TFW-SH14-91-007

A ROAD DAMAGE INVENTORY FOR THE UPPER DESCHUTES RIVER BASIN

By
Steven Toth

TIMBER/FISH & WILDLIFE

JANUARY 1991

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A Final Report
Submitted to the SHAMW Committee
by
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January, 1991

ACKNOWLEDGEMENTS

This was a joint cooperative project between the Squaxin Island Tribe Fisheries and Weyerhauser Company. The support and guidance of Dave Schuett-Hames with the Squaxin Island Tribe Fisheries helped get the project underway and finished. Jim Ward of Weyerhauser Company helped do the landslide inventory and drew up the road age class map from air photos. Steve Barnowe-Meyer and Ken Lentz, Weyerhauser Company road engineers, were invaluable in identifying damage sites and explaining what really happened. They also drew up the road maintenance level map. Thanks also to the many people who helped develop the field form.

ABSTRACT

In early January, 1990, a 100+ year storm event hit the upper Deschutes River basin causing extensive road damage. This study examined a number of road damage sites to evaluate the factors that contributed to road system problems. Physical terrain features, road construction standards, and road maintenance levels were analyzed for each damage site. A landslide inventory for the basin was also done using air photos. Roads built in the last fifteen years survived the storm with minimal damage, but roads built 16-45 years ago had very high damage rates. The majority of problems occurred because of steep cutslopes and blocked culverts. Since culvert problems cause the most amount of environmental damage, first priority should be given to replacing older culverts and developing a better inventory of their condition. Another recommendation is to base road maintenance levels on sensitivity to problems rather than on amount of use. Finally, better organization of and access to accumulated data would allow engineers to utilize this information for planning road system maintenance and reconstruction.

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Introduction

Forest roads have long been implicated in contributing to landslide initiation and downstream sedimentation in the Pacific Northwest. Mass failures from poorly located or constructed roads have been shown to be a major source of sediment and erosion in forested lands (Dyrness, 1967; Swanson & Dyrness, 1975). Over the past few years, forest managers have reduced this risk by improving construction methods and upgrading maintenance levels. This has become especially important as more logging takes place in the upper reaches of watersheds where there is steeper and potentially more unstable terrain.

In the first part of January 1990, a high intensity storm passed through the Deschutes River watershed causing extensive road damage. From January 5-9, the storm delivered a total of 44.2 cm (17.4 in) of precipitation as measured at the Ware Creek gaging station which is at an elevation of 475 m (1500 ft). The storm averaged about 5.5 cm (2.2 in) per day, culminating with 20.93 cm (8.24 in) on January 9th. Using rainfall data from the National Oceanic and Atmospheric Administration (Miller et al., 1973), the 100-year 24-hour precipitation event at the gaging station was calculated to be approximately 17.8 cm (7.0 in), so this storm was well in excess of that amount.

The large storm event initiated many road-related failures throughout the basin, providing an opportunity to examine how roads built under different construction standards survived a storm exceeding design specifications. An inventory of storm related damage would also identify other problems such as areas of unstable soil or inadequate road maintenance. This information could help in the development of a road system inventory that would evaluate the condition of roads before serious problems occur.

The purpose of this project was to examine a number of sites that sustained damage and to analyze factors contributing to road prism failures. This information would help evaluate the effectiveness of changes in road construction and identify areas that may be prone to future problems.

Physical Description of the Deschutes River Basin

The area of study encompasses the upper portion of the Deschutes River watershed, from the town of Vail to its headwaters (see figure 1). The area is owned by Weyerhauser Company and is part of the Vail Tree Farm management area.

The basin is characterized by deep valleys with long steep slopes, often exceeding 35 degrees. Elevation ranges from about 210 m (700 ft) at Vail to 1100 m (3600 ft) at the highest points in the watershed. Surface deposits on ridges are shallow to unweathered bedrock; while on the gentler slopes, deeper residual soils have formed (Steinbrenner & Gehrke, 1964). Parent material is primarily composed of basalt and andesite flows from the Eocene Epoch. A small portion in the northern part of the basin is covered by Quatenary glacial and alluvial deposits (see figure 2). Soils are variable in depth ranging from less than 40 cm to 100 cm (Sullivan, et al., 1987).

The vegetation is composed primarily of Douglas-fir (Pseudotsuga menziesii), western hemlock (Tsuga heterophylla), and Pacific silver fir (Abies amabilis) in the upper elevations. Logging in the basin has been ongoing since the 1950s and most of the watershed now consists of second-growth forest. An extensive road system is in place with a total road mileage in the upper basin of 575.2 km (see figure 3).

The average annual precipitation ranges from 115 cm (45 in) to more than 230 cm (90 in) (Miller et al., 1973). Much of the basin is within the transient snow zone that ranges from 350 - 1100 meters (1100-3600 ft). Within this zone, the rapid melting of warm snowpacks during rainfall events can cause higher input rates of water than expected from precipitation alone. Timber harvesting in the transient snow zone has been shown to cause increased peak flows in both small and large watersheds (5 to 637 km^2) (Harr, 1986; Christner & Harr, 1982). The January storm did produce some snow at higher elevations, but the snowpack was too small to consider this a rain-on-snow event.

Methods

Three factors that would help determine the ability of a road to survive a major storm event were identified; road age, road maintenance level, and physical terrain features. A road age map was developed from air photos by Jim Ward of Weyerhauser Company. The road maintenance level map was drawn up by Ken Lentz, the district road engineer for Weyerhauser Company. Physical terrain features were evaluated by visiting a number of damage sites, and then analyzing them in relation to road age and maintenance level.

A total of 76 road damage sites were evaluated for this study (see figure 4). The sites were chosen by the Vail Tree Farm road engineer. Since there were hundreds of sites that incurred varying degrees of damage, a sample of them needed to be taken. The sites, however, were not catalogued in any way, and therefore were simply chosen from memory by the engineer. Statistical analysis of the data was not possible because this was not a random and non-biased sample, but the information could still provide insight into the various types of problems in the watershed. The engineers felt it was a proportionately representative sample including most of the larger and more obvious problems that caused serious damage, as well as the smaller and less serious damage sites. Many of the sites had been repaired by the time of this study, making it difficult at times to accurately assess the causes for failure. The engineers, though, were able to provide the necessary information to evaluate the site conditions prior to repair work.

A road damage form was developed to describe the type of damage, the reasons for the failure, and the pertinent physical terrain and road features. A sample form is shown in figure 5.

Five different types of road damage were categorized on the form with a list of possible causes. Shoulder damage could range from cracking in the sidecast material to complete loss of the shoulder down the hillside. Road slumps included any damage to fill material such as loss of fill due to mass wasting or slight depressions due to settling of the road. Backslope problems were usually associated with cutslope failures, but included any road prism damage due to a ditch problem or poor grading. Since culvert problems did not involve loss of soil integrity like landslides, additional stream channel information was included. If the road problem contributed sediment into a channel, it was marked as causing environmental damage. Finally there were sites that had damage caused by non-road related failures or failures from another road. In these cases, there was some damage to the road, but not because of a problem with that particular road.

Information on the terrain features around the damage sites was recorded to determine their contribution to road damage. While the geologic map provides general descriptions of the bedrock on a gross scale, it was not adequate for this more site-specific aspect of the study. The soil type was determined in the field to provide a general description of its porosity and cohesion. Soil maps were also used to identify the soil class in each area, but like the geologic map, the scale used was not fine enough to adequately describe the site specific characteristics. Characterizations of the slope form, position of the failure on the slope, and vegetation type and age were also included.

The final aspect of the study consisted of developing a landslide inventory from air photos at a scale of 1:12,000. The inventory included both non-road and road related problems due to the January storm. Old landslides that had been reactivated were included. Other details such as stand age around the landslide and sediment entry into a stream were also noted.

Results and Discussion

Road Characteristics by Age Class

Figure 6 contains the road age map and figure 7 shows the proportion of roads in the basin by age class. The age classes were defined according to changes in construction standards. The oldest roads, 46-65 years old, were built upon old railroad grades, and had large amounts of fill with cedar puncheon culverts at stream crossings. Cedar puncheon culverts consist of two large cedar logs placed parallel along the stream channel with shorter pieces spiked or cabled crosswise on top of the logs (see figure 8). The roads generally had poor surface water drainage with few, if any, relief culverts. These roads are further classified into abandoned, partially-reconstructed, and fully- reconstructed roads. Abandoned roads were not considered because they were inaccessible. Partially-reconstructed roads have had some improvements made to allow for heavy truck traffic and for additional placement of relief culverts. Fully-reconstructed roads have had puncheon culverts replaced with steel ones, new fill material, and a better drainage network installed.

The next age class, roads built 16-45 years ago, were built by Weyerhauser Company construction crews. There were no forest-practice standards or permits required at that time. By present standards, these roads generally had small culverts and too few of them. All waste material from the roads was placed as sidecast.

All roads constructed 6-15 years ago were built using the same construction techniques as the prior age class of roads; however, these roads had to be built to state forest-practice standards such as the inclusion of culverts designed for at least a 50-year storm event.

For the past five years, there has been more excavator construction on roads, with excavated material on steep slopes being removed to a waste site. Almost all of the construction is completed under contract by non-Weyerhauser Company personnel.

Combining the information from the age class map and road damage form showed significant differences in the damage rate between road age classes (see figure 9 and table 1). There was no damage to roads built in the last five years. Roads built from 6-15 years ago averaged .078 damage sites/km. Roads built from 16-45 years ago averaged .170 damage sites/km. Railroad grade roads averaged .092 damage sites/km. All of the damage on railroad-grade roads occurred in partially-reconstructed sections.

There are many reasons for the ability of the newer roads to withstand a storm that far exceeded design standards. First, culverts are designed to withstand at least a 50-year flood event, and often times, the present engineers will exceed the size recommendation given by the United States Geological Survey (U.S.G.S.) culvert sizing equation (Cummans et al., 1975) to increase their margin of safety. Perhaps the most important change in construction is that waste material is no longer placed as sidecast on steep slopes, preventing shoulder failures and possible debris flows. In the basin just south of the Deschutes River watershed, the only damage to a newer road occurred at a section where waste material was mistakenly placed as sidecast on a steep slope. Finally, it is easier for the road engineers to make sure that roads are built to their satisfaction because construction is completed under contract by non-Weyerhauser Company personnel.

