The endangered phenomenon of animal migration, and the dissonance between doing science and achieving conservation

For conservation to succeed across broad scales, more than science and more vocal scientists are needed. The public must be motivated and attendant concerns rendered into policy actions. Despite burgeoning data sets coupled with substantive concerns about the persistence of land, water, and aerial migrations, sadly not enough is being done to sustain Earth's animal migrations. Among an array of bold tactics that will help are these: Universities, among other educational institutions, need to restructure their internal reward systems so that faculty can be incentivized for biodiversity activities to benefit ecological health. And, regardless of age or background, spokespersons from all walks of life must emerge and defend migration as an intrinsic and important component of biodiversity and its conversation.

If all the people of this country were assembled and a rising vote taken on the question – Are our birds and mammals worth preserving? – we believe every man, woman, and child would stand up to be counted. (Source given in main body)

We've all probably asked why a conservationist should remain optimistic with the world's population growing toward 8 billion and beyond. Indeed, any wistful dreams I may have had were shattered by the numbers presented in the recent *Global Assessment Report on Biodiversity and Ecosystem Services* (IPBES, 2019): 1 million species threatened with extinction and greater than three-quarters of the planet's terrestrial habitat in serious trouble. Exacerbating the loss of biodiversity and habitat is the deterioration of ecological *processual* phenomena, and among the most greatly threatened are long-distance migrations (LDMs) – defined, most elementarily, as the seasonal movement to and from a given area. Already, many aerial, marine and terrestrial migrations have collapsed (Harris *et al.*, 2009; Berger *et al.*, 2014). Yet, a bewildering and impressive array of migrations still continue and inspire:

- red knots (*Calidris canutus*) – roughly 15,000 kilometres in travel between Patagonia and the Arctic (Wilcove and Wikelski, 2008);
- Antarctic krill (*Euphausia superba*) – oceanic ascents and descents of 40-plus metres (Tarling and Johnson, 2006);
- Atlantic horseshoe crabs (*Limulus polyphemus*) – from shoreline to at least 100 kilometres beyond (Swan, 2005).

For large-bodied terrestrial animals, the situation differs and the conservation of LDMs represents a massive challenge because substantive amounts of unfettered space are required; already most African elephant (*Loxodonta africana*), plains zebra (*Equus quagga*) and wildebeest (*Connochaetes* spp.) LDMs are lost. Others, like those for wood bison (*Bison bison athabascae*) expand in Alaska's and Yukon's northern boreal realms; however, in Mexico, the US and Canada, plains bison (*B. bison bison*) LDMs were gone nearly 150 years ago (Sanderson *et al.*, 2008).

What's an optimist to do?

What's an optimist to do? Wear thick skin and change hats. Communicate broadly and simply about animals and their behaviours, including LDMs. It is not that the science banner *per se* should be ignored or dismissed. When I give public talks – unlike presentations to

Joel Berger

About the author

Joel is the Barbara Cox Anthony Chair of Wildlife Conservation at Colorado State University, Fort Collins, CO, USA, and a Senior Scientist of the Bronx-based Wildlife Conservation Society, NY, USA.

Citation

Berger J (2019) The endangered phenomenon of animal migration, and the dissonance between doing science and achieving conservation. *The Ecological Citizen* **3**(Suppl A): 79–85.

Keywords

Biodiversity; conservation; conservation movement

professional audiences or government or appointed officials – I do not tout the data on the spectacular journeys of Monarch butterflies (*Danaus plexippus*), reindeer (*Rangifer tarandus*), Arctic terns (*Sterna paradisaea*) or humpback whales (*Megaptera novaeangliae*). I do not discuss scientific details of salmon (*Salmo* spp.) or sturgeon (27 species within Acipenseridae) or mention ecological function or intrinsic value. I talk not about millions of migrating individuals, young or old, or about tenacious journeys across hostile environments. I make no mention that such phenomena have repeated for thousands of generations, across millions of years, subject to evolutionary and ecological pressures. Instead, I simply ask a few members of the general audience to raise their hands. I ask each to tell the group about their favourite migratory animals. I ask what actions will be required to sustain their migrations in an increasingly human-dominated world. I ask these questions whether the audiences are indigenous or not, hunter or vegetarian, poor or rich, English speaker or other. And, they answer with examples including *x*, *y* and *z* animal species. They are drawn into the conversation; it is clear that they care.

