

Central government efforts to improve conditions for cyclists

– the accessibility study

Joakim Hveem, SAI Sweden



Summary

Auditees: The Swedish Transport Administration and the Swedish Transport Agency on

Audit criteria: the Parliament's objective to improve conditions for cyclists.

Our assessment: The central government's efforts have not been effective. Measures implemented by the Government and agencies in the form of regulation, infrastructure and other governance have not contributed in any substantial way to more and safer cycling.

The ambitious objectives set by the Parliament and the Government have not been matched by measures that sufficiently impact actual conditions.



Contribution of the quantitative study to the audit

- Provided the first overall picture of **bicycle accessibility** in commuting routes and identified state responsibility for major shortcomings.
 - Formed the **factual basis** for the audit's background and conclusions, adding genuinely **new knowledge**.
 - Gave the project team a quantitative foundation that aligned with case studies and **strengthened interviews** with state representatives.
- The results were consistent with our investment analyses (analysis of preparatory work for infrastructure investments), **leading to sharper criticism** of the state due to low ambition despite evident shortcomings.

Data

We were in luck:

- We discovered that a consultancy group had created a map service for people who want to find quality cycling routes between A and B. Kind of like Google Maps but this **route-finding algorithm took bicycle path qualities into account.**
- The underlying data was publicly available
 - Official data from the National Road Database.
 - Classification method (mainly car flow rate and maximum speed) developed by the consultancy group. All was available in SHAPE-files.
 - Other geopackages (Urban areas) downloaded from Statistics Sweden .
- But the mapping tool is for ad-hoc travel, we want to measure relevant overall cycling **accessibility**

Is the quality of the bicycle road network sufficient?

- *How to operationalize this?*

What roads are relevant?

What is more important?

Our focus is the plausible bicycle commuter. –

Thus, we do not consider all roads in Sweden and not all roads are equally important.



Defining our population helps clarifying the structure and what is important

- We consider the 100 largest urban areas in Sweden, called "Central areas".
- From each centroid of these areas, we include other urban areas within a 25 km radius
 - 2 484 unique origin-destination pairs
 - For each origin-destination pair we compute 4 distances



Type 0: as the crow flies



Type 1: Shortest legal route



Type 2: Connected traffic safe route (allows for 1 percent unsafe track)

- Type 2 soft: Allows unsafe tracks (but only if there is no other way)

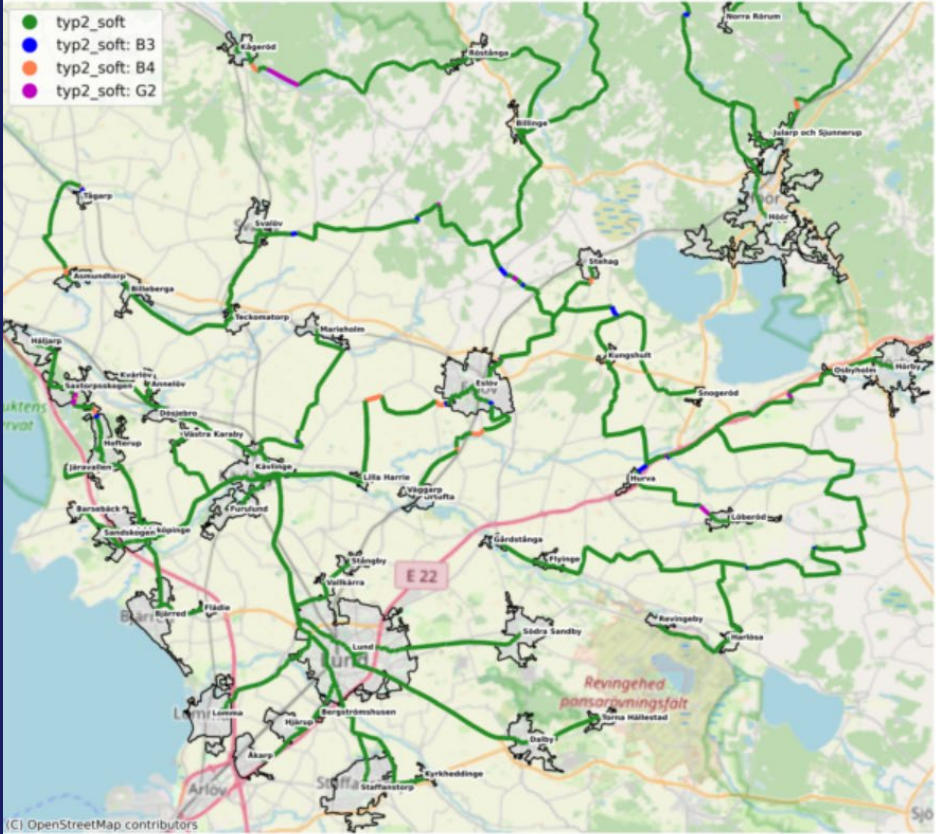


Type 3: Shortest car route

Objective

Provide the project group with a single table with multiple indicators derived from different assumptions and hyperparameters.

Each row is an origin-destination pair with different distance measures depending on the restrictions we assert on the model to find the nearest route.