It is important to note, however, that there was a small sample of the newest age class roads (10.5 km), making it difficult to do an adequate comparison with roads in the other age classes. The oldest age class of roads and those built 6-15 years ago only averaged a damage site every 10.9 km and 12.8 km respectively. The durability of the youngest roads can be better tested in the future as more roads are built, and as they weather the elements longer.

The roads built from 6-15 years ago fared better overall than the older roads with about half the damage rate of the 16-45 year age class of roads. The most notable difference between these age classes, though, was that in the 6-15 year age class, there was not a single stream or relief culvert problem. Since the only major difference in the construction methods of these two age classes was the improved standards from the state forest practice regulations, it is assumed that they played a significant role in the reduction of culvert related problems. In addition, this information shows that culverts designed for a 50-year flood event in this basin can adequately accomodate flows from a 100+ year flood event.

Certainly the fact that older roads have had to weather the elements longer and have had more time to deteriorate contributed to their higher damage rate, but the data indicates that state forest practice regulations have helped reduce culvert problems, one of the greatest sources of environmental damage.

The road age category with the highest damage rate, .170 damage sites/km, was the 16-45 year group. Most of the problems occurred with steep cutslopes and with culverts, but shoulder failures and road slumps were also significant problems. Averaging a damage site every 5.8 km, these roads should be a prime candidate for some reconstruction.

The oldest age class of roads built over 45 years ago had a moderate damage rate of .092 damage sites/km, similar to the 6-15 year age class. The moderate damage rate is probably due to the partial reconstruction of these roads. If the puncheon culverts had been replaced during reconstruction, these roads would have had very few damage sites. Another reason for the lower damage rate is that the old railroad grades are on rather flat terrain where we would naturally expect less problems with soil movement.

Road Characteristics by Road Maintenance Level

In figure 10, the road maintenance level map divides roads into four categories, and in figure 11 the proportion of roads in the watershed by maintenance level is shown. Level 1 roads are closed roads that have been water barred, but have no drainage maintenance, grading or repairs. They may be inspected after major storms to identify any potential major damage. Level 2 roads are open for forestry operations, administrative use, and fire access. They are inspected annually, usually following a major storm event. Clearing of ditches and culverts, brush control, and grading are done by priority, as identified by the annual inspection. Level 3 roads are active log haul roads. Inspections are ongoing during hauling, and annually preceding and following the haul. Culverts and ditches are more actively maintained to prevent any road or resource damage. Grading is also done more often to keep the road crowned and the surface smooth. These roads are also graded after all hauling is completed. Level 4 roads are mainline roads and main arterial haul roads. Inspections are ongoing during hauling, with more intensive inspections following major storm events. There is active maintenance of culverts and ditches as well as periodic grading. The road is maintained to allow for 100% of designed traffic and speed.

Examining the information from the maintenance level map and the road damage form showed significantly different damage rates for each maintenance category (see figure 12). Level 1 roads averaged .031 damage sites/km, while level 2 roads averaged .308 damage sites/km. The damage rate for level 3 roads declined to .110 damage sites/km and for level 4 roads declined further to .058 damage sites/km.

One would expect the damage rate to decline progressively as maintenance increases, but level 1 roads seem to present an anomoly with its very low damage rate. One reason could be that most of these are spur roads with few culverts, and many have been waterbarred to prevent any large accumulations of water on the road. Also, many of them are inaccessible and rarely visited. Inspection of level 1 roads are a very low priority, and there may have thus been more damage to these roads than indicated.

In order to better understand the relationship between road maintenance and road damage, the reasons for failures were separated into construction-related problems and maintenance-related problems (see table 2). Seventy percent of the sites had problems because of construction-related causes, while only 17% had maintenance-related causes. A combination of construction and maintenance-related causes was found at 13% of the sites.

While the number of problems directly due to poor maintenance was low (17%), the fact that there is a progressive decrease in damage rate with better maintenance levels indicates it is of some importance. There is no record of how much damage was prevented by better maintenance, but the difference in damage rates between level 2 and 3 maintenance shows it was significant. One reason why railroad-grade roads might have fared better than expected was because they were all at either level 3 or 4 maintenance. This fact helps support the need for having a good road maintenance system.

Future road damage might be prevented if maintenance levels were based on sensitivity to problems, rather than just the amount of road usage. The sensitivity of a road could be addressed by considering some combination of road age and physical terrain factors. For example, the Lincoln Creek watershed has had a history of slope stability problems, yet most of the roads are at level 2 maintenance. Increasing the maintenance level would help prevent or at least mitigate problems before they become too serious.

Physical Terrain Features

Terrain features must play an important role in determining the sensitivity of an area to landslides, but examining individual landscape elements provided little insight in this study. For example, data on parent material showed that 63% of the damage sites occurred in areas of weathered volcanic rock, 20% in areas of granitic intrusion mixed with weathered volcanic material, and 13% in areas of hard bedrock.

The granitic intrusion is localized in a small area within the Lincoln Creek watershed, and has a disproportionately high amount of road damage. It is unclear, however, if the other bedrock categories have a disproportionate number of damage sites because most of the watershed is weathered volcanic material, and the amount of hard bedrock is difficult to quantify.

Site aspect data yielded some interesting results. Two-thirds of the damage sites had a northerly orientation, while only 20% had a southerly orientation. The rest of the damage sites had a western orientation.

The reason for the large number of northerly oriented damage sites is uncertain. These sites may be prone to failures because less evapotranspiration from trees on these slopes allow groundwater levels to remain higher. A simpler explanation might be that there are more roads in the southern part of the basin that face north accounting for the higher number of damage sites. More research should be done to determine if this is consistent with other storm events and in other basins. It would be premature at this point to consider this information of significant predictive value.

Other terrain features such as slope form, position of failure on the slope, and vegetation type proved to be of little predictive value.

It seems that physical terrain features need to be examined collectively to be of any value. Rather than looking for a single terrain feature like unstable soils, problem areas might be identified by looking for the presence of a certain number or combination of significant terrain features. For example, a road system inventory might identify a potential problem area if the slope form is concave on the upper part of a slope with weathered volcanic parent material. If the site was on the lower part of a slope, though, it might not be considered a potential problem.

The difficulty, of course, lies in identifying what constitutes the significant terrain features. An interdisciplinary team of experts might be able to generate a list of conditions that would identify potential problem areas. This information would be incorporated into the road survey so that any manager could identify a potential problem area by seeing if these certain conditions are met.

Slope Stability Problems

Figure 13 contains the frequency distribution of the different types of road damage. The largest number of problems (34%) were located in the backslope. Of these failures, 65% were due to steep cutslopes. The average cutslope angle for all backslope sites was 43.7 degrees. The presence of unstable soil significantly contributed to failures in 58% of the cases. Unstable soils were defined as either coarse grained granitic soils or weathered volcanic soils with a high clay content that occurred on slopes exceeding 35 degrees. These areas usually had a past history of slides that were visible on the surrounding hillslopes.

Steep backslopes accounted for the most road damage of any of the different failure types. The cause of this seems to be steep cutslope angles in areas of unstable soil. This was especially apparent in the Lincoln Creek watershed. Many times the failures would simply land on the road and just needed to be cleared away. Just as often, however, they blocked a ditch or culvert and more serious damage resulted.

Reducing the cutslope angle in areas with unstable soils and a history of failures would be of great help. Much of the road system, though, has problems with steep cutslopes and it is not very practical to reduce the angle of every slope. Another more feasible alternative would be to pull the ditches out a bit so that small failures and cutbank raveling do not immediately cause problems. Also, maintaining a good crown on the road would keep excess water from flowing onto sidecast material and reduce the chance of failure.

Shoulder failures were another important problem comprising 18% of the sites. Excess sidecast on steep slopes was a significant factor in 93% of the shoulder failures. The average fill slope was 38.9 degrees. Twenty-nine percent of the failures caused significant environmental damage.

Road slumps accounted for only 12% of the sites. Seventy-eight percent of the problems were due to inadequate drainage. Unstable soil and fill on steep slopes were significant causes in 67% of these sites. One-third of the sites were responsible for environmental damage.

Shoulder failures and road slumps turned out to be similar problems with some common causes. The combination of unstable soil and steep slopes was the major cause of most problems. Areas with a high potential for or a past history of slides need to be identified so that measures can be taken to pull back the sidecast material and make sure that adequate drainage exits. Simply doing some mapwork that identifies areas with slopes greater than 35 degrees, would greatly aid in the process of highlighting problem areas.

Another cause that might have been an important factor was woody debris in the fill material. As the wood decays, it provides channels for water to seep into and reduces the integrity of the fill. The road engineer said that finding large stumps and pieces of wood was not uncommon, but without actually digging up the fill it was difficult to assess the magnitude of the problem.

Culverts

Culverts were the next most significant problem accounting for 29% of the damage sites. Stream culverts represented 22% and relief culverts 7% of the sites. Nearly half of the stream culvert problems involved cedar puncheon culverts, all of which caused some environmental damage. Eighty-one percent of the stream culvert problems caused significant environmental damage. The major cause of culvert problems was blockage of culverts (68% of the cases).

Culverts provided a special case of problems different from the other failure types. To work properly, they must be large enough to carry the runoff, be clear of obstructions, and be properly installed. Since most of the culverts in this basin were designed to withstand the 50-year storm event at best, it is surprising that there were not more problems with them in this 100+ year event.

Sizing a culvert is an inexact science at best. The U.S.G.S. culvert sizing equation (Cummans et al., 1975) used by the road engineers requires input of mean annual precipitation and total drainage area to the culvert. The estimate for mean annual precipitation, however, often comes from less than 50 years of rainfall record, making it difficult to accurately estimate the 50-year flood. Also, the sizing may not adequately take into account processes like rain-on-snow events where relatively small rainfall amounts can produce large runoff. The runoff from the January storm could probably be equalled or exceeded by a smaller event if rain-on-snow conditions existed. In addition, predicting the amount of runoff from the watershed area is difficult without more complete knowledge of subsurface water movement. Increasing culvert size to raise the factor of safety seems both a practical and economical precaution considering these facts. With the installation of new culverts, the present road engineers are trying to increase the factor of safety by placing larger culverts.

