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## Mapping the world's free-flowing rivers using the Connectivity Status Index (CSI)

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Free-flowing rivers (FFRs) are the freshwater equivalent of wilderness areas and they support many of the most diverse, complex and dynamic ecosystems globally, providing important societal and economic services. We define FFRs as rivers where ecosystem functions and services are largely unaffected by changes to the fluvial connectivity, allowing unobstructed movement and exchange of water, energy, material and species within the river system and with surrounding landscapes. However, there is immense anthropogenic pressure on natural connectivity in rivers: river connectivity can be compromised by physical infrastructure in the river channel, along riparian zones or in adjacent floodplains; hydrological alterations of river flow due to water abstractions or regulation; and changes to water quality that lead to ecological barrier effects caused by pollution or alterations in water temperature.

We developed the Connectivity Status Index (CSI), a novel methodology to measure of the current state of connectivity at a river reach scale (river segment of ~2.5 km length). The CSI considers five 'pressure factors' that represent the main human interferences within the four dimensions of river connectivity: a) river fragmentation (longitudinal); b) flow regulation (lateral and temporal); c) sediment trapping (longitudinal, lateral, and vertical); d) water consumption (lateral, vertical, and temporal); and e) infrastructure development in riparian areas and floodplains (lateral and longitudinal). We developed proxy indicators for these components informed by available global data and numerical model outputs and combined these layers into the CSI using a weighted overlay model. We assessed the connectivity status of 12 million kilometres of rivers globally and identified rivers that remain free-flowing in their entire length.

We found that only a third of rivers longer than 1,000 kilometres remain free-flowing over their entire length and less than a quarter flow uninterrupted to the ocean. Very long FFRs are largely restricted to remote regions of the Arctic and of the Amazon and Congo basins. In densely populated areas only few very long rivers remain free-flowing, such as the Irrawaddy and Salween. Dams and reservoirs and their up- and downstream propagation of fragmentation and flow regulation are the leading contributors to the loss of river connectivity. Plans to rapidly develop new infrastructure in basins around the world threaten the loss of extensive kilometers of free-

flowing rivers, including status changes of several iconic long free-flowing rivers in tropical regions, such as the Amazon, Salween, Irrawaddy and Karnali rivers.

Given the current status and future perspective of free-flowing rivers, we will discuss a range of opportunities for application of the Connectivity Status Index, including a) as a component in studies of ecosystem health; b) to play a role in prioritizing rivers with high conservation value for protection; c) in optimizing the informed selection of low-impact infrastructure developments; and d) as a tool for national and global monitoring.