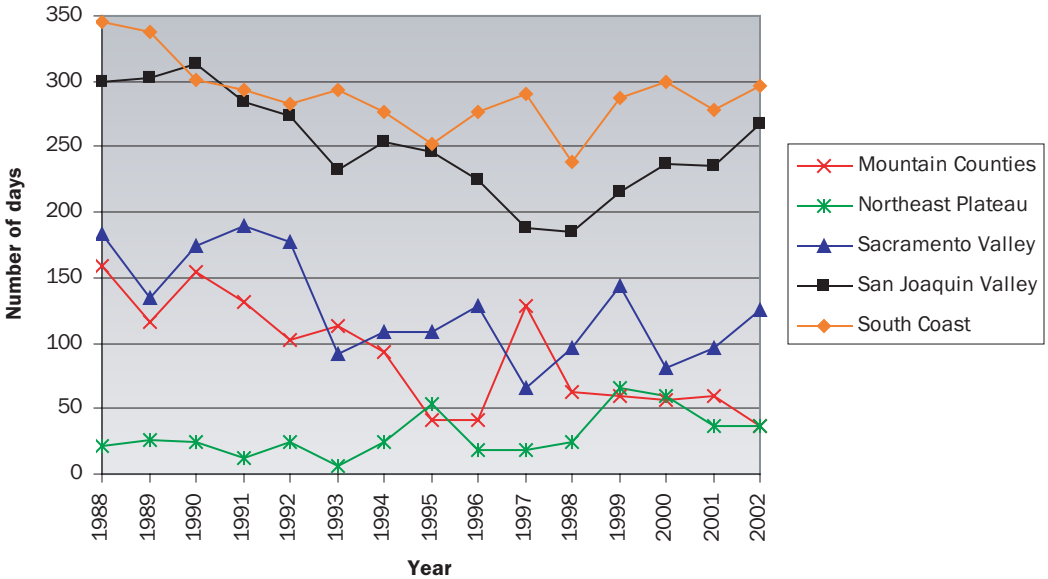
Health concerns and regulatory constraints related to particulate matter from smoke will likely affect the use of prescribed fire as a tool for hazardous fuel reduction. This constraint may lead to the need for other fuel management methods, such as mechanized harvesting, to reduce the risk of wildfire.

Los Angeles skyline visible south from Angeles Crest Highway, Angeles National Forest : G. Donald Bain, Geo-Images Project, UC Berkeley

Figure 66. Number of days PM10 exceeded state standard for selected air basins, 1988–2002



Source: Alexis et al., 2001

Soil Conservation and Water Quality Status and Trends

Soil and water, as basic elements of productivity, are key to natural resource sustainability and social well being. Soil condition affects tree growth and forage production and plays an important role in ecological processes such as nutrient storage and water or carbon cycling. In addition, forest and rangeland soil conditions play an important role in maintaining high quality water for drinking, agriculture, industry, and in-stream environmental uses.

Over the last decade, there has been increased recognition of the influence of forest and rangeland soil and water conditions on ecological processes operating at the watershed level. Federal and state agencies in California have spent millions of dollars for watershed assessment and project review while forest and range landowners have devoted time and money at the project and watershed level. These efforts have provided useful information to agencies and landowners, yet they have shown the difficulty of assessing the status and trends of soil and water conditions. Part of this difficulty lies in coping with the inherent variation in physical and biological processes, the complexity of linkages between human actions and impacts on natural processes, and the overriding impact of natural events such as wildfire, severe storms, and weather patterns.

Key to an evaluation of soil and water status and trends is an assessment of watershed conditions. Watersheds are the geographic area drained by a particular stream or network of streams. The quality and quantity of water depends upon a complex variety of linkages between land use, natural events, vegetation condition, climate, and geological formation. In some places where comprehensive watershed analysis has been done, there is abundant information but lack of consensus on how to evaluate it. In general, however, there is a lack of information with which to systematically examine watershed conditions across California.

