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# THE SETTINGS OF EROSION RESEARCH AND MANAGEMENT IN JAPAN AND THE WESTERN U.S.

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SUMMARY; Japan and the west coast of the United States are similar in geology and types of dominant erosion processes. However, contrasts in the social settings result in very different approaches to landslide and channel management. Japan places great emphasis on engineered structure; ecological factors receive greater emphasis in the western United States.

## 1. INTRODUCTION

An important aspect of country-to-country exchanges is the opportunity to compare research and management systems and to learn from their similarities and differences. Japan and the west coast of the United States present strikingly different social settings of landslide and sediment problems, although they share common aspects of physical setting, such as high levels of precipitation and unstable rocks in a tectronically active area. The approaches to management of landslide and sedimentation problems and emphasis in research differ greatly between these two areas, reflecting the differences in the social settings. Cultural and social factors that influence approaches to landslide research and management include: 1. technical and economic capability and 2. level of commitment to control erosion, which is related to population density, the geographic distribution of people relative to erosion-prone sites, laws guiding erosion control practices and environmental protection, and objectives of land management.

In this paper we briefly compare Japanese and United States approaches to erosion and landslide management in terms of these social factors. We also consider the extent of use of "biotic measures" (e.g., vegetation management) and what is known about their effectiveness. In making these contrasts between social settings and types of erosion control practices we may overstate the distinctions somewhat, but recognize that a broad spectrum of management objectives and approaches are found in both countries. We conclude with a discussion of research needs.

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## 2. THE SETTINGS AND PRACTICES OF EROSION CONTROL

The social and geographic settings of Japan and the western United States provide interesting similarities and contrasts which are expressed in the approaches to erosion control practices.

Japan has a high population density and a population dispersed throughout landscapes, even in very steep and unstable terrain and in lands designated as national parks. The area of natural ecosystems and geomorphic systems is extremely limited in extent--most of the country has been strongly influenced by human activities. Laws require rapid control of landslides that endanger life and property; disaster remediation measures are swift and thorough. Laws concerning protection of the environment are of secondary importance. There is great technical, social, economic, and institutional commitment to control of landslides and other erosion processes.

Japanese research activities relevant to erosion control have produced a huge literature on individual phenomena such as landslides, debris flows, and river sediment transport. Few papers concern connections among these processes and their drainage basin contexts. An engineering rather than geomorphological view dominates management of erosion problems.

The Japanese government, industry, and educational institutions have established a large and refined system for development and use of highly engineered erosion-control structures that are dispersed throughout the countryside. These structures, commonly composed of concrete and steel, are referred to as "hard measures" for combating erosion. Examples include check dams, concrete structures forming stream beds and banks, and a great variety of landslide control measures, such as concrete walls, drainage works, buttresses, and pilings driven through the landslide mass into the underlying stable material. The intent of most channel works is generally to regulate the longitudinal profile of channels using individual structures designed to function independently and to have long life times at fixed locations. All of these types of structures strongly modify natural processes.

In the western United States, on the other hand, the population density is low and the most unstable lands are managed by the Federal government, large timber companies, or other organizations that limit human occupation of these lands. National Park and Forest lands, for example, exclude most human occupation. This has the effect of separating people from the most hazardous lands; lands that would likely be occupied in the Japanese setting. The cost of land is much less than in Japan and land use in geologically unstable areas is primarily for resources of low to moderate commodity value, such as forestry and recreation, so economic justification for erosion control practices is less than in Japan. Land management agencies, such as the U.S. Forest Service and Park Service, have a legal mandate to protect natural processes and native species of plants and animals, so legal processes have been developed to limit development of natural forest and river landscape. Natural landscapes with little impact of human developments are much more extensive in the western United States than in most other developed countries.

Several decades of intensive research has focused on the natural ecosystems of the northwestern United States, including the diverse functions of landslides of various types in natural, mountain forest and stream ecosystems. This research has documented the important linkages between forests and river ecosystems, between surface river waters and valley floor groundwater systems, and, to a lesser extent, between up-basin activities and downstream sites.

