Technical Commentary

Erosion and Sedimentation Concerns Related to Hardwood Management in California

Theodore E. Adams, Jr.*, and Raymond M. Rice*

Lack of information on the status of hardwoods, particularly oaks (*Quercus* sp.), is creating concern in California that continued fuelwood harvest will aggravate erosion and sedimentation (Pillsbury et al. 1983). This concern is unsupported by data from the West Coast because few data exist, a fact acknowledged by Pillsbury et al. (1983).

Several county governments have recently imposed restrictions on the harvesting of hardwood (Mayer et al. 1986), and there is a possibility of similar policy at the state level. Thus there is a need to review what is known about the impacts of tree harvest on erosion and sedimentation, and how this might be interpreted with respect to the hardwood issue in California.

We have extrapolated from the data base on softwood logging to examine how hardwood harvesting might impact erosion and sedimentation. We acknowledge that the trees and equipment involved in hardwood harvest are normally much smaller than those encountered in softwood operations; and that many hardwoods grow on soils and in rainfall regimes that do not support softwoods (softwoods in California generally grow where annual precipitation is 30-35 in. or more, and most of the oaks occur in the oak-grass woodlands where rainfall is less than this). Nevertheless, the softwood logging experience can help us understand the effects of hardwood harvest on erosion and sedimentation in California.

The effect on erosion of plant cover and management has long been recognized, but different types of vegetation influence erosion differently. For example, a tree canopy intercepts raindrops, a primary source of energy for erosion. However, under normal conditions of precipitation in California, trees may be detrimental by aggregating small natural raindrops into larger throughfall drops (Chapman 1948, Mosley 1982, Tsukamoto 1975). If the canopy is more than a few yards above the ground surface, these throughfall drops have a greater erosional impact than naturally occurring raindrops. The effect of trees on raindrop erosion will, therefore, depend on the amount of litter or herbaceous cover available to dissipate energy of large throughfall drops.

In stands that have scant litter or other cover, harvesting the trees would probably be beneficial because of reduced drop size. The effect of removing trees that produce a thick layer of litter will depend on the pattern and extent of disturbance of this layer, how long the litter will last under a reduced canopy, and whether reduction of the canopy will favor development of herbaceous cover that can provide effective protection for the surface soil. Increased herbaceous cover was observed to occur in the northern Sacramento Valley when blue oaks (*Q. douglasii*) were cut (Kay and Leonard 1981).

High rates of erosion following logging or other forest disturbances are acknowledged problems, but a disproportionate share results from road construction that represents a small percentage of the disturbed area (Rice et al. 1972). McCashion and. Rice (1983) estimated 40% of erosion associated with logging in northwestern California could be attributed to roads. In the western Cascade Range, OR, Swanson and Dryness (1975) found that road right-of-way and clearcut areas in an unstable zone of the H. J. Andrews Experimental Forest contributed about equally to the total impact of logging on erosion by landslides. However, only 9% of the managed area was in roads.

The high rates of erosion induced by logging or other disturbance within a watershed are not sustained. Erosion rate declines steeply within a few years following cessation of logging operations (Lima et al. 1978, Rice et al. 1972).

Total erosion resulting from cable and tractor logging in northwestern California lies somewhere between 0.1 cubic yards/ac and about 2 cubic

[1] Authors are, respectively, Extension Wildlands Specialist, Agronomy Extension, University of California, Davis CA 95616, and Principal Hydrologist, USDA Forest Service, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521-6098.

yards/ac (Rice and Datzman 1981). The amount depends on whether surface erosion is considered alone or combined with gully erosion and whether mean or median erosion is measured. When weight per unit volume is considered, the highest value represents a loss of 2T/ac, and it must be considered a significant negative impact. Although the soils present, Dystric Xerochrepts, have a soil loss tolerance of 3T/ac per year according to the Soil Conservation Service, gully erosion involves much more of the soil profile than sheet and rill erosion to which the soil loss tolerance applies [soil loss tolerance " . . denotes the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely" (Wischmeier and Smith 1978)].

A hardwood of great interest in California is blue oak, which occupies more acreage than any other hardwood in the state (Mayer et al. 1986). It is generally found away from water courses on soils representing Typic Xerocherpts, Ultic Haploxeralfs, and Mollic Haploxeralfs. These soils have soil loss tolerances of 2-3T/ac per year. They occur in the foothills surrounding the Sacramento-San Joaquin Valley, and in inland coastal valleys where rainfall is 12-35 in. per year.

Evaluations of the logging impacts in steep areas probably have limited application to the gentler slopes on which many hardwood are found. In areas too flat for landslides, road construction will be almost the sole source of erosion.

This may be unimportant if hardwood operations do not result in significant road construction, as some observations suggest. Furthermore, future management must consider the multiple values of hardwood stands, including their contribution to wildlife habitat. Management guidelines for several of these values have been prepared (Passof et al. 1985).

A frequently cited study of the impacts of deforestation was conducted on the Hubbard Brook Experimental Forest in New Hampshire, a northern hardwood forest ecosystem. All trees and other woody vegetation were cut and left in place followed by repression of growth with herbicides for 3 years (Pierce et al. 1970). Bormann et al. (1974) observed an increase in erosion that reached a peak of 0.17T/ac per year in the third year compared with a rate of 0.01T/ac per year from the mature forested ecosystem. However, soil survey information indicates the soil loss tolerance for soils dominating on the Forest–Typic Haplorthods covered with a thick layer of forest humus 2-6 in. deep–is 3T/ac per year.

Vegetation management in the above study does not compare with standard logging practices. The effects of treatment cannot be used as examples of logging impacts. In addition, it is inappropriate to extrapolate from the Hubbard Brook experience to California with its Mediterranean-like climate and different soils.

