News & views

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Figure 1 | The dried-up Darling River in New South Wales, Australia, February 2020. Messager and colleagues' analysis[1] shows that most rivers and streams run dry for at least one day per year, including sections of major rivers in arid regions.

Hydrology

Most rivers and streams run dry every year

Kristin L. Jaeger

A model of the world's rivers and streams has been developed to predict which of these watercourses flow all year round and which go dry. The analysis shows that rivers and streams that run dry are ubiquitous throughout the world. **See p.391**

The flowing waters of surface rivers and streams efficiently transport sediment, organic material and nutrients, among other things, from hillsides and overland areas to downstream lakes, reservoirs and the ocean. Along the way, rivers and streams (hereafter referred to collectively as streams) provide important resources for our communities and support rich, complex ecosystems. Non-perennial streams, which do not flow year-round, are crucial in this context. However, because non-perennial streams are less reliable sources of surface water than perennial ones, they are less-well studied than their perennial counterparts. On page 391, Messager *et al.*[1] provide a much-needed estimate of the total proportion of the world's stream network, by length, that is non-perennial — and find that most fall into this category.

Messager and colleagues combined streamflow data from sites around the world with information describing the hydrology, climate, physical geography and land cover at those sites, to model the probability that water does not flow for at least one day per year. They then expanded their predictions to all stream segments recorded in a global stream-network database (RiverATLAS)[2].

The authors report that 51–60% of the world's streams do not flow for at least one day per year, and that 44–53% of global stream length is dry for at least one month (about 30 days) each year. Their modelling shows that non-perennial streams occur in all climates and biomes on every continent (see Fig. 1 of the paper[1]). The model also shows that 95% of the stream network in hot, dry regions — which represent 10% of the global landmass — runs dry each year (Fig. 1). Astonishingly, even segments of major rivers, such as the Niger River in West Africa, are predicted to dry up in these arid regions. The vast prevalence of non-perennial streams in such locations highlights how even streams that do not flow continuously substantially affect water availability and water quality. The results emphasize the need for more-detailed maps of perennial and non-perennial flows at regional and local scales, and for further studies of how non-perennial streams affect overall water availability and quality.

Small headwater streams (those that have no tributaries) make up 70–80% of stream length worldwide[3], similar to the way in which the collective length of one's fingers is much greater than the length of the palm of the hand. Messager and co-workers' model predicts that, even in the wettest regions, such as the Amazon River basin and portions of central Africa and southeast Asia, up to 35% of these headwater streams stop flowing at some point in the year. However, it should be noted that headwater streams are monitored by relatively few stream gauges, which tend to be located on larger, perennial rivers downstream. The model might therefore provide highly uncertain estimates for the upstream regions of stream networks.

Lack of streamflow data is a common problem for the modelling of headwater streams, and so data-collection efforts are being implemented to fill this knowledge gap. For example, France has developed the Observatoire National des Étiages (ONDE) network, which complements the national stream-gauging network but focuses on headwater streams. However, these programmes are costly and require considerable investment of resources.

Stream gauges are also scarce for non-perennial streams more generally. In Messager and colleagues' analysis, for instance, there were no gauges in non-perennial streams in Argentina; just one in New Zealand; and 10 in the United States Pacific Northwest, out of a network of 250 gauges. To improve models that map perennial and non-perennial streams, low-cost field observations will be needed, coupled with the development of high-resolution remote-sensing technology that frequently detects — or at least predicts — surface flow in streams.

Messager and co-workers' analysis provides a robust, quantitative confirmation of the ubiquity of non-perennial rivers. Their results indicate the need for a fundamental change in the fields of river and stream science and management, in which non-perennial streams have been largely overlooked[4]. In arid regions, the predominance of non-perennial streams might be a major driver of water availability and quality. And in areas where services developed by humans are not readily available, ecosystem services such as flowing water in streams are used to meet basic needs and will, in part, determine the well-being and prosperity of people in that area[5]. The new findings therefore shine a light on the need for global accounting of both perennial and non-perennial streams.

Moreover, changes in the distribution of streams can have far-reaching impacts on carbon and biogeochemical cycles at global and continental scales[6], and on the survival of stream-dwelling organisms, including many endangered species[7]. A global benchmark of the prevalence of perennial and non-perennial streams is therefore crucial for evaluating the effects of future changes in their distribution associated with climate and land-use change. Finally, regional and local models of streams are needed, as well as better data for headwaters and non-perennial portions of the stream network, to further increase the value of global models.

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Coronavirus

Contact-tracing app curbs the spread of COVID

C. Jason Wang

Digital contact tracing has the potential to limit the spread of COVID-19. A contact-tracing smartphone app that has been readily adopted by people in England and Wales has shown efficacy in reducing disease spread. **See p.408**

The idea behind digital contact tracing is that, when an individual tests positive for an infectious disease such as COVID-19, an app on their smartphone can send a notification to other smartphones that have been in close proximity, such as within 2 metres, for more than a certain period of time, say 15 minutes. However, such apps can be difficult for people living in a democracy to accept because of concerns about data privacy. On page 408, Wymant *et al.*[1] demonstrate effective implementation of a digital contact-tracing app on a large scale in a democratic society: England and Wales in the United Kingdom.

The technology used in the app, which was named the NHS COVID-19 app after Britain's National Health Service, is the Google Apple Exposure Notification (GAEN) system. This uses low-energy Bluetooth-enabled radio signals to send a randomly generated identification code from one phone to another that is in close proximity, creating a sort of 'handshake'; these codes change every 10–20 minutes. The codes of phones that have been in close physical contact over the previous 14 days are stored in the app on a user's phone. When a user tests positive for COVID-19, they can consent to have their codes sent anonymously to a central server. Other app users can sync with the central server for a match. Thus, the app can help to alert people who have potentially been exposed to COVID-19, so that they can then get tested, voluntarily place themselves in quarantine and inform their contacts that they should do the same.

A contact-tracing app will make a meaningful difference in the population only if a large enough proportion install and use it. The NHS COVID-19 app experience shows that there is enough participation in app use for it to be useful. An estimated 33.9 million people were eligible to download the app (that is, they were aged 16 or over, were located in England or Wales and had a compatible smartphone). Between its launch on 24 September 2020 and the end of 2020, the app was downloaded on 21 million separate devices and, between 1 November and 11 December 2020, it was regularly used by an average of about 16.5 million users, which is about 49% of the eligible population, or 28% of the total population of England and Wales. Moreover, 72% of app-using 'index' cases (individuals who tested positive for COVID-19) consented to an app-based exposure notification being sent after testing positive.

Knowing that a randomized, controlled trial of a digital contact-tracing app is probably not feasible, Wymant *et al.* used two ways of estimating the impact of the app on the spread of COVID-19 from October to December 2020. First, using the number of observed notifications and the secondary attack rate — the proportion of contacts identified who ended up becoming infected — they modelled the number of cases averted as a result of app use. Second, they performed statistical comparisons of cumulative cases in neighbouring regions that had similar baseline infection rates but differing levels of app use, after adjusting for factors known to correlate with app uptake (such as areas being more rural, and having less poverty and a stronger local economy) and with infection rate.