Data per tätort för 53 relationer.

centralort	tatort	bef_central	bef_tatort	typ1	typ2	typ2_soft	typ3	typ0/typ1
Eslöv	Vallkärra	19,794	421	16,192.8403	None	27,714.9415	16,417.5464	0.8363
Eslöv	Röstånga	19,794	927	21,709.1254	None	31,012.8804	21,711.8691	0.827
Eslöv	Hörby	19,794	7,692	24,463.2795	None	40,500.9663	25,580.3965	0.9325
Eslöv	Bergströmshu	19,794	403	23,200.2806	None	32,427.7417	24,586.3541	0.8512
Eslöv	Flädie	19,794	244	24,517.5725	None	32,490.1164	24,658.1627	0.7804
Eslöv	Lomma	19,794	13,772	27,562.9107	None	34,960.4943	27,800.8565	0.8323
Eslöv	Åkarp	19,794	6,359	28,037.5315	None	37,264.9926	29,326.2277	0.8463
Eslöv	Hjärup	19,794	5,675	25,240.114	None	34,474.067	27,483.2407	0.8377

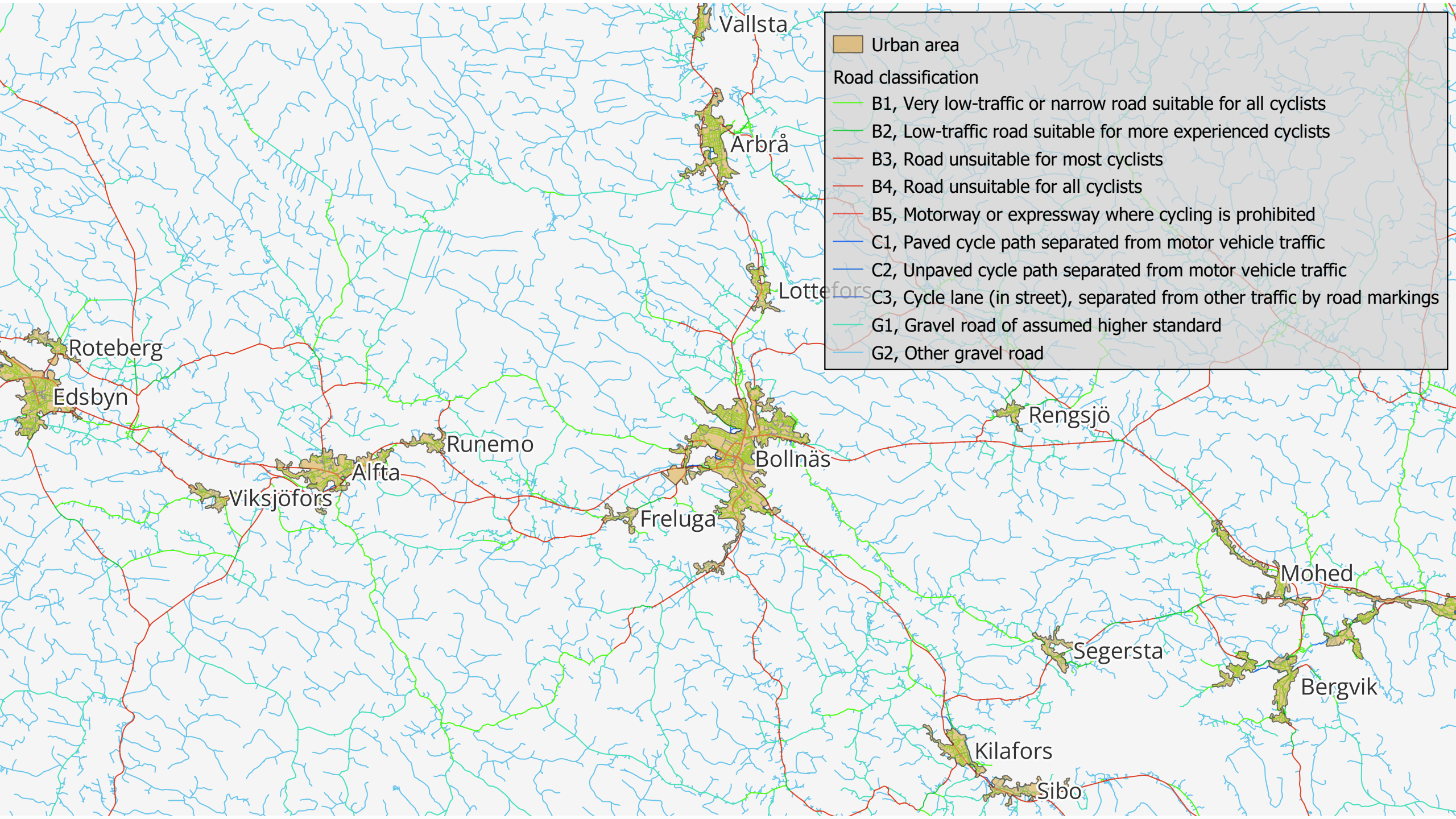
Example: Bollnäs

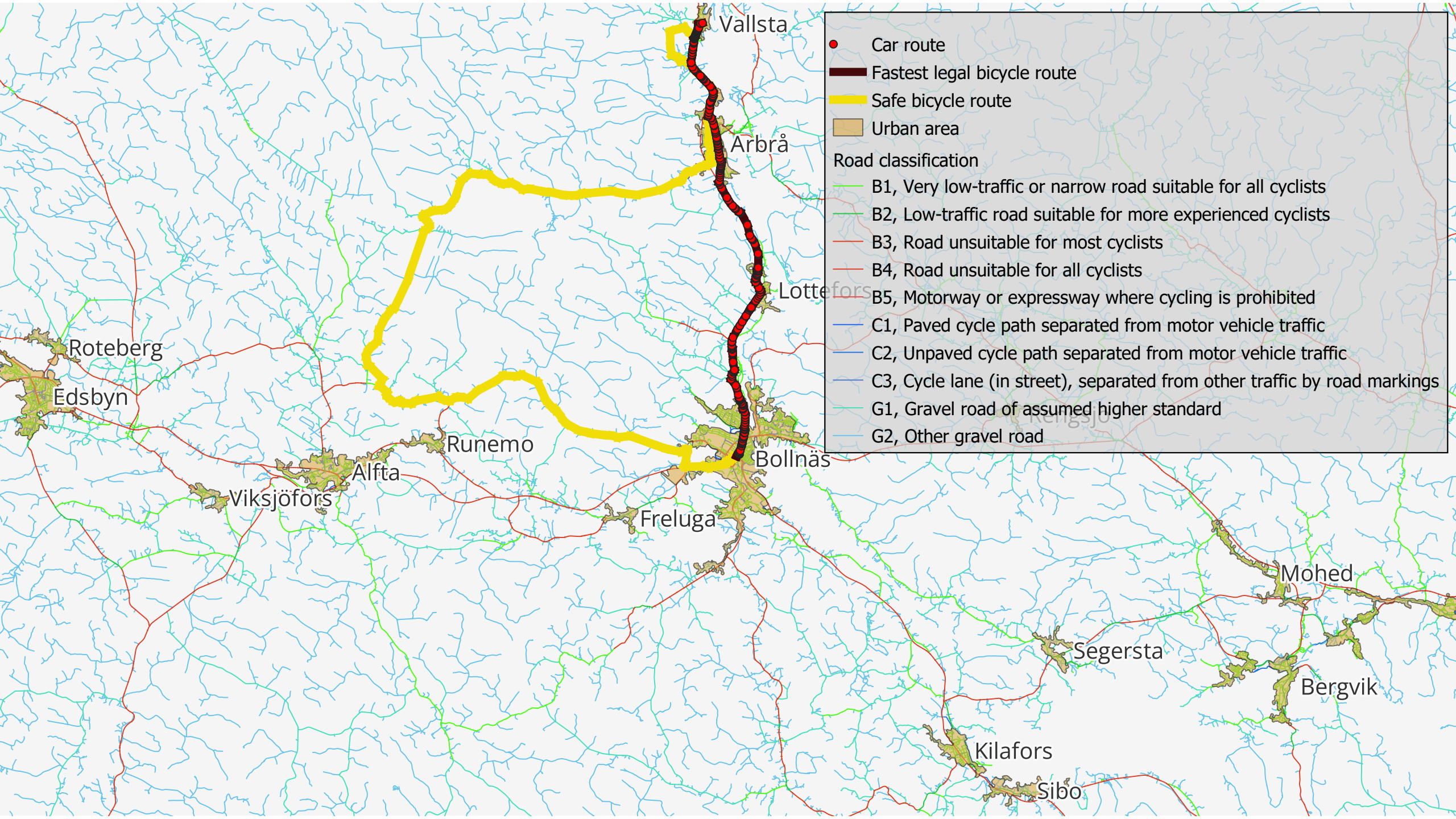
Population in urban center: ~14,000

Neighboring urban areas: 14

- ❖ Bandy (Team: Bollnäs GIF)
- ❖ Bollnäs (medieval) Church
- ❖ Hälsingegårdar – World Heritage Farms
- ❖ Hiking & Scenic Lookouts
- ❖ Epic Nature Trails
- ❖ Växbo Lin (traditionally made linnen factory)