With quantitative information on water and soil quality generally lacking, basic information is provided regarding the linkage between conditions and land use along with findings on regulatory status of water quality. The specific indicators are shown below.

Soil Conservation and Water Quality Indicators

- Land Use in Watersheds
- Regulatory Status of Water Quality Impairments
- Trends in Salmon Populations
- Monitoring Results of Private Timber Management Practices
- Monitoring, Watershed Assessment, and Cumulative Watershed Effects

Soil Conservation and Water Quality

Representative Goal

Ensure that protection of beneficial uses of streams and soil erosion associated with timber operations is adequately controlled to protect soil resources, forest productivity, and water quality *(paraphrased from Z'Berg-Nejedly Forest Practice Act, Article 5, 4562.5,4562.7).*

Controllable water quality factors … shall not cause further degradation of water quality *(paraphrased from State Anti-degradation Policy, Basin Plan, Chapter 3, Water Quality Objectives).*

Findings

- Watershed quality is directly related to the mix of land uses and management goals that are found in the watershed. Watersheds with forests and rangelands typically provide the highest water quality in California.
- Regulatory profiles of water quality in California as of 2002 indicate that 14 percent of California rivers and streams have some impairment of beneficial uses.
- Land management on forests and rangelands (timber and grazing activities) are listed as at least one of the many causes of water quality impairment, particularly in the North Coast and Lahontan Regional Water Quality Control Board regions.
- Trends in salmon populations are largely a function of habitat quality including water quality and quantity and general environmental conditions. The combination of habitat conditions and other environmental influences has resulted in a long-term, downward trend in populations of specific salmon stocks.
- Monitoring of hill slope erosion conditions found that individual timber harvesting practices required by the California Forest Practice Rules are very effective in preventing soil erosion.
- While there is broad agreement on the linkages between management practices, and cumulative watershed effects, a consensus is lacking on how to measure, monitor or evaluate effects. Continuing efforts to improve the information and understanding of watershed process will be necessary to facilitate improvements in watershed conditions and protection of soil and water resource values. Limited recent studies in the central Sierra Nevada continue to indicate that native surface roads are the primary human-caused source of sediment.

Land Use in Watersheds

On-line Technical Report:
http://frap.cdf.ca.gov/assessment2003/Chapter4_Soil_and_Water/watershedquality.html
Data Quality: Partial data ◐

Fundamental to understanding watershed condition is knowing how land use within a watershed affects the water quality. While other natural environmental conditions such as wildfire and climatic changes can affect water quality, the mix of land uses in any one watershed largely determines the levels of protection from human disturbances (Figure 67). Using the concept of the Management Landscape (land use, ownership, and housing density), forests and rangelands can be grouped into classes that broadly describe how land is used and managed, thus producing a basis for understanding the interactions of land use and watershed conditions.

Each type of Management Landscape class is indicative of a different land use mix and potential impact on watershed conditions. The general classes of interest to watersheds are Reserve, Working, Rural Residential, Agriculture, and Urban.

Reserve lands, such as national parks and wilderness areas, are permanently managed consistent with statutory designations, which often have strict limits on mangement activities. Typically, these lands' ecological structures and processes remain intact and function within their natural range of variation. Generally, Reserve lands contribute positively towards water quality and aquatic habitat.

