Instituto de la Mexicanidad

Conoce, exige, participa

Innovation in financial risk management for universal coverage

November 2017

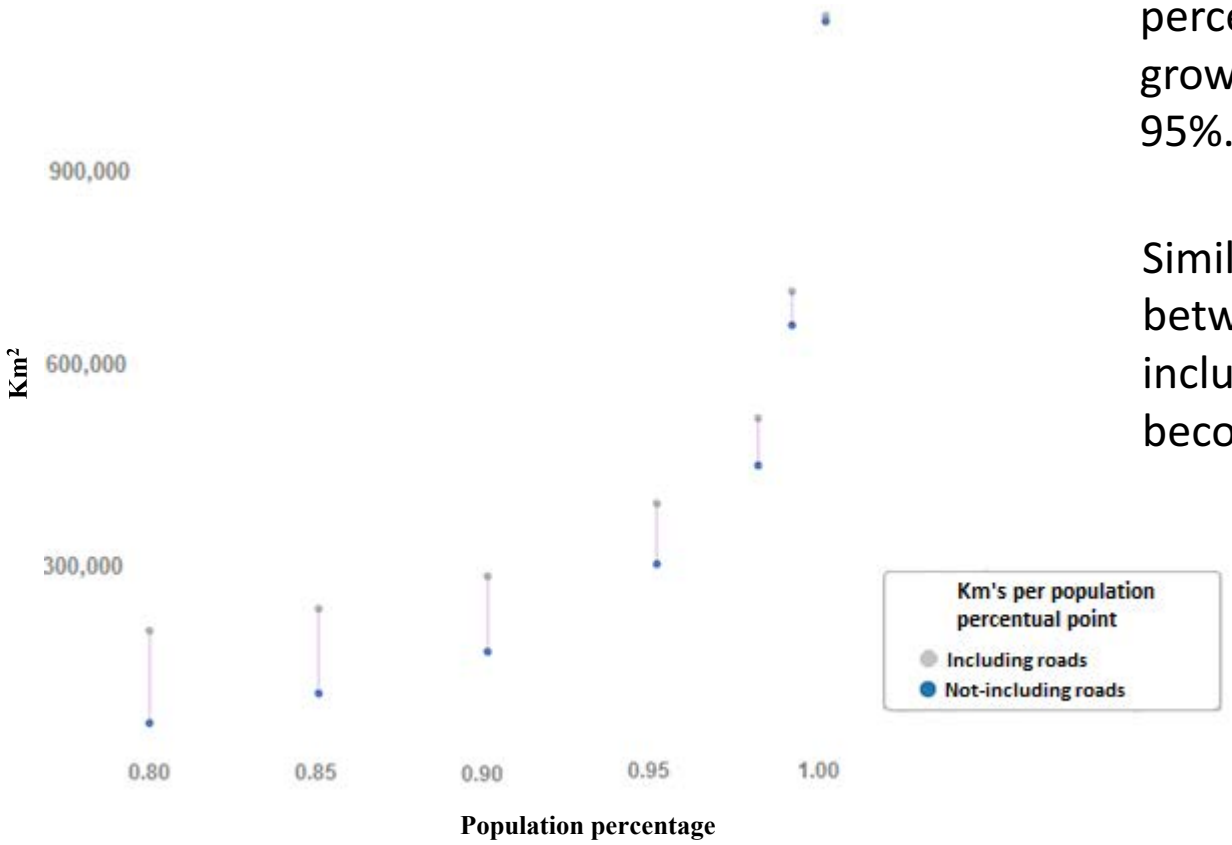
i. Objective and problem definition

Can we realistically cover 100% of the populated surface of Mexico?

iii. Results

% Population	Km²	Growth factor from 80%
100%	**1,121,144**	**16.7**
99%	**664,676**	**9.9**
98%	**454,081**	**6.8**
95%	**305,966**	**4.6**
90%	174,333	**2.6**
85%	111,723	**1.7**
80%	67,159	**1.0**

iii. Trends



The growth in kilometers per percentage of population grows “exponentially” after 95%.

Similarly, the difference between number of km^2 including and excluding roads becomes insignificant.

investment risks

How to cover the last 10%?
What to sell there?
How to fund it?