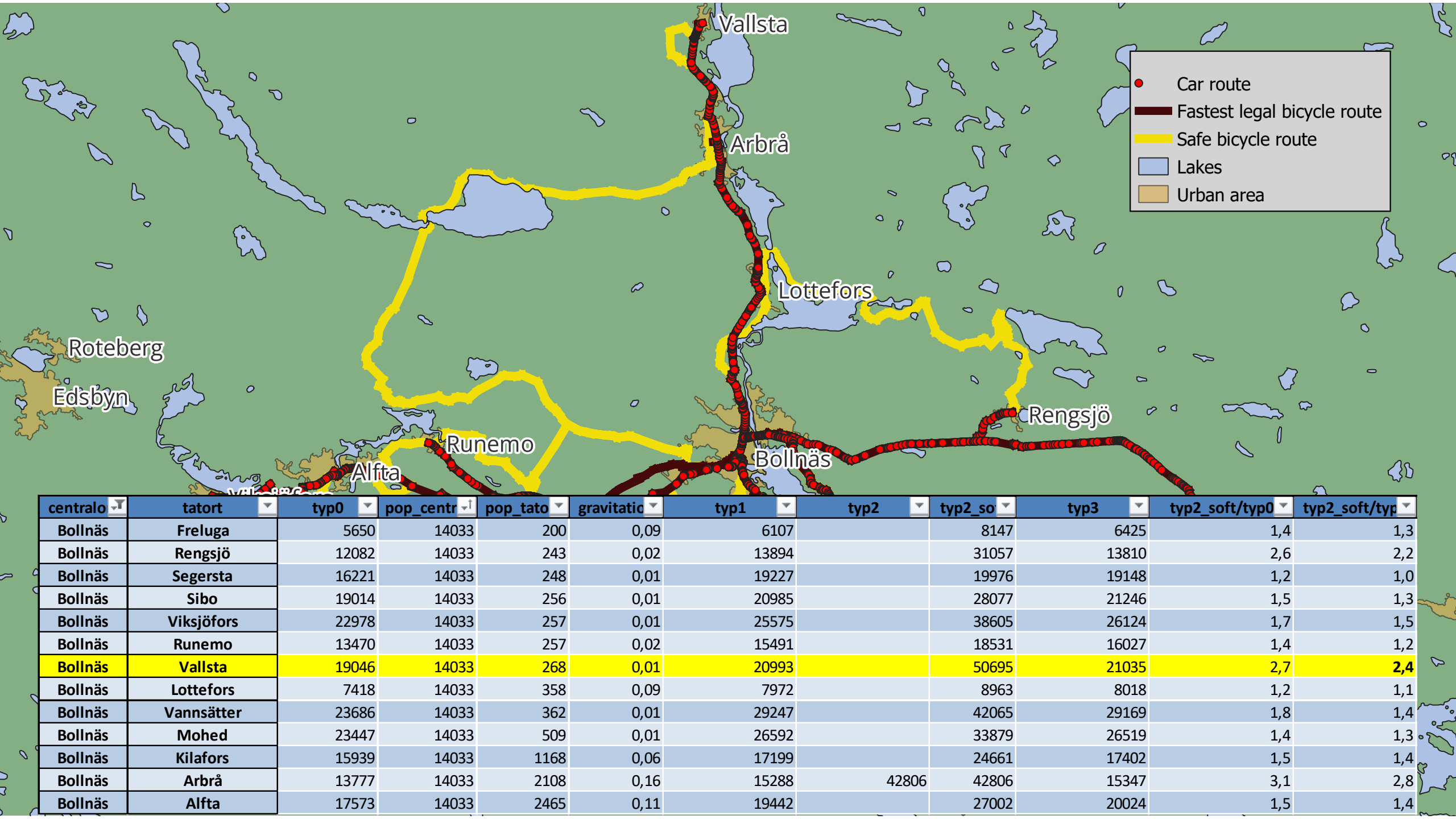








●	Car route
—	Fastest legal bicycle route
—	Safe bicycle route
■	Lakes
■	Urban area



centralo	tatort	typ0	pop_centr	pop_tato	gravitatio	typ1	typ2	typ2_so	typ3	typ2_soft/typ0	typ2_soft/typ
Bollnäs	Freluga	5650	14033	200	0,09	6107		8147	6425	1,4	1,3
Bollnäs	Rengsjö	12082	14033	243	0,02	13894		31057	13810	2,6	2,2
Bollnäs	Segersta	16221	14033	248	0,01	19227		19976	19148	1,2	1,0
Bollnäs	Sibo	19014	14033	256	0,01	20985		28077	21246	1,5	1,3
Bollnäs	Viksjöfors	22978	14033	257	0,01	25575		38605	26124	1,7	1,5
Bollnäs	Runemo	13470	14033	257	0,02	15491		18531	16027	1,4	1,2
Bollnäs	Vallsta	19046	14033	268	0,01	20993		50695	21035	2,7	2,4
Bollnäs	Lottefors	7418	14033	358	0,09	7972		8963	8018	1,2	1,1
Bollnäs	Vannsätter	23686	14033	362	0,01	29247		42065	29169	1,8	1,4
Bollnäs	Mohed	23447	14033	509	0,01	26592		33879	26519	1,4	1,3
Bollnäs	Kilafors	15939	14033	1168	0,06	17199		24661	17402	1,5	1,4
Bollnäs	Arbrå	13777	14033	2108	0,16	15288	42806	42806	15347	3,1	2,8
Bollnäs	Alfta	17573	14033	2465	0,11	19442		27002	20024	1,5	1,4

