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An Analysis of Resource Development in the Talkeetna Basin, Alaska

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ABSTRACT

This study focuses on the economic viability of developing timber and agricultural resources with public and private capital in the Talkeetna Subbasin, Alaska. The feasibility of agricultural and logging activities was examined for 25 sets of alternative parameters. Producing some timber could be feasible, but producing barley for export is not feasible at present prices.

Keywords: Alaska, economic development, forest management, Alaska agriculture, benefit-cost analysis, interindustry analysis, linear programming.

ACKNOWLEDGMENTS

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CONTENTS

SUMMARY

An analysis of the economic viability of developing timber and agricultural resources with public and private investments was conducted during the Susitna Cooperative River Basin Study. The analysis was conducted in three phases.

In the first phase, demands for Alaskan timber and agricultural commodities were estimated and converted into acres of farm and timberland necessary to meet estimated demands. These acreage equivalents indicate the maximum amount of land that should reasonably be reserved for timber and agriculture. During phase I, past and expected trends in commodity consumption, production, population growth, and production efficiencies were considered.

The capability of meeting all or part of the needs for agriculture and timberland with land in the Talkeetna Subbasin was examined in the second phase of the study. The feasibility of developing subbasin agriculture and timber resources was examined using a variation of standard benefit-cost analysis. This type of analysis compares benefits (returns) of resource investment with costs (expenditures) incurred. Feasibility requires that benefits exceed costs by a margin at least as great as some prespecified interest rate.

Benefits and costs were compared using linear programming, a mathematical technique that sorts through a myriad of alternatives and picks those that maximize a prespecified objective, in this case net benefits. Net benefits are the difference between benefits and costs for each of several development levels. The advantage of linear programming in determining investment levels is that, if computer-aided, it can rapidly discern the optimum investment level and then find new optima if any of the parameters, data items, or assumptions are altered. In this manner, many alternative scenarios can be examined within a short period of time.

The third and final study phase involved estimating the effects alternative investment scenarios would have on the Alaskan economy. Economic multipliers were estimated for several economic sectors using a current Alaskan interindustry analysis.

The economic analysis focused on the Talkeetna Subbasin, which lies west and north of Anchorage. The area was subdivided into homogeneous land production units (LPUs). Using Soil Conservation Service (SCS) and Forest Service (FS) soils and vegetation data stored in an automated geographic information system (GIS), suitable agricultural and timberland areas within each LPU were estimated. Road access routes to the LPUs were mapped, again using the stored GIS data. Road construction costs for each of the access links were estimated.

Land clearing, commodity production, and commodity transportation costs were estimated for three commodities: barley, sawlogs, and fuelwood. Commodity selling prices were estimated. We tested 25 alternatives by varying study parameters. An input-output matrix, based on the economies of Alaska and Washington, was simplified (aggregated into fewer sectors) and used to estimate income and employment multipliers for Alaska's agricultural and timber commodities sectors.

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INTRODUCTION

The Susitna Cooperative River Basin Study (CRBS) was initiated in 1976, when Alaska's Department of Natural Resources (DNR) petitioned the U.S. Department of Agriculture (USDA) for assistance in developing data and information necessary for public decisions regarding the Susitna Valley's natural resources. USDA authorized the Susitna CRBS under Public Law 83-566, with joint sponsorship by Alaska's DNR and Department of Fish and Game (ADF&G), and the Fish and Wildlife Service, U.S. Department of the Interior. The Susitna Basin was divided into four subbasins (fig. 1): Willow, Talkeetna, Upper Susitna, and Beluga. The Willow Subbasin was studied first because of its severe natural resource problems and conflicts. Investigations of soils, timber and other vegetation, wildlife habitat, flood plains, geology, and archeological and other cultural aspects of the Susitna River Basin were conducted. USDA's Willow Subbasin report was completed in 1981, and a land-use plan for the Willow Subbasin was adopted by the State and borough in 1982.

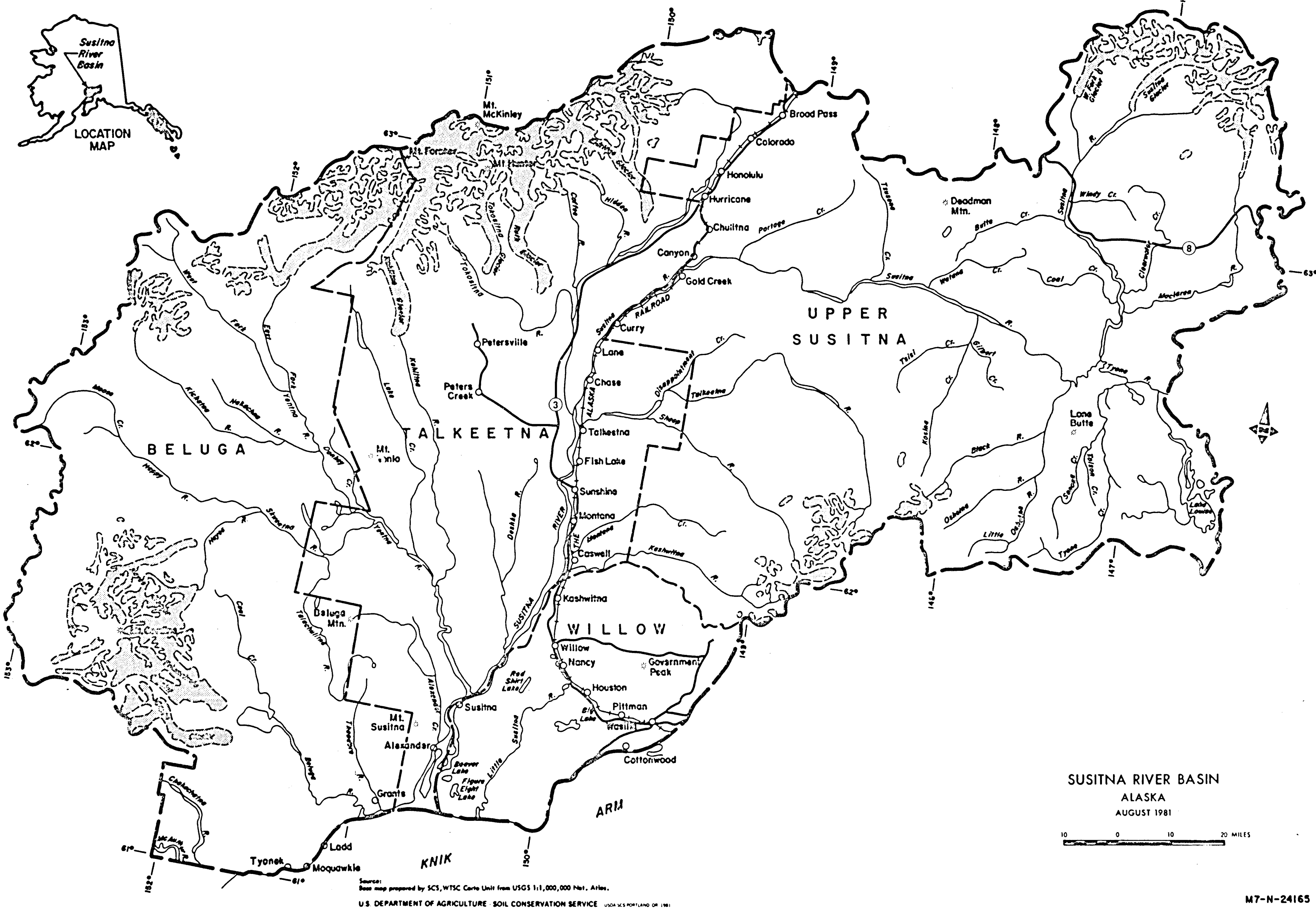
The Talkeetna Subbasin was the next area studied. This area was expected, and has begun, to experience conflicting land uses because of its proximity to roads, large tracts of State-owned land, and many recreational resources. This report presents results of our economic evaluation of timber and agricultural potential in the Talkeetna Subbasin and discusses an analysis of the economic viability of public and private investment in the Talkeetna Subbasin's agricultural and timber resources. This report supplements the main CRBS report (USDA, 1984).

The criterion for public or private investment viability is that total future economic returns be greater than present expenditures by an amount that at least equals the investor's monetary time preference, that is, a suitable interest rate. Development of subbasin land resources will require a combination of both public and private investment; primary road access must be developed by the public sector, while logging and farming machinery, land clearing, and on-site roads will be financed privately.

ANALYTIC METHODS

The analysis of the Talkeetna Subbasin's economic development was conducted in several phases. First, we estimated in-State demand for selected agricultural

FIGURE 1. Susitna River Basin (map)



and timber commodities that could be produced in the subbasin. Commodity demand was translated into acres needed to produce the desired farm and timber products. These land needs place an upper limit on the acreage that should be reserved for timber and agriculture. This analysis examined past and expected trends of commodity consumption, production, population growth, and production efficiencies.

The ability to meet all or part of in-State needs for agricultural and timber commodities from the Talkeetna Subbasin was examined in the second phase of the study. The feasibility of developing agricultural and timber resources was examined using a variation of standard benefit-cost analysis. This type of analysis compares benefits (returns) of resource investment with costs (expenditures) incurred. Feasibility requires that benefits exceed costs by a margin at least as great as some prespecified interest rate.

Benefits are measured as the monetary value society places on the flows of goods and services that result from investments. Costs are expenditures measured in dollars. The benefits of agricultural and timber development include the value of the commodities produced, in this case barley, sawlogs, houselogs, and fuelwood. The cost of producing these commodities includes road construction, land clearing, and materials used in commodity production, such as fuel, fertilizer, and chainsaws.

Benefits and costs were compared using linear programming, a mathematical technique that sorts through alternatives and picks those that maximize a prespecified objective, in this case net benefits. Net benefits are the difference between the benefits and costs of several development levels. The advantage of computer-aided linear programming in determining investment levels is that we can rapidly discern the optimum investment level and find new optima if any of the parameters, data items, or assumptions are altered. Many alternatives can be examined quickly.

Finally, we estimated the effects of alternative investments on the Alaskan economy. We estimated economic multipliers for several economic sectors, beginning with an Alaskan interindustry analysis prepared by Butcher and associates. These multipliers can be useful in estimating the total effects of increased agriculture and timber sector outputs on the State economy.

DATA AND ASSUMPTIONS

Data were compiled from on-ground investigations, computerized geographic information systems, and other sources. DNR's Divisions of Forestry, Agriculture, and Research and Development assisted in developing data sets, study parameters, and assumptions.

Study Area

The Talkeetna Subbasin lies west and north of Anchorage, across Cook Inlet and the Susitna River (fig. 1). The subbasin encompasses about 2.3 million acres; nearly three-quarters of this acreage is below treeline. Timber types are mostly mixed hardwoods (birch, cottonwood, aspen) with some white spruce stands and in the low-lying, marshy areas, black spruce. Soils are typically of loess or volcanic origin, underlain by sand or gravel.

Transportation facilities include the Alaska Railroad and the Parks Highway; both run north to south in the eastern portion of the Subbasin. A road runs west from the Trapper-Cache Creek area to Peters Creek and Petersville. Small aircraft and river boat transportation is available throughout much of the area.

There are no incorporated communities in the study area. Unincorporated Talkeetna has a population of about 376. Another 771 persons reside in the subbasin, primarily along roads, railroad, and rivers.

Tourism and outdoor recreation, mining, a small amount of logging and milling, and fur trapping are the main commercial activities. Many residents live in the Bush and have adopted a subsistence or semisubsistence lifestyle.

Land Production Units

Natural resources were mapped during 1979-81 by soil scientists, geologists, and foresters of USDA's Forest Service (FS) and Soil Conservation Service (SCS). During the same period the FS conducted a timber inventory. All data were digitized and entered into a geographic information system (GIS) data base maintained at the Alaska DNR. Individual or combined land-based attributes can be extracted from the GIS and displayed in tabular or mapped form using Boolean techniques.

DNR generally focuses on small, homogeneous, scattered land units. These units are outlined so that their suitability for various land uses can be determined and classified. DNR delineated 50 small, disaggregated subunits to analyze the feasibility of agricultural and timber development. These land production units (LPUs), shown in fig. 2, became the focus of our economic analysis.

Rescurce Base

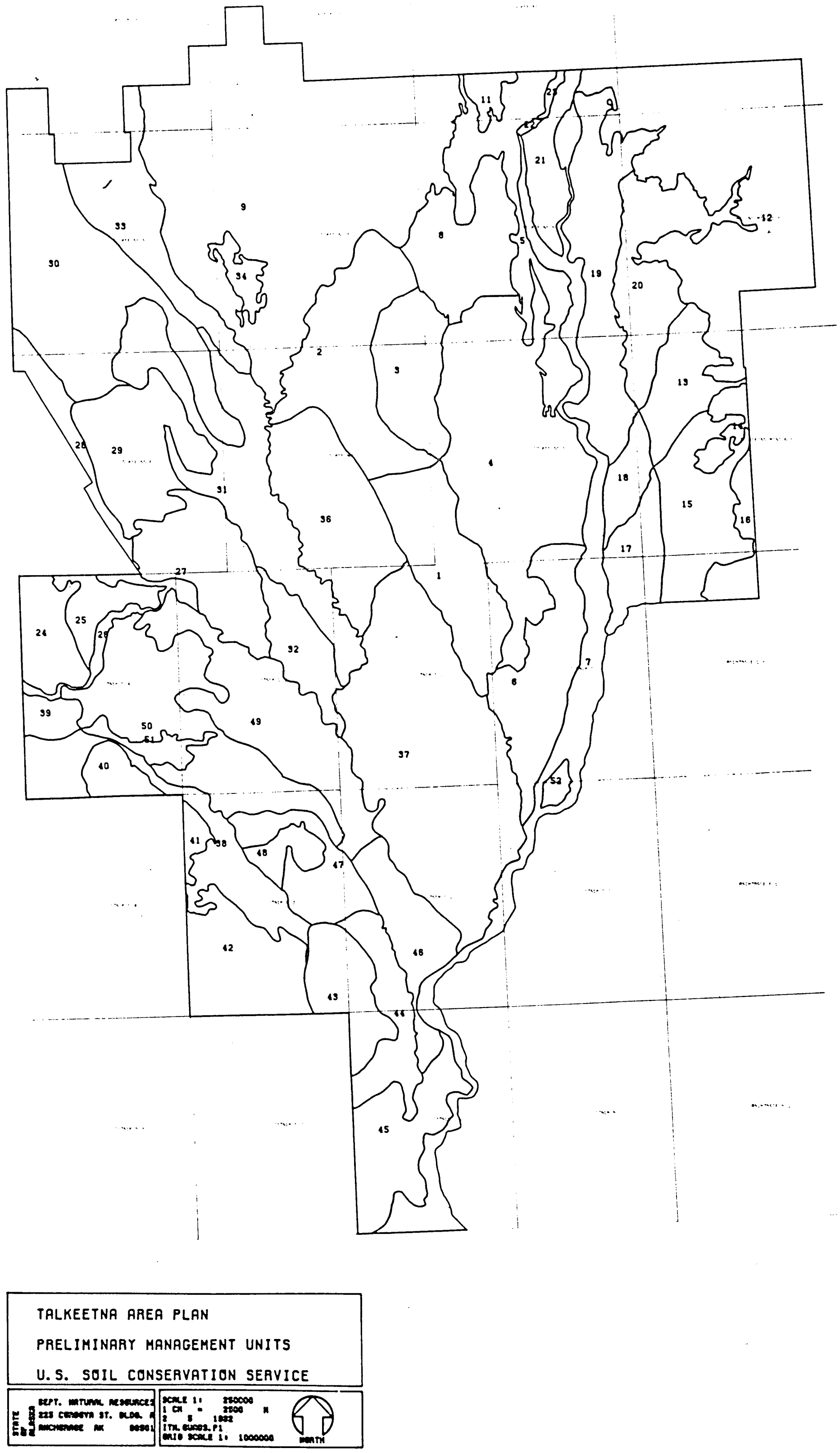
The most important parameters of economic viability are the quantity and productivity of available resources. We estimated the extent and distribution of the better soil and timber resources using GIS data, primarily soil surveys and timber inventories. The location and extent of capable soils, high-volume timber types, and areas where they coincide were estimated by comparing (overlaying) automated soil and vegetation maps.

Only soil types in SCS capability classes II and III were considered. Soils of lower capability classes were excluded because of potential constraints associated with their use, including excessive slope, poor drainage, erodibility, and high elevation.[1/] Timber types were selected on the basis of average per acre volume reported by the FS Pacific Northwest Experiment Station.[2/] Average timber volumes represent existing conditions and do not account for the potential effects of forest management on production.

1/ There are no capability class I soils in Alaska.

2/ The timber types included in the analysis were: closed white spruce; young, medium-aged, and old, closed, mixed deciduous; closed, medium-aged and old cottonwood; and open, old, mixed deciduous and cottonwood.

FIGURE 2. The 50 Land Production Units



Because financial and staff resources were limited, timber inventory procedures were not used to estimate timber volumes in individual LPUs. The FS inventory area was much larger than the area we analyzed, and included a statistical sample of 152 plots distributed over 5.6 million acres. Only 107 plots were located within the 2.3 million acre study area and 68 plots, representing conditions on about 815,000 acres, contained timber types considered in this analysis. The average volume of sawtimber and poletimber on these 68 plots was 1,039 net cubic feet (ft^3) per acre.[3/] Loggers typically would not harvest low-volume areas; harvested areas would be expected to contain higher volumes than the inventory average. Consequently, only plots of commercial timberland and operable, noncommercial forest land were considered.

Thus, the timber resource base was reduced from 68 plots to 50 typical plots that best represented conditions for all LPUs. Typical plots are those most likely to be used by the timber industry. These 50 plots represented 599,400 acres, with an average timber volume of 1,246 net ft^3 per acre. The average per acre timber volume in each LPU was assumed to be 1,246 net ft^3.

The land resource base is shown in table 1. Acreages were estimated from the automated GIS data for each LPU. The actual resource acreages used were somewhat more conservative than those shown in table 1. Only 80 percent of the available acreage in each resource class was assumed to be suitable for agricultural or timber development. This assumption was made because mapped soil classes and timber types include small and isolated parcels unsuitable for development. Land areas deemed suitable for timber production were reduced an additional 27 percent to reflect only the typical plots discussed earlier.

Road Access

Although the subbasin is bisected by the Parks Highway, most of the area (fig. 1) has no roads and is accessible only by air or water. Resource development in these remote areas will require road access. The cost of road construction is usually beyond the means of individual entrepreneurs. An individual can capture only a portion of the returns from road investment unless the individual is the sole user of the road. One justification for public investment in natural resources, such as roads and dams, is that because everyone benefits from such investments everyone should assume their costs.

The cost of road construction will largely determine the economic viability of developing these units because almost all LPUs are presently inaccessible by road. It was necessary to estimate the costs of providing road access to each LPU, and alternative routes to and among the LPUs to evaluate investment viability.

Routes

Roads to the approximate center of each LPU from existing roads or from other LPUs were mapped (fig. 3). Mapping criteria were based primarily on engineering considerations, including landforms, slope gradients, geologic hazards, soil characteristics, proximity to fill material, and type of

3/ Forest Service inventory definitions are provided in Appendix A.

