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The Science and Politics of BMPs in Forestry: California Experiences

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Abstract

Best management practices (BMPs) are the result of political compromises based on what is scientifically known, technically feasible, economically reasonable, and socially acceptable. Consequently, forestry BMPs vary from state to state on the Pacific coast, and their detail and rigor seem to be related to the degree of urbanization and the economic importance of the forest products industry in each state. California, being the most urbanized and having a forest products industry that is a relatively minor part of its economy, has the most restrictive forestry BMPs. Similar rules are likely to be adopted in the other states as they become more urbanized. Studies spanning changes in forest practice regulations suggest that California's increasingly strict forest practice rules have reduced erosion and maintained water quality. Researchers have also found that most erosion comes from a tiny fraction (0.5–1.8%) of the terrain. Therefore, discriminant functions have been developed to identify sites at risk of causing large amounts of erosion if logged or roaded. Methodologies, such as the Bayesian approach, can assist managers in choosing an acceptable risk threshold that optimally balances competing demands for forest-related resources. If forest managers can become accustomed to rigorously evaluating competing values and site conditions, greater improvements in erosion control may be obtained without reducing harvests.

Key words. Erosion, forest roads, timber harvesting, discriminant functions, risk assessment.

Introduction

Best management practices (BMPs) are defined in federal regulations as what is practicable in view of "technological, economic, and institutional considerations" (Council on Environmental Quality 1971). Therefore, BMPs are political compromises taking into account what is scientifically known, technically feasible, economically reasonable, and socially acceptable. BMPs can be procedural or prescriptive. In California, for example, U.S. Forest Service BMPs are largely procedural, describing the steps to be taken in determining how a site will be managed. In contrast, BMPs on private land are almost exclusively prescriptions of practices to be employed in response to site conditions. Prescriptive BMPs usually include a practice and some way of determining when and where the practice should be applied.

In this paper it will be argued that because of the political component of BMPs, California is a bellwether of future changes in forest practice regulations in other Pacific coast states. Data will be presented suggesting that California's prescriptive BMPs have resulted in reduced erosion and sedimentation. Recent erosion studies in California will be reviewed, but the main focus will be the ways of estimating erosion hazard. Finally, an objective method of estimating and managing erosion risk will be presented. The method has been tested and found effective in estimating risk, but problems impede its use as a management tool. These will be explored.

Forestry Best Management Practices

Most of the measures to protect water quality in current forestry BMPs owe their origin to the Federal Water Pollution Control Act Amendments of 1972 (PL 92–500), which mandated the control of nonpoint sources of water pollution. Silviculture was one of the nonpoint sources specifically mentioned in the Act. Section 208 also required the states to develop areawide management plans to reduce water quality degradation. Forest practice regulations are part of each state's efforts to satisfy the requirements of Section 208. It was recognized early that forestry regulations would have to be mainly prescriptive rather than reactive. Three considerations make the prescriptive approach appropriate: (1) Because most forestry-related pollutants are natural substances, such as sediment, their origin may be difficult to determine. (2) The practice that results in pollution may be difficult or impossible to correct once the pollution has occurred. (3) The level of pollution is the result of the interaction of a practice and the subsequent weather. If rules were based on the measured level of pollution, an appropriate practice followed by an extreme storm might become a violation, while a careless disregard for the environment might go unnoticed if followed by benign weather. It is unknown whether current forest practice rules will result in achieving PL 92–500's specific water quality targets.

The wide variability in the forest practice rules of the Pacific coast states is exemplified by requirements for approval of timber harvest plans. In California, operations must be described by a Registered Professional Forester, approved by the Department of Forestry, and conducted by a Licensed Timber Operator (State of California, n.d.). In Washington, forest practices are divided into four classes: two classes require approval, one can proceed five days after notifying the Department of Natural Resources (if the Department fails to object), and one requires no notification (Washington State Forest Practices Board 1988). In Oregon, notification is the rule and only operations involving certain practices require approval of written plans (State of Oregon 1987). In Alaska, the rules have yet to be written, but indications are that they will be still more lenient (Alaska Department of Natural Resources 1989). This progression suggests that the detail and rigor of regulations are linked to the urbanization of each state and the relative economic importance of its forest products industry. California has the most detailed and rigorous rules, followed by Washington, Oregon, and Alaska. As political entities, BMPs respond to public perceptions of what is acceptable, as well as increased scientific understanding of relevant processes. It appears that demographics play a large role in determining BMPs in each state. If this inference is correct, California's northern neighbors can see in its Forest Practice Rules what lies ahead as their states become more urbanized and industrially diversified.