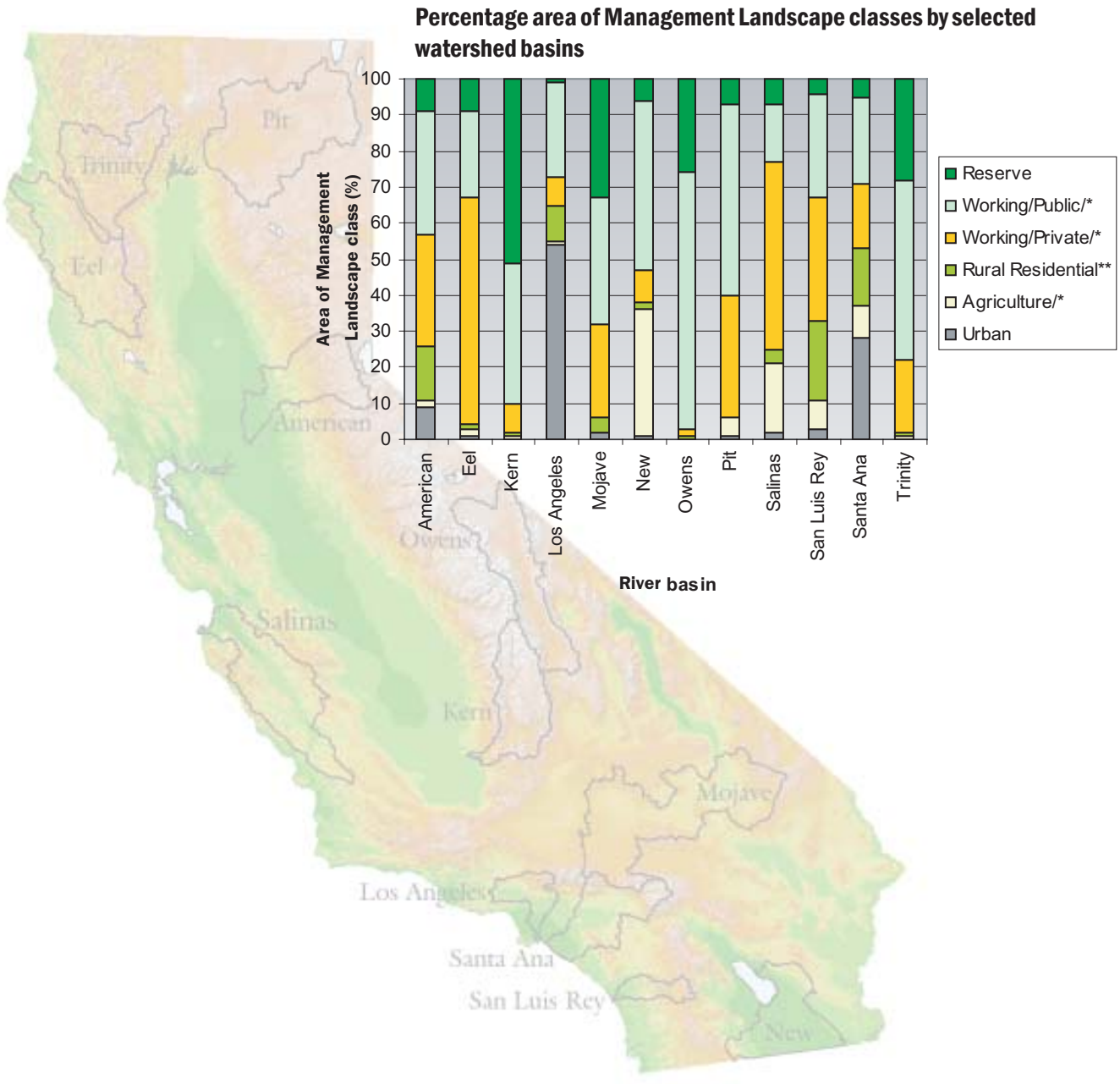
Working landscapes, both Public/Sparsely Populated and Private/Sparsely Populated, have a wide range of historical and current watershed conditions. Lands may have conditions caused by past practices, such as sediment from roads or damaged hillsides, that continue to cause problems. Other lands may have minimal disturbance with little or no impacts on water or soil quality. However, managed forests often provide beneficial protection to water quality by mitigating conditions that contribute to episodic wildfire and other natural catastrophes that degrade water quality.

Some more intensively managed private lands have a greater potential for water quality impacts, but also have heightened efforts to protect water quality. These efforts on both public and private working landscapes have been guided by standards implemented under state and federal clean water laws.

