Future rivers, dams and ecocentrism

In this article the authors look at the subject of ecocentrism and future rivers, focusing mainly on the effects of hydroelectric production. Although rivers also have been dammed for irrigation and flood control in addition to hydroelectricity, the production of 'carbon-free' energy has recently been touted as a major solution to climate change. The trade-off between clean energy and the negative impacts of hydropower offers much food for thought for ecocentric theory – how much biodiversity loss are we justified in allowing now, for example, to avert complete ecosystem collapse in the future if we continue to rely on fossil fuel? The authors intend this article to be a starting point for discussion of rivers and ecocentrism in general, and they conclude with some specific suggestions regarding rivers and hydropower.

For as long as we have been human, people have wondered about our relationship with the rest of the natural world. In particular, freshwater rivers and streams have played a pivotal role in the evolution of human culture. Indeed, our relationships with rivers can be said to be older than humanity itself – ancestral species of the genus *Homo* certainly shared the banks of rivers with myriad species before we became *sapiens*. In the early days of human culture, the benevolent river gods brought nourishing floods to the fertile valleys where human culture first began to flourish; if angered, the gods could withhold their flows, causing drought and famine, or unleash their wrath in terrible floods that could wash entire villages into the sea. These same forces, responsible for the ebbs and flows of rivers, have shaped both river landscapes and the diverse forms of life that have evolved to be dependent upon them. The forests and lush vegetation of river corridors provide shelter and sustenance for humans and non-humans alike – great herds need not migrate to mountains to find the source of the life-giving water because the water flows to their downstream pastures. The rivers themselves are corridors for thousands of migratory species that often carry great quantities of nutrients from distant places both up- and downstream. The seeds of future grasslands and forests are carried downstream and deposited on fertile river bends, whilst vast schools of fish migrate upstream to their spawning grounds to begin a new generation. In this drama, human relationships with rivers, therefore, are ancient, complex and multifaceted. Moreover, our own history of co-evolution with rivers is merely a microcosm of the story of how life on Earth has been formed by, and helped to form, the freshwaters that flow across its landscapes.

The ways in which we humans have carried on our relationships with rivers are diverse and have changed dramatically during the course of our history. Early on, we occupied the riverbanks, using complex tools (a hallmark of *Homo sapiens*) to capture fish and collect water for sustenance. Later, simple boats were built to float downstream or paddle upstream to reach new foraging grounds or transport goods and people. Then, we learned to divide portions of the river and divert its waters to sustain our domesticated herds with graze and drink, and eventually to irrigate and cultivate wheat and other plants. It was along the riverbanks then, that settlements were founded. Humans eventually learned that water courses could be altered to bring the water to certain places, not only where it was needed,

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but when it was needed. Aldo Leopold's timeless essay 'Song of the Gavilan' (1949) describes his experience of deer hunting in an old desert riverbed where Native Americans long ago built step dams to control the flow of the life-giving water. In the early days, water wheels harnessed the immense hydropower of rivers and turned the grindstones to make the flour that for thousands of years supplied humanity with the energy necessary for ever larger settlements.

Since the scientific and industrial revolutions, however, our ability to control river flow and harness hydropower has grown exponentially, as has the demand for irrigation and the energy required by the expanding human population. Most of the world's largest river systems have been drastically altered by hydroelectric development, irrigation withdrawals, flood control and pollution (Nilsson *et al.*, 2005). River ecosystems have not escaped the "biological annihilation" that much non-human life has been subjected to (Ceballos *et al.*, 2017). Many river systems have been so degraded that they no longer sustain even a fraction of the life that they once did. Indeed, freshwater biodiversity is among the most threatened on the planet (Vörösmarty *et al.*, 2010; Winemiller *et al.*, 2016). Those free-flowing and unpolluted rivers that remain are under increasing threat of development, and the human relationship with rivers is becoming even more one-sided. Continued human population growth and increasingly rampant consumerism, as well as further dam development for industrial irrigation and hydroelectric offsets to reduce carbon emissions, all bode ill for the future health of river ecosystems. How shall we think and act in an ethical and sustaining manner towards future rivers? How should we reconcile the ever-increasing human demand for freshwater and clean energy with the intrinsic health of river ecosystems?