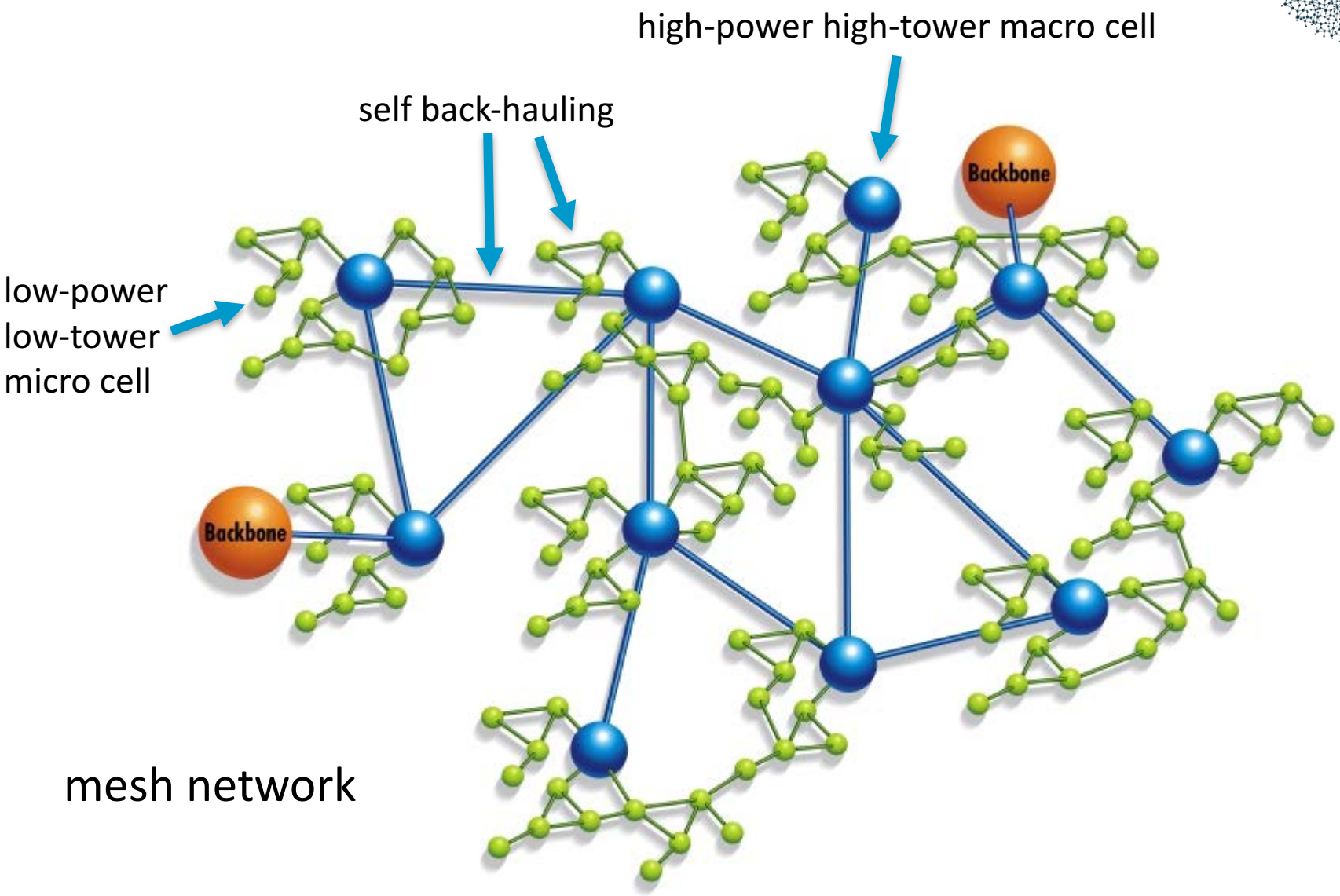
investment risks

How to cover the last 10%?

How to cover the last 10%?

high-power high tower
mesh networks
self back-hauling
voluntary spectrum sharing

How to cover the last 10%?



How to cover the last 10%? The enablers

fixed wireless
quasi-line-of-sight
high-modulation schemes
carrier aggregation

investment risks

What to sell there?

What to sell there?

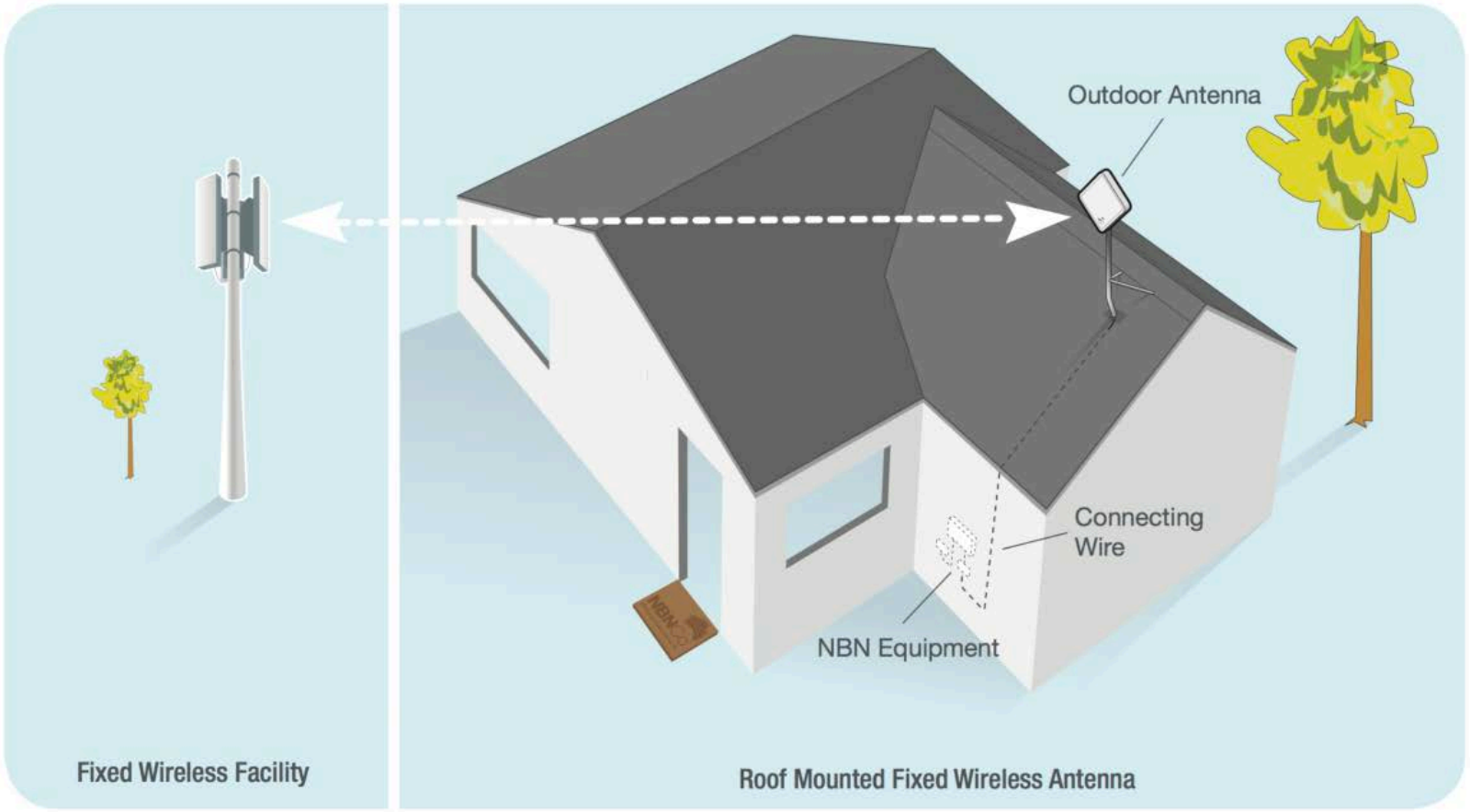
WiFi to the car
fixed broadband
Internet of things

What to sell there?