Table 1--Land class acreage by land production unit (LPU), Talkeetna Subbasin, Alaska

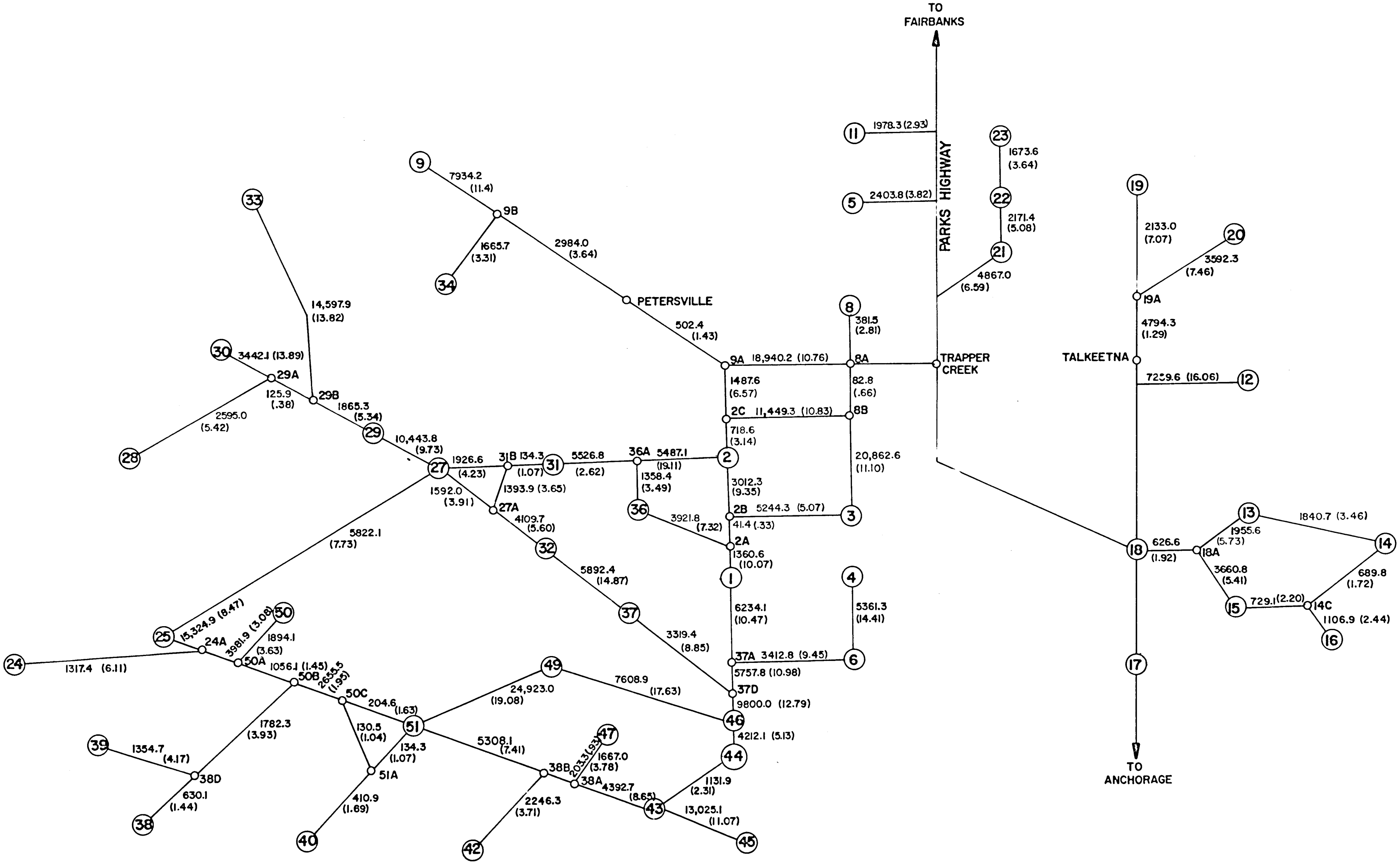
LPU No.	Untimbered		Timbered			Other land	Water	Total land area
	Class II	Class III	Class II	Class III	Other			
	Acres							
1	100	90	20,160	7,710	5,090	21,370	500	55,020
2	1,130	10,110	5,230	16,320	13,250	23,550	240	69,830
3	0	10	2,650	17,060	4,510	12,780	490	37,500
4	780	890	21,960	8,540	11,000	85,070	3,270	131,510
5	1,790	810	13,290	6,710	15,170	10,610	1,220	49,600
6	120	160	22,320	2,270	7,130	17,630	1,380	51,010
7	12,830	2,390	5,730	1,540	2,050	18,470	41,520	84,530
8	160	220	11,540	3,900	12,320	17,620	540	46,300
9	2,770	15,860	2,110	1,910	9,770	226,480	1,480	260,380
11	0	510	0	280	1,170	4,030	390	6,380
12	2,470	1,050	180	280	1,150	146,530	2,020	153,680
13	650	3,410	4,570	3,400	11,750	4,740	40	28,560
14	0	40	110	100	650	8,100	20	9,020
15	320	2,020	7,170	12,860	15,470	8,200	60	46,100
16	0	110	20	360	1,520	10,110	10	12,130
17	1,830	940	3,720	6,030	2,060	8,290	330	23,200
18	630	960	4,600	2,310	820	4,630	110	14,060
19	4,190	1,060	17,410	15,620	15,400	8,510	2,480	64,670
20	4,710	2,610	12,320	6,170	16,370	5,570	1,440	49,190
21	400	1,260	10,570	2,100	1,620	3,200	550	19,700
22	0	10	160	160	160	210	30	730
23	0	540	20	0	80	920	40	1,600
24	710	3,490	1,360	2,290	2,470	12,450	480	23,250
25	660	50	2,000	130	600	11,020	430	14,890
26	1,390	250	720	150	230	4,220	3,670	10,630

--continued

Table 1--Land class acreage by land production unit (LPU), Talkeetna Subbasin, Alaska, continued

LPU No.	Untimbered Class II	Untimbered Class III	Timbered Class II	Timbered Class III	Timbered Other	Other land	Water	Total land area
	Acres							
27	370	420	3,750	11,270	18,730	11,220	2,210	47,970
28	0	350	0	1,590	6,330	7,030	0	15,300
29	10	1,590	0	350	290	49,530	280	52,050
30	13,040	8,580	1,370	790	1,780	82,900	4,590	113,050
31	1,170	5,470	4,360	25,990	16,370	25,120	1,240	79,720
32	1,310	410	280	3,670	7,200	8,430	2,370	23,670
33	1,690	2,340	60	130	1,640	34,780	3,490	44,130
34	250	940	10	630	3,770	2,710	20	8,330
36	30	180	3,690	24,230	12,020	23,380	1,350	64,880
37	4,450	390	18,790	50,250	32,810	47,740	6,230	160,660
38	2,440	8,400	2,530	8,940	4,260	19,790	110	46,470
39	0	290	0	230	1,310	6,710	260	8,800
40	10	250	0	0	0	11,020	50	11,330
41	0	10	0	0	80	4,940	0	5,030
42	160	2,260	0	940	800	41,590	0	45,750
43	0	740	0	350	830	26,630	0	28,550
44	770	840	4,170	6,280	9,330	6,670	140	28,200
45	4,630	0	350	80	1,610	29,300	6,130	42,100
46	270	1,100	2,560	8,510	10,600	8,680	550	32,270
47	0	190	150	12,410	5,070	9,670	410	27,900
48	0	0	60	1,470	1,310	6,980	390	10,210
49	2,070	540	6,540	11,340	15,410	31,920	1,490	69,310
50	1,280	1,600	0	1,900	3,690	68,220	1,690	78,380
51	4,960	1,660	0	0	20	1,630	0	8,270
52	3,100	0	0	0	0	10	340	3,450
Total	79,650	87,400	218,590	289,550	307,070	1,240,910	96,080	2,319,250

FIGURE 3. Schematic of Roads Connecting the 50 Land Production Units



vegetation. This information is available in the GIS and can be used to evaluate the suitability of alternative routings when specific environmental characteristics, such as slope and landform, are rated for individual effects on road construction. Composite ratings account for all of these characteristics and were used to identify the least costly routes among LPUs.

Costs

We estimated costs for seven categories of roads based on composite route suitability ratings. These costs ranged from $125,000 per mile to $18.6 million per mile. Costs included bridges and culverts where necessary. Overhead costs (administration, design, engineering) were initially estimated to be 35 percent of construction costs. Annual operating and maintenance costs were assumed to equal 1 percent of the original construction costs. Road costs are discussed in detail in Appendix B.

Land Clearing

Significant land preparation is required to develop an adequate seedbed for agricultural production. Many land clearing methods and types of machinery have been tested throughout the State with varying success and cost. Clearing costs range from $200 per acre on large farms in the Interior to $500-$600 per acre in south-central Alaska. Clearing cost was initially estimated to be $300 per acre for land in soil capability classes II and III.

Commodity Production

Agricultural commodities were selected on the basis of crop suitability, transportability, and marketability. Many of the agricultural and timber products that can be produced in Alaska require large investments in intermediate facilities to make them transportable or marketable.

Agriculture

Many crop and livestock commodities can be successfully produced in Alaska. Those included met criteria of agronomic viability, access to markets, and data availability. Marketing of livestock products is difficult to assess because of the intermediate processing required. Truck crops are popular and profitable for many small farmers in Alaska, but because the overall acreage demand is extremely low, they were not included in this analysis. Vegetable processing facilities are virtually nonexistent, making vegetables a poor choice for startup crops.

Barley was selected because production and cost data were available, there is a strong in-State market for barley as a feed grain, and there is the potential for export to world markets.

Although Alaska's barley production will have no appreciable effect on export prices, these prices can significantly affect production. The worldwide recession currently restricts international demand for feed grains. Today's export barley price cannot meet the cost of production, even in the lower 48 States. Many analysts think that this situation is temporary and that the intermediate and long-range outlook for barley export prices is favorable. The current world barley price served as a parameter input for several of the alternatives examined. Several alternative barley prices can be used as inputs to determine the effects of price changes on production feasibility.

The break-even price, or minimum price necessary for investment viability, can also be determined for each alternative.

Farm operations are critical variables in estimating production costs. Cost estimates were developed for a typical two-section farm with 1,000 acres planted to barley. It was assumed that the crop would be produced annually in continuous rotation. The equipment required for each farm under the assumed operation schedule is shown in table 2. The sequence of tillage operations begins in May with fertilizer broadcasting, disking, and seeding. Herbicide was assumed to be applied in June, with swathing and combining occurring in August and September.

The estimated production costs for farming operations are shown in table 3. Prices and costs were estimated using survey data obtained from Alaska farmers and suppliers. Costs shown in table 3 are in 1982 dollars. The estimated total cost of $176.04 per acre represents the sum of fixed and cash costs per acre of farmed land, and includes a 20-percent charge for overhead, risk, and management.

It is impossible to accurately estimate future crop yields because of limited information about farming experience or farmer management skills in this area. Yields were varied to test their effects.

Timber

The FS estimated that there are 5.4 billion board feet (fbm) of standing timber in the inventory survey area. In the study area, which represents about 40 percent of the FS inventory area, it was estimated that there were 2.9 billion fbm on the 815,210 acres of timbered land (table 1), or an average of 3,500 fbm (1,039 ft^3)4/ per acre. Typical stands were estimated to include 2.6 billion fbm on 599,400 acres, or 1,246 ft^3 per acre.

Location of the best timber stands could not be determined from available data, so it was assumed that they were uniformly distributed throughout the 50 LPUs. It was estimated that a ft^3 of wood taken from our typical stand was composed of 1.128 thousand board feet (Mbm) of spruce (Scribner scale), 1.030 Mbm of cottonwood, 0.0052 cords of birch, and 0.000318 cords of aspen. Using initial analysis prices, a ft^3 of wood is worth 72 cents. We estimated the cost of logging using standard equipment and cutting practices. The logging operation (table 4) was suggested by DNR's Division of Forestry. We estimated the cost per hour for a logging operation using the same accounting procedures and background assumptions as in the farm budget (table 5). The cost per cord of wood or Mbm depends on timber stand density and logging productivity.

Productivity of the logging operation (in ft^3 per hour) was estimated by tree size (table 6) using machinery productivity data in Cubbage. Average tree size was estimated for each species using FS data. By interpolation it was estimated that logging productivity in our typical stand was 283.9 ft^3 per hour.

4/ There are usually 3 to 5 fbm per ft^3 depending on tree species, age, size, and defects.

Table 2--Farm machinery complement, Talkeetna economic analysis, Alaska

Machine and size	List price	Annual use	Life
	Dollars	Hours	Hours
Tractor:			
50 hp	17,500	145	12,000
125 hp	50,000	160	12,000
Truck:			
3/4 ton	12,000	400	4,000
2-1/2 ton	25,000	160	4,000
Combine, 24 ft	80,000	165	2,000
Swather, 24 ft	17,000	75	2,000
Tandem disk, 16 ft	7,540	160	2,000
Grain drill, 24 ft	13,900	120	1,000
Sprayer, 45 ft	4,000	85	1,000
Fertilizer spreader, 45 ft	9,450	65	1,000

Table 3--Farm cost of production, Talkeetna economic analysis, Alaska 1/

Item	Quantity	Cost per acre
		Dollars 2/
Cash operating expenses:		
Fertilizer	300 lbs	42.75
Seed	71 lbs	19.88
Herbicide	1 pt	1.90
Fuel and lube		10.73
Repairs		7.12
Labor expenses	1.736 hr @ $9.75	16.92
Fixed expenses:		
Interest on investment		14.44
Ownership cost 3/		32.95
Subtotal - production costs		146.69
Overhead, risk, and management (20 percent of production cost)		29.34
Total - onfarm operations		176.03

1/ See Appendix C for definitions of major production cost items.

2/ Costs are reported in 1982 dollars.

3/ Depreciation, taxes, and insurance.

Table 4--Logging machinery complement, Talkeetna economic analysis, Alaska

Machine and Size	List price	Annual use	Life
	Dollars	Hours	
Chainsaw (2)	550 ea.	800	800
Cable skidder, 80 hp	58,000	1,070	7,000
Crawler, 50 hp	58,000	960	7,000
Self-loading truck, 2-1/2 ton	70,000	1,025	10,000

Table 5--Logging cost, Talkeetna economic analysis, Alaska

Item	Cost per hour
	Dollars
Cash operating expenses:	
Fuel and lube	10.84
Repairs	14.10
Labor expenses	48.75
Fixed expenses:	
Interest on investment	9.43
Ownership cost 1/	14.12
Subtotal production costs	97.24
Overhead, risk, and management (20 percent of production costs)	19.45
Total	116.69

1/ Depreciation, taxes, and insurance.

Table 6--Timber harvest productivity by tree size, Talkeetna economic analysis, Alaska

Tree Size	Fell, delimb, and buck with chainsaw		80 hp cable skidder 1/	
	Full	Effective 2/	Full	Effective 2/
d.b.h.	Cubic feet per hour			
4	93	47	31	21
5	118	59	62	42
6	130	65	102	68
7	169	85	152	102
8	198	99	216	145
9	220	110	260	174
10	252	126	326	218
11	270	135	386	259
12	306	153	442	296
13	320	160	492	330
14	364	182	524	351
15	369	185	558	374
16	371	186	580	389
18	398	199	617	413
20+	441	221	667	447

1/ 1,000 ft one-way skid.

2/ Includes machine downtime.

Sources: Cubbage, Frederick W., Machine rate calculations and productivity rate tables for harvesting southern pine, Univ. Minn., Dept. Forest Res., Staff Pap. Ser. 24, Apr. 1981.

Miyata, Edwin S., Determining fixed and operating costs of logging equipment, U.S. Dept. Agr. Forest Serv., General Tech. Rep. NC-55, 1980.

Cost per acre was estimated by multiplying cost per hour ($116.68) by hours per acre (1,246 ft^3 per acre divided by 283.9 ft^3 per hour). The resulting $512.09 is the per acre cost of logging our typical stand. The logging operation yields 1.4 Mbm (thousand board feet) of spruce sawlogs, 1.3 Mbm of cottonwood sawlogs, and 6.9 cords of fuelwood per acre.

Commodity Prices

Product marketability is the most important parameter affecting commodity production feasibility. Without readily accessible outlets producers cannot meet costs. The Talkeetna Subbasin is largely inaccessible to markets and this dictated the commodities to be included in the analysis.

Agricultural Commodities

The current export price of barley in Portland, Oregon, about $2.72 per bushel (bu),[5/] is too low to support barley production, even in the lower 48 States. Most experts agree that this price is a short-term phenomenon caused by world economic malaise. If this is true, price-cost relationships may change dramatically. The price-cost relationship will affect the viability of agricultural development in Alaska.

Domestic (Alaska) barley prices are much higher today than export prices, and they will permit viable barley production to the point where domestic production meets domestic demand. In the first four analyses, an unlimited world barley market was presumed as the study area's outlet. These four analyses could be termed no barley alternatives because barley cannot be successfully grown at the current world price. Other alternatives used a higher price, reflecting in-State demand.

Timber Commodities

Because the only timber products currently marketable are sawlogs and fuelwood, local prices were used for these commodities. Sawlog processing facilities were limited to those producing rough, green, dimension lumber because they are representative of local mill outputs. Prices paid by mill operators for spruce and cottonwood sawlogs were obtained from the most recent FS survey of the Matanuska-Susitna Valley. The average price paid was approximately $160 per Mbm for spruce, and $125 per Mbm for cottonwood. Fuelwood prices in the valley, excluding delivery, range from $50 per cord to over $100. We used a market price of $75 per cord.

ANALYSIS AND RESULTS

Our analysis was conducted in three phases. The first phase consisted of a resource needs assessment, an analysis of the acreage required for commodity production. The second phase involved analyzing the economic feasibility of resource development and the final phase involved estimating the effects of resource development on the State's economy.

5/ Week of May 23, 1983.

Commodity Demands and Resource Needs

Agricultural Land

Existing Production. Table 7 illustrates recent trends in planted and harvested cropland[6/] in the Matanuska-Susitna Valley and Alaska. Table 8 shows the distribution of crops on harvested land. Data for these 15 years indicate that statewide production has increased rather rapidly, particularly since 1980, although cropland in the State's traditional breadbasket, the Matanuska-Susitna Valley, has remained relatively stable.[7/]

While the study area is within 60 miles of the Matanuska-Susitna Valley, the two areas do not have similar agricultural production. The SCS estimated that fewer than 500 acres in the study area were planted in crops in 1982.

Outputs of noncrop agricultural commodities in both the valley and State are relatively minor when compared to production from any of the lower 48 States.[8/] State and valley production of noncrop commodities is shown in table 9.

Existing Consumption/Demand. A distinct difference exists between actual consumption (representative of currently available supply) and demand for some resources included in the Susitna River Basin Study. For example, demand for remote, recreation cabin sites currently exceeds land being made available for this purpose. Similarly, current demand for particular minerals also appears to exceed mined supplies.

No shortfall exists between supplies of agricultural commodities and demand. People within and near the study area can readily obtain food products comparable in quality and quantity to those available in the remainder of the United States and far better supplies than those available in most countries throughout the world. The population has sufficient supplies to meet demand.

Many Alaskans have a strong desire to develop the State's renewable resources and become less dependent on outside sources for consumer goods. Although Alaska's demand for agricultural commodities is currently being met, this has little effect on Alaskan's demand for agricultural commodities and self-sufficiency.

Achieving agricultural self-sufficiency will result in negative economic effects unless this goal is economically feasible. While most of Alaska's citizens favor self-sufficiency in concept, most actually favor it only if self-sufficiency results in lower consumer prices. Alaska prices tend to approximate Seattle, Washington, prices plus transportation up to the point of meeting local demand. Beyond this point, prices tend to drop sharply toward Seattle prices less transportation. These geographic price differentials

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6/ Includes land in oats, barley, grain mixtures, grass, potatoes, lettuce, cabbage, carrots, and miscellaneous vegetables.

7/ The 15-year data indicate that the amount of Matanuska-Susitna Valley land in crops is declining at an annual average rate of 0.4 percent. For the most recent 5 years, the declining rate averages 2.5 percent annually.

8/ Every State in the United States has more land in crops than Alaska.

Table 7--Cropland statistics, Alaska

Year	Alaska: Planted	Alaska: Harvested	Matanuska-Susitna Valley: Planted: Actual	Matanuska-Susitna Valley: Planted: Change from previous year	Matanuska-Susitna Valley: Harvested
	Acres			Percent	Acres
1967	17,425	16,970	10,893		10,695
1968	17,020	16,590	10,661	-2.1	10,476
1969	16,895	16,230	10,334	-3.1	10,018
1970	17,430	16,210	10,518	1.8	10,141
1971	19,310	17,825	11,770	11.9	10,637
1972	19,905	18,720	11,965	1.7	10,970
1973	20,005	18,865	11,009	-8.0	10,789
1974	19,345	18,825	11,130	1.1	10,960
1975	20,335	19,815	12,145	9.1	12,081
1976	19,017	18,485	11,436	5.8	11,319
1977	19,005	18,382	11,222	1.9	10,859
1978	20,181	19,828	11,142	-.1	11,034
1979	20,432	19,988	11,091	1/	10,928
1980	30,484	29,162	10,399	-6.2	10,071
1981	36,881	25,173	10,006	-3.8	9,728
15-year average	20,911	19,405	11,048	-.4	10,714

1/ Less than 0.05 percent.

Source: Alaska Crop and Livestock Reporting Service.

Table 8--Acreage harvested, 1981

Crop	Matanuska Valley	Alaska
	Acres	
Potatoes	395	500
Other vegetables:		
Lettuce	86	100
Cabbage	34	41
Carrots	21	27
Miscellaneous	92	105
Subtotal	233	273
Grains:		
Oats	450	4,200
Barley	850	6,700
Grain mixtures	650	700
Subtotal	1,950	11,600
Grass hay	7,150	12,800
Total	9,728	25,173

Source: Alaska Crop and Livestock Reporting Service.

Table 9--Production of selected agricultural commodities, 1981

Commodity	Unit	Matanuska-Susitna Valley	Alaska
		-------- Acres -------	
Beef and veal	lbs. dressed weight	274,000	749,000
Lamb and mutton	lbs. dressed weight	Not available	18,000
Pork	lbs. dressed weight	134,000	293,000
Poultry	lbs. dressed weight	104,600	231,000
Milk	lbs.	11,900,000	13,400,000
Eggs	doz.	420,000	558,000

suggest that in-State producers have an advantage over outside suppliers. While this is true, it is true only in terms of transportation costs. Other in-State costs, for example, labor and equipment, often offset the transportation cost advantage. To assume a positive correlation between self-sufficiency and feasibility is extremely unwise without additional economic analyses. Alaska is likely to remain the most dependent State in the United States with regard to agricultural products, as illustrated in table 10.

One objective of this study is the allocation of land for various uses, therefore values in table 10 must be converted into acres. Differences in land quality and managerial ability make this conversion extremely difficult and it relies heavily on yield assumptions. Those even slightly familiar with the State's agricultural development over the past few years are aware of the controversy surrounding yield projections and land feasibility assessments. In order to provide a better understanding of the problems associated with yield projections, table 11 shows barley yields in selected areas for the past 3 years.

The vast yield differences among areas of the world reflect the availability of three basic types of resources: physical (including environmental), technological, and human (management) resources. Lower yields in developing countries are primarily a function of limited technology, while high yields in developed nations[9/] indicate that all resources are sufficiently available.

