PATHS TO PRESERVE

Tap into the advancements of landscape ecology, not just expert knowledge, to identify and restore elephant corridors

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POPULATION FRAGMENTATION is the split of a large single population into smaller, isolated units, which increases the risk of extinction for endangered species due to population isolation. The Asian elephant is a flagship species; protecting its habitat and ensuring connectivity through corridors will help maintain a genetically viable population and conserve biodiversity. However, efforts to reconnect elephant corridors must be carefully planned.

Landscape ecology in the 1960s defined a corridor as an elongated stretch of land joining two reserves. The landscape was conceived as a patchwork of habitat "patches", usually reserves, within a "landscape matrix" used by humans. A corridor would help animals cross the matrix in a relatively safe manner to go from one protected area to the next. In the absence of better techniques, experts would rely on field knowledge and mark a typically long and narrow passage to be preserved or restored as a corridor.

This conception guided the "Right of Passage: Elephant Corridors of India" report (ROP) by the Wildlife Trust of India in 2005 and 2017. ROP has limitations, such as the lack of a working definition of corridor. The passages that are identified in the document as corridors are based on expert knowledge.

This older concept of corridor began to be questioned in the 1990s. A corridor seen or designed by humans may not hold true for animals, because their sensory world and physiological requirements are entirely different from ours and they decide their movement based on many variables unknown to us.

Moreover, expert identification of corridors is fraught with difficulties as experts know some parts better than others and thus do not have a synoptic view of larger landscapes, which leads to a bias. Humans may also overlook disruptions, such as a noise barrier that may deter animals from crossing and render the reconnection effort ineffective. Thus, there is no guarantee that a corridor proposed by an expert is the best possible choice or will even work at all.

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From a scientific point of view, personal expertise does not allow the test of hypothesis. To verify variables that can predict the path a roaming elephant would take or the landscape features that would prevent elephants from staying within a corridor, one must put animal movement at the centre of investigations. This realisation influenced a new era in the early 2000s. Landscape ecology became more accurate and new frontiers of scientific exploration opened up to include aspects of animal behaviour, physiology and evolutionary biology.

The advancements in detecting core areas and corridors are now based on three factors: intensive use of field data; improvement in GIS (Geographic Information Systems) and availability of geospatial data; and adapted algorithms.

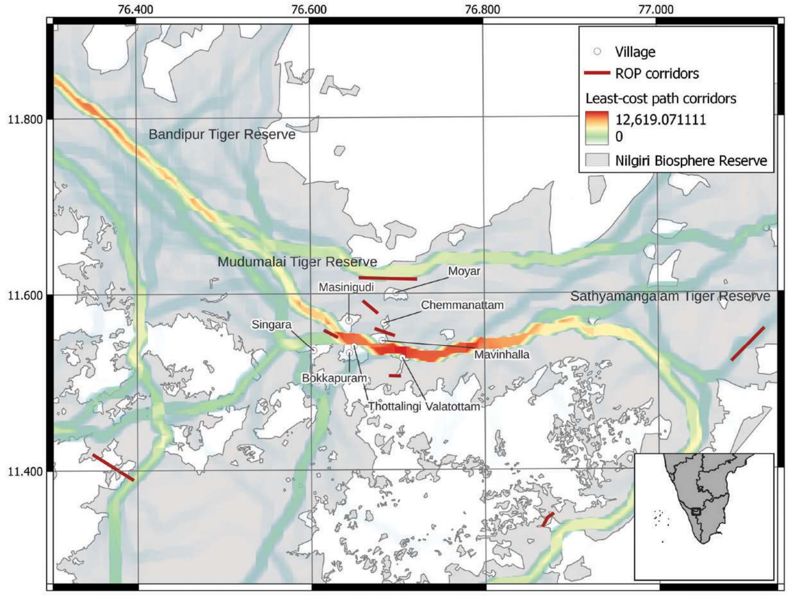
Field data helps collect essential knowledge on animal presence, movement records where they go and genetic profile indicates patterns of genetic exchange between sub populations. These can be used independently or together for better prediction of elephant movement. Animal presence is obtained from camera trapping or from georeferenced indices, movement paths by radio or satellite telemetry and genetic makeup is derived non-invasively from dung piles.

