FLUVIAL GEOMORPHOLOGY

Wood and river landscapes

The influence of trees and dead wood on river dynamics has long been overlooked. Recent work suggests that large wood pieces can stabilize the land surface, contributing to a large-wood cycle that profoundly affects floodplain morphology and ecology.

Angela Gurnell

Flows of water and sediment sculpt river channels and floodplains. Traditionally, the assessment of these processes has formed the core of research seeking to explain the enormous variety of river landscapes on Earth. Vegetation has traditionally been relegated to a secondary role in this process, whereby plants were thought to colonize the relatively stable areas of land left by the interactions between water and sediment. However, more recently, many important contributions of vegetation — both dead and living — to river habitat mosaics have been discovered. Writing in *Geomorphology*, Collins and colleagues[1] propose that the recruitment, transport and retention of large wood pieces in rivers that drain forested areas contribute to the construction and dynamics of river and floodplain landforms, with consequences for river ecosystem functioning and resilience[2].

The fast-growing field of fluvial biogeomorphology is exposing the long-overlooked but fundamental importance of vegetation — particularly trees — for river landscape form and change. The importance of vegetation becomes apparent when looking at fluvial styles throughout the Earth's history. The origin of stable single- and multiple-channel rivers during the Palaeozoic era is coincident with the evolution and expansion of tree-like plants[3]. This impact of early tree-like vegetation on the style of rivers across the Earth's surface provides a very robust context for recognizing vegetation as a third control, along with flows of water and sediment, in river landscape construction. It is also a long-term backdrop for exploring the impact of trees and dead wood on modern river forms and processes.

Indeed, Collins and colleagues suggest[1] that trees and large wood are key components of modern fluvial landscapes. They propose that large trees that are undermined and fall into rivers tend to be retained as stable, large wood pieces within the river system (Fig. 1). The pieces accumulate in river channels and ultimately form erosion-resistant hard points in floodplains. These stable hard points in turn provide an environment within which trees are able to grow to maturity before they are eventually eroded by the river. Collins and colleagues term this the floodplain large-wood cycle. They conclude that the recruitment of very large wood pieces to form floodplain hard points is dependent on the presence of particular foundation tree species; the exact species vary among ecological regions. The presence or absence of these large, mature trees and very large wood pieces acts as a switch, dictating whether a river landscape evolves towards a relatively complex or simple state.


A.M. GURNELL

Figure 1 | Wood and water. Collins and colleagues[1] propose that large wood, like that seen here in Mack Creek, HJ Andrews Experimental Forest, Oregon, USA, is key to the formation of stable areas in river channels and floodplains. The wood becomes incorporated into the floodplain and forms a stable surface on which new trees can grow to maturity, in turn propagating the floodplain large-wood cycle.

In proposing the floodplain large-wood cycle, Collins and colleagues focus mainly on humid temperate mountain rivers where large, slow-decaying pieces of dead wood form hard points within river corridors. However, as the authors acknowledge, the stabilizing impact of large wood and its consequences for river characteristics have been observed in many other environments, from lowlands to uplands, and within desert, tropical, temperate and boreal forest biomes[4]. This suggests the widespread applicability of the floodplain large-wood-cycle concept, albeit with local variations in the precise way in which wood functions.

A notable variant of the floodplain large-wood cycle emanates from the ability of some riparian tree species to sprout when they are uprooted and deposited, allowing a 'living-wood cycle' to dominate in some fluvial systems. Within this cycle, deep complex root systems replace dead-wood hard points as the key mechanism stabilizing river landforms[4,5]. Whether dead or living wood pieces, or rapidly growing tree seedlings, underpin the development of the floodplain forest mosaic, laboratory flume experiments[6] and numerical modelling[7] have demonstrated robust feedbacks between river flows, sediment transport and vegetation. These factors profoundly affect the styles of rivers and floodplains that evolve in different environmental settings and the ecosystems that they support[8].

As Collins and colleagues point out, rivers that are naturally influenced by significant inputs of large dead wood are likely to change rapidly to a completely new state if the supply of wood is reduced or removed. This complex interplay between vegetation and fluvial systems complicates attempts at land management. For instance, the removal of wood in river systems affected by sprouting wood also causes channel widening and the disappearance of wooded islands[9]. Similarly, the overgrazing of wooded floodplains leads to floodplain unravelling and a transition from single- to multi-thread channel patterns[10]. Conversely, changes in river discharge can allow alien woody species to invade the floodplain; the encroaching vegetation can cause the channel to narrow, and can stabilize the new channel edges[11].

These examples, along with the floodplain large-wood cycle identified by Collins and colleagues[1], demonstrate that a landscape-scale approach to river management is needed to underpin sustainable restoration of river ecosystems. Restoration plans need to allow crucial components of the native vegetation to establish and interact freely with water and sediment to reinstate the natural dynamics of rivers and their floodplains, albeit within more restricted corridors than may have existed historically. ❒

Angela Gurnell is in the School of Geography, Queen Mary, University of London, Mile End Road, London E1 4NS, UK.
e-mail: a.m.gurnell@qmul.ac.uk

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ECOLOGY

Plants on the edge

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The base of a steep mountain is a foreboding place. Debris — ranging from sand-sized grains to massive boulders — rains down constantly, forming what are known as talus slopes. These slopes are at the edge of stability, prone to failing and sliding. The debris piles hold little water and are seemingly inhospitable to plant life.

Yet on the alpine talus slopes of the Lassen Volcanic Park in the Cascades Range, North America, an abundance of vascular plants, ranging from herbs to the occasional pine tree, make their home on the debris-swept slopes. Francisco Pèrez of the University of Texas, Austin, documented these plants and their interaction with the geomorphology of the talus slopes (*Geomorphology* **138,** 29–48; 2012).

The talus vegetation — which commonly includes buckwheat plants, herbs and low-lying shrubs — shows a number of adaptations for life on a slippery slope. Young, mostly perennial plants typically have shallow root systems that allow them to be carried downslope with the shifting talus. Many of these plants have root systems that trail back up the slope. Only older plants have deep root systems that allow them to resist the downward debris flow. Annual plants are rarely observed in the talus.

Once the plants establish themselves against the frequent grain and rock slides, snow avalanches and frost creep, they in turn begin to influence the dynamics of the debris flow. Mat-forming plants capture fine-grained debris as it moves downhill, eventually growing up through the accumulating sediment. Compact herbs and shrubs with dense foliage also block debris from moving down the slope. The blockages form mounds, debris wedges and even small terraces. The sheltered areas beneath the blocking plants are often less steeply sloped and contain a higher percentage of fine-grained debris than the surrounding slope. In some cases, the presence of a strong root network even prevents some surface sliding.

This hardy, if uneven, assemblage of plants in such an extreme environment highlights the ability of some plants to cope with the most trying of habitats, and shows how plant tenacity can eventually add some stability to the immediate surroundings.

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