

space decimate algal standing crops and initiate periods of rapid recovery (succession). For a large, intermittent drainage basin, however, spatial patterns of drying (loss of surface water) more strongly control abundance and thus total ecosystem productivity than do floods. These disparate conclusions underscore the need for an appreciation of the scales at which disturbance effects operate on patterns and processes in lotic ecosystems.

H31B-4 0930h

Temporal Variability of Large Pools and Sediment in Selected Rivers of the Columbia River Basin, 1936-1990.

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From 1936-1942 over 8,000 km of tributaries to the Columbia River were systematically inventoried for pool and substrate characteristics. Pools were classified by different size and depth criteria, while substrate was divided into size classes. This information was collected every 100 m for hundreds of streams and rivers within the basin. The object of the survey was to document stream habitat conditions as they related to anadromous salmonids before additional dams were built on the Columbia and Snake Rivers.

We selected river basins ranging from 100-1500 km² in size to resurvey and evaluate changes in stream habitats. Rivers were chosen where only natural disturbance occurred and others where human impacts and floods were the major disturbances.

In general, human-impacted river systems have lost 50-75% of the large pools (>1 m depth, >20m²) in the past 50 years. Rivers in wilderness areas have either stayed the same or shown increases in pool frequencies and depth, most often due to stream interaction with alluvial forests and large woody debris. Small gravel sediments in Cascade MT streams have decreased, going from 17% of the area to <3%. The loss of fine gravels (2-8 cm diameter) was most likely due to woody debris removal from the channel after the 1964 flood.

This data and recent resurveys are the most extensive quantitative channel information in North America. From such temporal snapshots over a large area, the extent of channel feature and sediment size changes over the last 50 years can be established and used in the identification of fish habitat potentials. Additionally, the extent to which aquatic systems have become less resistant to droughts or ice damage can be assessed.

H31B-5 0945h

Temporal Variability of Lateral Channel Change on the Santa Cruz River, Pima County, Arizona

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Temporal variability of lateral channel change on the Santa Cruz River, Pima County, Arizona, analyzed on aerial photographs taken from 1936 to 1986, depends on the dominant channel-changing mechanisms operating in a reach and on the relation of hydroclimatic controls to geomorphic, geologic, and artificial controls. Hydroclimatic controls govern timing and magnitude of lateral channel change. Geologic, geomorphic, and artificial controls in a reach determine whether channel change will occur in response to a particular range of flow conditions and what channel-changing mechanisms will dominate. The major channel-changing mechanisms on reaches that have active flood plains are channel migration (meander extension, translation, and rotation), avulsion and meander cutoff, and channel widening. On reaches that have entrenched channels (arroyos), the major mechanism is arroyo widening by a combination of fluvial and slope processes. On active flood plains, a regime of low to moderate flows favors continuous, gradual shift of channel position by migration. Large overbank flows produce abrupt shifts in channel position by avulsion and meander cutoff, as much as 600 m in a single flood, when new channels are incised into the flood plain. Increased resistance to erosion on the flood plain as a result of vegetation growth increases the magnitude of overbank flow necessary to produce such shifts. In the absence of high flows, channel widths tend to remain stable or decrease in reaches with active flood plains. Extreme channel widening of as much as 370 m in a single flood may occur when high erosion thresholds caused by vegetation or armoring are exceeded and unprotected banks are subjected to large shear stresses. On reaches that have entrenched channels, arroyos formed in a young, uncohesive alluvium widen gradually during periods of low to moderate flows (1.3 m/yr for 1936-60) and widen at an increased rate during periods of high flows (3.5 m/yr for 1960-86). Arroyos in well-indurated alluvium of Pleistocene age show little widening even during record floods.

H31B-6 1000h

Persistence and Impacts of Fine-grained Sediment on an Anadromous Fish, Gravel-bed Stream, Northwestern California

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In October, 1989, several hundred tons of fine-grained material (mostly < 1.0 mm) eroded from a highway construction site in upper Prairie Creek, a highly productive anadromous fish stream. Eroded fines settled in downstream reaches. Monitoring measured physical and biological impacts in Prairie Creek and assessed impact duration. Suspended sediment concentrations and loads were consistently higher in Prairie Creek than in a control stream. A silt layer up to 6 cm thick covered surfaces in low-energy environments (pools, organic debris traps, eddies). Silt layer depths decreased slightly, if at all, during the winter. Fine-grained sediments infiltrated gravel beds to at least 30 cm deep. These subsurface gravel fines (percent by weight and by volume) remained in Prairie Creek throughout the winter. Permeability (measured as standpipe inflow rates) in riffles cleaned of fines decreased through the winter. Cross section surveys and scour chains showed only minor channel bed movement during a mild winter. Eyed steelhead eggs placed in artificial redds in late winter showed good survival to hatching, but they were not subjected to storm flows. Mean percent fines in natural redds increased to 24% by volume. Until the gravel bed is significantly mobilized during high flows, it is likely fines will remain on bed surfaces in low water velocity areas and within subsurface gravel interstices.

H31B-7 1035h

Effects of Removal of Large Woody Debris on Bedload Transport in a Small, Gravel-bed Stream

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Bedload sediment transport rate was measured during seven consecutive storm seasons prior to removal, and one season following removal, of large woody debris (LWD) from a 100 m reach in a small, gravel-bed stream located on Chichagof Island, Alaska. This study was designed to simulate possible land management-related alterations of the natural disturbance regime and to evaluate the function of LWD with respect to sediment transport.

