from zero. For this reason this variable was dropped from the analysis.

Two basic measures of agricultural potential were considered--the forage producing potential from the county tax classification records and the miner's inches of irrigation water. It was believed that these two variables would, in combination, influence price substantially. The t ratio again indicated no statistically significant relationship (neither of these factors, considered separately, showed a significant relationship either). There might be several reasons for this. First, the possession of a water right does not necessarily assure the occupier of lands an abundant or even reliable or adequate supply of irrigation water. Second, the relative shortness of mid and late season streamflow on many of the streams in the area [65,p.325]; and third, the distinct possibility of a more senior right on the stream may render the water right to a given tract virtually valueless. Forage production potential may not have shown as significant due to the existence of a speculation or subdivision market for land existing between the agricultural market and the recreation-residential market. The fact that the initial classification was completed some 10 years prior to this study and not subsequentially up-dated lends the credibility of this indicator to question. The rather wide adoption of sprinkler irrigation in the interim has substantially improved the marginal value product of both land and water on many of the formerly less productive lands.

Information on the presence or absence of trees on the tract was asked of the seller. Where trees were indicated the tax classification was checked to determine whether or not these were of commercial (timber) importance, and if so, X_{12} was assigned a value of 1 (0 otherwise). If the classification records did not show these trees to be of commercial value, this fact was similarly noted in X_{13}. If there were no trees on the tract, both X_{12} and X_{13} carried a value of zero. The results indicate that tracts supporting stands of commercial timber brought about $116.50 more than those not having commercial timber, other things remaining the same. The presence of noncommercial timber trees apparently did not significantly influence the per acre price and this variable was omitted in the final run of the program.

The presence of such special water features as lakes, ponds, springs, etc., and the presence of detriments (objectionable industrial activity on adjacent sites, excessive boginess, lack of access, etc.) showed significant and sizable influences on price.

Tracts situated on a hilltop or hillside so as to permit the occupier a more or less unobstructed view for some distance out over the valley also indicated a sizable and significant premium. While it is said that "every Bitterroot tract has a good view of the mountains" it appears that recreation-residential occupiers are willing to pay a premium to enjoy a view below the horizontal even if of pastoral, rather than mountain character in the foreground.

The coefficient on the time variable indicates that over the period 1960-1970, these tracts have increased in value at a rate of about $60 per year. It is probably not too useful to try to read very much into the coefficient as it likely reflects the influences of a host of factors which probably have an influence but have tended to drift more or less together through time (e.g., income, employment, population, prices of town lot alternatives). Whether these factors will respond similarly to future economic winds is questionable.

A Note on the Assumptions of the Regression Model

In attempting to estimate the benefits from recreation-residential use of lands by use of the multiple regression techniques used here expose one to a quite strong likelihood of violation of one or more of the assumptions which underlie this technique.

Autocorrelation

One such assumption is independence in the distribution of the error term. The magnitude and direction of the error term in the model is assumed to be independent of the size of the dependent variable (price per acre), and independent from the size or sign of its counterpart for any other observation. When the size and/or sign of the error term is dependent upon any of the factors cited here, the condition is described as autocorrelation or serial correlation in the case of time series data.

Probably the most common cause of autocorrelation is failure to properly and completely specify the multiple regression model. If one were to specify a straight line relationship between two variables when the true relationship were a curve, the size and sum of the error term would be related to the value of the variables. Such a situation is shown in Figure IV-3 where the broken curved line represents the true relationships and the straight line the improperly specified line. The errors (difference between the observed value of Y and that specified by the straight line) will be positive in the regions below Y_1 and above Y_2 and negative in the region between Y_1 and Y_2. Further, the absolute value of the errors will be small near the points of intersection of the true and the specified lines but become larger as one moves away from these intersection points.

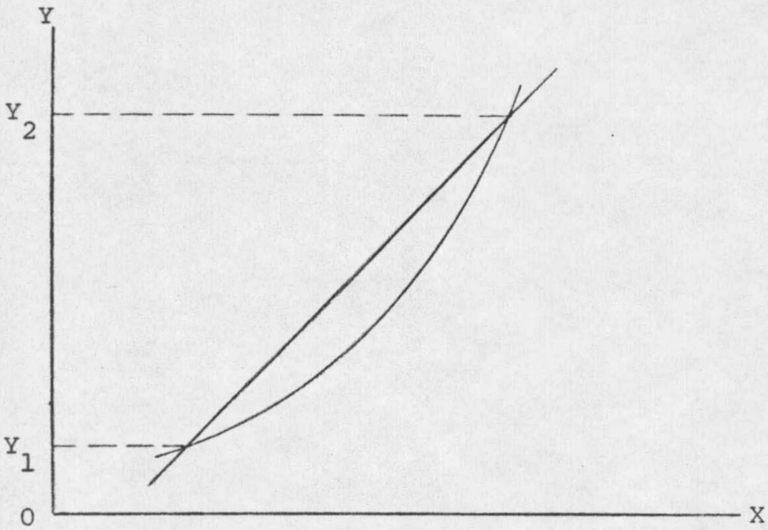

Figure IV-3. Nature of Specification Error.

As previously stated, the price per acre of recreation-residential land is influenced by a host of factors, only a few of which were isolated by the regression and the rest have their influences merged with the error term. The inclusion of the time variable was an attempt to remove from the error term those several things suspected of moving together through time and related to the price variable.

Some autocorrelation is likely still present in the final runs of the regression model. The result of such a condition is that the variances of the regression coefficient estimators may be larger than would be the case in the absence of autocorrelation. The estimations themselves will, however, be unbiased [26,p.179]. These two conditions combine to make it excessively difficult to detect a statistically significant contribution by some factors in the model.

The Lund program contains a subroutine to test for autocorrelation based upon the squared differences of successive error terms from observation-to-observation. As such this test (usually known as the Durbin-Watson test) is highly dependent upon the order in which the observations are fed into the computer. In this case the order was the order in which the data was collected and thus no particular significance should attach to the failure to reject a hypothesis of serial correlation based on the Durbin-Watson statistic.

Multicollinearity

When two or more of the explanatory variables in a regression study are highly correlated with one another the condition is known as multicollinearity. It is thus extremely difficult to separate the effects of the several correlated variables and estimate those effects with any precision.

There is some reason to suspect a fairly strong relationship between several of the explanatory variables considered in this study. One would suspect a fairly strong relationship between irrigation water and productivity; between distance to commute and distance to the National Forest; between size of tract and length of stream frontage, etc.

One can take comfort in the observation that few of the coefficients in Table IV-6 are high enough to raise a question of severe multicollinearity problems. Heady and Dillon [21,p.111] suggest that one not attempt to separate and measure the effects of related variables if the correlation coefficients approach 0.6. Few of the correlation coefficients show a very strong relationship--the highest being 0.4648 between commercial timber and distance to Missoula (indicating that one is more likely to encounter commercial timber on tracts as he moves further from Missoula). There is thus little reason to suspect multicollinearity in this sample. Even if it is present, Johnston [26,p.207] suggests that one may use the model for forecasting purposes with slight cause for worry.

TABLE IV-6. CORRELATION MATRIX--ESTIMATED FEET OF STREAM FRONTAGE MODEL, 134 SMALL, UNIMPROVED TRACTS, BITTERROOT VALLEY AREA.

Variable		X_1	$1/X_3$	$1/X_5$	X_6	X_9	X_{12}	X_{16}	X_{18}	X_{18}
X_1	Time	1.0								
$1/X_3$	Size	.1946	1.0							
$1/X_5$	Frontage	-.2514	-.1402	1.0						
X_6	Distance local	.2240	-.0220	-.3403	1.0					
X_9	Distance commute	-.0258	-.2254	.1363	-.1699	1.0				
X_{12}	Commercial timber	.0186	.0056	-.0204	-.1092	.4648	1.0			
X_{16}	Special feature	-.1181	-.1966	-.0322	-.1429	-.0676	-.1017	1.0		
X_{17}	Detriment	.0682	.0319	-.0483	-.1070	.1141	-.1235	-.1589	1.0	
X_{18}	View	-.1964	.0207	.3784	-.3929	.0221	.1480	.1513	-.0179	1.0

CHAPTER V

A LINEAR PROGRAMMING MODEL OF BITTERROOT VALLEY AREA

An aggregative linear programming model was developed in an attempt to estimate some of the impact of alternative development patterns on the well being of valley residents. The basic model was then modified slightly to reflect changes in the institutional framework of development.

In selecting this type of model several alternatives were considered. At the time the study was initiated an input-output model of the economy of Montana had recently been developed [23] and plans for its up-dating were underway. An attempt was made to build an input-output model of the Bitterroot Valley area for use in analyzing the impact of water development and institutional modifications. Such a study had been done for the water economy of California and the results appeared to have useful policy implications. It became apparent, however, that the refinement of the statewide model to approximate the economy of the Bitterroot Valley area would be neither feasible nor very useful so this approach was abandoned after some 3 or 4 months of background analysis and attempts at model building.

At that point a linear programming model quickly became the most reasonable alternative (one of the uses contemplated for the input-output model was an attempt to incorporate an optimizing technique such as linear programming). A simulation model was not considered due to the ability of the linear programming model to supply solutions that can be described as economically efficient. Where a simulation model may be developed to approximate the resource allocations observed in the past and certain changes projected into the future, it can always be argued that there might have been better allocations in each case. The linear programming solution will have the characteristic of simulating competitive equilibria [12,pp.404-407] thus no better allocations are possible.

