Connectivity Conservation: an Australian Perspective

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Australia's unique biodiversity

We all know that Australia has a unique biodiversity and distinctive ecosystems. It should come as no surprise therefore to learn that the reasons why we need connectivity conservation in Australia differ from those invoked in other continents.

In North America and Africa, connectivity conservation is often argued as essential for meeting the conservation needs of large predators and migratory herbivores. For large predators such as black bears, landscape connectivity is vital for the conservation of these species in human-modified landscapes, lessening population declines and genetic depression caused by habitat loss and fragmentation[1]. Landscape connectivity is also vital for the health and persistence of the great seasonal migrations of large herbivores such as elk[2].

The evolution and biogeographic history of Australia's biodiversity has taken a different course to that travelled by North America's. Our top terrestrial predator is a dingo not a bear. And we have large mobs of emus rather than elk. While we lack large land predators and migratory herbivores, there are other compelling reasons for connectivity conservation in Australia. Here I consider five reasons that focus on processes operating at a range scales from landscape to continental and which often escape the focus of our conservation efforts[3]:

- Conserving dispersive fauna;
- Maintaining critical micro-habitat networks;
- Hydro-ecological connectivity;
- Facilitating species adaptive response to climate change; and
- Achieving coordinated, multi-scale conservation outcomes

These factors are actually not unique to Australia and are also important to conservation efforts in other continents including North America and Africa.

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[1] M.G. Gantchoff and J.L. Belant Regional connectivity for recolonizing American black bears (*Ursus americanus*) in south central USA (2017) *Biological Conservation* DOI: 10.1016/j.biocon.2017.07.023.

[2] Meredith L. McClure, Andrew J. Hansen and Robert M. Inman (2016) Connecting models to movements: testing connectivity model predictions against empirical migration and dispersal data (2016) *Landscape Ecology* 31(7), 1419–1432.

[3] For further discussion see: B.G. Mackey B.G., M.E. Soulé, H.A. Nix, H.F. Recher, R.G. Lesslie, J.E. Williams, J.C.Z.R. Woinarski, J. Hobbs and H.P. Possingham (2007) Towards a scientific framework for the WildCountry project. In *Key Topics and Perspectives in Landscape Ecology***.** Jianguo Wu and Richard J. Hobbs (eds.). Cambridge University Press, pp. 92-208; M.E. Soulé, B.G. Mackey, H.F. Recher, J.E. Williams, J.C.Z. Woinarski, D. Driscoll, W.C. Dennison and M.E. Jones, M. E. (2006) The Role of Connectivity in Australian Conservation. In *Conservation Connectivity. Conservation Biology 14*. Kevin R. Crooks and M. Sanjayan (eds.) Cambridge University Press, pp. 649-675.

Conserving dispersive fauna

Large scale species movements

Of Australia's 677 land and freshwater birds species, 342 (51%) are migratory, undertaking regular annual migration, less regular more opportunistic (nomadics. eruptives and vagrants) and extensive re-colonization movements. Evidence also points to large scale dispersive movement for 36 (16%) freshwater fish species, 2 (1%) frogs, 5 (0.6%) land and freshwater reptiles, 7 (100%) marine reptiles, 88 (56%) marine birds, 27 (8%) land and freshwater mammals and 28 (50%) marine mammals. As the scale of dispersive fauna movements can often extend far beyond any one jurisdiction or tenure, dispersive fauna have special conservation needs compared with resident species[4].

Connectivity for meta-population dynamics

Species naturally occur in multiple disjunct populations and in many cases these populations are connected through the flow of individuals. This phenomenon is called meta-population dynamics. The broad-toothed rat (*Mastacomys fuscus*) on the Barrington Tops NSW provides a classic example[5]. Researchers found 12 swamps where the broad-toothed persists and 13 where there has been a history of colonization and extinction. The species was found to be entirely absent from seven of these latter swamps. The conservation challenge here is to identify the factors that are limiting dispersal and re-colonization so that the species' decline can be slowed and reversed. Depending on the species, different kinds of barriers arise to the dispersal of individuals between these vital habitat patches such as land clearing in the intervening landscape that exposes them to predators.

