Pilot Study of the Influence of Vegetation and Other Factors on Pavement Condition

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Historically, the extent to which nonrhizomatous and nonstoloniferous vegetation, particularly grasses, on the road shoulder contributes to the premature deterioration of road pavement by impeding the off-surface flow of water has proven, in the absence of empirical evidence, to be controversial. Anecdotal evidence has been used to support the need to remove such vegetation. A pilot study was conducted to determine the relationship, if any, between the presence and abundance of road-shoulder vegetation and pavement condition ratings through an attempt to reveal the existence and strength of any correlation between the variables. Besides vegetation and pavement condition factors such as cracking and raveling, a number of other variables were investigated, including average daily traffic counts at the nearest road intersection, soil factors, roadway and shoulder grade, ditch condition, and canopy cover over the roadway. Whereas the purpose of the study was to collect and analyze data testing the null hypothesis that nonrhizomatous, nonstoloniferous vegetation does not cause premature pavement deterioration by impeding the off-surface flow of water, the purpose of this paper is to stimulate further research. The results of the pilot study indicate an apparent lack of association between the presence and abundance of shoulder vegetation and pavement condition because the correlation coefficient was not statistically significant. Other factors, however, are shown to be significantly correlated with pavement condition. Therefore, the study should be expanded to account for the influence of factors not considered in the pilot study because of data gaps.

The Lane County, Oregon, Department of Public Works recently adopted an integrated vegetation management (IVM) program. The IVM approach requires that a problem, actual or potential, be identified before vegetation management is conducted. Historically, the extent to which nonrhizomatous and nonstoloniferous vegetation, particularly grasses, on the road shoulder contributes to the premature deterioration of road pavement by impeding the off-surface flow of water has proven, in the absence of empirical evidence, to be controversial. Anecdotal evidence has been used to support the need to remove such vegetation.

A pilot study was conducted to determine the relationship, if any, between the presence and abundance of road-shoulder vegetation and pavement condition ratings through an attempt to reveal the existence and strength of any correlation between the variables. Besides vegetation and pavement condition factors such as cracking and raveling, a number of other variables were investigated, including average daily traffic (ADT) counts at the nearest road intersection, soil factors, roadway and shoulder grade, ditch condition, and canopy cover over the roadway.

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PROCEDURES

The parameters listed below were sampled, either from existing data or by in-the-field sampling, for 61 sites around the county. For those shown with an asterisk (*), the data were collected in the field.

- ADT,
- Soil pH*,
- Liquid limit of the soil*,
- Plastic limit of the soil*,
- Soil plasticity index*,
- Roadway grade*,
- Shoulder grade*,
- Ditch condition*,
- Alligator cracking of the pavement, hairline,
- Alligator cracking of the pavement, spalling,
- Longitudinal cracking of the pavement, less than 0.25 in.,
- Longitudinal cracking of the pavement, greater than 0.25 in.,
- Transverse cracking of the pavement, less than 0.25 in.,
- Transverse cracking of the pavement, greater than 0.25 in.,
- Patching, 0.1 to 0.5 in.,
- Patching, 0.5 to 1.0 in.,
- Edge raveling,

- Edge patching,
- Edge, lane less than 10 ft,
- Percent canopy cover (from trees over the lane at the sampling point)*,
- Percent bare ground*,
- Total percent aboveground vegetative cover*, and
- Composite pavement condition score (a score generated from measures of alligator cracking, longitudinal cracking, transverse cracking, and patching).

The sites were selected in a stratified random manner with at least 10 sites in each of 6 geographically distributed road maintenance zones. Sites were excluded from roads for which the paved surface or the shoulder had been rehabilitated within 2 years before sampling or since the date of the last pavement evaluation. Sites were determined to be the mid-point of randomly computer-selected road segments taken from the county's maintenance management data base. Soil samples were taken from the road shoulder material with a soil auger (except where the material was too rocky to allow the auger to penetrate), stored on ice in zip-lock plastic bags, and returned to the department's materials lab for analysis. Roadway and shoulder grades were determined with an abney. Ditch condition was subjectively determined by assigning the condition of the ditch at the sampling site to one of four condition classes; the higher the class ranking the poorer the condition of the ditch in terms of the ability of the ditch to convey water. Factors contributing to the ranking included ditch cross-sectional area and the presence or absence of congesting vegetation or other obstructions. Percent canopy cover over the road at the site was also subjectively determined. Total percent aboveground vegetative cover, and its near converse, percent bare ground and litter, were determined using a 0.1 m^2 circular quadrat placed at the pavement edge.

ANALYSIS

A correlation analysis was run on the variables listed previously. Shown in Table 1 are the correlation coefficients for the sampled variables.