The Basic Model

The model attempts to isolate that allocation of resources which produces the highest present value of net benefits. (Most of the physical resources of the valley have at least some alternative uses.) In some cases the benefits to be enjoyed from a specific resource employment may be extremely difficult or impossible to measure. An example might be the satisfactions to highway users from a view of suburban tracts as opposed to say, a pastoral view of a sparsely timbered grassland area along the highway. The benefits considered in the model are thus restricted to some of the more easily quantifiable ones that are privately appropriable and evaluated by some market mechanism. The direct private costs associated with a particular resource use are assumed to be deducted from revenues to determine private net revenue. These costs are thus reflected in the prices prospective purchasers would be willing to pay for resources to be employed in their highest and best use. In addition to the private costs associated with any resource employment, there may exist some external costs borne by various members of the community other than the party who enjoys the direct benefits of that resource employment. Both categories of costs may be influenced by the distance from the service center to the point of delivery. A model for resource allocation that reflects the well being of all members of the community must recognize both categories of costs as well as the influence of distance.

Such a model might be expressed in linear programming form as:

$$\text{Maximize } vB = \sum_{j=1}^{9} \sum_{k=1}^{2} v(P_{jk} - C_{jk} - C'_{jk})X_{jk}$$

An alternative expression of the same model is: Let

$$B_{jk} = P_{jk} - C_{jk} - C'_{jk}$$

$$\text{Maximize } vB = \sum_{j=1}^{9} \sum_{k=1}^{2} vB_{jk}X_{jk}$$

subject to restrictions on resource availability and user preferences in the form:

$$\sum_{i=1}^{12} \sum_{j=1}^{9} \sum_{k=1}^{2} A_{ijk}X_{jk} \lesseqqgtr b_i \qquad x_{jk} \geq 0 \quad \text{for all } j \text{ and } k.$$

where: v is a factor for time-weighting benefits and costs;

B is the net measurable social benefit from resource use;

P_{jk} is the gross measurable benefit from the j^{th} use of resources in the k^{th} region;

C_{jk} is the private cost associated with the j^{th} use of resources in the k^{th} region;

C'_{jk} is the public cost associated with the j^{th} use of resources in the k^{th} region;

X_{jk} is the level of use j in region k;

B_{jk} is the net social benefit from the j^{th} use of resources in the k^{th} region;

A_{ijk} is the quantity of the i^{th} resource required to sustain the j^{th} use in the k^{th} region, or the number of units of X_{jk} required to satisfy one unit of market demand; and

b_i is the quantity of the i^{th} resource that is available, the limit on market demand, or a minimum level for a particular use of resources as indicated by the pattern of preferences or imposed for analytical purposes.

Estimation of Technical Coefficients and Restrictions

A description of the types of lands, acreages in each distance zone and the uses permitted of each is presented in Table V-1. Note that grazing is not permitted on timber lands in conflict with historical practice. This departure from realism was overcome by the inclusion of grazed timber acreage in the grazing land category also resulting in double counting of grazed timber lands. The acreage total will not be realistic, but value of production will properly reflect these two uses.

Dryland croplands were merged with grazing land. Neither require irrigation water and a preponderance of the dryland cropland is located in regions of the valley that have experienced little or no recreation-residential development. In all the analysis, the dry cropland is treated as grazing land and no attempt is made to modify the activities proposed for these lands to compensate for this simplifying merger.

TABLE V-1. TYPES OF LAND RESOURCES, USES PERMITTED IN THE LINEAR PROGRAMMING FORMULATION AND ACREAGES 1/ ASSUMED IN EACH DISTANCE ZONE, TOTAL ACREAGES.

Land Type Uses	Crop Agriculture	Grazing	Commercial Timber	Tracts	Lots	View Tracts	Wooded Tracts	Riparian Tracts	Tracts with Detriment	Acreage Zone 1	Acreage Zone 1	Total Acreage
Irrigated cropland	x	x		x	x				x	21,217	53,651	84,868 2/
Nonirrigated grazing land		x		x	x					21,079	63,238	84,317 3/
Flood plain		x		x	x					9,808	29,424	39,232 5/
Timber land			x		x		x			31,364	94,935	126,580 4/
Riparian cropland	x	x			x			x		2,740	8,220	10,960 6/
View lands		x			x	x				4,144	12,431	16,575 5/

1/ Acreage figures supplied by Ravalli County Reclassification Office.
2/ Includes wild hay lands (approximately 7,500 acres) and irrigated pasture.
3/ Includes dryland croplands (approximately 16,954 acres) and some grazed private timber lands.
4/ Private commercial timber lands (some double counted in grazing land).
5/ Acreages estimated from soils maps by Bitterroot Valley Resource Conservation and Development Project office.
6/ Estimated acreage adjacent to live streams.

The figures for total acreage of flood plain lands and "view" lands were supplied by the Bitterroot Valley Resource Conservation and Development Project office from analysis of soil maps of the valley. These lands were assumed to be a part of private nonirrigated grazing lands and their acreage was deducted from the total of nonirrigated grazing land showing in the reclassification records.

The acreage of land suitable for riparian tracts presented some special difficulties. Although such lands apparently are rather attractive to recreation-residential occupiers and command a significant premium in the market, no resource inventory contains an estimate of the extent of these lands. After considerable study of topographic and soils maps of the area and in consultation with the Bitterroot RC&D Project, estimation of the acreage of riparian croplands was made as follows. First, a list of year-round streams entering the Bitterroot Valley was obtained from the district Fish and Game Department office in Missoula. Second, the total mileage these streams traverse private lands was estimated from Forest Service maps of the area. Third, it was assumed that half the lands adjacent to these streams was suitable to cropping (irrigated pasture and wild hay, principally). Fourth, the total suitable frontage was divided by 758.6 feet (the average frontage for those surveyed, Table IV-2) to determine the number of tracts possible using this average frontage figure. Fifth and finally, this number was multiplied by the average tract size (8.375 acres) to determine the number of acres of riparian cropland.

The allocation of land resources between the two distance zones (one could have as many zones as he chose but two will illustrate the nature of changes in resource use as influenced by distance) was based on the relation between the areas of concentric circles. It was assumed that the various classes of land were evenly distributed throughout a region encompassed by a circle 6 miles in diameter with a service center community (a preponderance of the private land in the valley is within 6 miles of a town). This region is divided in two parts by a smaller circle 3 miles in diameter which encompasses the lands in distance zone 1. Distance zone 2 can then be conceived as a donut shaped region whose outer boundary is 6 miles and inner boundary 3 miles from the center. The areas of zone 1 and zone 2 are in the ratio of 1/4 to 3/4. The various classes of land resources were thus assigned to the two regions in this ratio. All production is assumed to take place and all services assumed to be delivered to the mid-range of these regions 1.5 and 4.5 miles from the service center, respectively.

In addition to the land resources, water in the form of streamflow is essential to current and future activities in the valley. Figures for average streamflow into the valley were obtained from the USGS Geology and Water Resources Survey [34,p.92]. As irrigation uses are usually greatest during July and August with late season supplies being critical, surface water inflows for the months of July, August and September water and requirements for these months were included in the analysis. In addition, the water stored in the Painted Rocks Reservoir on the East Fork of the Bitterroot River was included as additional supply available throughout the irrigation season. The volumes of water and quantities required for the several uses considered are presented in Table V-2.

Footnotes to Table V-2 explain the rationale of the calculations and the sources of basic information with one exception. The assumption about the use of water for irrigation on the tract activities where such uses are possible is based on a rather frequent practice of the developers of tracts having water rights. As the live stream is a valuable (as was shown in Chapter IV) amenity to the riparian tract, the developers seek to assure prospective purchasers of the viability of the stream during low flow by transferring only half the water rights associated with the original agricultural property to recreation-residential purchasers. The portion of the rights not purchased are vested in a landowners' association to do with as that body sees fit. Obstensibly, this water is to flow in the stream bed to preserve the fishing or other values that the lowering (or stopping entirely) of streamflow might endanger. (Until such a use of water is legally recognized as a beneficial use, the expectations of recreation-residential occupiers are in some danger of upset.) There is some evidence to indicate that

TABLE V-2. RESOURCE REQUIREMENTS PER TIME PERIOD: AGRICULTURAL AND RECREATION-RESIDENTIAL ACTIVITIES.

Item	Land Requirement	Surface Water		
		July	August	September
	Acres			
Crop agriculture 1/	1.	1.1	0.9	0.5
Grazing 2/	1.	.00018	.00018	.00018
Commercial timber 3/	1.	0	0	0
Tracts on dryland 4/	8.375	.049	.049	.049
Lots 4/	0.67	.049	.049	.049
View tracts 4/	8.375	.049	.049	.049
Wooded tracts 4/	8.375	.049	.049	.049
Riparian & tracts with detriment tracts 5/	8.375	4.65545	3.81795	2.14245
Tracts on irrigated land 5/	8.375	2.3523	1.9335	1.0961
TOTAL SURFACE WATER INFLOW 6/		193,200 7/	70,370 7/	43,350 7/

1/ U. S. Department of Interior, Bureau of Reclamation, [65,p.324].

2/ Beef cattle require approximately 10 gallons of water per day during the summer according to [64] or 300 gallons per month or approximately .00092 acre-feet per animal unit. The weighted average production of grazing land in Ravalli County is 0.2033 AUM's per acre thus the stock water requirement is .2033 x .00092 = .00018 acre-feet per month per acre.

3/ No diversion of streamflow assumed.

4/ Bonneville Power Administration in [64] suggests urban domestic use of from 100 to 250 gallons per person per day. Rural (farm) domestic use of 100 GPD per person. Assuming 200 GPD per person for recreation-residential domestic use yields a monthly requirement of .049 acre-feet for a family of three.

5/ These tracts were assumed to have a water right and to use one-half the agriculture requirement per acre or 4.1875 of their acres plus domestic water as above.

6/ See [34,p.92].

7/ It was assumed that streamflow could be supplemented by water stored in Painted Rocks Reservoir--some 31,700 acre-feet [45] per year. The inflow figures include releasing water from all reservoirs in the drainage [65]. Such releases from Painted Rocks Reservoir have been nominal.

purchasers of recreation-residential tracts have little concern for either water rights or the agricultural productivity of the land (see Chapter IV). For analytical purposes it was assumed that occupiers of tracts that had water rights (those located on cropland or riparian land) would divert only one-half as much per acre as would be required for normal agricultural use. Riparian tracts were further assumed to be comprised of half riparian cropland as defined here and one-half flood plain.