The technical process

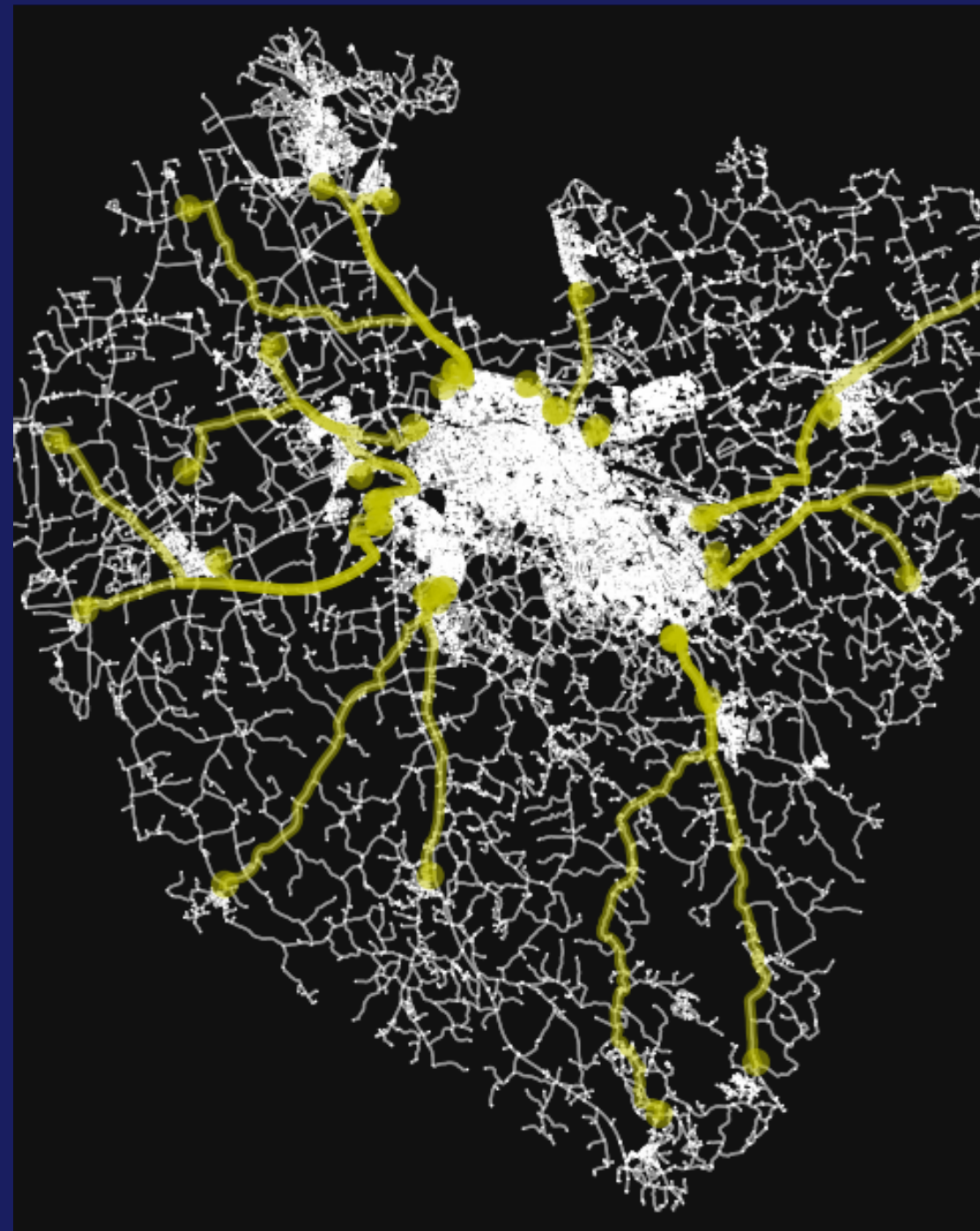
Finding the way and computing the distances

Pathfinding

Geodata consists of a graph of nodes and edges, where each edge represents a section of road and each node an intersection.

A pathfinding algorithm identifies a path between two points in the graph that minimizes the sum of edge weights. The resulting path is a set of edges.

The weight of an edge is variable, which allows us to influence the type of routes that are found.



Edge Weights

While length is the usual edge weight, we use different weights to suit various needs. Non-bike paths get infinite weight to keep routes on bike paths, and a small penalty based on road quality helps distinguish similar-length roads. We created multiple weight sets allowing different levels of low road quality.



Edges to variables

Different aggregations over edge sets are used to compute the final variables.

Conditional sums based on edge labels help calculate ownership shares and the distribution of various road types.

More complex queries can also be applied, such as determining state ownership of low-quality sections of a bike route when the car route is significantly shorter.



Process for every origin-destination pair

- Find the nodes closest to the center of both urban areas.
- Run the pathfinding algorithm with the different edge weights.
- From the sets of edges compute the variables.
- Concatenate to a single row.

centralort	tatort	bef_central	gravitation	bef_tatort	typ1	typ2	typ3
Mölnlycke	Olofstorp	18,392	0.3008	4,146	23,781.983	23,528.9894	25,50
Piteå	Hortlax	23,934	1.1826	1,085	6,232.8955	6,192.4464	7,608
Staffanstorp	Vallkärra	16,854	0.0558	421	13,005.4633	12,930.6664	12,755
Linköping	Tallboda	115,682	20.368	3,334	5,648.6657	5,621.8154	5,851
Linköping	Ekängen	115,682	4.8928	2,698	8,914.4599	8,887.6097	9,198
Köping	Kolsva	18,720	0.3036	2,517	13,063.1724	13,026.5201	13,221
Skellefteå	Ursviken	36,388	1.2997	3,844	11,142.825	11,113.2615	11,807
Skellefteå	Skelleftehamn	36,388	0.5743	3,213	15,516.6483	15,487.0848	16,361
Höganäs	Mölle	16,001	0.0988	575	10,009.1173	9,990.9846	10,628
Torslanda	Olofstorp	22,448	0.1533	4,146	31,024.2025	30,972.0055	29,269
Linköping	Linghem	115,682	3.6955	3,186	12,351.807	12,342.1646	12,843
Stockholm	Jordbro	1,617,407	52.4003	11,607	22,705.9569	22,692.7319	22,269
Kalmar	Smedby	41,852	4.5014	3,730	7,041.2614	7,039.5547	7,607
Vetlanda	Landsbro	13,674	0.1393	1,510	13,321.9692	13,321.9692	14,352
Vetlanda	Ekenässjön	13,674	0.3358	1,545	8,689.0729	8,689.0729	9,215
Lomma	Dalby	13,772	0.3148	6,838	20,318.4865	20,318.4865	20,799
Lomma	Lund	13,772	18.3353	94,393	9,867.7604	9,867.7604	10,013
Lomma	Malmö	13,772	47.1945	325,069	11,276.2513	11,276.2513	11,
Lomma	Bjärred	13,772	3.5104	9,916	6,791.5574	6,791.5574	6,722
Lomma	Löddeköpinge	13,772	0.7804	6,707	12,443.3137	12,443.3137	13,035
Lomma	Sandskogen	13,772	0.0768	730	14,114.0918	14,114.0918	15,733
Lomma	Barsebäck	13,772	0.0762	983	16,175.0007	16,175.0007	17,247

