

and technology by appropriate NGOs to generate income.

Based on their stated social needs and overall SSR goals, knowledge institutions and employees must develop action plans to implement various SSR schemes¹.

SSR can carry logical and imaginative answers for cultural issues, particularly concerning marginalized segments of society, to aid in their upliftment.

The benefits of SSR are as follows⁵.

- Increasing the scope of science and its benefits to the community by encouraging students to pursue science by mentoring and handholding them.
- Providing an opportunity for researchers at universities and colleges to collaborate and share science and technology laboratory resources.
- Providing instructions for improving scientific knowledge and skill acquisition.

- Encouraging scientists to participate in innovation for rural implementation.
- Using the scientific intervention to empower women, the disadvantaged and weaker sections of society.
- Identifying SSR success models and best practices for nationwide replication, which can have a multiplier effect.

Science is an invaluable part of our society that helps improve the quality of life for individuals and communities. With SSR, scientists can make a positive impact on their local communities by utilizing their knowledge and research to benefit all members of society⁵. By implementing sustainable practices and using science as a fulcrum, we can ensure that all members of society receive equal access to resources and opportunities while simultaneously paving the way for a brighter future. The time to act is now.

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COMMENTARY

Return of the giants: are the traditional elephant corridors being revived?

Kanchan Puri and Ritesh Joshi

In the recent past, some cases of unpredictable movement of elephants have been reported from different parts of India, wherein the species was found moving beyond its natural ranges. Whether such abrupt movement by the elephants indicates the revival of their historic corridors or a shift in their natural ranges remains uncertain. However, some identified populations have been observed to move long distances as part of their traditional seasonal migration. Some cases of unusual sightings and dispersal of elephants beyond their ranges and in new landscapes indicate the revival of corridors and consequent capabilities of the animal to respond to the changing environment. Long-term studies are needed to verify how developmental and anthropogenic activities alter environmental niches. Moreover, in order to understand and address the issues related to the restoration of viable ecological corridors, revisiting and restructuring the conservation priorities and strategies would be paramount. This would enable the species to move long distances through the landscapes and ensure long-term survival.

Large-range movements among wild animals help them acclimatize to the immediate environmental changes and develop the ability to maintain population continuity for gene flow. They also influence plant community dynamics through seed dispersal and thus shape biodiversity. Species' movement across large distances and successful survival are essential to their evolutionary success. Animal movement is a core component of an ecosystem, and maintaining movement patterns may be vital for sustain-

ing ecosystem processes like trophic and species interactions^{1,2}. Though the movement of species across new grounds results in competitions for space and resources, and sometimes human–animal conflict, it provides the scope of addressing the edge effects and habitat fragmentation. As often there is a lack of knowledge of where, when and why species move, the field of movement ecology has grown rapidly in the last decade and is now providing the knowledge needed to incorporate move-

ments of species into management planning³.

Once present in almost all the forest tracts of the Indian subcontinent, elephants are now restricted to disjointed habitats across 13 range countries across South and Southeast Asia. In India, the northern population of elephants ranges across the western Himalayan foothills in Uttarakhand and Uttar Pradesh (through Nepal). However, the northeastern population ranges across Sikkim, north Bengal, Assam and

eastwards towards the Mishmi Hills in Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Mizoram and Tripura. The east-central population occurs in the southern part of Bihar, south Bengal, Jharkhand, Chhattisgarh and Orissa, whereas the southern population ranges across parts of Karnataka, Tamil Nadu and Kerala.

In the 1990s, considering the presence of this giant animal, it was presumed that they became extinct in five states, namely Punjab, Rajasthan, Madhya Pradesh, Maharashtra and Andhra Pradesh, during the last 100 years⁴. The memoirs and writings of the Mughal emperors of the 16th and 17th centuries indicate that elephants were once widespread from southern Uttar Pradesh through Madhya Pradesh and Chhattisgarh, from where they have disappeared^{5,6}. However, during the last 4–5 decades, a few random observations of elephant movement in their former ranges (from where their movement has completely disappeared) have compelled researchers to revisit our existing knowledge and restructure our management planning. A study pointed out that elephants in the east-central Indian range used to move across neighbouring States since 1986, particularly in parts of southern West Bengal, Chhattisgarh and northeastern Andhra Pradesh⁶.

Elephants are intelligent and social species, and have well-developed cognitive abilities and the capability to respond to the changing environment, which makes them less vulnerable. Though a few solitary individuals and groups move within a defined area, most migrate long distances in search of new feeding grounds and water. Elephants migrate over long distances across landscapes, which enables them to search for new feeding grounds and resources, strengthening gene flow among the populations and altering the forest ecosystem and biodiversity^{7,8}. Another study conducted in the northwestern Indian elephant range highlighted that the elephants are learning to adapt to the changing environment to fulfil their requirements⁹.