The information presented thus far in this chapter has described the basis for estimates of several important parameters in the linear programming model. Specifically, Table V-1 contains the identification of the various activities to be analyzed and the quantity of land resources available. These conform to the X_{jk}'s and the b_i's for the land resources in the model. Table V-2 contains the estimates of the resource requirements for the various activities (the A_{ijk}'s) as well as the b_i's for the monthly streamflow resources.

In addition, constraints were specified on the level of recreation-residential development and also for various types of such development. The annual demand for recreation-residential tracts was assumed to be equal to the total of the annual increase in the number of households in the county and thus an upper limit on this type of development. As the incorporated towns have not been at all aggressive in expanding their areas and services, the inflow of population to the Bitterroot Valley and the intracounty off-farm migration has been accommodated by a dispersed urban settlement pattern mainly on the periphery of the towns and in the hinterlands.

The 1970 Census of Population [61] shows a net inflow of population of 2,068 persons into Ravalli County during the decade of the Sixties, the advance report of this document also showed an average of 3.0 persons per occupied housing unit. This increase in population would result in a net demand for housing of 2,068/3 or 687 housing units over the 10-year period. The average annual increase would be about 68 or 69 units per year. 1/ For analytical purposes it was assumed that this level of demand for housing units would reflect a similar level (69 per year) of demand for recreation-residential tracts.

The survey (described in Chapter IV) of recreation-residential tract lands revealed that only 3.5 percent had their value impaired by some activity on adjacent property which apparently was not in harmony with recreation-residential use (such tracts were described as having a detriment). An attempt was made to introduce this phenomena of unplanned development into the model by requiring at least this proportion of growth in households to take place on tracts with detriments.

1/ An analysis of private household electrical hookups during this same interval would indicate a substantially higher rate of increase. The electrical hookup data also reflect a more rapid rate of growth in the later years of the decade than that for the earlier years.

Under an assumption of linear growth in households (69 per year) the number of detriment tracts were three. It was also assumed that such tracts would require equal portions of irrigated crop and dry grazing land.

Estimation of Objective Functions

The present value of benefits from resource use is, in the absence of monopolies and externalities, a measure of the contribution to well being arising from a specific resource employment. Chapter IV of this paper is devoted to the development of such measures for the land resources of the Bitterroot Valley. The measures developed therein were modified to convert them to a 1970 price base and to reflect the influence of distance from service center on net benefits. The results of this evaluation are the objective function values presented in Table V-3.

The intensive settlement activities (lots) were assumed to preclude all agricultural, riparian and view benefits. Lots on forest land allowed the timber benefits to be counted in the value on the assumption that the timber value could be captured by removal of the timber prior to settlement, preserving the timber for its value as an amenity, or some combination of the two. The stumpage value of the timber was added to the normal lot value in this case.

The cost of providing some public services are more or less directly related to distance. Maintenance and snow removal on county

TABLE V-3. OBJECTIVE FUNCTION VALUES: AGRICULTURAL AND RECREATION-RESIDENTIAL ACTIVITIES, 1970 BASIS.

Activity Type	Contribution to Objective Function: Road and Route Costs Ignored	Contribution to Objective Function: Road and Route Costs Considered 5/
	--------Dollars--------	
Distance Zone 1: 1/		
Irrigated crop	279.42	279.42
Grazing	25.984	25.984
Forestry	190.35	190.35
Tracts without features	8,307.16 2/	7,932.16
Lots without features	2,307.16 3/	1,974.88
Tracts on timber land	9,282.85 2/	8,907.85
Lots on timber land	2,139.91 4/	2,120.41
Riparian tracts	9,324.73 2/	9,477.35
View tracts	9,852.35 2/	9,477.35
Tracts with detriments	5,744.63 2/	5,369.63
Distance Zone 2: 1/		
Irrigated crop	279.415	279.415
Grazing	25.984	25.984
Forestry	190.35	190.35
Tracts without features	8,120.74 2/	7,558.24
Lots without features	1,997.46 3/	1,941.21
Tracts on timber land	9,096.42 2/	8,533.92
Lots on timber land	2,124.99 4/	2,068.74
Riparian tracts	9,138.30 2/	8,575.80
View tracts	9,665.92 2/	9,103.42
Tracts with detriments	5,569.71 2/	5,007.21

1/ Distance Zone 1 averages 1.5 miles from town, Zone 2 averages 4.5 miles.

2/ Tract activities evaluated according to the following formula: 8.375 [381.10 + 60.39 (years since 1960) - 47.92 (miles from town) - 3.176 (miles from Missoula) + 121.5 (if a riparian tract) + 116.50 (if a timbered tract) + 184.50 (if a view tract) - 304.60 (if a tract with detriment)].

3/ Lots evaluated same as tracts except for the size--lots assumed to average two-thirds acre rather than 8.375 acres.

4/ Timbered lots priced as lots plus stumpage value of the timber (.67 acres x 1903.5 per acre).

5/ Road and route costs assumed: Zone 1 tracts \$375.00; lots \$37.50
Zone 2 tracts \$562.50; lots \$56.25

roads, mail delivery, public school bus transportation are some examples that come quickly to mind. If one begins with a fairly sparse settlement pattern, the cost per receiving unit might reasonably be expected to increase as the distance from one unit to the next was increased. Further, a more densely (but still not congested!) settled population might reasonably be able to enjoy a given quality and quantity of service at a lower cost per capita than a more sparsely distributed population similarly situated in all other respects. If a local government agency encourages (or at least does not discourage) a sparse settlement pattern it will find that it costs more to provide its growing population with a given quality and quantity of service than it otherwise might. Alternatively the quantity and/or quality of services provided may have to be curtailed as population grows and per capita public outlays for such services are held constant.

Most local government activities are financed by ad-valorem taxes on property (of which taxes on real estate comprise a substantial portion). Properties of similar value pay the same tax regardless of the cost to the local government of servicing the owners of these properties (of two similar properties one located close to services and the other more distant, the former is likely to be the more valuable reflecting the private costs as obtaining some important services such as shopping, entertainment, supplies, medical services, etc.). Persons who live close to services then likely subsidize to some degree or another their fellow citizens who choose more remote locations but demand the same services from local government.

Two public services of some importance that are likely to be demanded rather quickly by new occupants are school bus transportation and road maintenance (including snow removal).

As soon as the roads in a subdivision are brought up to county standards (see Appendix C for an example of such standards) upon petition by three or more landowners, and dedication of the road to public use, it becomes the county's responsibility to maintain the road. The Montana Highway Maintenance Department estimates this cost at $350 per mile per year. The cost of such maintenance experienced in Ravalli County in recent years is not inconsequential as Table V-4 indicates. From the data in this table, it appears that there is little relationship between either total expenditure or expenditure per mile and the mileage maintained when all expenditures are converted to dollars of common purchasing power. A two-variable analysis of the data confirm the suspicion of little or no relationship (see Appendix B).

Failure to identify a meaningful relationship led to the use of the highway department maintenance cost estimate in subsequent analysis.

School districts which operate school buses directly or on contract report their annual costs to the county superintendent. Copies of the reports for fiscal year 1969-1970 were made available through the Ravalli County Superintendent's Office for use on this study. Table V-5

TABLE V-4. TOTAL EXPENDITURES FOR ROADS AND BRIDGES, MILEAGE OF ROADS MAINTAINED AND AVERAGE COST PER MILE, RAVALLI COUNTY, FISCAL YEARS 1962-1970.

Fiscal Year	Expenditures for Roads & Bridges Total Current 1/	Expenditures for Roads & Bridges 1970 Basis 2/	Mileage Maintained Dec. 31 3/	Expenditure Per Mile (1970 Basis 4/
	----------Dollars----------			
62-63	197,087	293,659.63	1,032.2	284.49
63-64	276,950	402,408.35	1,038.1	387.64
64-65	278,100	400,185.90	1,033.6	387.18
65-66	307,647	427,321.68	1,054.0	405.43
66-67	313,620	407,392.80	1,054.5	386.34
67-68	339,103	425,913.37	1,354.0	314.56
68-69	307,266	373,328.19	1,373.9	271.73
69-70	321,294	360,973.81	1,373.9	262.74
70-71	389,970	328,970.00	1,378.6	282.87
AVERAGE				331.44

1/ Transcribed from records in Clerk and Recorder's Office, Hamilton, Montana.

2/ Adjusted to dollars of 1970 purchasing power using index of construction costs--highway construction [62,pp.S10,57,51].

3/ Total mileage including approximately 105 miles of FAS Rural Highway. Mileage estimates provided by Office of Planning Survey Director, Montana Highway Commission.

4/ Found by dividing expenditures for roads and bridges, 1970 basis by mileage maintained on December 31.

