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PREDICTING THE DURABILITY OF FOREST RECREATION SITES IN NORTHERN UTAH--PRELIMINARY RESULTS

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ABSTRACT

By using a special roller, trampling was simulated in equal amounts on 40 small plots representing potential recreation sites throughout the Cache National Forest in northern Utah. Surviving vegetation was related to soil and topographic factors by multiple regression procedures. Resultant equations explained up to 64 percent of the variability in amounts of surviving vegetation, which suggests the possibility of predicting the durability of potential recreation sites. Site factors that can be measured on aerial photos explained approximately as much variability as factors requiring on-the-ground measurements.

One of the more serious problems facing recreation site managers today, particularly on campground and picnic areas, is that of maintaining adequate ground cover. This is an especially difficult task in semiarid regions such as the Intermountain West, where sites tend to support a sparse cover of ground-level vegetation. Because of different soil, moisture, and topographic conditions, some sites are much more durable than others in terms of the persistence of ground-cover vegetation. If we had tools for rating the durability of potential recreation sites, less durable sites either could be avoided or designed and managed in ways to increase their durability. Moreover, knowledge of the probable level of vegetation damage to a fragile site might allow managers to estimate any additional expenditures that may be needed if such a site is developed and used as a campground or picnic area.

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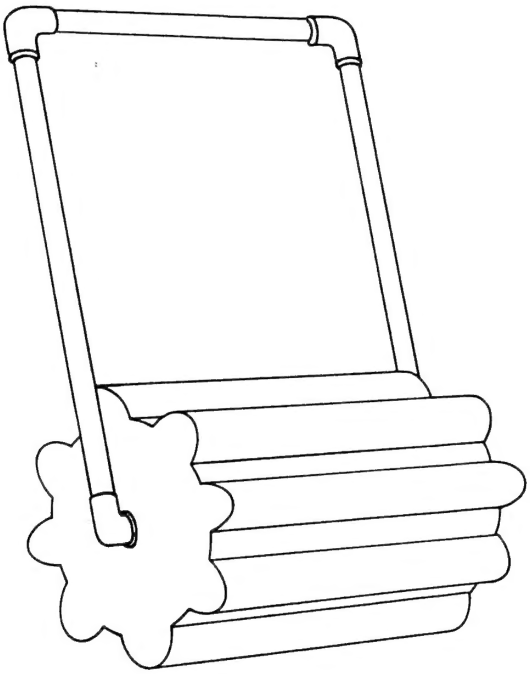
[1] This paper is based on the senior author's master's thesis accepted at Utah State University in 1968. The senior author is now Supervisor of Planning and Research for the Maine State Park and Recreation Commission. At the time this work was done, the junior author was leader of the Cooperative Recreation Research Unit maintained by the USDA Forest Service in cooperation with Utah State University at Logan. He is currently leader of a similar unit maintained at the University of Washington in Seattle by the Pacific Northwest Forest and Range Experiment Station, USDA Forest Service.

Figure 1.--Configurated roller used in the study to simulate trampling from recreation use.



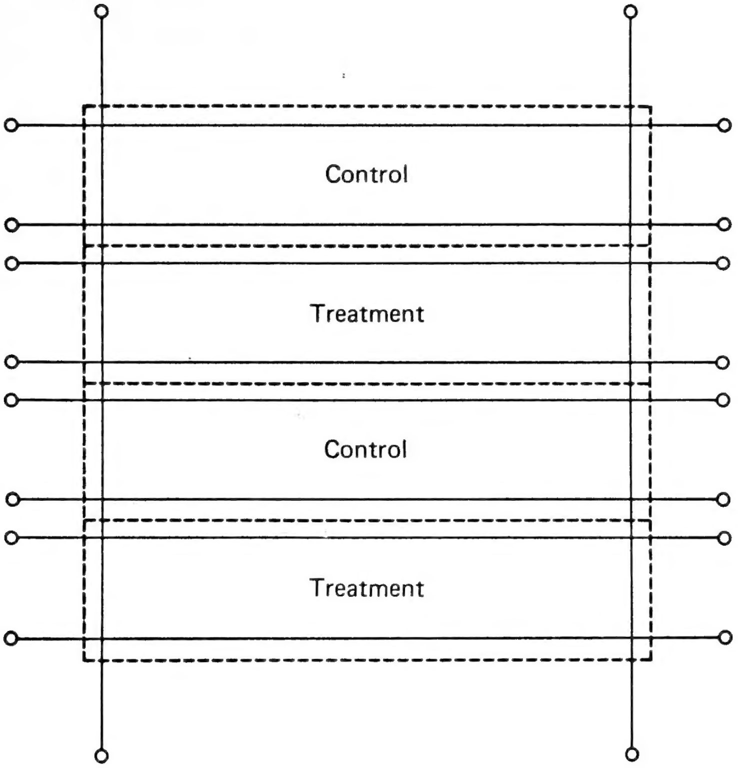
To provide procedures for rating the durability of site vegetation, a study was established on the Cache National Forest in northern Utah in 1965. A 100-lb. configurated cement roller (fig. 1) that applied a rolling pressure of about 6 lbs./in.^{2} was used to simulate trampling on the 16- by 64-inch plots. Identical amounts of simulated trampling were applied to each plot in the study. Plots then could be arranged in order, according to resistance to damaging forces.