People indeed adore nature and wildlife. Support for this love affair is evident from a simple metric – attendance at cherished pastimes. Annual visitation to US national parks or zoos, for example, singularly exceeds that of the combined number of attendees to professional American baseball, football and basketball games (Berger *et al.*, 2014). It's easy therefore to imagine that the italicized quote that introduced this articles was written today. It was not. The quote derives from a 1901 New York Zoological Society (now, the Wildlife Conservation Society) report in which the ethics of wildlife conservation were becoming institutionalized (Hornaday, 1901).

Fortunately, across the nearly 120 years that have now elapsed, biodiversity is being valued at levels from genes to ecological processes. At least two countries – Namibia and Bhutan – have the word 'biodiversity' in their founding legislation, and phenomena such as migrations are often showcased by ecologists for their sea- and land-shaping properties, which include nutrient transport and cycling, regardless of whether the animals are fish, terrestrial mammal or aerial aficionado (Bauer and Hoye, 2014). The Convention on Migratory Species – instituted 40 years ago under the auspices of the United Nations Environmental Program – and the Neotropical Migratory Bird Conservation Act of 2000 underscore demonstrable progress.

"In 2016, 2018 and 2019, US Senator Tom Udall (New Mexico) and Representative Don Beyer (Virginia) have proposed a Wildlife Corridors Conservation Act to Congress. If the bill is successful, a protected network would be created to sustain biodiversity at different scales."

Baby steps and not giving up

Optimism and public engagement aside, progress on the protection of LDMs is painfully sluggish, or more likely stifled, when scientists refuse to move beyond their data-shields to mobilize support for a biodiverse and healthy environment. At the plenary lecture of the 2011 North American meetings of the Society of Conservation Biology (SCB) in Oakland, California, Michael Soulé – the *de facto* founding father of SCB – was interviewed by journalist and writer Mary Ellen Hannibal (Hannibal, 2011). When asked about successes for protection of corridors and migratory pathways, Soulé acknowledged with chagrin only one formal case of federal protection, in the USA, dating to 2008: *Path of the Pronghorn*, a 70-kilometre-long and 2-kilometre-wide strip leading south from Grant Teton National Park in Wyoming (Berger and Cain, 2014). More than a decade later, no others have been added.

Staying with the American context, the failed efforts to safeguard some of its great land migrations have not resulted from a lack of cumulative effort (Aycrigg *et al.*, 2016). In 2016, 2018 and 2019, US Senator Tom Udall (New Mexico) and Representative Don Beyer (Virginia) have proposed a Wildlife Corridors Conservation Act to Congress. If the bill is successful, a protected network would be created to sustain biodiversity at different scales. A Yellowstone to Yukon model (Chester *et al.*,

Figure 1. Pronghorn movements in mass helped motivate public interest in migration in the US.

2012) might be envisioned that includes diverse habitats and protected areas to bolster connectivity across thousands of kilometres in a mosaic with humans; specific pathways are envisaged to assure finer-grained animal and plant movements between important habitats. The bill provisions for enhanced interagency cooperation (Udall, 2019). Principles from the proposed corridor act follow components of the unanimously passed 2007 resolution of the Western Governors' Association led by Dave Freudenthal, then Governor of Wyoming. This promised to "protect wildlife migration corridors and crucial wildlife habitat in the West." My colleagues and I had met previously with the governor to seek advice and to offer our data-based insights. He indicated support for our concept of statutory protection but only if his constituents, the Wyoming citizenry, favoured it. Freudenthal was right, I feel, to back such ideology, which was, and remains, immensely polarized by bipartisanship (as it was during 2007–08 with George W Bush and Dick Cheney in the White House).

It was not the science that created the victory for federal protection of *Path of the Pronghorn* during this acrimonious period (Berger and Cain, 2014), though this was of course required for identification of a corridor through which the animals move, one they have used for nearly 6000 years (Berger, 2004; Berger *et al.*, 2006). *Path of the Pronghorn* became a reality by petition and by vote, and by advocates for science and for people who donned thick skin and wore many hats. Success came from engaging the public with simple messages, sharing a beer or coffee with strangers, attending untold meetings in administrative offices, pitching ideas, taking risks with the people who can implement change, and accepting many insults for meddling. Indeed, beyond the science lies the real work in achieving conservation goals (see Figures 1 and 2).