TABLE V-5. COSTS OF SCHOOL BUS ROUTES FOR YEAR JULY 1, 1969 TO JUNE 30, 1970, RAVALLI COUNTY, MONTANA. 1/

Route		Bus Miles Per Year	Bus Miles Per Day	Length 2/ of Route	Total Cost	Cost Per Mile of Route 3/
		----------Miles	-------		------Dollars	-----
Corvallis	#1	6,696	37.2	18.6	4,275.00	229.839
	#2	5,868	32.6	16.3	4,275.00	262.270
	#3	4,860	27.0	13.5	4,651.00 4/	344.518
	#4	6,480	36.0	18.0	4,320.00	239.976
	#5	6,120	34.0	17.0	4,500.00	264.672
	#6	7,470	41.5	20.75	4,770.00	229.860
	#7	3,960	22.0	11.0	4,950.00	450.000
Stevensville	#1	11,520	64.0	32.0	4,815.00	150.444
	#2	7,236	40.2	20.1	4,185.00	208.188
	#3	8,640	48.0	24.0	3,915.00	163.125
	#4	9,216	51.2	25.6	4,140.00	161.712
	#5	9,000	50.0	25.0	4,500.00	180.000
	#6	7,020	39.0	19.5	4,196.00 4/	215.172
	#7	5,760	32.0	16.0	4,012.00 4/	250.740
Hamilton	#1	5,460	30.0	15.0	3,807.00	253.800
	#2	4,914	27.0	13.5	4,455.00	330.000
	#3	6,188	34.0	17.0	4,455.00	262.059
	#4	6,188	34.0	17.0	3,771.00	221.824
	#5	2,548	14.0	7.0	4,380.00	625.714
	#6	4,550	25.0	12.5	4,275.00	342.000
	#7	9,464	52.0	26.0	4,815.00	185.192
	#8	4,841	26.6	13.3	4,492.50 5/	172.769
	#9	4,623	25.4	12.7		
Victor	#1	5,828				
	#2	5,683	49.3 7/	24.65	8,159.49 6/	331.014
	#3	6,226				
	#4	5,792	16.1 7/	8.05	3,167.00 6/	393.416
Darby	#1	21,960	122.0	61.0	7,486.50	122.729
	#4	7,056	39.2	19.6	4,590.00	234.184
	#5	10,080	56.0	28.0	5,481.00	195.750
	#7	14,400	80.0	40.0	4,185.00	104.625
	#3	6,264	34.8	17.4	4,950.00	180.657
	#2	3,600	20.0	10.0		
Lone Rock	#1	7,240	40.0	20.0	3,498.10 4/	174.905
Florence-Carleton	#1	4,706	26.0	13.0	3,615.00	278.077
	#2A	6,878	38.0	19.0	2,656.95	139.839
	#2B	3,982	22.0	11.0	5,271.10	479.191
	#3	6,697	37.0	18.5	2,551.09	137.897
AVERAGE COST PER ROUTE MILE						250.475

1/ Source: County Superintendent of Public Instruction, Ravalli, County.
2/ Defined here as one-half bus miles per day.
3/ Total Cost divided by length of route.
4/ These buses operated by the district rather than under contract.
5/ Both routes apparently operated under the same contract.
6/ All three routes apparently operated under the same contract.
7/ Bus miles per day not listed for the Victor routes. Assumed to be 1/180 of combined bus miles per year (or two trips a day for 180-day session).

presents these costs and an estimate of $250.475 as the average total cost per mile for school bus routes.

These two costs--road maintenance and school bus service--amount to (using the Highway Commission maintenance cost figure) some $600 per year per mile of new road, assuming, of course, that such new roads are served by a school bus. Converting this annual cost to its present value 2/ equivalent at 5 percent interest would yield a present value of $12,000 per mile for the cost of providing these two services.

If one were to try to subdivide a section of land (640 acres) into 10-acre tracts, say, in such a way as to minimize the cost of interior roads, the approach might be to lay out the tracts 1 mile long and 82 1/2 feet wide with each abutting the road. Such a layout might not have much appeal to potential buyers. Making the tracts 1/2 mile long and 165 feet wide abutting roads on the parallel sides of the section might still be unappealing to potential purchasers (not to mention passers-by). Some lands might, however, lend themselves to partitioning into tracts 1/4 mile long and 1/16 mile (330 feet) wide. Such an arrangement might even enhance the occupiers' feelings of spaciousness even more than the obvious 1/8 mile (660 feet) square. A section of land bordered by roads could be opened by the addition of 1 mile of road to the system if the 1/4 by 1/16 mile tracts were used. Three miles would be required

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2/ See Chapter IV for a discussion of the rationale of present value.

in the same situation if a 1/8 mile square layout were used. Under the 1/4 by 1/16 tract scheme an average of 1/64 mile of new road would be required per tract. All this assumes that the access of the perimeter tracts to the county road would not cause undue congestion.

It may be that congestion of thoroughfares would be sufficient to preclude direct access by the occupiers in which case 2 miles of additional road would be required (entering the existing roads at just four points for the 1/4 by 1/16 mile arrangement). Such an arrangement would likely concentrate structures near the interior roads preserving to some extent at least, a less cluttered view from the main road and substantially reducing the problems of dust and congestion which might occur if the one interior road approach were used. For purposes of analysis the two interior road approach was assumed leading to the functional assumption of a minimum requirement of 1/32 mile of road (and bus route) per tract.

It was further assumed that tracts located in the nearer distance zone could be accommodated by only the assumed minimum road-route extension but that those in the outer zone would require 1 1/2 times as much. (Eleven plots of small tract developments from this study area indicate some 278 feet of road-route extension or 168% of minimum but several have tracts accessing directly to existing public roads.) Intensive settlements were assumed to impose one-tenth the cost (per lot) as the tract alternative. These cost adjustments were used in developing the objective function values with "road and route" costs considered in Table V-3.

The cost, in present value terms, of stored water supplied from Painted Rocks Reservoir was estimated at $28 per acre-foot regardless of the month in which it was delivered. This value was computed by discounting the annual amortization and operating costs currently used as a point of departure in pricing water from the reservoir. Each sale of water from the reservoir is separately negotiated by the State Water Board but as a policy the contracted price per acre-foot must cover the principal and interest charge ($1.30) and the estimated annual operation and maintenance charge (currently $0.10).

Results of the Linear Program Model and Selected Modifications

The initial program, formulated as described, was set up for solution using a Montana State University modification of the Rand Corporation's MFØR Linear Programming Code. This code solves the programming problem by <u>minimizing</u> the objective function subject to constraints. The most obvious modification to allow solution of the problem considered here was to convert the present model to a minimization problem by simply multiplying the objective function by -1. The information for the program was coded in accordance with the manual by Asmus [2]. A discussion of the original formulation with those who had had experience with this program prompted the insertion of several additional constraints in order to provide sufficient rows in the problem so that the simple structure did not impose any meaningful limitations on the solution. This resulted in a problem with 31 rows (30 constraints and an objective function), 75 columns (activities, of which only 48 were real activities) and 301 matrix entries.

Initial Optimum Solution

The initial optimum solution indicated a maximum possible present value for all land and water resources in the system of $54,449,232+. The activities in this solution and the level of those activities appear in Table V-6. Of particular interest here are the numbers of the various types of tracts. Notice that the maximum possible number of view tracts (10) were developed, no more than the minimum of the tracts with detriments (3) were developed. The rest of the inflow of household units (56 of the total 69) would be accommodated in the riparian tracts in the absence of a maximum restriction on that type of development. If there had been no restrictions on the type of tracts, one would expect all the 69 household units to be settled on view lands to bring about a maximum value even higher than that achieved under this situation. Conversely, had riparian tracts been constrained at some maximum level less than the unfilled demand, additional tracts would have to be taken in either the grazing land of Zone 1 of the flood plain of Zone 1 (any recognition of the flood hazard would quickly discourage development of the flood plain, however).

TABLE V-6. ACTIVITIES IN INITIAL OPTIMAL SOLUTION, LINEAR PROGRAMMING MODEL.

Nature of Activity	Distance Zone	Level	Units	Contribution to Objective/Unit Dollars
Irrigated crop	1	21,204.4	Acres	279.42
Grazing	1	21,066.4	Acres	25.98
Graze flood plain	1	9,573.5	Acres	25.98
Timber	1	31,364.0	Acres	190.35
Crop riparian land	1	2,505.5	Acres	279.42
Irrigated crop	2	63,651	Acres	279.42
Grazing	2	63,238	Acres	25.98
Graze flood plain	2	29,424	Acres	25.98
Timber	2	94,935	Acres	190.35
Crop riparian land	2	8,220	Acres	279.42
Graze view lands	2	12,431	Acres	25.98
View tracts	1	10	Tracts (8 3/8 acres)	9,852.35
Riparian tracts	1	56	Tracts	9,324.75
Tracts with detriments	1	3	Tracts	5,744.63
Buy water--August		15,792.58	Acre-feet	- 28.00
Buy water--September		4,530.79	Acre-feet	- 28.00

In addition to the optimal (primal) solution, the MFΘRD program furnishes information of the imputed value of constraining resources. This information gives us an answer to the question, "What would be the impact on the objective of relaxing a particular constraint"? This information is frequently referred to as the shadow price of that resource or its marginal value productivity.

One additional acre of cropland in Zone 1 would allow the objective function to increase by $240.22, one additional household would permit an increase of $8,125.00. Increasing the requirement for tracts with detriments by one would decrease the objective function by $3,580.14. The other shadow prices in Table V-7 may be similarly interpreted.

The potential uses of resources which did not figure in the optimal solution can be of some interest. The MFΘRD program supplies a listing of these together with a calculation of the change in the contribution of each to the objective function which would be required before the resource employment would just tie for a position in the optimum solution. For example, tracts on grazing land--Zone 1 (fourth row, Table V-8), with a value in (or contribution to) the objective function of $8,307.16 would have to have an increase in that value of $38.38 to tie for a place in the optimal solution. An increase larger than $38.38 would result in this activity replacing one of those currently in the optimal solution (probably the riparian tracts). This rather slight change in value seems surprising in view of the rather sizable difference in objective function values specified. It is likely due to the

TABLE V-7. CONSTRAINING RESOURCES, TOTAL QUANTITY AVAILABLE, AND SHADOW PRICES, INITIAL OPTIMAL SOLUTION.

Constraint		Total Quantity		Shadow
Type	Location Zone	Available	Units	Price
				Dollars
Cropland	1	21,217	Acres	240.22
Grazing land	1	21,079	Acres	25.97
Flood plain	1	9,808	Acres	25.97
Timber land	1	31,364	Acres	190.35
Riparian land	1	2,740	Acres	240.22
View land	1	4,149	Acres	25.97
Cropland	2	63,651	Acres	240.22
Grazing land	2	63,238	Acres	25.97
Flood plain	2	29,424	Acres	25.97
Timber land	2	94,935	Acres	190.35
Riparian land	2	8,220	Acres	240.22
View land	2	12,431	Acres	25.97
August water		70,370	Acre-feet	28.00
September water		43,350	Acre-feet	28.00
Δ Population/3		69	Households	8,125.25
View tracts		10	Tracts	1,506.81
Tracts with detriments (required)		3	Tracts	-3,580.14

TABLE V-8. VALUE OF ACTIVITIES NOT IN ORIGINAL OPTIMAL SOLUTION AND INCREASE REQUIRED TO PERMIT ENTRY IN OPTIMAL SOLUTION.