Alaska now has a 3-year average barley yield of 38.8 bu/acre, which is approximately equal to the world average (36.9 bu/acre), but is far below that of most developed nations. One frequently overlooked explanation for Alaska's lower yields is lack of farmer experience. Alaska has access to the best technology, adequate soils, excellent photoperiods, and adequate growing seasons (similar to other areas with yields in excess of 60 bu/acre). Because Alaska appears to be well equipped both technologically and physically to produce higher yields, management must be considered in explaining low yields.

Yields and yield projections vary greatly in Alaska and the amount of land needed to achieve 100 percent self-sufficiency in various agricultural products has been calculated using several yield assumptions. The higher the assumed yield, the less land is required to produce a particular quantity of a product. Tables 12, 13, and 14 show land required per capita to satisfy current demand for particular items, assuming various yields/acre. These figures indicate the amount of land required to produce the average person's annual intake of each commodity. All items are for human consumption, except horses which are produced primarily for recreational use.

When per capita land requirements are multiplied by population, the amount of land needed to meet demand for agricultural products can be calculated. Table 15 provides this information for the 1982 population and the State's projected population for the year 2000.

9/ The most important reason for mediocre barley yields in the United States, although the United States possesses all of the basic resources, is that economics dictate that higher value crops be grown on the best soils. As a result, much of the U.S. barley crop is grown on poorer soils, accounting for lower yields.

Table 10--Existing supply and demand of selected agricultural commodities in Alaska 1/

Commodity	Per capita 2/ demand	Total demand	1981 supply	Imports	
				Quantity	Percentage
	Pounds	1,000 pounds			Percent
Potatoes	74.8	31,580	9,500	22,080	69.9
Vegetables	158.3	66,832	3/ 2,320	64,512	96.5
Beef and veal	4/ 124.3	52,478	749	51,729	98.6
Lamb and mutton	4/ 2.0	844	18	826	97.9
Pork	4/ 56.1	23,685	293	23,392	98.8
Poultry	4/ 49.3	20,814	231	20,583	98.9
Milk	5/ 546.0	230,514	13,400	217,114	94.2
Eggs	6/ 35.4	14,945	874	14,071	94.2

1/ Assuming a 1981 population of 422,187.
Source: Alaska Population Overview - 1981, Alaska Department of Labor.

2/ U.S. Dept. Agr., Agricultural Statistics and Food Consumption, Prices, and Expenditures (national averages).

3/ Represents 1980 supply; 1981 figures not available.

4/ Dressed weight; for poultry, dressed and retail weight are assumed to be equal.

5/ Represents milk equivalent of per capita demand for all dairy products.

6/ One case = 30 doz. eggs = 47 lbs. (7.66 eggs = 1 lb.).

Table 11--Barley yields

Location	1978	1979	1980	Average
	Bushels per acre			
Alaska	37.5	49.5	29.5	38.8
United States	49.2	50.9	49.6	49.9
Africa	14.9	15.1	16.6	15.5
Asia	23.1	23.4	22.9	23.1
Australia	26.8	27.9	20.3	25.0
Canada	45.4	42.2	44.8	44.1
European Community	69.7	75.3	79.2	74.7
Finland	47.8	48.5	62.1	52.8
Norway	67.3	57.8	64.7	63.3
South America	23.8	23.8	22.5	23.4
Sweden	67.1	61.9	70.3	66.4
World average	39.4	33.8	37.6	36.9

Source: Derived from Agricultural Statistics, U.S. Dept. Agr., 1981.

Table 12--Barley and hay land required to meet per capita demand, Alaska

Item	Assumed yield/acre			
	40 bu. barley or 1.0 ton hay	50 bu. barley or 1.5 tons hay	60 bu. barley or 2.0 tons hay	70 bu. barley or 2.5 tons hay
	Acres			
Dairy	0.415	0.322	0.264	0.224
Eggs	.092	.074	.061	.053
Horses	.066	.048	.038	.032
Meat	2.154	1.681	1.385	1.178
Poultry	.126	.101	.084	.072
Total	2.853	2.226	1.832	1.559

Table 13--Vegetable land required to meet per capita demand, Alaska

Item	Assumed yield/acre			
	70 cwt	80 cwt	90 cwt	100 cwt
	Acres			
Vegetables produced	0.023	0.020	0.018	0.016

Table 14--Potato land required to meet per capita demand, Alaska

Item	Assumed yield/acre				
	9 tons (180 cwt)	10 tons (200 cwt)	11 tons (220 cwt)	12 tons (240 cwt)	13 tons (260 cwt)
	Acres				
Potatoes	0.0042	0.0038	0.0034	0.0031	0.0029

Table 15--Total land demand for agricultural purposes, Alaska

Crop	Assumed yield per acre	Total demand 1983	Total demand 2000 1/
		Acres	
Barley and Hay	40 bu barley and 1.0 ton hay	1,204,500	1,925,700
	50 bu barley and 1.5 tons hay	939,800	1,502,500
	60 bu barley and 2.0 tons hay	773,400	1,236,600
	70 bu barley and 2.5 tons hay	658,200	1,052,300
Vegetables	70 cwt	9,700	15,500
	80 cwt	8,400	13,500
	90 cwt	7,600	12,100
	100 cwt	6,800	10,800
Potatoes	9 tons	1,800	2,800
	10 tons	1,600	2,600
	11 tons	1,400	2,300
	12 tons	1,300	2,100
	13 tons	1,200	2,000
Total 2/		666,200	1,065,100
Total 3/		1,216,000	1,944,000

1/ Estimated population for 1983 is 422,187 and 2000 is 674,983.

2/ Assuming highest yields.

3/ Assuming lowest yields.

Source: Alaska economic projections for estimating electricity requirements for the railbelt, Batelle Pacific Northwest Labs., moderate projection.

Table 15 values indicate that 1982 demand for agricultural land ranged from 666,200 to 1,216,000 acres, while 2000 demand is projected to be somewhere between 1,065,100 and 1,944,000 acres. Midpoint agricultural acreage demands, based on 1982 and 2000 projected populations are 941,100 and 1,504,550 acres, respectively. All acreage represents harvested not planted acres. On the average, in 1978, 1979, and 1980 planted acres exceeded harvested acres by about 10 percent nationally. Demand estimates for total agricultural land have been adjusted to account for this discrepancy. This adjustment yields midpoint agricultural land demands, for 1982 and 2000 populations, of 1,035,200 and 1,655,000 acres, irrespective of location. Alaska's 1982 population required roughly 1 million acres to meet its demand for agricultural commodities, although those acres are now primarily located somewhere other than Alaska. Economic constraints are the primary reason for existing dependency on out-of-State resources. Full-scale substitution of in-State resources must await satisfactory economic feasibility, which is dependent on development of both adequate infrastructure and markets.

Timberland

Historically, timber harvesting in the Matanuska-Susitna-Beluga study area has been only light and intermittent. The first commercial use of area timber probably occurred at the turn of the century and coincided with mining activities. Heavy timber use continued into the twenties when the Alaska Railroad was constructed.

Between 1920 and the present, commercial timber use has been light, with wood being harvested primarily for personal use, namely houselogs and firewood. The Alaska DNR and Matanuska-Susitna borough have periodically held commercial timber sales and small personal use sales for houselogs and firewood. In the past 12 years, these sales have been concentrated along the first 10 miles of the Petersville Road, near Talkeetna; along the Glenn Highway; and along the Skwentna, Yentna, and other rivers in the Susitna Lowlands.

Table 16 identifies local mills. It is estimated that their current output is 2,334 Mbm annually, consisting primarily of rough-cut dimension lumber and houselogs.

Almost all lumber mill production is sold locally. Assuming 200 work days per year (typical for the logging industry), the annual output capacity of these mills is about 18,040 Mbm (200 x 90.2 Mbm daily capacity). The large discrepancy between capacity and production (capacity is nearly eight times actual production) reflects timber availability, mill management, and market acceptance of locally produced lumber.

Availability. Many sawmill operators believe that they could sell more lumber if State, borough, and private sources made more timber available; however, mills are often owned and operated by families with little or no hired labor.

Demand is expressed largely through personal contacts with potential customers looking for low-cost lumber to use in barns, outbuildings, or for general purposes. Some mills cut-to-order for the same market or for other special uses. Developing new markets and expanding sales (or making firm production commitments) are uncommon. Consumer demand, mill capacity, or timber availability are not currently limiting mill outputs; operator preference and family objectives are. The typical operators are a husband and wife who own and operate a sawmill because they like the work. They cut enough wood to

Table 16--Sawmill production and capacity,
Susitna Basin and vicinity, Alaska

Location and mill number	Annual production	Daily capacity	Products
	- - - Thousand bd. ft. - - -		
Palmer:			
1	100	4	Houselogs, dimension lumber
2	10	2	Houselogs, lumber
3	20	4	Houselogs, dimension lumber
4	200	2	Houselogs, dimension lumber, and 200 Mbm firewood
5	50	4	Houselogs, lumber dimension
6	20	4	Houselogs, lumber
7	NA	2	NA
8	10	2	Lumber
9	NA	2	NA
10	NA	2	NA
11	150	5	Lumber, houselogs
Willow:			
12	200	5	Dimension lumber
13	1/ 564	3.3	Houselogs, dimension lumber
14	NA	2	NA
15	NA	2	NA
16	150	4	Houselogs, dimension lumber
17	100	2	Dimension lumber, houselogs
Wasilla:			
18	NA	4	NA
19	50	5	Houselogs, dimension lumber
20	NA	NA	Birch flooring
Trapper Creek:			
21	200	5	Houselogs, dimension lumber
22	10	2	Dimension lumber
23	250	5	Houselogs, dimension lumber
24	20	2	Lumber, houselogs, shingles
Sutton, 25	30	2/ 4.9 4	Houselogs
Moose Creek, 26	NA	2	Lumber, timbers
Anchorage, 27	200	5	Houselogs, dimension lumber
Total	2,334	90.2	

NA = not available.

1/ Assume 1 lin. ft. = 1.88 board foot (fbm) in houselog production. Data collected from this mill was reported in linear feet only.

2/ 4.9 logs and 4 sawmill.

Source: U.S. Dept. Agr., Forest Serv., 1982 Sawmill Inventory.

meet their financial needs and spend their remaining time on other activities. They have no commitments to markets or customers other than those they choose to make.

Acceptance. Many contractors and retailers, and several mill operators have strong reservations about the widespread acceptability of domestically produced lumber. The Alaska Department of Commerce and Economic Development (1979) identified poorly manufactured (dried) products, irregular dimensions, lack of grading, irregular or undependable supplies, and a preference for Pacific Northwest hemlock and fir dimension lumber as reasons for weak consumer acceptance of domestically produced lumber.

Unfinished lumber, houselogs, fuelwood, furniture stock, flooring, and cabinets are made from study area timber. For about 9 years a facility at Tyonek produced woodchips for export; however, poor economic conditions (woodchip prices have decreased over 50 percent in the past 3 years) resulted in the shut down of that operation. The mill owner has no plans to reopen and the mill will be mothballed until it can be operated economically.

Table 17 summarizes nationwide consumption of selected timber products. Consumption per capita is shown in table 18. The per capita values presented in table 18 for total U.S. consumption must be adjusted to reflect conditions necessary for self-sufficiency of an Alaskan industry.

Achieving Alaskan self-sufficiency in timber production may have negative economic effects unless this goal is economically feasible. While most Alaskans favor self-sufficiency in concept, they favor self-sufficiency in actuality only if it results in lower consumer prices. Alaska prices tend to approximate Seattle, Washington, prices plus transportation to the point where local demand has been met. These geographic price differentials suggest that in-State producers have an advantage over out-of-State suppliers. This is true in terms of transportation cost savings only. Other in-State costs, for example, labor and equipment, often offset this transportation cost advantage. To assume a correlation between self-sufficiency and feasibility is extremely unwise without additional economic analysis.

Lumber and Plywood/Veneer Adjustment. Table 19 compares actual per capita consumption in Alaska's railbelt with average U.S. consumption in 1977. The FS (1982, pub.) estimated that national per capita consumption of lumber and plywood/veneer will be 230 fbm and 8.3 ft^3, respectively, in 2000.

Assuming that the relationship between national and railbelt consumption continues, it is estimated that annual per capita consumption in the planning area will be 267 (1.16 x 230) fbm of lumber and 7.3 (0.88 x 8.3) ft^3 plywood/veneer by 2000. The FS projects a sharp increase through 1990 (planning area consumption per capita would be 276 fbm of lumber and 7.6 ft^3 of plywood/veneer in 1990), followed by a decrease through 2000. Average annual per capita demand through 2000 will be approximately 266 fbm of lumber and 7.2 ft^3 of plywood/veneer. This value represents the planning area for the period of this analysis.

Pulp Products Adjustment. Per capita consumption of pulp products in the planning area was assumed to equal the existing national average, 21.18 ft^3 annually.

Table 17--U.S. consumption of selected timber products

Product	1977	1978	1979
	Million cubic feet		
Lumber	7,140	7,460	7,145
Plywood and veneer	1,600	1,645	1,545
Pulp products	4,320	4,625	4,925
Fuelwood	635	680	780
Other 2/	390	400	410

1/ Derived from Agricultural Statistics, U.S. Dept. Agr., 1981 (1979 figures are preliminary). All figures are based on roundwood equivalent.

2/ Includes cooperage logs, poles and piling, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and miscellaneous items.

Table 18--U.S. per capita 1/ consumption of selected timber products

Product	Per capita consumption			
	1977	1978	1979	3-year average
	Cubic feet			
Lumber	32.99	34.18	32.46	33.21
Plywood and veneer	7.39	7.54	7.02	7.32
Pulp products	19.96	21.19	22.38	21.18
Fuelwood	2.93	3.12	3.54	3.20
Other	1.80	1.83	1.86	1.83

1/ Based on U.S. populations of 1977 = 216,416,000, 1978 = 218,258,000, and 1979 = 220,099,000.

Table 19--Railbelt vs. national per capita consumption, 1977

Item	Per capita consumption		Railbelt percent of national consumption
	National	Railbelt 1/	
	Board feet		Percent
Lumber	214	248	116
	Cubic feet		
Plywood/veneer	7.4	6.5	88

1/ Source: The Domestic Market for Alaska Wood Products, Alaska Department of Commerce and Economic Development, Division of Economic Enterprise, June 1979.

Fuelwood Adjustment. Because fuelwood consumption is largely influenced by climate and alternative energy prices, no attempt was made to derive planning area demand from national averages. Instead, a substitute method, based primarily on 1980 U.S. census data, was used to calculate fuelwood demand. Demand was analyzed from the borough and Anchorage.

(1) Borough demand - According to census data, 1,436 households used wood as a primary source of heating fuel in the Matanuska-Susitna borough in 1980. In 1979, the Matanuska Electric Association (MEA) estimated that annual electricity consumption for space heating was 18,172 kilowatt hour (kWh) per customer.[10/] This represents the equivalent of 7.73[11/] cords of wood per household per year and falls within previously estimated ranges.[12/] This value estimates fuelwood consumption in 1,436 households using wood as a primary source of heat. In a home using additional sources of heat, wood consumption was assumed to be about 10 percent of that for a home using wood only, or about 0.77 cords. Per capita fuelwood consumption within the borough is calculated as follows:

Households where wood is the primary source of heat = 1,436,

1,436 x 7.73 cords = 11,098 cords,

Households where wood is not the primary source of heat = 4,248,

4,248 x 0.77 cords = 3,271 cords,

Total cords consumed = 11,098 + 3,271 = 14,369,

14,369 cords - 17,816[13/] = 0.81 cords per capita.

(2) Anchorage demand - Anchorage demand for fuelwood was calculated using identical per household values with one exception: it was assumed that households not using fuelwood as the primary source of heat consumed only 5 percent as much as those that did because fuelwood use is more incidental, alternative energy sources are less expensive, and winter temperatures are usually higher in Anchorage. Per capita consumption for Anchorage is calculated as follows:

Households where wood is the primary source of heat = 456, [14/]

456 x 7.73 cords = 3,525 cords,

10/ Railbelt Study, Institute of Social and Economic Research, University of Alaska, Appendix D, components of the end use model, p. D-24.

11/ One kWh = 3,413 British thermal units (Btus), 1 cord of wood (96 percent birch and 4 percent aspen) assuming 20 percent moisture content = 8,025,000 Btus assuming a 35-40 percent heating plant efficiency.

12/ Welbourn, p. 5.

13/ 1980 Matanuska-Susitna Borough population. Alaska Department of Labor, Alaska Population Overview, 1981, draft.

14/ U.S. Bureau of Census, 1980 data.

Households where wood is not the primary source of heat = 59,978,

59,978 x 0.39 cords = 23,391 cords,

Total cords consumed = 3,525 + 23,391 = 26,916,

26,916 cords - 174,431 [15/] = 0.15 cords per capita.

Other Wood Products Adjustment. We assumed that per capita consumption in the planning area was identical to the national average, 1.83 ft^3 annually.

Table 20 summarizes demand for wood products within the planning area.

Demand for wood products is not synonomous with demand for timber. The amount of timber needed per unit of production may differ greatly, depending on the product. Table 21 converts wood product demand to timber demand.

Once the actual per capita demand for timber products has been determined, the demand for timber producing land can be calculated based on average volume per acre of local stands.

This calculation is made using the following equations:[16/]

Equation No. 1

$$\text{Annual timberland demand} = \frac{\text{population x per capita lumber consumption}}{0.529 \text{ x volume per acre}}$$

Equation No. 2

$$\text{Annual timberland demand} = \frac{A(C+D)}{B}$$

where: A = population,

B = volume per acre,

C = per capita lumber consumption, and

D = per capita consumption of all products other than lumber.

Equation 1 is used only when per capita consumption of all wood products other than rough dimensional lumber (including houselogs) is less than

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15/ 1980 Anchorage population. Alaska Department of Labor, Alaska Population Overview, 1981, draft.

16/ Per capita consumption figures are for timber (see table 21).

Table 20--Annual wood products demand, Alaska 1/

Product	Matanuska-Susitna borough demand			Anchorage demand				
	Per capita	1983 total	2000 total	Per capita	1983 total	2000 total	1983 total	2000 total
Lumber (fbm)	266	6,308,722	20,064,646	266	47,724,060	66,793,132	54,031,782	86,857,778
Plywood/ Veneer (ft^3)	7.2	170,762	543,103	7.2	1,291,752	1,807,934	1,462,514	2,351,037
Pulp (ft^3)	21.2	502,800	1,599,137	21.2	3,803,492	5,323,362	4,306,292	6,922,499
Fuelwood (cords)	.81	19,211	61,099	.15	26,912	37,665	46,123	98,764
Other	1.8	42,691	135,776	1.8	322,937	451,984	365,629	587,760

1/ Based on populations as follows: Anchorage, 1983 = 179,410, 2000 = 251,102; Matanuska-Susitna Borough, 1983 = 23,457, 2000 = 75,071.

Table 21--Timber demand conversions, Alaska

Product	Annual per capita product demand	Timber required1/ per ft^3 product	Annual per capita timber demand
Lumber	266 fbm	4.716 fbm	56.404 ft^3
Plywood/veneer	7.2 ft^3	2.0 ft^3	14.4 ft^3
Pulp	21.2 ft^3	2.0 ft^3	42.4 ft^3
Fuelwood:2/			
Matanuska-Susitna	.81 cords	1.0 ft^3	68.85 ft^3
Anchorage	.15 cords	1.0 ft^3	12.75 ft^3
Other	1.8 ft^3	2.0 ft^3	3.6 ft^3

1/ Source: U.S. Forest Service, personal communication.

2/ One cord = 85 ft^3 of solid wood.

Table 22--Timberland demand, Alaska

Demand 1/	Assumed volume				
	1246	1500	1800	2100	2400
	Acres				
Annual Matanuska-Susitna (1983)	3,534	2,935	2,446	2,096	1,836
Annual Anchorage (1983)	18,654	15,496	12,913	11,068	9,685
Annual total (1983)	22,188	18,431	15,359	13,164	11,520
Annual Matanuska-Susitna (2000)	11,239	9,336	7,780	6,669	5,835
Annual Anchorage (2000)	26,109	21,688	18,073	15,491	13,555
Annual total (2000)	37,348	31,024	25,853	22,160	19,390
80-year total (1983)	1,775,040	1,474,480	1,228,720	1,053,120	921,600
80-year total (2000)	2,987,840	2,481,920	2,068,240	1,772,800	1,551,200

1/ Populations used were: Matanuska-Susitna (includes Tyonek), 1983 = 23,717; Matanuska-Susitna (includes Tyonek), 2000 = 75,431; Anchorage, 1983 = 179,410; Anchorage, 2000 = 251,102.

89.04 percent[17/] of per capita lumber consumption. Equation 2 is used only when per capita consumption of wood products other than rough dimensional lumber is greater than 89.04 percent[17/] of per capita lumber consumption.

Because per capita consumption of wood products other than lumber is over 89.04 percent of the per capita lumber consumption, equation 2 was used. Assumptions underlying this equation are:

1. On an average timbered acre, 52.9 percent can be used for production of rough, dimensional lumber.

2. On an average timbered acre, 47.1 percent can be used for the production of all wood products other than rough, dimensional lumber, up to the point where the lumber demand has been satisfied. At that point, 100 percent of all additional timber can be used for the production of other products.