Culvert size is an important consideration presently because many of the older culverts need replacing. The cedar puncheon culverts were predicted to last 25-30 years (Silversides, 1949) and their replacement with steel culverts is long overdue. Many of these culverts have been replaced, but many remain in place. Considering the potential for environmental damage when they fail, replacing cedar culverts should be the top priority.

Another issue to consider is replacing the galvanized steel or aluminum culverts that have been in the ground for 30-40 years. Abrasion from sediment and acidic forest soils can greatly accelerate the deterioration of culverts, especially once the galvanized coating is lost. Depending on the thickness of the culverts, their design life under these conditions could range from 20-40 years (American Iron & Steel Institute, 1971). An inventory of culverts with their location and age would prove useful so that systematic, thorough inspections and maintenance could be done.

Again considering the possible damage to both the road and channel downstream, it seems economically sound to take these preventative measures now.

Most of the culverts were blocked by debris that was carried down by a stream or by runoff in ditches. A greater effort should be made to keep slash out of the channels and away from culverts. Another preventative measure with culverts would be to install trash racks in front of them. This would prove to be most helpful in recently logged areas where slash has accumulated in the channel. There were no trash racks in evidence at any of the sites, and they may have helped to reduce the number of blocked culverts.

Landslide Inventory

The landslide inventory data contained similar information to that collected in the road damage survey, but since the landslide inventory was a complete, non-biased sample, it was possible to do some statistical analysis. Figure 14 shows the location of the landslides and table 3 summarizes other information collected in the inventory. Two-thirds of the landslides in the sample were road related. There was no significant correlation between the origin of failure and the frequency of stream entry. The frequency of stream entry for both road and non-road related failures was approximately 60%.

Stand age data, on the other hand, provided some interesting results. For the sample as a whole, there was a significant difference in the frequency of slides between the younger and older stand age classes (X^2 =11.4, α =0.5), with nearly 80% of the failures occuring in stands less than 16 years old.

If we divide the sample into road and non-road related groups, however, there is a significant difference. For non-road related failures, there is still a significant difference in the frequency of slides between stand age classes (X^2 =8.33, α =0.5), but for the road related failures there is no significant difference. The results for non-road related failures agrees with other studies that have shown that as root strength diminishes, usually within 5-15 years after harvesting, the chances for failures greatly increases (Sidle et al., 1985). Stand age information, though, does not appear to be an important factor in determining the probability of road related failures.

Conclusions & Recommendations

Roads in the Deschutes basin built in the last 15 years weathered the January storm event well, but most of the older roads had significant problems. Since little new road construction will take place in the future, more time and effort must be placed in upgrading older road segments. Replacement of cedar puncheon culverts should be the first priority with a subsequent inspection of older metal culverts. A better inventory of culverts for the road engineers would prove invaluable in preventing future problems. It would provide for a more systematic schedule of inspections and maintenance and help point out problem areas.

A general road condition survey would also help identify areas that might need extra work during large storm events. This would dictate maintenance levels based on sensitivity to problems rather than just amount of road usage. Finally, such a survey would provide a base of information so that the information is not lost when an engineer retires or leaves.

Much of the data needed for the inventory has already been collected, and just requires some consolidation and organization. Setting up a computer database would seem the most efficient means for achieving this. Once the inventories are completed, problems could be easily identified and monitored. This will help to prevent or at least mitigate problems before they become too serious.

Table 1. Road damage rate for each age class of road by type of road damage.

Road Damage Rates (damage sites/km)

	Road Age Class (yrs)			
	0-5	**6-15**	**16-45**	**>45**
Backslope	0	0.039	0.057	0.015
Culvert	0	0	0.057	0.046
Shoulder	0	0.033	0.027	0
Road Slump	0	0.013	0.021	0

Table 2. Description of construction and maintenance related problems.

<u>Construction-related</u>

1. Inadequate drainage - lack of culverts, ditch too shallow, inadequate slope to ditchline
2. Sidecast or fill on steep slopes
3. Problem with fill material or compaction of fill
4. Backslope too steep
5. Wrong size culvert
6. Poor installation of culvert

<u>Maintenance-related</u>

1. Ditch problem - debris in ditches, cutbank raveling
2. Poor grading
3. Culvert blocked

Table 3. Landslide inventory data.

Site #	Road Related	Stream Entry	Stand Age
1	0	0	6
2	0	1	30
3	1	0	6
4	1	1	6
5	1	1	6
6	0	1	6
7	0	1	6
8	0	1	0
9	0	1	0
10	1	1	0
11	1	0	6
12	1	1	6
13	0	1	0
14	0	0	0
15	1	0	0
16	1	1	0
17	1	0	6
18	0	1	0
19	1	0	6
20	1	0	6
21	0	0	6
22	1	0	16
23	1	1	16
24	1	0	6
25	1	1	0
26	1	0	0
27	1	1	0
28	1	1	0
29	0	1	6
30	1	1	30
31	1	1	16
32	1	1	0
33	1	0	0
34	0	0	0
35	0	0	6
36	1	1	16
37	1	1	16
38	1	1	16
Total	25	23	

Legend

Road Related

0 = Non-road related
1 = Road related

Stream Entry

0 = Non-stream entry
1 = Stream entry

Stand Age

0 = 0 - 5 years
6 = 6 - 15 years
16 = 16 - 30 years
30 = > 30 years

Figure 1. General Location of Deschutes River Basin
(from Sullivan et al., 1987)

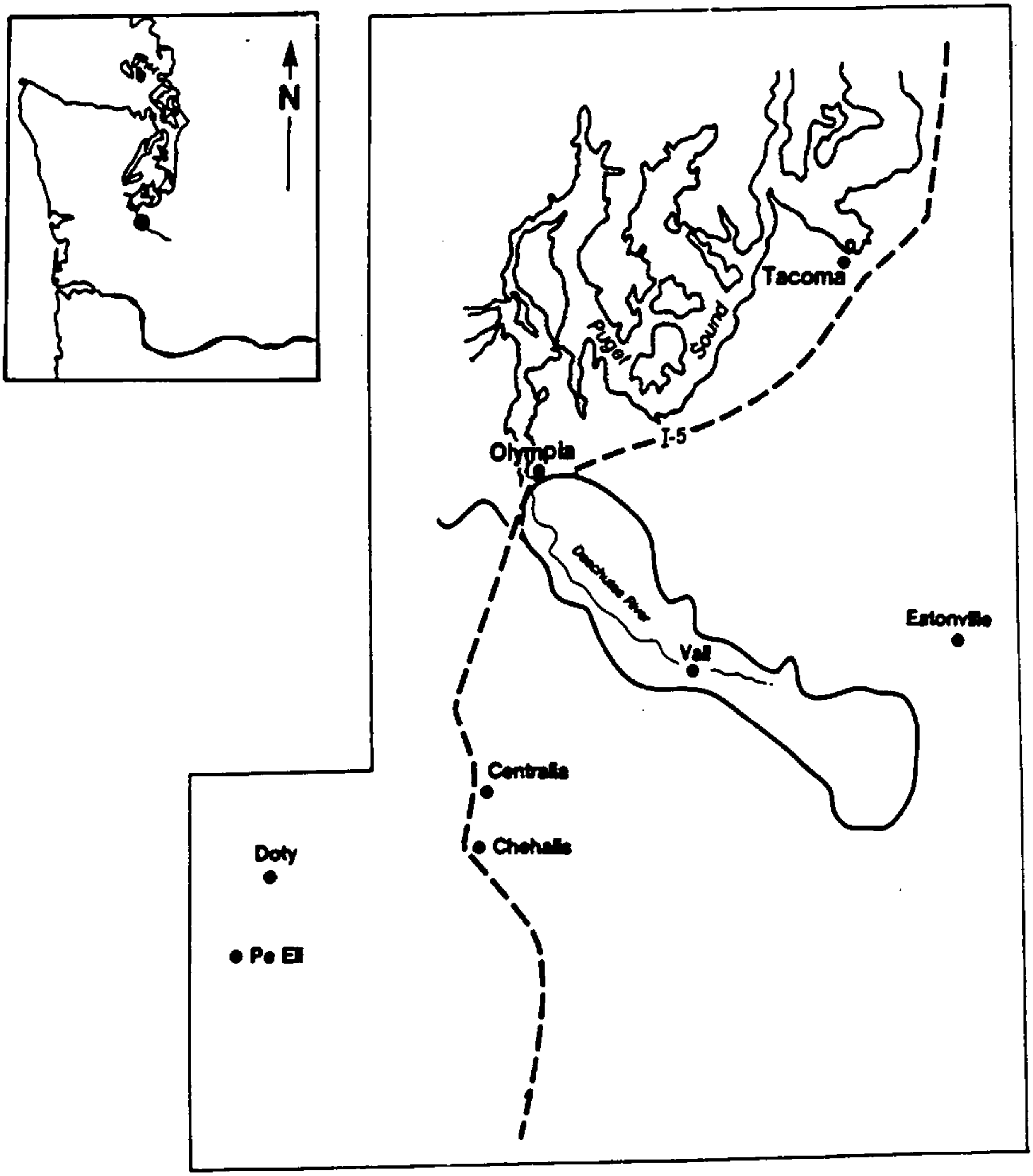


Figure 2. Geologic Map of the Upper Deschutes River Basin (from Sullivan et al., 1987)

