AN ABSTRACT OF THE THESIS OF

Daniel John Feeney for the degree of Master of Science in Forest Engineering presented on April 27, 1984

Title: An Economic Evaluation of Logging Road Maintenance

Abstract approved: Marvin R. Pyles

This thesis describes the results of a project conducted to determine the economics of forest road maintenance alternatives between periods of timber harvesting. An open road and a closed road alternative will be compared to the economics of clearcutting an entire area and obliterating the road system until reentry at the end of the rotation. Road maintenance data was collected from the Siuslaw and Willamette National Forests in Oregon. An average present value cost per mile was determined for each location for U.S. Forest Service level one and level two maintenance. Level one is the maintenance performed on a road that is closed to vehicular traffic. Level two is the maintenance performed on roads open to high ground clearance vehicles. Reconstruction costs before each reentry were also included in the present value calculations.

Results show that for short-term reentry periods, it is economically better to leave road systems open and maintain at level two than it is to close the roads and maintain at level one. The third alternative of clearcutting and obliterating the system until the end

of the rotation was by far the best economic alternative. Only costs for actual maintenance were included in the analysis. Administrative costs, and costs associated with other resource values were not considered.

To help demonstrate how maintenance costs compare to total timber revenues, road maintenance costs for different road densities were compared to associated timber value. Road densities per section (640 acres) for different logging systems were used to calculate a present value road maintenance cost per section. This was compared to timber values per section for three different volume per acre figures. These volumes represented site classes II, III and IV. It was found that road maintenance and reconstruction make up a small percentage of the total timber revenue. Although the percent of total revenue was low, road maintenance appears to be a significant investment.

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Typed by Mary Ann (Sadie) Airth for Daniel J. Feeney

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Above all, I would like to dedicate this thesis to my wife Norma for her complete support during the long hours spent with this project instead of her.

An Economic Evaluation of
Logging Road Maintenance

by

Daniel John Feeney

A THESIS

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INTRODUCTION

In the National Forest System, it is common practice to leave logging roads open after timber harvesting. The primary use of these roads is timber harvesting. After completion of logging these roads are left open and maintained for use by the public for recreation and the Forest Service for fire control and silvicultural work. Some local and collector roads could be closed after harvest without greatly affecting access by the public or the Forest Service. The purpose of this project was to economically compare different road maintenance options under different forest management alternatives.

The type of road that will be analyzed is a short, local or collector system that extends into a secondary drainage and ends. An example of the type of road analyzed in this study is shown on the map in Figure 1. The road systems examined in this project do not tie through to another system nor serve any other purpose than hauling timber. Road systems that connected to other systems were not considered because these types of roads will be used more often for hauling timber, serve a greater area, and would be more difficult to close for any length of time.

Two ranger districts were selected for this study. Data was collected from the Mapleton Ranger District on the Siuslaw National Forest and the Sweet Home District on the Willamette National Forest.

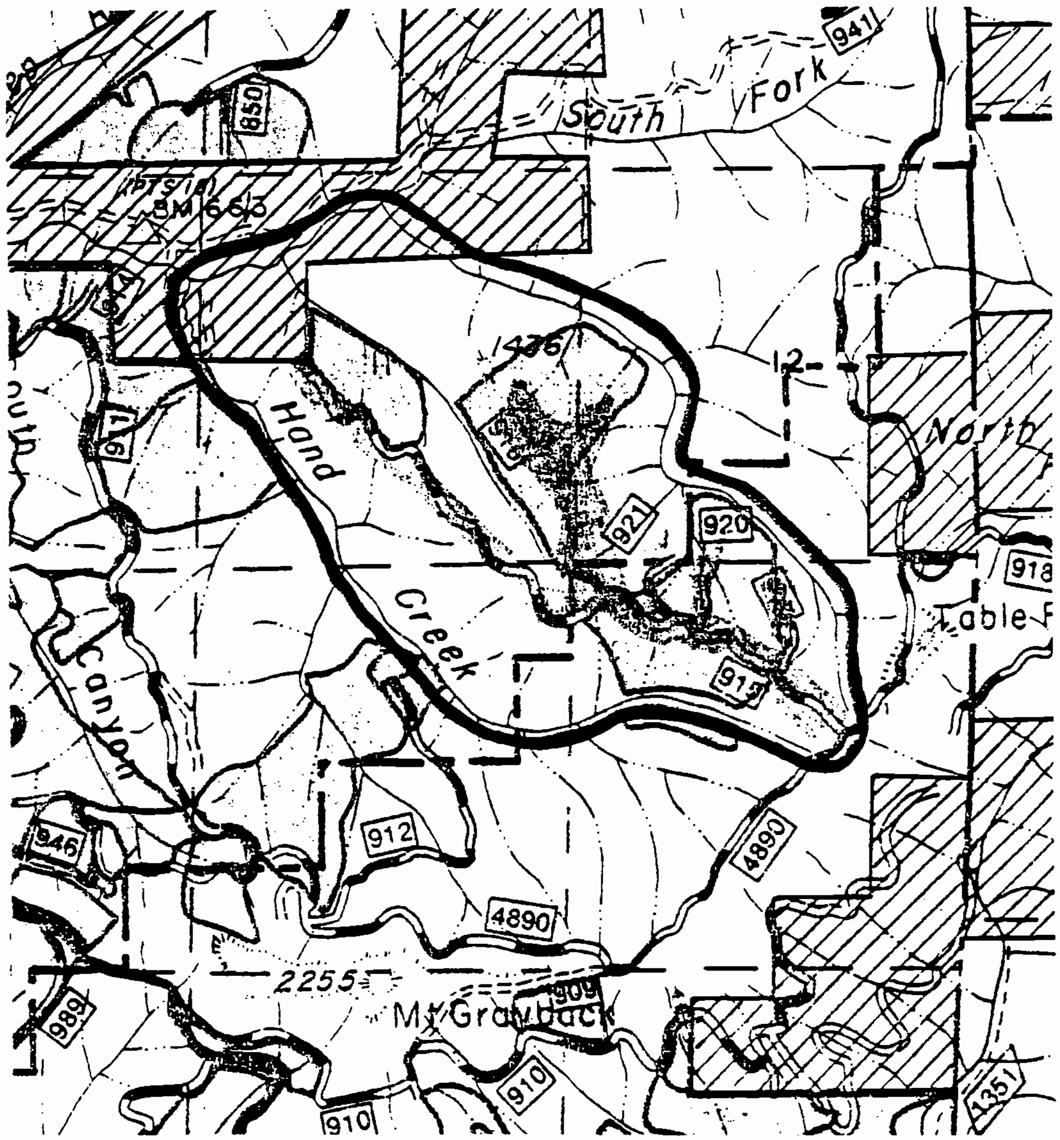


Figure 1. Typical road system.

The Mapleton District is in the Coast Range of western Oregon and the Sweet Home District is in the Cascade Range in west central Oregon. These two districts are shown on a map in Figure 2.

No previous work could be found comparing the economics of different road management alternatives under varying forest management options. It is hoped this project will open the door to further study in this area.