The demand equation is generally accurate for estimating total timberland necessary to achieve self-sufficiency and given existing productivity. The rotation acreage demand is more important to land planners than the annual demand. The former is the minimum number of acres required for a consistent, sustained yield of wood, the annual figure indicates only the number of acres that will be harvested annually.

Table 22 shows demand for timberland, both annually and for an 80-year period, the commonly used rotation for Matanuska-Susitna area timber. To calculate demand for any other period, multiply the period, in years, by the annual values in table 22. For example, total land demand for a 50-year period would be 1,109,400 acres (22,188 x 50).

Yield, or productivity, of forest lands varies greatly thoughout Alaska. An average yield of 1,246 net ft^3 per acre was considered representative of commercial timberland in the area. Foresters and others in the timber industry maintain that productivity can increase significantly with active timber management. To illustrate the effect of increased productivity on land demand, table 22 shows demand levels under several increases in average volume per acre.

Given that the bulk of current production consists of fuelwood, rough lumber, and houselogs, the total demand values in tables 21 and 22 were modified to reflect probable timber production in the Matanuska-Susitna Basin.

1. Lumber demand

Current lumber demand (dimensional lumber including houselogs) was estimated at 56.404 ft^3 per capita for both Anchorage and the Matanuska-Susitna borough. Most of this demand is for dried, finished

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17/ This percentage is derived using the following ratio:

$$\frac{1 - (\text{portion of a typical acre that can be used for lumber})}{(\text{portion of a typical acre that can be used for lumber})}$$

The ratio is calculated as: $\frac{1-0.529}{.529}$ or $\frac{0.8904}{1}$

lumber, which is currently imported. One source[18/] showed that local products can compete with imports, given development of an infrastructure, for example, kilns, planers, and a transportation network. Therefore, we assumed that local demand could be met with local resources; that is, the 56.404 ft^3 per capita figure was used as the demand ceiling. This total demand value was disaggregated into demand for lumber and demand for houselogs.

Twenty percent of borough demand is assumed to be for houselogs and 80 percent for dimensional lumber, while the Anchorage demand is entirely for lumber (houselog demand in Anchorage is statistically insignificant).

2. Plywood/veneer, pulp, and other products demand

Production of these products generally requires large scale operations that were not included in this analysis.

3. Fuelwood demand

The per capita fuelwood demand values shown in table 6 were not revised because this demand is being met by local resources.

The demand for land (demand ceilings) calculations are shown in tables 23 and 24.

Table 23 indicates theoretical demand ceilings. There is an implicit assumption that loggers would continue to harvest[19/] as long as demand exists.

Resource Development

Economical development of a resource often depends on the feasibility of public investment in that resource. The question is: "Will the increase in net benefits to society justify the investment?" Over time, an initial up-front social investment must generate positive net benefits greater than the original investment. Figure 4 shows net benefits over time. Net benefits are negative at first because of initial investment outlay, but they reach a breakeven point sometime in the future. Feasibility requires that area B be larger than area A.

Discounting is used to make dollars from different time periods comparable, usually with present day values. It is generally acknowledged that future values are not as desirable as present values because of the lag between time of investment and time at which the realized value can be used. The inconvenience is known as time preference and is reflected by the interest or discount rate. To find the present-value equivalent of a value from some future year, say 20 years hence, divide the future value, by the sum, raised to the 20th power, of the discount rate plus one.[20/]

18/ Reid and Collins, p. 37.

19/ Includes houselogs.

20/ That is, divide the future value by $(1 + i)^{20}$. If "i" is 10 percent then the divisor becomes $(1 + 0.1)^{20}$ or 6.7275.

Table 23--Susitna River Basin timber demand constraints, Alaska 1/

Demand	Lumber			Houselogs			Fuelwood			Total wood products	
	Per capita (ft^3)	Annual acres	80-year acres	Per capita (ft^3)	Annual acres	80-year acres	Per capita (ft^3)	Annual acres	80-year acres	Annual acres	80-year acres
1983:											
Matanuska-Susitna	45.123	1,624	129,920	11.281	406	32,480	68.85	2/ 354	2/ 28,320	2,384	190,720
Anchorage	56.404	15,353	1,228,240	0	0	0	12.75	3/ 0	3/ 0	15,353	1,228,240
2000:											
Matanuska-Susitna	45.123	5,165	413,200	11.281	1,291	103,280	68.85	2/ 1,127	2/ 90,160	7,583	606,640
Anchorage	56.404	21,488	1,719,040	0	0	0	12.75	3/ 0	3/ 0	21,488	1,719,040

1/ Based on existing volume of 1,246 net ft^3 per acre. The 80-year acres reflect the common replacement or rotation period. Populations are the same as those used for table 7.

2/ A portion of the fuelwood demand is met by the same acres that provide lumber and houselogs. The figures represent acres cut solely for fuelwood.

3/ All of the fuelwood demand is met by the same acres that provide lumber. See Equation 1, page 33.

Table 24--Timberland needs, Alaska

Demand	Product demand 1/						Volume	Production limit	
	Lumber		Houselogs		Fuelwood				
	Annual	80-year	Annual	80-year	Annual	80-year		Annual	80-year
	Acres						Ratio	Acres	
1983:									
Matanuska-Susitna	1,624	129,920	406	32,480	2,782	222,560	1.22:1.0	2,030	162,400
Anchorage	15,353	1,228,240	0	0	3,898	311,840	0.23:1.0	3,898	311,840
Matanuska-Susitna and Anchorage	16,977	1,358,160	406	32,480	6,680	534,400	0.34:1.0 2/	6,680	534,400
2000:									
Matanuska-Susitna	5,165	413,200	1,291	103,280	8,849	707,020	1.22:1.0	6,456	516,480
Anchorage	21,488	1,719,040	0	0	5,455	436,400	0.23:1.0	5,455	436,400
Matanuska-Susitna and Anchorage	26,653	2,132,240	1,291	103,280	14,304	1,144,320	0.45:1.0 2/	14,304	1,144,320

1/ The acreage demand figures are mutually exclusive, that is, there is no assumption that acres can be used for more than one product. This problem is mitigated in the production limit columns when totals are corrected so that acres cleared solely for one purpose are eliminated from totals.

2/ Weighted average.

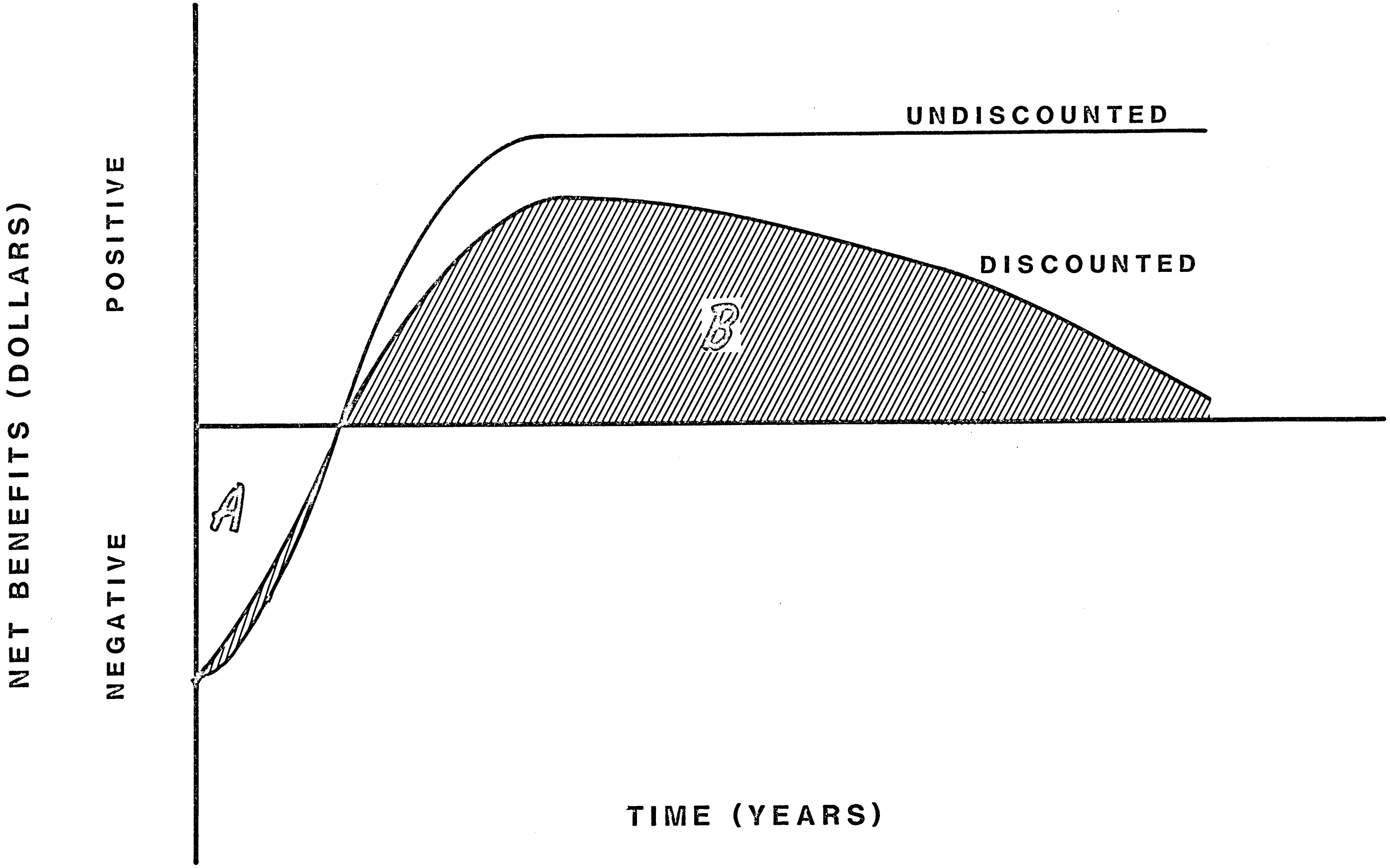

FIGURE 4. SCHEMATIC OF UNDISCOUNTED AND DISCOUNTED NET BENEFITS OVER TIME.

Initial social investments required to produce future positive net benefits consist of investments in roads, bridges, and culverts, plus the present value of future road operating and maintenance costs. Under any set of assumptions and economic parameters, it is difficult to determine which LPUs, if any, should be accessed to achieve the largest possible present value of net benefits. Economic feasibility in any LPU depends on the quantity and quality of its resources, its neighbors' resources, and the expense of gaining access to the resources. It is easily seen that with 50 LPUs, 71 interconnecting road segments, 2 soil classes, and 3 commodities, thousands of alternative situations must be analyzed to find the economic optimum.

The optimum solution, which maximizes net benefits, can readily be found using linear programming. If any parameter or assumption changes, a new optimum can readily be determined. In this analysis, 25 alternatives were considered, thus 25 optima were obtained. The variable parameters included length of period analyzed, discount rate, cost of roads, share of road costs to be borne by timber or agricultural development, clearing cost, commodity production cost, crop yields, timber volume, logging productivity, commodity prices, and commodity demand ceilings. The values of the parameters used in each of the alternatives are shown in table 25.

Altering one or several parameters can significantly affect the results. These effects are compared in table 26. Comparison provides insight into the importance of one or more variables to resource development. As an example, the only parameter change between alternatives 5 and 6 is the discount rate, from 7 5/8 percent to 10 percent. Yet, this is sufficient to make timber a more attractive investment than barley production on class II timbered land. In alternative 6, barley production is down while the production of timber commodities is up.

Another interesting comparison is between alternatives 14 and 21. Total benefits increase 6 times in the latter alternative but net benefits increase only 13 percent. This is because of the large acreage devoted to barley production, noneconomic in the former, in alternative 21. The discounted gross return per acre times the number of acres in production largely accounts for the increase in total benefits. When total costs are netted out, net benefits are only slightly affected. Another interesting comparison between these alternatives is the effect of road costs. Costs are zero in alternative 14 but equal 10 percent of total construction, overhead, and operating and maintenance costs in alternative 21. The effect of this change in road cost assumptions is to make nine LPUs noneconomic for either agricultural or timber production. In all alternatives where 100 percent of road costs are charged, production is feasible in only three LPUs, and two of these are on existing roads.

Table 25--Alternative parameters for resource development, Talkeetna Subbasin, Alaska

Parameters	Unit	Alternatives 1	2	3	4
Analysis period	Years	50	50	20-70	20-70
Discount rate	Percent	7.63	10	7.63	10
Road costs:					
Overhead	do.	35	35	35	35
Operating and maintenance	do.	1	1	1	1
Timber/agriculture cost share	do.	100	100	100	100
Clearing cost	Dollars/acre	300.00	300.00	300.00	300.00
Production cost:					
Barley, class II	do.	146.69	146.69	146.69	146.69
Barley, class III	do.	146.69	146.69	146.69	146.69
Logging	Dollars/hour	97.24	97.24	97.24	97.24
Overhead:					
Barley	Percent	20	20	20	20
Logging	do.	20	20	20	20
Barley yield:					
Class II	Bushels/acre	50	52.5	52.5	52.5
Class III	do.	50	47.5	47.5	47.5
Timber volume	Cubic feet/acre	1,246	1,246	1,246	1,246
Logging productivity	Cubic feet/hour	283.9	283.9	283.9	283.9
Prices:					
Barley	Dollars/bushel	3.12	3.12	3.12	3.12
Spruce sawlogs	Dollars/Mbm	160.00	160.00	160.00	160.00
Cottonwood sawlogs	do.	125.00	125.00	125.00	125.00
Fuelwood	Dollars/cord	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	Mbm/year	6,600	6,600	23,400	23,400
Fuelwood	Cords/year	11,000	11,000	37,500	37,500
Barley	Million bushels/year	57.5	57.5	57.5	57.5

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Table 25--Alternative parameters for resource development, Talkeetna Subbasin, Alaska, continued

Parameters	Unit	Alternatives 5	6	7	8
Analysis period	Years	20-70	20-70	50	50
Discount rate	Percent	7.63	10	7.63	7.63
Road costs:					
Overhead	do.	35	35	35	35
Operating and maintenance	do.	1	1	1	1
Timber/agriculture cost share	do.	100	100	100	10
Clearing cost	Dollars/acre	300.00	300.00	300.00	300.00
Production cost:					
Barley, class II	do.	146.69	146.69	146.69	146.69
Barley, class III	do.	146.69	146.69	146.69	146.69
Logging	Dollars/hour	97.24	97.24	97.24	97.24
Overhead:					
Barley	Percent	20	20	20	20
Logging	do.	20	20	20	20
Barley yield:					
Class II	Bushels/acre	52.5	52.5	52.5	52.5
Class III	do.	47.5	47.5	47.5	47.5
Timber volume	Cubic feet/acre	1,246	1,246	1,246	1,246
Logging productivity	Cubic feet/hour	283.9	283.9	283.9	283.9
Prices:					
Barley	Dollars/bushel	3.96	3.96	3.96	3.96
Spruce sawlogs	Dollars/Mbm	160.00	160.00	160.00	160.00
Cottonwood sawlogs	do.	125.00	125.00	125.00	125.00
Fuelwood	Dollars/cord	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	Mbm/year	23,400	23,400	6,600	6,600
Fuelwood	Cords/year	37,500	37,500	11,000	11,000
Barley	Million bushels/year	57.5	57.5	57.5	57.5

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Table 25--Alternative parameters for resource development, Talkeetna Subbasin, Alaska, continued

Parameters	Unit	Alternatives 9	10	11	12
Analysis period	Years	50	50	50	50
Discount rate	Percent	7.63	7.63	10	10
Road costs:					
Overhead	do.	35	35	35	35
Operating and maintenance	do.	1	1	1	1
Timber/agriculture cost share	do.	20	33 1/3	0	10
Clearing cost	Dollars/acre	300.00	300.00	250.00	300.00
Production cost:					
Barley, class II	do.	146.69	146.69	175.30	175.30
Barley, class III	do.	146.69	146.69	175.30	175.30
Logging	Dollars/hour	97.24	97.24	144.52	144.52
Overhead:					
Barley	Percent	20	20	17	17
Logging	do.	20	20	20	20
Barley yield:					
Class II	Bushels/acre	52.5	52.5	52.5	52.5
Class III	do.	47.5	47.5	47.5	47.5
Timber volume	Cubic feet/acre	1,246	1,246	1,246	1,246
Logging productivity	Cubic feet/hour	283.9	283.9	517.0	517.0
Prices:					
Barley	Dollars/bushel	3.96	3.96	3.99	3.99
Spruce sawlogs	Dollars/Mbm	160.00	160.00	178.00	178.00
Cottonwood sawlogs	do.	125.00	125.00	125.00	125.00
Fuelwood	Dollars/cord	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	Mbm/year	6,600	6,600	86,858	86,858
Fuelwood	Cords/year	11,000	11,000	98,764	98,764
Barley	Million bushels/ year	57.5	57.5	82.75	82.75

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Table 25--Alternative parameters for resource development, Talkeetna Subbasin, Alaska, continued

Parameters	Unit	Alternatives 13	14	15	16
Analysis period	Years	50	50	50	50
Discount rate	Percent	10	10	10	10
Road costs:					
Overhead	do.	35	0	35	35
Operating and maintenance	do.	1	0	1	1
Timber/agriculture cost share	do.	50	0	10	50
Clearing cost	Dollars/acre	325.00	250.00	300.00	325.00
Production cost:					
Barley, class II	do.	175.30	177.52	177.52	177.52
Barley, class III	do.	173.04	173.04	175.30	175.30
Logging	Dollars/hour	144.52	144.52	144.52	144.52
Overhead:					
Barley	Percent	17	17	17	17
Logging	do.	20	20	20	20
Barley yield:					
Class II	Bushels/acre	52.5	52.5	57.5	57.5
Class III	do.	47.5	47.5	52.5	52.5
Timber volume	Cubic feet/acre	1,246	1,246	1,246	1,246
Logging productivity	Cubic feet/hour	517.0	517.0	517.0	517.0
Prices:					
Barley	Dollars/bushel	3.99	3.99	3.99	3.99
Spruce sawlogs	Dollars/Mbm	178.00	178.00	178.00	178.00
Cottonwood sawlogs	do.	125.00	125.00	125.00	125.00
Fuelwood	Dollars/cord	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	Mbm/year	86,858	86,858	86,858	86,858
Fuelwood	Cords/year	98,764	98,764	98,764	98,764
Barley	Million bushels/year	82.75	82.75	82.75	82.75

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Table 25--Alternative parameters for resource development, Talkeetna Subbasin, Alaska, continued

Parameters	Unit	Alternatives 17	18	19	20
Analysis period	Years	50	50	50	50
Discount rate	Percent	10	10	7.88	7.88
Road costs:					
Overhead	do.	0	0	0	0
Operating and maintenance	do.	0	0	0	0
Timber/agriculture cost share	do.	0	0	10	10
Clearing cost	Dollars/acre	300.00	300.00	225.00	225.00
Production cost:					
Barley, class II	do.	175.30	177.52	172.24	169.83
Barley, class III	do.	173.04	175.30	172.24	169.83
Logging	Dollars/hour	144.52	144.52	144.00	144.00
Overhead:					
Barley	Percent	17	17	17	17
Logging	do.	20	20	20	20
Barley yield:					
Class II	Bushels/acre	52.5	57.5	55.0	55.0
Class III	do.	47.5	52.5	52.5	52.5
Timber volume	Cubic feet/acre	1,246	1,246	1,246	1,246
Logging productivity	Cubic feet/hour	517.0	517.0	413.6	465.0
Prices:					
Barley	Dollars/bushel	0	3.99	3.99	4.20
Spruce sawlogs	Dollars/Mbm	178.00	0	178.00	178.00
Cottonwood sawlogs	do.	125.00	0	125.00	125.00
Fuelwood	Dollars/cord	75.00	0	75.00	75.00
Demand ceilings:					
Sawlogs	Mbm/year	86,858	86,858	86,858	86,858
Fuelwood	Cords/year	98,764	98,764	98,764	98,764
Barley	Million bushels/ year	82.75	82.75	82.75	82.75

--continued

Table 25--Alternative parameters for resource development, Talkeetna Subbasin, Alaska, continued

Parameters	Unit	Alternatives 21	22	23	24
Analysis period	Years	50	50	50	50
Discount rate	Percent	7.88	7.88	7.88	7.88
Road costs:					
Overhead	do.	0	0	0	0
Operating and maintenance	do.	0	0	0	0
Timber/agriculture cost share	do.	10	10	10	10
Clearing cost	Dollars/acre	250.00	250.00	250.00	250.00
Production cost:					
Barley, class II	do.	172.24	169.83	157.25	169.83
Barley, class III	do.	172.24	169.83	157.25	169.83
Logging	Dollars/hour	144.00	144.00	144.00	172.00
Overhead:					
Barley	Percent	17	17	17	17
Logging	do.	20	20	20	20
Barley yield:					
Class II	Bushels/acre	55.0	55.0	55.0	55.0
Class III	do.	52.5	52.5	52.5	52.5
Timber volume	Cubic feet/acre	1,246	1,246	1,246	1,246
Logging productivity	Cubic feet/hour	568.7	517.0	517.0	517.0
Prices:					
Barley	Dollars/bushel	4.20	3.99	3.99	4.20
Spruce sawlogs	Dollars/Mbm	178.00	178.00	178.00	178.00
Cottonwood sawlogs	do.	125.00	125.00	125.00	125.00
Fuelwood	Dollars/cord	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	Mbm/year	86,858	86,858	86,858	86,858
Fuelwood	Cords/year	98,764	98,764	98,764	98,764
Barley	Million bushels/ year	82.75	82.75	82.75	82.75

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Table 25--Alternative parameters for resource development, Talkeetna Subbasin, Alaska, continued

Parameters	Unit	Alternatives: 25
Analysis period	Years	50
Discount rate	Percent	7.88
Road costs:		
Overhead	do.	0
Operating and maintenance	do.	0
Timber/agriculture cost share	do.	10
Clearing cost	Dollars/acre	225.00
Production cost:		
Barley, class II	do.	169.83
Barley, class III	do.	169.83
Logging	Dollars/hour	200.00
Overhead:		
Barley	Percent	17
Logging	do.	20
Barley yield:		
Class II	Bushels/acre	55.0
Class III	do.	52.5
Timber volume	Cubic feet/acre	1,246
Logging productivity	Cubic feet/hour	517.0
Prices:		
Barley	Dollars/bushel	3.99
Spruce sawlogs	Dollars/Mbm	178.00
Cottonwood sawlogs	do.	125.00
Fuelwood	Dollars/cord	75.00
Demand ceilings:		
Sawlogs	Mbm/year	86,858
Fuelwood	Cords/year	98,764
Barley	Million bushels/ year	82.75

Table 26--Alternative results for resource development, Talkeetna Subbasin, Alaska

Results	Unit	Alternatives 1	2	3	4
Total benefits	Thousand dollars 1/	6,424	4,983	1,478	741
Net benefits	do.	2,218	1,605	510	239
Benefit/cost	Ratio	1.53	1.48	1.53	1.48
Roads built:					
Length	Miles	2.81	2.81	2.81	2.81
Cost	Thousand dollars 2/	564	553	130	82
LPUs accessed	Map no. 3/	8,17,18	8,17,18	8,17,18	8,17,18
Acres in production: 4/					
Agriculture	Acres/year	0	0	0	0
Timber	do.	556	556	556	556
Commodities produced:					
Barley	Thousand bushels	0	0	0	0
Spruce sawlogs	Mbm	782	782	782	782
Cottonwood sawlogs	do.	714	714	714	714
Fuelwood	Cords	3,842	3,842	3,842	3,842
Annual employment:					
Agriculture	Person/years	0	0	0	0
Timber	do.	6.1	6.1	6.1	6.1

--continued

See footnotes at end of table.