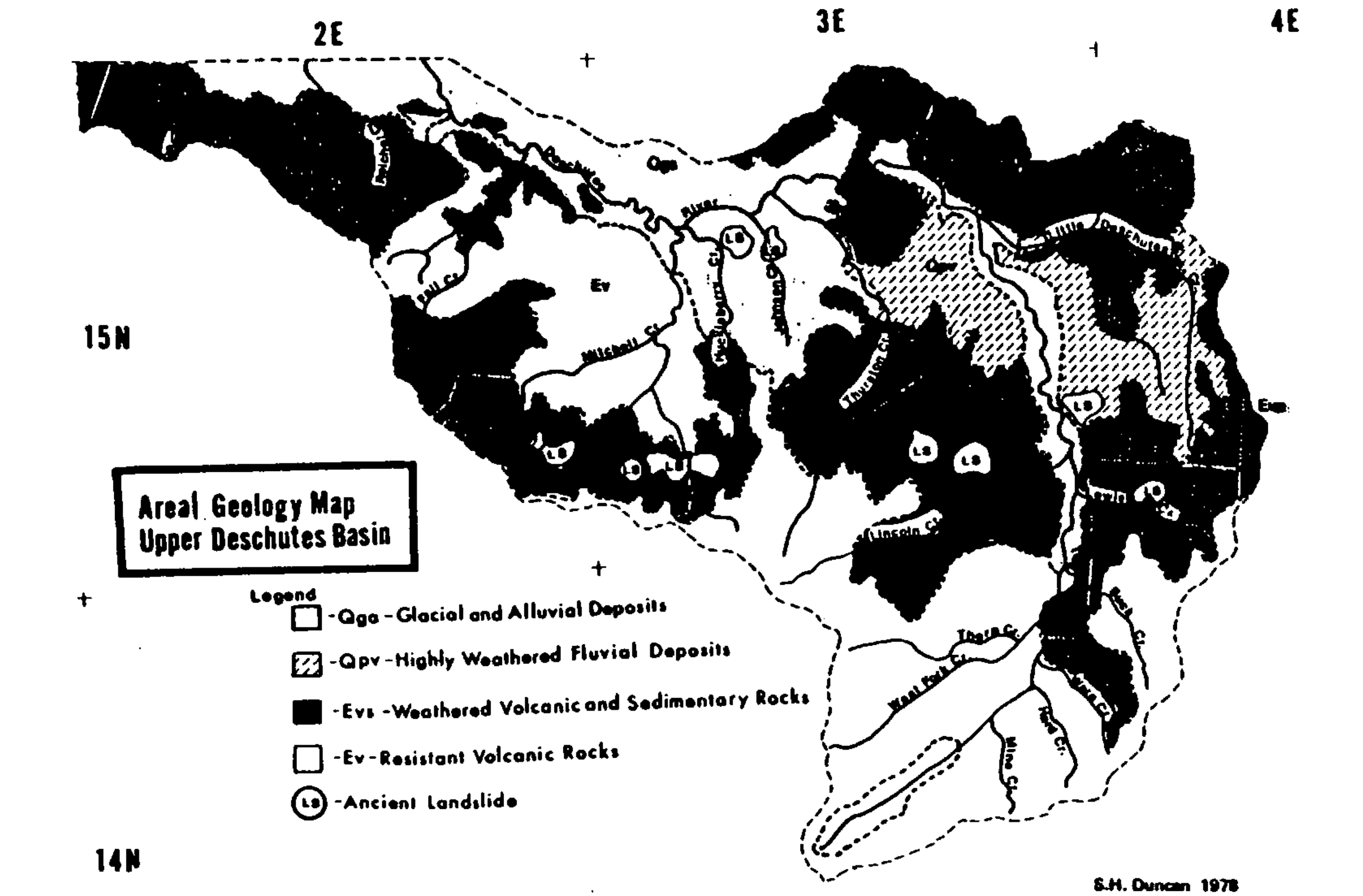


Figure 3. Upper Deschutes Basin Road Map

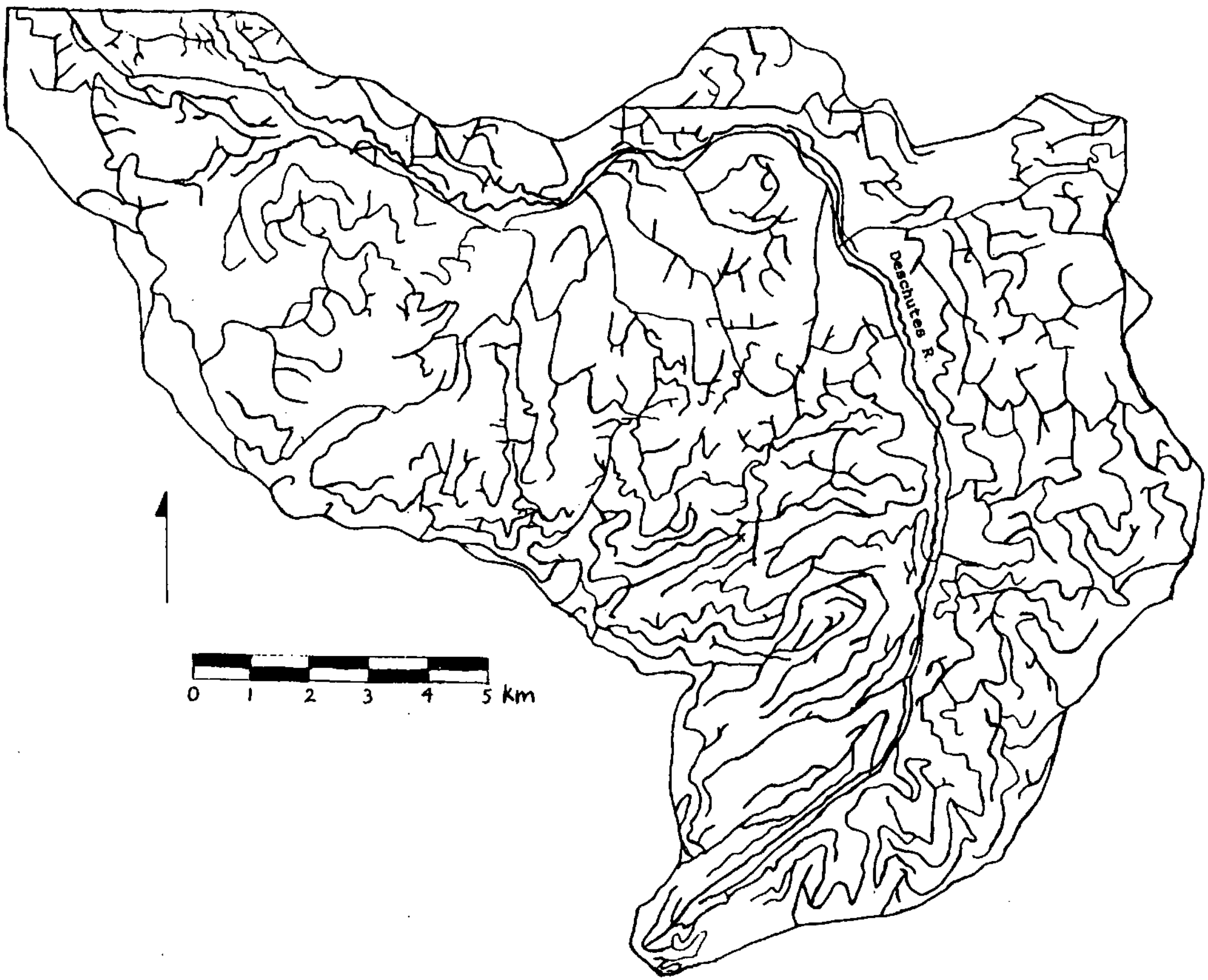


Figure 4. Location of Sample Road Damage Sites

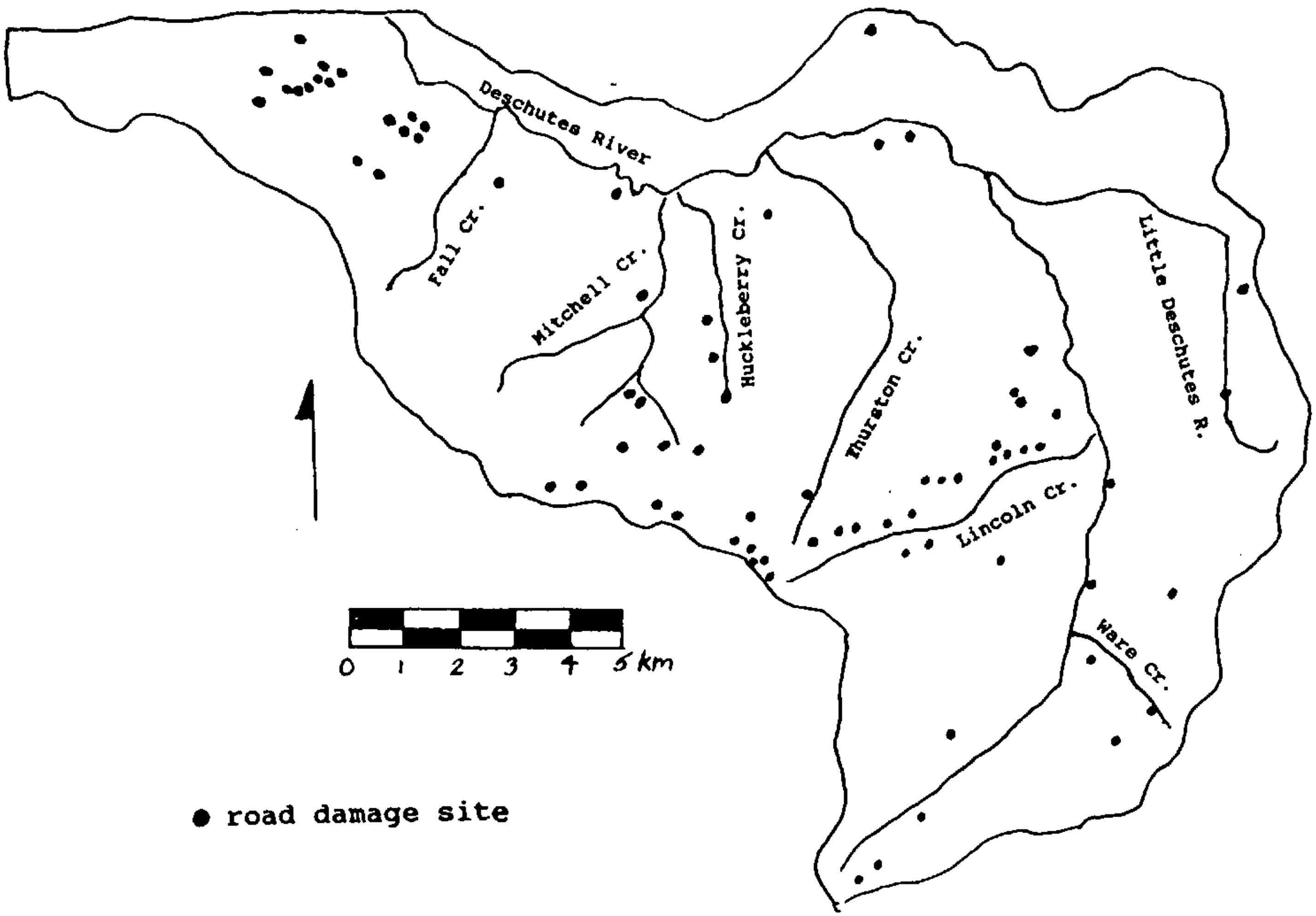


Figure 5. Road Damage Field Form

Deschutes Road Damage Inventory Form

SLIDE # _____
ROAD # _____

SUB-BASIN __________
ELEVATION __________
ASPECT __________

Road Construction

Road Age(yrs): 0-5   5-15   15-45   45-65
Road Type: RR Grade   Spur   Landing
1) Abandoned
2) Reconstructed
3) Fully Reconstructed
Maintenance Level: __________
Constr. Design: Sidecast   Endhaul
Gradient: __________
Slope Angle: Cut __________
Fill __________
Failure Type & Causes:

Shoulder	**Road Slump**	**Backslope**	**Road-related** dist from road
Subsurf. H2O	Inadequ. fill compact	Cutbank raveling	__________
Excess sidecast	Inadequ. drainage	Steep cutslope	
Woody debris in fill	Unstable soil & woody debris	Debris in ditches	**Non-road related mass failure**
		Too shallow ditch	
Surface H2O	Fill on steep slopes	Slope to ditchline	
No fill protect.	Subsurface H2O	Poor grading	

Stream Culvert
Relief Culvert

Stream Order __________
Stream Type __________

Culvert blocked
Wrong size
Poor installation
Stream channel change

Channel Gradient __________
Bankfull Width __________
Environmental Damage __________

PHYSICAL FACTORS

Bedrock Type: Volcanic Intrusive Glacial Other_____
Bedrock Structure: Hard Fractured Weathered Unknown
Soil Type: Cobble Gravel Sand Silt Clay Loam   Class: __________
Slope (Natural): Above Road __________
Below Road __________
Average __________
Slope Form: V-notch Concave Convex Straight
Position of Failure: Ridge Upper 3rd Mid 3rd Low 3rd Bottom
Stand Age(yrs): 0-5   5-15   15-30   >30
Vegetation: Few trees Patchy Conifer Hardwood Conifer
Brush Alder & Brush Fern & Brush Fern
Slide Type: Slump Earthflow Shallow Slide Deep Slide Debris Flow

Figure 7. Proportion of Roads in Basin
By Road Age Category

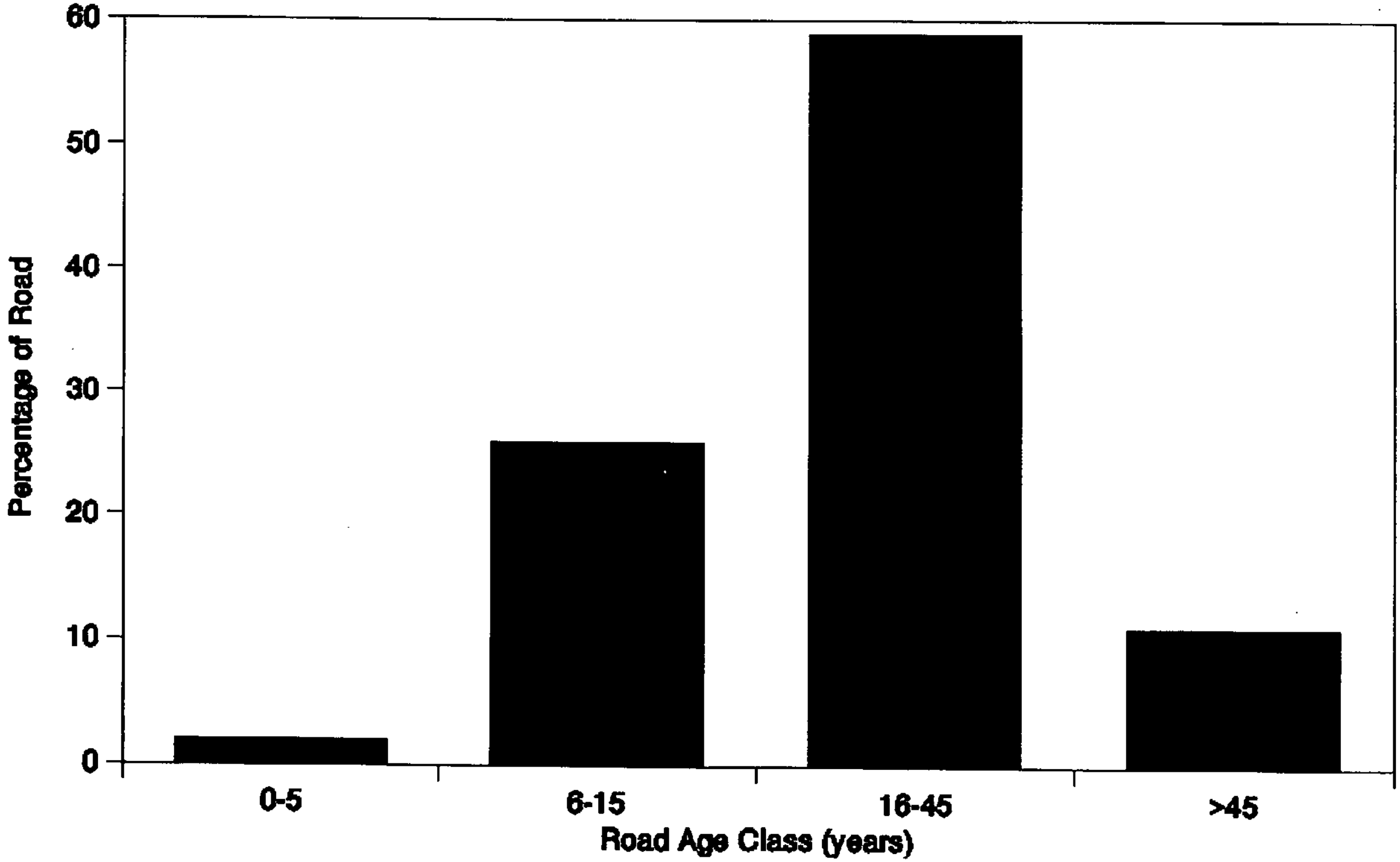
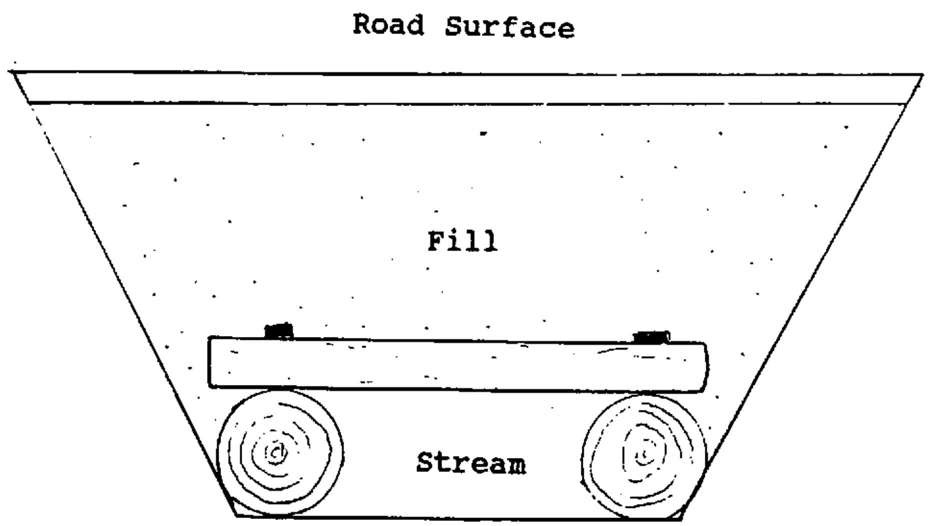
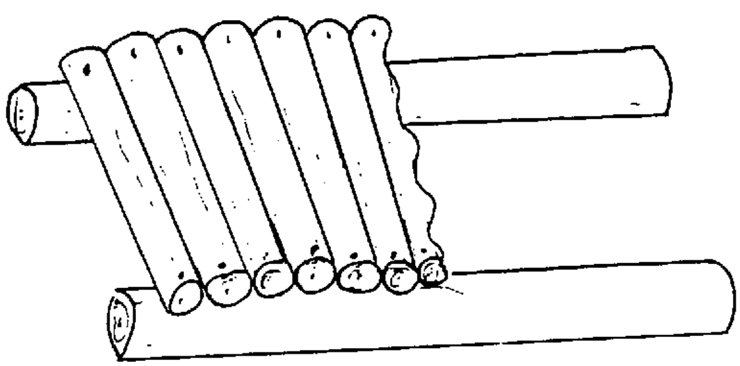