Nature of Activity	Distance Zone	Value Specified Dollars	Units	Increase in Value Required Dollars
Graze cropland	1	25.98	Acres	214.25
Tracts on cropland	1	8,307.16	Tract	1,996.81
Lots on cropland	1	2,012.38	Lots	6,276.57
Tracts on grazing land	1	8,307.16	Tracts	38.38
Lots on grazing land	1	2,012.38	Lots	6,133.03
Tracts on flood plain	1	8,307.16	Tracts	38.38
Lots on flood plain	1	2,012.38	Lots	6,133.03
Tracts on timber land	1	9,282.85	Tracts	439.34
Lots on timber land	1	2,139.91	Lots	6,115.63
Graze riparian land	1	25.98	Acre	214.24
Lots on riparian land	1	2,012.38	Lots	6,276.57
Lots on view land	1	2,012.38	Lots	6,133.03
Graze cropland	2	25.98	Acres	214.24
Tracts on cropland	2	8,120.74	Tracts	2,183.19
Lots on cropland	2	1,997.46	Lots	6,291.49
Tracts with detriments	2	5,569.71	Tracts	174.90
Tracts on grazing land	2	8,120.74	Tracts	224.80
Lots on grazing land	2	1,997.46	Lots	6,147.95
Tracts on flood plain	2	8,120.74	Tracts	224.80
Lots on flood plain	2	1,997.46	Lots	6,147.95
Tracts on timber land	2	9,096.42	Tracts	625.77
Lots on timber land	2	2,124.99	Lots	6,130.55
Graze riparian land	2	25.98	Acres	214.24
Riparian tracts	2	9,138.30	Tracts	186.43
Lots on riparian land	2	1,997.46	Lots	6,291.49
View tracts	2	9,665.92	Tracts	186.43
Lots on view land	2	1,997.46	Lots	6,146.95
Buy water in July		28.00	Acre-feet	- 28.00

relatively higher valued agricultural alternatives for the land and water demanded by riparian tracts in the program. (Slight as it is, the increase is larger than the per acre contribution of the grazing activities.)

The substantial increase in value of lots required to allow these activities to enter the solution ($6,133.03 to $6,291.49) reflects the fact that from a recreation-residential development viewpoint, it is not land and water resources that are scarce. The true scarcity is in the number of customers for such lands. Why sell them a lot for $2,000 when you can sell them a view tract for $9,800? There is certainly a greater sacrifice in agricultural value associated with the larger tract but this sacrifice is far overshadowed by the increase in return on another scarce "resource"--occupiers of recreation-residential lands. Tracts on cropland involve a considerable sacrifice as compared to the alternative which utilizes only part cropland (tracts with detriments are specified to use half irrigation cropland and half grazing land while the riparian tracts require half irrigated cropland and half flood plain). This is evidenced by the rather substantial increase in value, $1,996.81 for Distance zone 1 and $2,183.19 for Zone 2, required to allow these activities to enter the solution. Tracts with only dryland grazing agricultural alternatives exhibit a much lower threshold value: $38.38 in Zone 1 and a range of $224.80 to $186.43 in Zone 2.

The increase in value required for grazing on cropland ($214.25) or for cropland to revert to dryland grazing may be viewed as a measure of the present value added by complete irrigation of lands in this area. One has to keep in mind that this involves a time dimension; i.e., 0.9 acre-feet of water is required in July, 11 acre-feet in August, and 0.5 acre-feet in September. It also involved purchasing some water in August and September at a present value of $28 per acre-foot. It can also be seen from Table V-8 that before it would appear attractive to buy July water, much is in surplus, the present value of cost would have to decrease by $28 per acre-foot (essentially drop to zero) for it to tie for a place in the solution. If the present value of cost for July water became negative (export July water, at a profit), this activity would enter the solution and the value of the optimal allocation would be increased. Unfortunately, there are few ready, willing and able purchasers of flood water.

Additional information of the possible values added by irrigation water will be considered later when parametric changes in the program isolate such measures.

Impact of Relaxing the Requirement for Tracts with Detriments

When the requirement that any solution contain at least three tracts with detriments was relaxed the value of the optimal solution increased to $54,459,972+, an increase of $10,740.

A restructuring of the environment in which development takes place to avoid the creation of additional tracts with detriments would offer at least this magnitude of annual increase in the wealth of landowners in the area assuming that the present environment allows at least three such tracts to come into being.

The increase in the value of the optimal solution in the absence of tracts with detriments is accomplished by satisfying the additional demands of immigrant households with riparian tracts. As the agricultural alternatives were specified as essentially the same for these two classes of tracts there are no additional, subtle, influences on value. One might expect a real-world substitution in such a situation to involve tracts with different agricultural alternatives and an evaluation of the substitution should properly consider those differences. The attempt here was to illustrate rather clearly the nature of the impact of such a change in the planning environment apart from the secondary influences on the agricultural activities.

Two possibilities should be discussed at this point. First, the inflow of recreation-residential occupiers may exceed, in future years, the number postulated here. If this is the case, one might expect a higher number, if not a higher proportion, of tracts with deteriments as a result of increased demand pressure and a desire to locate close to present service facilities in order to reduce private costs. Such an eventuality should reasonably be expected to increase the incentive to avoid the creation of this value-destroying phenomenon.

Secondly, if for reason of unavailability of riparian tracts or personal preference, the increased demand were met by some other types of tract the change in this benefit can be approximated by reference to Table V-8, the column headed, "Increase in Value Required". For example, if the requirement for detriments were relaxed by some change in the development environment and those demands were met by occupation of tracts on grazing land in Zone 1 the benefit referred to above would be lower by 3 x $38.38 = $115.15. If met by occupation of tracts on cropland in Zone 1, the benefit would be lowered by 3 x $214.25 = $642.75, etc.

Optimal Solution when Road and Route Costs are Considered

When the program was modified to have the road maintenance and school bus transportation costs reflected in the objective function the value of the objective function was reduced to $54,442,208, a reduction of some $7,024. This adjustment seems rather modest in view of the magnitude of the road and route costs reflected in the new objective function for this solution. Absorbing the costs with such a small impact on the value of the optimal solution was accomplished by an adjustment in the type of tract activities brought into the solution. When road and route costs were ignored the development took place on view tracts, tracts with detriments, and riparian tracts. When the road and route costs were considered, tracts on dry grazing land were substituted for the riparian tracts. This resulted in a substantially smaller impact on the agricultural base as there was no sacrifice of irrigated cropland nor irrigation water associated with this development pattern.

If the development, when road and route costs are considered, were forced to take place in the same manner (all demand not met by view tracts met by riparian tracts) as before these costs were considered, the result would be a reduction in the value of the optimal solution of some $21,000--almost three times as great a reduction. This is a result of the much higher valued agricultural alternatives for the land and water specified for the riparian tracts.

Inclusion of a further modification to remove the requirement of a minimum number of tracts with detriments allows the value of the optimal solution, when road and route costs are considered, to increase to $54,453,958; an increase of $11,750.00. The nature of the development activities changed only to avoid the tracts with detriments, i.e., all 69 immigrant households are accommodated on the 10 view tracts and 59 tracts on dryland grazing lands.

Examination of the activities not included in the optimal solution can give one an insight into the likely order of development. Table V-9 contains a listing of the tract activities not in the solution when roads and route costs are considered and no tracts with detriments are

TABLE V-9. ACTIVITIES NOT IN OPTIMAL SOLUTION: ROAD AND ROUTE COSTS CONSIDERED, VALUE PER UNIT AND INCREASE IN VALUE REQUIRED.

Nature of Activity	Distance Zone	Value Specified	Increase in Value Required
		--------Dollars-------	
Tracts on cropland	1	7,932.16	2,333.44
Tracts with detriments	1	5,369.63	3,916.76
Tracts on flood plain	1	7,932.16	375.01
Tracts on timber land	1	8,907.85	775.96
Riparian tracts	1	8,949.73	336.64
Tracts on cropland	2	7,558.24	2,707.31
Tracts with detriment	2	5,007.21	4,279.16
Tracts on grazing land	2	7,558.24	748.92
Tracts on flood plain	2	7,558.24	748.92
Tracts on timber land	2	8,533.92	1,149.89
Riparian tracts	2	8,575.80	710.55
View tracts	2	9,103.42	373.93

required. It can safely be asserted that as the supply of grazing land in Zone 1 were exhausted the next most attractive alternative, *ceteris paribus*, would be the riparian tracts in Zone 1. The next most attractive, without considering potential flood damage, of those not otherwise constrained is tracts on the flood plain in Zone 1. One would expect, as the more attractive land resources were exhausted, for the optimal allocation to bring in further activities in the reverse order of the increase in value required. An exception, of course, is the view tract activity which is constrained (if this requirement were relaxed it would be optimal to sell only view tracts as long as suitable land was available for this purpose).

Solutions Under a Random Settlement Pattern

The analysis of settlement to this point has proceeded as if the process was subject to the control of some centralized authority bent on maximizing the wealth of the region. Such is, of course, not the case in the real-world nor would very many of us be willing to make the sacrifices in personal freedom necessary to fully achieve such a solution. Decisions to convert agricultural resources to recreation-residential use are currently very decentralized with individual buyers and sellers almost wholly responsible for the decision of which resources in which location are to be so transformed. In many cases a site is selected by a potential buyer and he seeks out the owner, enters into direct negotiations with him, they pace out the boundaries, negotiate price, the tract is surveyed and a purchase contract is executed. All of this is more or less independent of any central guidance although most are probably aware, to a limited extent at least, of the prices of comparable tracts and of the private costs associated with the occupation of the site.