Table 26--Alternative results for resource development Talkeetna Subbasin, Alaska, continued

Results	Unit	Alternatives 5	6	7	8
Total benefits	Thousand dollars 1/	11,847	1,383	51,520	433,011
Net benefits	do.	684	244	2,984	15,173
Benefit/cost	Ratio	1.06	1.21	1.06	1.04
Roads built:					
Length	Miles	2.81	2.81	2.81	132.61
Cost	Thousand dollars 2/	130	82	564	10,004
LPUs accessed	Map no.	8,17,18	8,17,18	8,17,18	1,2,4,5, 6,8,13, 14,15,17, 18,19,20, 21,37
Acres in production:					
Agriculture	Acres/year	17,984	2,096	17,984	156,016
Timber	do.	323	556	323	1,593
Commodities produced:					
Barley	Thousand bushels	944	110	944	8,191
Spruce sawlogs	Mbm	454	782	454	2,239
Cottonwood sawlogs	do.	414	714	414	2,044
Fuelwood	Cords	2,229	3,842	2,229	11,000
Annual employment:					
Agriculture	Person/years	15.6	1.8	15.6	135.4
Timber	do.	3.5	6.1	3.5	17.4

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See footnotes at end of table.

Table 26--Alternative results for resource development Talkeetna Subbasin, Alaska, continued

Results	Unit	Alternatives 9	10	11	12
Total benefits	Thousand dollars 1/	207,629	195,728	86,847	78,878
Net benefits	do.	9,963	6,251	47,753	26,581
Benefit/cost	Ratio	1.05	1.03	2.22	1.51
Roads built:					
Length	Miles	37.48	29.78	423.45	225.04
Cost	Thousand dollars 2/	5,659	8,666	0	16,791
LPUs accessed	Map no.	5,8,13, 14,15,17, 18,19,20	5,8,15, 17,18, 19,20	All except LP Unit # 40	1,2,3,4, 5,6,8,13, 14,15,17, 18,19,20, 21,27,31, 32,36,37, 43,44,46, 47,49
Acres in production:					
Agriculture	Acres/year	71,208	66,944	0	0
Timber	do.	1,593	1,543	9,434	8,568
Commodities produced:					
Barley	Thousand bushels	3,738	3,515	0	0
Spruce sawlogs	Mbm	2,239	2,170	13,259	12,043
Cottonwood sawlogs	do.	2,044	1,761	12,107	10,996
Fuelwood	Cords	11,000	10,659	65,144	6,700
Annual employment:					
Agriculture	Person/years	61.8	58.1	0	0
Timber	do.	17.4	16.9	79.6	72.3

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See footnotes at end of table.

Table 26--Alternative results for resource development Talkeetna Subbasin, Alaska, continued

Results	Unit	Alternatives 13	14	15	16
Total benefits	Thousand dollars 1/	8,932	86,847	78,878	8,932
Net benefits	do.	2,893	47,753	26,581	2,893
Benefit/cost	Ratio	1.48	2.22	1.51	1.48
Roads built:					
Length	Miles	6.63	423.45	225.04	6.63
Cost	Thousand dollars 2/	3,175	0	16,791	3,175
LPUs accessed	Map no.	5,8, 17,18	All except LP Unit # 40	1,2,3,4, 5,6,8,13, 14,15,17, 18,19,20, 21,27,31, 32,36,37, 43,44,46, 47,49	5,8, 17,18
Acres in production:					
Agriculture	Acres/year	0	0	0	0
Timber	do.	970	9,434	8,568	970
Commodities produced:					
Barley	Thousand bushels	0	0	0	0
Spruce sawlogs	Mbm	1,364	13,259	12,043	1,364
Cottonwood sawlogs	do.	1,245	12,107	10,996	1,245
Fuelwood	Cords	6,700	65,144	59,166	6,700
Annual employment:					
Agriculture	Person/years	0	0	0	0
Timber	do.	8.2	79.6	72.3	8.2

--continued

See footnotes at end of table.

Table 26--Alternative results for resource development
Talkeetna Subbasin, Alaska, continued

Results	Unit	Alternatives			
		17	18	19	20
Total benefits	Thousand dollars 1/	86,847	525,616	98,998	849,079
Net benefits	do.	47,753	24,150	31,796	52,660
Benefit/cost	Ratio	2.22	1.05	1.47	1.07
Roads built:					
Length	Miles	423.45	413.66	226.83	319.50
Cost	Thousand dollars 2/	0	0	11,697	16,905
LPUs accessed	Map no.	All except LP Unit # 40	All except LP Unit # 11, 28,39	1,2,3,4, 5,6,8,13, 14,15,16, 17,18,19, 20,21,27, 31,32,36, 37,43,44, 46,47,49	All except LP Unit # 11,12,22, 23,25,33, 39,40,42, 45
Acres in production:					
Agriculture	Acres/year	0	219,528	0	271,576
Timber	do.	9,434	0	8,591	6,812
Commodities produced:					
Barley	Thousand bushels	0	12,623	0	14,782
Spruce sawlogs	Mbm	13,259	0	12,074	9,575
Cottonwood sawlogs	do.	12,107	0	11,025	8,743
Fuelwood	Cords	65,144	0	59,320	47,041
Annual employment:					
Agriculture	Person/years	0	190.6	0	235.7
Timber	do.	79.6	0	90.6	63.9

--continued

See footnotes at end of table.

Table 26--Alternative results for resource development Talkeetna Subbasin, Alaska, continued

Results	Unit	Alternatives 21	22	23	24
Total benefits	Thousand dollars 1/	679,506	180,178	815,783	849,079
Net benefits	do.	53,898	43,333	70,394	52,466
Benefit/cost	Ratio	1.09	1.32	1.09	1.07
Roads built:					
Length	Miles	319.50	249.20	323.21	319.50
Cost	Thousand dollars 2/	16,905	12,519	17,130	16,905
LPUs accessed	Map no.	All except LP Unit # 11,12,22, 23,25,33, 39,40,42, 45	All except LP Unit # 9,11,12, 22,23,24, 25,28,29, 30,33,34, 39,40,42, 45	All except LP Unit # 11,12,22, 23,25,33, 39,40,45	All except LP Unit # 11,12,22, 23,25,33, 39,40,42, 45
Acres in production:					
Agriculture	Acres/year	209,616	28,744	273,512	271,576
Timber	do.	6,812	8,841	6,833	6,812
Commodities produced:					
Barley	Thousand bushels	11,529	1,581	14,884	14,782
Spruce sawlogs	Mbm	9,575	12,427	9,603	9,575
Cottonwood sawlogs	do.	8,743	11,347	8,769	8,743
Fuelwood	Cords	47,041	61,054	47,182	47,041
Annual employment:					
Agriculture	Person/years	181.9	24.9	237.4	235.7
Timber	do.	52.2	74.6	57.6	57.5

--continued

See footnotes at end of table.

Table 26--Alternative results for resource development Talkeetna Subbasin, Alaska, continued

Results	Unit	Alternatives 25
Total benefits	Thousand dollars 1/	158,113
Net benefits	do.	26,350
Benefit/cost	Ratio	1.20
Roads built:		
Length	Miles	224.39
Cost	Thousand dollars 2/	11,586
LPUs accessed	Map no.	All except LP Unit #1,2,3,4,5, 6,8,13,14,15,17, 18,19,20,21,27, 31,32,36,37,43, 44,46,47,49
Acres in production:		
Agriculture	Acres/year	21,800
Timber	do.	8,568
Commodities produced:		
Barley	Thousand bushels	1,199
Spruce sawlogs	Mbm	12,042
Cottonwood sawlogs	do.	10,996
Fuelwood	Cords	59,166
Annual employment:		
Agriculture	Person/years	18.9
Timber	do.	72.3

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of operating and maintenance costs.

3/ From figure 2.

4/ These figures are on an annual basis. Because agricultural enterprises use the same acres year after year, the acreage figures for agriculture are total acres feasible for the evaluation period. Timber acreage, however, must be adjusted because different acres are used annually. To determine total feasible timber acres, multiply annual acres in production times length of the evaluation period in years. For example, the total timber acres feasible for alternative number 1 are 556 acres times the 50-year evaluation period or 27,800 acres.

Economic Effects

The feasibility of publicly funded economic activity can sometimes be enhanced through secondary or indirect benefits that accompany the primary economic effects. As an example, public investment may cause a particular firm or an industry to expand production of some commodity. Expanded output will increase the demand for inputs, thus increasing demand for the outputs of suppliers serving these firms. The suppliers in turn purchase more of their own inputs because of the expanded demand for their outputs and so on, creating a ripple effect throughout the regional economy. As a result, total overall investment benefits can be greater than those experienced by the primarily affected industries.

Overall, regional effects can be estimated by using multipliers. Income and employment multipliers were estimated by interindustry or input-output analysis. Interindustry analysis involves accounting for all transactions, purchases, and sales occurring among the industries in an economy during a particular time period. Mathematical techniques (Jones; McKusick and others; Miernyk) can be used to derive economy-wide multipliers caused by single-industry expansions. Interindustry transactions used to derive multipliers were estimated by Butcher and others.

The Talkeetna Subbasin economy is immature, that is, population, employment, and economic activity are at low levels, and most firms purchase and sell commodities outside the subbasin. In such a case, expansion of a local industry produces few ripple effects within the subbasin, instead, indirect (multiplier) effects are felt in areas where secondary industries are located. We examined the indirect effects in Alaska's economy, which is more mature than that of the subbasin.

The Butcher study estimated Alaskan interindustry transactions for 1976, and Alaska's economic conditions differed substantially in 1982, the base year of this study. However, interindustry effects were substantially similar in both years for timber and agricultural products. Table 27 shows employment and income multipliers for these industries. The income multiplier indicates total change in personal income throughout the economy resulting from income change in a particular sector. Employment multipliers define total change in employment throughout the economy resulting from a 1-unit change in employment for a particular sector (Jones). Expansion of employment or increase in personal income may or may not mean that local individuals are better off economically. Expanded economic activity may attract individuals from outside an economic area, leaving original residents no better off than they were previously.

CONCLUSIONS AND IMPLICATIONS

Feasibility of agricultural and timber investments in the Talkeetna Subbasin was examined using 25 sets of alternative parameters. As expected, the more optimistic the parameters, the more viable the results. Some timber activity could be viable if it did not have to share the burden of road construction costs or cover the value of standing timber. Producing barley for export is not feasible at today's prices.

This type of economic study is not predictive, that is, it does not analyze what the future will be but what the future can be. Planners can use this

Table 27--Alaska income and employment multipliers, 1976

Product	Income	Employment
Agriculture	1.873	1.056
Timberland	2.042	1.132

Source: Butcher, *et al*.

study to test their perceptions of what the future should be. When social and economic goals and needs have been identified, analyses of this type can assist planners in determining the best paths toward goal achievement and need resolution. For instance, the enterprise structures used in this study, 1,000-acre farms and five-person logging crews, may not be the best way for Alaska's social and economic goals to be attained.

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APPENDIX A

Glossary of Timber Inventory Terms[1/]

Allowable cut:--The volume of timber that could be cut on commercial forest land during a given period under specified management plans for sustained production, such as those in effect on National Forests.

Acceptable trees:--Trees meeting the specifications for growing stock but not qualifying as desirable.

Area condition class:--Area condition class provides a general stratification of commercial forest land by management opportunity class, as indicated by the stocking or area controlled by tree and cover class.

Commercial forest land:--(CFL) Forest land producing or capable of producing crops of industrial wood and not withdrawn from timber utilization. Areas qualifying as commercial forest land have the capability of producing in excess of 20 cubic feet per acre per year (20 MAI) of industrial wood under management.

Commercial species:--Trees presently or prospectively suitable for industrial products.

Cull:--Portions of a tree unusable for industrial products because of rot, form, or other defect.

Cull trees:--Live trees of sawtimber or poletimber size unmerchantable for saw logs now or prospectively because of defect, rot, or species.

Desirable trees:--Growing stock trees with no serious defects in quality limiting present or prospective use, relatively high vigor, and hosting no pathogens that could result in death or serious deterioration before rotation age. They include the type of trees forest managers aim to grow; that is, the trees left in silvicultural cutting or favored in cultural operations.

Forest land:--Land at least 16.7 percent stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for nonforest use.

Forest types:--A classification of forest land based on the species forming a plurality of the live tree stocking.

black spruce:--Forests in which a plurality of the stand is black spruce. Black spruce most often occurs in nearly pure stands but can be found mixed with tamarack, white spruce, paper birch, and aspen. Black spruce is fairly characteristic of poorer forest land.

white spruce:--Forests in which a plurality of the stand is white spruce. Common associates include paper birch and balsam poplar, and occasionally black spruce or quaking aspen.

1/ Source: U.S. Dept. Agr., Forest Service, Forest Service Handbook, Title 4813.1, 1967, except for local forest types.

tamarack:--Forests in which a plurality of the stand is tamarack. Tamarack rarely occurs as a pure type and is more often found as an associated species in the black spruce type.

balsam poplar:--Forests in which a plurality of the stand is balsam poplar. South of the Alaska Range balsam poplar may be replaced by black cottonwood or hybrids between the two. As the poplar ages it is usually replaced by white spruce, however, it is usually found as a nearly pure type with only an occassional white spruce or paper birch associate.

black cottonwood:--Forests in which a plurality of the stand is black cottonwood. Black cottonwood is found south of the Alaska Range in pure stands along the major rivers. It hybridizes extensively with balsam poplar where their ranges overlap, and in this overlap area types are not distinguished by species but are usually reported as cottonwood/poplar. Black cottonwood stands are replaced by white spruce as they age and the pure stands contain only an occassional white spruce or paper birch.

paper birch:--Forests in which a plurality of the stand is paper birch. Paper birch can occur in pure stands but is more often mixed with white spruce, quaking aspen, or black spruce.

quaking aspen:--Forests in which a plurality of the stand is aspen. Aspen is usually found as a pure type following fire and a willow stage. As the aspen ages it is usually replaced by spruce, except on very dry sites where it may remain as a pure type. Common associates include black spruce and white spruce and occassionally paper birch.

Growing stock trees:--Sawtimber trees, poletimber trees, saplings, and seedlings; that is, all live trees except cull trees.

Growing stock volume:--The net volume of sound wood in the bole of growing stock trees 5.0 inches and larger in diameter at breast height, from stump to a minimum 4.0-inch top outside bark or to the point where the central stem breaks into limbs.

Hardwoods:--Broadleaved trees which are usually deciduous. Interior Alaska hardwood species are balsam poplar, black cottonwood, paper birch, and quaking aspen.

Inhibiting vegetation:--Cover sufficiently dense to prevent establishment of tree seedlings.

Inoperable noncommercial forest land:--Noncommercial forest land with a gross volume of less than 800 cubic feet per acre.

International 1/4-inch rule:--A rule used to determine the tree volume in board feet (Bruce and Schumacher, 1950).

Land area:--The area of dry land and land temporarily or partly covered by water such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than 120 feet wide; and lakes, reservoirs, and ponds less than 1 acre in area.

Log grades:--A classification of logs based on external characteristics as indicators of quality or value.

Mean annual increment:--(MAI) A measure of the volume of wood, in cubic feet, produced on 1 acre during 1 year. The Forest Service minimum standard for commercial forest land is the ability to produce 20 cubic feet per acre per year.

Mortality:--Number or sound wood volume of live trees dying from natural causes during a specified period (5 years).

Net annual growth of growing stock:--The annual change in volume of sound wood in live sawtimber and poletimber trees.

Net annual growth of sawtimber:--The annual change in net board-foot volume of live sawtimber trees.

Net volume:--The gross volume of a tree, less deductions for rot, sweep, or other defects affecting product use.

Noncommercial forest land:--(NCFL) Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions (producing less than 20 cubic feet per acre per year), and productive forest land withdrawn from commercial timber use through statute or administrative regulation.

Noncommercial species:--Tree species of typically small size, poor form, or inferior quality which normally do not develop into trees suitable for industrial products.

Nonforest land:--Land that does not qualify as forest land. Includes land that has never supported forests and lands formerly forested where forest use is precluded by development for nonforest uses, such as crops, improved pasture, residential areas, and city parks. Also includes improved roads and certain areas of water classified by the Bureau of Census as land. Unimproved roads, streams, canals, and nonforest strips in forest areas must be more than 120 feet wide, and clearings in forest areas must be more than 1 acre in size to qualify as nonforest land.

Nonstockable land:--Areas of forest land not capable of supporting forest growth because of rock, water, etc.

Nonstocked areas:--Commercial forest lands less than 16.7 percent stocked with growing stock trees.

Operable noncommercial forest land:--Noncommercial forest land with a gross volume in excess of 800 cubic feet per acre.

Overstocked areas:--Areas where growth of trees is significantly reduced by excessive numbers of trees.

Poletimber-size tree:--Softwood tree of 5.0- to 8.9-inch d.b.h. and hardwood tree of 5.0- to 10.9-inch d.b.h.

Poletimber stands:--Stands at least 16.7 percent stocked with growing stock trees of which half or more of this stocking is in poletimber and sawtimber trees, and with poletimber stocking exceeding that of sawtimber.

Rough cull trees:--Live trees of 5.0-inch and larger d.b.h. that do not contain a sawlog now or prospectively, primarily because of roughness, poor form, or because they are a noncommercial species.

Rotten cull trees:--Live trees of 5.0-inch and larger d.b.h. that do not contain a sawlog now or prospectively, primarily because of rot.

Salvable dead trees:--Standing dead trees that are considered currently or potentially merchantable by regional standards. A poletimber tree must be more than one-half sound; a sawtimber tree more than one-third sound (board measure).

Sapling-size tree:--A tree of 1.0- to 4.9-inch d.b.h.

Sapling-seedling stands:--Stands at least 16.7 percent stocked with growing stock trees of which more than half of the stocking is saplings and seedlings

Sawlog:--A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight, and with a minimum small end diameter inside bark of 6 inches for softwoods (8 inches for hardwoods).

Sawlog portion:--That part of the bole of sawtimber trees between the stump and the sawlog top.

Sawlog top:--The point on the bole of sawtimber trees above which a sawlog cannot be produced. The minimum sawlog top is 7.0-inch d.o.b. (diameter outside bark) for softwoods and 9.0-inch d.o.b. for hardwoods.

Sawtimber-size tree:--Softwood tree of 9.0-inch d.b.h. and larger. Hardwood tree of 11.0-inch d.b.h. and larger.

Sawtimber stands:--Stands at least 16.7 percent stocked with growing stock trees, with half or more of total stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

Seedling-size tree:--An established tree of less than 1.0-inch d.b.h.

Site class:--A classification of forest land by its capacity to grow crops of industrial wood.

Softwoods:--Needle-leaved trees, usually evergreen. Interior Alaska species are white and black spruce and tamarack.