Figure 8. Cedar Puncheon Culvert

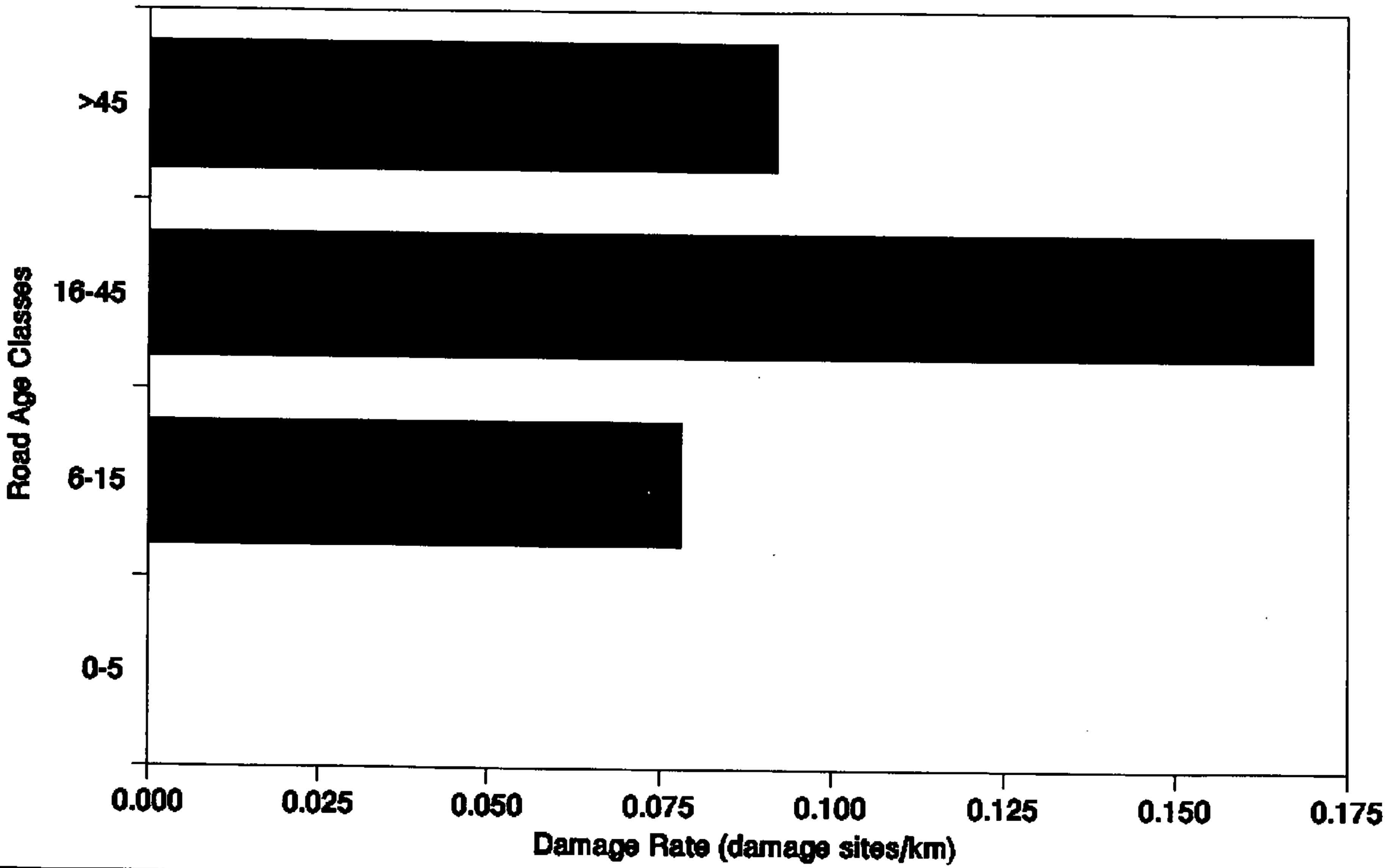


Front View



Top View

Figure 9. Damage Rate by Road Age Class



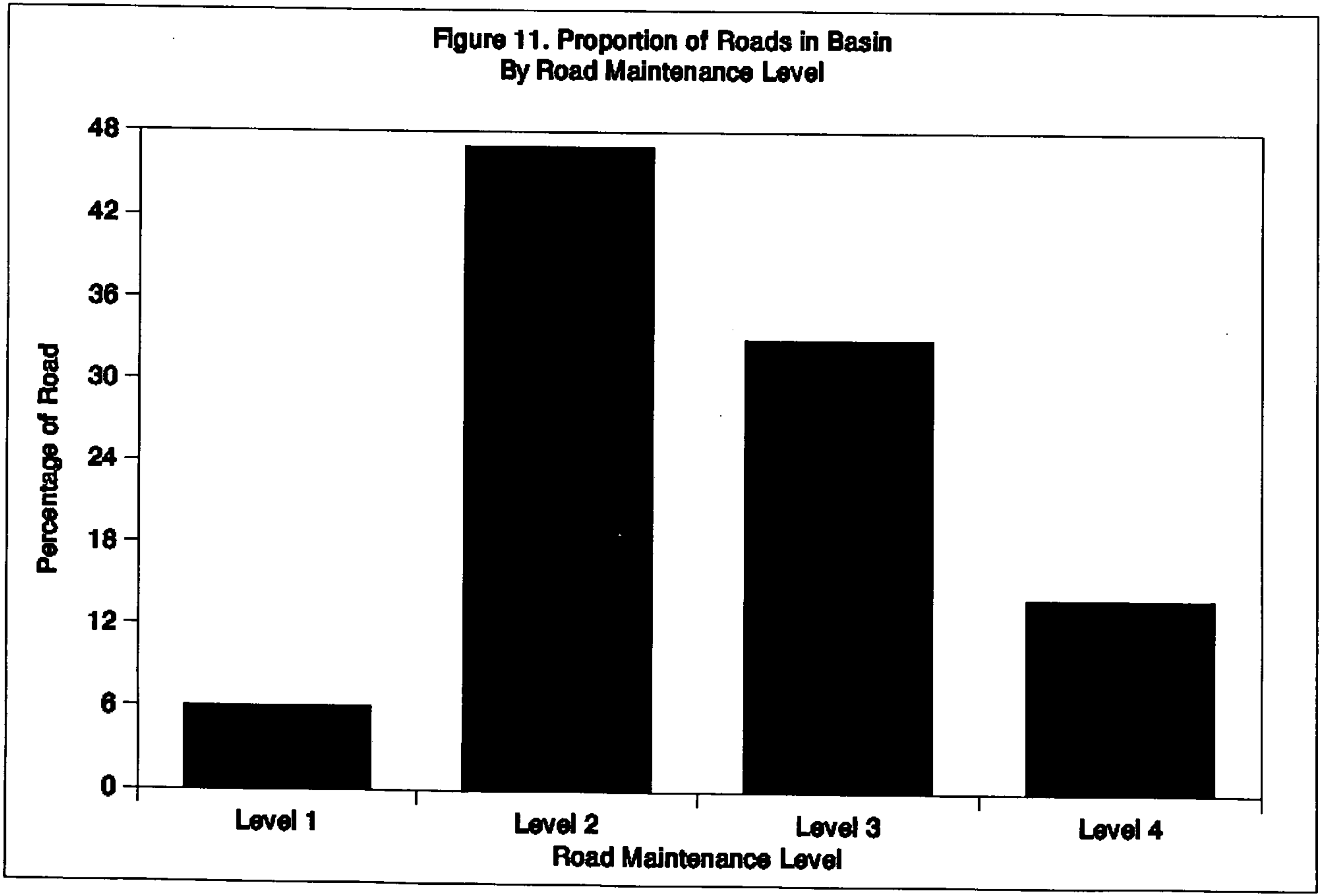


Figure 11. Proportion of Roads in Basin
By Road Maintenance Level
48
42
36
30
24
18
12
6
0
Percentage of Road
Level 1
Level 2
Level 3
Level 4
Road Maintenance Level

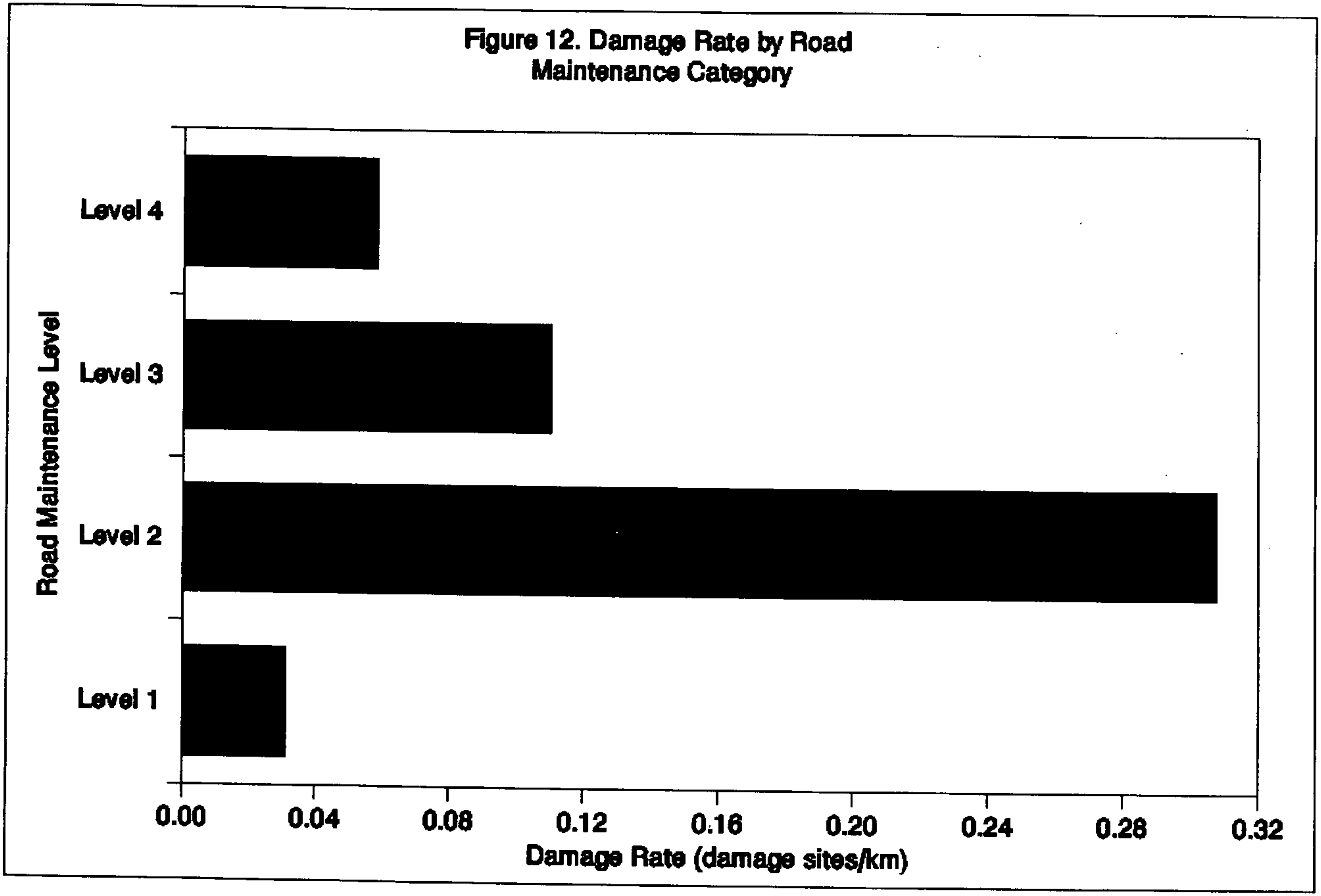


Figure 12. Damage Rate by Road Maintenance Category
Road Maintenance Level
Level 4
Level 3
Level 2
Level 1
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
Damage Rate (damage sites/km)