Gravity

To estimate the expected bike traffic for a given route, a physics-inspired heuristic was used, substituting mass with population and taking the square root:

$$\sqrt{\frac{Pop_{src} * Pop_{dst}}{Distance^2}}$$

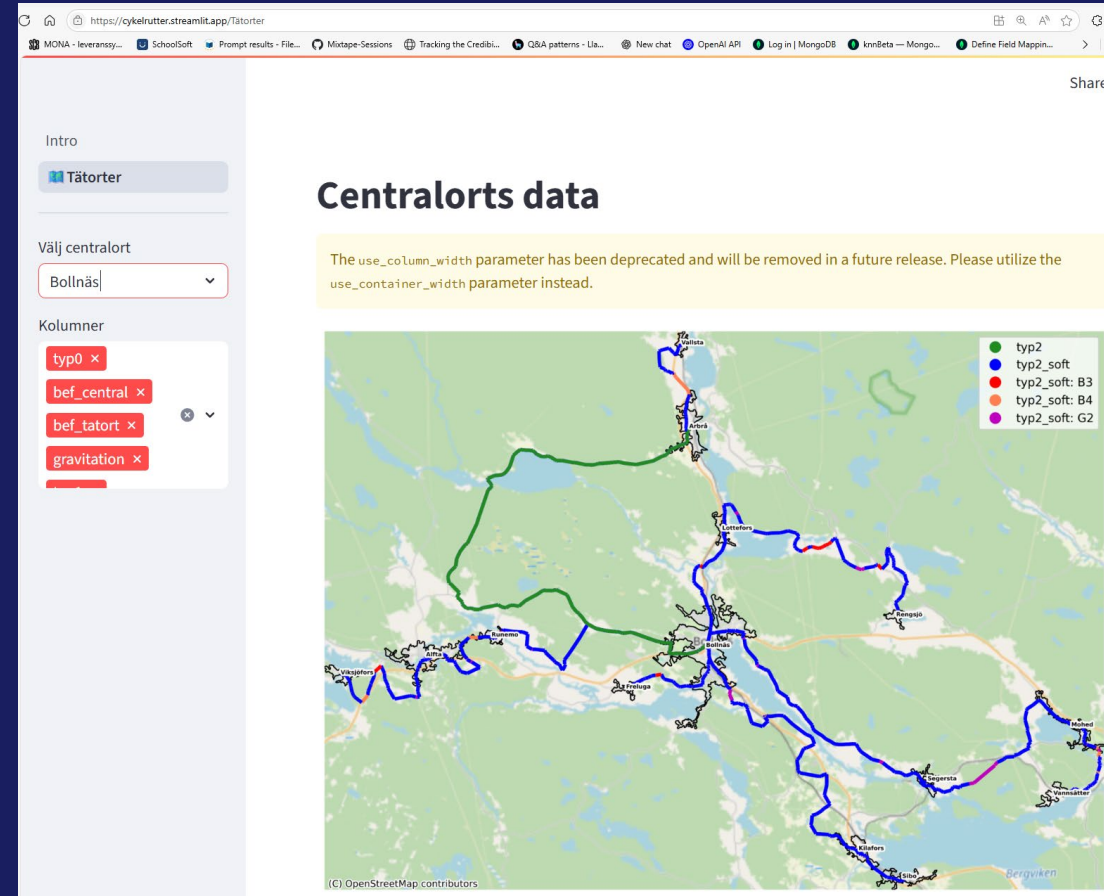
This formula assumes that the likelihood of cycling decreases with distance and that commuting activity is generally higher between larger urban areas.



An app to communicate

There is a lot of assumptions and parameters to try out and test.