Frog Lake, Mokelumne Wilderness, Sierra Nevada Mountains

Figure 67. Regional Soil Conservation and Water Quality Indicator

Different watersheds have different mixes of land uses and management goals. The different management emphases influence watershed conditions, potential nonpoint source pollutants, and in-stream water quality, as well as levels of financing for protection and restoration investments.



* Sparsely Populated
** includes Working/Public/Rural Residential, Working/Private/Rural Residential, and Agriculture/Rural Residential
Source: California Interagency Watershed Mapping Committee, 1999; FRAP, 2002b
Map: Selected CALWATER (v2.2) watershed basins

Rural Residential lands can be either Working/Public or Working/Private landscapes but they have a low density of housing structures (density of one or more units per 20 acres and less than one unit per acre). These lands, however, still retain wildland characteristics and have resource values, although management is more oriented towards open space, viewsheds, places of rural lifestyle, or recreation, than commodity production or ecological integrity. Rural Residential lands introduce complex urban impacts to a watershed including permanent road systems that alter overland flow of stormwater runoff, fertilizer, herbicide, and pesticide residues, wastes from human activities, fragmentation/parcelization of continguous habitats, and the introduction of non-native plant and animal species.

Agricultural lands refer to areas where natural vegetation has been replaced by irrigated crops and orchards. Housing densities may be either Sparsely Populated (less than one housing unit per 20 acers) or Rural Residential. Urban lands are those lands having housing densities of one or more units per one acre or intensive commercial or industrial uses. Water quality impacts from these land uses are beyond the scope of this assessment. However, common degradations associated with these land uses include exposure of soil to erosion, introduction of contaminants into waterways, modification of water courses, and removal of natural vegetation resulting in increased rates and volume of stormwater runoff. These can have substantial impacts on watershed conditions, particularity in comparison to lands with limited human disturbance.

Regulatory Status of Water Quality Impairments

On-line Technical Report: http://frap.cdf.ca.gov/assessment2003/Chapter4_Soil_and_Water/watershedquality.html

Data Quality: Partial data ◐

The State Water Resources Control Board (SWRCB) and its nine Regional Water Quality Control Boards (RWQCB) establish water quality standards and compliance for California's waterways. Every two years, the RWQCBs identify waterbodies tdeemed to not be attaining their beneficial uses and places them on the list of imparied waters. This EPA approved list identifies the portion of the waterbody impaired as well as the types and suspected sources of pollutants for each waterbody. Currently, the RWQCBs are required to develop a Total Maximum Daily Load (TMDL) for each listed waterbody. The TMDL is the amount of pollutant over time that can enter the waterbody without limiting its beneficial uses. The RWQCBs then develops and adopts implementation plans for achieving the necessary reductions in pollutant loading specified by the TMDL. A review of the 2002 list of impaired waterbodies re-

Riparian forest, Putah Creek. Photo courtesy of Marc Hoshovsky, California Department of Fish and Game.

veals that California has over 26,000 miles of impaired streams, about 14 percent of the total miles of streams and rivers in California. Although not all water bodies have been monitored to assess water quality status, the list of impaired waters represents those waterbodies where the RWQCBs have scheduled committments to addressing water quality problems on a watershed basis.

Impairment information for RWQCB watersheds provides a description of the cause of pollution that results in impairment. Most watercourses have many different potential causes. Silviculture, rangeland grazing, and agriculture were sometimes listed as at least one of the causes of pollution impairment (Table 34). The high proportion of impairments identified as unknown indicates the lack of certainty in identifying nonpoint source pollution sources.

