



A response to Correia *et al.*

In their letter, Correia and colleagues raise two issues about our original article (Burivalova *et al.* 2018). Their first point questions the proposition that a growth in absolute search volume reflects an increase in public interest. We fully agree that this is unlikely to be a straightforward relationship: it would be affected by disparities in internet access, different reasons for searching the internet, and so forth. Indeed, we highlighted these caveats in our article, where we further warned that: “interest does not necessarily equal support; conservation scientists and practitioners should therefore encourage this growing interest by redoubling efforts to present objective, evidence-based findings about conservation in an accessible, engaging, and relatable way”. Correia *et al.* also argue that the absolute number of searches is likely to have increased for any topic. We showed that the absolute search volume on certain conservation-related topics, such as “monkeywrenching” (non-violent sabotage carried out by environmental activists; WebFigure 2b), did not substantially increase during the study period. We do, however, fully support a more nuanced analysis, which would combine multiple approaches to better understand the relationship between search volume, public interest, and public support.

We believe the authors’ second point stems from a misunderstanding. We did not think that conservation and climate change-related topics had similar levels of public interest. Rather, we thought that the *rate and direction of change* in interest in these two topics was similar and synchronized (WebFigure 5). Indeed, the overall search volume for climate change is currently about five times as high as that for biodiversity, as indicated by Google AdWords and Keywords Everywhere. However, when searches for climate change rise, so do searches for biodiversity. This was not the case for control terms, such as “cupcakes” or “HIV/AIDS” (WebFigure 6). Our original worry, or suspicion, was that interest in climate change displaces interest

in biodiversity conservation, and we believe that comparing the short-term rates of increase and decrease are a suitable method to assess whether this is true.

We presume that a direct comparison between topics, as the authors propose in their Figure 1b, would only be possible if we had the true absolute historical value for search volume. We also believe that Google Trends data, as available at the time of our analysis, do not allow such comparison. Although it would have been possible to scale our results by the current absolute search volumes as obtained from Google AdWords and Keywords Everywhere, we decided against this, as it would have introduced too much uncertainty due to the way these two tools smooth their results over time (differently relative to Google Trends).

Regardless, we fully agree with Correia *et al.* that conducting further studies, combining multiple sources of information, and incorporating all available culturomics tools are needed, and we welcome the establishment of the Conservation Culturomics working group within the Society for Conservation Biology. Far more understanding is required in the field of public conservation interest, and how to leverage it, if we are to prevent further species’ extinctions and halt climate change.

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Small hydropower goes unchecked

As compared to the contentious construction of new large hydropower plants in Asia, Africa, and South America, the

global boom of investment in small hydropower plants (SHPs) receives much less attention. SHPs are usually defined by having an installed capacity of <10 megawatts (MW) but in some countries include capacities up to 30 MW (eg Brazil) or 50 MW (eg Canada, China) (WSHPDR 2016). A typical SHP comprises a dam that abstracts water (Figure 1) and leads it to the turbines.

The dramatic expansion in the number of SHPs is due in part to international commitments to achieve climate goals and phase out nuclear power, as well as to growing resistance against large hydropower plants in light of their adverse impacts on nature and human livelihoods. For example, Brazil is projected to augment the country’s total installed capacity of SHPs from 5.5 gigawatts (GW) to 12 GW by 2050, and Switzerland plans a 0.36 GW increase in its total capacity by 2050, of which 0.18 GW will be generated by new SHPs (WSHPDR 2016). To date, more than 82,000 SHPs have been constructed worldwide, and an additional 10,569 SHPs are currently planned (Couto and Olden 2018), although this may be a substantial underestimate. However, despite their large numbers, SHPs contribute little to global hydropower production (Lange *et al.* 2018). In the US, SHPs account for 65% of the country’s 2,320 hydropower facilities but provide only 3.5% of the generating capacity (Sharma *et al.* 2019).

SHPs have been heavily promoted by national policies (Couto and Olden 2018). In the US, for instance, they are incentivized by a simplified licensing process and by local governments providing “feed-in tariffs” (a guaranteed payment at a fixed price over a substantial period) (Johnson and Hadjerioua 2015). Likewise, in Switzerland the government is providing investment grants and feed-in tariffs over a duration of 15 years, and in China provinces offer feed-in tariffs while the government strongly supports the financing of SHPs by local investors (WSHPDR 2016).