Windthrow and bank erosion deliver LWD to stream channels from the adjacent riparian zone, causing a temporally variable disturbance to the fluvial environment. Input may be chronic or result from episodic high-magnitude wind or precipitation events. Current land management practices rarely include removal of naturally-occurring LWD from stream channels. However, alteration of the riparian and adjacent forest may affect timing of input, characteristics, and volume of delivered material, changing LWD loading over time.

Removal of LWD resulted in a four-fold increase in bedload transport rate at bankfull discharge. This increase was attributable to 1) elimination of LWD buttressing of sediment storage sites in the channel bed and banks, 2) reduction in number and size of low-energy, backwater zones associated with LWD, and 3) increase in boundary shear stress associated with removal of the LWD component of flow resistance. Importance of factors 1) and 2) diminished as bed material was redistributed early in the first post-removal year by six stormflows of 0.20 to 1.0 bankfull discharge. Subsequent bedload transport rates continued to be significantly greater than pre-removal rates. This increase provided an estimate of the component of total shear stress attributable to LWD.

Increased bedload transport rates indicated potential impacts on aquatic organisms such as 1) destabilization of sediment storage sites, which function as habitat, 2) scour and coarsening of the channel bed and banks by increased boundary shear stress, and 3) release of fine sediment, which can infiltrate spawning gravel. Measurements of post-removal changes in channel morphology, aquatic habitat, and salmonid populations are continuing at this site.

H31B-8 1050h

Effects of Land use, Climate, and Large Floods on Gravel Aggradation, Instability, and Fisheries in Missouri Ozark Streams

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During the last 100 years, Ozark stream channels in Missouri have experienced an unprecedented episode of gravel aggradation and instability. The Ozark stream geomorphology project was developed to: 1) determine the history of aggradation and instability, 2) assess the effects of disturbance on channel morphology and fish habitat, and 3) develop models to predict changes in channel morphology. Components of the project are: 1) compilation of oral and written history to document land use and channel changes since 1840, 2) evaluation of channel changes due to large floods of the last century using dendrochronologic techniques on valley-bottom vegetation, 3) precise photogrammetric mapping of changes from 1938 to the present, 4) stratigraphy of valley bottoms to evaluate changes in the alluvial regime during the Holocene, 5) monitoring of channel cross sections for changes over 10¹ to 101 year timescales, and 6) measurement of bedload and suspended sediment discharge over 10⁻¹ - 10¹ year timescales.

Factors that may explain the present episode of stream channel aggradation and instability include land use, large floods, and climate change. Extensive timber cutting in the mid- to late 1800's and subsequent burning to maintain open range in the uplands have been proposed as stresses leading to basin-wide instability through increases in storm runoff and sediment supply. Oral history and tree-ring dates of deposits confirm a history of gravel aggradation with filling of deep pools and shallowing of channels during the last 100 years. Preliminary analysis of historical photography from 1938 to the present indicates reduced stream-fauna habitat resulting from bar instability and channel migration. Maps of unstable channel reaches and riparian vegetation indicate that local channel instability also can be linked in part to removal and suppression of woody vegetation in the riparian corridor. Tree-ring data document that large floods in the mid 1980's had a large effect on stream channels, disturbing 25-75% of the surface areas of prominent gravel bars.

Stratigraphic data from Ozark valley bottoms show a four-part succession of unconformity bounded units with contrasting sedimentology. Two of the units predate European settlement of the Ozarks; the transition between the two units is probably attributable to climate change sometime in the late Pleistocene or Holocene. The next younger unit, of probable early post-settlement age, records a transition from stable, meandering stream patterns to shallow streams with multiple channels choked with organic-rich silt and sand. The youngest unit, dating from the early 20th century, consists of thick, massive gravel deposits. The stratigraphic observations demonstrate that changes in the alluvial regime of Ozark streams during the period of intense land use are much more severe than those changes that have occurred from past climate change alone.

H31B-9 1105h

Frequency of Disturbances in Urban Streams

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Changes in land use generally yield changes in runoff and stream channels, with the greatest impacts accompanying urbanization. Although traditional analyses focus on increases in flood discharge, urbanization alters the temporal distribution of runoff events even more profoundly, a change with dramatic effects on physical and biological stability.

The hydrologic effects of urbanization have been numerically modeled and integrated with extensive field data. Habitat in small, lowland streams are disrupted primarily by moderate-to-large storm flows. Although smaller (i.e. sub- to near-bankfull) flows may transport the most sediment over time, that movement appears to occur largely within a stable channel framework; we cannot document significant channel or habitat degradation by urban-induced increases in the duration of such flows. In contrast, larger flow peaks (recurrence intervals greater than about 5-10 years in the predeveloped state) are capable of removing bank vegetation, washing out woody debris in the channel, and eroding bank and floodplain sediment. Wood, in particular, is critical in the stability and biological diversity of many of these channels. Wash-out by larger flows, however, occurs 5-20 times more frequently in urbanizing basins. Barren, riffle-dominated channels evolve as a result, displaying reduced channel roughness, limited sediment storage, and habitat of low diversity that favors disturbance-tolerant fish.