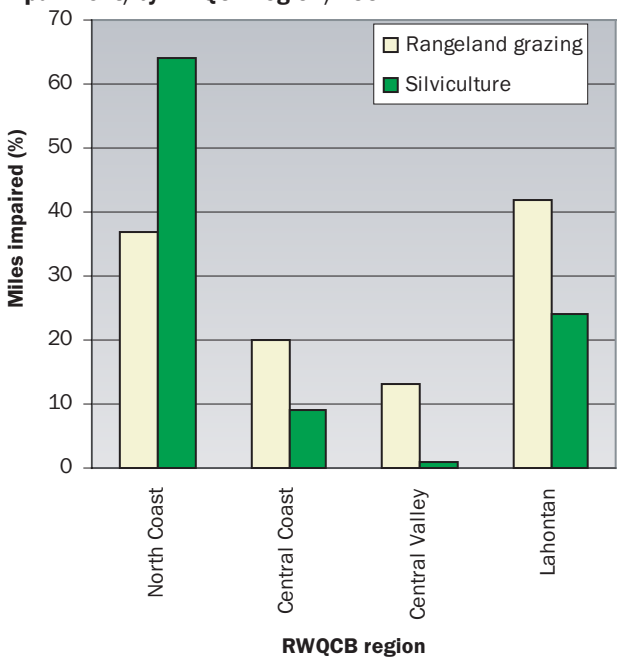
Figure 68 shows a regional review of the percentage of impaired water bodies where silvicultural or rangeland grazing activities are one of the many causes of pollution. Over 60 percent of the impaired water bodies in the North Coast list silviculture as one of the causes of pollution. Rangeland grazing activities are one listed cause of impairment on approximately 42 percent of the impaired waterbodies in the Lahontan Regional Water Quality Control Board region (Sierra Nevada mountain range).

Table 34. Sources of nonpoint pollution in California's impaired lakes, wetlands, and rivers, 2002

General pollution source	Lakes and reservoirs	Freshwater wetlands	Rivers and streams
	Surface Area		Miles
Agriculture (non-rangeland)	25,616	73,598	10,638
Rangeland grazing	113,569		8,278
Construction	88,285	62,590	6,702
Silviculture	106,068		13,374
Habitat modification	93,932		19,723
Hydromodification	89,467		15,598
Industrial/municipal point sources			2,938
Land disposal	23,600		1,596
Marinas	108,682		
Unknown sources	192,533	62,590	19,042
Other	155,925	65,636	9,562
Resource extraction	101,202		6,675
Urban runoff	112,970		1,939

** Most water body have more than one pollution source. Therefore miles impaired by each pollution source does not add up to total miles impaired.*
Source: Compiled by FRAP from California State Water Resources Control Board, 2000

Figure 68. Percentage of impaired river and stream miles with silviculture or rangeland activities as a cause of impairment, by RWQCB region, 2002



Source: Compiled by FRAP from California State Water Resources Control Board, 2000

Trends in Salmon Populations

On-line Technical Report:
http://frap.cdf.ca.gov/_assessment/Chapter4_Soil_and_Water/watershedquality.html

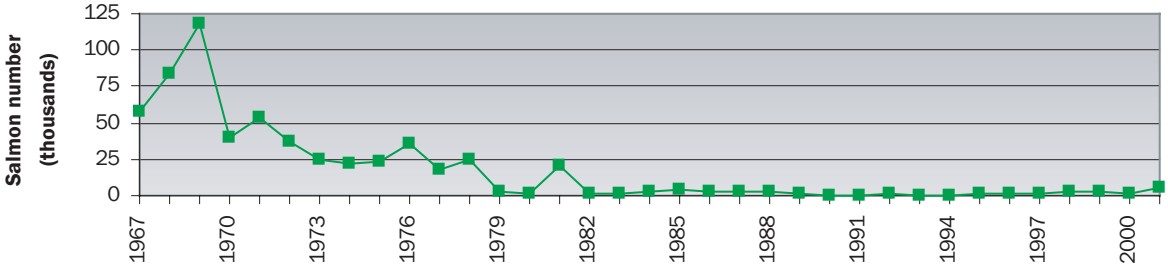
Data Quality: Partial data

The ability of a watershed to produce juvenile salmon is largely a function of the quality and quantity of stream habitat conditions, including water quality and quantity. Important elements of water quality include water temperature within a suitable range that corresponds with migration, egg development, growth of young, and the production of invertebrates as food sources. The extent to which water quality and availability issues influence estimated annual escapement of adults and numbers of juveniles (smolts) produced is not readily separated from other environmental conditions. However, water quality and quantity are clearly some of the most fundamental measures of habitat suitability and ultimately salmonid production.