Ecocentrism can be broadly defined as a worldview that acknowledges the inherent values and rights of both human and non-human life and the ecosystems of which we are a part (Washington *et al.*, 2017a, 2017b). In the rest of this article we begin to address the issue of rivers and ecocentrism, perhaps raising more questions than we answer. We take a broad-brush approach in outlining both human and non-human relationships with rivers, focusing on the issue of hydropower dams. We use one simple example of a salmon–human system in Sweden because we currently conduct ecological research there. Our intention is to open a discussion about rivers and ecocentrism, with the hope that we and others can use this as a platform for a meaningful path forward.

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Freshwater – essential for life on Earth but limited and growing scarcer

Freshwater is vital for most life. Owing to the physical laws of nature, it moves across the surface of the Earth in rivers, streams, brooks and creeks. For the majority of terrestrial organisms, access to freshwater limits their existence more than any other factor; without access to freshwater, most terrestrial organisms quickly perish. Human culture, too, is born of freshwater. Evidence for most early human civilizations is found along watercourses. The Tigris–Euphrates River Valley (now under threat of hydropower development) is known as the cradle of civilization, and great cities ancient and modern – including Babylon, Cairo, Rome, Xi'an, London, Paris, New York and Seoul – are all founded on the banks of rivers. Indeed, it might be said that rivers are as vital for human culture as they are for terrestrial life; the agricultural revolution, which primed us for the cultural and scientific revolutions that followed, was made possible by domesticating grains (Harari, 2014). This could only have been accomplished through delivery of freshwater to stationary settlements. Yet, despite our utter dependence upon freshwater for both our past and our future, no other biota is more imperilled by human activity than that of the Earth's freshwater habitats (Dudgeon *et al.*, 2006).

Ecocentrism and salmon streams

I (JP) am standing waist-deep in the rushing water of a river in middle Sweden, looking down at several landlocked salmon or trout fingerlings engaged in their characteristic 'drift-feeding' behaviour. They hold themselves in place in the river by swimming at the same speed as the current, and they capture small invertebrates that drift past. The best feeding positions, where fish can obtain the most energy and grow fastest, are highly contested. The ancestors of these landlocked salmon and trout have been foraging in these same places since the glaciers receded from Sweden some 10,000 years ago, but salmon very much as we know them today have been shaped by (and have shaped) rivers for at least the past 20 million years (Behnke, 2002). Most of the 100 or so extant species of salmonids worldwide spend significant parts of their lives in rivers; their relationship with flowing water is many million of years older than is ours – yet in the past few hundred years we have driven countless populations of salmon to extinction, and those that remain are often at less than 10% of their historic abundance. Biologists in Sweden, in fact, were among the first to publish studies on drift-feeding ecology (Nilsson, 1957; Kalleberg, 1958); they were also among the first to understand the eco-evolutionary processes that have resulted in river-specific, locally adapted salmon species. Thus, they preserved many unique, river-specific populations when Sweden underwent intensive hydroelectric power development in the 20th century. Although far from ideal, this preservation at least means that there are many remnant salmon populations which can be reintroduced to rivers as they are restored.

Today there are very few undammed rivers remaining in Sweden. The parents of the fish I am watching were wild salmon or trout who returned to the river six or seven years after they were hatched. For the past 50–100 years, many of their kind have met with an impassable concrete migration barrier, typically only a few kilometres from the river mouth – a locally important hydroelectric dam. That the fish have continued to survive is a testimony to their resilience, combined with the hard work of two generations of local biologists. From an ecocentric perspective these fish have a right to their future existence; it would appear most of the local biologists, managers and citizens agree – salmon fishing has been prohibited here for a long time, and restoration efforts have continued to expand. Across the country, a growing number of people aim to protect and enhance their local migratory fish populations through fish passage and even dam removal. At the same time, however, human demand for hydroelectric power and freshwater continues to rise.