Although such a market for recreation-residential does not meet the economists' lofty standard of perfect competition, we might characterize it as a micro-competition (many small scale sellers and buyers) situation afflicted with a quite imperfect market information system, non-homogeneous products, capital rationing, and perhaps some individual (selling of very unique sites, say) influence on price.

The locational aspects of such a micro-independent, lowly-competitive system were approximated by having a random tract location pattern between the two regions. The lack of centralized control to achieve maximum value was approximated by constraining several of the tract activities to be developed in approximately the proportion observed in the survey described in Chapter IV (see Table IV-1). This resulted in requiring that of the 69 total tracts to be developed, at least 3 were tracts with detriments. At least 21 riparian tracts and 22 tracts on timber were required. View tracts were not allowed to exceed 15. It was further required that tract activities for each class of tract be apportioned between the distance zones in the same ratio as that assumed for the land resources (1 to 3).

These modifications in the development environment resulted in a value of the optimal solution of $54,437,479 or a reduction in value from the centralized model of $11,753 despite the allowance of a larger number of the high-valued view tracts. A description of the assumed conditions and differing results under the centralized versus decentralized selling situations is presented in Table V-10. Probably the most dramatic feature of this table is the rather sizable differences observed between the two when road maintenance and school bus route costs are considered.

Estimate of the Planning Benefits

The several forces discussed piecemeal so far have each pointed out some saving or increase in the value of resources that might be achieved by a modification in the framework within which development takes place. It is perhaps worthwhile to recap these several situations to bring into a clearer perspective the things that have been shown. If one looks over the several sets of results discussed in a little bit different order a clearer picture may also emerge.

Begin with the micro-competitive decentralized model with detriments but ignoring road and route costs-as an approximation of the present situation. If a centralized firm accommodated the inflow of households in the manner that would make optimum (nonrandom settlement) use of the potential of valley resources an increase in value or wealth of about $11,753 per year would result over the planning period. If

TABLE V-10. VALUE OF SOLUTION AT OPTIMUM, CENTRALIZED VERSUS DECENTRALIZED SELLERS AND DIFFERENCES IN VALUE.

Situation	Centralized Control	Decentralized Control	Difference
	Dollars		
Road and route cost ignored with detriments	54,449,232	54,437,479	11,753
Road and route cost ignored--no detriments	54,459,973	54,448,193	11,780
Road and route costs considered with detriments	54,442,208	54,402,344	39,864
Road and route costs considered--no detriments	54,453,958	54,413,224	40,714

this firm were rational, as assumed, it would locate activities in such a way that incompatibilities in uses would be avoided (no tracts with detriments) and an increase in value or wealth of about $10,780 would result. Forcing the firm to bear all road and route costs would result in its economizing on that factor and bring about a potential annual saving of some $40,714 over the noncentralized settlement pattern. The total benefit would then sum to approximately $63,000 per year.

It is safe to presume that this level of combined savings and wealth increase would occur each year for the several years--until certain attractive resources such as view lands or riparian lands in the interior zone were entirely developed. A proper estimate of the total value to be generated by planning might be approximated by discounting this annual benefit over the number of years over which it is expected to obtain at some appropriate rate of interest. If one were to assume again, a 5 percent discount rate and that at least this level ($63,000) of annual benefits could be expected from planning for the foreseeable future, the total present value would be $1,260,000. From this total value one must deduct the present value of costs of instituting and administering the resource use plan. Financial assistance in instituting the plan is available through the Department of Housing and Urban Development [56,p.13] so that local people do not have to bear this entire cost. Formulation and administration of the plan can (and perhaps should) involve many local people on a voluntary basis, but continuing professional administration will substantially increase the likelihood of success and general acceptance of the plan [56,p.11;63,p.9].

Water Supplies and Distribution

Implicit in the analysis so far is the assumption that the water distribution system and its underlying institutions impose no restrictions on the use of water. Water, whether streamflow or in reservoir storage, could be used on any irrigated land in the system. The fact that water supplies are inadequate in some areas has been observed on several occasions [59,p.8;49,p.317]. The relative abundance of water for irrigation on lands irrigable by the Bitterroot River mainstem is recognized in the soil survey of the area [59,p.8] and in the Bureau of Reclamation report [65,p.318] on the Bitterroot Project.

In runs of the model under the assumption of a complete, unobstructed distribution system the original solution left some stored water (Painted Rocks Reservoir) unused. This would tend to indicate that the combination of present storage and normal streamflow is adequate to meet the needs of the valley for domestic livestock and irrigation water. In the real-world situation, there are irrigated areas which do not receive an adequate supply of late season water and the physical and institutional difficulties involved in perfecting the distribution system to fully supply these lands are all but insurmountable.

The Painted Rocks Reservoir with an active capacity of 31,700 acre-feet was built to supplement streamflow for irrigation purposes to ditch systems diverting out of the Bitterroot River. Due apparently to relatively plentiful water from normal flow, the sale of water from this source has not been very large. The Montana Fish and Game Commission has subscribed to 5,000 acre-feet with which they attempt to maintain fish habitat along the mainstem when irrigation diversion threatens to dewater the Bitterroot (usually in the region between Victor Crossing and Stevensville). These attempts have met with limited success as the releases were also diverted for irrigation purposes in the absence of legal recognition of habitat maintenance as a beneficial use of water.

In an attempt to more realistically evaluate the water resource in agricultural and recreation-residential uses, a separate run of the model was made assuming no water from Painted Rocks Reservoir was available. This change resulted in a reduction of $3,878,827 in the value of the optimum solution under the centralized model and a reduction of $3,890,944 in the micro-competitive or decentralized case.

One might interpret the differences in the values of optimal solutions of otherwise similar models with and without this water available as measures of the upper limit of present value of design, construction, and operating and maintenance costs of improving the water distribution system. In other words, it would make sense for the people of the valley to commit no more than about $3.8 or $3.9 million to design, construction and operating and maintenance costs to perpetuity of improvements in the water distribution system in the valley.

As water is scarce in the solution where Painted Rocks water is not available, an additional measure of the value of water is the shadow price for this scarce water as given by the program output. As August streamflow is in critically short supply, the inability to satisfy water demand in August so reduces the acreage of cropland that September water is in surplus. July water is so abundant as not to impose any effective restriction on resource use. The shadow price of the scarce August water is $281.65. Converting this present value to annual value at a 5 percent interest rate would yield an annual marginal value productivity of $14.0825 per acre-foot for August water.

Table V-11 presents the values of various optimal solutions and the level of the activities in those solutions under centralized and decentralized control and with and without Painted Rocks Reservoir water available. It is perhaps of interest to point out the kinds of adjustments that were made when water was not available. All riparian lands in Zone 2 went out of crop to grazing and some of the Zone 2 cropland was grazed also. Beyond this, there were no further changes attributable to changes in the Painted Rocks water parameter. One would expect then, that agricultural and not recreation-residential users of water would bear the amount of the burden imposed by inadequacy of the water storage and distribution system in the valley.

Again referring to Table V-11, the noninteger values for level of development on the tract activities make little sense and one would not

TABLE V-11. VALUE OF OPTIMAL SOLUTIONS AND LEVEL OF ACTIVITIES IN OPTIMAL SOLUTION.

			Painted Rocks Reservoir Water			
			Available		Unavailable	
Value of Solution			Centralized $54,449,232	Decentralized $54,437,479	Centralized $50,570,405	Decentralized $50,546,535
Activity	Zone	Units	Dollars			
Irrigated cropland	1	Acres	21,204.4	21,213.9	21,204.4	21,213.9
Grazing	1	Acres	21,066.4	21,075.9	21,066.4	21,075.9
Graze flood plain	1	Acres	9,573.5	9,777.6	9,573.5	9,777.6
Timber	1	Acres	31,364.0	31,317.9	31,364.0	31,317.9
Crop riparian land	1	Acres	2,505.5	2,709.64	2,505.5	2,709.64
Graze view lands	1	Acres	4,065.25	4,117.6	4,065.25	4,117.6
Irrigated cropland	2	Acres	63,651.1	63,641.6	54,320.18	54,163.1
Graze cropland	2	Acres	0.0	0.0	9,330.82	9,478.5
Grazing	2	Acres	63,238.0	63,228.6	63,238.0	63,228.6
Graze flood plain	2	Acres	29,424.0	29,332.9	29,424.0	29,332.9
Timber	2	Acres	94,935.0	94,796.8	94,935.0	94,796.8
Crop riparian land	2	Acres	8,220.0	8,128.9	0.0	0.0
Graze riparian land	2	Acres	0.0	0.0	8,220.0	8,128.9
Graze view lands	2	Acres	12,431.0	12,336.8	12,431.0	12,336.8
View tracts	1	Tracts	10.0	3.75	10.0	3.75
Riparian tracts	1	Tracts	56.0	7.25	56.0	7.25
Wooded tracts	1	Tracts	0.0	5.5	0.0	5.5
Tracts with detriments	1	Tracts	3.0	0.75	3.0	0.75
View tracts	2	Tracts	0.0	11.25	0.0	11.25
Riparian tracts	2	Tracts	0.0	21.75	0.0	21.75
Wooded tracts	2	Tracts	0.0	16.5	0.0	16.5
Tracts with detriments	2	Tracts	0.0	2.25	0.0	2.25
Buy water--August		Acre-feet	15,792.58	15,843.47	0.0	0.0
Buy water--September		Acre-feet	4,530.79	4,559.07	0.0	0.0

expect to translate such nonsense to action. It is possible to avoid noninteger values by using an integer programming routine but the computational difficulties imposed are almost overwhelming. Deininger, in a linear programming study to determine the optimum number of sewage treatment plants [11] found that the integer programming approach sometimes yielded a solution and sometimes did not! The output of any of the models of this chapter should not be construed as a policy recommendation but rather viewed as a very rough estimate of the magnitude of the impact of specific, hypothetical policy. The direction of the impact of a hypothetical policy on the well being of property owners is probably correct but the magnitude is at best, a systematic guess.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A survey of sales of some 143 small, unimproved tracts of land in the Bitterroot Valley area indicated that some aesthetic features do have a significant and even sizable impact upon the per acre sales price of those tracts. The presence of stream frontage (not necessarily involving the use of the waters of the stream for irrigation) was observed to be associated with an increase of some $121.50 per acre in the selling price of a tract. Tracts which provide the occupant with a view below the horizontal were associated with an increase in per acre sales price of $184.50. If special water features, lakes, ponds or springs, were present on a tract the value appeared to be some $331.20 per acre higher than a similar tract not so endowed. The presence of coniferous timber was associated with an increased value per acre of some $116.50. On the negative side, distance to a local service community and the distance to Missoula appeared to reduce value per acre by $47.92 and $3.18, respectively. Another force apparently exerting a negative influence was the presence of certain incompatible (to recreation-residential use, anyway) uses on adjacent lands. This factor was associated with a reduction of some $304.60 per acre in the value of the tract.