The Effectiveness of BMPs

The evolution of forest practice regulations in California provides a few clues to the effectiveness of BMPs. What follows are only clues because the results of different locales and different experimental methods will be compared. Between 1945 and 1973, forest practice rules dealt primarily with forest regeneration and fire protection. However, in 1959 and 1960 some rules concerning erosion control and stream protection were adopted. The effectiveness of these rules may be inferred by contrasting the results of two watershed experiments. In 1959, prior to adoption of the rules, a tractor-yarded partial cut removed 9,900 m^3 of timber (12% of the merchantable volume) from the 10.4 km^2 Castle Creek watershed in the Sierra Nevada (Rice and Wallis 1962). During the first two postlogging years, suspended sediment discharge increased fivefold. In 1971–72, a tractor-yarded partial cut removed 84,600 m^3 (38% of the merchantable volume) from the 4.1 km^2 South Fork Caspar Creek watershed in northwestern California (Rice et al. 1979). During those two years, suspended sediment discharge also increased about fivefold. This relative increase was held constant even though the Caspar Creek logging removed about twenty times more volume per hectare than the Castle Creek logging. Furthermore, Caspar Creek presented a greater erosion hazard than Castle Creek. It was somewhat steeper (average slope 34% versus 17% in Castle Creek), had soils developed from marine sediments that were considerably more erodible than those developed from the igneous rocks of Castle Creek, and had postlogging unit area peak discharges that were four times higher.

Table 14.1. Changes in erosion rates due to mass movements and gullies caused by forest roads and logging measured in studies conducted in 1975–76 and 1985–86.

	Erosion Rate (m³/ha)		
Area	1975–76	1985–86	Ratio
Roads	132.6	27.6	0.21
Harvest areas	17.5	11.0	0.63

Two studies of erosion provide a more valid measure of the effectiveness of BMPs. In 1973 the Z'Berg-Nedjedly Forest Practice Act began an era of increasingly restrictive forest practice regulations (Arvola 1976. Martin 1989). In 1975 and 1976 a study of logging-related erosion measured 57 plots on private land averaging 4.5 ha (Rice and Datzman 1981). Plots were selected from strata based on slope, annual precipitation, geologic parent material, yarding method, and time since logging. Each plot was 201 m wide and included a landing and the area yarded to it. The average age of the plots was 4.6 years, most of them having been logged prior to the new rules. In 1976, erosion was measured on 344 1.6-km segments of Forest Service logging roads (McCashion and Rice 1983). McCashion and Rice estimated the average age of these roads to be 11.5 years, but expressed little confidence in the accuracy of their age information. Road plots were selected from strata based on slope, annual precipitation, geologic parent material, road standard, and time since construction or reconstruction of the road segment. These results can be contrasted with the data collected during a 1985–86 study that measured 0.81 ha plots randomly located on private roads and harvest areas where operations had been completed between November 1978 and October 1979 (Lewis and Rice 1990). This comparison (Table 14.1) reveals that road erosion in the 1985–86 study has dropped to one-fifth of its value in the 1975–76 study but that harvest area erosion was still 63% of its former value. Since roads are responsible for most of the erosion associated with forest operations, the aggregate reduction in erosion over the decade was about two-thirds.

These comparisons argue that changes in forest practices have resulted in lower erosion rates and, presumedly, improved water quality in California. Although the rules changed considerably during that time, the addition of 48 Forest Practice Inspectors by the California Department of Forestry may be of at least equal importance. Correct application of a BMP is the responsibility of the timber operator. Human nature being what it is, compliance varies with the operator's motivation and understanding of regulations. In the course of measuring 426 plots in northwestern California, Durgin et al. (1988) observed that compliance with regulations tended to diminish with distance from the point of entry to the harvest area. This suggests that the effectiveness of BMPs will depend, in part, on the level of review and enforcement. Whatever the reason, there were environmental dividends from California's investment in better forest practices.