The critical values for the correlation coefficients, with 59 degrees of freedom, were determined by interpolation to be 0.252 for alpha = 0.05, and 0.328 for alpha = 0.01.

RESULTS

Correlations (indicated as "variable/variable") significant at the alpha = 0.05 level include the following:

- Soil pH/liquid limit of the soil,
- Liquid limit of the soil/ditch condition,
- Liquid limit of the soil/patching, 0.5 to 1.0 in.,
- Liquid limit of the soil/composite pavement condition score,
- Plastic limit of the soil/edge patching,
- Soil plasticity index/ditch condition,
- Soil plasticity index/patching, 0.5 to 1.0 in.,
- Ditch condition/edge raveling,
- Ditch condition/edge patching,
- Longitudinal cracking, less than 0.25 in./transverse cracking, less than 0.25 in.,
- Transverse cracking, less than 0.25 in./percent canopy cover,
- Patching, 0.5 to 1.0 in./composite pavement condition score, and
- Edge patching/edge, lane less than 10 ft.

Correlations (indicated as "variable/variable") significant at the alpha = 0.01 level include the following:

- Soil pH/soil plasticity index,
- Liquid limit of the soil/plastic limit of the soil,
- Liquid limit of the soil/soil plasticity index,
- Liquid limit of the soil/longitudinal cracking, greater than 0.25 in.,
- Liquid limit of the soil/edge raveling,
- Liquid limit of the soil/edge patching,
- Plastic limit of the soil/soil plasticity index,
- Plastic limit of soil/longitudinal cracking, greater than 0.25 in.,
- Plastic limit of the soil/edge raveling,
- Soil plasticity index/alligator cracking, spalling,
- Soil plasticity index/longitudinal cracking, greater than 0.25 in.,
- Soil plasticity index/edge raveling,
- Soil plasticity index/edge patching,
- Soil plasticity index/composite pavement condition score,
- Roadway grade/edge patching,
- Roadway grade/edge, lane less than 10 ft,
- Roadway grade/percent canopy cover,
- Alligator cracking, hairline/longitudinal cracking, less than 0.25 in.,
- Alligator cracking, hairline/composite pavement condition score,
- Alligator cracking, spalling/composite pavement condition score,
- Longitudinal cracking, less than 0.25 in./composite pavement condition score,
- Longitudinal cracking, greater than 0.25 in./edge patching,
- Patching, 0.5 to 1.0 in./edge patching,
- Patching, 0.5 to 1.0 in./patching, 0.5 to 1.0 in.,
- Edge raveling/edge patching,
- Edge raveling/edge, lane less than 10 ft,
- Edge patching/composite pavement condition score, and
- Percent bare ground/total percent aboveground vegetative cover.

DISCUSSION OF RESULTS

If it is true that vegetation plays a significant role in the premature deterioration of pavement by creating a barrier to the free flow of water off the paved surface, then as vegetation abundance (measured as percent aboveground cover) increases, pavement condition scores should decrease. If this were to occur in every case, this perfect inverse relationship would produce a correlation coefficient (r) of -1. Such an inverse association is well illustrated by the nearly perfect (i.e., nearly equal to -1) correlation between vegetative cover

TABLE 1 MATRIX OF CORRELATION COEFFICIENTS

	ADT	Soil pH	Liq. Limit	Plast. Limit	Plast. Index	Road Grade	Shldr. Grade	Ditch Cond.
ADT	1							
Soil pH	-.128	1						
Liquid Limit	-.123	-.327	1					
Plastic Limit	-.159	-.224	.913	1				
Plasticity Index	-.066	-.372	.913	.688	1			
Road Grade	.032	.092	-.037	-.056	-.011	1		
Shoulder Grade	.180	-.120	.010	.084	-.065	-.038	1	
Ditch Condition	.037	2.052E-4	.272	.241	.257	.040	-.240	1
Allig. Cr. Hairline	.188	-.025	-.004	.020	-.027	-.118	.042	-.012
Allig. Cr. Spalling	-.103	-.056	.225	.083	.328	-.143	.038	-.210
Long. Cr. <0.25 in.	.213	-.002	-.144	-.107	-.158	-.171	.247	-.070
Long. Cr. >0.25 in.	-.068	-.120	.485	.350	.535	.128	.024	.014
Trans. Cr. <0.25 in	-.006	-.168	-.107	-.118	-.077	-.130	-.121	-.096
Trans. Cr. >0.25 in	-.003	-.050	-.061	-.067	-.043	.084	-.082	-.178
Patching 0.1-0.5 in	-.033	.022	-.052	-.067	-.028	.147	.012	-.073
Patching 0.5-1.0 in	-.073	-.030	.248	.177	.276	.135	.085	.189
Edge Raveling	-.150	-.099	.547	.526	.474	.223	-.033	.271
Edge Patching	-.065	-.132	.524	.306	.653	.353	-.073	.252
Edge, lane <10 ft	-.101	.092	.019	.038	-.002	.447	.005	.179
% Canopy Cover	-.133	-.148	-.096	-.077	-.099	.336	-.024	-.101
% Bareground	.081	-.147	-.020	-.093	.056	-.127	-.170	-.114
% Total Veg. Cover	-.086	.122	.057	.132	-.027	.144	.159	.148
Comp. Pvmt. Score	-.008	.051	-.286	-.145	-.377	-.022	-.107	.053