Whether the roller damage was greater or smaller than that resulting from human trampling is not known but probably is unimportant. We assumed that after moderate trampling the amount of vegetation surviving through one or more growing seasons would express site durability. Then, if amounts of surviving vegetation could be related to soil and topographic factors, the resulting relationships would enable us to predict site durability.

Because simulated trampling had been used in only one other study (Wagar 1964a), the 1965 growing season was used to test the effect of different intensities and timings of simulated use. On 48 plots--24 under a cover of lodgepole pine (*Pinus contorta* Dougl.) and 24 under a cover of aspen (*Populus tremuloides* Michx.)--we learned that plot vegetation responded quite differently to varying amounts of rolling, but little differently to the same amount of rolling applied with different timings. The response was about the same whether plots received two passes of the roller on 3 days of each week or the same amount of trampling applied as 12 passes of the roller once every other week. This seemed to justify the once-a-week rolling treatment that was planned for the second phase of the study.

Based on results from 1965, 40 sites were selected in May 1966. Sites represented the range of conditions judged suitable for recreation occupancy sites on the Cache National Forest. The sites chosen were concentrated on slopes ranging from 0 to 15 percent. To help us define the form of relationships, we included a few sites on steeper slopes (up to 30 percent). Sites represented overstory types ranging from lodgepole pine to aspen to maple to willow. The 40 plots selected included the following ranges of conditions: all aspects; elevations of from 5,100 to 8,400 ft.; soil pH values of

Figure 2.--Arrangement of 16- by 64-inch plots at each site location.



5.0 to 7.4; plot positions on the slope ranging from the bottom of the drainage to the top of the slope; a variety of soil textures in both the A and B soil horizons; percent stones in the soil (2 mm. and larger) from 6.9 to 64.8; season-long percentages of possible direct sunlight ranging from 1 to 40; and basal area of trees ranging from 26 to 313 ft.^{2} per acre. Measurements were recorded for each of these site characteristics.[2] The most northerly plots and the most southerly plots were 52 airline miles apart.

The grass and forb species at the sites included the following: *Polygonum durslasia; Aconitum columbianum; Bromus marginata; Melica bulbosa; Aster engelmannii; Achillea lanulosa; Agropyron spicatum; Wyethia amplexicaulis; Thalictrum fendleri; Senecio serra; Lathyrus leucanthus; Agastacha urticifolia; Rudbeckia occidentalis; Delphinium barbeyi; Osmorhiza chilensis; Sidalacea neomexicana; Lupinus laxiflorus; Veronica campylopoda; Agoseris glauca; Arnica cordifolia; Taraxacum officinale; Hydrophyllum capitatum* var. *thompsonii;* and several *Carex* species.

At each site location, four 16- by 64-inch plots were placed in stands of ground-cover vegetation judged to be uniform. As shown in figure 2, two treatment plots were alternated with two control plots in each plot group. Beginning the latter half of June 1966, each treatment plot was rolled once a week with 12 passes of the roller. Treatments continued for 11 weeks. A 1-week interval between treatments provided sufficient time for all plot locations to be treated in a repetitive sequence and also allowed time for measurement of site variables at each location.

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[2] Aspect was coded as 1.0 plus the sine of the azimuth from southeast. This gave values ranging from 0.0 on cool northeastern exposures to 1.0 on moderate southeastern and northwestern exposures to 2.0 on hot southwestern exposures. Season-long percentage of possible direct sunlight was measured by using an insolation grid (Wagar 1964b). The point density procedure developed by Spurr (1962) was used to measure the basal area of trees.

During the growing season, plots at three locations were damaged so severely by livestock grazing that they could not be used in the analysis. Consequently, analysis was based on plots at only 37 locations.

At the end of the growing season (between September 10 and October 25) vegetation within a 12- by 60-inch zone in each plot was measured in two different ways. First, a 12- by 30-inch grid with two hundred 1.2- by 1.5-inch rectangles was placed over each half of the measurement zone and a count was taken of the number of stocked rectangles, i.e., rectangles having living vegetation anchored in them. This number then was expressed as a percentage of the total number of 400 rectangles and used as dependent variables Y_1 and Y_2. As a second measurement procedure, all plants from the measurement zone of each plot were clipped one-half inch above their root collars. Clippings then were ovendried and weighed for a measure of dependent variable Y_3.