Erosion Hazard Ratings

Any effort to apply BMPs should be governed by an estimate of the erosion hazard. This reasonable assumption has led to some rather unreasonable schemes. Perhaps foremost were attempts to adapt the Universal Soil Loss Equation (USLE; Wischmeier and Smith 1965) to a forested environment. The USLE was a good procedure in its time and place, but its time was 1960 and its place was on agricultural lands east of the Rocky Mountains. It was an inappropriate starting point for an index of erosion hazard resulting from forest management. It was developed in a totally different environment from the Pacific coast forests, and it estimated erosion due to processes that were of little importance in mountainous forests. In mountains, slope is much more important than it is on agricultural lands because of the dominance of mass erosion processes. For the same reason, long-duration rainfall amounts and subsurface water replace short-term rainfall intensity and overland flow in determining erosion.

An erosion hazard rating (EHR) was made part of the Forest Practice Rules for the Coast Forest Practice District in California in 1973. It was developed by four scientists (Henry Anderson, Bill Colwell, Paul Zinke, and the author) in a few days. The basic structure of the EHR came from Anderson's (1974) regression analysis, modified by the group's collective professional judgment. It is doubtful that any forestry EHRs have a less questionable parentage. When the EHR was tested empirically (Datzman 1978), it had a coefficient of determination (r^2) with measured erosion of 0.01. In an empiric test of another EHR, Llerena et al. (1987) found: "The rankings by the proposed rating system showed poor agreement with those based on actual measurements." Datzman's (1978) findings led to the 1980 revision of the EHR. The new procedures dealt with surface erosion and mass erosion separately. Beyond that, the new methods were a step backward. The surface EHR was patterned after one used by the Forest Service and has never been tested empirically. The Board of Registration of Geologists and Geophysicists objected that the mass EHR would require foresters to practice geology without a license. Consequently, the mass erosion procedure is only found hidden in definitions of the terms "slide areas," "unstable areas," and "unstable soils." These terms are found mainly in rules related to roads and landings. In harvest areas, slope and the surface EHR regulate practices. Presumedly, harvest-related mass wasting is dealt with only indirectly through the consideration of slope.

Quite apart from the lack of a sound scientific basis, most EHRs err by taking too broad an approach. The 1980 EHR was applied to areas no smaller than about 4 ha. Erosion in the forest almost always occurs in a tiny fraction of the operating area. Inspection of Datzman's (1978) data revealed that 68% of all erosion measured occurred on just 4 of 102 plots. In a companion study of road-related erosion, only 0.6% of the road length had events displacing more than 15 m^3 of eroded material (Rice and Lewis 1986). Durgin et al. (1988) reported: "Almost all the measured erosion was produced on 12% of the study area—and nearly all erosion was concentrated in a few geographic areas." Others have also noted that most erosion from forest operations occurs on a few critical sites (Dodge et al. 1976, Peters and Litwin 1983). Peters and Litwin concluded that the key to reducing adverse environmental effects lay in developing a way to identify high risk sites. What was needed was an EHR that estimated the risk that serious erosion would occur, not how serious the erosion might be.

Managing Erosion Risk

The Critical Sites Erosion Study

The Peters and Litwin (1983) report led to the Critical Sites Erosion Study (CSES), a study of the occurrence of critical sites (erosion >189 m^3/ha) in harvest areas and on forest roads (Lewis and Rice 1989). The sampled population came from the areas covered by Timber Harvest Plans completed between November 1978 and October 1979. The 1978–79 period was chosen for the study because it was a year of heavy cutting and because enough time had elapsed for the occurrence of logging- or road-related mass wasting. Earlier studies had shown mass wasting to be the most important erosional process (Dodge et al. 1976, Rice and Datzman 1981, Peters and Litwin 1983). Due to the cooperation of most landowners, the study came close to obtaining a truly random sample of the target population. Access was granted to lands covered by 415 of the 638 Timber Harvest Plans (THPs) in northwestern California. They included all the THPs on industrial ownerships and covered 75% of the area in the total 638 THPs.

