RESEARCH EXCERPT — METHODS & FINDINGS

The Invisible Network

A reproducible GIS methodology for measuring natural surface trails as transportation infrastructure

About this document

This is a methods-focused excerpt from a Master's Project completed in the Department of City and Regional Planning at UNC Chapel Hill (2026). It presents the quantitative GIS methodology and findings only; the literature review, practitioner interviews, and full policy discussion from the academic version are omitted here. For the complete paper, contact hello@pathfinderplanning.design.

The Question

Across the United States, cities have invested heavily in paved active transportation infrastructure: greenways, protected bike lanes, sidewalk networks, and multiuse paths. These investments reflect a growing consensus that walkable, bikeable cities are healthier, more equitable, and more sustainable. Yet this consensus rests on a definition of transportation infrastructure that systematically excludes one of the most widespread forms of non-motorized travel in American cities: the natural surface trail.

When transportation agencies calculate walksheds, evaluate development proposals, or prioritize capital investments, they work from official networks that treat paved infrastructure as the boundary of legitimate transportation. Natural surface trails fall outside that framework not because they are unimportant, but because the frameworks themselves were never designed to include them.

This research examines the question through a case study of Chapel Hill and Carrboro, North Carolina, two neighboring municipalities that share a school district and effectively function as a single community. It asks how natural surface trail systems support everyday mobility in mid-sized American cities, and quantifies what it costs a community when planning frameworks don't count them.

Methods

The methodology combines a GIS-based network analysis with a comparative school walkshed analysis: one measuring how much connectivity natural surface trails add to a study area, the other translating that connectivity into a concrete measure of real-world access.

Data Collection and Preparation

All transportation infrastructure data for Chapel Hill and Carrboro was acquired through OpenStreetMap (OSM) using Overpass Turbo queries. Paved infrastructure included sidewalks, hard-surface trails and greenways, in-street bike lanes, and walkable streets, defined as roads with posted speed limits of 30 mph or below. Where speed limit data was absent, walkability was assigned based on OSM highway classification: residential and living street classes were treated as walkable; arterials and collectors were excluded. Natural surface trails were

filtered by surface type and included both established trails and informal social paths that have developed through repeated pedestrian use. Building footprints were also acquired through OSM, with commercial, industrial, and institutional structures excluded, retaining only residential buildings as the unit of measurement in accessibility analyses. All spatial data was projected to NAD 1983 (2011) State Plane North Carolina FIPS 3200 to ensure accurate distance measurements.

Natural surface trails in the study area present a notable data quality issue: many features appear in OSM with null surface attributes despite satellite imagery confirming their existence as unpaved connections. Local spot checks found no paved surfaces among the segments reviewed, supporting the decision to include all null-surface-attribute trail segments in the natural surface dataset. This decision is further supported by the structure of the data itself: all formally designated paved infrastructure in the study area carries explicit surface or facility type tags in OSM, suggesting that null values here reliably indicate informal or natural surface routes rather than missing data.

OSM's coverage of the Chapel Hill/Carrboro trail network was supplemented through field verification and by cross-referencing OSM data with GPS activity aggregators such as Strava heatmaps, which reveal patterns of movement along informal routes not captured in official datasets. Approximately two dozen short connecting trails confirmed to be absent from OSM were added directly using OSM's public editing interface, improving the accuracy of the network while contributing to the broader open-source dataset.

Comparative Network Analysis

Two comparison networks were constructed to quantify the transportation value of natural surface trails. Network_Formal includes walkable streets and paved hard-surface trails and sidewalks only, representing the official transportation infrastructure currently recognized in planning documents. Network_Complete includes all features from Network_Formal plus natural surface trails, representing the actual on-the-ground network that residents use for everyday mobility.

Both networks were built as network datasets in ArcGIS Pro using the Network Analyst extension. Network topology was managed using the Feature to Line tool to planarize the network, ensuring proper connectivity between trail segments and at trail-street intersections. Service area analyses were conducted to quantify differences in school accessibility between the two networks. Using a three-quarter-mile threshold, equivalent to a 15-minute walk at average pedestrian speed, walksheds were generated from each public school in Chapel Hill and Carrboro under both network scenarios. Residential buildings falling within each walkshed were then counted to measure how many additional homes gain school access when natural surface trails are included.

Findings

Natural surface trails add approximately 138 miles of connectivity to the study area, a 45% increase over the dedicated sidewalk and greenway network alone. Even when walkable residential streets are included in the formal network, natural surface trails still represent a 19% increase in connectivity. The infrastructure residents actually use is substantially larger than what appears in any official planning document.