In recent years, reports of elephants straying outside their protected habitats have been received occasionally, especially on their long-distance movements towards areas where they have not been reported for many years. Even though only identified groups and solitary bull elephants were observed performing such movements beyond their ranges, the exact cause of such large range movement is unknown due to a lack of scientific studies. Protected Area (PA) network plays a crucial role in managing

biodiversity in an ecosystem and, more markedly, in the landscapes surrounding the PA, and also has a vital role in managing biodiversity existing within the PA.

Rajaji National Park, Uttarakhand, is one of the protected habitats of the elephants in northwestern India, which is spread across an elevation of 302–1000 m amsl (ref. 4). There were no reports of elephant movement in this state beyond this elevation till 2012. However, the movement of adult bull elephants and a few identified groups was observed at an elevation of about 1200 m amsl (across Talla banas, Kasaan and Garakot villages) in the outskirts of the Rajaji National Park, mainly to feed upon palatable crops¹⁰. Bull elephants perform such abrupt movements at higher ridges mostly during monsoon, when all the natural water sources spread within the hilly terrain are filled with rainwater and several species of grasses like Madagascar grass (*Neyraudia arundinacea*), salt reed-grass (*Desmostachya bipinnata*) and bamboos (*Dendrocalamus strictus*) grow in abundance at higher elevations. A study carried out in Uttarakhand revealed that the elephants are distributed up to 1450 m amsl elevation, but their presence above 1200 m amsl is less¹¹.

During 2017, reports highlighting elephant movement at an elevation of ~1220 m amsl were also received from Chopra village near Jeolikot in Uttarakhand¹². Further, in 2020, elephant presence was recorded at an elevation of 1450 m amsl in the Almora Forest Division during a population esti-

mation¹³. Recently, in January 2022, a report of elephant movement near Devidhura village was also received from the State at an elevation of ~1850 m amsl (ref. 14), where elephants were never reported before. The closeness of the Ramnagar range with Devidhura is one of the reasons for elephants straying into the area.

It is worth mentioning that some changes in the food plant species of elephants have been observed over the years in Uttarakhand. In 2006, elephants were observed feeding on teak (*Tectona grandis*) and katagon (*Fernandoa adenophylla*) in the Rajaji National Park, the first report on the new observation of food plant species of elephants from the Park¹⁵. Similarly, during 2007–09, elephants were observed feeding on eucalyptus (*Eucalyptus obliqua*), clammy cherry (*Cordia obliqua*), tellicherry bark (*Holarrhena antidysenterica*), kaim tree (*Mitragyna parvifolia*) and wild guava (*Careya arborea*) in the Park area^{10,16}.

In 2021, an elephant group comprising about 25 individuals was spotted near the Mohammadi range of the south Kheri Forest Division in Uttar Pradesh (UP), almost after three decades (last observed in the 1980s). After staying in the area for 3–4 days, the group finally reached the Aonla Forest¹⁷. Prior to this, in July 2019, two bull elephants were observed from the Mandanpur village along the border of districts Bareilly and Rampur, crossing the Amaria Forest of Pilibhit in UP¹⁸. Though elephants used to move across the border of UP and Uttarakhand as well as Nepal, it was



A group of adult male elephants moving in Haridwar–Bijnor national highway across Rawasan–Sonanadi wildlife corridor.

suspected that they had strayed from the adjoining forests of Uttarakhand, crossing the Surahi–Khatima–Kilpura corridor and Pilibhit Forest Division. Considering that the same population of elephants used to move across Uttarakhand and UP, it might be possible that they strayed from the Shuklaphanta Reserve in Nepal through the Lagga Bagga corridor and Pilibhit Tiger Reserve, or used the forest tracts across Ramnagar, Haldwani and Terai East, West and Central Forest Divisions through Surahi–Khatima–Kilpura and the Gola river corridor. These forest tracts have been the migratory corridor for elephants to move across the Shuklaphanta Reserve in Nepal, crossing the Sharada River and the Lagga Bagga corridor.

These incidences indicate the revival of the corridors that pass through the historic elephant ranges and link the elephant habitats in UP and Uttarakhand. The Pilibhit Forest in UP is connected to the Corbett Tiger Reserve in Uttarakhand in the northwest by the Surai range in the Haldwani Forest Division, and to the Shuklaphanta Reserve in Nepal to the northeast through the forests of Lagga Bagga¹⁹. The Surai–Khatima–Kilpura corridor is located across the Khatima forest range and serves as an important link to connect Haldwani and Terai East Forest Divisions in Uttarakhand, Pilibhit Forest Division in UP and the forest in Nepal respectively. The movement of elephants in this belt is restricted mainly because of the fragmentation of habitats²⁰. Similarly, the movement of elephants between Shuklaphanta Reserve through the Lagga Bagga corridor to Pilibhit Forest Division and Kishanpur Wildlife Sanctuary has been almost impaired due to fragmentation and extreme biotic pressure²⁰.

