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Tracks of Death: Elephant Casualties along the Habaipur–Diphu Railway in Assam, India

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Railway development is an important component of sustainable transportation systems but also affects wildlife habitats worldwide. Here, we assess spatiotemporal patterns of elephant–train collisions and mortalities within the state of Assam, India, and relate them to spatial and temporal land cover change (LCC) from 1988 to 2018. The results indicate that an extension of railways into forested landscapes is associated with large-scale LCC and increased elephant–train collisions and mortality. Prior to 1997, when the railway system used narrower gauge rails, elephant deaths from collisions occurred at a rate of one or two per year. After 1997, when the system was converted to larger gauge rails, elephant deaths increased starkly and now occur at a rate approaching ten per year. While the rail gauges were being converted, the landscape around the Habaipur–Diphu railway line saw a sevenfold increase in annual net loss of dense forest. The transition from forest to croplands was the most dominant process of deforestation and forest fragmentation during the postconversion period. Although elephant–train collisions are strongly associated with the land use transitions shown here, conservation and remediation measures can help to stem further declines in forest habitats and promote safe movement by elephants between resource patches. *Key Words: elephant–train collisions, forest fragmentation, land cover change.*

Transportation infrastructure has rapidly expanded across the globe (Dulac 2013; Laurance and Balmford 2013). Moving forward, the largest infrastructural additions through 2050 are expected to occur in China and India (Dulac 2013) and in the tropics more broadly (Alamgir et al. 2017; Laurance and Burgués-Arrea 2017), where the planet's most diverse ecosystems remain. Within India, railways are an important mode of transport, and its network has expanded rapidly in recent decades, with nearly 123,000 kilometers of railway tracks crossing its diverse biophysical environments as of 2018 (Indian Railways 2017–2018). Although an efficient and increasingly important means of sustainable transportation, such extensive railway networks present a number of environmental problems, including habitat loss (Andrews 1990) and landscape fragmentation (Ito et al. 2017). In addition, a very direct "impact" is the mortality of wildlife caused by wildlife–train collisions (Santos, Carvalho, and Mira 2017).

Railway ecology, a relatively new subject with connections to ecology, geography, and engineering (Borda-de-Água et al. 2017), explores the relationship between railways and natural environments (Forman et al. 2003). The conceptual basis of railway ecology thus arises with lateral disconnection of water flows, vegetation, and wildlife movements; the modification of microclimate; soil erosion; land-cover change (LCC); habitat fragmentation; edge effect; and, most important here, wildlife mortality from collisions with trains (Andrews 1990; Blanton and Marcus 2009; Van der Ree, Smith, and Grilo, 2015). Although railway ecology is at a nascent stage, conservation requirements for road networks (Forman 2004; Więcław et al. 2019; Mata, Herranz, and Malo 2020) have received considerably more attention. Of late, railway–wildlife relationships have garnered increasing attention in relation to elephants (Mukherjee et al. 2019; Chamling and Bera 2020; Huang et al. 2020; Nezval and Bíl 2020).

Many of these studies incorporated Landsat imagery to assess LCC and used gravity models to analyze the spatial structure of urban and agriculture areas. Given that forest cover change affects the foraging movements and behavior of numerous wide-ranging animals (Tucker et al. 2018), deforestation and forest regrowth along railroads could be a potential factor in collision hotspots. Species that forage regrowing vegetation along the tracks and that, in

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