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At the interface between hydrology and ecology

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Bridging the gap between hydrology and ecology, ecohydrology recognizes that water resources cannot be studied in isolation from ecosystems.

Ecohydrology emerged in the face of pressing environmental challenges associated with climate change and human activities. At its core, it recognizes the critical role of water in controlling ecosystem functions and how ecosystems in turn help sustain water resources[1].

Diverse ecosystems, including natural ones (rivers, lakes, forests and so on) and those dominated by humans (urban areas, agricultural land and so on) serve both terrestrial life and humans, directly or indirectly. Those services relevant for the benefits to human well-being are defined as ecosystem services and are grouped into four categories[2]: provisioning, such as water and energy production; regulating, such as floods, water purification and climate regulation; cultural, such as educational, spiritual, and recreational benefits; and supporting, such as nutrients cycling. Understanding these services would be impossible without ecology.

From the treelines to the meandering river channels, water regulates vegetation dynamics, biogeochemical processes, and element cycling via various hydrological processes. Hydrology is the foundation of our understanding of those processes.

Both water and people are components of the ecosystem framework, and how we use water impacts ecosystems and ecosystem services, and eventually human well-being. This is why a number of scientists, arguably led by Ignacio Rodríguez-Iturbe[3], founded and then contributed substantially to ecohydrology, a synergistic discipline that can provide information on the changes of both terrestrial and aquatic systems, as well as how those changes may affect both living (biotic) and non-living (abiotic) components of ecosystems. Ecohydrologists delve into the intricate relationships within ecosystems, including climate–soil–vegetation–groundwater interactions, inland water carbon processes and associated biogeochemical mechanisms, and diverse flow systems, aiming to answer questions such as "should we plant more trees across the globe?", "are lakes carbon sinks or sources?", and "why do we need to care about wetlands and constructed wetlands?".

Our cover depicts a UNESCO Ecohydrology Demonstration Site: the Eddleston Water Project near Peebles, UK. The Eddleston Water Project serves as a dynamic testing ground for natural flood management techniques, which aim to bolster flood resilience through the restoration of natural processes that slow water flow and increase water retention within the river system. This project adopts an ecohydrology approach that leverages river ecosystem resilience to buffer against the impacts of climate variability for the well-being of both the local community and wildlife[4]. It demonstrates ecohydrology's emphasis on resilience: the ability of ecosystems to withstand and recover from disturbances including intensifying hydroclimatic extremes under climate change. Moreover, it shows how ecohydrology research supports flood risk management, climate change adaptation and biodiversity enhancement at catchment scale, while also providing educational and recreational value to communities.

A crucial aspect of ecohydrology is that it provides the tools to address water-related challenges in those environments managed or modified by human activities. For instance, evapotranspiration (ET), compromising both the evaporation of water vapour from the soil and the transpiration of water through vegetation into the atmosphere, ranks as the second most important component of the terrestrial water balance[5] and stands as a vital and prevalent topic in ecohydrology research. Taking a careful look at our February issue cover, we can find a map of the annual ET rates computed from OpenET for irrigated agricultural lands and wetland areas near the confluence of the Columbia and Snake rivers (US), in contrast to ET from the surrounding shrubland and grassland ecosystem. Farmers, land and water managers can more accurately know the amount of water used by ET, allowing for more cost-effective irrigation water usage, particularly essential for arid and semi-arid areas. Here, through techniques such as modelling and remote sensing, ecohydrology research can empower resource managers and policymakers to make informed decisions that balance human well-being with water sustainability.

Despite its establishment and increasing appearance in the past decades, ecohydrology remains a relatively young discipline. Realizing its full potential to addressing water-related challenges requires concerted action on multiple fronts. Continuous investment in research, such as monitoring (see the Comment by Dean and Battin in this issue), modelling (see the Comment by Wang and Zeng and the Review Article by Zhi et al.) and better integration of ecosystem water demands (see the Comment by Cui et al.), is critical to deepen our understanding of the complex interactions between water and ecosystems. Furthermore, interdisciplinary collaboration must be fostered, bridging the gap between scientists, practitioners, policymakers, and local communities. Only through collective effort can we transform scientific ecohydrological insights into real-world applications.

We are in a transition to a new age of water[6], and ecohydrology may offer a path forward. That said, we work with nature, rather than against it. As proposed by Andrea Rinaldo in his World View, "refocusing ecohydrology must therefore be seen as part of a new intellectual frontier for the Earth/environmental sciences".

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References

1. McClain, M. E. et al. *Hydrol. Earth Syst. Sci.* **16**, 1685–1696 (2012).
2. Millennium Ecosystem Assessment. *Ecosystems and Human Well-being: Synthesis* (Island Press, 2005); https://www.millenniumassessment.org/documents/document.356.aspx.pdf
3. Levin, S. & Rinaldo, A. *PNAS* **119**, e2217606119 (2022).
4. The Eddleston Water Project. *Tweed Forum* (2024); https://tweedforum.org/our-work/projects/the-eddleston-water-project/
5. Volk, J. M. et al. *Nat. Water* **2**, 193–205 (2024).
6. *Nat. Water* **1**, 659 (2023).