The sampled units were 0.81 ha plots. All erosion features displacing more than 10 m^3 were measured and tallied. The plots were classed as critical (erosion >189 m^3/ha) or noncritical. Harvest area noncritical plots were randomly located with the probability of selection in proportion to the area covered by each THP (Lewis and Rice 1989). Road noncritical plots were randomly located on each THP with the probability of selection in proportion to length of roads in the THP area. Data from all harvest area critical sites were included in the harvest area analysis, and a randomly chosen two-thirds of the road-related critical sites were used in the road analysis.

Each plot was characterized by 172 variables to ensure that it was fully described. Only 31 variables were used in the statistical analysis of the harvest plot data and 25 variables with the road plot data. The fieldwork was carried out between May 1985 and December 1986. Each plot was visited

Table 14.2. Distribution of erosion features larger than 10 m^3 on critical plots (Lewis and Rice 1990).

	Road Plots Percentage by:		Harvest Plots Percentage by:	
Erosion Type*	Number	Volume	Number	Volume
Debris flow	17.0	18.4	35.3	45.4
Debris slide	43.4	31.5	47.1	41.7
Earthflow	2.8	21.0	2.0	0.6
Slump	12.3	4.1	2.0	0.8
Translational/Rotational	6.6	18.2	3.9	7.2
Deep-seated translational	7.5	3.4	3.9	1.9
Rotational	0.9	0.6	2.0	0.8
Total Mass Movements	90.6	97.2	96.1	98.5
Gully	9.4	2.8	0.0	0.0
Streambank	0.0	0.0	3.9	1.5
Total Other Types	9.4	2.8	3.9	1.5

*Using the nomenclature of Bedrossian (1983).

by an interdisciplinary team composed of a forester, a geologist, and a soil scientist. In addition to making measurements, the team attempted to discover why each critical event had occurred. They measured 57 management variables and only 13 site variables, but concluded that natural site conditions were most important (Durgin et al. 1988).

The results of the investigation confirmed previous findings. It was estimated that erosion features displacing more than 10 m^3 of soil occurred on only 12% of the plots (Durgin et al. 1988). Critical plots contained 65.4% of the erosion but occupied only about 2% of the road length and 0.5% of the harvested area (Lewis and Rice 1989). When the area of erosion features is considered rather than plot area, only 0.2% of the 1978–79 THP area was scarred by erosion features displacing more than 10 m^3. Mass wasting was also found to be the cause of almost all of the erosion (Table 14.2). The study confirmed the dominance of road-related erosion over harvest area erosion, which has been noted in studies since at least 1954 (Anderson 1954). Roads yielded 70% of the total erosion volume. The erosion rate on roads was 21.5 times that in harvest areas, a ratio close to the 17 reported by McCashion and Rice (1983).

Discriminant Analysis

Linear discriminant analysis (Fisher 1936) is a statistical procedure well suited for distinguishing unstable sites from stable ones. Its use to assess landslide potential on road alignments has been proposed by Duncan et al. (1987). Several studies have used discriminant analysis for problems similar to the CSES (Furbish and Rice 1983, Rice et al. 1985, Rice and Lewis 1986). In each of these studies the accuracy of the discriminant function was tested with data not used in its development. The test accuracies varied from 75 to 81%. Consequently, in the CSES all the data were used to develop the discriminant functions and none were held back for testing (Lewis and Rice 1990). The accuracies of the equations were estimated using bootstrapping techniques (Efron and Gong 1983). The discriminant function for identifying critical and noncritical sites on forest roads was:

$$\begin{aligned} DS = {} & -0.0281 - 0.1142*SLOPE \\ & + 22.91*HCURVE + 1.0075*HUE. \end{aligned} \tag{1}$$

and for logged areas it was:

$$\begin{aligned} DS = {} & 5.032 - 0.1633*SLOPE + 20.69*HCURVE \\ & - 1.215*WEAKROCK. \end{aligned} \tag{2}$$

where:

DS	is the discriminant score;
SLOPE	is the terrain slope in degrees;
HCURVE	is the horizontal curvature of the road centerline in Eq. 1 and of the terrain in Eq. 2 (Horizontal curvature is the radius of a circle passing through the measurement site and two other points on the same contour at distances of about 18 m. It was coded negative in swales and positive on ridges, being zero on planar slopes.);
HUE	is the Munsell hue of moist subsoil (Y = yellow, YR = yellow-red) coded: 1 if the hue is 5Y, 2 if 2.5Y, 3 if 10YR, 4 if 7.5YR, 5 if 5YR;
WEAKROCK	is coded +1 if a bedrock specimen crumbles or deforms under hammer blows and -1 if the specimen fractures. This variable is a simplification of a more refined scale of rock strengths proposed by Williamson (1984).

