Wildlife Corridors in Biodiversity: Boon or Bane

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Abstract:
Many large-scale connectivity initiatives have been proposed around the world with the aim of maintaining or restoring connectivity to offset the impacts on biodiversity of habitat loss and fragmentation. Wildlife corridors are one such example, constituting one of a number of increasingly influential strategic nature conservation tools deployed in urban green space planning. These corridors are frequently vegetation-based habitats that ease movement, while offering less risk of predation compared to when travelling through open lands. Habitat loss and fragmentation are the two main backers to enduring biodiversity decline across the landscape. Wildlife corridors allow an exchange of individuals between populations, which may help prevent the negative effects of inbreeding and reduced genetic diversity that often occur within isolated populations. An essential tool for wildlife conservation is the wildlife corridors, used by various species to migrate, breed and feed. The ability of a species to successfully use a corridor is dependent in part upon the width and length of the corridor. Wider corridors provide greater diversity; have less impact from adjoining land uses, adjoining edge effects like weeds and provide habitat in their own right. Corridors also facilitate the restoration of population that have been reduced or excluded due to random events such as fires and diseases. Wildlife corridors permit acceleration in gene flow between small and fragmented wild populations which is important for sustaining biodiversity through the conservation of potentially at-risk local populations in the wild and has accepted to significantly improve species richness (Kiffner et al.,2014).

Keywords: *Wildlife corridors, restoring connectivity, urban green space, habitat loss and fragmentation, gene flow, sustaining biodiversity, species richness*

1. Introduction

Ecological connectivity provides the capacity for the movement of organisms, gene flow, and range shifts thereby a key factor in the long-term viability of populations, particularly for wild species. In human dominated landscapes, loss and altered configuration of habitats have substantially modified and decreased connectivity resulting isolation limits the ability of populations to respond adequately to perturbations. The ecosystem of world is inter-connected. This is somewhat that ecologists have learned when studying the species trying to protect; It's not good adequate to create protected habitats that are isolated, like islands enclosed by roads, fences, farmlands, cities, etc. That's not how most species have evolved. Their habitats need to be connected to others via wildlife corridors to truly flourish life and be healthy enough to survive in the long-term. Wildlife corridors, used by various species to migrate, breed and feed, are increasingly becoming relevant as essential tools for wildlife conservation. Rapid increase in industrial and infrastructural development, especially around forests, has resulted in widespread habitat fragmentation and isolation.

The main goal of applying habitat corridors is to increase biodiversity (Aars and Ims 1999, Bennett 1999). Corridors can contribute to three factors that stabilize a population:

1. **Colonization** animals are able to move and occupy new areas when food sources or other natural resources are lacking in their core habitat.

2. **Migration** species that relocate seasonally can do so more safely and effectively when it does not interfere with human development barriers.
3. **Interbreeding** animals can find new mates in neighbouring regions so that genetic diversity can increase and thus have a positive impact on the overall population.

2. Role of Wildlife Corridors

The potential utility of corridors in maintaining species number within nature reserves has been recognized by ecologists for quite some time as well as has theoretical basis in the equilibrium theory of island biogeography which states that the number of species on an isolate represents a dynamic equilibrium between rates of immigration to and extinction on an isolate. Corridors should increase the rate of immigration and thus increase species number within a reserve by permitting species that have become extinct to recolonize the reserve. In addition, corridors should permit individuals to supplement resident reserve populations; thereby reduce the likelihood of local extinction of these populations. Furthermore, wildlife corridors can increase the effective size of the reserve and thus lower the probability of extinction of individual populations by providing additional feeding and breeding habitat as well as cover.

4. Types of wildlife corridors

There are various diverse types of wildlife corridors together with naturally occurring corridors and man-made corridors. In areas where human populations are dense, there are frequently physical barricades for migration and dispersion of wild populations (Dondina et al., 2014). For this reason, man-made corridors are often constructed to make a safe passageway that eases migration of wild species, whereas dropping the potential human-wildlife conflicts that can ascend in areas where the natural environment meets urbanized areas.

