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Managing temporary streams and rivers as unique rather than second-class ecosystems

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ABSTRACT

Temporary streams and rivers support biodiversity and provide valuable goods and services, especially in arid and semi-arid landscapes. However, temporary streams and rivers are being degraded at alarming rates owing to development, hydromorphological alteration, and disposal of waste water, among other stressors, and pressure will likely increase under global change. Here we propose that it is key to manage temporary streams and rivers as a unique ecohydrological type and not as a permanent waterway or a terrestrial ecosystem. Nevertheless, two challenges hinder this goal. First, data availability on intermittent low regimes and associated biotas is currently scarce. As a consequence, flow-ecology relationships in temporary waterways are largely unknown, and appropriate metrics to define and monitor their ecological status are missing. Second, the ecological and social values of temporary streams and rivers are often underestimated, being regarded as secondary ecosystems relative to permanent waterways. To conserve temporary streams and rivers, ecologists need to define them as unique ecosystems and conservation targets, and practitioners need to systematically collect biological and hydrological data in these ecosystems. Innovative approaches at the intersection of ecology, citizen science, and management, can also contribute to their management and conservation by: i) mapping them, ii) informing people about their ecological values, iii) safeguarding them from further human threats, iv) preserving their flow regime when managing reservoirs, wastewater treatment plants, and water abstraction activities, and v) restoring physically-degraded temporary reaches (e.g. due to gravel mining and off-road use) or reaches that have lost historical flows due to increasing drought severity, diversions, and groundwater overuse.

1. What are temporary streams and rivers?

Temporary streams and rivers are waterways that cease to flow at some points in space and time along their course (Acuña et al., 2014). These systems are therefore characterized by alternating wet and dry phases, with and without surface flow, respectively (Fig. 1). They can be characterized by the spatial and temporal components of the dry phase (i.e., the extension of the waterway that remains without flow or dry; and the frequency, duration, timing, and predictability of the dry phase). Flow cessation and eventual disappearance of surface water (i.e., dry events) may or may not be considered a disturbance depending on its magnitude and underlying causes, that is, whether flow intermittency falls within the historical range, and whether it is human-induced or natural. When occurring naturally and within the historical range, dry events should not be regarded as ecological disturbances, but rather as a characteristic of the natural flow regime (sensu Poff et al., 1997) that has shaped the life-history strategies of the associated biotas (Bunn and Arthington, 2002; Lytle and Poff, 2004). In contrast, dry events of extraordinary magnitude, or those directly or indirectly caused by humans, are decoupled from the life history, behavioral, and morphological adaptations that plants and animals have developed to persist in the face of drought. Therefore, these events may present stronger impacts at the population, community, and ecosystem levels (Fig. 2).

Contrary to what is generally assumed, temporary streams and rivers are not restricted to arid regions but occur in all biomes, representing around 69% of first-order streams below 60° latitude and 34% of fifth-order rivers (Raymond et al., 2013). Temporary streams and rivers do however account for a higher proportion of the total waterway network in arid biomes, with this proportion ranging from 10 to 80% in different COSCAT regions (COastal Segmentation and related CATchments) (Meybeck et al., 2006; von Schiller et al., 2014). The distribution of temporary streams and rivers within river networks also varies tremendously among regions, as temporary streams and rivers usually predominate only in the headwaters in temperate regions