A decade after this first federally protected corridor, the phenomenon of migration has arrived into the public lexicon. Migration is discussed broadly and in local municipalities; the *New York Times* and *Washington Post* – even the *Salt*

Lake Tribune – carry stories. As recently as ten years ago, when I asked state management agencies about their most endangered migrations, eyes dimmed. There was little recognition. Because of the work of many practitioners and non-profit organizations (*e.g.* the Yellowstone to Yukon Conservation Initiative), this has changed. States have wildlife action plans, many including migrations. Practical solutions will always be complex and fraught with controversy because, in the times we still live in, land cannot simply be tucked away for animals at the exclusion of humans.

> "Conservation failures derive in part because of academic timidity to engage at levels required to bring forth policy change."

To further facilitate our conservation goals, I will make two general points about LDMs. First, we need clarity in the words we use. The concepts of 'connectivity', 'corridors' and 'crossings' frequently blur when reported under the migration umbrella and popularized in social media, digital communications and outreach. This has had an unfortunate effect in political and agency circles when taking up challenges and considering solutions for LDM protection (Beckmann, 2010; Hilty *et al.*, 2012). Second, despite substantive data collection steeped within the ecology of migration, conservation failures derive in part because of academic timidity to engage at levels required to bring forth policy change (compare this with medical professionals engaging with societal health issues). Climate scientist James Hansen, in a different, albeit related, context, called this "scientific reticence" – an unfortunate reluctance on the part of many scientists to speak in a forthright manner about the ecological predicament and become involved in policy and activist struggles (Hansen, 2016).

Confusion – connectivity, corridors, and crossings

Words such as migration and dispersal carry important process-based meanings; these vary from gene flow to colonization, and from immigration and emigration to movements from birth areas. Table 1 offers provisional