Types of corridors	Description
Natural corridors	Wildlife Corridors can naturally occur by means of already existing geographic features such as mountain ranges. An example of mountain ranges that functions as a corridor would be the Terai Arc Landscape. This natural corridor stretches over 900 km in length and an area of over 51,000 km from Nepal's Bagmati River right across the country to the Yamuna River in India. Riparian zones are also a great example of a naturally occurring corridor for wildlife.
Man-made corridors	Corridors that have been purposefully created by humans to support biodiversity are often overpasses or underpasses for roads and large highways that have created habitat fragmentation upon their construction. Other man-made corridors are often hedgerows found in rural pastures environments and domestic gardens, acting as land margins. The main purpose of man-made corridors is to ease movement of wild populations that have experienced habitat fragmentation due to human activities such as urbanization and infrastructure. A noble illustration of a man-made corridor would be the overpass created in Banff National Park located in Alberta, Canada. The overpass allows for the migration of wildlife within the park as the construction of large motorways has divided natural habitats and wild populations. The success of these man-made corridors can be monitored by the use of camera traps.

Regional corridors	Regional corridors are crucial landscape links between larger important areas of habitat. They are generally considerable in width (> 500m) and provide not only for dispersal of individual species but act as habitat in their own right for a range of species. Regional corridors typically connect along major ecological gradients such as altitudinal and/or latitudinal migratory pathways (e.g. coast to hinterland and tablelands corridors).
Sub-regional corridors	Sub-regional corridors should be wide enough to provide landscape connections for species movement and dispersal (generally > 300m). Sub-regional corridors may not be large enough to provide substantial species habitat. Sub-regional corridors typically connect larger vegetated landscape features such as ridgelines and valley floors.
Local corridors	Local corridors are a significant component of an overall regional landscape conservation agenda. Local corridors are smaller, less defined linkages that provide local connection of remnant patches of vegetation and landscape features such as creek lines, gullies, wetlands and ridgelines. They may in some cases be less than 50m in width and as such may be influenced by edge effects.

Elephant using a riparian zone as a corridor in the Terai Arc Landscape in Nepal (www.twisteredsifter.com)

5. Arguments for Corridors / In Favor of Corridors

1. Enhanced immigration, which would enhance gene flow, increase genetic diversity, allow re-colonization of extinct patches, and enhance overall meta population survival in connected patches.
2. Preservation of ecological process through connectivity.
3. The opportunity for some species to avoid predation.
4. Accommodation of range shifts due to climate change.
5. Provision of a fire escape function.

6. Arguments Against Corridors

1. Scarcity of data on corridor use and lack of sufficient controls in corridor field studies.
2. Scarcity of data on significance of loss of genetic variation due to inbreeding and in small populations. 3. Habitat incompatibility of corridors (i.e. riparian corridors will not serve as a conduit for non-riparian species).
3. High rates of poaching or trapping in corridors.
4. Increased acquaintance to domestic animals harboring disease.

5. Opportunities for the spread of catastrophes (predators, fire, and disease) may be provided through corridors.
6. Entry routes, paths, and reservoirs for weedy or exotic species may potentially be provided by corridors.
7. Corridors may function as genetic traps or sinks.

7. Legal Frameworks for Wildlife Corridors Protection and Management

Corridors, in the larger space of ecological conservation, occupy a unique space. Their role and vitality in species conservation is well documented, but their definition is a source of constant confusion. Though, although the instantaneous and rising threats of climate change and other anthropogenic burdens on natural habitats, a wildlife corridor has yet to be dignified as a legal tool for ecological conservation in India or, indeed, elsewhere in the world.

8. International Laws

The major international instruments relevant to biodiversity conservation – the Convention on Biological Diversity, 1992 ('CBD') the Convention on Wetlands of International Importance, 1971 ('Ramsar Convention'); the Convention on the Conservation of Migratory Species, 1979 ('Bonn Convention') or the World Heritage Convention, 1972 – expressly refer to wildlife corridors.

Since legal provisions have the ability to be appropriately permitting without referring to the exact term – Article 8(a) of the CBD, for example, encourages the development of 'a system of protected areas', and 8(d) the 'protection of ecosystems, natural habitats and to up keep viable populations of species in natural surroundings'. Article 10 of the European Council Directive 92/43/EEC ('the Habitats Directive') provides for the conservation of corridors without actually referring to the term (Wilson et al., 2014). These measures include, by necessary implication, the development and conservation of corridors, in signatory countries where habitats have become fragmented as a result of anthropogenic pressures (which is true for almost every country today).