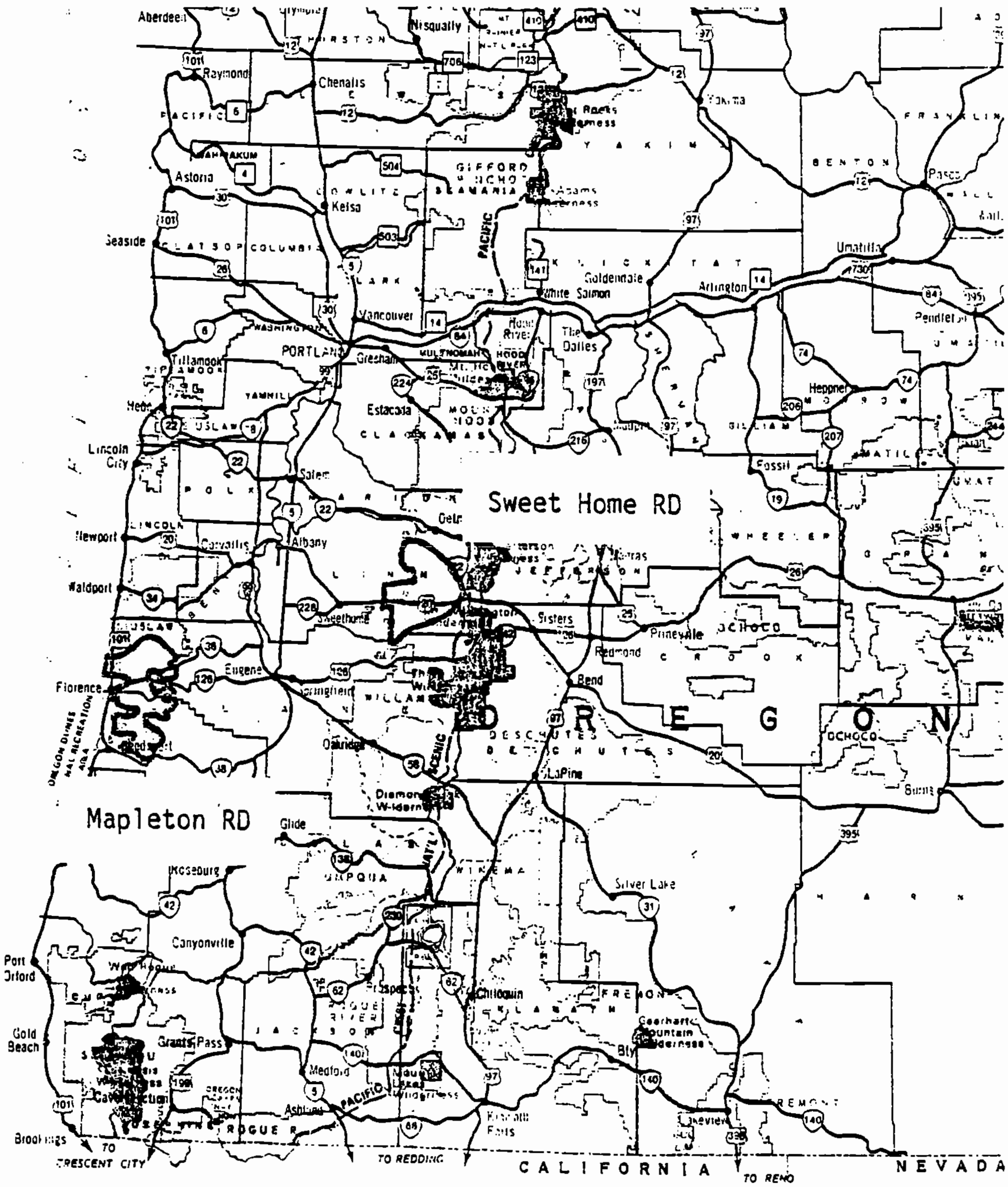


Figure 2. Vicinity map.

OBJECTIVES

There are four main objectives of the project. They are to:

1. economically compare different road management alternatives.
2. collect actual forest road maintenance costs and determine how much money is spent for varying levels of maintenance.
3. determine deficiencies in the Forest Service maintenance record keeping.
4. see how road maintenance costs relate to the value of timber served by the road system.

The first objective will look at the economics of leaving roads open versus closing them following timber harvesting. Both short and long term closures will be analyzed. At the present time decisions on road closures are often made without the benefit of an economic analysis. This study will help demonstrate a generalized analysis procedure that could help managers with closure decisions. All data collected for this project was from Federal Land. Even though the numbers are not directly applicable to private timber land, the analysis procedure is the same. Private owners may not do as much maintenance as on government land but costs for the maintenance done will be similar to costs collected for this study. Road managers will be able to use the format that will be described to analyze their own costs.

The second objective is an attempt to collect costs and find what is being spent for maintenance at individual areas. Many times costs are averaged together over a wide regional area with a large range in values. This project will collect costs from two distinct areas. Actual costs for different levels of maintenance will be summarized.

The third objective will be to find where the Forest Service has deficiencies in maintenance record keeping. This will focus primarily on the computerized system of record keeping for road maintenance.

The last objective is to see how road maintenance costs relate to the value of the timber stands. This will give an indication of how maintenance costs compare to the overall timber revenue.

A final comment, the objective of the project is not to develop a detailed exact model, but a generalized comparison of different maintenance alternatives. The data collected was not sufficiently accurate to make a definitive statement between these maintenance alternatives.

MAINTENANCE LEVELS

Road management in the Forest Service has been divided into five levels depending on road standards.

Roads of the lowest standard are maintained at level one. Roads with the highest standards are maintained at level five. The definitions for each level (10) are:

Level 1. Roads in this level are to be in a long-term storage category, and not used for motor vehicle access. Minimal maintenance will be performed to ensure proper drainage and minimal environmental impact.

Level 2. Roads in this level are maintained for use by high ground clearance vehicles and are not for use by public passenger car travel. Use is permitted by Forest visitors unless specifically prohibited. Maintenance is performed to maintain drainage and keep a minimum ten foot usable travel-way. Proper drainage to ensure minimal environmental impact is provided.

Level 3. This is the minimum level for hauling timber. The road is maintained to be passable for public passenger cars operated at prudent driving speeds. The traveled way and turnouts have been maintained to at least single-lane width. Brush and limbs are removed to provide sight distance. Necessary under-road drainage is provided.

Level 4. Level four roads have better geometrics than level three. Brush is removed to provide greater sight distance for speeds to 35 miles per hour. During the dry season the road is dust-abated. Pavement cracks are sealed to prevent water entry. Necessary under-road drainage is provided.

Level 5. Roads in this level are maintained for safe travel at prudent speeds above 35 miles per hour. Dust has been controlled by asphalt paving or surface treatment. Brushing has been done to retain needed sight distance for travel at the advisory speed. Necessary under-road drainage is provided.

This project is concerned with level one and level two roads. These two levels are what forest roads analyzed in this study will be classified as after timber harvest. Roads that are closed will be maintained at level one. Roads that are left open will be maintained at level two. These two levels of road make up the majority of the districts' road system. Because of this a large portion of the maintenance budget is spent on these roads. These two levels are most representative of a very large portion of the road systems on private timber land. For these reasons it is important to find what maintenance activities are being done and how much it costs for these levels. Roads in both of these levels have either gravel or native surfacing.

MAINTENANCE ALTERNATIVES

All maintenance alternatives considered in this study will be analyzed for one rotation. The rotation length for each alternative will be eighty years. This length is representative of the areas studied and the equal lengths will enable an equitable comparison between alternatives. Funding for maintenance performed during timber harvesting will be supplied from timber revenues for all alternatives. These costs will not be included in the analysis because maintenance during harvesting will be assumed the same for all alternatives. The timber volume removed for each alternative will be equal over the length of the rotation so this should be a reasonable assumption. Funds for reconstruction and obliteration of roads will be included in the analysis for all alternatives. Including these is necessary because the cost for bringing roads up to timber harvesting standards will differ for each alternative. These included costs will give a more realistic comparison between the alternatives. Each alternative will consider only clearcut harvesting.

Alternatives

Three maintenance alternatives will be considered in this study. They include:

1. Leaving the road system open after each harvest and maintaining at level two. At the time of reentry, re-

construction will be required to upgrade the road to level three.

2. Closing the road system after each harvest and maintaining at level one until the roads are reconstructed for the next reentry.
3. Clearcutting the entire area served by the road system and obliterating the roads until reentry at the end of the rotation.