The variables in these equations are good surrogates for the factors affecting slope stability. Slope indexes the partitioning of the force of gravity into a normal component (promoting stability) and a tangential component (promoting failure). Horizontal curvature indexes the convergence of subsurface water and zones of accumulation of colluvium (both conditions promoting failure). And HUE most likely indexes subsurface water, because most of the yellower soils had a bluish cast due to reduced iron. WEAKROCK separates stable and unstable geologic materials.

The estimated accuracies of the equations, corrected for bias using bootstrapping, are 78% for roads (Eq. 1) and 69% for harvest areas (Eq. 2). The accuracy of Eq. 2 was lower than that in the earlier harvest area studies (Furbish and Rice 1983, Rice et al. 1985), but those studies were developed and tested in limited environments, whereas Eq. 2 was developed from data spanning a variety of conditions. Therefore, Eq. 2 may be more general and more stable if applied outside the range of its developmental data.

The overall risk of a critical site in the population is called a prior probability. It must be known or estimated before a discriminant score can be used to estimate the risk at a site. The predicted risk at a site is known as a posterior probability. Prior probabilities are usually defined as the ratio of the area being identified (critical sites) to the total area (all 1978–79 harvest areas or roads). Lewis and Rice (1990) estimated the prior probability of a harvest area critical site to be 0.0050 and a road critical site to be 0.0177. The posterior probability of a critical site is:

$$PP = 1/\{1 + [(1 - PC)/PC]\exp(DS)\} \quad (3)$$

where PP is a posterior probability and PC is the prior probability of a critical site. Using Eq. 1 or 2, the posterior probabilities are the risks that road construction or timber harvesting will result in more than 189 m^3/ha of erosion. All estimates of posterior probability are not equally precise (Figures 14.1a and 1b). The wide error bands around sites with high posterior probabilities may partially explain the documented tendency of experts to overestimate risk (McGreer and McNutt 1981). There are many stable sites that appear identical to unstable ones, within the precision of our measurements.

Acceptable Risk

In order to use an erosion hazard rating to manage risk, a threshold of acceptable risk must be set. Often this is done intuitively, but more objective methods have been proposed. Rice and Pillsbury (1982) developed a method to estimate a threshold for use in an area, such as a whole harvest unit. It requires the collection of data from the whole unit in question so that local hazard, as well as the prior probability, can affect the choice of an acceptable risk threshold. Lewis and Rice (1990) proposed an equation that uses only the prior probabilities and measurements of the site being evaluated. Both methods, however, require that all four possible outcomes of a prediction (Figure 14.2) be explicitly evaluated. Condition A is the correct identification of a stable site. It carries the net value (V) of changes in all resources affected by the activity. Condition B is the incorrect designation of a stable site as unstable. The value (v) of this result has the value of Condition A minus the cost of any mitigation undertaken as the result of the misclassification. Condition C is the failure to identify an unstable site. It carries the value of Condition A minus the cost (D) of the resulting damages. Condition D is the correct identification of an unstable site. Its value is that of Condition C minus any residual excess damage (d) to resources that may occur, even with mitigation. According to the Bayesian rule (Green 1978), the cutpoint (TC) in the discriminant function which minimizes the expected cost is:

$$TC = \ln PC/(1 - PC)[(D - d) - (V - v)]/(V - v) \quad (4)$$

Evaluating the four conditions of Figure 14.2 is difficult, but doing so

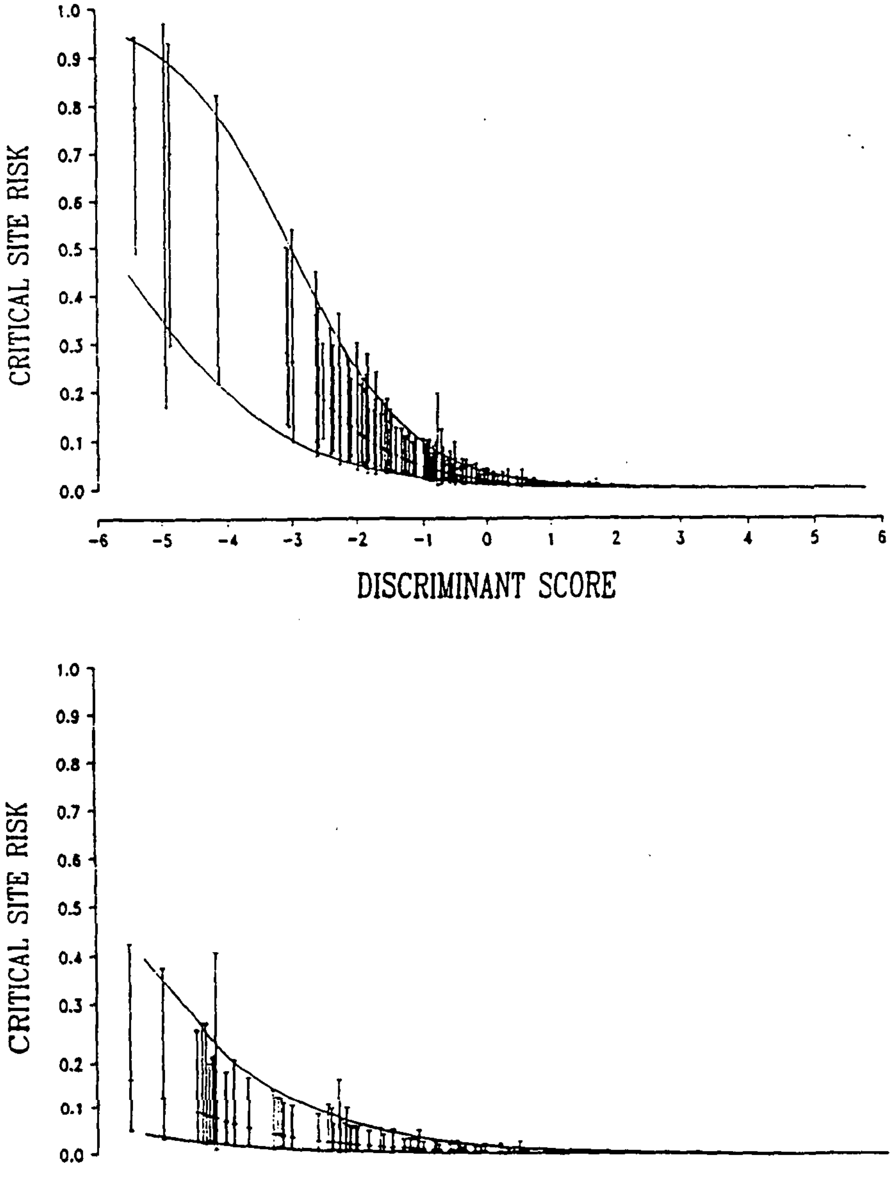

FIGURE 14.1. Variability associated with critical site predictions based on Eq. 1 for roads (top) and Eq. 2 for harvest areas (bottom). The bars show the bootstrap standard deviation at each discriminant score. The curves were fitted to the standard deviations using logistic regression.

	Predicted Condition	
Actual Condition	Stable	Unstable
Stable	A	B
Unstable	C	D

FIGURE 14.2. The matrix of possible results when predicting the stability of a site.

makes it possible to estimate the acceptable risk threshold that will maximize return from competing resources, based on a manager's value system. It also provides a framework for displaying and discussing alternatives.

The individual manager's value system will affect both the benefits and the costs of operations, whether using the system proposed here or sticking with intuition. A small survey was conducted to gain some insight into the effect of managers' value systems on clearcutting in steep inner gorges and the resulting landslide erosion. Part of the data came from responses to a questionnaire mailed to 54 Forest Supervisors and District Rangers in northwestern California and western Oregon. The same questionnaire was passed out at a meeting of the Jedediah Smith Chapter of the Society of American Foresters (SAF). Replies were obtained from 48 Forest Service personnel and 12 employed in private industry. Statistical treatment of these data was not appropriate because the respondents were self-selected and not independent observers. Although such a sample does not warrant rigorous extrapolation to the population of forest managers, the results may be instructive. Any insights must be tempered by recognition of the limitations of the sampling and the small number of industry responses.