9. European Law

The Bern Convention on the Conservation of European Wildlife and Natural Habitats, 1979 ('Bern Convention') obliges its parties to take all measures needed for the conservation of the natural habitats of wild flora and fauna species. It is, more required in its instructions than the CBD, by specifically commanding the responsibility to take 'necessary legal and administrative measures' in furtherance of its goals.

10. American Law

Observing the legal frameworks for corridor protection and habitat connectivity in national perspectives afford a better perspective to the interplay of politics and economics that are imitated in legal conservational consequences. In the United States, federal statutes such as the Endangered Species Act ('ESA'), the Migratory Bird Treaty Act ('MBTA') and the Marine Mammal Protection Act ('MMPA') all exist for the protection of migratory species and thus also corridors, but they have their limitations. The MBTA and MMPA, exist for the advantage of specific animals- there is a lack of an integrated framework for the conservation of migratory species and corridors.

11. Indian Law

The National Tiger Conservation Authority (NTCA), constituted under the Wildlife (Protection) Act, 1972 (amendment 2006), defines wildlife corridors as inherent geographical linkages (through forests, river courses or other habitat attributes) which facilitate movement of tigers and often occur over long periods. Protecting ecological processes through managing for ecological connectivity in the immediate term can offer the best opportunity for evolution other wild animals from one source area to another. According to the MoEF Guidelines, a corridor can be included in the Eco-sensitive zone.

Section 4.2 of the guideline's states, "In case where sensitive corridors, connectivity, and ecologically important patches, crucial for landscape linkages, are even beyond 10 KM width, these should be included in the Eco-Sensitive Zone." As per the guidelines, a primary step towards the notification of ESZs is to make an inventory of the diverse land use patterns and the different types of activities, types and number of industries working around each of the PAs as well as important corridors.

12. Wildlife corridors of Uttar Pradesh

The Tarai Arc Landscape (TAL) in India shelters an area of approximately 30,000 sq. km across the states of Uttaranchal, Uttar Pradesh and Bihar. The area within TAL that is covered by forests is roughly 15,000 sq. km. TAL lies between the Mahakali (Sharda) River in the west and the Bagmati River in the east, and contains four forest management categories: protected areas, reserve forest, protected forest (corridors) and community-managed forests. There are 14 protected areas in TAL which covers the links the all corridors between India and Nepal. In Nepal, Parsa Wildlife Reserve, Chitwan National Park, Banke National Park, Bardia National Park and Shuklaphanta Wildlife Reserve sustain tiger populations. In India, Dudhwa National Park, Pilibhit Tiger Reserve (formerly Forest Division), Kishanpur Wildlife Sanctuary (WLS), Katerniaghat Wildlife Sanctuary, Valmiki Tiger Reserve, and Nandhaur Wildlife Sanctuary hold resident tiger populations. Other sites such as Suhelwa and Sohagibarua WLSs appear to have sporadic tiger occurrence.

Forests in Uttar Pradesh comprise remote and disintegrated green patches. The state is also observing a growing conflict of humans with tigers, leopards, elephants and, at times, rhinos. In such a case, wildlife corridors would function as buffering zones to dense forest areas rich in wildlife and help animals move from one patch to another with minimum or no interference. The **smallest corridor** of 2km would lie in Pilibhit while the **longest**, of 25km, would be between North Kheri, Pilibhit and Dudhwa. The one lying between Dudhwa and Katarniaghat would be a considerable 16 km long. The others would vary in distance between 2km and 25km.

1. **Bardia-Katerniaghat (Khata Corridor)**
   Khata corridor, connecting Bardia National Park in Nepal with Katerniaghat Sanctuary in UP, is a trans-boundary initiative that has boosted wildlife conservation with the help of local communities.It has an outstanding assemblage of endangered wildlife such as Asian elephant, one-horned rhino, Bengal tiger, river dolphin and endemic birds.
2. **Shuklaphanta-Pilibhit (Lagga-bagga Tatarganj Corridor)**
   The Lagga-Bagga Forest Block, in particular, supports populations of swamp deer, migratory rhinos from Nepal's Suklaphanta Reserve and rare hispid hare. There are some areas subjected to illegal grazing in this division. People from far and wide maintain Gauris (cattle camps) inside the forests. A huge reservoir, of many sq. km in extent called the Sharda Sager has engulfed many prime habitats in the distant past and now the ever-growing human population around it is posing further threats to wildlife and habitats. It is connected with two tiger reserves in India: Pilibhit and Dudhwa in the south via narrow links of Churia forests and the Laljhadi and Basanta corridors; and the eastern part of Indian Terai Arc Landscape across Mahakali River through the Brahmadev corridor.
3. **Basanta Corridors**
   Basanta forest is 17,500 hectares and serves as asignificant wildlife corridor connecting Churia hills in north and Dudhwa National Park of India in south (Fig.13). The area with rich biodiversity resources is a dispersal habitat of endangered wildlife species, like tiger, rhinoceros, and wild elephants. Besides, Ghodaghodi Lake, a Ramsar Site of Nepal is also situated adjacent to Basanta Corridor. Dolphins and 43 species of fish species are available in various river systems around the Corridor. The forest is a source of various products like firewood, timber and non-timber resources for over 50,000 households of 14 Village Development Committees of Kailali District.