Sweden enjoys one of the world's highest standards of living, gender equality, democracy and social care. It also gets approximately half of its electricity from hydropower, with the result that it now has just a handful of free-flowing rivers remaining. Although progress has been made in understanding the effects of hydropower on salmon, the effects on most other riverine species are almost unknown (Calles and Greenberg, 2009). We are proud to live in a country that is among the first to declare its intention to become fossil fuel-free within one generation. But the road to river restoration in Sweden will be long and winding, and we feel a great sense of loss for river ecosystems. Much of what has been lost is unknown and may never be regained. The lessons learned in Sweden will be valuable for people elsewhere who are grappling to restore rivers, and more so for those that are planning further hydroelectric development.

Difficult decisions for managing freshwater

Ecocentrics, while recognizing intrinsic non-human value, also recognize the pivotal role human action will play in the future of the ecosphere. In the coming century, humanity has to meet at least three daunting challenges: we will need to (1) significantly reduce our ecological footprint, through drastic reduction

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of consumption (particularly in the Global North); (2) openly address and find equitable solutions to the problem of human overpopulation; and (3) end our reliance on fossil fuels. These three challenges are interconnected in a myriad of ways. If in a century we are able to make real progress in setting humanity on a sustainable trajectory, the hope is that some significant portion of biodiversity will remain and ecosystems will not collapse. If it takes much more than a century, the ecosphere as we know it faces a grim future.

Given that it is likely to take many decades to turn the ship around, and that ending the fossil fuel era must be a global goal, existing and future hydropower facilities will continue to serve as significant carbon-free energy sources. In order to achieve global sustainability, therefore, river ecologists will need to reconcile their goal of protecting aquatic biodiversity with humanity's long-term goals. Our advice for achieving such a reconciliation is simple and straightforward, although unlikely to be popular:

1 In those parts of the world that have already been extensively developed for hydropower, work towards a dam-free future by accepting that hydropower is only an *interim* solution to society's long-term sustainability. Start by identifying those dams that are no longer effective and prioritize these for removal. In places where dams cannot yet be removed, continue to develop management solutions such as environmental flows, fish passage solutions, habitat restoration and genetic rescue that can maintain and protect as much biodiversity and ecosystem function as possible.
2 In places with plans for future hydropower development, we should work for international collaboration at multiple scales in society (*e.g.* political and scientific) that could lead to other, less-damaging carbon-neutral forms of energy being developed. There are now many real alternatives to developing centralized hydroelectric grids – with perhaps the most promising including distributed solar and wind (*e.g.* Lopes *et al.*, 2007).
3 Least desirably, where new hydropower facilities are inevitable, we should work to the best of our ability to provide the management guidance and technical assistance that will result in the most ecologically sensitive dam projects possible.

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The current case of Balkan rivers (Wiesner, 2018) provides a very important and timely example. As freshwater scientists and conservationists, we would first and foremost do all we can to support keeping Balkan rivers wild and free-flowing. We realize, however, that the people of the region want livelihoods and that hydropower contributes to a clean-energy future for all. Can Balkan energy demands, compatible with a living Earth, be met by alternative sustainable energy sources while sparing the region from damming these rivers? It seems technically possible, but is the international community prepared to step up support for alternative sustainable future options without hydropower? This will require active cooperation in areas of social and ecological expertise far outside the knowledge of freshwater scientists, along with the political will to make it happen. We sincerely hope this can be realized, but in the worst case (and these words are difficult to write) – that of a decision to develop a new hydropower dam – freshwater scientists must be prepared to offer technical expertise to maintain as much biodiversity and ecosystem function as possible while awaiting future removal of such projects. As Weisner (2018) writes, it seems absurd that millions of euros are being spent on river restoration in the rest of Europe while thousands of dams are being planned in the Balkans.

Ecocentrism is multi-scalar in both time and space. Freshwater ecologists will need to think both locally and globally, both short- and long-term, in assessing their approach to future rivers. Ensuring a fossil fuel-free future will go a long way towards

the long-term flourishing of the ecosphere; without global solutions to climate change, short-term and local gains will be meaningless in the long run. Conversely, increased hydropower development will continue the degradation of freshwater ecosystems, already among the most imperilled on the planet. Ecocentric river ecologists will need to persevere in thinking globally and acting locally, and work tirelessly and creatively to balance present and future concerns for Earth. ■

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