The northwestern elephant population in India once had a continuous range from Katarniaghat Wildlife Sanctuary in the east to the Yamuna River in the west²¹. However, over time this continuity has been broken, and now the whole population occurs in six isolated sub-populations²². Considering the importance of landscape and elephant conservation, the Ministry of Environment, Forest and Climate Change, Government of India, has recently permitted the establishment of the Terai Elephant Reserve across the Dudhwa–Pilibhit landscape in UP. This would boost elephant conservation across the large landscape²³.

Though there are sporadic records of elephant presence in Maharashtra, the state does not have a resident elephant population. In 2021, an elephant group comprising

22 individuals reached the forest of Gadchiroli in Maharashtra and stayed there for about a month. It was presumed that they had strayed from Odisha, crossing the Rajnandgaon Forest in Chhattisgarh. Extensive farming, infrastructure projects and mining activities in Chhattisgarh are some of the reasons given by researchers for this migration. The Gadchiroli area has never been known for wild elephants for several centuries. It comprises a dense forest that the elephants prefer to move across. Further, the contiguous forest stretch across the Indravati National Park in Chhattisgarh, bordering the Kolamarka Reserve in Maharashtra, has given the elephants a wider path to move across a large landscape.

Elephants started arriving in the forests of Chhattisgarh in 2013 and stayed in the districts of Kanker, Balod, Gariaband and Dhamtari. Later they started moving towards Maharashtra in September–October, wherein one elephant had also given birth to a calf²⁴. Since 2002, wild elephants have also been reported moving across Maharashtra from Karnataka, and in 2013, three groups comprising a total of 11 individuals were observed inhabiting the Kolhapur and Sindhudurg districts of Maharashtra²⁵. Though elephants in southern India are mainly distributed in the hilly tracts of the Western Ghats and its adjacent Eastern Ghats in Karnataka, Kerala and Tamil Nadu, they have also been reported from Andhra Pradesh, Maharashtra and Goa from a small area⁶. Andhra Pradesh did not have elephants for the past 200 years, but they have started re-colonizing the state in the last 30 years²⁶.

All these incidences insist that the respective State Governments and researchers revisit our knowledge and restructure our conservation priorities and actions. Besides, such incidences have also opened new doors to study sporadic movements of the identified elephant populations with reference to the cycle of shifting to new grounds. During the last 4–5 decades, contiguous habitats of elephants have been fragmented, which has shrunk their historical range and converted large groups into smaller ones. A study predicted that elephants might lose nearly 40% of their habitat by the end of this century, mainly due to human-induced disturbances and global climate change in human-dominated regions, which may lead them to shift towards higher elevation along the river valleys²⁷.

Studies carried out on the home-ranges of elephants in India revealed that their home-range size varies between 250 and

1000 km² (refs 28–30). In such a situation, the movement of elephants across highlands and large landscapes in their traditional corridors urgently calls for inter-state cooperation and trans-boundary conservation. Whether some of the identified populations used to roam in their traditional ranges and do such new landscapes serve as a potential habitat for the species are some questions which need to be studied thoroughly. Elephants migrate over long distance to fulfil their requirements, and interestingly, large home-ranges and dispersal facilitate them to avoid inbreeding and maintaining gene flow among populations. Appropriate environmental conditions and availability of water and feeding grounds are important factors which reinforce such movements. Further, such large range movement of elephants may alter the vegetation composition and structure and thus facilitate biodiversity management of the respective region. A study conducted in the forest–Savanna landscape revealed that the elevational migration of individual elephants, relative to shorter migrations, depends on the availability of high-quality forage and water sources on a year-round basis³¹. Changes in the movement and behaviour of elephants have also been observed following severe droughts triggered by El Niño events³².

Some of the elephant population which uses to move beyond their defined historical ranges, would experience the advocacy of development and conservation together. Scientifically addressing all the conservation issues would be challenging, especially those relating to space. It is, however, important to observe and document in the next few years, how the wide-ranging elephants acclimatize to new landscapes and environments, and how the development of the area would help the locals without affecting conservation. Moreover, understanding ecological consequences behind such abrupt movements, assessment of corridors, especially the availability of food resources, and elephant breeding success are important points to consider before reaching a firm conclusion. A strategic framework is needed involving all stakeholders, especially local communities, to give the elephants a wider path to move across their traditional ranges.

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