Figure13.Frequency of Road Damage Types

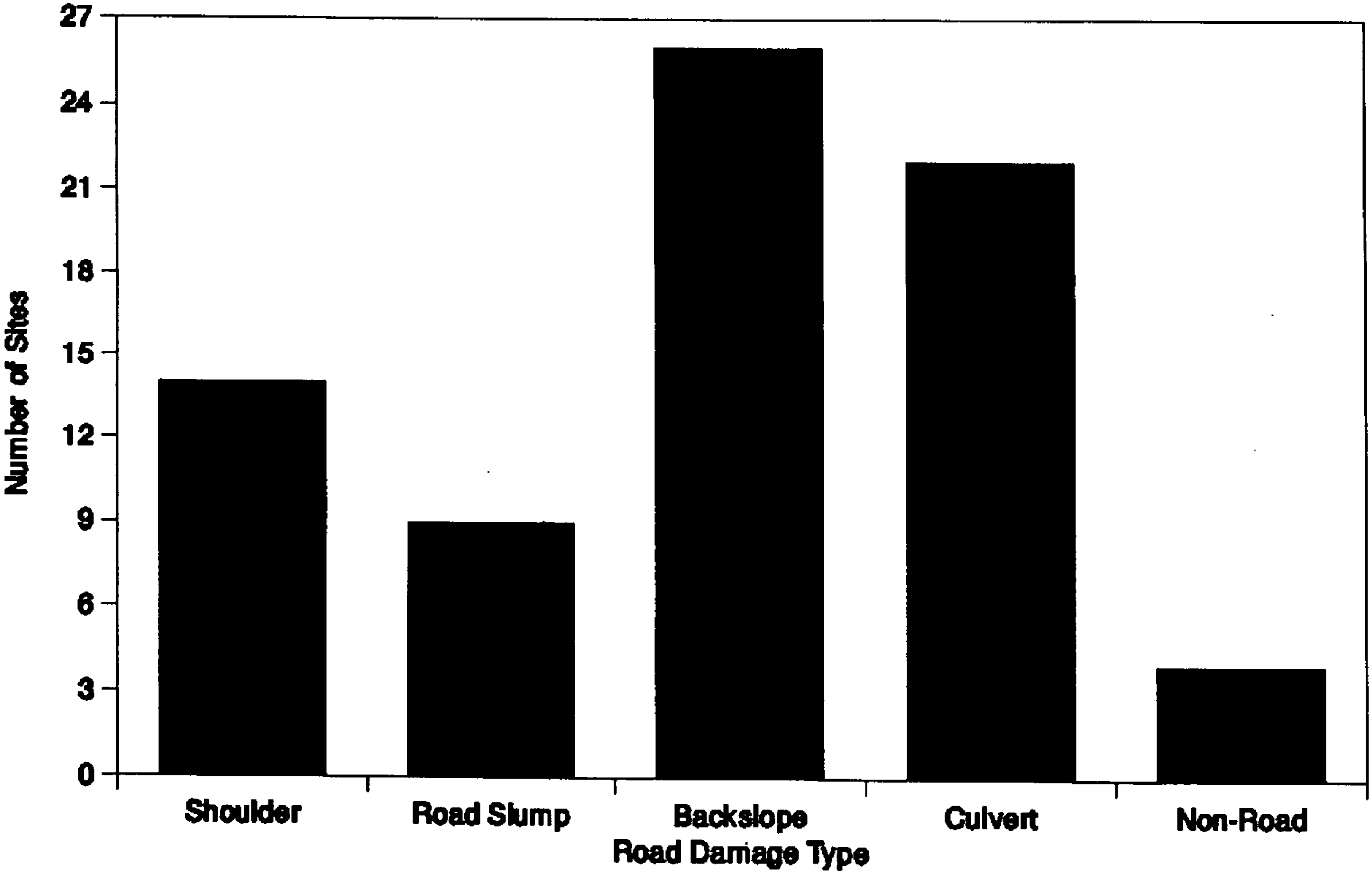


Figure 14. Landslide Inventory Sites

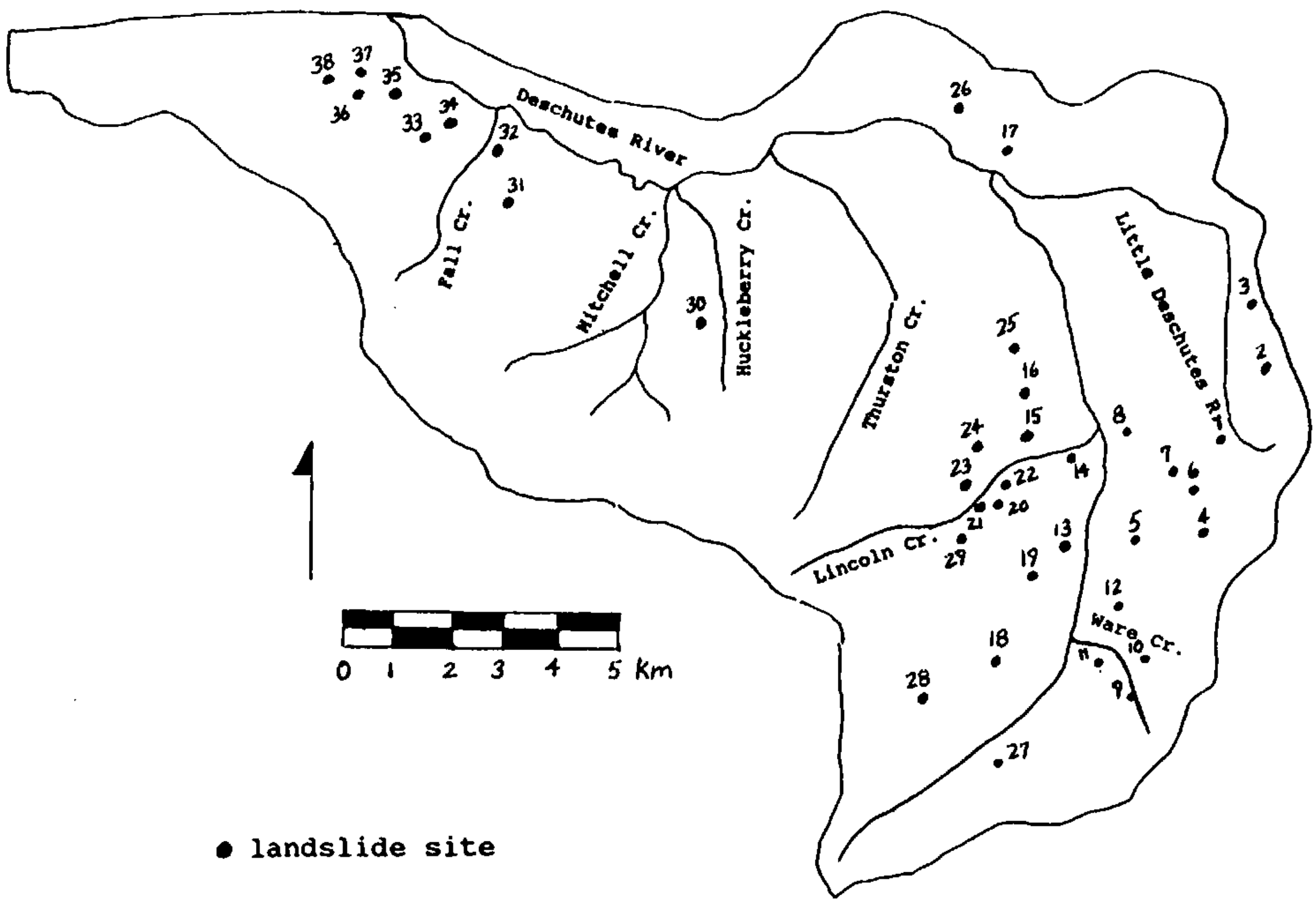
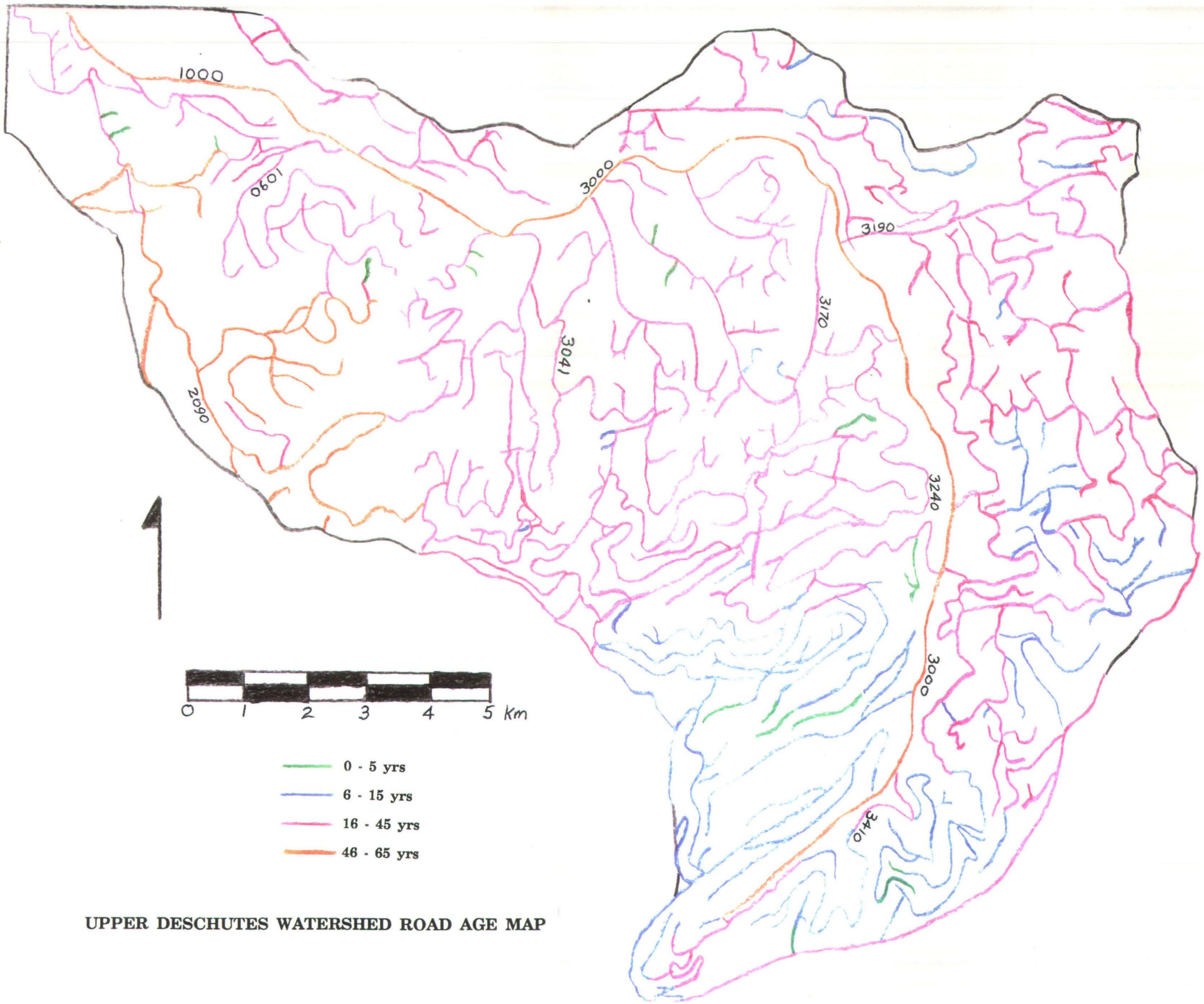
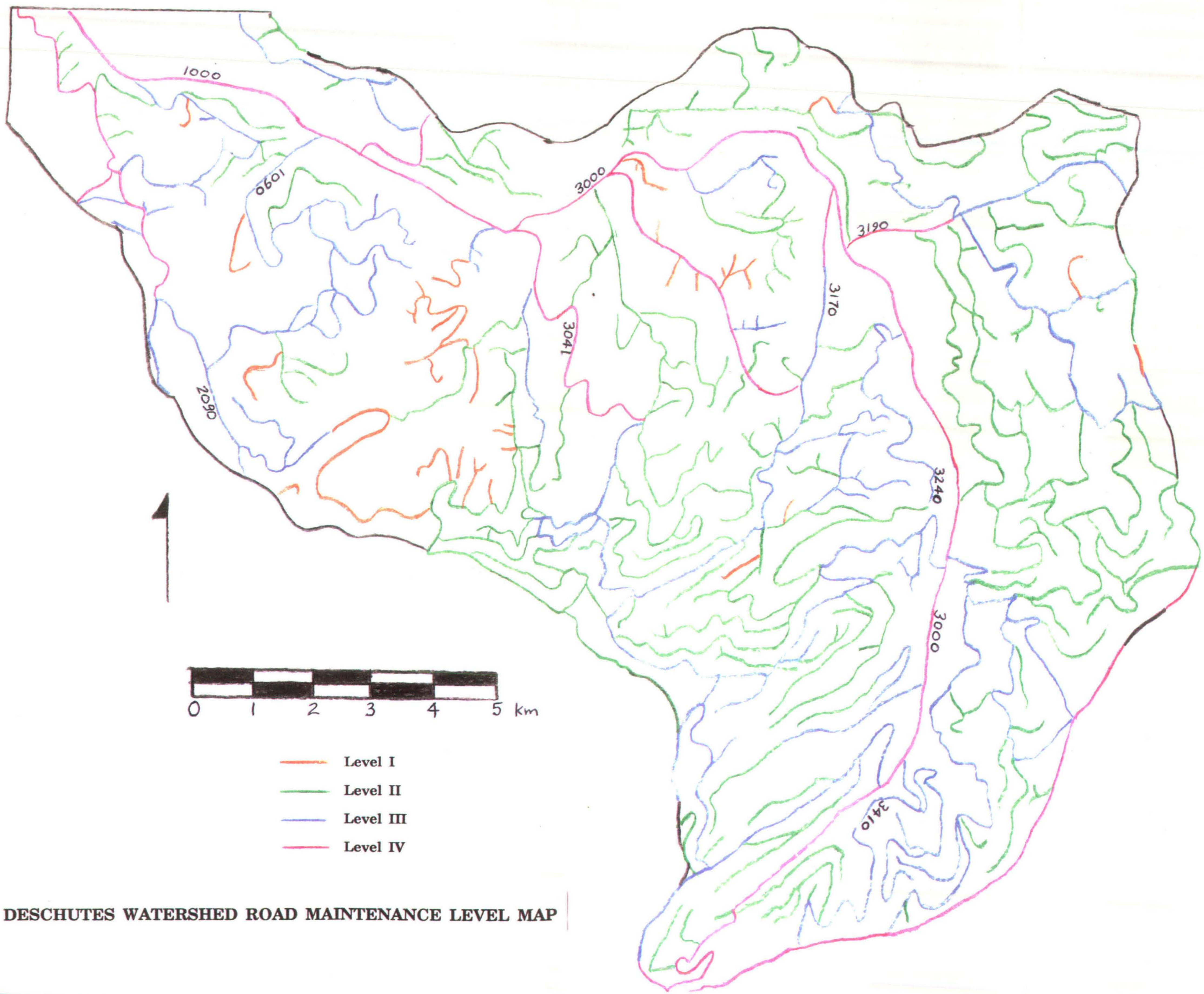


Figure 6. Upper Deschutes Basin Road Age Map