An aggregative linear programming model of the valley was formulated. Estimates were made of the extent of lands possessing each of the above amenities and incorporated in the linear programming model.

Several runs of the program were made under varying assumptions about the forces guiding resource use. It was observed that combined increases in wealth and reductions in public costs from modification of the institutional environment would approach $63,000 annually if population inflow were sufficient to support the settlement of only 69 recreation-residential tracts. This saving could be realized if, first, the settlement pattern took proper cognizance of the agricultural values sacrificed when resources are transferred from agricultural to recreation-residential use and; second, if developers and/or occupiers are forced to consider external costs of development associated with incompatible land use, road maintenance costs, and school bus transportation costs. Measures were developed of the values of water and the potential for investment in the water distribution system. It was estimated that some $3.9 million could be profitably committed to investment in design, construction, operation and maintenance of improvements in the water distribution system of the valley.

The welfare (as estimated by changes in wealth) of Bitterroot Valley residents can be improved by introducing some greater measure of guidance into the recreation-residential land development system. If in the process, the risks of organic and inorganic pollution of ground and surface waters are reduced; if open spaces and vistas are preserved along roadways and thoroughfares; if congestion is reduced; if households are grouped in such a way as to allow reductions in the cost of providing still other services (electric and telephone service, mail delivery, etc); if transactions in the market for recreation-residential tracts can move closely to approach the perfectly competitive model; then the benefits will be even greater than those measured in this study.

Recommendations

In view of the potential for increased settlement in the valley and the apparent inability of a decentralized market to bring about a consistently acceptable pattern of development, it would appear wise for residents of Montana's mountain valley areas to move ahead with deliberate action to protect their areas from the ravages of rapid and unguided growth. It would appear wise to take steps to improve the effectiveness of the recreation-residential real estate market. Participants in market transactions tend to have much stronger incentives in the justice of the outcome of a set of events than do officials of regulatory agencies or the courts [51,pp.913-915]. If a mechanism can be found to make the information on the suitability of certain areas for recreation-residential use available to all participants in the market, some potential losses can certainly be avoided. By the time that local planning boards digest the information necessary to formulate a reasonable land use plan for their areas they should be well enough informed themselves to serve as a centralized source of the information.

Means of reflecting costs of public services in market decisions should also be sought. Changing from service-oriented subsidies to cash subsidies may be a decided aid in this effort if subsidies are to be used.

There will probably remain, despite efforts to improve it, cases where real-world market forces will not correctly reflect the wishes of all who are potentially to be influenced by certain recreation-residential developments. In such cases regulations ranging from perhaps minor ones to such severe measures as the outright prohibition of settlement in some areas (e.g., flood plains) may be appropriate. In formulating these regulations planning groups and public decision makers should be aware that increases in the simplicity and ease of administration of regulations may have to come at the price of equity.

The legal basis for land use planning in rural areas of Montana is, as yet, untried. Local officials endeavoring to function under this law should keep in close touch with their legislators so that weaknesses in the law can be repaired by legislative action if need be.

In view of the substantial value added to adjacent lands by free flowing streams and the continuing pressure on Montana's wildlife resources, habitat maintenance, recreation, and aesthetics should be recognized as beneficial uses of water. This action would secure a resource base for the industries dependent on water-based recreation, protect values of stream amenities, and encourage more effective use of waters appropriated for irrigation. Attendant reductions in bogging and salinity damage would likely result also.

Local and private action to encourage exchanges of water rights should be encouraged. Many of the higher lands of the valley will suffer chronic shortages of mid and late season irrigation water while those along the valley floor hold the senior rights on the tributary streams. These valley floor lands could be alternatively served by developments of ground water and/or mainstream storage and diversion developments. A recent study in the Gallatin Valley area produced an estimate of approximately $7,250,000 increase in annual net farm income if proper management of all farm land and water available for irrigation could be accomplished [69,p.163]. The Montana Water Resources Board now has the tools to undertake a similar analysis for the Clark Fork-Bitterroot Basin and likely will carry out an analysis of the integration of ground and surface waters in that basin. These analyses should serve to stimulate local interest and support of exchanges in water rights. The impact of these exchanges on wildlife habitat and aesthetic values should be carefully considered also.

The benefits attributed to changes in the institutional environment for recreation resource development which were measured in this study perhaps appear to be quite modest. They probably area. They probably are also analogous to the tip of the iceberg--just a fraction of the whole which as yet can only partially be measured. Additional research needs to be done in measuring the external costs of recreation-residential development. Some costs and benefits (e.g., value to travelers of a roadside view) may remain unmeasured for sometime but researchers must endeavor to provide information for decision makers.

Whether citizens choose to undertake to control the changes coming to Montana's mountain valleys or be controlled by them must remain their decision.

APPENDICES

APPENDIX A

CLASSES, GRADES, AND VALUE FOR MONTANA AGRICULTURAL LAND AS APPROVED BY THE STATE BOARD OF EQUALIZATION*

NONIRRIGATED FARM LAND

Grade	Bu. Wheat/Acre on Summer Fallow	Assessed Value/Acre Dollars
1A5	34 & over	61.37
1A4	32 - 33	54.80
1A3	30 - 31	48.60
1A2	28 - 29	42.79
1A1	26 - 27	37.31
1A	24 - 25	32.22
1B	22 - 23	27.50
2A	20 - 21	23.15
2B	18 - 19	19.17
2C	16 - 17	15.56
3A	14 - 15	12.31
3B	12 - 13	9.44
4A	10 - 11	6.94
4B	8 - 9	4.81
5	Under 8	3.06

GRAZING LAND

Grade	Acre/1,000# Steer 10 Mos.	Assessed Value/Acre Dollars
1A2	Under 3	71.69
1A1	3 - 5	44.18
1A	6 - 10	20.51
1B	11 - 18	10.53
2A	19 - 21	7.17
2B	22 - 27	5.42
3	28 - 37	3.72
4	38 - 55	2.52
5	56 - 99	1.47
6	100 or over	.82

WILD HAY LAND

Grade	Tons of Hay Per Acre	Assessed Value Per Acre Dollars
1	3.0 & over	67.60
2	2.5 - 2.9	53.03
3	2.0 - 2.4	41.38
4	1.5 - 1.9	29.43
5	1.0 - 1.4	19.38
6	.5 - .9	10.05
7	Less than .5	5.54

NONIRRIGATED CONTINUOUSLY CROPPED FARM LAND

Grade	Bu. of Wheat/ Acre each Year	Assessed Value/Acre Dollars
1	34 & over	81.86
2	32 - 33	73.09
3	30 - 31	64.81
4	28 - 29	57.05
5	26 - 27	49.75
6	24 - 25	42.96
7	22 - 23	36.67
8	20 - 21	30.87
9	18 - 19	25.56
10	16 - 17	20.75
11	14 - 15	16.41
12	12 - 13	12.59

TILLABLE IRRIGATED LANDS

Class 1--(Maximum Rotation) Assessed Value Per Acre by Water Cost Classes

Grade	Tons of Alfalfa/Acre	Under $1.50	$1.50 2.49	$2.50 3.49	$3.50 4.49
		Dollars			
1A	4.5+	110.40	103.74	97.07	90.40
1B	4.0 - 4.4	94.70	88.98	83.26	77.55
2	3.5 - 3.9	78.70	73.96	69.20	64.45
3	3.0 - .34	63.70	59.85	56.00	52.16
4	2.5 - 2.9	48.53	45.60	42.67	39.74
5	2.0 - 2.4	31.92	30.00	28.07	26.14
6	1.5 - 1.9	19.86	18.67	17.47	16.27
7	1.0 - 1.4	11.37	10.69	10.00	9.31
8	-1.0	4.55	4.28	4.00	3.72

Grade	Tons of Alfalfa/Acre	$4.50 5.49	$5.50 6.49	$6.50 7.49	$7.50 & Over
		Dollars			
1A	4.5+	88.74	77.07	70.40	63.74
1B	4.0 - 4.4	71.83	66.11	60.39	54.68
2	3.5 - 3.9	59.70	54.94	50.19	45.44
3	3.0 - 3.4	48.31	44.47	40.62	36.78
4	2.5 - 2.9	36.81	33.88	30.95	28.02
5	2.0 - 2.4	24.21	22.29	20.36	18.43
6	1.5 - 1.9	15.07	13.87	12.67	11.47
7	1.0 - 1.4	8.63	7.94	7.25	6.57
8	-1.0	3.45	3.18	2.90	2.63