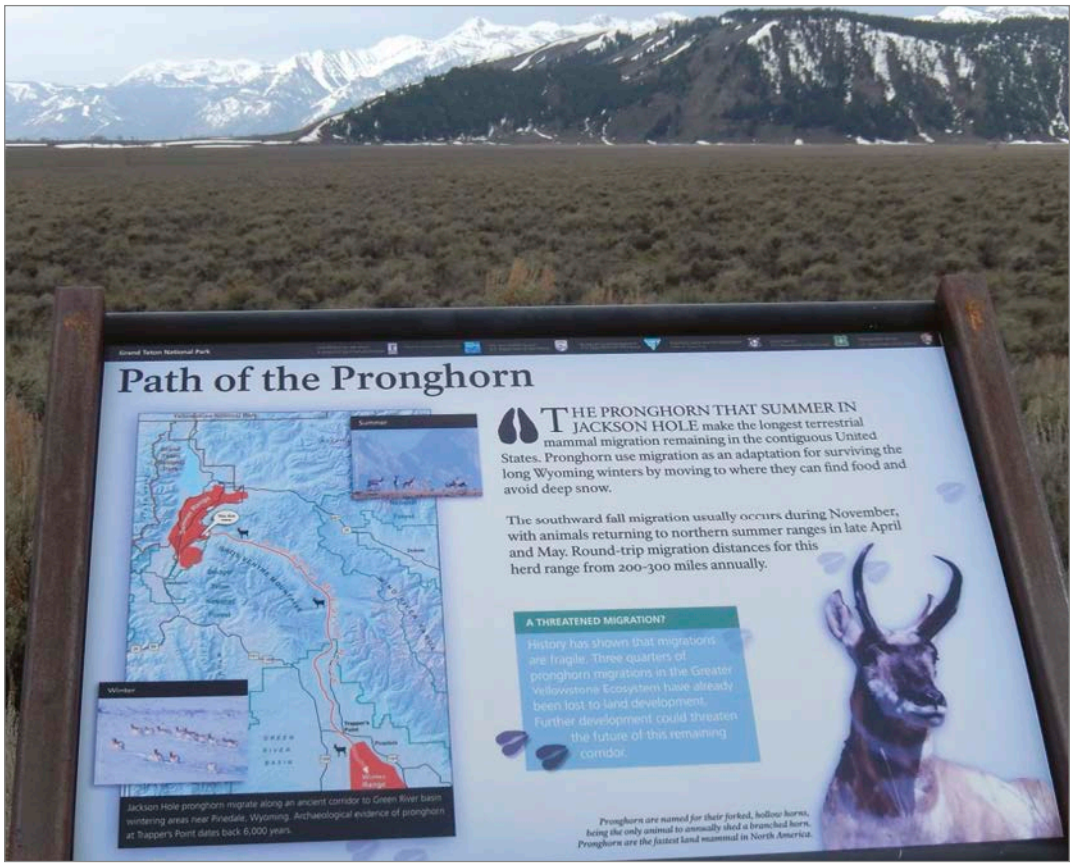

Figure 2. One of several public outreach signs in the US to commemorate migration.

Table 1. Commonly used words in migration literature (used more loosely in media).

Theme	Operational definition	Comment and examples
Migration	A two-way temporal movement involving a shift from one area and then a return to the previous general vicinity	Typically a seasonal phenomenon, but not uniformly true; yellow warblers, rattlesnakes, elk and grey whales[1–4]
Corridor†	A fixed place that links habitats; can be stepping stones or continuously fixed microhabitat locales that pass through unsuitable landscapes	Wetlands as stop-over sites, riparian zones, vineyards and mountain tops[5–7]
Dispersal	Movement away from natal area or philopatric range	Mostly one-way movements in the parlance of behavioural ecology[8]
Connectivity	Offers individual movement between appropriate habitats and links populations to assure gene flow	The term is also used to facilitate access to seasonal habitats[9–11]
Crossing‡	Allows for traversing inimical zones (*e.g.* roads or mountain passes)	Typically human constructs which promote connectivity (*e.g.* under- or overpasses); these mitigate against death by funnelling animals safely past danger zones[5–6]

†The phrase "migration corridor" is sometimes used although not all corridors connote 'migration' though ecological function may be similar. ‡ These are physical sites which may be human or natural constructs where animals pass.

[1]Berger, 2004; [2]Sawyer *et al.*, 2009; [3]Sawyer and Kauffman, 2011; [4]Wilcove, 2010; [5]Hilty *et al.*, 2012; [6]Beckmann, 2010; [7]Beckmann *et al.*, 2012; [8]Pusey, 1987; [9]Berger, 2004; [10]Berger *et al.*, 2006. [11]Berger *et al.*, 2014.

definitions of key terms associated with pathways and migration as commonly accepted in the peer-reviewed scientific literature. Sometimes these meanings mutate and reify when used popularly but conservation messages must be clear and simple. For instance, a concrete bridge that links habitat across a major highway is a *crossing* structure, which might serve as a conduit for migrants; it is not a *migration corridor* although it may be placed in a *corridor*. It may also facilitate *migration* by assuring *connectivity* to enhance gene flow, and in the process reduce road mortality (Table 1). Differing from true migrations are movements of individuals who spread across landscapes nomadically in search of food or mates. Even the 2019 massive swarm of ladybirds (ladybugs) – numbering in the millions, spanning an area of 30 kilometres by 130 kilometres and detected by weather service radar – was clearly an occurrence involving movement but not a migration event (Dobuzinskis, 2019).

Academic timidity

There is no question that science underlies all biodiversity conservation, including the conservation of migrations. An empirically documented understanding of migration has led to substantive gains for aerial, aquatic and terrestrial migrants, resulting in such actions as removal or restriction of impediments (*e.g.* dams, roads and fencing), while bolstering wetland protections and expansion (Berger *et al.*, 2014). Overpasses and underpasses have been constructed – their placement would not have been possible in the absence of data. To cite some American examples, new ones will soon be deployed in California (for deer and cougars), as well as in Nevada, Oregon, Idaho and Wyoming. On Montana's Flathead Reservation, more than 40 crossing structures aid species from fish and amphibians to grizzly bears. Yet, owing to backlash or repercussions for speaking out, numerous scientists remain quiescent in public arenas, even though

the reality is that we must convey simple messages, have those beers and coffees, and meet in untold administrative offices. Such work beyond the science does not compromise scientific objectivity, rigour or calibre.