Two other variables also were constructed and used to express results. Vegetation surviving on treated plots was expressed as a percentage of the vegetation surviving on adjacent control plots. This percentage was used as dependent variable Y_4 when based on clipping weights, and as dependent variable Y_5 when based on stocking measurements.

Multiple regression analysis procedures were used. Results for the five regression models tested are summarized in table 1.

In the equations for Y_1 and Y_2, approximately 60 percent of the variability was explained. It should be noted that the equation for Y_1 is limited to variables that either were or could have been measured from aerial photographs. From this we conclude that the possibility of determining site durability from aerial photos is promising. However, because this equation was based on measurements from only 29 plot groups,[3] results for this equation are not quite comparable to others.

In the equation for Y_1, most of the variability appeared to be due to topographic factors, and studies are being continued to determine whether site durability can be satisfactorily predicted from aerial photograph measurements.

Independent variables were examined for consistency from equation to equation and for statistical significance (defined as 5 or less percent probability that association with the Y variable was a chance occurrence). Variables that were both significant and consistent included slope percent, aspect, elevation, and the interaction between slope percent and aspect. Three additional variables, although not statistically significant, had no inconsistencies from one equation to another and occurred in the equation that had the best predictive value (lowest mean square error) for one or more of the models tested. These were percent clay at a soil depth of 1 to 4 inches, basal area of trees, and percent stones (>2 mm. in diameter) at a soil depth of 1 to 4 inches. Four variables were either inconsistent or explained too little variability to be included in the equations. These were pH of soil at a depth of 1 to 4 inches, position of plot on slope, season-long percentage of direct sunlight, and distance from drainage bottom to plot.

Within the narrow range of slopes studied, the steeper slopes showed greater durability than gentle slopes. This result was not expected and may be related to soil coarseness or some other factor associated with slope rather than slope itself.

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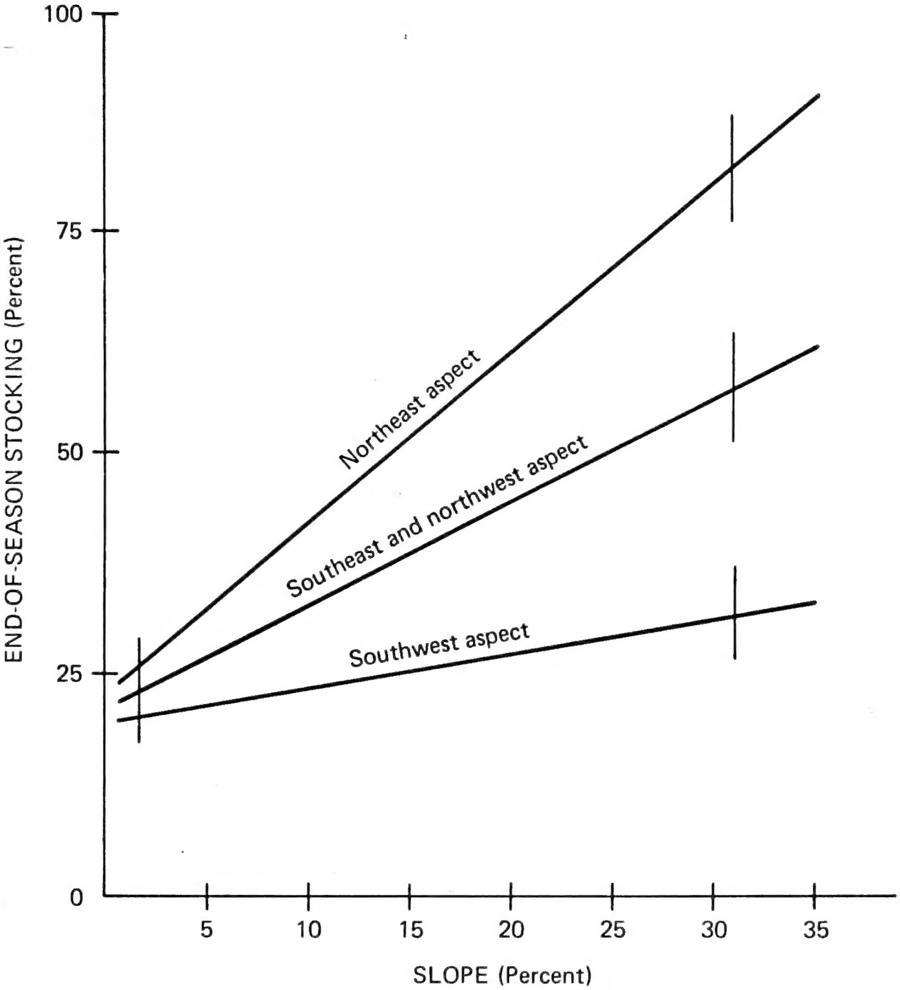
[3] At the time an expert photo interpreter was available, only 29 of the plot groups had been located on aerial photos. The authors are grateful to Karl E. Moessner of the Intermountain Forest and Range Experiment Station, USDA Forest Service, for making the aerial photograph measurements used in this study.