An effective tool for Tida to communicate with the project group was through a simple app ([Cykelstudie · Streamlit](https://cykelrutter.streamlit.app/tatortor))



Toolbox

QGIS

Python (main libraries used)

- Geopandas
- OSMnx
- Shapely
- Contextily

Excel

Stata





Some results



Mixed results

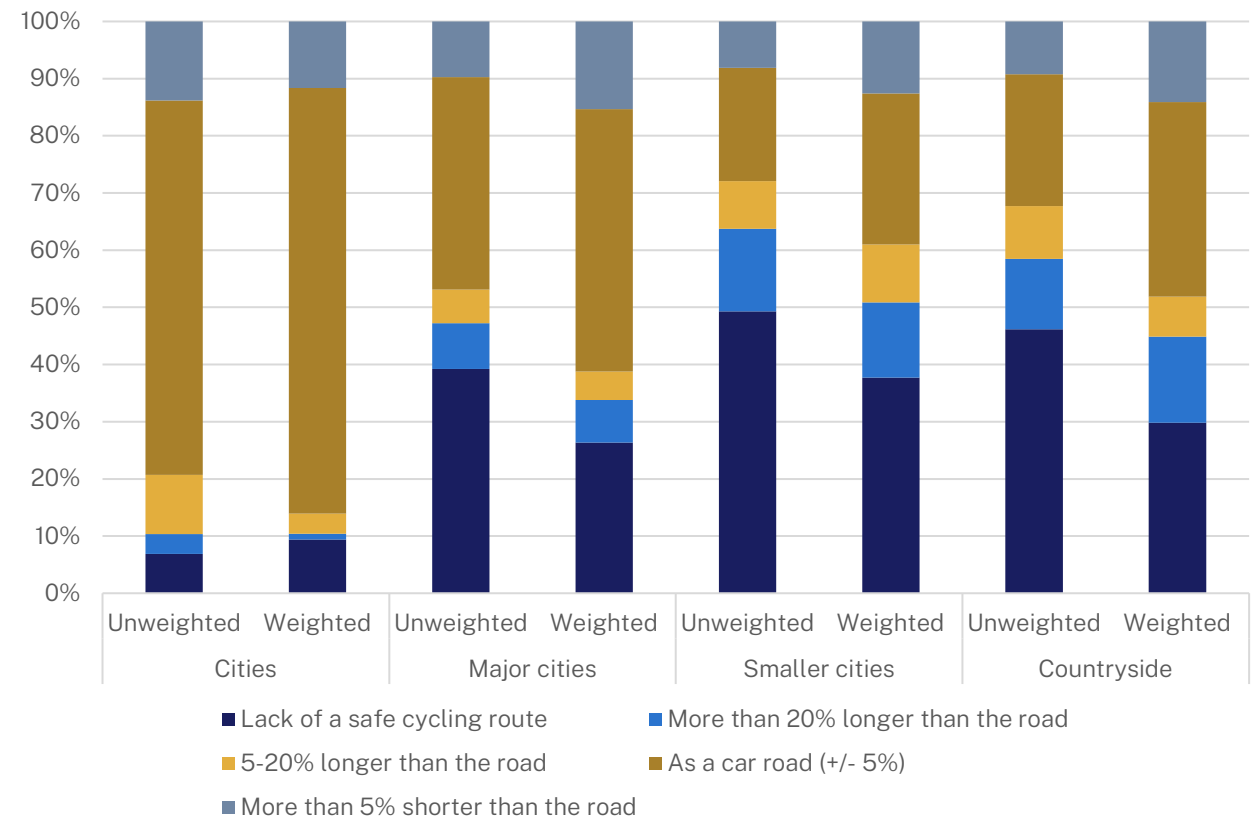
The good

- Best results in the 3 big cities
- Improved result when we account for distance and population, implying that many of the best routes are already built

The bad

- The other city categories (population between 200 000 and ~13 000) are much worse off
- Basic connectivity is missing in 30-50% of the cases

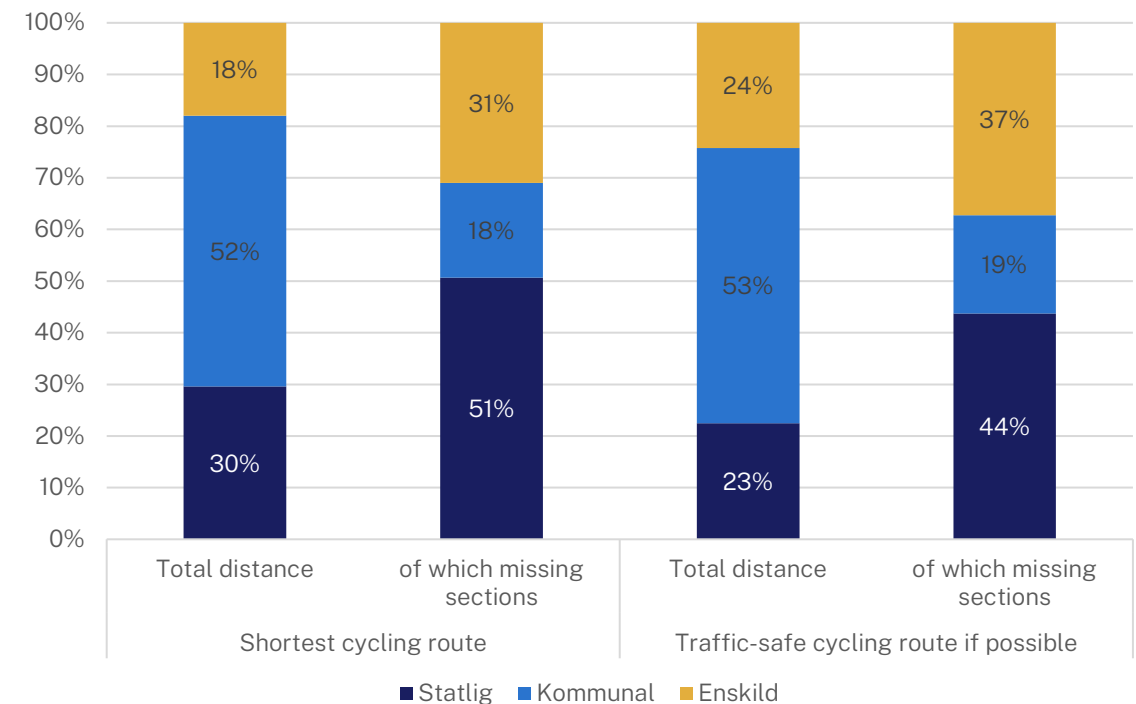
Accessibility on traffic-safe cycling routes, distributed in different areas based on population and within commutable distance (shorter than 12.5 km)