The RWQCB designates several water bodies with salmon populations as impaired based on water quality concerns that arise from unacceptable levels of sediment load, elevated water temperature, pollutant occurrence and other factors. Eight water bodies within the range of the Southern Oregon/Northern California Coast population of coho salmon have been designated as impaired by the SWRCB and Environmental Protection Agency under section 303(d) of the federal Clean Water Act. The primary basis for listing the Mattole, Eel, Van Duzen, Mad, Shasta, Scott, Klamath, and Trinity River basins as impaired is excessive sediment load and elevated water temperatures.

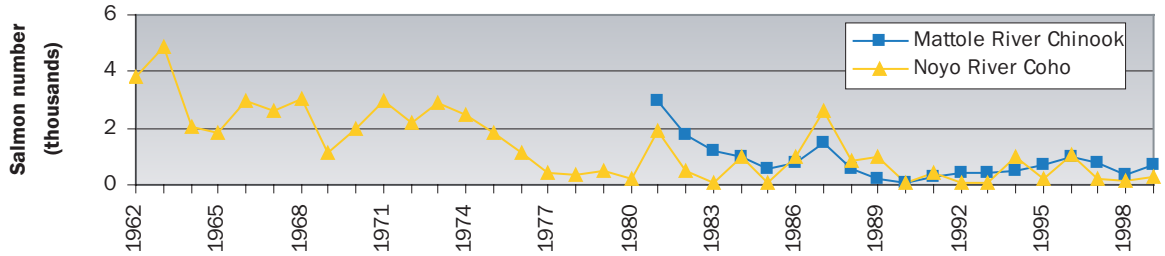
Annual estimates of salmon population levels exhibit marked variation due to a large number of interacting environmental conditions. These include specific stream habitat availability to accommodate freshwater life history requirements, water quality and availability, rainfall pattern as an influence on stream flow and out migration rate of juveniles, oceanic conditions during early residence, wildfire, level of commercial and recreational harvest, and historic and current land use activities (e.g., agriculture, timber management, and urbanization). These environmental and other conditions have resulted in long-term downward trends in populations for specific salmon stocks (Figure 69, Figure 70) and for some, formal listing under the California and/or federal Endangered Species Act.

Figure 69. Annual adult winter chinook salmon returns, Sacramento River, Red Bluff Diversion Dam, 1967–2001



Source: California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, 2002.

Figure 70. Annual adult salmon returns, Noyo River coho and Mattole River chinook, 1962–1999



Source: Southwest Fisheries Science Center, 2001; Downie et al., 2002.

Monitoring Results of Private Timber Management Practices

On-line Technical Report:
http://frap.cdf.ca.gov/assessment2003/Chapter4_Soil_and_Water/watershedquality.html

Data Quality: Partial data

On non-federal lands, Forest Practice Rules (FPR) govern timber operations. These rules are adopted by the Board of Forestry and Fire Protection (BOF) and implemented by CDF. During the 1990s, the BOF through its Monitoring Study Group (MSG), developed a program to monitor the implementation and effectiveness of the FPR in protecting water quality. The early efforts of the program have been directed at monitoring impacts on the hillslope as opposed to in-stream. Hillslope impacts are usually easier to identify and quantify than those instream, thus providing more immediate feedback about the impact of timber operations on sediment. Connections between hillslope activities and instream channel conditions are much harder to define.

The BOF adopted a strategic plan to guide this program in 2000. The plan calls for four key parts: 1) continuation of the Hillslope Monitoring Program; 2) use of CDF Forest Practice Inspectors to assemble hillslope monitoring data on a random sample of completed Timber Harvest Plans (THPs); 3) development of scientifically credible monitoring plans for cooperative watershed monitoring projects in selected basins to provide in-stream data; and 4) design and/or fund monitoring projects that can answer focused questions about FPRs implementation and effectiveness.