Parallel to the field data, environmental data are now easily obtained at the landscape scale in the form of rasters (such as elevation images) or vectors (such as road maps). Scientists try to gather as many candidate GIS layers as they deem valuable. With the raster or vector images, they can calculate a landscape distance among the same individuals. For example, with slope, they calculate the easiest path between two points, which is usually where the gradient is gentler. Genetic data, similarly, helps establish a genetic distance among individuals, which could be correlated with the landscape distance along least-cost paths (a path that costs the least to traverse in terms of time, distance or other variables).

The correlation process is repeated for each selected variable and then for a mix of variables. With careful selection,

Reconnection potential

Using information from field data, GIS and adapted algorithms can help identify functional corridors to target for restoration



In this figure, connectivity is represented in the form of factorial least-cost paths. Corridors are calculated over a composite resistance map including land use, slope, elevation and habitations. The corridors start from core areas (the tiger reserves) and sometimes extend beyond the limits of the Nilgiri Biosphere Reserve, where "structural" corridors should be established and eventually restored. Areas with highest connectivity in red are essential to elephant populations. In comparison, expert corridors, as identified in the "Right of Passage: Elephant Corridors of India" report (ROP) by the Wildlife Trust of India, do not display an overall logic regarding connectivity. Most are in protected areas or reserved forests, a few cut across villages and most seem to be placed at random. Corridors have not been prioritised based on their relative importance
Source: "Predicting landscape connectivity for the Asian elephant in its largest remaining subpopulation", *Animal Conservation,* October 2016

one ultimately creates the best possible composite image called a resistance map, which optimally summarises resistance to animal movement in two dimensions.

The resistance map can be compared to a road map with speed limits: which road the vehicles choose depends on the road capacity and speed limit. The same way, animal movement is modelled on the resistance map through several algorithms known to specialists such as circuit theory, factorial least-cost paths or resistant kernel that connect the dots of animal locations and extrapolate it over the landscape. This analyses will provide the final document, the connectivity map.

In the connectivity map, regions with highest connectivity start in the core areas, usually within reserves, and extend into the landscape matrix, guided by the animal's biology rather than expert knowledge. In a 2016 study published in the journal *Animal Conservation*, we have created a connectivity map of factorial least-cost path elephant corridors in the Nilgiris Biosphere Reserve.

If two reserves need to be reconnected, it is better to restore a "functional corridor", known to be used at present or in the past, using analysis. Consequently, a more modern definition of "corridor" is "a place where connectivity is higher". Whether it is inside or outside protected areas is irrelevant as it reflects the biology of a species, which is the ultimate reality to consider for effective conservation.

The identification of elephant corridors has become a point of debate in India. Only half the corridors in the Nilgiri Biosphere Reserve as per ROP could be validated with modern techniques. In 2023, the Union Ministry of Environment, Forest and Climate Change released another report on elephant corridors that attempted validation with field data, an improvement over ROP.

But during a standing committee meeting of the National Board for Wildlife in August 2023, Raman Sukumar, senior scientific editor of ROP, defined a corridor as "a small patch of land that provides connectivity for elephant movement across habitats, largely within a landscape of the elephant reserve" ("Elephant corridor report plagued with inconsistencies, could escalate conflict with humans, says expert", *Down To Earth* website, November 2, 2023). This definition is no longer valid in landscape ecology. It oversimplifies reality, largely ignores animal behaviour and increases risk of accepting corridors that do not work.

Both ROP and the recent, more accurate Union environment ministry report are interesting efforts to identify corridors. But it is urgent to develop a national framework based on recent scientific methods that use movement data to secure habitat connectivity and conservation of a key species. DTE

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