

Scientists find vast numbers of illegal 'ghost roads' used to crack open pristine rainforest

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One of Brazil's top scientists, Eneas Salati, once said, "The best thing you could do for the Amazon rainforest is to blow up all the roads." He [wasn't joking](#). And he had a point.

In an [article published](#) in *Nature*, my colleagues and I show that illicit, often out-of-control road building is imperiling forests in Indonesia, Malaysia and Papua New Guinea. The roads we're studying do not appear on legitimate maps. We call them "ghost roads."

What's so bad about a road? A road means access. Once roads are bulldozed into rainforests, illegal loggers, miners, poachers and landgrabbers arrive. Once they get access, they can destroy forests, harm native ecosystems and even drive out or kill [indigenous peoples](#). This looting of the natural world robs cash-strapped nations of valuable natural resources. Indonesia, for instance, loses around [A\\$1.5 billion each year](#) solely to timber theft.

All nations have some unmapped or unofficial roads, but the situation is especially bad in biodiversity-rich developing nations, where roads are proliferating at the [fastest pace in human history](#).

Mapping ghost roads

For this study, my Ph.D. student Jayden Engert and I worked with Australian and Indonesian colleagues to recruit and train more than 200 volunteers.

This workforce then spent some 7,000 hours hand-mapping roads, using fine-scale satellite images from [Google Earth](#). Our team of volunteers mapped roads across more than 1.4 million square kilometers of the Asia-Pacific region.

As the results rolled in, we realized we had found something remarkable. For starters, unmapped ghost roads seemed to be nearly everywhere. In fact, when comparing our findings to two leading road databases, [OpenStreetMap](#) and the [Global Roads Inventory Project](#), we found ghost roads in these regions to be 3 to 6.6 times longer than all mapped roads put together.

When ghost roads appear, local deforestation soars—usually immediately after the roads are built. We found the density of roads was by far the most important predictor of forest loss, outstripping 38 other variables. No matter how one assesses them, [roads are forest killers](#).

What makes this situation uniquely dangerous for conservation is that the roads are growing fast while remaining hidden and outside government control.

Roads and protected areas

Not even [parks and protected areas](#) in the Asia-Pacific are fully safe from illegal roads.

But safeguarding parks does have an effect. In protected areas, we found only one-third as many roads compared with nearby unprotected lands.

The [bad news](#) is that when people do build roads inside protected areas, it leads to about the same level of forest destruction compared to roads outside them.

Our findings suggest it is essential to limit roads and associated destruction inside protected areas. If we can find these roads using [satellite images](#), authorities can too. Once an illegal road is found, it can be destroyed or at least mapped and managed as a proper legal road.

Keeping existing protected areas intact is especially urgent, given more than 3,000 protected areas have already been [downsized or degraded](#) globally for new roads, mines and local land-use pressures.

Hidden roads and the human footprint

The impact we have on the planet differs from place to place. To gauge how much impact we're having, researchers use the [human footprint index](#), which brings together data on human activities such as roads and other infrastructure, land-uses, illumination at night from electrified settlements and so on. You can use the index to make heat-maps showing where [human impacts](#) are most or least pronounced.

We fed our ghost road discoveries into the index and compared two versions for eastern Borneo, one [without ghost road information](#) and one with it. The differences are striking.

When ghost roads are included in mapping the human impact on eastern Borneo, areas with "very high" human disturbance double in size, while the areas of "low" disturbance are halved.

Artificial intelligence

Researchers investigating other biodiversity-rich developing regions such as [Amazonia](#) and the [Congo Basin](#) have found many illegal unmapped roads in those locales too.

Ghost roads, it seems, are an epidemic. Worse, these roads can be actively encouraged by aggressive infrastructure-expansion schemes—most notably [China's Belt and Road Initiative](#), now active in more than 150 nations.

For now, mapping ghost roads is very labor-intensive. You might think AI could do this better, but that's not yet true—human eyes can still outperform image-recognition AI software for mapping roads.

At our current rate of work, visually mapping all roads—legal and illicit—across Earth's land surface just once would require around 640,000 person-hours (or 73 person-years) to complete.

Given these challenges, [our group](#) and [other researchers](#) are now testing AI methods, hoping to provide accurate, global-scale mapping of ghost roads in close to real time. Nothing else can keep pace with the contemporary avalanche of proliferating roads.

We urgently need to be able to map the world's [roads](#) accurately and often. Once we have this information, we can make it public that so authorities, NGOs and researchers involved in forest protection can see what's happening.

Without this vital information, we're flying blind. Knowing what's happening in the rainforest is the first step to stopping the destruction.

More information: Jayden E. Engert et al, Ghost roads and the destruction of Asia-Pacific tropical forests, *Nature* (2024). [DOI: 10.1038/s41586-024-07303-5](https://doi.org/10.1038/s41586-024-07303-5)

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