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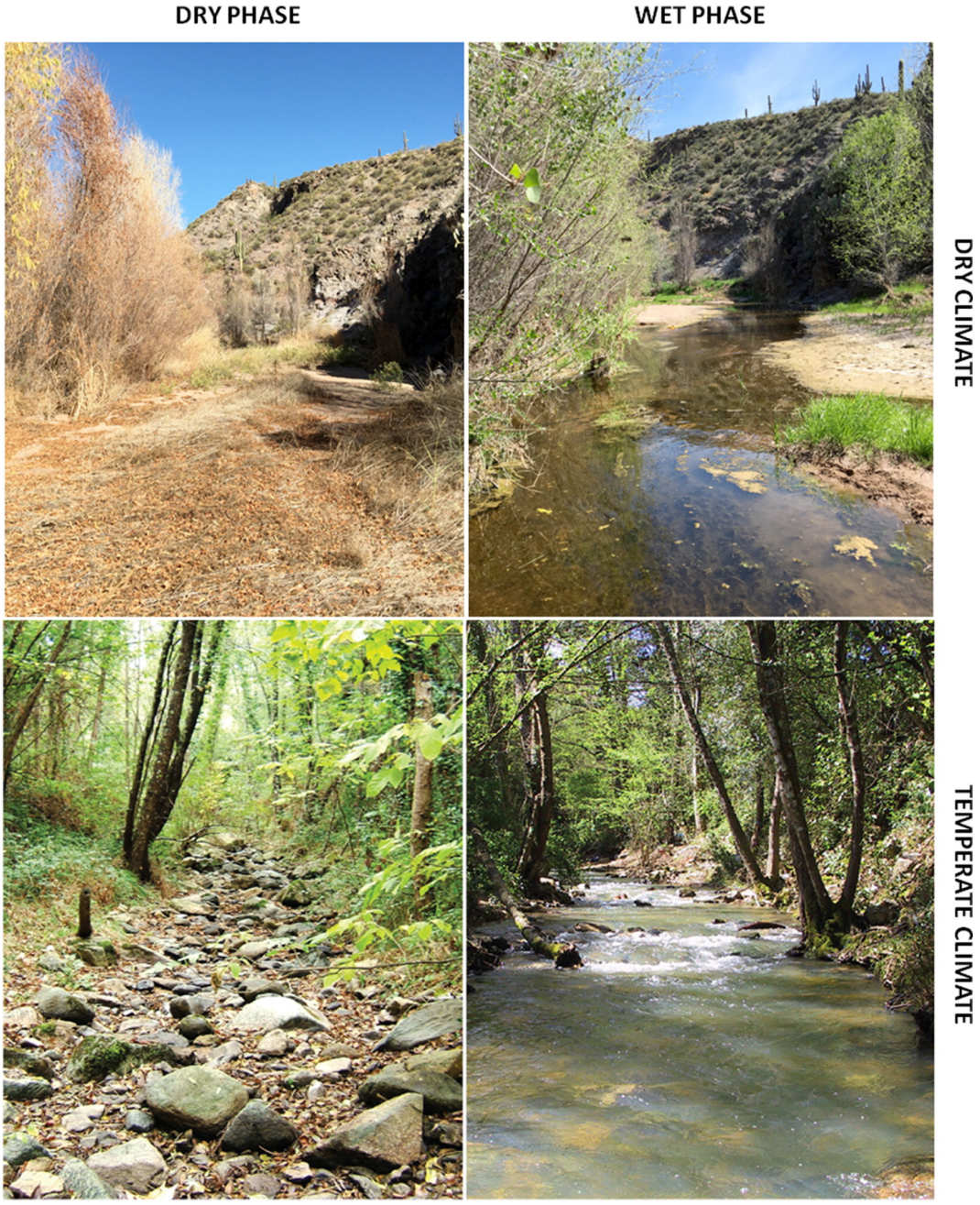

Fig. 1. Examples of temporary streams during their dry (on the left) and wet (on the right) phases, from dry (Sycamore Creek, AZ, U.S.A.) and temperate (Fuirosos Stream, in Catalonia) climates.
Photographs of the Sycamore creek by Albert Ruhí, and of the Fuirosos stream by Sergi Sabater.

(Fritz et al., 2013), but occur at any position along arid watersheds. The location of temporary streams and rivers within river networks is particularly important (Datry et al., 2016) because it influences the connectivity of aquatic and terrestrial species at the regional scale, which in turn controls community resilience to drought (Bogan et al., 2015; Stubbington et al., 2016). Because the spatial distribution of temporary reaches within a river network influences density and richness of organisms at the local and regional scale (Davey and Kelly, 2007), drying disturbances need to be considered from a landscape perspective.

Because of their high contribution to biodiversity and ecosystem services relative to their small size, temporary streams and rivers can be considered as Small Natural Features (SNF) with large ecological roles, as detailed in the next section, and further conceptually developed in the introductory section of this special issue (Hunter, 2017).

2. Why are temporary streams and rivers important, both ecologically and economically?

Temporary streams and rivers are important for biodiversity in four basic ways, as they can: i) harbor unique aquatic organisms with strategies that favor resilience to, and resistance against, desiccation (e.g., high dispersal capabilities, dormancy) (Boersma et al., 2014; Bogan et al., 2015); ii) attract terrestrial taxa that circumstantially use dry riverbeds for refuge and foraging (e.g., riparian and upland arthropods) (Leigh et al., 2013a; Sánchez-Montoya et al., 2015) or that have them as their optimal habitat (Lalley et al., 2006; Steward et al., 2011); iii) function as corridors for terrestrial biota (e.g., used for dispersal by large mammals and for migration by migratory songbirds) (Steward et al., 2012), and (iv) support fauna not found in the surrounding