The most extensive information comes from the Hillslope Monitoring Program. Results to date indicate that implementation rates of the FPRs related to water quality are high. They also show that individual practices required by the Rules prevent hillslope erosion when properly implemented. Implementation ratings were greater than 90 percent for the landings, roads, skid trails, and watercourse protection zones sampled (Table 35). Watercourse crossings had the lowest implementation ratings at 86 percent.

CDF's Forest Practice Rules enforcement statistics suggest similar findings. Typically, water quality violations of the Forest Practice Rules are identified and corrected, where possible, as part of CDF's Forest Practice Inspection process. Information from CDF's Forest Practice Program database indicates that 975 violations were issued on the 4,749 Timber Harvesting Plans open from 1998 through 2000. These violations fell into three basic groups: harvesting practices and erosion control (347); watercourse and lake protection (308); and logging roads and landings (320). The highest numbers of violations involved waterbreaks, drainage, and operations near streams.

Since 1992 the U.S. Forest Service has also conducted a hillslope monitoring program on federal lands focused on implementation and effectiveness of its management practices. Preliminary results show that USFS silvicultural Best Management Practices (BMPs) are generally implemented and effective. Statewide, average implementation and effectiveness rates from 1992–2001 were both approximately 87 percent. Yearly rates and those for specific practices have varied. Streamside management zones and elements of road construction were areas of concern.

In addition to evaluation of hillslope conditions, work is on-going for monitoring in-stream conditions. Pilot work on cooperative in-stream monitoring has been done on the Garcia River where an in-stream monitoring plan, watershed assessment, and documentation of baseline conditions have been completed. In 2002/2003, smaller scale cooperative in-stream monitoring projects have been planned in Mendocino County with Campbell Timberland Management/Hawthorne Timber Company and in the Sierra Nevada/Cascade province (northern California) with Sierra Pacific Industries.

Table 35. Forest Practice Rule implementation ratings for 300 Timber Harvest Plans and Non-industrial Timber Harvest Plans, 1996–2001

Hillslope Monitoring Program sample area	Percentage of acceptable* implementation
Road transects	93
Skid trail transects	95
Landings	94
Watercourse crossings	86
Watercourse protection zones	98
All areas	95

** meets or exceeds requirements*
Source: Ice et al., 2002; Cafferetta and Munn, 2002

Monitoring, Watershed Assessment, and Cumulative Watershed Effects

On-line Technical Report: http://frap.cdf.ca.gov/assessment2003/Chapter4_Soil_and_Water/watershedquality.html

Data Quality: Additional development ?

The current Hillslope Monitoring Program traces timber harvest disturbances downhill to the receiving watercourses, but does not determine downstream channel and habitat impacts. Hence, the MSG results do not allow conclusions to be drawn about whether the existing rules provide properly functioning habitat for aquatic species. This requires analysis of linkages between channel conditions and hillslope disturbances. Such analysis is complex because channels receive and reflect the results of all watershed processes, including current and past, natural and forest practice-related impacts alike. Channels vary greatly in their dynamics between the North Coast and the Sierra, and even within each of these areas. Channels also change naturally over time and poor condition may just be part of this dynamic process.

Different factors may be relevant to measuring the health of the channel. For example, on the North Coast key parameters may include channel morphology, large woody debris (LWD) and potential LWD recruitment, canopy and shading, stream temperature, spawning gravel composition and permeability, spawning levels, sediment transport corridors, and turbidity.

The National Marine Fisheries Service and others have identified various channel form-related indices that identify healthy stream habitat for salmonid fisheries. However, desired target conditions or indices are not always known. One example is the acceptable length and frequency of fish exposures to high water temperature and turbidity.