All of these factors have resulted in emphasis on "biotic measures" of erosion control in the western United States, i.e., working with natural material and processes where possible. Examples of biotic measures for stream management include using large logs in streams to create complex habitat, desirable as fish habitat and managing vegetation along streams to produce large logs for streams, to limit streambank erosion, and to shade the stream to control water temperature. Efforts to control hillslope erosion when forest cutting is done include leaving hectare-scale patches of forest vegetation at the steep, headward tips of streams (zero-order basins) in sites judged to have high probability of experiencing small landslides if the forest is cut. The intent of this practice is to maintain tree root strength on marginally stable slopes. Mapping and zoning unstable areas as off limits to timber harvest, road construction, or other land uses is another hazard control measure commonly used in the western United States.

Such biotic measures may not be fixed in place (e.g., logs in streams may or may not be anchored in place), and often involve use of native material from the local forest or stream area; they may also involve indirect management of processes such as managing the streamside forest for future production of logs in streams. One objective in use of these practices is to allow natural processes to continue, including the interactions between rivers and riparian vegetation. Hard measures have tended to focus on streams themselves, while biotic measures consider streamside areas as well. Reasons for using these biotic measures rather than hard measures are economic efficiency and sensitivity to environmental concerns.

Hard measures, such as concrete-lined channels and sediment retention structures, are found in the United States primarily in urban areas, such as in the vicinity of Los Angeles and San Francisco, where property values are extremely high.

## 3. COMPARISONS--STRENGTHS AND UNKNOWNS

With the increasing concern over the effects of humans on the global environment, both Japan and the United States have become more sensitive to the degree of human impact on natural systems. Included in these concerns are the uncertainties of how human impacts accumulate through time and what the effects of climate change may be. Perhaps the greatest source of uncertainty for policy makers is changing public expectations.

There is an interesting asymmetry in the strengths and weaknesses in engineering and in ecological terms between the hard and biotic measure approaches used in Japan and the United States. The hard measure approach is grounded in engineering technology and seems well suited to meet its immediate, on-site engineering objectives of efficient conveyance of water and sediment and retention of landslide debris and sediment in desired locations. However, engineering problems arise when structures create unforeseen effects downstream, such as reduction of sediment yield to rivers and beaches. Furthermore, ecological consequences in both on-site and downstream areas are poorly understood, as are alternative techniques that might be ecologically less damaging. Design of erosion control practices are best based on a system-level perspective incorporating both physical and biological aspects.

The biotic-measures approaches used in the Pacific Northwest of the United States, on the other hand, are relatively untested in both ecological and engineering terms. The ecological objectives of these practices have greater potential for success, since the practices are designed on the basis of ecological considerations and research. The extent to which engineering objectives are met is much more poorly understood. For example, the effectiveness of vegetation left for landslide control, a practice which dates to 1975, is still unknown because no controlled studies or experiments have been undertaken to examine their effectiveness. Logs in streams have been used for fish habitat improvement for a similar period of time, but studies of their ecological effectiveness and log movement during big floods and possible associated damage to riparian vegetation, bridges, and roads are just beginning.

## 4. RESEARCH NEEDS AND FURTHER CONSIDERATIONS

We observe some convergence of approaches to erosion control in Japan and the western United States. However, the social settings of these two areas are so different that fundamental differences will persist.

Despite these differences, there are some common research needs:

- Understanding of water and sediment routing through drainage basins in natural and engineered systems. This includes understanding linkages among successive geomorphic processes.

- Understanding of the ecological effects of altering the routing of water and sediment through basins. A useful theme for doing this is to focus on the above- and below-ground dynamics of stream and riparian networks as a means to link hillslope and channel form and processes with hydrology, vegetation, and wildlife.

- Understanding the effects of interactions between forests and streams, surface and groundwater systems, and up-basin and downstream areas.

The differences between Japanese and United States approaches may provide useful experimental opportunities. For example, the interaction of streams and the groundwater systems of floodplain areas could be investigated in areas where channel works have greatly reduced this interaction. Areas with such restricted surface-groundwater interactions could be compared with natural systems where these interactions operate freely. Critical questions concern the effects of eliminating surface-groundwater interactions on the timing, quantity, and quality of stream and groundwaters.

These two regions seem to represent two end members of a spectrum of emphasis on hard engineering solutions versus vegetation-based approaches to erosion problems. Both Japan and the western United States have high levels of technical capability. A broader analysis involving other social settings would provide examples of landslide and sediment management in areas where technical and economic capabilities are much less. A more thorough analysis should include quantitative cost:benefit considerations and assessment of environmental effects.