Understanding biology above all else is no longer the critical tool in a conservationist's toolkit, because challenges are frequently neither biological in nature nor related to data vacuums. There exists a broad portfolio of tactics available to specialists too timid or reluctant to speak directly on behalf of conservation interests. These include writing opinion pieces, blogging, offering services or making presentations to non-specialists, helping non-governmental organizations, developing podcasts and working more with journalists and other media specialists (Wittemyer *et al.*, 2018). Other productive means of engagement include liaising with the Connectivity Conservation Specialist Group (within the IUCN's World Commission on Protected Areas), which aims to shore up support for reducing the rate of habitat fragmentation so that migrations continue. Among other related conservation easement initiatives are the work of the Center for Large Landscape Conservation (https://largelandscapes.org/) and the Freedom to Roam campaign started by outdoor clothing company Patagonia.

Why not these two actions?

While there are no uniformly single best steps to achieve actionable conservation, some bold approaches will help.

- Conservation is about *doing* and not about publishing *per se*. First, then, college- and university-level systems that operate as land-grant institutions (and thus have a mission to serve the public good) must go beyond just rewarding their faculties for the number and quality of peer-reviewed publications and grants. Although such incentive systems have helped make some American universities enviable in many parts of the world, faculty are not incentivized to engage in conservation action, especially when tenure and promotion are at risk. If this cannot change, why would we expect faculty commitment? Fortunately, there are simple solutions. A number of universities have adopted new approaches, including the University of California's faculty-based extension agents (people tasked with applying research findings to practice) focused on biodiversity. A similar approach has been taken by the University of Nevada's College of Agriculture, Biotechnology and Natural Resources. Intrepid reform is required. Modifying tenure policies to recognize practical contributions to conservation achievement is an easy start. Similar considerations apply in other countries.
- Second, we need more Greta Thunbergs to inspire future generations. In this case, it would be to highlight migration as a critical component of biodiversity. Greta, of course, is the sensational Swedish student lauded in 2018 Presidential candidate Bernie Sanders for chastizing world leaders for a lack of leadership on climate change (Newburger, 2018). Conservation scientists cannot achieve the success we would like to see if we rest behind doors touting our science but somehow expecting others to be the spokespeople.

The Wildlife Corridors Conservation Act proposed by Udall and Beyer has relied, in the initial phases, on science. In the end, however, success will come only if, as conservationists, we wear hats that reach beyond our comfort zones and enjoin distant partners. In 1901, Hornaday suggested something along similar lines. Non-governmental organizations, ranchers, farmers, painters, corporations, outdoor recreationists and citizen scientists must care. When people do not have favourite animals, lack ecological champions, shut down in the face of endless scientific debate, are engaged only with statistics or data, fail in their compassion for other species, remain uninspired, or care disproportionately about money, then optimism will fade. Attitudes change with activism (Teel and Manfredo, 2010). ■

"When people do not have favourite animals, lack ecological champions, shut down in the face of endless scientific debate, are engaged only with statistics or data, fail in their compassion for other species, remain uninspired, or care disproportionately about money, then optimism will fade."

Acknowledgements

Work on Path of the Pronghorn was supported by the Wildlife Conservation Society, the Liz Claiborne and Art Ortenberg Foundation and the National Park Service. Steve Cain and Jon Beckmann were critical to facilitating the federal protection, as were Jodi Hilty and Bill Weber, the National Park Service, the U.S. Fish and Wildlife Service, and especially Nicki Hamilton and the U.S. Forest Service. Joanna Lambert, as always she does, helps conservation biologists and people everywhere, and provided comments on this manuscript. Eileen Crist also offered insightful guidance.

References

Aycrigg JL, Groves C, Hilty JA *et al.* (2016) Completing the system: Opportunities and challenges for a national habitat conservation system. *BioScience* **66**: 774–84.

Bauer S and Hoye BJ (2014) Migratory animals couple biodiversity and ecosystem functioning worldwide. *Science* **344**: 1242552

Beckmann JP, ed (2010) *Safe Passages*. Island Press, Washington, DC, USA.

Beckmann JP, Murray K, Seidler RG and Berger J (2012) Human-mediated shifts in animal habitat use: Sequential changes in pronghorn use of a natural gas field in Greater Yellowstone. *Biological Conservation* **147**: 222–33.