Maintaining critical micro-habitat networks

Another striking feature of Australia's ecology is the importance of micro-habitat networks to the persistence of a surprisingly large number of plant and animal species. In Northern Australia, for example, small patches of monsoon rainforests comprising only 0.4% of the land area of Kimberley and the northern half of N.T. provide habitat for 585 plant species. Furthermore, during the long dry monsoonal "summer", these riparian habitats and rainforest patches provide a critical source of water and food for an array of animal species.

The climatic seasonality of Northern Australia, and the year-to-year variability in rainfall over much of the Australian continent in the arid and semi-arid zones, results in massive annual fluctuations in the amount and distribution of resources available for wildlife[6]. Recent evidence indicates that regional persistence of irruptive species, particularly small mammals, during the extensive dry periods of unpredictable length that occur between resource pulses in drylands occurs as a result of the presence of refuge habitats or refuge patches into which populations contract during dry (bust) periods[7]. Networks of micro-habitats are also critical

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[4] S. Gilmore, B. Mackey and S.B. Berry (2007) The extent of dispersive movements in Australian vertebrate animals, possible causes, and some implications for conservation. *Pacific Conservation Biology* **13**, 93-103; P.A. Griffioen and M.F. Clarke (2002) Large-scale bird-movement patterns evident in eastern Australian atlas data. *Emu* 102(1), pp.99–125. Available at: http://www.publish.csiro.au/paper/MU01024.

[5] C.M. O'Brien et al. (2008) Metapopulation dynamics and threatened species management: Why does the broad-toothed rat (Mastacomys fuscus) persist? *Biological Conservation* 141(8), pp.1962–1971.

[6] J.C.Z. Woinarski et al. (2005) Landscapes without boundaries: Wildlife and their environments in northern Australia. *Wildlife Research* 32(5), pp.377–388.

[7] Chris R. Pavey, Jane Addison, Rob Brandle, Chris R. Dickman, Peter J. McDonald, Katherine E. Moseby and Lauren I. Young (2017) The role of refuges in the persistence of Australian dryland mammals. Biol. Rev. 92, 647–664 doi: 10.1111/brv.12247.

throughout our eastern forests and woodlands as drought and fire refugia, including narrow riparian strips along major water[8]. To enable the persistence of many species under these conditions, the entire network of micro-habitats need to be conserved. This presents a challenge to conventional approaches to conservation as these networks can span continental scales, jurisdictions and tenures.

Hydro-ecological connectivity

The basis of the food chain is the new plant biomass produced through photosynthesis, largely by plants. Photosynthesis, it turns out, is thirsty business with plants having to transpire about 20lt of water to produce 1kg of biomass. As the driest continent, characterized by unreliable rainfall and extremes floods and droughts, the distribution and availability of water has been a major selective force in the evolution of Australia's plants and animals and is the key to the biota's ongoing ecology and survival.

We need to be thinking about not just surface water but also ground water and the linkages between them. Water moves constantly between ground waters and surface waters. Most rivers, lakes and wetlands are fed by, and feed groundwater to varying degrees at varying times. Groundwater feeds soil moisture through capillary action and percolation, and many terrestrial vegetation communities depend directly on either groundwater or the percolated soil moisture above the groundwater, for at least part of each year[9].

When ecosystems are allowed to function free from disruptive human activities, the natural vegetation cover reaches a stable equilibrium with their climate and soil environments such that canopy density and species act to minimize water stress. The diversity of species within natural vegetation cover allows for many possible ecological strategies by which this can be achieved and that enable individual plants or species to persist at a site[10].

Recognizing the linkages between the stocks and flows of water and how these sustain wildlife and their habitats is therefore one of the most fundamentally important reasons for connectivity conservation in Australia.

Facilitating species adaptive responses to climate change

Climate change *per se* is a natural phenomenon as illustrated by the major changes in climate during repeated glacial cycles and through the massive climatic changes that occurred during the Miocene and Pliocene and evidenced from multiple palaeo-sources[11]. How is it that all the native species extant when Europeans first occupied the continent 230 years ago were able to persist through such dramatic swings in temperature, CO_2 concentration and wetness? This can be explained by five adaptive strategies[12]: (1) *micro-evolution* of new traits; (2) *phenotypic plasticity* arising from the genetic diversity found within a species' populations; (3) *dispersal* to a new location that has the required climate and habitat resources; (4) *refugia and range reductions*

[8] B. Mackey, S. Berry, S. Hugh, S. Ferrier, T. Harwood and K. Williams (2012) Ecosystem greenspots: identifying potential drought, fire and climate change micro-refuges. *Ecological Applications* 22, 1852–1864.

