

Redwood NP Geologist Reports On Gravel Bed Rivers Workshop in Italy

*Editor's Note: In September (23-28) 1990, Mary Ann Madej, Redwood NP geologist, and Thomas Lisle of the USFS presented an invited talk on "Spatial variation in armoring in a channel with high sediment supply" at a fall workshop held in Florence, Italy. Following is Madej's report on the conference, which she attended on an award from the Horace M. Albright Employee Development Fund. The paper she gave will be published by John Wiley and Sons in a book entitled **Gravel Bed Rivers**.*

By Mary Ann Madej

Environmental consequences of natural and anthropogenic changes in rivers have become areas of national and international concern. The Third International Workshop on Gravel Bed Rivers was held Sept. 24-28, 1990, in Florence, Italy to address river management problems and their underlying causes. The theme was "Dynamics of Gravel Bed Rivers"; 92 participants from 17 countries, including New Zealand, Japan, Switzerland, Israel, Germany, Iran, Somalia, and Czechoslovakia attended.

The 47 papers were distributed beforehand, and after two or three short presentations at each session, an hour-long discussion period allowed workshop participants to thoroughly debate controversial issues. Video sessions provided vivid illustrations of problems and studies in other countries. Discussion comments will be published with the conference papers.

Italy made a fascinating setting for the meeting, particularly for a scientist used to augmenting short-term records with sometimes ambiguous field evidence. I was startled to read accurate accounts of flooding from November 1333 (when the Arno River floodwaters overtopped the altar in the Duomo in Florence), and to see a landscape that has been cultivated intensively for at least 2000 years.

Post-conference field trips to research sites further enforced the urgency to deal with erosion and sedimentation in order to preserve natural and cultural resources. For example, soil loss from vineyards north of Florence was measured at 2.33 mm/yr (equivalent to 9 inches of soil erosion in 100 years). Such high erosion rates surely will influence long-term soil productivity, stream sedimentation rates, and the economic viability of a region.

Large sand bed rivers such as the Mississippi have been studied for centuries, but less attention has been focused on gravel bed rivers, which differ from sand bed rivers in several ways. Gravel bed rivers have riffle/pool bedforms rather than ripples and dunes. Sediment moves only at moderately high to high flows, and sediment transport dynamics are different. Gravel bed rivers tend to be steeper, are located in more rugged terrain, and are more stable in channel cross-sectional shape. Over the last decade interest in gravel bed rivers has grown, due to increasing pressures on upland areas in both developed and developing nations.

Rivers are critical for maintaining riparian and aquatic ecosystems and for influencing land management activities. They are used for recreation (swimming, boating, fishing, hunting, hiking, birding), navigation, water supply, power generation, sand and gravel supply, wildlife corridors, and flood routing. Human activities such as road construction, flood control, logging, and urban development have caused reservoir

siltation, sedimentation in navigation lanes, bank erosion, water quality degradation, water depletion, pollution by toxic wastes, and modifications in flooding frequency.

Concomitantly, development is encroaching on many areas that are susceptible to erosion and sedimentation problems, such as landslide prone sites. Catastrophic dam bursts, debris torrents, and floods also have highlighted the need for studies of gravel bed rivers.

River research (fluvial geomorphology) is basically a study of the nature of change through time and space. Discussions focused first on the nature of environmental change. How do we separate natural versus artificial change? Do we act now or later to reverse change? To what extent and at what scale do we act? How can we restore or conserve resources? As we try to understand implications of global climatic change, our knowledge of watershed responses to past climatic changes will help answer these questions and guide policy decisions.

Specific field studies came next. Erosion models and case studies of sediment yield incorporated remote sensing, GIS, and field documentation to evaluate short- and long-term soil loss from forested, logged, and cultivated areas. Streamland processes discussed during the conference included debris flow initiation and deposition, alluvial fan formation, and floodwaters with extremely high sediment loads generated from mountainous areas. Debris torrents can devastate highways, railroads, buildings, and vegetation. Several presentations stressed the necessity of interpreting debris flow deposits in order to understand debris flow mechanics and help predict future damage.

Many papers discussed the transport of sand and gravel in braided and meandering rivers. Research concerns included quantifying when sediment is moved, how far it moves, and what size and shape particles move. Painted rocks, magnetic tracers, and even radio transmitters have been used to track gravel movement. In some gravel bed rivers the dominant

size of transported sediment is actually sand. Innovative techniques to measure bedload and new statistical analyses were presented. Gravel size distribution influences salmonid spawning success. An input of fine-grained silts and sands can either penetrate spawning gravels or form a seal on streambeds, to the detriment of aquatic life. Streambeds consolidate (or become more compacted) through time, and this may affect spawning success as well.

Coarse gravel layers frequently form over finer streambed material (an armor layer). This layer may protect underlying streambed sediment from erosion until flows become quite high. How this armor forms, its spatial variability, and its importance in controlling bed mobility were explored. Bed mobility also influences the survival of salmonid eggs and juveniles. In Redwood Creek in north coastal California, severe erosion and sedimentation caused widespread channel instability in the past, threatening old growth redwood trees along the river and salmon population. Dr. Thomas Lisle of the USFS and I presented results of studies in Redwood NP, assessing channel stability, bed mobility, and armoring.

Channel stability affects both natural and cultural resource. Causes of bank erosion were debated. New solutions to bank erosion problems (besides unsightly and locally damaging riprap) were presented. Gravel mining can initiate channel instability (bank erosion, channel shifting, and channel downcutting). Erosion control structures have been used to stabilize river channels in Europe since the 1850s. The lessons learned from their successes and failures can help guide our decisions on the use of modern structures.

Long-term changes in river systems were explored. The record of flooding history can be extended through interpretation of floodplain sediments. Some upland rivers show significant channel pattern change, whereas others under similar geologic and landuse conditions remain stable. The main factors influencing channel change are landuse and climate; however, streambanks may erode and meandering bends may



Old-growth redwood trees along Redwood Creek in Redwood National Park.

evolve naturally through time, even without climatic or landuse changes.

In concluding remarks, Dr. Luna Leopold, (son of Aldo Leopold), cautioned us to keep our sights wide. As we focus narrowly on individual problems, he urged us to keep in mind the broad questions of river dynamics, climatic change, and landscape evolution.

Several problems of direct concern to Redwood NP received conference treatment. For example, gravel mining and bank erosion locally threaten park resources. Channel stability is important to the survival of Redwood Creek aquatic life and old growth redwood trees. Changes in bank erosion rates and locations or in gravel transport patterns can be detrimental to these resources. A highway construction project located in a headwater stream adjacent to Redwood NP delivered a large amount of fine-grained silts and sands to pristine reaches of the park farther downstream. Monitoring techniques presented at the conference gave me insights on how better to measure the impacts and

persistence of fine-grained sediment on aquatic life and stream dynamics.

Several of the new erosion and sediment modeling techniques and analyses described will be incorporated into the Redwood NP monitoring program. Our flood history project will benefit from new approaches to floodplain sediment analysis. I became convinced of the importance of incorporating climatic change monitoring into process studies in park watersheds.

Finally, it is important to note the social and economic implications of attending such a meeting. Europe is no longer a step behind the U.S. in river studies. Many papers made it clear that Europe, Japan, and New Zealand are devoting the money and energy needed to solve river management problems. Formation of a unified European Community in 1992 will affect science and resource management, through side-ranging government policies and a free exchange of scientists. U.S. scientists must stay abreast of international advances to maximize our efforts.