Berger J (2004) The longest mile: how to sustain long distance migration in mammals. *Conservation Biology* **18**: 320–32.

Berger J, Cain SL and Berger K (2006) Connecting the dots: an invariant migration corridor links the Holocene to the Present. *Biology Letters* **2**: 528–31.

Berger J, Cain SL, Cheng E *et al.* (2014) Optimism and challenge for science-based conservation of migratory species in and out of US national parks. *Conservation Biology* **28**: 4–12.

Berger J and Cain SL (2014) Moving beyond science to protect a mammalian migration corridor. *Conservation Biology* **28**: 1142–50.

Chester CC, Hilty JA and Francis WL (2012) Yellowstone to Yukon, North America. In: Hilty JA, Chester CC and Cross MS, eds. *Climate and Conservation: Landscape and Seascape Science, Planning, and Action*. Island Press, Washington, DC, USA: 240–52.

Dobuzinskis A (2019) *California ladybug swarm dozens of miles wide shows up on radar* (Reuters). Available at https://is.gd/zzDgFY (accessed July 2019).

Hannibal ME (2011) The slow migration from science to policy: Protecting wildlife corridors is still more theory than practice. *High Country News*, 26 December.

Hansen JE (2016) Dangerous scientific reticence. *Atmospheric Chemistry and Physics* **16**: 3761–812.

Harris G, Thirgood S, Hopcraft JG *et al.* (2009) Global decline in aggregated migrations of large terrestrial mammals. *Endangered Species Research* **7**: 55–76.

Hilty JA, Lidicker WZ Jr and Merenlender AM (2012) *Corridor Ecology: the science and practice of linking landscapes for biodiversity conservation*. Island Press, Washington, DC, USA.

Hornaday WT (1901) The destruction of our birds and mammals. *New York Zoological Society Annual Report* **2**: 77–106.

IPBES (2019) Global Assessment Report on Biodiversity and Ecosystem Services. IPBES Secretariat, Bonn, Germany. Available at https://is.gd/rYo3mq (accessed July 2019).

Newburger E (2018) Teen activist tells leaders they aren't 'mature enough' to take proper action on climate change. *CNBC Make It*, 18 December. Available at https://is.gd/8zuoIF (accessed July 2019).

Pusey AE (1987) Sex-biased dispersal and inbreeding avoidance in birds and mammals. *Trends in Ecology and Evolution* **2**: 295–99.

Sanderson EW, Redford KH, Weber B *et al.* (2008) The ecological future of the North American bison: Conceiving long-term, large-scale conservation of wildlife. *Conservation Biology* **22**: 252–66.

Sawyer H, Kauffman MJ, Nielson RM and Horne JS (2009) Identifying and prioritizing ungulate migration routes for landscape-level conservation. *Ecological Applications* **19**: 2016–25.

Sawyer H and Kauffman MJ (2011) Stopover ecology of a migratory ungulate. *Journal of Animal Ecology* **80**: 1078–87.

Swan BL (2005) Migrations of adult horseshoe crabs, *Limulus polyphemus*, in the Middle Alantic Bight: a 17-year tagging study. *Estuaries* **28**: 28–40.

Tarling GA and Johnson ML (2006) Satiation gives krill that sinking feeling. *Current Biology* **16**: R83–R84.

Teel TL and Manfredo MJ (2010) Understanding the diversity of public interests in wildlife conservation. *Conservation Biology* **24**: 128–39.

Udall T (2019) *S.1499 – Wildlife Corridors Conservation Act of 2019*. Available at https://is.gd/y2gjgN (accessed July 2019).

Wilcove DS (2010) *No Way Home: The decline of the world's great animal migrations*. Island Press, Washington, DC, USA.

Wilcove DS and Wikelski M (2008) Going, going, gone: Is animal migration disappearing? *PLoS Biology* **6**: e188.

Wittemyer G, Berger J, Crooks KR *et al.* (2018). To advocate or not is no longer the question: Paths to enhance scientific engagement. *BioScience* **68**: 13–14.

> "The Wildlife Corridors Conservation Act proposed by Udall and Beyer has relied, in the initial phases, on science. In the end, however, success will come only if, as conservationists, we wear hats that reach beyond our comfort zones and enjoin distant partners."