Investigating the Role of Ghost Roads in forest loss: Spatio-Temporal Remote Sensing Analysis in the Chiquitano Region

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Abstract

Ghost roads are informal, human-made access features visible in satellite imagery but absent from mapped road datasets. They can bias commonly used road indicators and thereby affect environmental assessments in forest frontiers. This thesis investigates ghost roads in the Dry Chaco and Chiquitano dry forests of central South America, focusing on (i) detectability across imagery resolutions, (ii) omission in existing road datasets, (iii) long-term temporal development, and (iv) statistical association with forest loss.

Ghost roads were identified through visual interpretation and manual digitization in QGIS. To assess resolution effects, ghost roads were mapped within a 400 km² probe region using Landsat 8 (30 m), Sentinel-2 (10 m), and very high resolution Google Earth imagery (~1–3 m) under a consistent digitising protocol. Omission was quantified by comparing a 2024 baseline ghost road network (Google Earth) with OpenStreetMap (OSM) roads across ten spatially independent sample areas. Temporal development was reconstructed for seven observation years (1985, 2000, 2016, 2018, 2020, 2022, 2024) within ten fixed 20 km × 20 km tiles using Landsat 5 (early years) and Sentinel-2 (later years). Forest loss was derived from the Global

Forest Change dataset (2001–2023) and analysed using 6 km × 6 km grid-cell correlations with road density metrics.

Results show a strong resolution dependence of ghost road detectability: total mapped length increased from 216 km (Landsat 8) to 361 km (Sentinel-2) and 526 km (Google Earth) within the probe region. Across the ten sample areas, ghost roads totalled 11,555.4 km compared to 7,040.8 km of OSM roads, with ghost roads representing 62% of combined road length. Detected ghost road length increased from 275 km (1985) to 2,346 km (2024), indicating substantial growth of informal access infrastructure. However, ghost road density showed only weak associations with forest loss at the grid scale, whereas OSM and all road density were more strongly aligned with the forest loss ratio.