WiFi to the car

What to sell there?

fixed broadband



What to sell there?

Internet of things

investment risks

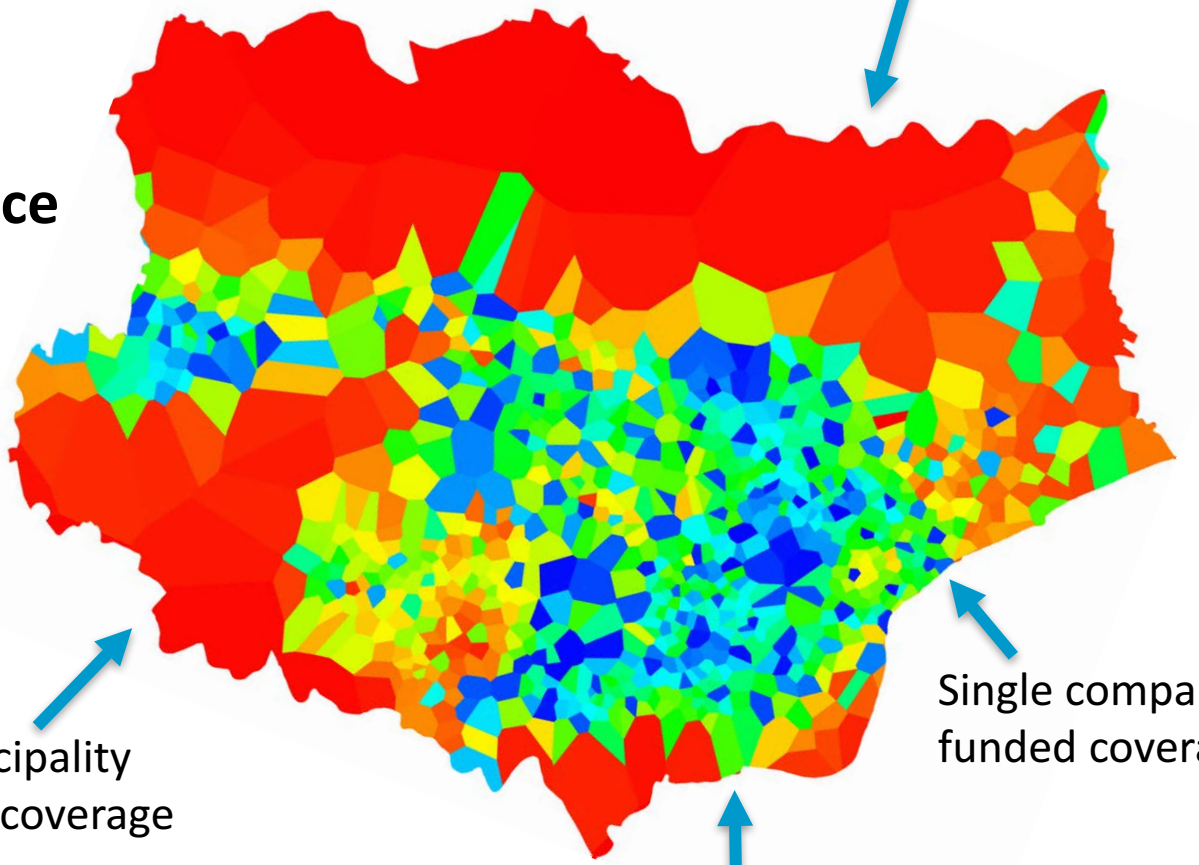
How to fund it?

Commercial risk management: Crowd Funding

Crowd funding

Coverage as a Service

Long term
prepaid wholesale
connectivity



Number crunching

How we got here

Methodology in a nutshell

Make a grid of the country with quadrilaterals

Sort the quadrilaterals in families according to the number of people inside it

Add the surface of the quadrilaterals of each family

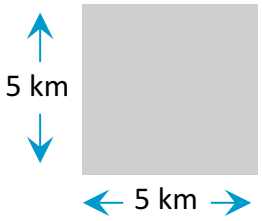
Add the population of the quadrilaterals above each family