Excess soil water is recognized as a contributing factor to mass wasting or landslides. This form of erosion is considered by Pillsbury et al. (1983) to be a major problem in the timber producing areas of northwestern California. It is suggested that trees, particularly hardwoods, can influence the occurrence of landslides by dewatering sites through evapotranspiration and that cutting trees will interfere with this process. There are no data to support or refute this idea, but the prevalent opinion is that trees cannot transpire enough water to be effective. Evapotranspiration is believed to be most important on the driest sites and probably has little or no effect in the well-watered north coast of California. The rationale behind these beliefs is that both cleared and forested sites will be at field capacity during most of the winter when storms are likely to be of sufficient magnitude to cause landslides. Evapotranspiration occurs even in the dormant season, but judging from climatic data, it is trivial in scale and would not be influenced by the widely occurring blue oak, a deciduous tree that does not transpire significantly during the wet season.

Roots contribute to the shear strength of soils, thus decreasing their erosion potential. Loss of relative root reinforcement due to decay can be 60-80%, 5 to 10 years after a softwood clear-cut (O'Loughlin and Ziemer 1982, Ziemer 1981 a, b). Following the logging of redwood, loss of root reinforcement can be 50%.[2] However, the effect of roots will depend on the type of soil. Soils with little cohesion will owe virtually all of their tensile strength to roots. On the other hand, roots may be irrelevant in very cohesive soils.

Hardwood and softwood species differ in root strength. For example, Ziemer (1981a) found ceanothus roots to be 1.6 times as strong as those of conifers. However, conifer root biomass was about 3.3 times that of hardwood. When comparing stands having trees of sufficient size and volume to be suitable for management, the best guess is that these two classes of plants are about equal with respect to adding tensile strength to soils.

Of much more importance when comparing softwood and hardwoods is whether or not the species in question sprouts, because most of the roots of sprouting species would not die while those of nonsprouters would. As an example, blue oak produces numerous root crown and coppice sprouts after cutting or burning (Sampson and Jespersen 1963).

Forest practices can alter the character of watersheds and streams, and logging can devastate aquatic habitat (Harr 1979, Harr et al. 1979, Swanson and Dryness 1975). Removal of riparian vegetation can result in increases in water temperature, intolerable for trout and salmon. Logging debris, including sediment, can destroy spawning beds, create barriers to fish migration, and, as the debris decomposes, deplete oxygen in the water, thus suffocating fish, their eggs, and other aquatic life. However, this impact does need qualification.

In short coastal streams of the north coast, the water is often too cool to achieve its maximum productivity and warming is beneficial to fish. While logs and slash can form dams and deplete oxygen, they also provide structures which resist erosion and maintain channel stability, providing cover for fish and a substrate for organisms at the lower end of the food chain. In a sediment-poor watershed, "Torrents created habitat diversity by adding boulders, rubble, gravel, and wood debris to the channel and increased both quantity and quality of habitat for juvenile and adult coho salmon" (Everest and Meehan 1981).

Peak flows may change after harvesting, but they do not always increase (Harr et al. 1979). In western Oregon, the annual peak flow in a small watershed was reduced 32%, and the average delay of all peak flows was nearly 9 hours following clearcut logging (Harr 1979, Harr and McCorison 1979). In addition, stream flow increases in late summer can be beneficial to the aquatic environment (Patric 1970).

The harvest of most hardwoods, blue oak for example, is unlikely to impact watersheds and streams in the same way as has logging of softwoods; environmental conditions are different and hardwood harvest has not been, and is not expected to be, as intensive. However, may people are concerned about the impact of clearing hardwoods and brush from steep watersheds in the mixed woodland-chaparral areas of the state. Managing this vegetation type for improved livestock forage is an established practice (Nichols et al. 1984). Such management is practiced by ro-

[2] Ziemer, R. R., Hydrologist, USDA Forest Service-Redwood Sciences Laboratory, Arcata, CA. (Telephone conversation with T. E. Adams, August 8, 1984).

tational burning and vegetation type conversion (clearing brush by using a combination of mechanical methods and fire followed by seeding of forage species, when necessary, and control of woody plant seedlings and sprouts). If vegetation type conversions take place in geologically unstable areas, the results can include increases in soil slips and sediment discharges from watersheds (Pitt et al. 1978). We suggest it is unreasonable to assume that the management of hardwoods will employ the approach used in range improvement for livestock production. The "clearcutting" of hardwoods cannot be a practice associated with future hardwood management in the mxied woodland-chaparral vegetation type where sustained yield and other considerations are important.

All of the information we have presented may be irrelevant. Testimony heard before the Coast District Technical Advisory Committee to the California State Board of Forestry suggests that hardwood operations on slopes steep enough to present any appreciable landslide risk are not economic. To paraphrase one statement, a merchantable hardwood tree is one you can drive to. Similarly, it is unlikely that hardwood operations can support the expense of extensive construction of roads or skid trails. If these assumptions are correct, the erosional impact of harvesting hardwood will be expressed almost exclusively as minor surface erosion.

The extensive acreage of blue oak has made it a target for fuelwood harvest. Future management of this resource will recognize the oak's contribution to maintenance of soil stability and be made compatible with other objectives through careful selection of harvest sites and coppice management to promote regeneration.

The main problem may be woodcutters going after riparian hardwoods such as valley oak (*Q. lobata*) and black walnut (*Juglans hindsii*). This could have negative impacts on both erosion and water quality. In addition, such activity would represent a threat to riparian wildlife habitat, a concern not addressed in this review. □

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