Cumulative watershed effects are another case where the desired condition is uncertain. Although there is broad agreement that management activities can produce cumulative watershed effects (CWE), a consensus is lacking on how to measure, evaluate, or monitor effects and conduct watershed assessments. Central to any evaluation of CWE is a broadly agreed upon conceptual model of how land use can alter the risk of damaging natural resources within a watershed (Dunne et al., 2001).

A great deal of research has been conducted in order to better understand forest management impacts and CWE. However, detailed quantitative data is often limited to a few watersheds with few examples of accurate methods to extrapolate site-specific relationships across watersheds and larger regions.

One recent example is a study of hillslope erosion on private and public lands in the central Sierra Nevada during 1999 and 2000. Based on 150 measurement points the initial results indicate that native surface roads (i.e., unpaved, dirt or gravel roads) are the primary human-caused source of sediment. The study also recorded high rates of sediment production from high severity wildfires and areas used for off-highway vehicles (MacDonald and Coe, 2001).

Much work has been conducted in the western states to improve assessments of watersheds and provide information for cumulative watershed effects analysis in both rural and urban landscapes. Watershed assessment on forests and rangelands typically focuses on establishing the linkages among past and present land management activities, geomorphic and hydrologic processes,

One of 147 sediment fences installed to measure sediment production rates in the central Sierra Nevada Mountains. Photo courtesy of Drew Coe (Cafferetta and Munn, 2002).

aquatic and terrestrial habitat, and salmonid population responses (Ligon et al., 1999). Examples of formal watershed assessment approaches include the State of Washington Watershed Analysis, the Oregon Watershed Assessment Manual, and the Federal Interagency Watershed Assessment methodology used on public lands in western states.

Within California the Resources Agency began the creation of an infrastructure for a coordinated state watershed program in forested watersheds in 1998. In 2000 the Resources Agency, in coordination with the California Environmental Protection Agency, initiated the North Coast Watershed Assessment Program (NCWAP) in part as a response to specific requests from landowners and watershed groups that California take a leadership role in conducting scientifically credible, interdisciplinary assessments that could be used for multiple purposes. To date, NCWAP has completed assessments for the Mattole and Gualala Rivers. Assessments for Redwood Creek, Big River, and Albion River are nearing completion.

The information from the NCWAP assessment was used to identify the underlying causes of stream habitat deficiencies and establish linkages to watershed processes and land use activities. Results of assessments conducted by various agency personnel were brought together in an integrated synthesis process. This process attempts to describe spatial and temporal relationships between watershed and stream conditions with respect to their suitability to support salmonids. The findings identified deficiencies in stream habitat, but also documented on-going recovery in channel conditions.

Clearcut harvesting near perennial streams.

Specific watershed assessments by local-level groups multi-county level include Fishery Network of Central California Coastal Counties (FishNet4C) and the Five Counties Salmon Conservation Program. The CALFED Bay-Delta Program has created a broader regional context for local watershed assessment for the watersheds of the Sacramento and San Joaquin Rivers, as well as Southern California and coastal watersheds that receive water supply from these river systems.

Landowners and private companies are also involved in watershed assessments. For example, the Fish, Forests, Farms Community, a landowner and industry-based group working with Humboldt State University developed standardized protocols for assessment and monitoring. They have worked closely with the Department of Fish and Game and will help to identify the best ways to implement and monitor factors critical for fish protection. A number of private companies also have conducted detailed watershed assessments over some or all of their lands.

The Watershed Project Inventory at the U. C. Davis Information Center for the Environment (ICE) has identified and surveyed over 700 groups in California that indicated involvement in watershed projects. It is difficult to establish by name those watershed groups that are collaborative and inclusive of stakeholders and those that are special interest and exclusive of those who can be involved. ICE estimates that there are between 100 and 140 local watershed partnerships in California representing varying levels of activity (Sommarstrom, 2002).

Building on the growth of interest and understanding of watersheds will be valuable to improving and protecting resource conditions in the future. While watershed assessments, including CWE, should not be expected to eliminate risk to natural resources from forest management activities, they have the potential to both quantify and reduce that risk, thus improving the decision making process (Dunne et al., 2001).