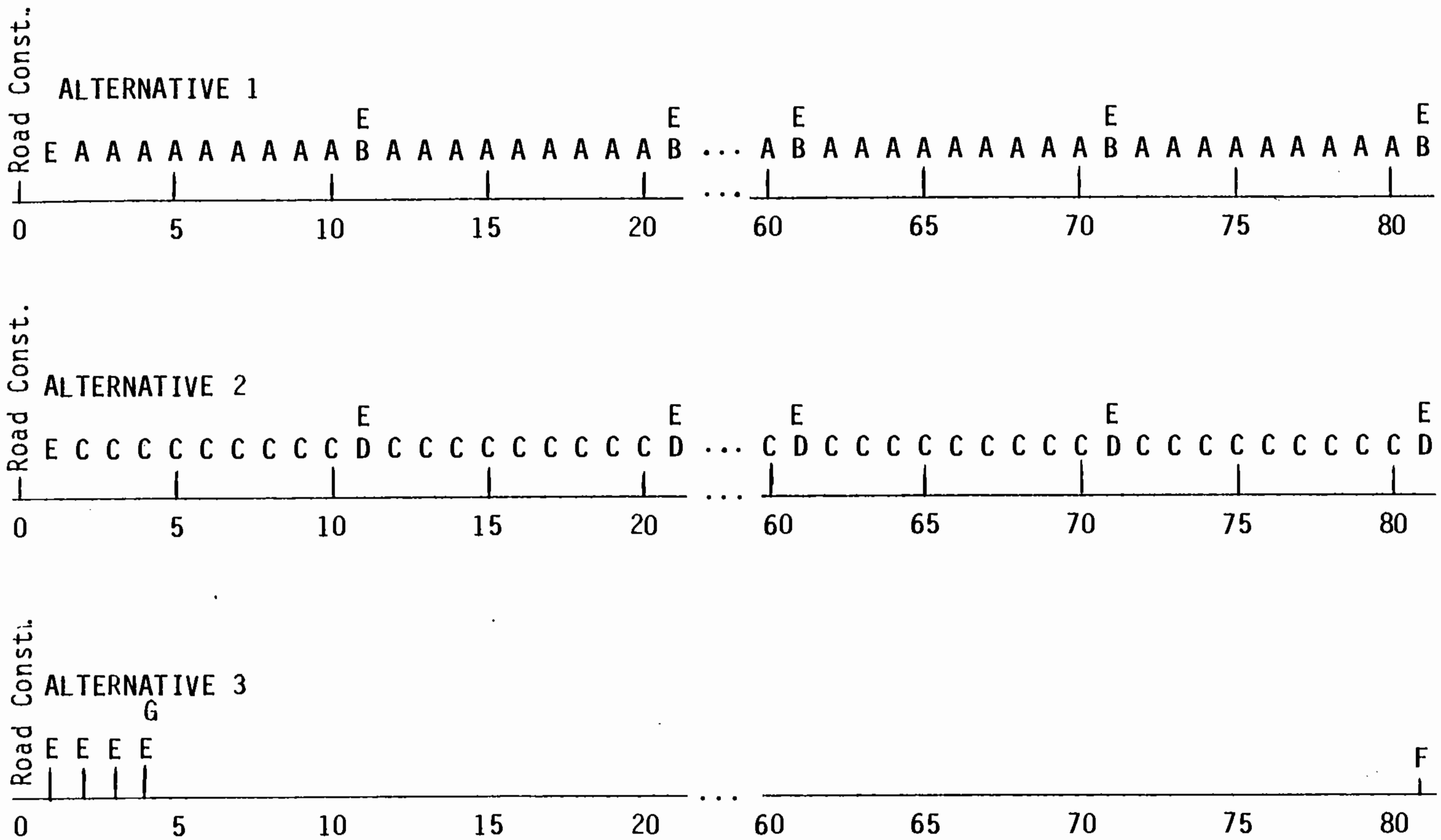
Alternatives one and two are very similar. These two alternatives will assume equal timber volume will be removed in eight entries with reentry occuring every ten years. Each harvest will take one year. The first harvest will occur in the first year of the rotation. The final harvest will occur in year seventy. This harvest schedule is based on an average area of two square miles (1280 acres). This is a typical area served by road systems analyzed in this study. For each harvest 160 acres will be clearcut. For typical volumes for the areas in the study this would be an average production for a typical yarding machine used in western Oregon.

After each harvest the roads in alternative one will be left open to vehicular traffic and maintained at level two until the next reentry ten years later. After the tenth year the road system is reconstructed to bring it up to level three. This is the minimum level for hauling timber. This same process continues for each reentry throughout the rotation.

Alternative two follows the same process as alternative one with one exception. After each harvest the road system is barricaded and the system maintained at level one. At the end of each ten year interval the level one roads will be reconstructed and upgraded to level three for timber hauling. Because level one roads receive less maintenance than level two roads, they deteriorate more during the ten year interval between harvests. Therefore the reconstruction for alternative two is more extensive and costly than the reconstruction for alternative one.

Alternative three will clearcut the entire area served by the road system in the first four years of the rotation. A quarter of the volume will be removed in each year. It will be assumed that two average yarding machines will log the area to expedite the harvesting. With this type of forest management, it is more economical to move in and harvest the timber at an accelerated rate and move out. This is the reason for using two yarding machines. At the end of the first four years the road system is completely obliterated. No access will be provided until the end of the rotation when the road system will be completely rebuilt. This alternative most closely approximates forest management on private timber land. A rotation diagram for all three alternatives is shown in Figure 3.

To help illustrate the effect these maintenance alternatives have on timber value a comparison will be made with various road densities and timber volumes. Average road densities for various logging systems will be used to calculate total maintenance costs per



A - Yearly road maintenance Level 2
B - Road construction Level 2 $3500/mile (6)
C - Yearly road maintenance Level
D - Road construction Level 1 $5000/mile (6)
E - Timber Revenues (amount depends on volume per acre)
F - Road construction $33,000/mile (6)
G - Road obliteration $1,000/mile (6)

Figure 3. Rotation Diagrams

section for each maintenance alternative. These total maintenance costs will be compared to timber value per section for different site classes. An average bid price for Forest Service timber on the west side of Oregon and Washington will be used to approximate the value of the timber. This value will vary by volume per acre representing different site classes.

DATA COLLECTION

Maintenance Data

The data collected from the two National Forests were retrieved from the Road Maintenance Information System (RMIS) which is a computerized maintenance accomplishment summary used by the Forest Service. This summary lists all maintenance work performed on each Ranger District by year. All maintenance is listed by road number, maintenance level, activity code, amount performed and cost. An activity code is a number given to a particular maintenance item, such as blading to identify it on the computer printout. A list of activity codes and their definitions appears in Table I . This table shows codes for maintenance performed on level one and two roads. There are many other codes for work performed at other maintenance levels. To simplify the data summary some activities were grouped with similar activities. The following activities were combined:

1. Sweeping rocks and shoulder shaping with a road grader were combined with blading.
2. Sign installation and sign maintenance were added together.
3. Gravel hauling cost was included with surface repair.

Also collected from each district was the total road miles in levels one and two on each district. These numbers vary yearly depending on whether timber sales are active or closed. A level one or two road would be upgraded to level three when a timber sale became

TABLE 1.

Activity Code Glossary

Code	Activity	Description
1010	Blading	Road conditioning work with a road grader.
1080	Slide and Sluff Removal	Removal of earth slides and debris
1085	Slide and Sluff Removal by private contractor	Removal of slides and debris by a private contractor.
3040	Machine Clean Culverts	Cleaning of culverts by machines
3041	Hand Clean Culverts	Cleaning of culverts by hand
3060	Culvert Repair	Repair work done on culverts
4020	Brushing Machine	Brushing done by a machine
4021	Brushing Hand	Brushing done by hand
5010	Lag Out	Removal of fallen trees blocking the roadway
1130	Surface Repair	Repair work done on the surface of a road
3010	Ditch Maintenance	Maintenance done on roadside ditches
7120	Sign Maintenance	Maintenance done on forest signs
3020	Slough Removal Ditch	Removal of ditch slough
4050	Brush Disposal	Disposal of roadside brush
6010	Repair Structures	Repair of major roadside structures

active. Conversely, if a timber sale closed, a level three road would revert to level one or two.

Maintenance Data Analysis

Both districts had RMIS printouts for five years, 1979 to 1983. As each year ended this maintenance data was erased from computer storage. The data was also not summarized by maintenance level. It was decided that the easiest way to summarize the numbers was to take the data off the printouts, enter it into a computer and store it on a floppy disk. The numbers were stored and summarized using a Hewlett-Packard 86B desktop computer. The data was sorted by district, year, maintenance level and activity code. This gave a printout showing what activities and associated costs were performed on a district during a given year for maintenance levels one and two. All road maintenance costs collected were for the work performed. Overhead costs were not included. The reason for this is that from Forest Service records it was not possible to determine accurately how much overhead should be allocated to each maintenance level. Figures 4 and 5 demonstrate the cost per mile for Mapleton over the five year period for both levels and 1982 and 1983 for Sweet Home. These figures are not corrected from inflation.

The summarized maintenance costs were separated into labor and equipment. On the RMIS computer printout there is a column for material costs. For maintenance levels one and two the cost for