A reprint of an article describing the proposed acceptable risk procedure (Rice et al. 1985) was mailed with the questionnaire. At the SAF meeting, the questionnaire was distributed after a lecture on using discriminant analysis to manage landslide risks associated with clearcutting. The respondents were asked to rate each of the four decision outcomes (Figure 14.2) on a scale ranging from -1.000 (the worst outcome) to +1.000 (the best outcome). They were asked to incorporate in their rating all factors that would customarily be weighed when considering how to harvest timber from a potentially unstable streamside area—not only the economic and environmental considerations, but the social, political, and personal career effects that might result.

The results were much as might have been expected (Table 14.3). Both public and private respondents gave high ratings for harvesting timber on stable land and mitigating high risk sites. The industrial foresters were more

Table 14.3. Average responses and management styles of Forest Service and privately employed personnel concerning logging high risk terrain.

Concern*	Private	Forest Service
A – harvesting a stable site	+992	+728
B – unnecessary mitigation	−733	−367
C – causing a landslide	−517	−831
D – mitigating a landslide	+617	+791
Environmental concerns |D-C| = E	1.133	1.622
Utilization concerns |A-B| = U	1.725	1.094
Management style U/E	1.96	0.79†

* A, B, C, and D are rated on a scale ranging from −1.000 (the least desirable result) to −1.000 (the most favorable result).

† One respondent with a management style of 2.000 was omitted. If he had been included, the value would be 42.4. The inclusion of this respondent in other means did not greatly change them.

concerned about being able to harvest timber, while their Forest Service counterparts expressed about equal concern for timber harvest and landslide prevention. Private foresters' appraisals of the loss from failing to cut timber on stable terrain was nearly twice that of Forest Service people, and they also attached a smaller penalty to causing a landslide.

The responses summarized in Table 14.3 were used to create an index of managerial style. The range between the reward for preventing a landslide and the penalty attached to causing one was taken as a measure of environmental concern. Timber utilization concerns were indexed by range between the penalty for carrying out unnecessary mitigation on stable land and the reward associated with harvesting timber on stable land. Private foresters' utilization concerns were 58% greater than those of public land managers. That difference was reversed for environmental concerns. Forest Service managers concerns for the environment were 43% greater than those of their private counterparts.

An index of managerial style was created by dividing timber utilization concerns by environmental concerns. Public land managers favored the environment, with a score of 0.79. Private foresters exhibited a wider range of concerns, but displayed a decided utilization bias with a score of 1.96.

Only Forest Service data were used for more detailed analysis of the effects of managerial style. The private data set was too small. The Forest Service managers were divided into six relatively homogenous groups at styles of 0.4, 0.7, 0.9, 1.1, and 2.0. Six terrains of varying landslide risk were hypothesized. The most stable had a prior probability of 1.45%, equivalent to the landslide risk in the inner gorges of the Six Rivers National Forest, California (Furbish 1981). The other five terrains had prior probabilities of 5%, 10%, 15%, 20%, and 25%—all extremely hazardous. Managers' acceptable risk thresholds were estimated using the method of Rice and Pillsbury (1982). Each manager's value system was tested in ten simulations. In each simulation a terrain was created by a random drawing of data points, defined in terms of variables in Furbish and Rice's (1983) equation.

The simulations showed managerial style to have much more influence on the threshold probability than does the prevailing risk of the area, as indexed by its prior probability. Landslide risk had its greatest influence on managers with middle managerial styles. Acceptable risk threshold probabilities are, however, only means to ends. What effect did they have on land management? For these simulations, it was assumed that mitigation consisted solely of not harvesting hazardous sites. Surprisingly, neither managerial style nor prior probability had much effect on timber utilization. The greatest difference attributable to management style was less than 2%. Landslide risk was more influential, but only ranged from 89% utilization by the most environmentally concerned managers on the most hazardous terrain to 99.5% utilization by the most timber production-oriented managers on the most stable terrain. Erosion was a different story. As would be expected, erosion was closely tied to landslide risk for all managerial styles. Style, itself, mainly separated the most environmentally concerned managers from the others.