TILLABLE IRRIGATED LANDS

Class 2--(Medium Rotation) Assessed Value Per Acre by Water Cost Classes

Grade	Tons of Alfalfa/Acre	Under $1.50	$1.50 2.49	$2.50 3.49	$3.50 4.49
		Dollars			
1A	4.5+	97.26	90.60	83.93	77.27
1B	4.0 - 4.4	81.72	76.12	70.52	64.92
2	3.5 - 3.9	67.27	62.66	58.05	53.44
3	3.0 - 3.4	53.90	50.21	46.51	42.82
4	2.5 - 2.9	41.60	38.76	35.90	33.05
5	2.0 - 2.4	30.39	28.31	26.22	24.14
6	1.5 - 1.9	19.86	18.67	17.47	16.27
7	1.0 - 1.4	11.37	10.69	10.00	9.31
8	-1.0	4.55	4.28	4.00	3.72

Grade	Tons of Alfalfa/Acre	$4.50 5.49	$5.50 6.49	$6.50 7.49	$7.50 & Over
1A	4.5+	70.60	63.94	57.27	50.60
1B	4.0 - 4.4	59.32	53.72	48.12	42.52
2	3.5 - 3.9	48.83	44.22	39.61	35.00
3	3.0 - 3.4	39.12	35.43	31.73	28.04
4	2.5 - 2.9	30.20	27.35	24.49	21.65
5	2.0 - 2.4	22.06	19.98	17.89	15.81
6	1.5 - 1.9	15.07	13.87	12.67	11.47
7	1.0 - 1.4	8.63	7.94	7.25	6.57
8	-1.0	3.45	3.18	2.90	2.63

TILLABLE IRRIGATED LANDS

Class 3--(Minimum Rotation) Assessed Value Per Acre by Water Cost Classes

Grade	Tons of Alfalfa/Acre	Under $1.50	$1.50 2.49	$2.50 3.49	$3.50 4.49
		Dollars			
1A	4.5+	86.26	79.60	72.93	66.27
1B	4.0 - 4.4	73.84	68.14	62.43	56.72
2	3.5 - 3.9	62.01	57.22	52.43	47.64
3	3.0 - 3.4	50.79	46.86	42.94	39.02
4	2.5 - 2.9	40.15	37.05	33.95	30.85
5	2.0 - 2.4	30.11	27.78	25.46	23.13
6	1.5 - 1.9	19.86	18.67	17.47	16.27
7	1.0 - 1.4	11.37	10.69	10.00	9.31
8	-1.0	4.55	4.28	4.00	3.72

Grade	Tons of Alfalfa/Acre	$4.50 5.49	$5.50 6.49	$6.50 7.49	$7.50 & Over
		Dollars			
1A	4.5+	59.60	52.94	46.27	39.60
1B	4.0 - 4.4	51.02	45.01	39.60	33.90
2	3.5 - 3.9	42.84	38.05	33.26	28.47
3	3.0 - 3.4	35.09	31.16	27.24	23.32
4	2.5 - 2.9	27.74	24.64	21.54	18.43
5	2.0 - 2.4	20.80	18.48	16.15	13.82
6	1.5 - 1.9	15.07	13.87	12.67	11.47
7	1.0 - 1.4	8.63	7.94	7.25	6.57
8	-1.0	3.45	3.18	2.90	2.63

*Source: Montana State Board of Equalization, Helena, Montana.

APPENDIX B

ANALYSIS OF RAVALLI COUNTY ROAD AND BRIDGE EXPENDITURES AND ROAD MILEAGE MAINTANED

On the basis of conventional economic theory one would expect a fairly strong relationship between county expenditure for road maintenance and the mileage of roads maintained.

Records of total expenditures from the Ravalli county road and bridge funds were transcribed from the annual reports of the county commissioners on file in the courthouse in Hamilton. The expenditure figures are reported on a fiscal year basis and represent total outlays between June 1 and July 1. Outlays for long lived equipment is not segregated from other outlays in the reports.

Estimates of the total mileage maintained are made each year by the Office of the Planning Survey Director of the Montana Highway Commission. These estimates are verified periodically (every 3 or 4 years) by a physical inventory. Where attempts are made annually to up-date the estimates by consulting with local officials, a majority of the changes in mileage estimates occur at the time of the inventories.

The data for Ravalli county as presented on Table V-4 was analyzed to determine if there was reason to suspect a relationship between expenditures and mileage. The expenditure figures were adjusted to dollars of 1970 purchasing power using the index of highway construction costs as a series closely related to the maintenance activity. The data were rounded to the nearest unit (dollars or miles) and read into a screening program. The data were fitted to six types of curves. The nature of the curves fitted and the closeness of the fits as measured by the index of determination are presented in Table B-1. Estimates of the parameters for a two-variable relationship are also supplied.

TABLE B-1. RELATIONSHIP BETWEEN EXPENDITURES FOR ROADS AND BRIDGES AND MILEAGE MAINTAINED, RAVALLI COUNTY, MONTANA, 1962-70.

Type of Curve Fit	Index of Determination (r^2)	a	b
1) $y = a + b(x)$	.0009408	378124	7.29742
2) $y = ab^x$	.0036710	366619	40376.3
3) $y = ax^b$	.0043538	264966	.05279
4) $y = a + b/x$	.0017732	399057	-1430360
5) $y = \frac{1}{a + bx}$	.0082030	.000003	-.000000001
6) $y = \frac{1}{a + bx}$	.0102428	.000274	.00000238

The index of determination is a measure of the relative closeness of the relationship between the two variables and can be interpreted as the proportion of the variation in total expenditures explained by variation in mileage maintained. It is apparent that even with the best of the six fits (curve #6) there is a very weak relationship. Only 1 percent of the variation in expenditures is explained while 99 percent is not explained by variation in mileage. While it must be conceded that expenditures of this sort are likely influenced by many factors it is somewhat surprising to observe as weak a relationship as indicated by this analysis.

A complete analysis of the relationship might properly include additional variables such as information on payments to the county by the U. S. Forest Service in connection with timber sales on the National Forests. These funds are allotted to the counties to be used in financing schools and roads in the county. The ups and downs of the lumber industry and resulting revenue from timber sales is likely of definite influence on expenditures.

APPENDIX C

RESOLUTION*

WHEREAS subdivisions are being extensively developed in Ravalli County and Ravalli County is being called upon to maintain other new roads, the following regulations concerning new roads to be maintained by Ravalli County are now in force.

1. GENERAL: The development of subdivisions and sale of lots and other parcels of land is a commercial venture for profit. The construction of streets and roads is one of the expenses of such developments and the entire cost of building such roads is the responsibility of the developer. To be accepted by Ravalli County for maintenance, the road must be completely finished and ready for maintenance without further expense by Ravalli County. If Ravalli County has to do any construction work to bring a road in a real estate development up to standard, the county would be subsidizing the developer at the taxpayers expense.

2. RIGHT OF WAY: Montana State Law specifies that the right of way of a county road shall be sixty (60') feet and narrower widths will not be accepted. The Board of County Commissioners may require a right of way wider than sixty feet where present or future traffic requires it. Part of the right of way may be developed for sidewalks or landscaping at the discretion of the Board of County Commissioners. If increased traffic in the future requires widening of the road or street, the Board of County Commissioners may authorize the County Road Department to remove such landscaping as is necessary.

3. ACCEPTANCE OF ROADS FOR MAINTENANCE BY RAVALLI COUNTY: When a real estate developer has completed the roads he wants maintained by Ravalli County, he must make application to the Board of County Commissioners for acceptance of such roads. The Board of County Commissioners and the County Superintendent of Roads will inspect the roads in person to decide whether the road meets specifications and should be accepted. If the road is not accepted, the County Supt. of Roads will specify the work necessary to make the road acceptable. After this work is completed, the developer may apply for another inspection. Cost of inspection must be born by the developer.

4. SPECIFICATIONS: A road must be able to sustain an H20 loading during any season of the year. This means 20 tons divided into 3 axles with tire sizes and axle spacing according to Montana State Law. Each road must have a base of sufficient thickness and proper material to hold the required load under all moisture conditions.

The use of clay, top soil, or other unstable material will not be allowed. Where such material is present in the original surface it must be escavated and replaced with stable material.
Each road must have a surface of gravel at least four inches thick; suitable for maintenance by a grader. Clay, top soil, or other unstable material must not be used. Material consisting of only one size may not be used. Rock over 1 1/2" in diameter may not be used. Material must be gradiated so that good compaction may be obtained. The top surface must be twenty-four (24) feet wide and the side slopes not greater than 1 on 2 unless the terrain prevents such slope. Side drainage must be constructed to prevent runoff water from gathering or running on the road and culverts of sufficient size must be placed under the road where necessary to transfer irrigation or drainage water.
Culverts must be large enough to carry any normal flow based on one year in 20. Culverts must be at least 26 feet long and 12 inches in diameter. Culverts must be of new material and must conform to the Montana State Highway Specifications. Culverts must be sufficiently covered to prevent crushing under load and to allow grader maintenance.
Culverts are preferred to bridges wherever possible. Where bridges are necessary, they must be 24 feet wide and built to carry H20 loading. Bridges must have concrete abutments and piers and all wood must be pressure treated to prevent rot. Wood decks must be 4" fir plank.

5. OILED STREETS OR ROADS: Ravalli County will consider only through streets or roads used for general traffic for hard surface at County expense. Streets or roads used primarily for traffic of the residents on the street will not be hard surfaced at county expense. Residents of such streets may surface the streets at their own expense. Such surfacing must be approved by the Board of County Commissioners before the job starts. Surfacing must be done according to specifications of the Ravalli County Superintendent of Roads so that it may be properly maintained by the county when built.

6. PRIVATE DRIVEWAYS: When private driveways are already located entering a road which is being inspected for maintenance by Ravalli County; they must conform to the Commissioners resolution on private drives entering county roads.

NOW, THEREFORE, BE IT RESOLVED by the Board of County Commissioners of Ravalli County at its regular meeting assembled this Third day of July, 1969, that the above regulations are now in force.

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*Source: <u>Minutes</u>, Board of City Commissioners, Ravalli County, Montana, July 3, 1969.

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