[9] J.C. Nevill, P. J. Hancock, B. R. Murray, W. F. Ponder, W. F. Humphreys, M. L. Phillips and P. K. Groom (2010) Groundwater-dependent ecosystems and the dangers of groundwater overdraft: a review and an Australian perspective. *Pacific Conservation Biology* 16, 187–208.

[10] P.S. Eagleson(1982) Ecological optimality in water-limited natural soil-vegetation systems 1.Theory and hypothesis. Water Resour. Res. 18, 325-340.

[11] G.S. Hope (1994) Quaternary Vegetation. Pp 368-389 in R. Hill (Ed.), History of Australian Vegetation. Cretaceous to Recent. Cambridge University Press, Cambridge; J.R. Petit et al. (1999) Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. *Nature* 399: 429-436

[12] B. Mackey, J.E.M. Watson and G.S. Hope (2008) Climate change, biodiversity conservation, and the role of protected areas: an Australian perspective. *Biodiversity* **9**, 11-18.

whereby species “retreat”, or their distributions are reduced, to stable micro-habitats that retain the required environmental conditions; and (5) *wide fundamental niche* whereby a species has evolved such that it can persist under a wide range of conditions.

The current climate emergency is of course different to our historic and palaeo experiences as it is driven by human perturbation of the global climate system through the greenhouse gas emissions - especially CO_2 - emitted from burning fossil fuel for energy and deforestation and degradation. Given the projected impacts of a rapidly changing climate, and the fact that the Earth climate system will be disrupted for millennia irrespective of our mitigation efforts[13], adapting to climate change must become central to our conservation planning efforts.

Connectivity conservation provides a much-needed focus on protecting and restoring those natural processes and responses that have enabled species to persist through past climate change and that will be needed to support the adaptations required to survive the rapid climate change impacts for this century and beyond.

Achieving coordinated, multi-scale conservation outcomes

A corollary arising from the reasons stated here for the importance of connectivity conservation to Australia’s biodiversity is that critical habitat and natural processes span *multiple scales* (continental, regional, landscape), *jurisdiction*s (states, territories and local governments) and *tenures* (private, leasehold, indigenous, crown). To achieve conservation outcomes therefore requires co-operation among a diverse array of land owners, managers, stewards and custodians. Connecting people and organizations is therefore critical to the realization of connectivity conservation thinking. Connectivity planning provides a strategic framework for guiding how a community’s land care actions and the protection and restoration of their local ecological assets can contribute to big picture conservation goals. It can help promote collaborative conservation efforts and outcomes among partner organizations that are more joined-up, cost effective and enduring.

It follows that connectivity conservation benefits from establishing networks of organizations focused on achieving conservation outcomes across extensive geographies and providing the capacity, tools and knowledge to more effectively collaborate around a shared vision and common strategic goals. One example is The Great Eastern Ranges Initiative (GER) that is bringing people and organizations together to protect, link and restore healthy habitats over 3,600 km from Western Victoria through NSW and ACT to Far North Queensland. GER is a strategic response to mitigate the potential impacts of climate change, invasive species, land clearing, and other environmental changes, on what are richly bio-diverse and iconic landscapes.

Concluding comments

Australia’s biodiversity face many challenges to their persistence and ecological viability including the urgent need to address the threats from feral cats and foxes, as well as changed fire regimes and introduced herbivores, which have caused many species extinctions and remain a serious threat to Australia’s vertebrate species, especially mammals[14]. In addition,

[13] D. Archer and V. Brovkin (2008) The millennial atmospheric lifetime of anthropogenic CO_2. *Climatic Change* 90, 283–297.

[14] See *Threatened Species Recovery Hub*, *Project: 1.1 Impacts and management options for introduced predator*. Project Leaders: Sarah Legge, John Woinarski; http://www.nespthreatenedspecies.edu.au/projects/developing-evidence-based-management-tools-and-protocols-to-reduce-impacts-of-introduced-predators-o

we need to give full consideration to those large scale natural processes that sustain vital habitat resources, manage for multi-scale dispersals including "species on the move", connect and buffer networks of micro-habitats wherever they occur and better coordinate conservation outcomes across land tenures. Herein lie our best chances for maintaining Australia's biological diversity and promoting its ecological resilience and adaptive capacity in the coming decades.