Stocking:--The degree of occupancy of land by trees, measured by basal area and/or the number of trees in a stand by size or age and spacing, compared with the basal area or number of trees required to fully utilize the growth potential of the land; that is, the stocking standard.

Stand-size classes:--A classification of forest land based on size of the growing stock present; that is, sawtimber, poletimber, or saplings and seedlings.

Tree-size classes:--A classification based on the diameter of the tree at breast height (4-1/2 feet above the ground on the uphill side of the tree).

Upper stem portion:--That part of the main stem or fork of saw-timber trees above the sawlog top to a minimum top diameter of 4.0-inch outside bark or to the point where the main stem or fork breaks into limbs.

Water:Bureau of the Census:--Streams, sloughs, estuaries, and canals more than one-eighth of a statute mile in width; and lakes, reservoirs, and ponds more than 40 acres in area.

Water:Renewable Resources Evaluation:--Lakes more than 1 acre in size and streams more than 120 feet wide up to the minimum sizes specified in the Bureau of the Census definition of water.

APPENDIX B

A Methodology for Estimating Road Costs in the Susitna River Basin

All costs are rough estimates and are not meant to be substituted for on-the-ground reconnaissance and subsequent detailed design and cost work. This information should enable planners to identify the most desirable access routes by establishing relative costs among routes.

Initial Construction

Initial construction costs include up-front costs for actual road construction. These costs include: cut and fill, cut and waste, backfill, surface material, clearing, seeding, culverts, and bridges.

The first six category costs are largely a function of slope and soil drainage, while the last two are a function of drainage patterns and slope. Engineering quantity and cost estimates were made for construction of gravel roads of varying widths on four soil types and five slope categories (app. table 1).1/ To estimate the initial construction cost of various routes, we evaluated each route individually to determine culvert and bridge requirements. Bridge and culvert costs can be estimated and added to the costs shown in app. table 1 to determine total initial construction costs. Criteria for estimating bridge and culvert requirements are presented in app. table 2.

Engineers assume that road crossings at streams, with a drainage area in excess of 25 square miles, require bridge construction. Bridge costs are estimated to be $101.50/ft.^{2}. Because fixed costs are a large portion of total bridge costs, and a planned route may be upgraded, it is unlikely that a bridge less than 32 linear feet wide would be constructed. Estimated bridge costs per linear foot for roads of varying width are:

Road width	Bridge cost
Feet	Dollars
18	3,248
24	3,248
32	3,248
36	3,654
40	4,060

Culverts would be necessary at many road crossings where stream drainage areas are less than 25 square miles. App. table 2 provides information concerning culvert size (diameter) requirements and unit costs as a function of stream drainage area. App. table 3 indicates the length of culverts required for varying road widths given alternative slope conditions. App. table 4 is a product of App. tables 2 and 3 and shows total culvert costs as a function of road width, slope, and stream drainage area.

1/ Basic data used to develop this table are found in Notes to Appendix B.

App. table 1--Road cost 1/ as function of top width

Soil drainage category	Slope	18 ft. Cost per:		24 ft. Cost per:		32 ft. Cost per:		36 ft. Cost per:		40 ft. Cost per:	
		Lin. ft.	Mile	Lin. ft.	Mile	Lin. ft.	Mile	Lin. ft.	Mile	Lin. ft.	Mile
	Percent	Dollars									
Well drained	0-3	21.43	113,100	28.57	150,800	38.09	201,100	42.86	226,300	47.62	251,416
	4-7	35.00	184,800	46.66	246,400	62.21	328,500	69.99	369,500	77.77	410,600
	8-12	55.36	292,300	73.81	389,700	98.41	519,600	110.72	584,600	123.02	649,500
	13-20	155.33	820,100	207.10	1,093,500	276.13	1,458,000	310.65	1,640,200	345.17	1,822,500
	21-30	233.27	1,231,600	311.02	1,642,200	414.69	2,189,600	466.53	2,463,300	518.37	2,737,000
Poorly drained	0-3	52.27	276,000	69.69	3[illegible],000	92.92	490,600	104.54	551,900	116.15	613,300
	4-7	63.18	333,600	84.24	444,800	112.32	593,000	126.36	667,200	140.40	741,300
	8-12	70.37	371,600	93.83	495,400	125.11	660,600	140.75	743,100	156.38	825,700
	13-20	198.28	1,046,900	264.37	1,395,900	352.49	1,861,200	396.56	2,093,800	440.62	2,326,500
	21-30	294.52	1,555,100	392.69	2,073,400	523.59	2,764,500	589.04	3,110,100	654.48	3,455,700
Shallow peat	0-3	57.79	305,100	77.05	406,800	102.73	542,400	115.58	610,200	128.42	678,000
	4-7	79.37	419,000	105.82	558,700	141.09	745,000	158.73	838,100	176.37	931,200
Deep peat	0-3	110.35	582,600	147.13	776,800	196.17	1,035,800	220.70	1,165,300	245.22	1,294,700

1/ Dollars - projected 2nd half, 1983.

App. table 2--Bridge and culvert size requirements[1/]

Drainage area	Item	Cost
Square miles	Culvert or bridge	Dollars/lin. ft.
Less than 0.3	one 2 ft.-diameter culvert	36.25
.3 - 1.0	one 4 ft.-diameter culvert	108.75
1.1 - 2.0	one 6 ft.-diameter culvert	217.50
2.1 - 5.0	one 8 ft.-diameter culvert	290.00
5.1 - 10.0	two 8 ft.-diameter culverts	580.00
10.1 - 20.0	three 8 ft.-diameter culverts	870.00
20.1 - 25.0	four 8 ft.-diameter culverts	1,150.00
		Dollars/sq. ft.
Greater than 25.0	bridge	101.50

1/ This is a shortcut method of determining requirements. Other factors, including discharge and fisheries effects, should be considered prior to actual construction.

App. table 3--Culvert length requirements

Slope	Culvert length as function of road width				
	18 ft.	24 ft.	32 ft.	36 ft.	40 ft.
Percent	Feet				
0-3	46	52	60	64	68
4-7	66	72	80	84	88
8-12	81	87	95	99	103
13-20	223	229	237	241	245
21-30	316	322	330	334	338

App. table 4--Culvert costs by drainage area and road width

Slope	Drainage area	Road width				
		18 ft.	24 ft.	32 ft.	36 ft.	40 ft.
Percent	Square miles	Dollars				
0-3	Less than 0.3	1,668	1,885	2,175	2,320	2,465
	.3 - 1.0	5,003	5,665	6,525	6,960	7,395
	1.1 - 2.0	10,005	11,310	13,050	13,920	14,790
	2.1 - 5.0	13,340	15,080	17,400	18,560	19,720
	5.1 - 10.0	26,680	30,160	34,800	37,120	39,440
	10.1 - 20.0	40,020	45,240	52,200	55,680	59,160
	20.1 - 25.0	53,360	60,320	69,600	74,240	78,880
4-7	Less than 0.3	2,393	2,610	2,900	3,045	3,190
	.3 - 1.0	7,178	7,830	8,700	9,135	9,570
	1.1 - 2.0	14,355	15,660	17,400	18,270	19,140
	2.1 - 5.0	19,140	20,880	23,200	24,360	25,520
	5.1 - 10.0	38,280	41,760	46,400	48,720	51,040
	10.1 - 20.0	57,420	62,640	69,600	73,080	76,560
	20.1 - 25.0	76,560	83,520	92,800	97,440	102,080
8-12	Less than 0.3	2,936	3,154	3,444	3,589	3,734
	.3 - 1.0	8,809	9,461	10,331	10,766	11,201
	1.1 - 2.0	17,618	18,923	20,663	21,533	22,403
	2.1 - 5.0	23,490	25,230	27,550	28,710	29,870
	5.1 - 10.0	46,980	50,460	55,100	57,420	59,740
	10.1 - 20.0	70,470	75,690	82,650	86,130	89,610
	20.1 - 25.0	93,960	100,920	110,200	114,840	119,480
13-20	Less than 0.3	8,084	8,301	8,591	8,736	8,881
	.3 - 1.0	24,251	24,904	25,774	26,209	26,644
	1.1 - 2.0	48,503	49,808	51,548	52,418	53,288
	2.1 - 5.0	64,670	66,410	68,730	69,890	71,050
	5.1 - 10.0	129,340	132,820	137,460	139,780	142,100
	10.1 - 20.0	194,010	199,230	206,190	209,670	213,150
	20.1 - 25.0	258,680	265,640	274,920	279,560	284,200
21-30	Less than 0.3	11,455	11,673	11,963	12,108	12,253
	.3 - 1.0	34,365	35,018	35,888	36,323	36,758
	1.1 - 2.0	68,730	70,035	71,775	72,645	73,515
	2.1 - 5.0	91,640	93,380	95,700	96,860	98,020
	5.1 - 10.0	183,280	186,760	191,400	193,720	196,040
	10.1 - 20.0	274,920	280,140	287,100	290,580	294,060
	20.1 - 25.0	366,560	373,520	382,800	387,440	392,080

Associated Costs

After total initial construction costs have been estimated, additional costs must be included to account for associated activities. These costs are expressed as a function (percentage) of total initial construction costs and are:

Item	Percent
Engineering services - design, soil testing, quantity and cost computations, survey work, etc.	20
Mobilization - transporting construction equipment to the work site and maintaining it at this location.	10
Contract administration/construction inspection - administration of contract, meals and lodging, on-site inspection of construction activities, and materials.	12
Contingencies - unforeseen problems in construction and other associated items.	10
Total	52

These percentages are estimates from the Alaska Department of Transportation (DOT). These costs may vary greatly depending on the agency or authority involved. The Matanuska-Susitna borough estimates total associated costs to be roughly 35 percent of initial construction.

Operating, Maintenance, and Replacement (OMR)

Unlike inital costs which are incurred once, OMR costs occur continually or repetitively. Operating and maintenance costs generally occur annually, while replacement costs occur at various times depending upon the life of the item.

Our evaluation period is 50 years. During this period, operating and maintenance costs will occur annually and they are estimated to be $4,727 per mile per year.[2/] The expected life of culverts and bridges is assumed to be 25 and 50 years, respectively. In order to compare operating, maintenance, and replacement costs with initial costs, we determined their present value. Present value is a function of both discount rates and time. Because the time period is known, every year for operating and maintenance and every 25 years for culverts,[3/] only the discount rate is important.

2/ See Notes to Appendix B for derivation of annual operating and maintenance costs.

3/ Because the life of a bridge is equal to the evaluation period, 50 years, bridge replacement costs are not factored into the analysis.

The following alternative factors can be applied to annual operating and maintenance costs and to culvert costs to determine their present value.

Item	Annual discount rate						
	8	9	10	11	12	13	14
	Percent						
Operating and[1] maintenance	12.233	10.962	9.915	9.042	8.304	7.675	7.133
Replacement[2]	.146	.116	.092	.074	.059	.047	.038

The following examples are provided to illustrate how those figures should be used:

Example 1 - The present value of annual operating and maintenance per mile, given a 10-percent discount rate, is $4,727[3] x 9.915 or $46,868.

Example 2 - The present value of replacing a 4 ft.-diameter culvert,[4] 72 ft. in length, given a 10-percent discount rate, is $7,830 x 0.092 or $720.

No associated cost percentages should be applied to operating, maintenance, or replacement costs because generally they are part of an ongoing program.

Total Cost Summary[5]

The information presented in the previous sections will enable planners to estimate relative costs of alternative access routes. This example illustrates a typical situation and can serve as a guide.

1/ Present value of a constant annuity of 1 per year for 50 years.

2/ Present value of 1, 25 years hence.

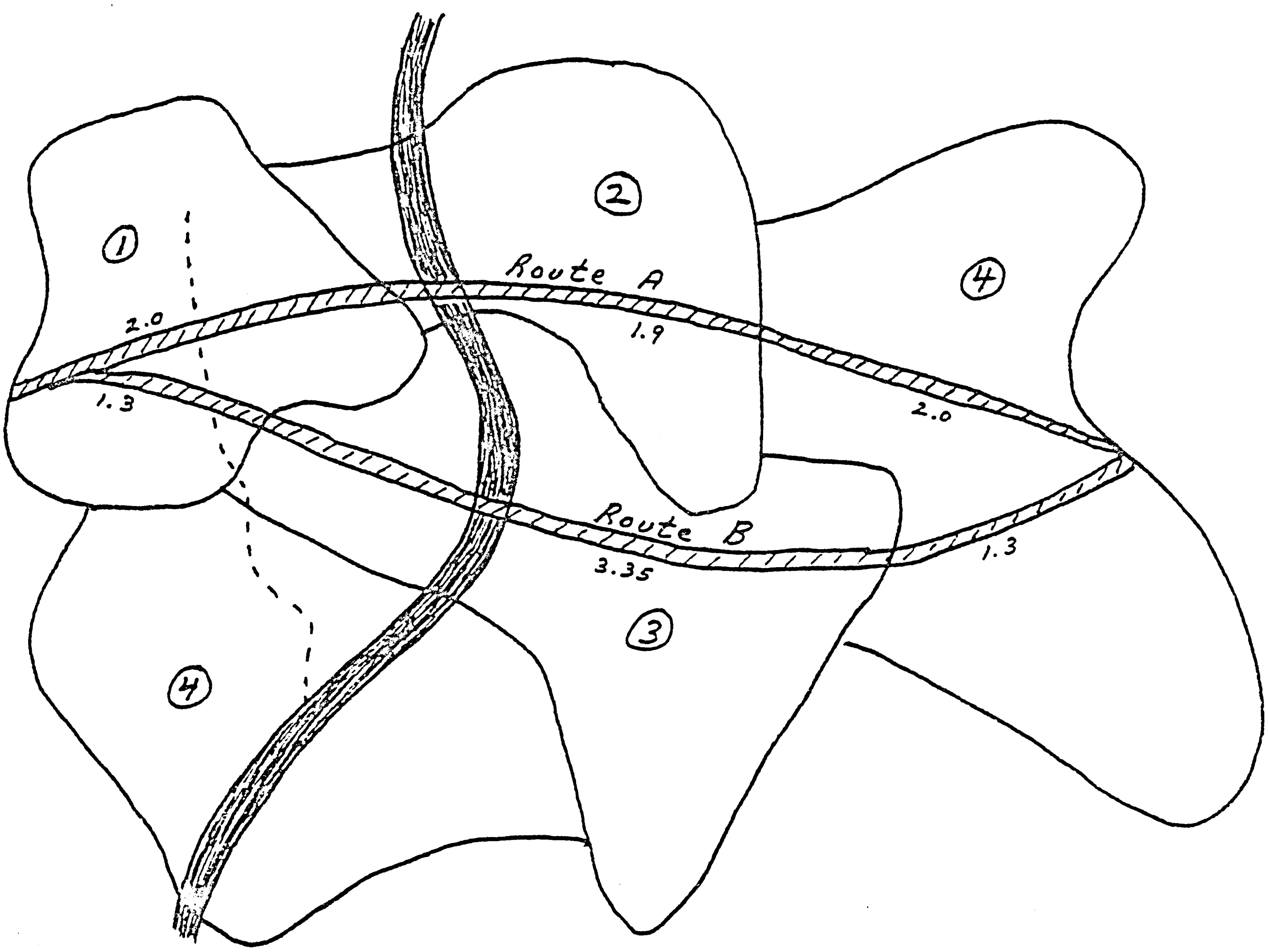
3/ See Notes to Appendix B for derivation of annual operating and maintenance cost.

4/ Size of culvert required where road width is 24 feet, terrain is 4-7 percent slope, and stream drainage area is 0.3-1.0 $mi.^2$ above road crossing.

5/ Land-rights costs are not included in this analysis because they are highly variable, but they may be an important factor in route selection.

Scale: 1 inch = 1 mile

Figure B1. Total road cost example



Key:

(1) = Well-drained soil area, 4-7 percent slope.

(2) = Deep peat soil area, 0-3 percent slope.

(3) = Poorly drained soil area, 0-3 percent slope.

(4) = Well-drained soil area, 8-12 percent slope.

(hatched line) = Proposed route.

(shaded band) = Major stream drainage area = 50 mi^2.

---- = Tributary drainage area = 3.6 mi^2.

ROUTE A Given:

Width of road = 24 ft.

Miles of road in area 1 = 2.0

Miles of road in area 2 = 1.9

Miles of road in area 4 = 2.0

Length of bridge required at major road crossing = 42 ft.

Discount rate = 10 percent

COMPUTATIONS:

I. Initial construction

Road

2.0 mi. x $246,400 = $492,800

1.9 mi. x $776,800 = $1,475,920

2.0 mi. x $389,700 = $779,400

Bridge

42 ft. x $3,248 = $136,416

Culverts

1 at $20,880 (app. table 4) = $20,880

Subtotal = $2,905,416

II. Associated costs

$2,909,766 x 0.52 = $1,510,816

III. Operating and maintenance

2.0 mi. + 1.9 mi. + 2.0 mi. = 5.9 mi.

5.9 mi. x $4,727/mi./year = $27,889

Present value = 9.915 x $27,889 = $276,522

IV. Replacement

$20,880 x .092 = $1,921

Total = $4,694,675

ROUTE B Given:

Width of road = 24 ft.

Miles of road in area 1 = 1.3

Miles of road in area 3 = 3.35

Miles of road in area 4 = 1.3

Length of bridge required at major road crossing = 42 ft.

Discount rate = 10 percent

COMPUTATIONS:

I. Initial construction

Road

1.3 mi. x $246,400 = $320,320

3.35 mi. x $368,000 = $1,232,800

1.3 mi. x $389,700 = $506,610

Bridge

42 ft. x $3,248 = $136,416

Culverts

1 at $20,880 = $20,880

Subtotal = $2,217,026

II. Associated costs

$2,221,376 x 0.52 = $1,152,854

III. Operating and maintenance

1.3 mi. + 3.35 mi. + 1.3 mi. = 5.95 mi.

5.95 mi. x $4,727/mi./year = 28,126

Present value = 9.915 x $28,126 = $278,866

IV. Replacement

$20,880 x .092 = $1,921

Total = $3,650,667

App. table 5--Unit costs of road construction

Item	Unit	Cost 1/ 1980	Adjustment 2/ Factor	Cost, 1983
		Dollars		Dollars
Cut and fill or waste	$yd.^3$	3.25	1.45	4.71
Peat excavation	do.	4.50	1.45	6.53
Surfacing (crushed gravel)	do.	16.00	1.45	23.20
Seeding	1000 sq. ft.	35.00	1.45	50.75 ($.0508/sq. ft.)
Outside fill (backfill)	$yd.^3$	6.00	1.45	8.70
Clearing	acre	2,500.00	1.45	3,625.00 ($.0832/sq. ft.)
Culverts:				
2 ft.	lin. ft.	25.00	1.45	36.25
4 ft.	do.	75.00	1.45	108.75
6 ft.	do.	150.00	1.45	217.50
8 ft.	do.	200.00	1.45	290.00
Bridges	sq. ft.	70.00	1.45	101.50

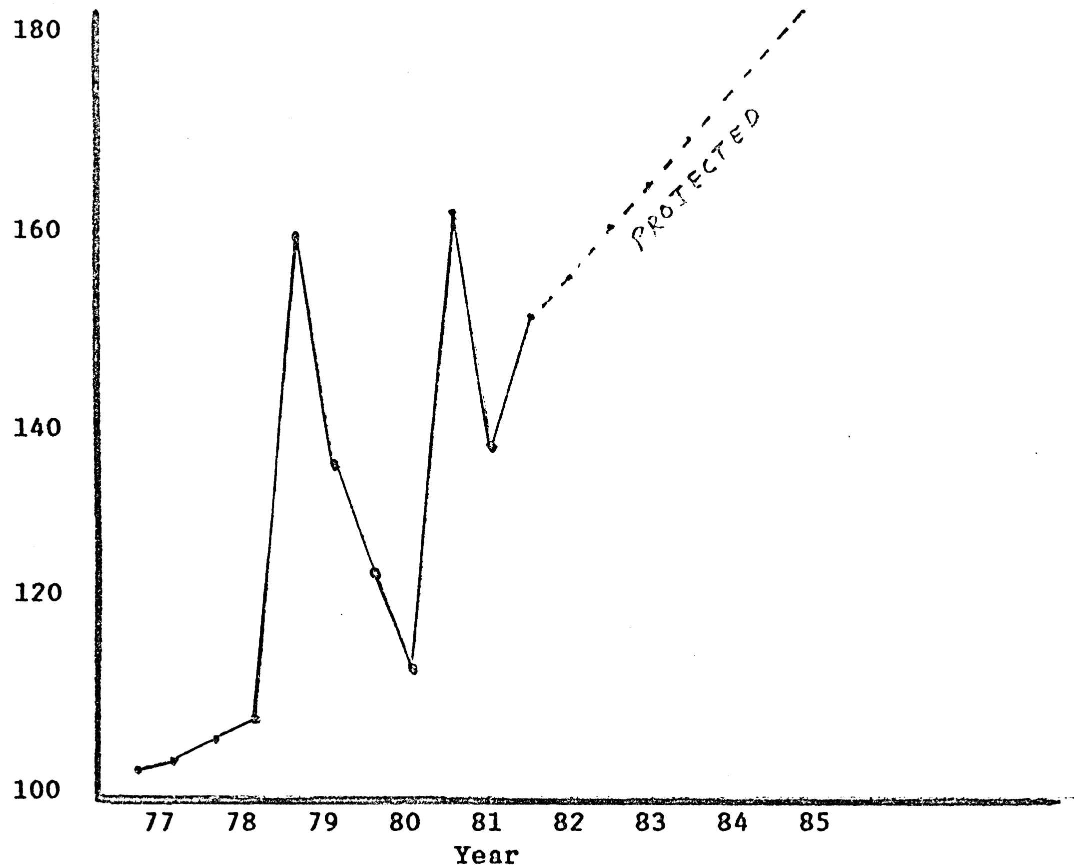
1/ Provided by Carl Molby and Bill Humphreys, Alaska Dept. Transportation, Nov. 1980.