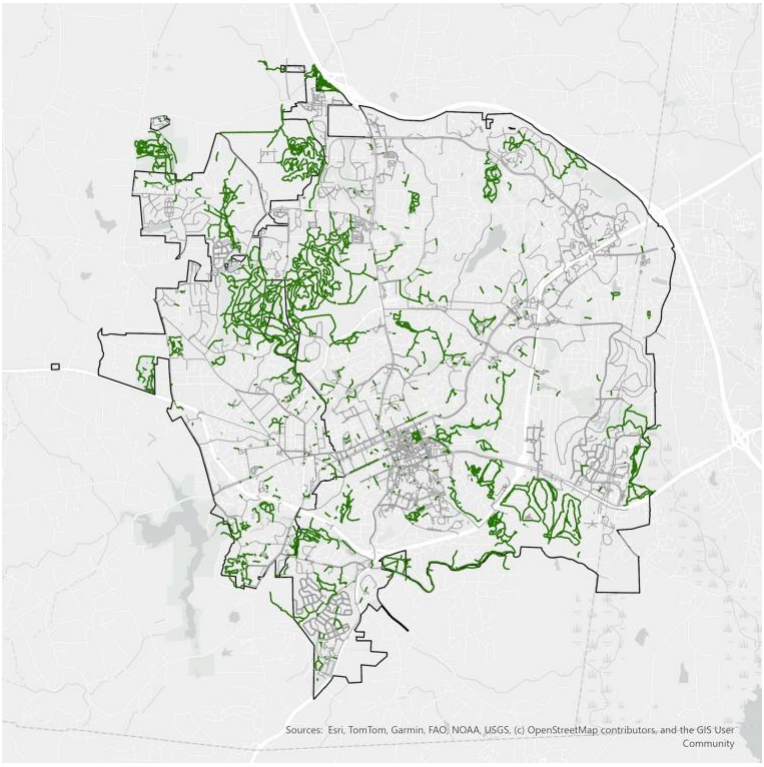

Figure 1. Paved network (gray) and natural surface trails (green), Chapel Hill and Carrboro, NC.

System-wide, the complete network provides walkable school access to over 1,700 more homes than the formal network alone, a 14% increase. The gains were unevenly distributed across schools, with the largest improvements occurring where formal pedestrian infrastructure is thinnest and natural trail networks are most extensive. Chapel Hill High School showed the most dramatic change: the number of homes within the three-quarter-mile walkshed increased from 77 to 271, a gain of over 250%, driven by the school's adjacency to densely wooded areas laced with trails that provide the only low-stress walking connections for nearby neighborhoods. Schools in areas with comprehensive formal pedestrian networks saw little change, confirming that natural trails provide the greatest transportation value precisely where formal infrastructure has historically underinvested.

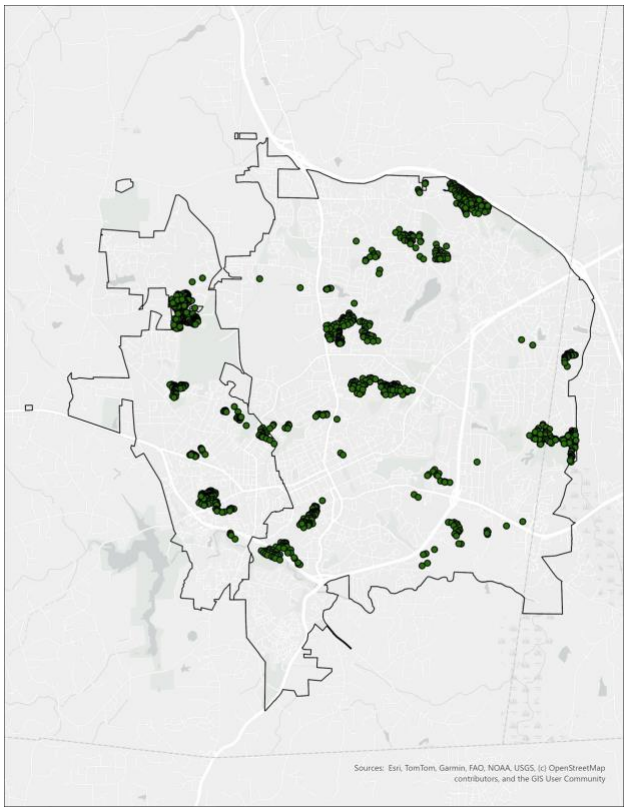

Figure 2. 1,700+ homes gain walkable school access via natural surface trails.

138 mi of connectivity added by natural surface trails, a 45% increase over the paved network	**1,700+** additional homes gain walkable school access system-wide, a 14% increase	**252%** growth in Chapel Hill High School's walkshed once trails are included

Reproducing This Analysis Elsewhere

The quantitative methodology used in this research is reproducible in any community with OpenStreetMap coverage and standard GIS network analysis tools. A school walkshed comparison of the formal network versus the complete network including natural surface trails is an effective entry point for a local planning conversation, because it translates an abstract classification question into numbers that are immediately meaningful to school administrators, Safe Routes to School program staff, parents, and elected officials. Established benchmarks for safe walk distances to school make the findings actionable in ways that general connectivity metrics are not.

The analysis requires no proprietary data or specialized software beyond what most planning departments already have: OpenStreetMap data, Overpass Turbo for extraction, and a GIS package with network analysis capability (ArcGIS Pro's Network Analyst extension was used here). Gallagher, Marshall, and Atkinson-Palombo's (2013) methodology for incorporating informal pedestrian networks into accessibility analyses provides the

methodological precedent for treating unofficial paths as measurable transportation infrastructure rather than excluding them by default.

References

Gallagher, P., Marshall, W. E., & Atkinson-Palombo, C. (2013). Missing links: How social paths can improve pedestrian accessibility to light rail. Transportation Research Record: Journal of the Transportation Research Board, 2393(1), 59-65. https://doi.org/10.3141/2393-07

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