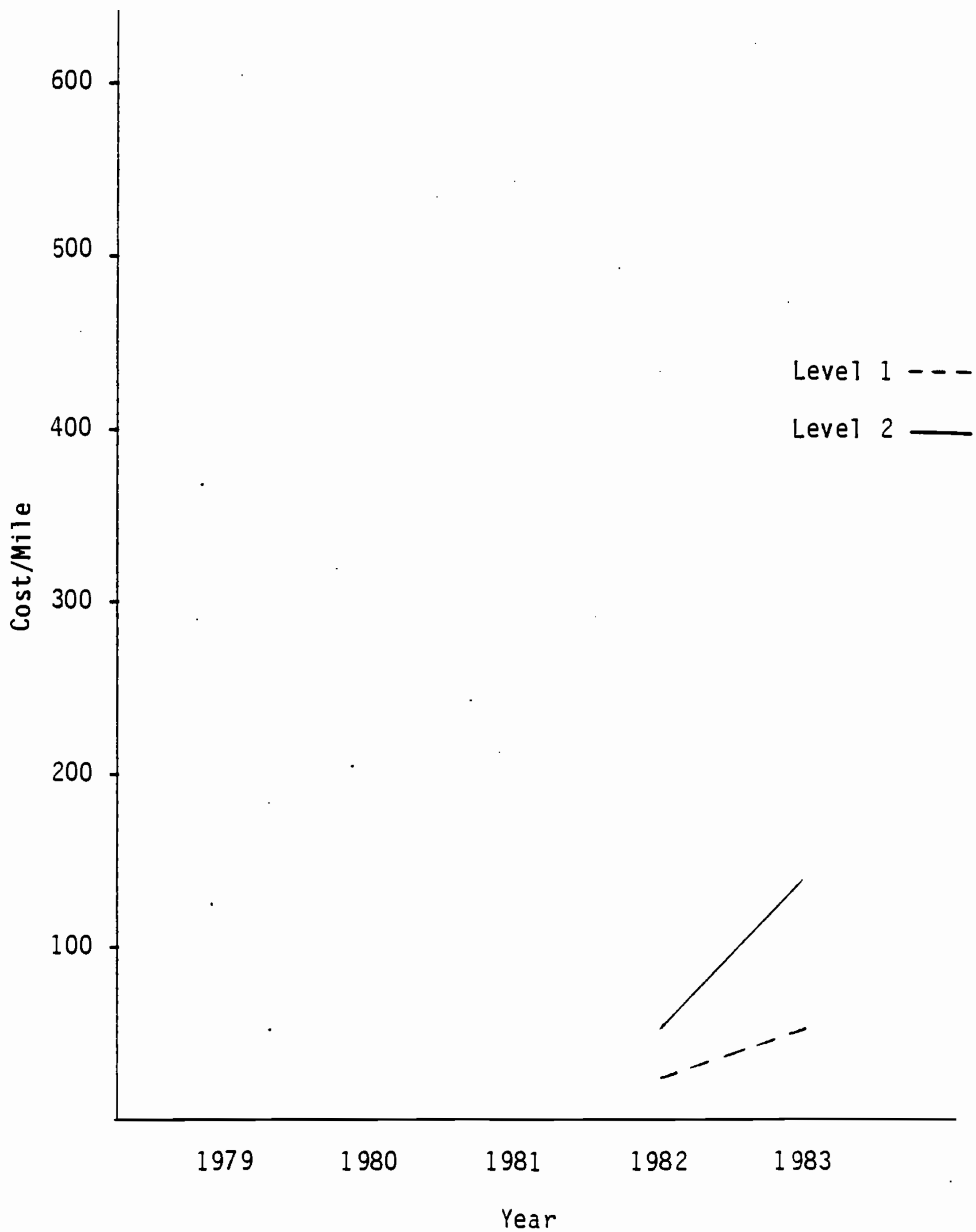


Figure 4. Maintenance Cost/Mile Sweet Home

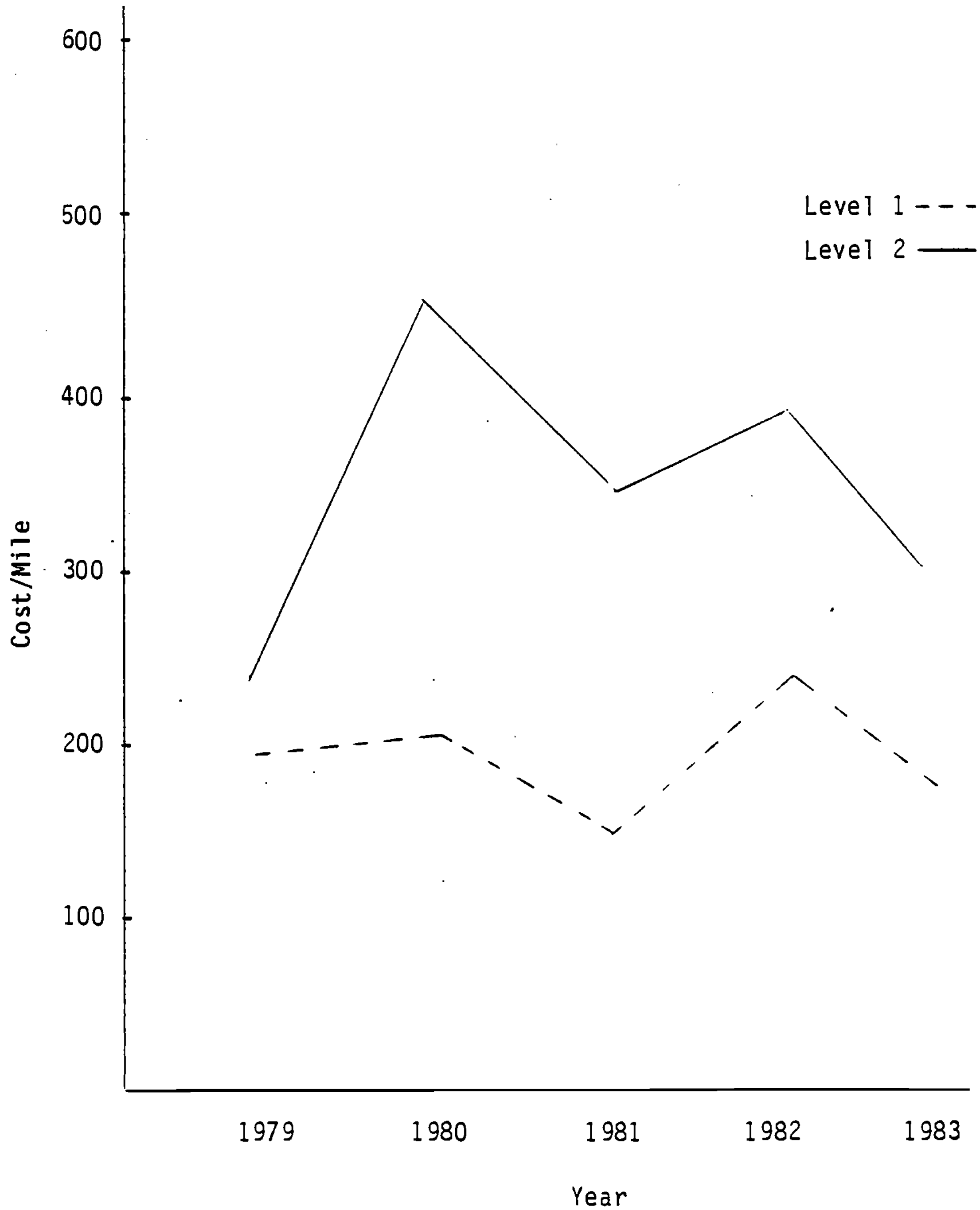


Figure 5. Maintenance Cost/Mile Mapleton

materials was very small. Because the material costs were was so small it was included with the equipment cost.

After reviewing the maintenance summaries, large differences appeared in the yearly amount of maintenance performed on the Sweet Home District for level one and two. The maintenance personnel (7) for the district indicated the disparity was primarily due to poor record keeping, especially from 1979 to 1981. It was felt that maintenance done on level one local roads was being included with work done on level two collectors. Level two work was being overestimated and level one underestimated. As the years progressed from 1979 to 1983 the record keeping improved. Further discussions with maintenance personnel revealed that total road system miles catagorized by maintenance level were only available for 1983. Without these mileage figures for the previous years there was no way to determine an average cost per mile for each level. For these reasons only the maintenance data from 1983 for the Sweet Home District was used. The cost summary in Tables II and III for Sweet Home is based on the 1983 data.

The Mapleton District had more accurate data entries through all five years of record. This is based on consistent data through all five years and from discussions with district personnel (4). This allowed an average cost per mile for each level to be calculated based on five years of data.

Because the Sweet Home costs are in 1983 dollars it was easiest to use 1983 as a base year and convert the Mapleton costs from other

Table II.

Sweet Home, 1983 Level 1 Maintenance Costs

ACTIVITY CODE	MILES OF ROAD	UNITS TREATED	EQUIP-[2] MENT COST	LABOR COST	TOTAL COST	COST[1] MILE	% of Total
1010 BLADING	0	0	0	0	0	0	0
1080 SLUFF RMV	0.1	96.0	62.25	98.64	160.89	1.31	3
1085 SLUFF RMV CNTR	0	0	0	0	0	0	0
3040 MCH CL CLV	61.1	332.0	650.26	2420.02	3070.28	25.04	55
3041 HAND CL CLV	0	0	0	0	0	0	0
3060 CULV RPR	0	0	0	0	0	0	0
4020 BRUSH MACH	0.1	0.6	0	129.50	129.50	1.06	2
4021 BRUSH HAND	0.1	1.3	0	17.00	17.00	0.14	1
5010 LOG OUT	1.40	1.80	12.45	65.57	78.02	0.64	1
1130 SUR RPR	0	0	0	0	0	0	0
3010 DITCH MTN	2.0	4.10	402.44	222.33	624.77	5.10	11
7120 SIGN MTN	8.5	30.0	73.20	381.48	454.68	3.70	8
3020 SLF DITCH	6.7	70.0	360.20	189.36	549.56	4.48	10
4050 BRUSH DISP	0	0	0	0	0	0	0
6010 RPR STRUCT	8.6	14.50	129.22	371.87	501.09	4.09	9
TOTALS			1690.02	3895.77	5585.79	45.56	100

Average total system miles for Level 1 = 122.6

[1]Total cost/122.6 miles

[2]Includes materials cost

Table III.

