CENTER for LARGE LANDSCAPE CONSERVATION

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Contaminated Corridors: The Indirect Consequences of Linear Infrastructure Expansion

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Introduction

Linear infrastructure (LI) development, such as roads, railways, and pipelines, is essential for economic growth and development. However, these projects often have unintended consequences, including pollution and increased risk of zoonotic disease transmission. LI can fragment natural habitats and disrupt ecological processes, leading to the destruction of biodiversity and the emergence of new diseases. Furthermore, construction activities associated with linear infrastructure can generate significant amounts of pollutants, including particulate matter, noise, and chemical contaminants, which can have adverse effects on the health of apes and humans alike.

Environmental Contamination from Linear Infrastructure

During the construction phase of any linear infrastructure (LI) project, there is necessarily a large environmental impact as heavy machinery and work crews work to install roads, rails, power lines and canals. Noise, light, vibrations, human construction crews and human-made materials all disturb the environment and wildlife. Additionally, once constructed, maintenance and use of LI can become a regular source of disturbance. Disturbance to wildlife and surrounding communities can be mitigated through better LI design, especially when nations or development financiers prioritize safeguarding natural resources during all phases of LI development. Developers should focus on climate resilient LI, increased carbon storage and thoughtful planning for restoration and maintenance of ecological corridors surrounding LI development.

Vehicles using roads generate petroleum-based emissions, as well as road surface and tire particle pollution that contribute micro-plastics as well as other forms of contamination. These collective impacts may be the largest generator of long-term environmental contamination from roads. Tire wear contributes significantly to microplastic pollution along and extending out from roadsides, as runoff and air currents carry these particles into more pristine habitats[1]. We have much to learn as we don't understand the toxicology of most runoff and how far contaminants are carried in storm water and other run off. We also don't understand the full effect of contaminants on aquatic and terrestrial species and systems.

In Alaska, proximity to roads is correlated with skeletal abnormalities in wood frogs[2]. In Kibale National Park in Uganda, not only were chimpanzees killed on the 4.6 km long paved road, over 5,000 plastic bottles were picked up along this short stretch of road and even more worrisome, plastic contaminants (BPS and BPA) were found in the hair of chimpanzees, indicating a much wider and harmful spread of pollutants into wildlife populations in this protected area[3]. In addition to microplastics, heavy metals are found in runoff and storm water: copper, lead, zinc and other metals are found at levels that lead to deleterious effects on aquatic life. It is evident that proximity to roads affects wildlife in many ways: by collision, attraction (to mowed areas or exotic, edible vegetation), avoidance and myriad behavioral changes that can affect population size and structure.

Paved Pathogens: The Role of Linear Infrastructure in Spreading Disease

The greatest threats to great apes globally are habitat loss, hunting and disease. All of these are caused (or accelerated) by developing linear infrastructure in ape habitats. The recent and ongoing global pandemic has brought renewed attention to the potential for spillover events of disease between humans and wildlife. The impact and human death toll of Human Immunodeficiency Virus (HIV) brought greater attention to the risks of disease transfer from non-human primates to humans, as the close phylogenetic relationship between humans, apes and monkeys allow mutations and gene translocation ease in disease transfer. Non-human primate hunting, meat handling and consumption is understood to be the source of Simian retrovirus (SIV) in apes, which mutated into HIV in humans. Increased human presence, activity and contact with wildlife, primates in particular, create opportunities for disease transfer between species.

In many parts of the world, hunting wildlife is a primary source of meat and hunting to eat or sell monkey or ape meat is part of many cultures. As human populations increase and pressures on tropical habitats spread, road density increases. Roads facilitate easier to access primate range that used to be a barrier to farmers, wood-gatherers and hunters, and as contact between people and primates increases, so do the chances of more zoonotic disease transfer. Bushmeat can more easily be transported to urban areas with new roads, increasing the number of humans in contact with wildlife products. Bushmeat markets thrive in many places and in the early 2000's, 9,500 non-human primates were sold at the Liberia – Ivory coast markets annually[4]. Contact with wildlife is unequally distributed among social classes, and the most marginalized people tend to be at much higher risk of exposure as hunting bushmeat, including apes, may be part of their livelihoods as well as restricted access to healthcare and political voice in preserving forest integrity[5].