Note: with and without weighting based on the estimated cycling potential

- It is usually in the state infrastructure where the limiting shortcomings are found.
 - The state is responsible for 51 percent of the deficient sections that mean that traffic-safe cycling routes are lacking on the shortest routes between urban areas. Significantly more than the share of the total distance that the state is responsible for (30 percent)

The proportion of state, municipal and private road on the routes where there is no traffic-safe cycle path for commutable distances (within 12.5 km)



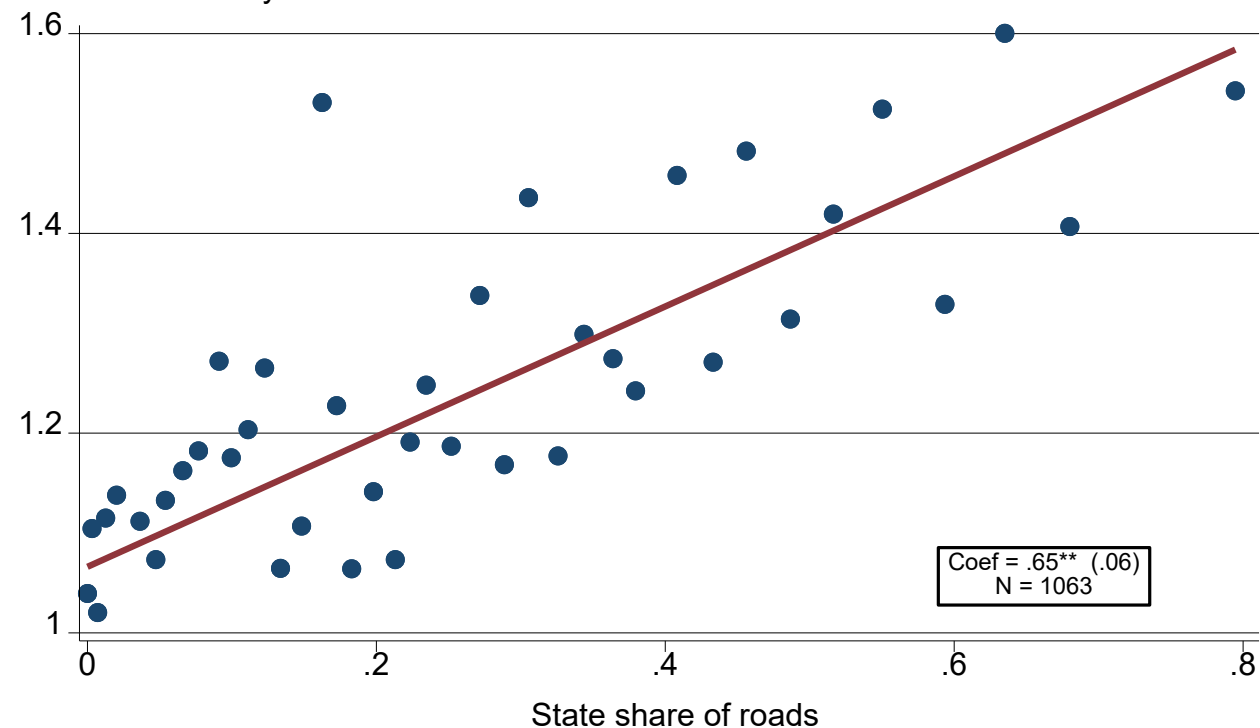
Note: weighting based on the estimated cycling potential

Larger detours correlates positively
with State road responsibility

	under 25 km	under 25 km (unweighted)	under 12.5 km	under 12.5 km (unweighted)
Share of State road	0,652**	0,733**	0,525**	0,568**
	(0,062)	(0,070)	(0,097)	(0,114)
Intercept	1,066**	1,122**	1,060**	1,121**
	(0,017)	(0,025)	(0,024)	(0,036)
Number of observations	1063	1063	462	462

The relationship between the proportion of state road maintenance responsibility (on the shortest cycle route) and the detour on the safe cycle route compared to the shortest cycle route between urban pairs within 25 km, weighted by cycling potential

Detour on a safe cycle route



Headaches

Weighting routes (commuting potential)

- No weights: All roads deemed equally important – aggregated result would be dominated by countryside circumstances
- Weight by gravity: Large urban areas completely dominates result
- $\sqrt{\text{gravity}}$: Dampens the dominance of urban areas
- No weights but grouping on population

Fair start and endpoint

Should routes go to city centre or to the border? What choice will influence bias?