Sweet Home 1983 Level 2 Maintenance Costs

ACTIVITY CODE	MILES OF ROAD	UNITS TREATED	EQUIP-[2] MENT COST	LABOR COST	TOTAL COST	COST[1] MILE	% of Total
1010 BLADING	15.5	10.5	918.78	643.42	1562.20	4.55	3
1080 SLUFF RMV	29.9	1916.0	3891.21	2445.65	6336.86	18.47	13
1080 SLUFF RMV CNTR.	0	0	0	0	0	0	0
3040 MCH CL CLV	148.9	641.0	5151.75	4604.72	9756.47	28.44	21
3041 HAND CL CLV	0	0	0	0	0	0	0
3060 CULV RPR	14.6	6.0	437.15	429.21	866.36	2.53	2
4020 BRUSH MACH	30.2	18.30	212.54	4820.86	5033.40	14.67	11
4021 BRUSH HAND	24.9	19.50	42.00	928.50	970.50	2.83	2
5010 LOG OUT	27.70	17.0	612.77	835.47	1448.24	4.22	3
1130 SUR RPR	29.50	485.0	1226.77	806.04	2032.81	5.93	4
3010 DITCH MTN	102.10	99.10	4846.70	4703.58	9550.28	27.84	20
7120 SIGN MTN	25.70	31.00	120.48	283.01	403.49	1.18	1
3020 SLF DITCH	49.50	2937.0	5299.19	3681.96	8981.15	26.18	19
4050 BRUSH DISP	0	0	0	0	0	0	0
6010 RPR STRUCT	13.80	6.0	73.49	258.08	331.57	0.97	1
TOTALS			22832.83	24440.50	47273.33	137.82	100

Average total system miles for Level 2 = 343.0

[1]Total cost/343.0 miles

[2]Includes materials cost

years. This meant that maintenance costs for all other years would have to be adjusted for inflation. Inflation rates were thus needed for labor and equipment. Because a large portion of the maintenance was performed by Forest Service wage grade employees, the inflation rate for labor was taken as the cost of living increase given to wage grade employees each year during the five year period. The inflation rate for equipment was harder to estimate. It was felt a good approximation could be obtained from the Construction Cost Index for equipment published by Engineering News Record (1). This rate was used because the Forest Service did not have a definitive equipment inflation rate. The labor and equipment inflation rates are found in Table IV. The maintenance costs for each year were inflated to 1983 and an average was calculated for each level. This average cost was divided by the average miles of road for each level. This gave us a cost per mile for level one and level two maintenance in 1983 dollars. These cost figures appear in Tables V and VI.

Not all level one and level two roads receive maintenance every year. Maintenance on these roads occurs periodically depending on storm frequency, storm intensity and local geology. Developing a model to predict maintenance frequency for each level was beyond the scope of this project. To simplify the allocation of maintenance funds to the roads the average cost per mile for each level was used. What this did was take the total yearly maintenance dollars spent for each level and divide it by the total miles in each level. This spreads the dollars spent over each of the miles in the system

Table IV.

Inflation Rates

	EQUIPMENT[1]	LABOR[2]
1979-80	7.5%	6.0%
1980-81	8.9%	5.8%
1981-82	8.2%	4.7%
1982-83	4.1%	4.0%

[1]Construction Cost Index - Engineering News Record

[2]U.S.D.A. - wage grade cost of living increases

Table V.

Mapleton Combined Level 1 Maintenance Costs

ACTIVITY CODE	MILES OF ROAD	UNITS TREATED	EQUIP-MENT COST[2]	LABOR COST	TOTAL COST	COST[1] MILE	% of Total
1010 BLADING	18.40	21.70	2404.40	2075.28	4479.68	70.77	29
1080 SLUFF RMV	3.10	740.0	1438.29	1058.38	2496.67	39.44	16
1085 SLUFF RMV CNTR.	4.20	1746.0	1719.94	1895.36	3615.30	57.10	23
3040 MCH CL CLV	6.30	334.0	349.70	568.95	918.65	14.51	6
3041 HAND CL CLV	1.00	5.0	10.81	52.34	63.15	1.00	1
3060 CULV RPR	0.7	1.0	8.17	18.48	26.65	0.42	0
4020 BRUSH MACH	18.50	184.0	1260.83	1159.04	2419.87	38.23	15
4021 BRUSH HAND	3.20	3.52	44.16	296.14	340.30	5.38	2
5010 LOG OUT	1.0	0.6	33.98	56.01	89.99	1.42	1
1130 SUR RPR	0.6	50.0	191.58	110.71	302.29	4.78	2
3010 DITCH MTN	6.9	6.50	402.52	322.42	724.94	11.45	4
7120 SIGN MTN	0.2	0.4	5.50	18.41	23.91	0.38	0
3020 SLF DITCH	0	0	0	0	0	0	0
4050 BRUSH DISP	0	0	0	0	0	0	0
6010 RPR STRUCT	1.80	1.2	65.67	123.28	188.95	2.98	1
TOTALS			7935.55	7754.80	15,690.35	247.87	

Average total system miles for Level 1 = 63.3

[1]Total cost/63.3 miles

[2]Includes materials costs

Table VI.

Mapleton Combined Level 2 Maintenance Costs

ACTIVITY CODE	MILES OF ROAD	UNITS TREATED	EQUIP-MENT COST[2]	LABOR COST	TOTAL COST	COST[1] MILE	% of Total
1010 BLADING	207.9	215.8	18529.13	16614.47	35143.60	133.02	35
1080 SLUFF RMV	35.80	4434.0	5572.94	4649.00	10221.94	38.69	10
1085 SLUFF RMV CNTR.	67.10	11513.0	12068.59	12025.17	24093.76	91.20	24
3040 MCH CL CLV	77.80	487.0	2224.98	3835.87	6060.85	22.94	6
3041 HAND CL CLV	27.60	95.6	75.01	520.91	595.92	2.26	1
3060 CULV RPR	9.90	9.0	257.96	1033.92	1291.88	4.89	1
4020 BRUSH MACH	172.80	327.2	7468.39	7949.57	15417.96	58.36	15
4021 BRUSH HAND	12.6	7.9	61.57	575.08	636.65	2.41	1
5010 LOG OUT	8.30	6.9	180.85	260.44	441.29	1.67	1
1130 SUR RPR	7.0	184.0	436.56	988.45	1425.01	5.39	1
3010 DITCH MTN	84.6	56.2	2378.81	2244.53	4623.34	17.50	4
7120 SIGN MTN	2.20	2.80	11.80	130.35	142.15	0.54	0
3020 SLF DITCH	0	0	0	0	0	0	0
4050 BRUSH DISP	0	0	0	0	0	0	0
6010 RPR STRUCT	7.40	4.0	147.71	804.01	951.72	3.60	1
TOTALS			49414.30	51631.77	101,046.1	382.46	100

Average total system miles for Level 2 = 264.2

[1]Total cost/264.2 miles

[2]Includes materials cost

equally for both levels. This was necessary because we only had five years of data with an eighty year rotation.

Reconstruction Costs

Needed for each of the three alternatives were costs for reconstructing the road systems prior to harvesting. For alternative one a reconstruction cost would be needed for upgrading a road from level two to level three. For alternative two the needed costs were for upgrading from level one to level three. For alternative three the reconstruction cost would be for a complete rebuilding of the road system following the obliteration of the road after harvesting. Cost figures obtained from the Forest Service Regional Office in Portland, Oregon (3) were from the Umpqua National Forest in southwest Oregon. These costs were almost identical to similar costs obtained from the Mt. Hood National Forest in north-central Oregon. The Umpqua has terrain similar to both the Willamette and Siuslaw Forests. Because the costs collected were similar to other forests in the Region it will be assumed these costs can be used on both districts in this study. The average reconstruction costs for each alternative are:

Alternative	Average	Range
Alternative 1	$3,500/mile	$1500/mile-$10,000/mile
Alternative 2	$5,000/mile	$2000/mile-$15,000/mile
Alternative 3	$33,000/mile	$16,000/mile-$44,000/mile

These average reconstruction values have wide variances. The individual values varied as much as 200 percent from the average.