TABLE 1 (*continued*)

	Allig. Crack. Hairline	Allig. Crack. Spall.	Long. Crack. <0.25"	Long. Crack. >0.25"	Trans. Crack. <0.25"	Trans. Crack. >0.25"	Patch. 0.1-0.5"	Patch. 0.5-1.0"
Allig.Cr.Hairline	1							
Allig.Cr.Spalling	-.178	1						
Long.Cr.<0.25 in	.381	.144	1					
Long.Cr.>0.25 in	-.131	.112	-.206	1				
Trans.Cr.<0.25 in	.078	-.082	.292	-.060	1			
Trans.Cr.>0.25 in	-.064	-.046	-.100	-.034	-.029	1		
Patching 0.1-0.5"	-.011	-.022	.047	-.078	-.067	-.038	1	
Patching 0.5-1.0"	.178	.210	.068	.043	-.097	-.055	-.125	1
Edge Raveling	.224	-.141	.049	.145	-.027	.034	-.014	.155
Edge Patching	-.042	.168	-.151	.459	-.071	-.040	-.092	.499
Edge,lane <10 ft	.024	-.074	-.022	.170	-.124	-.070	.030	.135
% Canopy Cover	.128	-.162	-.011	-.004	.278	-.058	.147	.213
% Bareground	-.025	-.068	.058	.027	.109	.169	.110	-.189
% Total Veg. Cover	.007	.051	-.079	-.030	-.105	-.167	-.115	.195
Comp. Pvmt. Score	-.452	-.522	-.387	-.179	.003	.013	-.281	-.596

	Edge Raveling	Edge Patching	Edge lane <10 ft.	Percent Canopy Cover	Percent Bare-ground	% Tot. Veg. Cover	Comp. Pvmt. Score
Edge Raveling	1						
Edge Patching	.388	1					
Edge, lane<10 ft	.366	.255	1				
% Canopy Cover	.098	.005	.222	1			
% Bareground	-.056	.005	-.099	-.102	1		
% Total Veg. Cover	.092	.055	.125	.105	-.989	1	
Comp. Pvmt. Score	-.161	-.350	-.108	-.125	.106	-.083	1

and bare ground ($r = -0.989$). Likewise, a perfect positive association would give a coefficient of $+1$, and a correlation coefficient of 0 would indicate a total lack of association between the variables.

The results of this pilot study are interesting in that the analysis of the data collected shows no statistically significant correlations between the presence or absence of vegetation adjacent to the pavement edge and scores indicating poor pavement conditions. However, there were some potentially influential limitations on the study.

- A number of potentially significant variables, such as pavement age, thickness of base material, and equivalent single axle loadings, were not included. (This information was not available at the time of the study.)
- Pavement condition scores are for road segments and are not specific for the point at which the vegetation and soil data were collected.
- ADT counts were for the nearest road intersection and were not available for all of the roads on which samples were taken. Where data were missing, the mean value for the variable was used.
- Sampling was conducted during July and August 1989. Therefore, temporal changes in the pavement's condition and changes in the soil moisture regime are not taken into account, nor is it known at what point in the life of the pavement the sampling was done. Furthermore, because the study was short term, the potential effects of the root structure of shoulder vegetation on subsurface drainage were not analyzed.

Therefore, the results do not support the traditionally held engineering theory that herbaceous, nonrhizomatous, nonstoloniferous vegetation is a major factor in the premature deterioration of pavement. No apparent association was found between pavement condition and vegetation on the road shoulder. However, the factors influencing the premature deterioration of pavement may well be acting in concert with one another, and the influence of a single factor may go unnoticed in a simple descriptive study as this because of the confounding influences of other factors. A review of the correlation coefficients presented in Table 1 reveals strong associations between pavement condition factors, the composite pavement condition score, and a number of variables, most notably soil plasticity.

The results are inconclusive and indicate the value of a more in-depth study. Therefore, the study should be expanded to address the caveats already mentioned, especially the influence of vegetation through time, and to provide a solid foundation of information on which to base long-range vegetation management decisions. If the results of this pilot study are supported by subsequent analyses, it may be possible to reallocate maintenance resources with potentially great cost savings and improved maintenance effectiveness.

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