2/ See attached index projection: 1980, 2nd half = 109; 1983, 2nd half = 158; factor = 158 - 109 = 1.45.

Alaska road construction cost index projections

Based on attached indices from Department of Transportation, 1977-82, the following projections use linear regression for 1982 (2nd half) through 1985 (2nd half).

Year	Composite index
Historical:	
1977*	99
1977	100
1978*	102
1978	104
1979*	153
1979	130
1980*	119
1980	109
1981*	155
1981	132
1982*	145
Projected:	
1982	149
1983*	154
1983	158
1984*	163
1984	167
1985*	172
1985	176



* 1st half.

App. table 6--Alaska construction cost index, price trends

(1977 = 100)

Year	Unclassified excavation: Bid 1/: price	Unclassified excavation: Index	Borrow select material: Bid price	Borrow select material: Index	Aggregate base: Bid price	Aggregate base: Index	Asphalt pavement: Bid price	Asphalt pavement: Index	Roadway index	Structural steel: Bid price	Structural steel: Index	Reinforcing steels: Bid price	Reinforcing steels: Index	Ft^2 bridge deck: Bid price	Ft^2 bridge deck: Index	Bridge index	Composite index
1967	1.01	49	0.62	20	4.55	62	13.65	66	40	0.53	50	0.29	40	40.70	50	49	43
1968	1.00	48	1.15	38	3.73	51	18.93	92	56	.48	45	.30	41	22.67	28	33	55
1969	.95	46	.63	21	3.51	48	16.74	81	44	.54	51	.27	37	36.44	45	47	45
1970	2.08	100	.99	32	3.32	45	15.39	74	65	.47	44	.28	38	47.82	59	54	61
1971	1.32	64	1.40	46	3.80	52	10.78	52	52	.58	55	.41	56	30.52	37	40	51
1972	1.15	56	.90	30	3.54	48	12.70	61	44	.64	60	.30	41	41.25	51	52	45
1973	1.61	78	1.32	43	4.68	64	15.50	75	70	.53	50	.26	36	44.98	55	53	61
1974	2.94	142	1.80	59	6.51	89	19.03	92	95	1.11	105	.88	121	44.63	55	85	91
1975	2.53	122	2.18	71	6.94	94	24.26	117	93	1.10	104	.63	86	56.14	69	77	88
1976	2.39	115	2.85	93	6.16	84	20.24	98	100	.91	86	.50	68	69.62	85	84	96
1977*	1.93	93	3.03	99	6.88	94	24.14	117	100	.86	81	.73	100	76.96	94	94	99
1977	2.07	100	3.05	100	7.35	100	20.67	100	100	1.06	100	.73	100	81.63	100	100	100
1978*	2.25	109	2.49	82	7.85	107	27.41	133	102	**		**		97.13	119	119	102
1978	2.39	115	2.95	97	7.90	107	21.02	102	106	2.07	195	.52	71	65.68	80	83	104
1979*	3.74	181	2.56	84	7.77	106	20.74	100	161	1.35	127	2.77	379	108.36	133	128	153
1979	3.11	150	3.80	125	8.09	110	19.26	93	132	1.43	135	.94	129	88.57	109	116	130
1980*	2.58	125	3.82	125	9.14	124	17.66	85	121	**		.89	122	86.53	106	107	119
1980	2.50	121	2.92	96	9.26	126	19.69	95	105	2.58	243	.80	110	85.37	105	136	109
1981*	4.69	227	4.39	144	11.66	159	25.94	125	157	1.91	180	1.03	141	96.04	118	133	155
1981	3.40	164	3.14	103	9.31	127	23.86	115	121	2.25	212	1.11	152	153.00	187	188	132
1982*	3.06	148	5.74	188	10.12	138	27.05	131	152	**		.78	107	91.00	111	111	145

1/ Bid price is weighted average price for period indicated.

* First half.

** No work bid.

Source: Alaska Dept. Transportation, Sept. 1982.

Associated Costs

Expressed as a percentage of initial construction costs:

	Percent
Engineering services	20
Mobilization	10
Contract administration Construction inspection	12
Contingencies	10
Total	52

Annual Operating, Maintenance, and Replacement

Operating and Maintenance

At present the Alaska DOT officially limits annual operating and maintenance to $1,500/mi. DOT representatives[5/] indicated that this figure is more of an average than a ceiling. Substantially more than $1,500/mi. is spent for operating and maintenance of heavily traveled roads.

DOT representatives indicated that, in the Matanuska-Susitna borough, operating and maintenance actually averaged $3,260 per mile over a 200-mile sample in 1980. Given projected cost indices through the second half of 1983, this figure would be updated to $4,727 (3,260 x 1.45[6/]).

Typical Road Cut and Fills[7/]

These computations are based on soil survey data. The following conditions were analyzed:

1. A typical well-drained soil for slopes A-E[8/].

2. A typical poorly drained soil for slopes A-E.

3. A shallow peat soil for slope A.

4. A deep peat soil for slope A.

Definitions

Cut and waste - The volume of material excavated that cannot be used for the roadway foundation; may replace topsoil to be seeded when not trashy; will generally be trashy, high in organic material, or otherwise unsuitable for fill.

Cut and fill - The volume of material that will be excavated from hills and compacted in lower areas to moderate the grade of the road.

Backfill - The volume of material used to build up the roadbed to assure adequate drainage; will be applied to A and B slopes.

5/ Based on discussions with Carl Molby, Alaska Dept. Transportation.

6/ Index: 2nd half, 1980 = 109; 2nd half, 1983 = 158; adjustment = 1.45.

7/ All calculations are for roads with a 24 ft. top width. Estimates for roads of varying width in the text were derived from 24 ft. road estimates assuming a direct correlation between cost and width.

8/ From SCS soil classification system:

A = 0-3 percent
B = 4-7 percent
C = 8-12 percent
D = 13-20 percent
E = 21-30 percent

Assumptions

Condition 1:

(a) Cut and waste will be 1 ft. deep.

(b) Cut and fill will be used to maintain a 3 percent or less grade change.

(c) Cut and fill will fill the waste volume.

(d) A slopes will use cut and waste, cut and fill.

(e) B slopes cut and fill will include cut and waste plus cut and fill grading volume. This will provide adequate roadbed without a backfill.

(f) C, D, and E slopes cut and fill will not include cut and waste, no backfill will be needed.

Condition 2:

(a) Cut and waste will be 30 in. deep.

(b) Cut and fill will maintain a 3 percent or less grade change.

(c) Cut and fill will fill the waste volume.

(d) A slopes will use cut and waste, cut and fill.

(e) B slopes cut and fill will include cut and waste plus cut and fill grading volume. This will provide adequate roadbed without a backfill.

(f) C, D, and E slopes cut and fill will not include cut and waste, no backfill will be needed.

Condition 3:

(a) Cut and waste will be 30 in. deep.

(b) Cut and fill will maintain a 3 percent or less grade change.

Condition 4:

(a) Cut and waste will be 9 ft. deep.

Clearing width for all roads will be maximum width of excavation plus 15 ft. rounded to +10, and will vary by slope.

Seeding will be all but 24 ft. roadway plus graded gravel of 3 ft. on either side of road.

Surface will be 6 in. of graded gravel.

Road cut and fills - typical

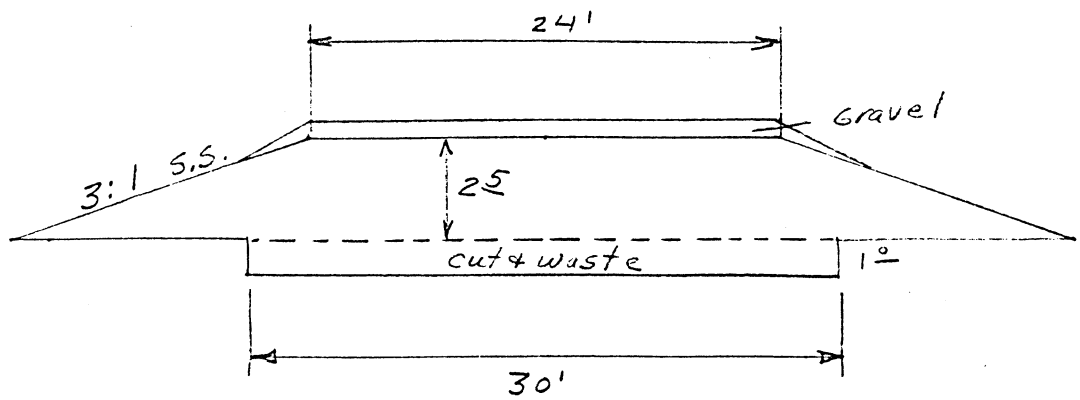
Assume: 24 ft. roadway top width

3:1 graded finished side-slopes

Well-drained A slope soil:

Cut and waste 1.0 ft.

Replace with good fill and backfill, additional 2-1/2 ft. on 3:1 slope



Typical Section Well-drained A Slope

Sum:

Cut and waste $\frac{30 \times 1}{27}$ = 1.11 yd.^{3}/ft.

Backfill $\frac{2.5\ (31.5)}{27}$ = 2.92 yd.^{3}/ft.

Gravel surface 0.5 $\frac{(27)}{27}$ = 0.5 yd.^{3}/ft.

Clear and grub 60 ft. width

Seed and mulch 30 ft. width

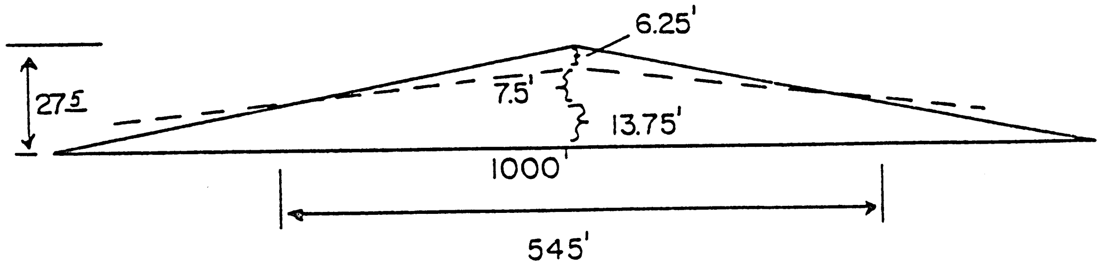
Susitna River Basin

Well-drained B slope:

Use same as well-drained A slope and add cut and fill to average the B slope to no more than 3-percent grade.

Assume average B slope is 5.5 percent and will occur over 1,000 ft.

Cut and waste is maximum cut width.



Road Profile

$$\text{CUT} \quad \frac{3.13(24 + 3(3.13))}{27} \; \frac{(545)}{1000} = 2.11 \; \frac{\text{c.y.}}{\text{ft.}}$$

Typical Section Well-drained B Slope

Sum:

Cut and waste = $\frac{24 + 2(3)(6.25)}{27}$ = 2.27 yd.^{3}/ft.

Cut and fill = 2.11 yd.^{3}/ft.

Backfill = 2.92 yd.^{3}/ft.

Gravel = 0.5 yd.^{3}/ft.

Clear and grub = 24 + 15 + 38, use 80 ft. width

Seed and mulch = 50 ft. width

Well-drained C slope:

Use same as A, except C slope will average 10 percent; grade back to 3 percent on 500 ft.

$$\text{Cut} = \frac{8.75 \times 50.25}{27}(.5) = 8.14 \text{ yd.}^3/\text{ft.}$$

Sum:

$$\text{Cut and waste} = \frac{8.75(3)(2) + 24}{27} = 2.83 \text{ yd.}^3/\text{ft.}$$

Cut and fill = 8.14 yd.^{3}/ft.

Backfill = assume none needed

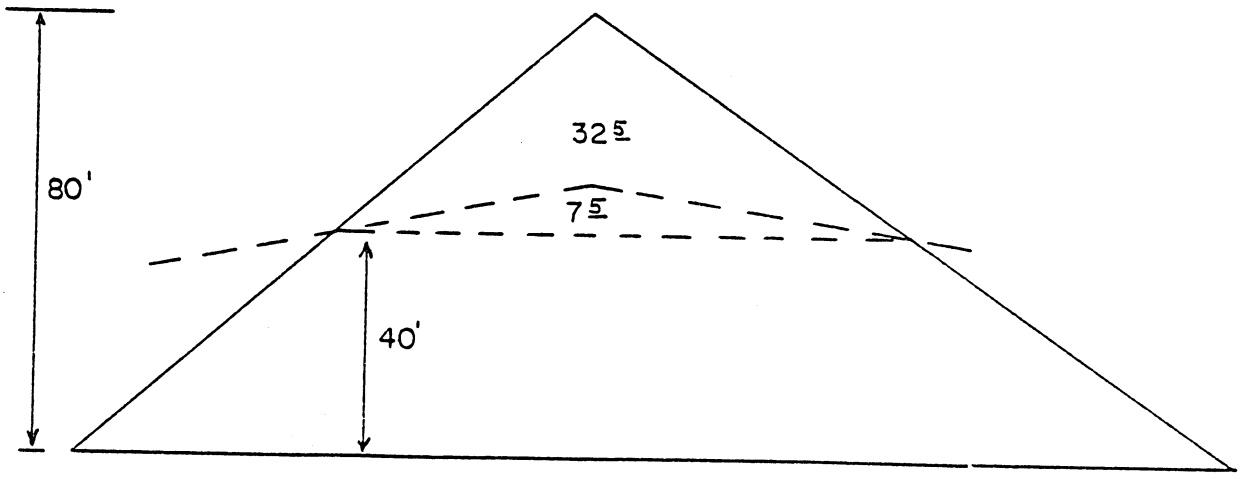
Gravel = 0.5 yd.^{3}/ft.

Clear and grub = 90 ft. width

Seed and mulch = 60 ft. width

Well-drained D slope:

Assume an average 16-percent slope



Typical Section Well-drained D Slope

Sum:

Cut and waste $= \frac{32.5(3)(2) + 24}{27} =$ 8.11 yd.^{3}/ft.

Cut and fill $= \frac{16.25(24 + 3(16.25))}{27} = \frac{43.78}{2} =$ 26.89 yd.^{3}/ft.

Backfill = none

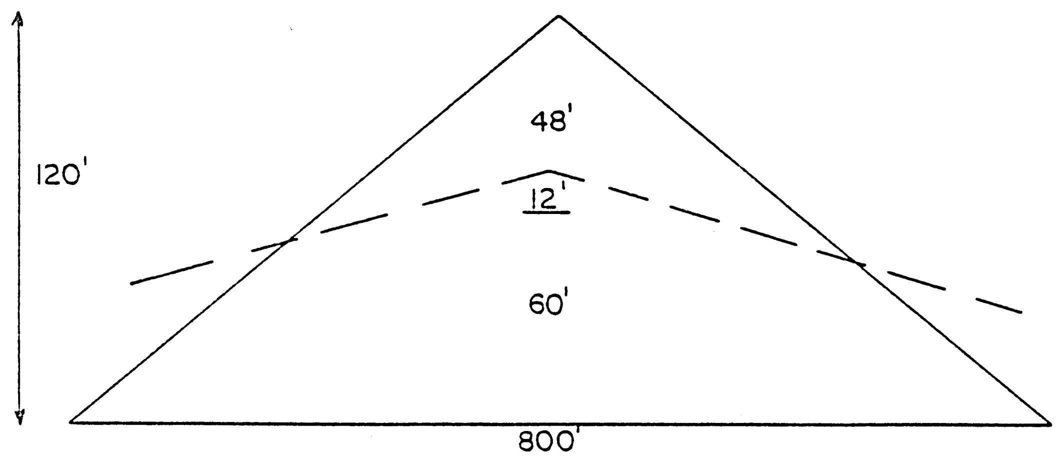
Gravel = 0.5 yd.^{3}/ft.

Clear and grub = 240 ft. width

Seed and mulch = 210 ft. width

Well-drained E slope:

Average slope = 30 percent for 400 feet



Typical Section Well-drained E Slope

Sum:

Cut and waste $= \frac{48(6) + 24}{27} =$ 11.56 yd.^{3}/ft.

Cut and fill $= 24 \frac{(24 + 3(24)}{27} (1/2) =$ 42.66 yd.^{3}/ft.

Backfill = none

Gravel = 0.5 yd.^{3}/ft.

Clear and grub = 340 ft. width

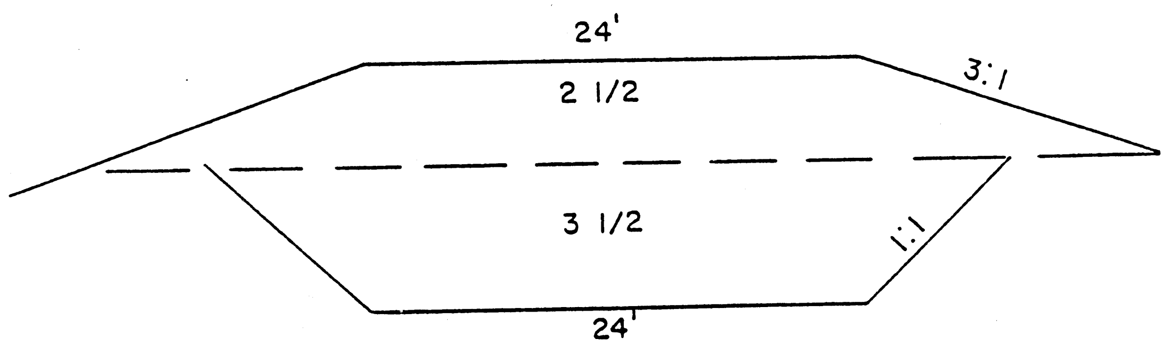
Seed and mulch = 310 ft. width

Poorly drained A soil - Use same as well-drained soil, except depth (cut and waste) = 2.5 yd.^{3}/ft.

Cut and waste $= \frac{2.5\ (30)}{27} = 2.78$ yd.^{3}/ft.

Use 2-1/2 times amount for well-drained soil

Shallow peat A slope:



Typical Section Shallow Peat

Cut and waste $(24 + \frac{(3.5)}{27}(3.5)) = 3.56$ yd.^{3}/ft.

Fill = 2.92 yd.^{3}/ft.

Clear and grub = 60 ft. width

Seed = 30 ft. width

Shallow peat B slope:

Add 2.11 yd.^{3}/ft. for grading slope to cut and fill level of well-drained B soil

$\frac{(24 + 6(6.25))}{27}\ 3.5 = 7.97$ yd.^{3}/ft.

Deep peat:

Average cut = 9 ft.

Cut and waste on 1:1 slope to 24 ft. bottom

$$\frac{9}{27}(24 + 9) = 1 \text{ yd.}^3/\text{ft.}$$

Clear and grub = 24 + 18 + 15 = 60 ft. width

All others are the same as shallow peat soil.

<u>A 30 ft. roadway</u>:

Cut and waste--

$$\text{A slope} = \frac{30}{24} = 1.25 \text{ yd.}^3/\text{ft.}$$

$$\text{B slope} = \frac{30 + 6(6.25)}{24 + 6(6.25)} = 1.10 \text{ yd.}^3/\text{ft.}$$

$$\text{C slope} = \frac{30 + 6(8.75)}{24 + 6(8.75)} = 1.08 \text{ yd.}^3/\text{ft.}$$

$$\text{D slope} = \frac{225}{219} = 1.03 \text{ yd.}^3/\text{ft.}$$

$$\text{E slope} = \frac{318}{312} = 1.02 \text{ yd.}^3/\text{ft.}$$

Cut and fill--

$$\text{A slope} = 1.25 \text{ yd.}^3/\text{ft.}$$

$$\text{B slope} = \frac{30 + 3(3.13)}{24 + 3(3.13)} = 1.18 \text{ yd.}^3/\text{ft.}$$

$$\text{C slope} = \frac{30 + 3(4.38)}{24 + 3(4.38)} = 1.16 \text{ yd.}^3/\text{ft.}$$

$$\text{D slope} = \frac{30 + 3(16.25)}{24 + 3(16.25)} = 1.08 \text{ yd.}^3/\text{ft.}$$

$$\text{E slope} = \frac{30 + 3(24)}{24 + 3(24)} = 1.06 \text{ yd.}^3/\text{ft.}$$

Deep peat--

$$\frac{30 + 9}{24 + 9} = 1.18 \text{ yd.}^3/\text{ft.}$$

Shallow peat--

$$\frac{30 + 3.5}{24 + 3.5} = 1.22 \text{ yd.}^3/\text{ft.}$$

App. table 7--Road cost estimates, 1/ soil type: well drained

Primary gravel road - 24 ft. top width, 3:1 side slopes.
Initial construction cost (culverts, bridges, drainage ditches not included).