These reconstruction values are the weakest part of the analysis and subject to the most variation. Unfortunately, these were the only numbers obtainable within the scope of this project.

ECONOMIC ANALYSIS

With all of the data collected and analyzed a present value for each alternative could be calculated. The costs that occurred in each year of the rotation diagrammed in Figure 3 were discounted back to the beginning of the rotation. The current Forest Service real planning interest rate of four percent was used for discounting. Future inflation was not used in the present value calculations. All costs occur at the end of the year. A present value was calculated for each activity code for both levels, for each reconstruction cost and for the cost to obliterate the roads in alternative three. For alternatives one and two the sum of the present values for the maintenance activities and the reconstruction results in the total present value. The total present value for alternative three is the sum of the discounted obliteration and reconstruction costs. Tables VII and VIII show the total present values for each alternative and activity code.

With the present values calculated for each activity code it is easy for a road manager to make a quick total present value calculation without selected activity codes. For example, if a road manager was interested in seeing the effect of not blading the system, he would only have to subtract the present value of blading from the total present value. This allows the reader to quickly calculate further maintenance options by including only the desired activity codes. Caution should be taken in changing the present values for

Table VII

Present Value Costs - Sweet Home $/Mile

Blading 1010	Sluff RMV 1080	SLF RMV Contr 1085	MCH CLV CL 3040	HAND CL CLV 3041	CLV RPR 3060	Brush MCH 4020	Brush Hand 4021	Log Out 5010	Sur RPR 1130	Ditch Mtn 3010	Sign Mtn 7120	SLF Ditch 3020	Brush Disp 4050	RPR Struct 6010	Total	Recon.	Total P.V.
Alternative 1 Level 2																	
96.01	389.45	0	599.62	0	53.25	309.34	59.65	89.01	124.93	586.95	24.80	551.97	0	20.38	2905.36	6703.63	9,608.99
Alternative 2 Level 1																	
0	27.66	0	527.91	0	0	22.27	2.92	13.42	0	107.43	78.18	94.49	0	86.16	960.44	9576.61	10,537.05
Alternative 3 Clearcut and Reentry																	
Obliterate = 854.80															854.80	1444.70	2,299.50

Obliterate at 4 years

Table VIII.

Present Value Cost - Mapleton $/Mile

Blading 1010	Sluff RMV 1080	SLF RMV Contr 1085	MCH CLV CL 5040	HAND CL CLV 3041	CLV RPR 3060	Brush Mach 4020	Bruch Hand 4021	Log Out 5010	Sur RPR 1130	Ditch Mtn 3010	Sign Mtn 7120	SLF Ditch 3020	Brush Disp 4050	RPR Struct 6010	Total	Road Recon.	Total P.V.
Alternative 1 Level 2																	
2804.07	815.60	1922.42	483.59	47.55	103.08	1230.18	50.80	35.21	113.70	368.89	11.34	0	0	75.94	8062.37	6703.63	14,766.00
Alternative 2 Level 1																	
1491.83	831.44	1203.97	305.93	21.03	8.88	805.87	113.33	29.97	100.67	241.42	7.96	0	0	62.92	5225.22	9576.61	14,801.83
Alternative 3 Clearcut and Reentry																	
Obliterate = 854.80															854.80	1444.70	2,299.50

Obliterate at 4 years.

the different activity codes. The activities listed are not independent. Changing one activity might not change other values in the next year but over a rotation it is bound to have some effect.

Cost/Revenue Comparison

To illustrate the effect that maintenance costs have on the value of timber, a comparison was made using different logging systems and various timber volumes. Road densities of five and three miles per section were used to figure total costs. The five miles per section is a typical average for highlead and ground based systems and the three miles per section is average for long-span skyline and multispan systems (12). The present value total cost can be calculated by multiplying the miles of road by the cost per mile. This figure will vary by maintenance alternative but will be the same regardless of the volume of timber served by the roads. These present value costs can be seen in Tables IX-XII.

The present value of the timber revenues were calculated with an average bid price of Forest Service timber sales for the westside of Oregon and Washington (8). This bid price is $131.56 per thousand board feet and is an average for all species. The bid price incorporates all logging systems and road construction. The present values for the timber were figured according to the rotation diagram in Figure 3. All revenues occurred at the end of the year and were discounted back to the beginning of the rotation. These revenues were figured with three different volumes per acre. These volumes per acre represent approximate volumes for Site Classes II, III, IV (5). The present values of the timber revenues varied with differing volumes but did not change by district or road density. The timber revenues for the first and second alternatives are the same because the harvesting occurs at the same intervals. These present value revenues can be seen in Tables IX-XII. The cost/revenue ratios for each maintenance alternative is compared to volume per acre in Figures 6-8.

Table IX. Cost-Revenue Comparison Long Span-Multispan Skyline Systems

Sweet Home - 3 miles per section

Analysis for 1 section (640 acres) $/section

	Maintenance Alternative	Present Value Timber Rev.	Present Value Costs	Cost/Revenue Ratio
Volume/Acre	Open	447,590.08	28,826.73	6.4%
15 MBF	Close	447,590.08	31,611.15	7.1%
(Site Class IV)	Clearcut	1,146,117.64	6,898.50	0.6%
40 MBF	Open	1,193,573.58	28,826.73	2.4%
(Site Class III)	Close	1,193,573.58	31,611.15	2.7%
	Clearcut	3,056,313.70	6,898.50	0.2%
65 MBF	Open	1,939,557.01	28,826.73	1.5%
(Site Class II)	Close	1,939,557.01	31,611.15	1.6%
	Clearcut	4,966,509.77	6,898.50	0.1%

Table X. Cost-Revenue Comparison Ground Based and Highlead Systems

Sweet Home - 5 miles per section

Analysis for 1 Section (640 acres) $/section

Volume/Acre	Maintenance Alternative	Present Value Timber Rev.	Present Value Costs	Cost/Revenue Ratio
15 MBF (Site Class IV)	Open	447,590.08	48,044.55	10.7%
	Close	447,590.08	52,685.25	11.8%
	Clearcut	1,146,117.64	11,497.50	1.0%
40 MBF (Site Class III)	Open	1,193,573.58	48,044.55	4.0%
	Close	1,193,573.58	52,685.25	4.4%
	Clearcut	3,056,313.70	11,497.50	0.4%
65 MBF (Site Class II)	Open	1,939,557.01	48,044.55	2.5%
	Close	1,939,557.01	52,685.25	2.7%
	Clearcut	4,966,509.77	11,497.50	0.2%

Table XI. Cost-Revenue Comparison Long Span-Multispan Skyline Systems

Mapleton - 3 miles per Section Analysis for

1 section (640 acres) $/section

	Maintenance Alternative	Present Value Timber Rev.	Present Value Costs	Cost/Revenue Ratio
Volume/Acre	Open	447,590.08	44,298.00	9.9%
15 MBF	Close	447,590.08	44,405.49	9.9%
(Site Class IV)	Clearcut	1,146,117.64	6,898.50	0.6%
40 MBF	Open	1,193,573.58	44,298.00	3.7%
(Site Class III)	Close	1,193,573.58	44,405.49	3.7%
	Clearcut	3,056,313.70	6,898.50	0.2%
65 MBF	Open	1,939,557.01	44,298.00	2.3%
(Site Class II)	Close	1,939,557.01	44,405.49	2.3%
	Clearcut	4,966,509.77	6,898.50	0.1%

Table XII. Cost-Revenue Comparison Ground Based and Highlead Systems

Mapleton 5 Miles Per Section Analysis

for 1 section (640 acres) $/section

	Maintenance Alternative	Present Value Timber Rev.	Present Value Costs	Cost/Revenue Ratio
Volume/Acre	Open	447,590.08	73,830.00	16.5%
15 MBF	Close	447,590.08	74,009.15	16.5%
(Site Class IV)	Clearcut	1,146,117.64	11,497.50	1.0%
40 MBF	Open	1,193,573.58	73,830.00	6.2%
(Site Class III)	Close	1,193,573.58	74,009.15	6.2%
	Clearcut	3,056,313.70	11,497.50	0.4%
65 MBF	Open	1,939,557.01	73,830.00	3.8%
(Site Class II)	Close	1,939,557.01	74,009.15	3.8%
	Clearcut	4,966,509.77	11,497.50	0.2%