Label characteristics of each quadrilaterals

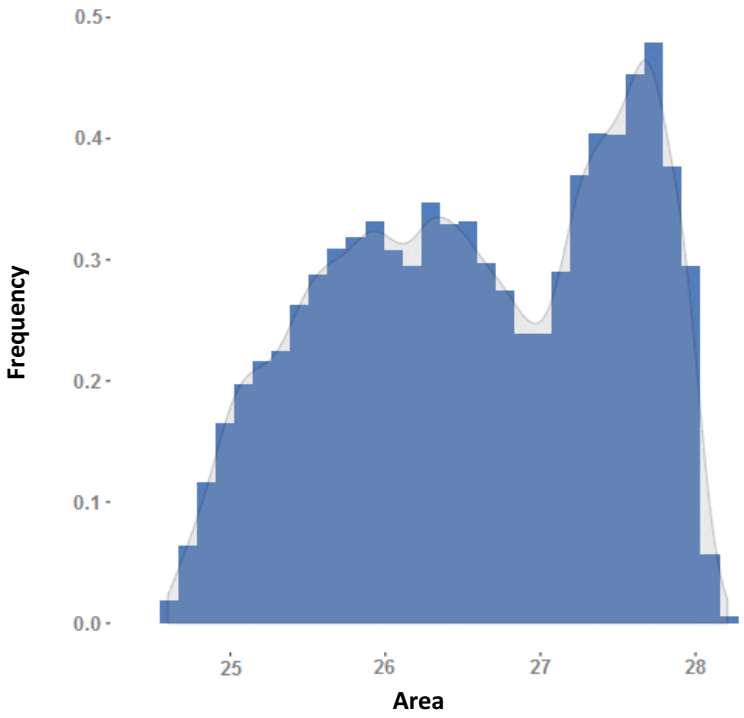
Look for patterns

ii. Methodology

In order to eliminate artificial geographic barriers (i.e. localities or municipalities) the Mexican territory was segmented into uniform square cells of approximately 25 Km^2.



ii. Methodology



Given that Earth's surface is not flat, the surface of each cell varies according to latitude and longitude.

The distribution of the surface of the cells has the following characteristics:

Minimum	24.6 km
1st quartile	25.8 km
Medium	26.6 km
Average	26.6 km
3rd quartile	27.4 km
Maximum	28.2 km

ii. Methodology

To ensure the uniformity of the segments the formula of the large circles was used to define the cutoff points:

$$d = r\Delta\sigma$$

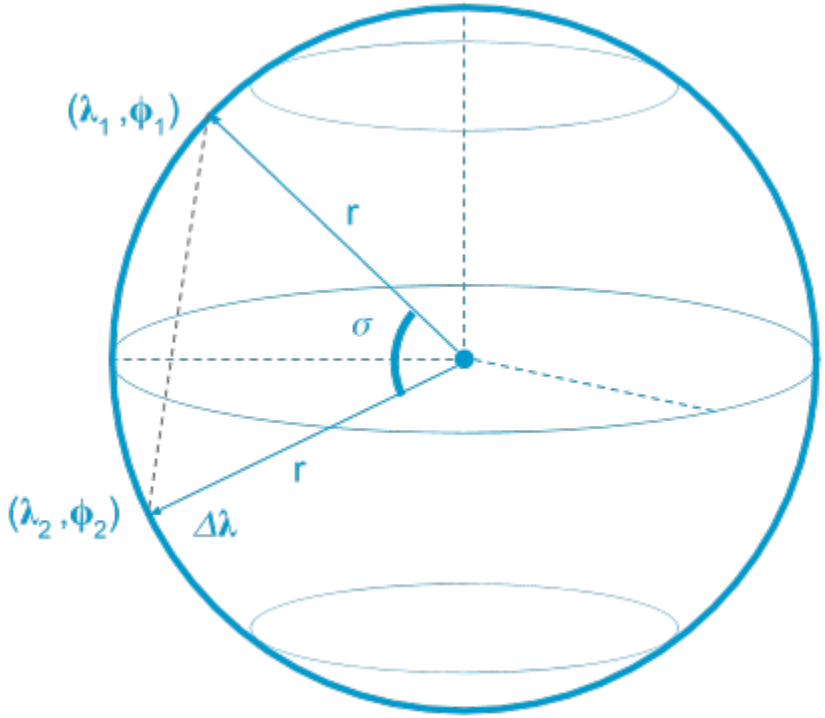
Where

$$\Delta\sigma = \arccos\ (sin\phi_1 \cdot sin\phi_2\ + cos\phi_1 \cdot cos\phi_2\ \cdot \cos(\Delta\lambda))$$

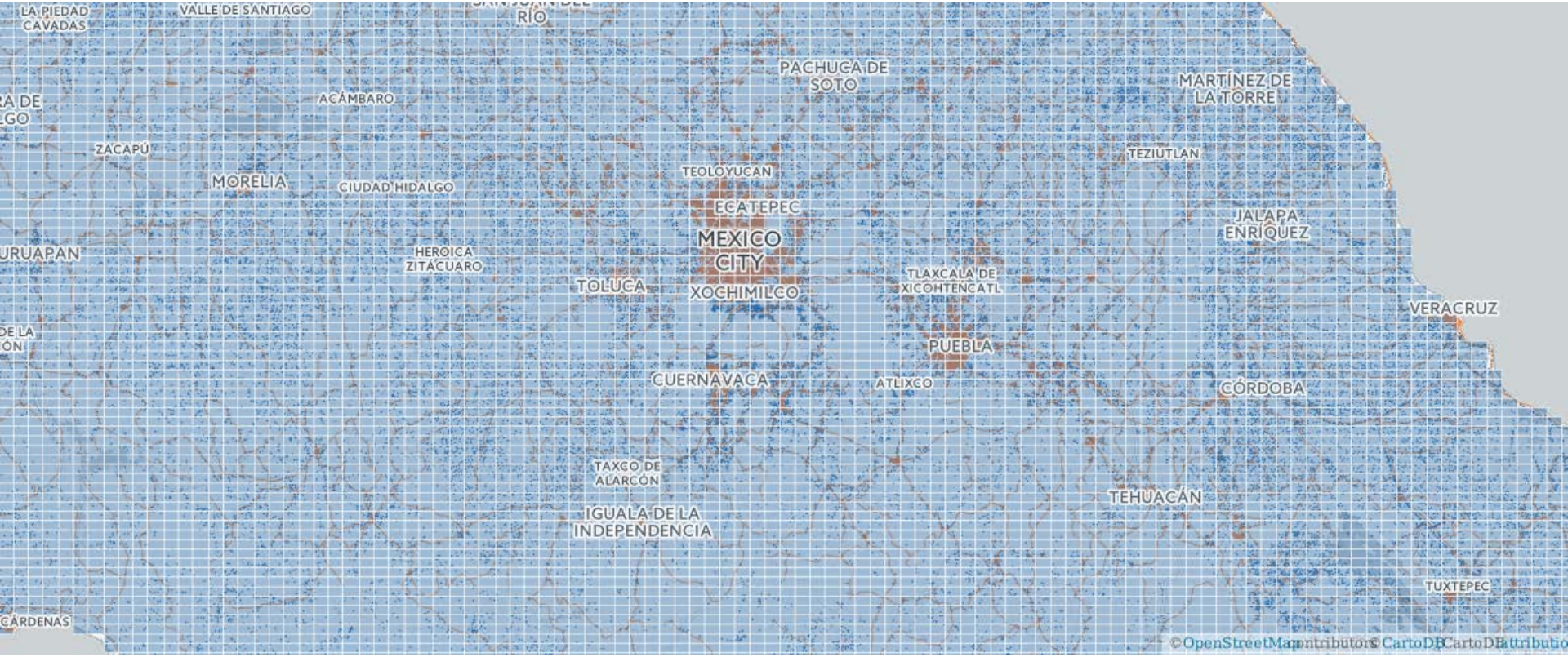
And ϕ_1, λ_1 and ϕ_2, λ_2 are the latitude and longitude of the two points.