Slope	Cut/waste		Cut/fill		Backfill		Surface		Clearing		Seeding			
	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per: lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per: lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per: lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)	Total cost per: lin.ft. (dollars)	Total cost per mile (dollars)
A	1.11	5.23	1.11	5.23	0	0	0.50	11.60	60	4.99	30	1.52	28.57	150,800
B	2.27	10.69	3.22	15.17	0	0	.50	11.60	80	6.66	50	2.54	46.66	246,400
C	2.83	13.33	8.14	38.34	0	0	.50	11.60	90	7.49	60	3.05	73.81	389,700
D	8.11	38.20	26.89	126.66	0	0	.50	11.60	240	19.97	210	10.67	207.10	1,093,500
E	11.56	54.45	42.66	200.93	0	0	.50	11.60	340	28.29	310	15.75	311.02	1,642,200

1/ Price base - 2nd half, 1983 projected.

App. table 8--Road cost estimates, 1/ soil type: poorly drained

Primary gravel road - 24 ft. top width, 3:1 side slopes.
Initial construction cost (culverts, bridges, drainage ditches not included).

Slope	Cut/waste		Cut/fill		Backfill		Surface		Clearing		Seeding		Total cost per lin.ft. (dollars)	Total cost per mile (dollars)
	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)		
A	2.78	13.09	2.78	13.09	2.92	25.40	0.50	11.60	60	4.99	30	1.52	69.69	368,000
B	5.68	26.75	7.79	36.69	0	0	.50	11.60	80	6.66	50	2.54	84.24	444,800
C	7.08	33.35	8.14	38.34	0	0	.50	11.60	90	7.49	60	3.05	93.83	495,400
D	20.27	95.47	26.89	126.66	0	0	.50	11.60	240	19.97	210	10.67	264.37	1,395,900
E	28.90	136.12	42.66	200.93	0	0	.50	11.60	340	28.29	310	15.75	392.69	2,073,400

1/ Price base - 2nd half, 1983 projected.

App. table 9--Road cost estimates, 1/ soil type: deep peat

Primary gravel road - 24 ft. top width, 3:1 side slopes.
Initial construction cost (culverts, bridges, drainage ditches not included).

Slope	Cut/waste		Cut/fill		Backfill		Surface		Clearing		Seeding			
	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)	Total cost per lin.ft. (dollars)	Total cost per mile (dollars)
A	11.00	51.81	11.00	51.81	2.92	25.40	0.50	11.60	60	4.99	30	1.52	147.13	776,800
B	Not applicable													
C	Not applicable													
D	Not applicable													
E	Not applicable													

1/ Price base - 2nd half, 1983 projected.

App. table 10--Road cost estimates, 1/ soil type: shallow peat

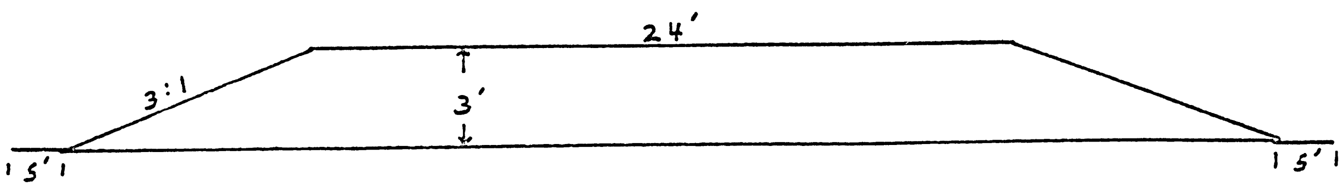
Primary gravel road - 24 ft. top width, 3:1 side slopes.
Initial construction cost (culverts, bridges, drainage ditches not included).

Slope	Cut/waste		Cut/fill		Backfill		Surface		Clearing		Seeding		Total	Total
	Volume yd.^{3} per lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per: lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per: lin.ft.	Cost per lin.ft. (dollars)	Volume yd.^{3} per: lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)	Area ft.^{2} per lin.ft.	Cost per lin.ft. (dollars)	cost per: lin.ft. (dollars)	cost per mile (dollars)
A	3.56	16.77	3.56	16.77	2.92	25.40	0.50	11.60	60	4.99	30	1.52	77.05	406,800
B	7.97	37.54	10.08	47.48	0	0	0.50	11.60	80	6.66	50	2.54	105.82	558,700
C	Not applicable													
D	Not applicable													
E	Not applicable													

1/ Price base - 2nd half, 1983 projected.

Culvert Lengths

A slope



L = 6 x 3 + 24 + 10 = 52 ft.

B slope

L = 6 x 6.25 + 24 + 10 = 72 ft.

C slope

L = 6 x 8.75 + 24 + 10 = 87 ft.

D slope

L = 6 x 32.5 + 24 + 10 = 229 ft.

E slope

L = 6 x 48 + 24 + 10 = 322 ft.

APPENDIX C

Definitions of Production Costs

Cash operating expenses - Include the variable components of tractor and equipment costs per acre (such as fuel, lubricants, and repairs) and the costs of other operating inputs (such as, fertilizer, seed, and herbicide). The quantities of these inputs are multiplied by their respective costs to arrive at total operating costs. These costs would be incurred only if production takes place.

Labor expenses - The costs of all labor needed to produce the crop. Only machinery labor is associated with barley production. Labor time is included for operation, repair, and maintenance of machinery.

Interest on investment - The capital charges (interest) that the farmer pays for the following inputs: (a) operating capital that finances the purchased inputs (such as, material and labor) until the output is sold, (b) nondepreciable assets (land), and (c) depreciable assets (such as, buildings and machinery).

Ownership cost - The cost of owning machinery, including depreciation, insurance, and taxes.

APPENDIX D

The Talkeetna Resource Development Model

Background

The Talkeetna mathematical programming model is a modification of the Willow Subbasin model (Fuglestad). While several differences exist between the models because of a change in study direction and emphasis, the two models share a common philosophy in terms of their objective and structure. The objective of both is to maximize the present value of net benefits of timber and agricultural development in the study area. The model was used to run the 25 alternative analyses.

Model Structure

The model maximizes net benefits subject to limitations of land, timber, and accessibility. Following Dorfman (Maass, et al., p. 105) a simple objective function was defined:

$$NB = dB - dC - K$$

where:

NB = present value of net benefits,
d = discount factor,
B = the annual stream of investment outputs,
C = the annual stream of investment inputs, and
K = the capital cost of initial investment.

B represents the value of timber and agricultural commodities produced annually. The products include barley, sawlogs, and fuelwood. C is the annual cost of production inputs (such as, seed, fertilizer, fuel, and machinery). K represents the initial cost of constructing roads to remote production sites and clearing agricultural land for production. The interest rate used in the discount factor, d, can be very critical to the results. The interest rate was varied to test its sensitivity. The period of analysis was 50 years.

The constraints to benefit maximization were principally resource limitations, land, and timber. Other partial constraints resulted from limitations of output sold on the domestic (Alaska) market because of limited local demand.

The model was constructed in five sectors: road construction, land clearing, commodity production, commodity transportation, and commodity sales. The interaction among the sectors is shown in figure D1.

The model is driven by commodity sales which have the only positive objective function values; commodity i sells at price P_i. Commodity i must be transported from LPU k, incurring transportation cost T_{ik}, per unit. Commodity i, then, must have been produced in LPU k, on land class j, incurring production cost C_{ijk} per acre and yielding Y_{ikj} commodity units per acre.

ACTIVITY SECTORS

	1 ROAD CONSTR.	2 LAND CLEARING	3 COMMODITY PRODUCTION	4 COMMODITY TRANSPORT.	5 COMMODITY SALES	RIGHT HAND SIDE
Objective Function (Maximize)	$-R_k$	$-L_{jk}$	$-C_{ijk}$	$-T_{ik}$	$+P_i$	$=NB$
Land Constraints	$-A_{jk}$	$+1$				≤ 0
Land Transfer Constraints		-1	$+1$			≤ 0
Commodity Production Constraints			$-Y_{ijk}$	$+1$		≤ 0
Commodity Transfer Constraints				-1	$+1$	≤ 0

Figure D1. Schematic of Model Structure

Before production can commence, each acre of class j land in LPU k must be cleared for production, incurring preparation cost L_{jk} per acre. L_{jk} can be the cost of land clearing or timber stumpage. The amount of land that can be cleared or otherwise transformed for production is limited in each LPU k by A_{jk}, the number of acres of class j land in LPU k. Road construction cost (plus overhead and discounted operating and maintenance) R_k must be incurred to make these acres available in each LPU. The road segments were defined as bivalent integer activities, ensuring that the entire road cost is incurred, even if all acres in the LPU are not used.

Annual activities, production, transportation, and sales are discounted. Road construction and land clearing are not discounted; they are considered initial investments.

Variables and Equations

The linear programming model can be symbolically characterized as:

Objective function (maximize):

$$NB = -\Sigma R_k I_k - \Sigma\Sigma L_{jk} A_{jk} - d\Sigma\Sigma\Sigma c_{ijk} X_{ijk} - d\Sigma\Sigma T_{ik} Y_{ik} + d\Sigma p_i Z_i$$

Constraints:

land constraint:

$$-\Sigma\Sigma a_{jk} I_k + \Sigma\Sigma A_{jk} \leq 0$$

land transfer constraint:

$$-\Sigma\Sigma A_{jk} + \Sigma\Sigma\Sigma X_{ijk} \leq 0$$

commodity production constraint:

$$-\Sigma\Sigma\Sigma y_{ijk} X_{ijk} + \Sigma\Sigma Y_{ik} \leq 0$$

commodity transfer constraint:

$$-\Sigma\Sigma Y_{ik} + \Sigma Z_i \leq 0$$

integer constraint:

$$I_k = 0, 1$$

nonnegativity constraint:

$$A_{jk}, X_{ijk}, Y_{ik}, Z_i \geq 0$$

where:

NB	=	present value of net benefits,
R_k	=	capital cost of road construction to LPU_k,
I_k	=	bivalent integer variable with values either zero or one,
L_{jk}	=	cost per acre of clearing class j land within LPU_k (may also indicate stumpage on timbered land),
A_{jk}	=	number of acres cleared on class j land within LPU_k,
d	=	$\frac{1 - (1+r)^{-t}}{r}$ (the discount factor),
r	=	discount interest rate,
t	=	number of years in the planning period,
c_{ijk}	=	cost per acre of producing commodity i on class j land within LPU_k,
X_{ijk}	=	number of acres devoted to the production of commodity i on class j land within LPU_k,
T_{ik}	=	cost per unit of transporting commodity i from LPU_k,
Y_{ik}	=	number of units of commodity i transported from LPU_k,
p_i	=	selling price per unit of commodity i,
Z_i	=	number of units of commodity i sold at price p_i,
a_{jk}	=	total number of acres of class j land available within LPU_k,
y_{ijk}	=	number of units per acre (yield) of commodity i produced on class j land within LPU_k,
i	=	1, 2, 3 for the commodities: barley, sawlogs, and fuelwood,
j	=	1, 2, 3, 4, 5 for the land classes: 1 = soil capability class II 2 = soil capability class III 3 = timber 4 = timber and soil capability class II 5 = timber and soil capability class III
k	=	1, 2, ... 50 for the land production units.

Two other constraints required for model solutions were: several transfer rows allowing access to remote LPUs after those near present roads were accessed, and preventing the closing of a loop among three or more interconnecting remote LPUs, which effectively circumvents the first constraint.

Data Handling

The model matrix measured 855 to 864 rows by 1,004 to 1,101 columns, depending on the alternative being run. Matrix density was 0.44. The model was solved on the University of Alaska's Honeywell Series 60, Level 66 mainframe computer. The software code was Honeywell's Mathematical Programming System (MPS). MPS is versatile because it also allows input of data formatted in IBM's Mathematical Programming System Extended (MPSX). The model was constructed using the MPSX data format because it is simple to construct. Each matrix element requires only a column identifier, a row identifier, and the coefficient value, and it can easily be transferred to other IBM-compatible machines.1/

It was impractical to enter data by hand because of the model's size and the need for multiple runs. Matrix generators were written for the first four model sectors. The fifth sector, commodity sales, was quite small and easily constructed by hand. A matrix generator is a computer program that writes matrix coefficients to a temporary disk file in the appropriate format. The file is then used as input data to the MPS system.

The matrix generators were written in BASIC programming language. The user enters the parameter values shown in table 25 in a question-answer session. The program combines these values with data stored on permanent disk file, including the resource base (acres in each land class within each LPU) and the road construction cost between each linked pair of LPUs, as shown in figure 3.

Figures D2 through D4 provide examples of the terminal sessions creating the first three sectors of the model representing alternative one (table 25). The first few data records of each sector are also listed. Sector 4, commodity transportation, is not shown because the same matrix was used in all 25 alternatives; the sensitivity of model results to this sector was not analyzed. Sector 5 was constructed by hand and includes selling activities for the three commodities and upper bounds representing the commodity demand constraints.

After the five matrix sectors are prepared, the data sets, MPS program (agenda control language), and required Honeywell job control language (JCL) are connected and written on a temporary disk file. This file is submitted as a batch job to the mainframe operating system.

These data handling procedures, while time consuming to develop, were quite helpful in facilitating quick turnaround when planners were developing the alternative analyses. Up to ten runs, including thousands of data records, were accomplished in 2 hours.

1/ MPSX row and colunm identifiers cannot exceed eight characters, while Honeywell permits up to 18 characters.

FIGURE D2. Matrix generator terminal session, Sector 1

```
* * * * TALKEETNA RESOURCE DEVELOPMENT MODEL * * * *

 * * * * * * LAND BASE MATRIX GENERATOR * * * * * *

NEED TIME PERIOD, INTEREST RATE, OVERHEAD FACTOR, AND O & M COSTS

TIME PERIOD (YEARS)            ?50
NO. YEARS BEFORE PROJECT BEGINS      ?0
INTEREST RATE                  ?7.625
OVERHEAD ON ROAD COST (% OF CONSTRUCTION COST)      ?35
ANNUAL ROAD O & M COST (% OF CONSTRUCTION COST)      ?1
TIMBER/AG SHARE OF ROAD ACCESS COSTS (%)      ?100


THE DISCOUNT FACTOR IS:           12.78202

THE CORRECTED DISCOUNT FACTOR IS:                 12.78202


ready
*LIST TEMPFIL1

    9990W 17  OBJECTV1           .0
    9990W 17  M17LAND1      -1464.0
    9990W 17  M17LAND2       -752.0
    9990W 17  M17LAND3      -1648.0
    9990W 17  M17LAND4      -2976.0
    9990W 17  M17LAND5      -4824.0
    9990W 18  OBJECTV1           .0
    9990W 18  M18LAND1       -504.0
    9990W 18  M18LAND2       -768.0
    9990W 18  M18LAND3       -656.0
    9990W 18  M18LAND4      -3680.0
    9990W 18  M18LAND5      -1848.0
    9990W118  OBJECTV1    -926003.0
    9990W118  A118B 13   -1.0
    9990W118  A118B 15   -1.0
    1180W 13  OBJECTV1   -2890026.0
    1180W 13  M13LAND1       -520.0
    1180W 13  M13LAND2      -2728.0
    1180W 13  M13LAND3      -9400.0
    1180W 13  M13LAND4      -3656.0
    1180W 13  M13LAND5      -2720.0
    1180W 13  A118B 13    1.0
    1180W 13  A 13B 14   -1.0
    1180W 13  1ONLY 13    1.0
     13KW 14  OBJECTV1   -2720224.0
     13KW 14  M14LAND2        -32.0
     13KW 14  M14LAND3       -520.0
     13KW 14  M14LAND4        -88.0
     13KW 14  M14LAND5        -80.0
     13KW 14  A 13B 14    1.0
     13KW 14  A 14B314   -1.0
     13KW 14  1ONLY 14    1.0
     14KK 13  OBJECTV1   -2720224.0
     14KK 13  M13LAND1       -520.0
```

FIGURE D3. Matrix generator terminal session, Sector 2

```
* * * * TALKEETNA RESOURCE DEVELOPMENT MODEL * * * *

 * * * * * LAND TRANSFER MATRIX GENERATOR * * * * *

INTEREST RATE:                  ?7.625
NO. OF YEARS BEFORE PROJECT BEGINS:      ?0

NEED AGRICULTURAL LAND TRANSFORMATION (CLEARING) COSTS:

     CLEARING COST FOR CLASS II AG. LAND:       ?300
     CLEARING COST FOR CLASS III AG. LAND:      ?300
     COST OF CLEARING TIMBERED LAND:            ?300
     COST OF CLEARING LOGGED OVER LAND:         ?300

NEED TIMBER LAND TRANSFORMATION COST:           ?0


ready
*LIST TEMPFIL2

    TR 1CLR1  OBJECTV1    -300.0
    TR 1CLR1  M 1LAND1     1.0
    TR 1CLR1  L 1AGRI1    -1.0
    TR 1CLR2  OBJECTV1    -300.0
    TR 1CLR2  M 1LAND2     1.0
    TR 1CLR2  L 1AGRI2    -1.0
    TR 1TIM3  OBJECTV1        .0
    TR 1TIM3  M 1LAND3     1.0
    TR 1TIM3  L 1MTMBR    -0.7353
    TR 1CAR3  OBJECTV1        .0
    TR 1CAR3  M 1LAND3     1.0
    TR 1CAR3  L 1NTMBR    -0.7353
    TR 1CLR4  OBJECTV1    -300.0
    TR 1CLR4  M 1LAND4     1.0
    TR 1CLR4  L 1AGRI1    -1.0
    TR 1TIM4  OBJECTV1        .0
    TR 1TIM4  M 1LAND4     1.0
    TR 1TIM4  L 1MTMBR    -0.7353
    TR 1CAR4  OBJECTV1        .0
    TR 1CAR4  M 1LAND4     1.0
    TR 1CAR4  L 1NTMBR    -0.7353
    TR 1CLR5  OBJECTV1    -300.0
    TR 1CLR5  M 1LAND5     1.0
    TR 1CLR5  L 1AGRI2    -1.0
    TR 1TIM5  OBJECTV1        .0
    TR 1TIM5  M 1LAND5     1.0
    TR 1TIM5  L 1MTMBR    -0.7353
    TR 1CAR5  OBJECTV1        .0
    TR 1CAR5  M 1LAND5     1.0
    TR 1CAR5  L 1NTMBR    -0.7353
    TR 2CLR1  OBJECTV1    -300.0
    TR 2CLR1  M 2LAND1     1.0
    TR 2CLR1  L 2AGRI1    -1.0
    TR 2CLR2  OBJECTV1    -300.0
    TR 2CLR2  M 2LAND2     1.0
```

FIGURE D4. Matrix generator terminal session, Sector 3

```
* * * * TALKEETNA RESOURCE DEVELOPMENT MODEL * * * *

 * * * PRODUCTION ACTIVITIES MATRIX GENERATOR * * *

NEED TIME PERIOD, INTEREST RATE, COSTS, YIELDS, AND
     FOREST ROTATION AGE

TIME PERIOD (YEARS)             ?50
NO. OF YEARS UNTIL PROJECT BEGINS      ?0
INTEREST RATE                   ?7.625
BARLEY YIELD ON CLASS II LAND    ?50
BARLEY YIELD ON CLASS III LAND   ?50
PER ACRE COST OF BARLEY PRODUCTION ON CLASS II LAND    ?146.69
PER ACRE COST OF BARLEY PRODUCTION ON CLASS III LAND   ?146.69
BARLEY PRODUCTION OVERHEAD FACTOR (PERCENT)    ?20
LOGGING MACHINERY COST PER HOUR      ?97.24
LOGGING OVERHEAD FACTOR (PERCENT)    ?20
LOGGING PRODUCTIVITY (CU FT/HR)      ?283.9
TIMBER INVENTORY VOLUME (CU FT/AC)           ?1246
TIMBER STAND ROTATION AGE (YEARS)            ?80

THE DISCOUNT FACTOR IS:              12.78202

THE CORRECTED DISCOUNT FACTOR IS:                   12.78202

BARLEY PRODUCTION COST ON CLASS II LAND (FARM GATE):
     PER ACRE               176.03
     PER BU                   3.52

BARLEY PRODUCTION COST ON CLASS III LAND (FARM GATE):
     PER ACRE               176.03
     PER BU                   3.52

LOGGING COST (LESS HAULING):
     PER MBF SPRUCE          93.48
     PER MBF COTTONWOOD      81.13
     PER CORD                34.94
     PER ACRE               512.13


NOW GENERATING PRODUCTION ACTIVITIES ON TEMPORARY FILE
     CALLED 'TEMPFIL3' IN MPSX FORMAT.....


ready
*LIST TEMPFIL3

    P 1BRLY1  OBJECTV1    -2249.99
    P 1BRLY1  L 1AGRI1        1.0
    P 1BRLY1  BARLYM 1      -50.00
    P 1BRLY2  OBJECTV1    -2249.99
    P 1BRLY2  L 1AGRI2        1.0
    P 1BRLY2  BARLYM 1      -50.00
    P 1MTIMB  OBJECTV1    -6546.03
    P 1MTIMB  L 1MTMBR       80.00
    P 1MTIMB  SLOGSM 1    -1.40549
    P 1MTIMB  CLOGSM 1    -1.28338
```