The average of the responses of the private foresters was contrasted with the average of the Forest Service respondents for the six terrains to gain some indication of the possible differences that private foresters' managerial styles might yield. The Forest Service managers had risk thresholds much below their private counterparts (Figure 14.3). That disparity, however, translated into almost imperceptible differences in timber utilization. On the other hand, compared with the average Forest Service style, private foresters' decisions had produced a fairly constant 14% more erosion. The excess erosion associated with the private management style increased from 12 m^3/ha on the least hazardous terrain to 287 m^3/ha on the most hazardous terrain. If these simulations reflect reality, the private foresters' style would be justified if the environmental costs of the 14% increase in erosion were offset by operational economies or other environmental benefits.

The differences seen in the simulations may be an artifact of the questionnaire. The Forest Service responses suggest that actual behavior may not reflect the managers' stated value systems. For example, timber harvests are severely constrained on inner gorge areas amounting to about 12% of the Six Rivers National Forest. This constraint would be justified if the prior probability of a landslide in that terrain was approximately 25%. It is actually only 1.45% (Furbish 1981). It may be that private foresters similarly are unaware of their implicit value systems and believe that their timber utilization orientation is greater than it really is. If the maximum benefit is to be gained from the erosion risk management method just presented, forest managers must become accustomed to setting acceptable risk thresholds explicitly and quantitatively. Until they are able to do so, their actions may not reflect their intentions.

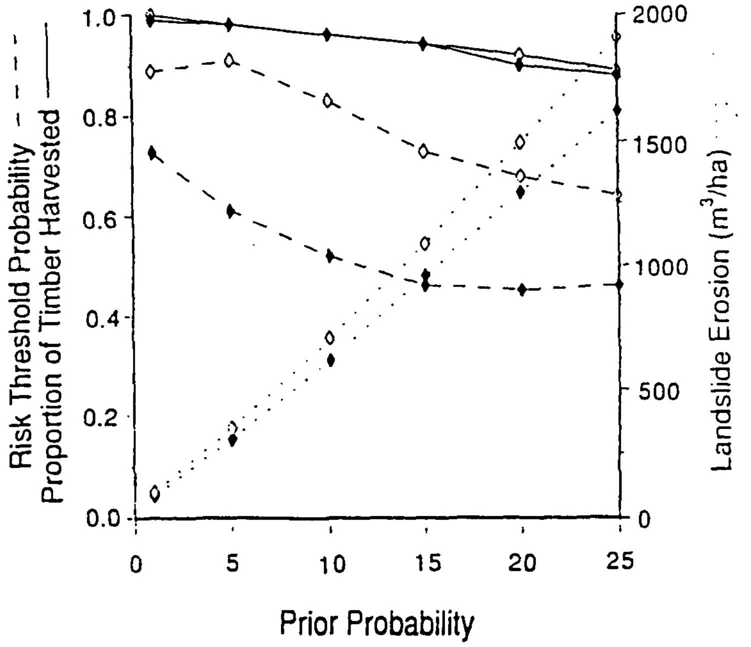

FIGURE 14.3. The effect of the managerial styles of public and private forest managers on the choice of an acceptable risk threshold to use when harvesting timber in an inner gorge, and the resulting erosion and timber utilization. The interaction between six prior probabilities (0.0145, 0.05, 0.10, 0.15, 0.20, 0.25) and the average managerial style of each of the groups. ◆ = Forest Service. ◇ = Private.

Summary and Conclusions

Best management practices, being partly the result of political processes, respond to the moods of the electorate. As states become more urbanized, forest practice rules protecting water quality tend to become more restrictive. The change in erosion and sedimentation accompanying the evolution of California's forest practice rules suggests that the tightening of rules has reduced erosion and improved water quality. Research has found that most erosion in forests comes from a small fraction of the terrain and that site conditions are the most important determinate of erosion risk. This suggests that identifying high risk sites is the key to effective erosion control. Erosion hazard ratings, however, tend to be poorly grounded in science and too broad in scope. One result, perhaps, is that some public land managers are unnecessarily restricting harvests on stable terrain. The discriminant functions presented here permit accurate estimation of erosion risk at a site and the choice of an optimal risk threshold. If forest land managers were to apply risk management tactics based on scientifically developed discriminant analyses, the impediments to forestry might be more in line with the resulting water quality benefits.

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