ii. Methodology

Graphically:



ii. Methodology



ii. Methodology

ii. Methodology

Each cell is given a population equal to the sum of the populations of all the localities enclosed in it.

This way, we have:
P_c = Population of each cell
p_x = Population of locality x

$$\Rightarrow P_c = \sum_{i=1}^{n} p_i$$

ii. Methodology

Inclusion of federal highways

All the cells that intersect with federal highways are included (figure 3).

In order to avoid duplication, any cell that has both, a population above the desired threshold and an intersection with a highway is included only once in the general calculation.

ii. Methodology

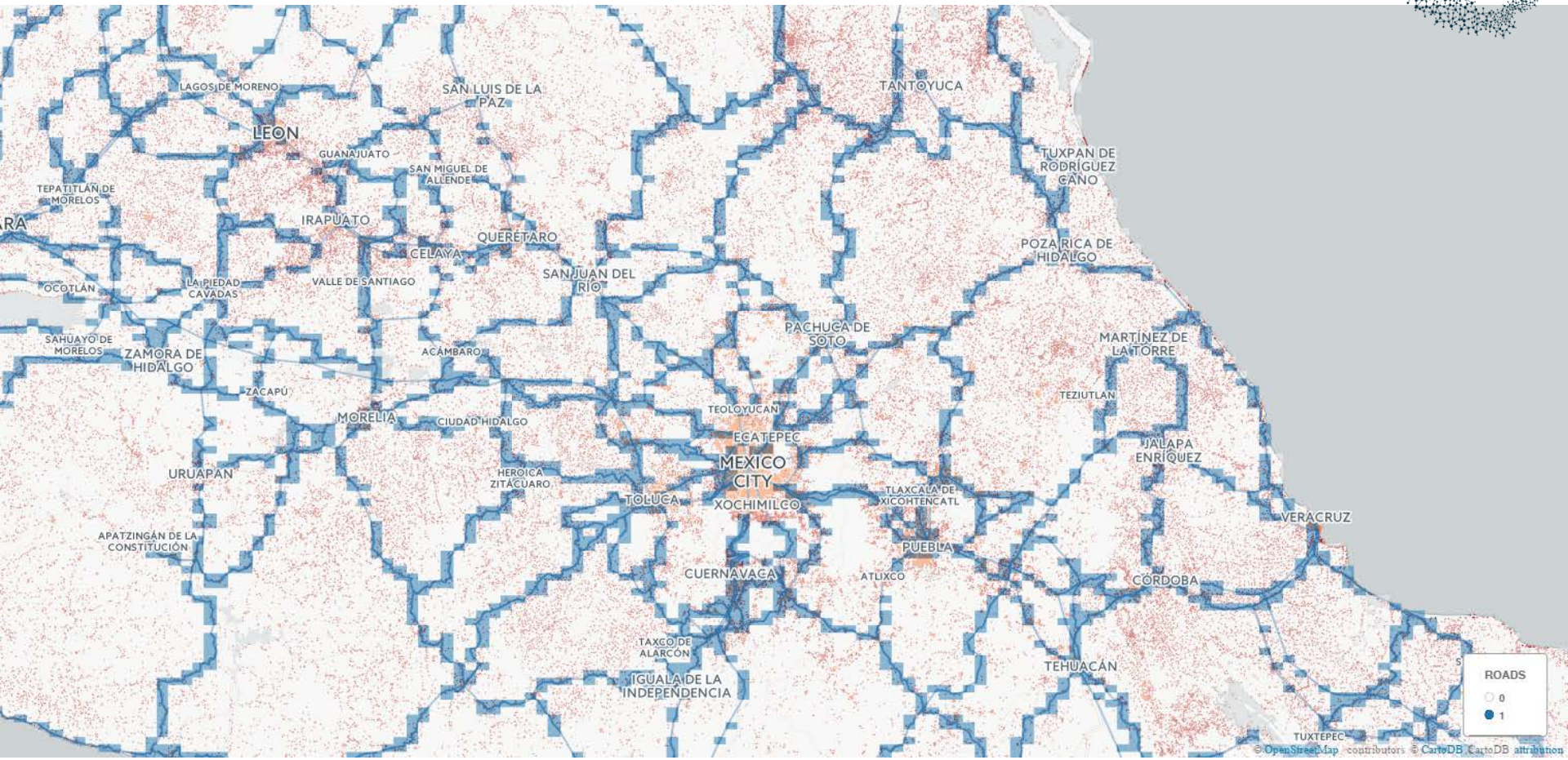
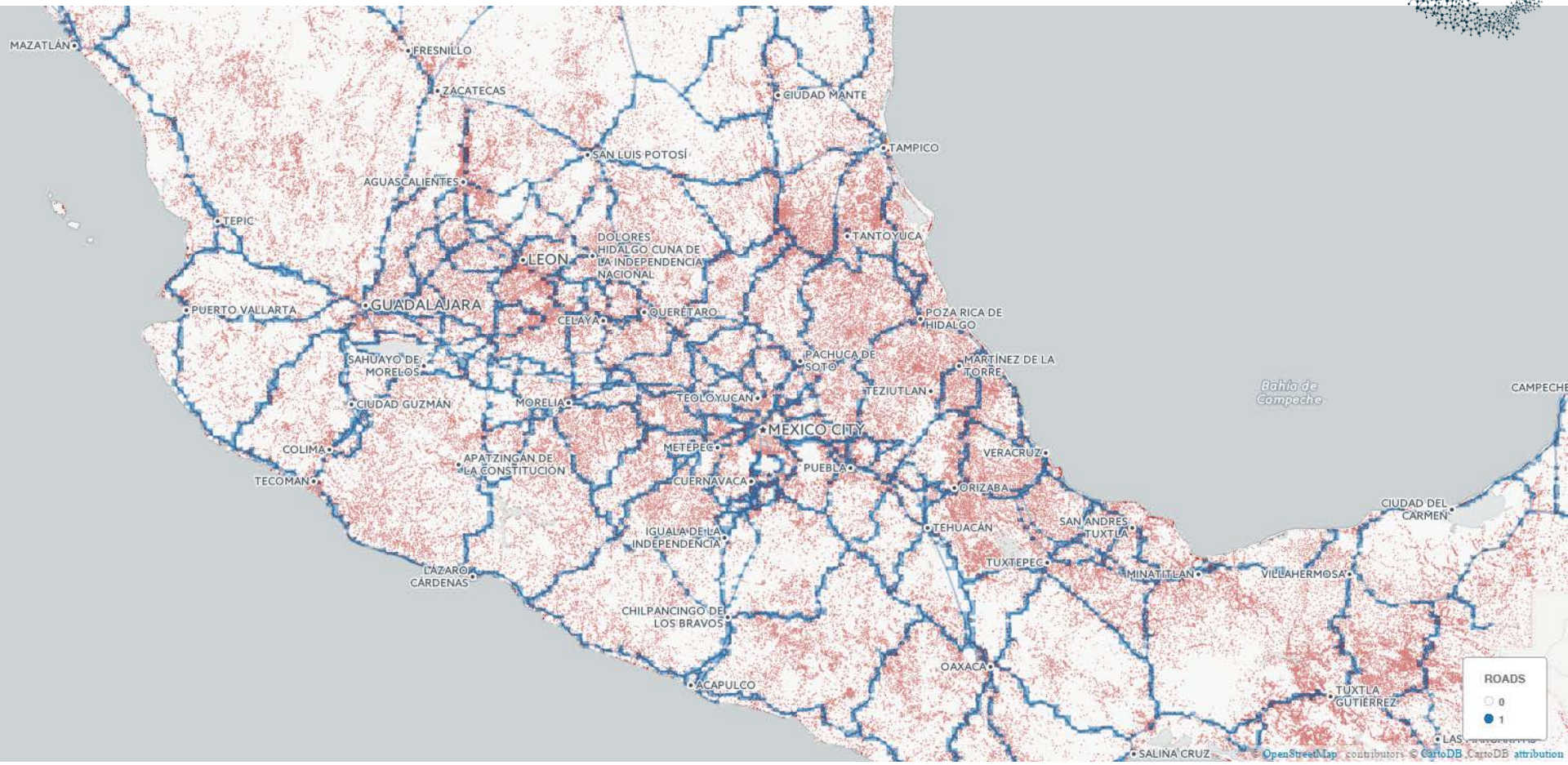


fig. 3

1 2 3 4

Roads inclusion

ii. Methodology



1 2 3 4

Roads inclusion

ii. Methodology

Cell selection according to population criteria.

In order to achieve a coverage of 98% of the population, an iterative approach was carried out.

Every cell containing a population greater or equal than a given threshold was considered as part of the calculation.

Afterwards, the threshold was adjusted in order to meet the coverage percentage.

For example, when the threshold takes the value of 0 all the population is considered.

ii. Methodology

Formally:

If we have that:

X%: percentage of the population to be covered
A_j: area of cell j
k_j: number of locations in the cell j
p_{ji}: population of the location i in cell j
T: total cells covered

ii. Methodology

Formally:

And if $ET_{X\%}$ is the territorial expansion needed to cover the *X*% population. Then:

$$ET_{X\%} = \sum_{j=1}^{T} A_j$$

Where $$T = \underset{t}{argmin} \frac{\sum_{j}^{t} \sum_{i=1}^{k_j} p_{ji}}{PobTot} \geq X\%$$

ii. Methodology

First cut:

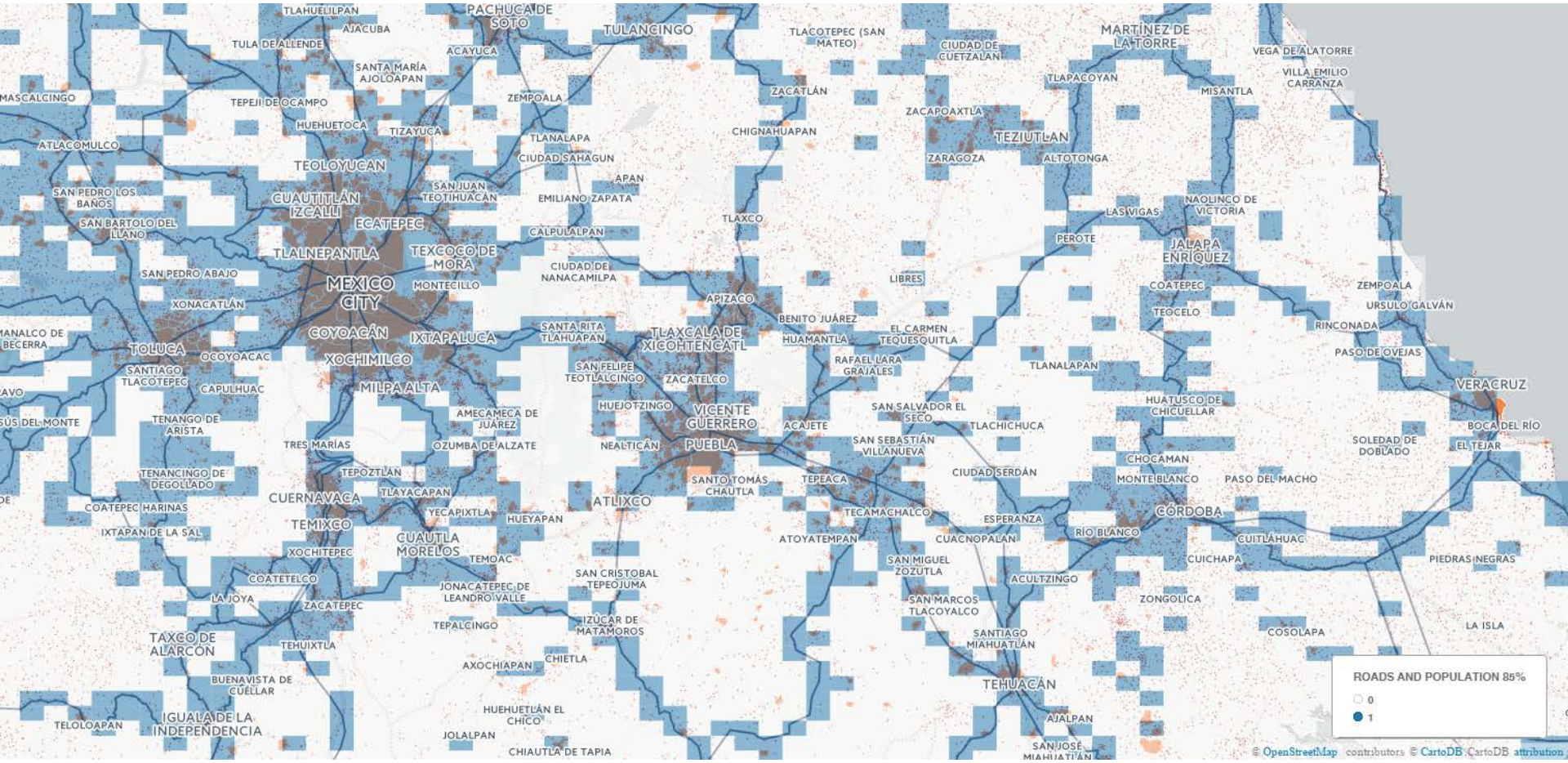
Minimum population per cell: 3,000 inhabitants