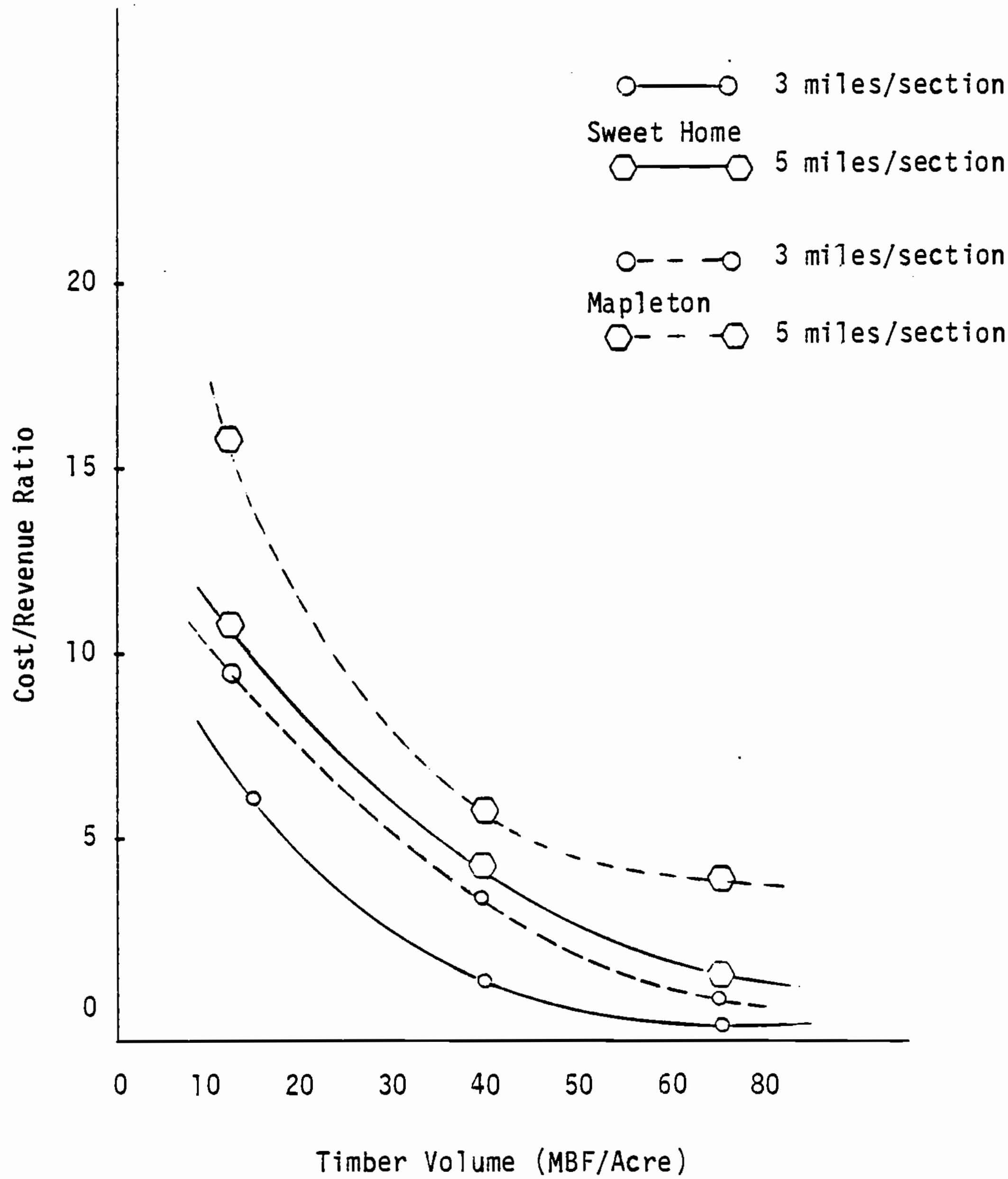


Figure 6. Cost/Revenue Ratio Alternative 1

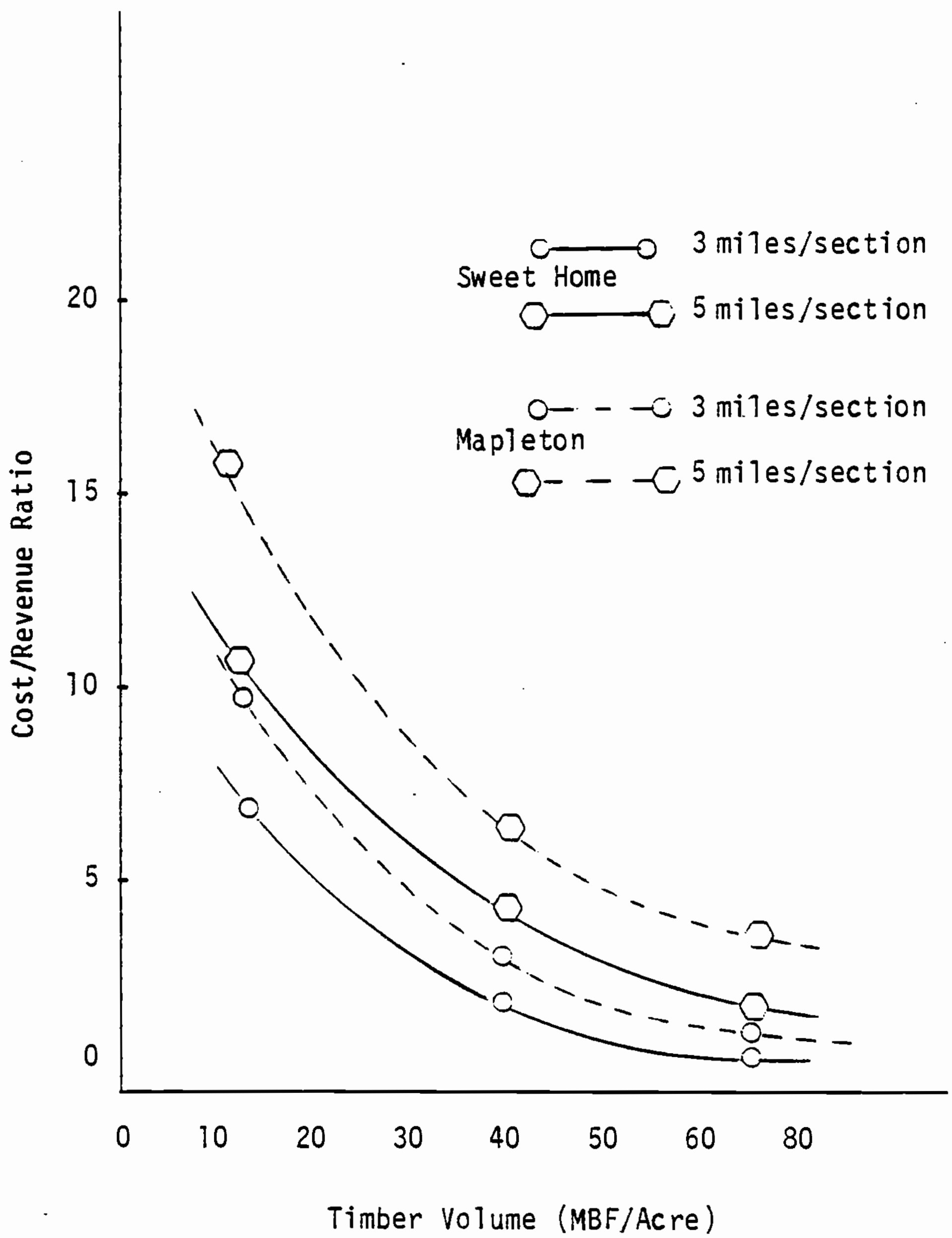


Figure 7. Cost/Revenue Ratio Alternative 2

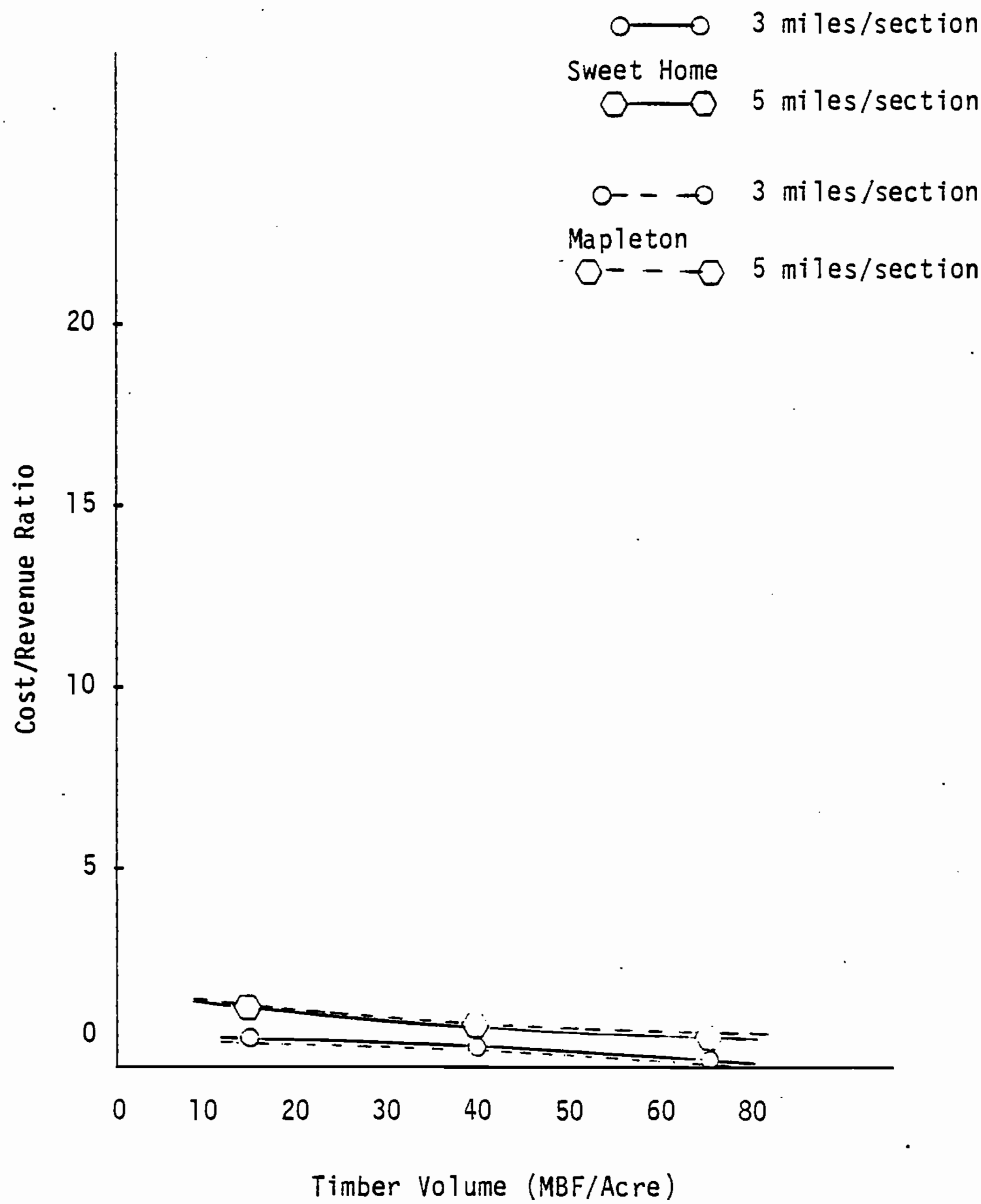


Figure 8. Cost/Revenue Ratio Alternative 3

RESULTS

Because the nature of the two districts is so different the maintenance costs for each level should be expected to be different. The maintenance costs presented amount to a regression relationship with maintenance level being the lone independent variable. In reality there are many more variables which could affect the cost values. Factors such as road grade, landtype, elevation, precipitation and type of road construction all may have an effect on needed maintenance.The Mapleton District has more unstable ground and a greater brush control problem. Also, a good portion of the Sweet Home District receives snow rather than rain during the winter months which results in a lower incidence of slope failure as evidenced by a larger expenditure for sluff removal at Mapleton. It is beyond the scope of this project to analyze these variables. In spite of these factors the level one maintenance cost seemed high on the Mapleton District. Part of this could be attributed to the blading cost. The Sweet Home District did no blading on level one roads.

The economic results of this study were somewhat surprising. The average figures from these two data sets indicate that it is more economical, based on present value, to leave a road system open and maintain at level two than it is to close and reopen roads for each reentry. It would be difficult to say whether alternative one or two is economically superior to the other within the variability of the data collected. The present values for both sets of data are very close. On the Mapleton District the difference between these two alternatives is very small. On the Sweet Home District there is a greater spread between the first two alternatives. The end result is still the same. It is more economical to leave roads open than it is to close and reopen with each entry. The reason for the larger spread between alternatives is that the average cost for each level of maintenance is lower at Sweet Home than on the Mapleton District. This lower maintenance cost gives greater weight to the reconstruction costs which results in a greater spread in the present values of the two alternatives for the Sweet Home data.

Clearcutting the entire area and obliterating the roads was by far the economically superior alternative. The costs for this alternative were 15 to 24 percent of the costs for the other two alternatives. This range depended on which district was considered and whether the roads were closed or left open.

When comparing the cost for maintenance to the total timber revenues the maintenance costs make up a small percentage of the total revenue. As would be expected, the larger the timber volumes, the smaller the percentage for a given density of roads. For the third alternative the percentage was very low regardless of the timber volume. For the first two alternatives as the timber volume decreased the percentage went up rapidly. These results are demonstrated graphically in Figures 6-8. Because the bid price used to calculate the revenues was an average value the logging cost associated with it is also an average of all logging systems. Therefore timber revenues are the same for each logging system for a given timber volume. It is not known how important different bid prices for different logging systems would affect the results.

SUMMARY

The results of this study reveal two major implications. The analysis indicates that it is not economically better to close roads after harvest if reentry is anticipated in the short term. These results also demonstrate dramatically the economic benefit of clear-cutting the entire area served by the roads and then obliterating the system for the length of the rotation.

Looking at the first of these observations the outcome depends more on the reconstruction cost than on the maintenance cost. From Tables VII and VIII the present value of the road reconstruction is much higher than for the road maintenance. Therefore if the road reconstruction values change depending on the terrain, either of the first two alternatives could be better economically. For example, a road in an arid climate and flat terrain would be very inexpensive to rebuild. In this case the reconstruction costs would be so low that the maintenance values would be the dominant cost and determine the best economic outcome. It would probably be cheaper to close the roads and reopen them for reentry.