Current policies fail to ensure that new SHPs meet environmental compliance standards. In many countries, the



Figure 1. A small hydropower plant in an alpine river in Switzerland.

degree of pre-assessment depends on the planned installed capacity; for instance, in India and Switzerland, such assessments are needed only in cases where capacities exceed 25 MW (Couto and Olden 2018) and 3 MW, respectively. This leaves many SHP projects without any assessment of their ecological and socioeconomic impacts, which – as compared to those of their larger counterparts – are often perceived as negligible by the public and by policy makers (due to their relatively smaller infrastructure and their location on smaller rivers).

Adverse consequences associated with large hydropower plants include slow but marked declines of fish stocks across entire watersheds, irreversible changes to ecosystems, and loss of livelihoods in fisheries (Ziv *et al.* 2012). The ecological and socioeconomic impacts of SHPs per megawatt of electricity produced have rarely been studied (Ziv *et al.* 2012), but available evidence suggests that they are larger than those of large hydropower plants due to the wide extent – in both space and time – of the impacts and cumulative effects of many small dams (Kibler and Tullos 2013). Globally, small rivers belong to some of the most pristine ecosystems, providing water and sediment to large iconic rivers, as well as offering refugia, nursery habitats, and spawning areas for fish and other organisms (Freeman *et al.* 2007). River fragmentation interrupts the pro-

cesses sustaining biodiversity by isolating populations and reducing genetic diversity (Horreo *et al.* 2011).

SHP investment also comes with socioeconomic uncertainties. Habitat degradation and landscape-scale changes can reduce the cultural services (including recreational uses) typically provided by rivers (Mattmann *et al.* 2016). Climate change-induced warming will, in some areas, reduce river flows (Barnett *et al.* 2005) and thereby diminish hydropower production, particularly in smaller rivers. Decreased energy production and lower profits make it difficult to buffer against fluctuating electricity prices. In the US, many small dams have been abandoned because of low economic return, transferring the costs for maintenance and dam removal to local governments (Poff and Hart 2002).

The World Commission on Dams (WCD 2000) stated that the socioenvironmental costs of many large hydropower plants were much larger than anticipated and that non-dam options (eg retrofitting existing drinking water systems for use as SHPs) should be considered for future projects. We believe that the unchecked development promoting single-purpose SHPs should be replaced by a new paradigm that builds on three points: (1) SHPs must be subject to the same environmental regulations as large hydropower plants because both are

associated with ecological threats and high socioeconomic costs. Effective mitigation measures such as fish passes or environmental flows can reduce, but never completely offset, the ecological footprint of SHPs (Noonan *et al.* 2012). (2) Regardless of their size, the development of hydropower plants needs to be guided by policies requiring long-term planning and assessment at the basin scale (Winemiller *et al.* 2016). Limiting impact assessments to the reach scale is insufficient because impacts will propagate over decades and cumulatively add up at the basin scale. (3) Governments, legislative bodies, international funding agencies, and private investors should revise their subsidy programs to consider the true ecological and socioeconomic costs and benefits of SHPs. Most SHPs are not economically viable without subsidies. The costs of dismantling the infrastructure must be included in long-term economic planning.

Stricter environmental policies, large-scale planning, and revised subsidy programs will help mitigate the irreversible adverse consequences for biodiversity and human well-being from SHP development. New SHPs may be warranted if they pass the same environmental controls as large hydropower plants, and if non-dam options are considered or if they are embedded in multifunctional dam systems (eg irrigation, flood protection). But if proposed SHPs do not meet these criteria, then we argue that such plans should be abandoned.

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Salmon, forage fish, and kelp

Kelp beds are prominent features of northeast Pacific coastlines. They are seasonal in nature, as are the communities that use them. Here, juvenile and adult Chinook salmon (*Oncorhynchus tshawytscha*) – key components of northeast Pacific marine food webs that link plankton and forage fishes to endangered killer whales – have just arrived at the coastal kelp beds (left) and are feeding on the large schools of forage fish such as young-of-the-year herring, which are also migrating in great numbers near the shore. Juvenile herring and smelt will soon move offshore to grow and feed, and finally return as adults to spawn along shorelines.

Rapid growth is critical to the survival of young salmon. They quickly learn to work together to herd the small, skittish prey into tight

groups. The kelp beds play an important role for both the salmon and their prey, providing refuge for feeding salmon and enhanced prey resources for hungry forage fish, which in turn feed incessantly at the surface of the kelp beds, except when they are disrupted by lightning-fast attacks by marauding salmon. By October, much of the kelp will be gone, as will the juvenile salmon and forage fish, replaced by their adult congeners (right) that have traveled for years and hundreds of miles to continue the cycle.

Globally, kelp forests are in flux. Disturbances, including those induced by climate change, may have serious implications not only for this critical nearshore phase of salmon and forage fish, but also for the future viability of our cold-water northeast Pacific marine ecosystems.

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