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Deep Time Ecosystem Engineers: The Correlation between Palaeozoic Vegetation, Evolution of Physical Riverine Habitats, and Plant and Animal Terrestrialization

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Evidence from the deep time geological record attests to the fundamental importance of plant life to the construction of physical habitats within fluvial environments. Data from an extensive literature review and original fieldwork has demonstrated that many landforms and geomorphic features present in modern river systems do not appear in the deep time stratigraphic record until terrestrial vegetation had adopted certain evolutionary advances that enabled them: for example, stable point bars are associated with the development of deep rooting in the Siluro-Devonian and avulsive anabranching fluvial systems appear at the same time as extensive arborescent vegetation in the Carboniferous. In this presentation, we demonstrate a correlation between the diversification of physical fluvial sedimentary environments and the expansion of terrestrial fauna and flora throughout the Cambrian to Carboniferous, and offer an explanation for this observation that considers plants as ecosystem engineers on an evolutionary timescale. Many extrinsic factors have been considered when attempting to identify controls on the evolutionary timelines of terrestrialization for various different organisms. Factors such as O_2 and CO_2 levels in the atmosphere, climatic events, global tectonic organisation, sea-level changes, extinction events, weathering rates and nutrient supply are all known to have played a role. However, another factor is likely to have been a fundamental prerequisite for achieving terrestrial biodiversity: the variety of physical habitats available for newly evolved organisms. In fluvial environments, this is a function of the diversity of hydrodynamic regimes (both temporal and spatial) within the world's river systems. In a world where only sheet-like ephemeral braided rivers existed, such as appears to be the case in pre-vegetation settings, both the geographic extent of riparian margins and the diversity of hydrodynamic regimes would be minimal. However, as fluvial corridors narrowed throughout the Ordovician and Silurian, the potential importance of riparian zones as a global biome would have increased as they became more extensive in continental environments. Furthermore, the move towards climatic controls on the ephemeral or perennial nature of streams would have boosted the diversity of temporally diverse hydrodynamic regimes. As single-thread meandering channels and extensive muddy floodplains, stabilised by vegetation, became significant components of the global suite of alluvial geomorphic components throughout the Siluro-Devonian, further diversification of the extent and diversity of physical habitats within the global riparian biome occurred. Into the Carboniferous, the evolution of the anabranching habit within alluvial systems created further new physical landforms for colonization and would have promoted increasingly complex hyporheic flow regimes. Furthermore the associated advent of arborescent vegetation and, specifically, the large woody debris supplied by this, would have created a wealth of new microhabitats for continental organisms. The expanding extent and diversity of physical alluvial niches during the Palaeozoic can be argued to be an underappreciated driver of the terrestrialization of early continental life. The study of the deep time fossil and stratigraphic record also illustrates that vegetation is a fundamental prerequisite for the creation of biogeomorphic alluvial landforms and physical habitats and microhabitats.