Table 1.--*Summary of results for five regression models. Study to predict the durability of potential recreation sites, 1966 data, Cache National Forest, northern Utah. Standard partial regression coefficients are shown in parentheses.*

		Constant a	Slope of plot, measured on ground (X_1) b_1 (b'_1)	Slope of plot location measured on photos (X_2) b_2 (b'_2)	Percent clay at soil depth of 1 to 4 inches (X_3) b_3 (b'_3)	Aspect (X_4) b_4 (b'_4)	Elevation (X_5) b_5 (b'_5)	Soil pH at 1 to 4 inches (X_6) b_6 (b'_6)	Plot position on slope, measured on ground (X_7) b_7 (b'_7)	Plot position on slope, measured on photos (X_8) b_8 (b'_8)	Percent stones (xmm) at soil depth of 1 to 4 inches (X_9) b_9 (b'_9)	Basal area of trees (X_{10}) b_{10} (b'_{10})	Interaction of slope and aspect (X_1X_4) b_{11} (b'_{11})	Multiple regression coefficient R^2: With all X variables included	Multiple regression coefficient R^2: At lowest mean square error
End-of-season stocking	Y_1	740.96		6.54 (.45)**		-84.38 (-.52)**	-9.17 (-.62)**			1.04 (.22)				0.64	0.64
	Y_2	333.12	7.98 (.62)**		388.65 (.16)		-4.66 (-.33)*				222.32 (.27)	-.12 (-.14)	-3.23 (-.50)**	.60	.59
End-of-season clipping wt.	Y_3	-14.62	.26 (.38)**		36.45 (.29)	-4.37 (-.55)**		2.64 (.25)						.40	.38
Percent survival, based on clipping weights	Y_4	.60	.005 (.29)		.84 (.28)	-.04 (-.22)		-.09 (-.35)*	-.14 (-.21)					.31	.31
Percent survival based on stocking	Y_5	-.40	.014 (.52)*		1.55 (.31)			.11 (.26)					-.006 (-.46)	.34	.30

* Significant at 0.95. ** Significant at 0.99.

Figure 3.--The combined effects of slope and aspect on survival of trampled vegetation, 1966 data, Cache National Forest, northern Utah.



Trampled vegetation is vulnerable to severe heat and drying. Consequently, survival of vegetation was greatest on northeast (coolest) aspects and decreased as location approached the southwest (hottest) aspects. As shown in figure 3, this effect was accentuated by slope steepness.

The coefficients for elevation were negative (table 1), an indication that the amount of surviving vegetation decreased as elevation increased. Two factors may explain this decrease at higher elevations: the season was shorter than that at lower elevations and the vegetation less well developed at the start of trampling. Apparently, the extra precipitation at higher elevations in the area studied did not offset the effects of a late season and low temperatures.

Although percent of clay at a soil depth of 1 to 4 inches was not significant, the coefficient for this variable was positive in all regression models in which it was tested. This indicates that, for the conditions studied, ground-cover vegetation survives best in soils that have a relatively high clay content.

CONCLUSIONS

Although results from a single growing season may not reflect the cumulative deterioration of vegetation in recreational areas over a period of years, several conclusions seem to be warranted:

1. It is possible to develop prediction equations for rating the durability of potential recreation sites. In fact, it may be possible to develop equations that will enable recreation managers to rate site durability from aerial photograph measurements alone. Such measurements would be much less expensive than on-the-ground evaluations. Lindsay (1969) reported that recreation areas could be accurately selected from aerial photos. He used seven criteria for selection. Durability would be an important additional criterion for selection.

2. In the development of equations for recreation site durability, end-of-season stocking seems to be a more effective dependent variable than the end-of-season weight of vegetation or than either the stocking or the clipping weight of treated plots expressed as a percentage of the same measurement for control plots. However, the reader should recognize that stocking measurements can be misleading, especially after a single season of treatment. Vegetation may be severely damaged and still give a high stocking percentage. If damaged plants disappear in subsequent seasons, first-year stocking measurements will not have given a valid indication of long-term site durability.

3. Use of a concrete roller to simulate trampling was effective. Simulation procedures permit the researcher to select the range of site conditions he wishes to examine and yet avoid the great variability associated with actual recreational use.

4. If simulated trampling is used to study areas grazed by livestock or wildlife, plots should be fenced.

5. Finally, it would be desirable to rate site durability under natural conditions and also under conditions of management. This is being done in a continuation of the study reported here.

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