Humans with new road access to intact forested areas comes at additional costs to habitat as agriculture and invasive plants replace native vegetation and consequently natural foods for wildlife. When native foods are scarce or missing, wildlife turn to artificial sources, like agricultural crops. This increases contact between wildlife and humans as well as changing wild behaviors, threatening human livelihoods and increasing retaliatory killings of crop raiding animals.

Cameron studied the effects of viral outbreaks in the Congo and modeled the impacts of viral outbreaks after one purported event. In areas of high ape density, such as the Congo Basin, rapid mass mortality events have been noted and assumed to be caused by highly contagious, infectious disease, most likely Ebola virus[6]. In 2006 – 2007, dead apes were documented in the Sangha Department of northern Congo, where one chimpanzee and eight gorilla carcasses were found in various states of decomposition, each carcass found near the main north-south road. Hunting was ruled out as a cause of these deaths because the bodies were not collected, nor were gunshot wounds detected. While collected tissues tested negative for Ebola and Marberg viruses, the bodies had decomposed to a point where virus was undetectable. Outbreaks of these viruses in humans were concurrent during these events. The veterinary teams developed a statistical model which predicted that these and future mortality events were due to disease outbreaks, facilitated by road presence and road access. Roads were “consistently associated” as a risk for disease transmission in great apes in their model.

Because of the genetic similarities among primates, some of the infectious diseases known to move between non-human primates and humans are: SIV (HIV), Marberg virus, Ebola virus, pneumonia, influenza, smallpox, meningitis, tuberculosis, measles, mumps, chicken pox, monkeypox, hepatitis B, Streptococcus, rabies, yellow fever virus and a handful of respiratory viruses as well as many blood and gut parasites[7]. With the increase in emerging diseases across the globe, it is likely that the number of cross-species infections will also continue to increase, as evidenced during covid, when humans transmitted SARS Co-V-2 to mustelids in mink farms, zoo animals, domestic animals and deer.

Though similar genetics closely binds primates and disease transfer, viruses can affect humans and non-human primates differently. Encephalomyocarditis virus (EMCV), a picornavirus which occurs in humans with mild symptoms, has caused outbreaks of heart and renal failure and cerebral swelling in[8-10]:

- Bonobos (*Pan paniscus)*
- Gibbons (*Hylobates lar)*
- captive macaques (*Macaca sylvanus)*
- captive baboons (*Papio hamadryas)*

Disease transfers came from human caretakers in the case of captive primates, but in wild population outbreaks, the source was less apparent. Identifying reservoirs of disease is important to containing outbreaks for all primates and other wildlife, although this requires robust and coordinated monitoring of species across landscapes, as well as domestic animals and bushmeat markets.

We know that fragmenting habitat, increasing human disturbance in forest habitats and increased contact with wildlife magnifies the chances of zoonotic disease transfer. We can mediate the frequency and severity of disease spillover by taking preventative action.

According to a report by the Center for Disease Control[11] steps to take include:

- Stop clearing and degrading tropical and subtropical forest
- Improve the health and economic futures of communities living in areas where emerging disease are likely (tropical forests)
- Improve biosecurity in animal husbandry
- Shut down or restrict and regulate wildlife trade and markets
- Improve and expand pathogen surveillance at wildlife/domestic animal/human interfaces

Conclusion

Through better forest and forest community care, we can help conserve primates across their ranges. Where the health and financial security of communities benefit from ecological environments intact, they should be paid for ecosystem services and carbon sequestration and have access to services that improve the quality of their lives.

These recommendations also apply to the development of LI through ape habitats. Future LI planning should first consider the feasibility of rerouting planned development around habitats. The planning process should also evaluate and consider the impact on forest degradation, the economic futures of communities while preserving forests and help improve animal husbandry in these communities. Regulating or stopping wildlife trafficking relies heavily on linear infrastructure to move wildlife to markets and improving law enforcement and community awareness of the risks of bushmeat hunting are needed. Improving surveillance of wildlife disease where humans interface with them is important along roads, rails, pipelines and powerlines.

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