Conversely, for a road in steep unstable terrain, it you would probably be better to leave the road open because the road reconstruction costs would be high. In this case, by closing the road the system would deteriorate much faster than if the road was left open and maintained. The reconstruction costs for the closed road would be much higher than the open road. The reconstruction costs would be

more dominant than the maintenance costs and the present value for the open road system would be lower. Using the average results from this study it appears that leaving roads open is better economically. But these results do not give a definitive best option. The present values are close and within the reliability of these numbers, no best alternative can be surmised from the first two alternatives. The third alternative is by far the best economic alternative. Under all conditions this will be the cheapest option.

Only economics is considered in the analysis of these alternatives. No value has been placed on other resources. In true multiple use management the third alternative will rarely happen. Clearcutting an entire area would have a large effect on wildlife habitat, stream quality, fish habitat and the soil. In areas managed primarily for timber, such as private land, this alternative has to look appealing from an economic standpoint. Even if a reentry was made in the middle of the rotation for silvicultural work, this would very likely still be the best alternative.

As seen in Tables IX-XII, the cost of maintaining and opening roads is a very small percentage of the total timber revenue. Although the percentage is small, present value costs of up to $75,000/section are nothing to dismiss lightly. What this means is if you put $75,000/section in the bank at the start of the rotation you would have enough money to pay for your maintenance and reconstruction, not considering inflation.

As mentioned previously, the results of this study were intended to be used as a tool by road managers and decision makers to help decide how forest roads should be maintained. It appears that in most cases, for westside forests in Oregon and Washington that whether a road is left open or closed, the economics are very similar with a slight edge going to leaving them open. This means that other multiple use factors such as fire control, wildlife, water quality, administrative access and public opinion will carry greater weight because of the similarity of the road maintenance economics.

During data collection it was discovered that information from past years has a tendency to get erased, lost or forgotten. The RMIS system does not summarize activities and costs by maintenance level. The nature of the Forest Service organization encourages personnel promotion by transfer of duty station. Because of this when a road manager transfers much information goes with him. For these reasons maintenance data collection on Forest Service road systems is difficult.

SUGGESTIONS FOR FURTHER RESEARCH

Nothing could be found comparing the economics of leaving roads open versus closing them. Possibilities for further research in this area are large. This study just scratches the surface on this topic. The data collected was far from absolute, which can be attributed partially to the maintenance summary system used by the Forest Service. The system is cumbersome and complex, although the process seems to be getting streamlined through gradual change. A better working knowledge of the system by technicians on the ground will also improve the quality of the cost data. From the data collected for this study, it seemed that the quality of the summaries increased with each passing year, especially at Sweet Home.

One other problem encountered was lack of information from past years. For further research to be done in this area quality information from the past must be retrievable. With good information more detailed and complex studies can be done. Also, results of this study are only applicable to the westside of Region 6. Other studies could be done on the eastside and other regions. As future studies develop, other resource values can be considered along with road costs.

As can be seen, there is considerable work that can be done in this area. It is hoped that this project is a starting platform for additional , more complex, study in this area.

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