Basanta Corridor encroachment issue has been in a lime light for few years. It is a prime concern of conservation as well as development workers. To maintain intrinsic value of Basanta Corridor, a package program that addresses conservation and poverty issues should be implemented at the earliest. Over and above a separate corridor conservation policy should be formulated timely. If government comes with the aforementioned policy and programs sooner, then there is a better chance for reviving Basanta Corridor.

Basanta Corridor

4. **Wildlife Corridor between Kaimur WLS and Chandraprabha WLS-RTI**
   The forest split between Kaimur Wildlife Sanctuary and Chandraprabha Wildlife Sanctuary. There is regular movement of animals between these forests due to which there is variation in numbers.
5. **Kishanpur WLS, Dudhwa NP, Katarniaghat WLS, nearby Reserved Forests and Corridors (Central TAL)**
   The Surahi range of Terai east Forests Division (FD) in Uttaranchal links the landscape to Mahob and Mala ranges of Pilibhit FD of UP through forested corridor in the east. Elephants from the CNP have been reported migrating to Pilibhit through this corridor. The total area of the Pilibhit FD is 710 sq. km. This is the largest territorial division in the state of UP and alone contributes about 10% of the total revenue generated by the state from forests. Despite being a territorial FD, the forests and grasslands of the Pilibhit upkeep a number of wild animal species counting tiger, sloth bear, and hog deer.
6. **The forest corridors between India and Nepal**
   Valmiki Tiger Reserve, Bihar, which shares its boundary with the Chitwan National Park and Parsa Wildlife Reserve in Nepal, and Sohagibarwa Wildlife Sanctuary in Uttar Pradesh, and plays a critical role in maintaining demographically stable and genetically robust populations of tigers. The forest corridors between India and Nepal are extensively used by tiger and other large mammals. With increasing development and land-use change, poaching and wildlife trade such connectivity and exchange however is at risk. To protect and re-establish the connectivity beyond national boundaries is therefore of utmost importance. The Chitwan-Valmiki Forest complex has a shared boundary of approximately 100 km, and this area is a large forest tract, different portions of which are administered by the two nations. However, we believe that in addition to the protected area complex, the large forest patch of Someshwor hill forest may be serving as a corridor.

Forest corridors between India and Nepal

13. Importance of Wildlife Corridors

The Corridors Plan distinguishes the critical task of connectivity for wildlife corridors —that is, the characteristics that make the landscape habitable for communities of plants and animals, allowing their movement, adaptation and evolution. Connectivity can be understood at four levels:

1. **Landscape connectivity** refers to the physical connections between habitat areas across a landscape. For example, linear strips of native vegetation along roadsides, paddock trees in fields and other structural elements such as rock formations can link larger patches of remnant habitat, allowing the movement of some animals and the transfer of plants through seeds and pollen.
2. **Habitat connectivity** refers to the connections between patches of habitat that are suitable for a particular species. For example, some bird species are able to traverse landscapes via 'stepping stones' such as paddock trees, while other species require continuous cover of a particular habitat.
3. **Ecological connectivity** is a broader concept that relates to the function of ecosystems across space and time. It considers the processes underlying healthy landscapes—for example, interactions between fruiting trees and the animals that eat their fruit and disperse their seeds; flows of water across the landscape, allowing plants and animals to live and breed; and the production of resources, such as nectar, that animals track from season to season. Many of these characteristics are supported by retaining habitat and landscape connectivity, allowing movement and flows across the landscape.
4. **Evolutionary connectivity** allows populations of species to interact naturally, share genes and, in time, adapt to changing environmental conditions. Evolutionary processes to occur.

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