UPPER DESCHUTES WATERSHED ROAD AGE MAP

Figure 10. Upper Deschutes Basin Road Maintenance Level Map



UPPER DESCHUTES WATERSHED ROAD MAINTENANCE LEVEL MAP igure 6. Upper Deschutes Basin Road Age Map

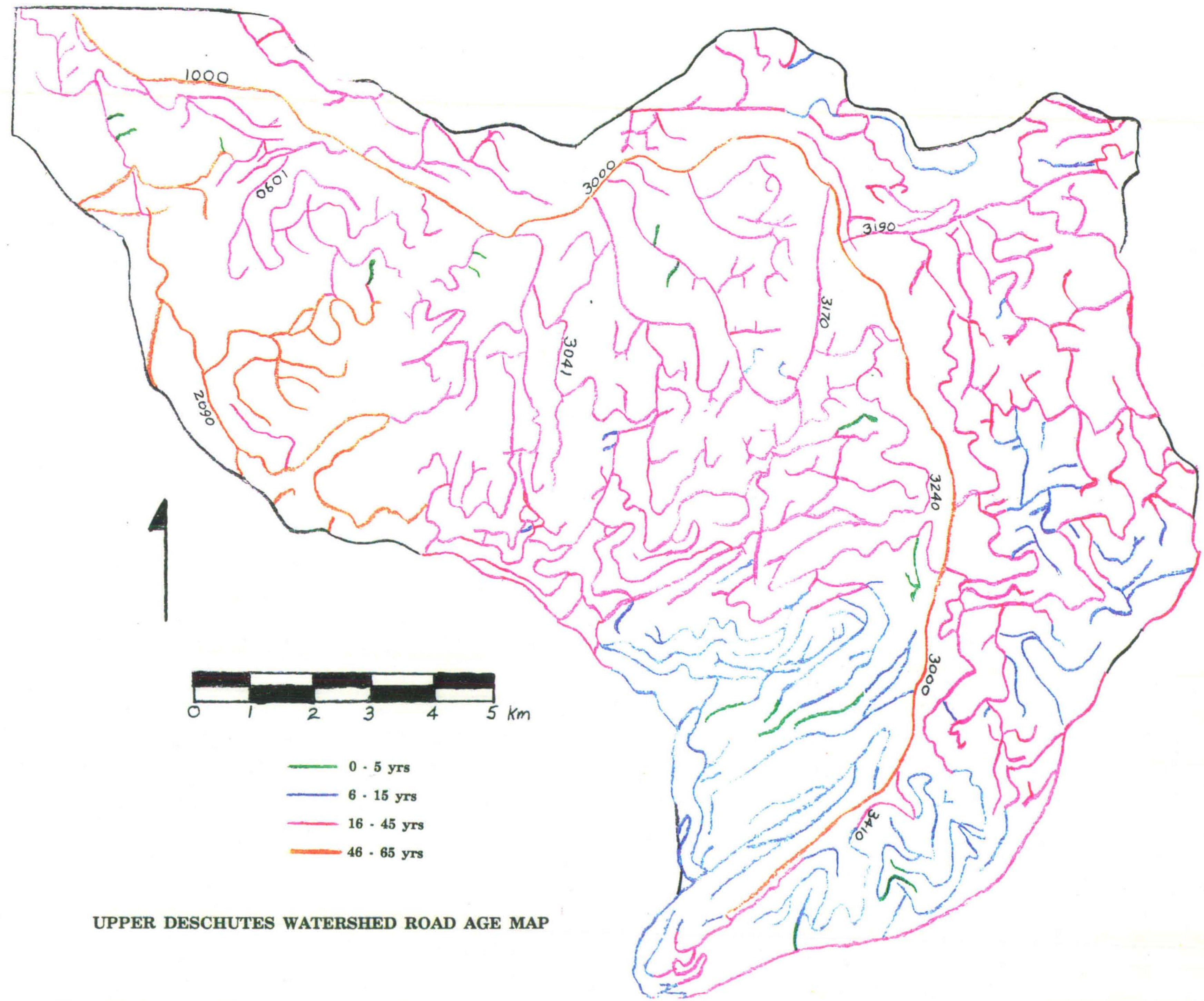


Figure 10. Upper Deschutes Basin Road Maintenance Level Map