Covered population: 85%

Surface (without highways): 111,723.2 km^2

Surface (including highways): 239,139.0 km^2

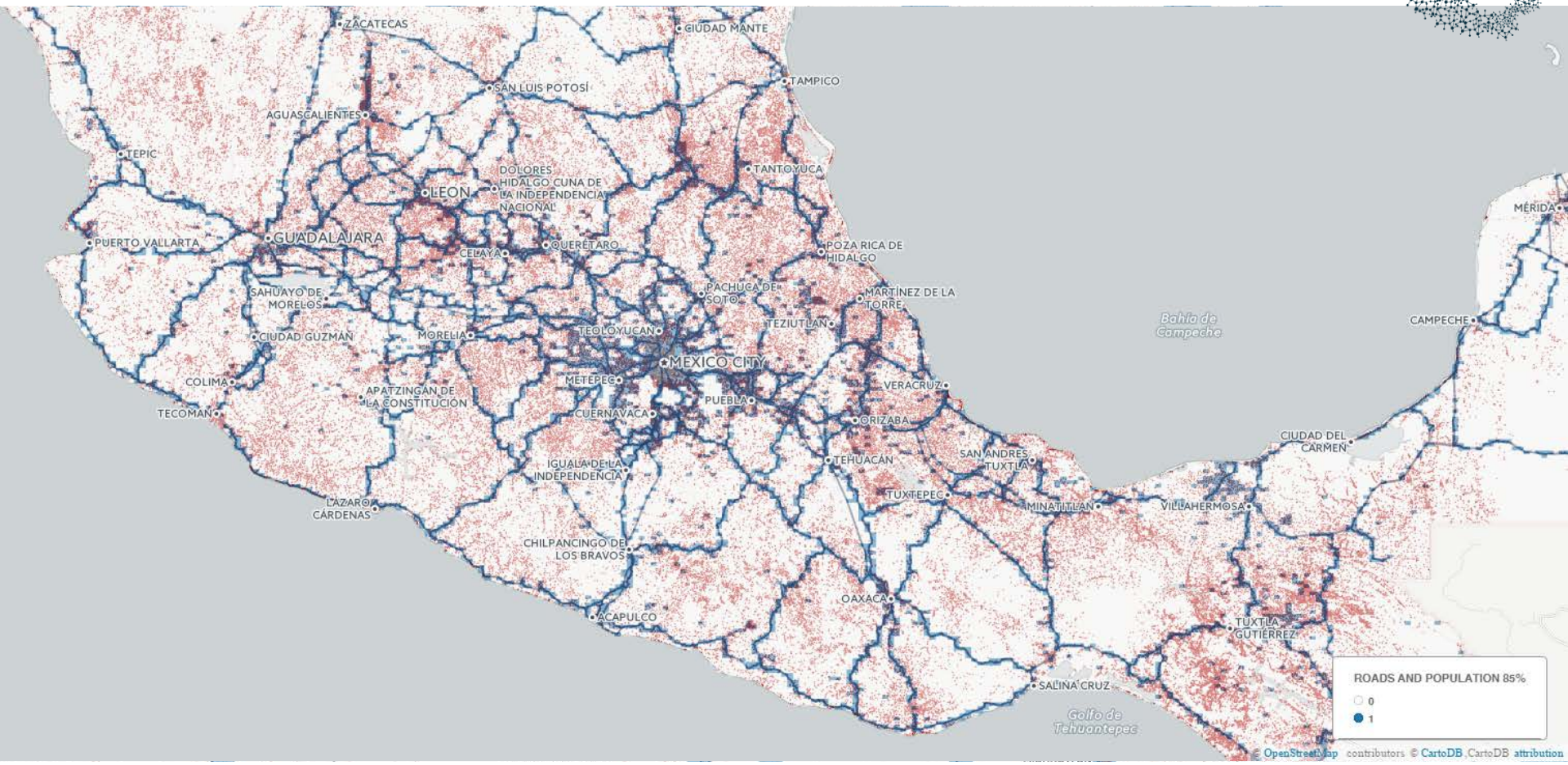
ii. Methodology



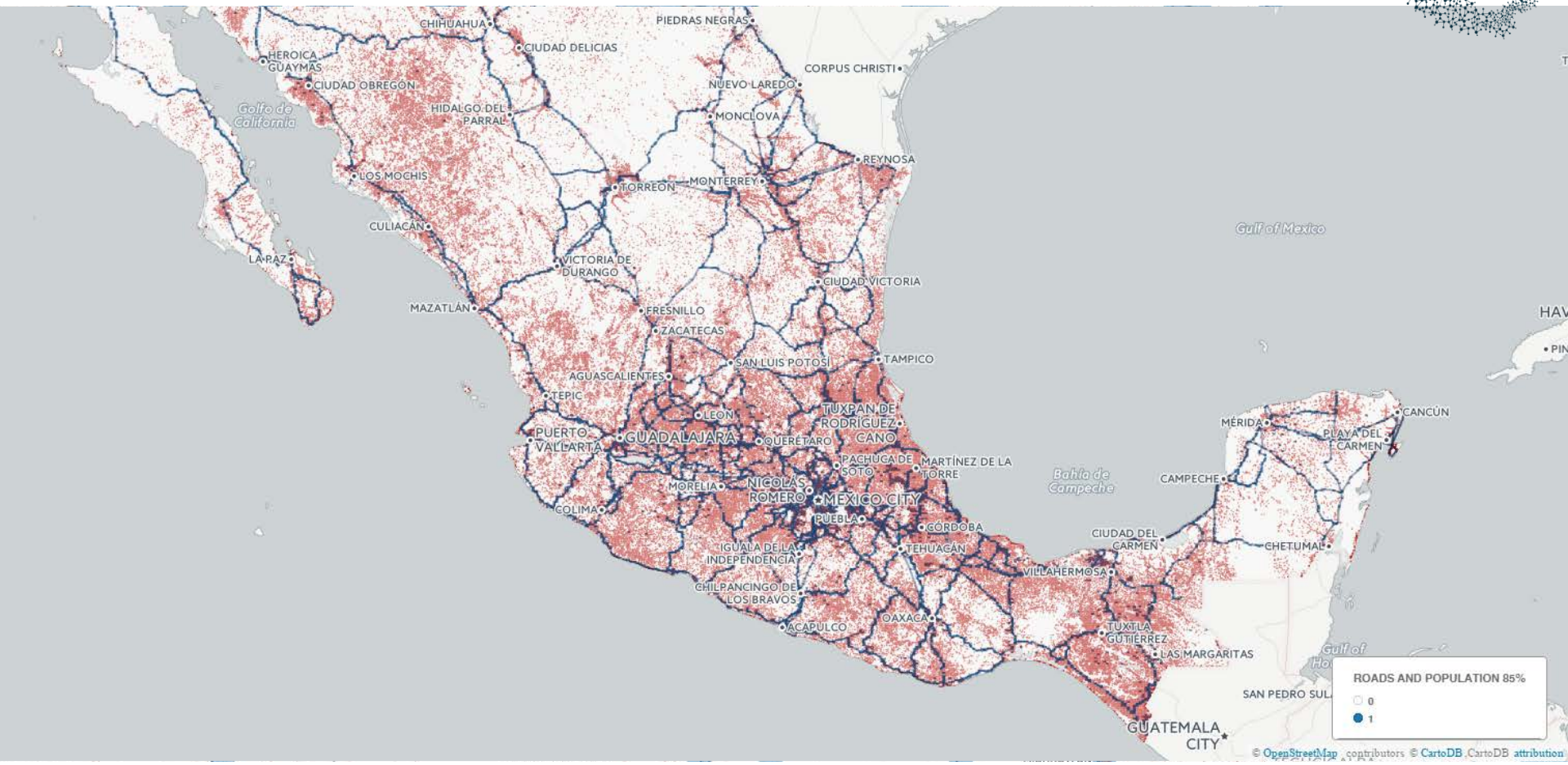
1 2 3 4

Territory-population estimation

ii. Methodology



ii. Methodology



ii. Methodology

Second cut:

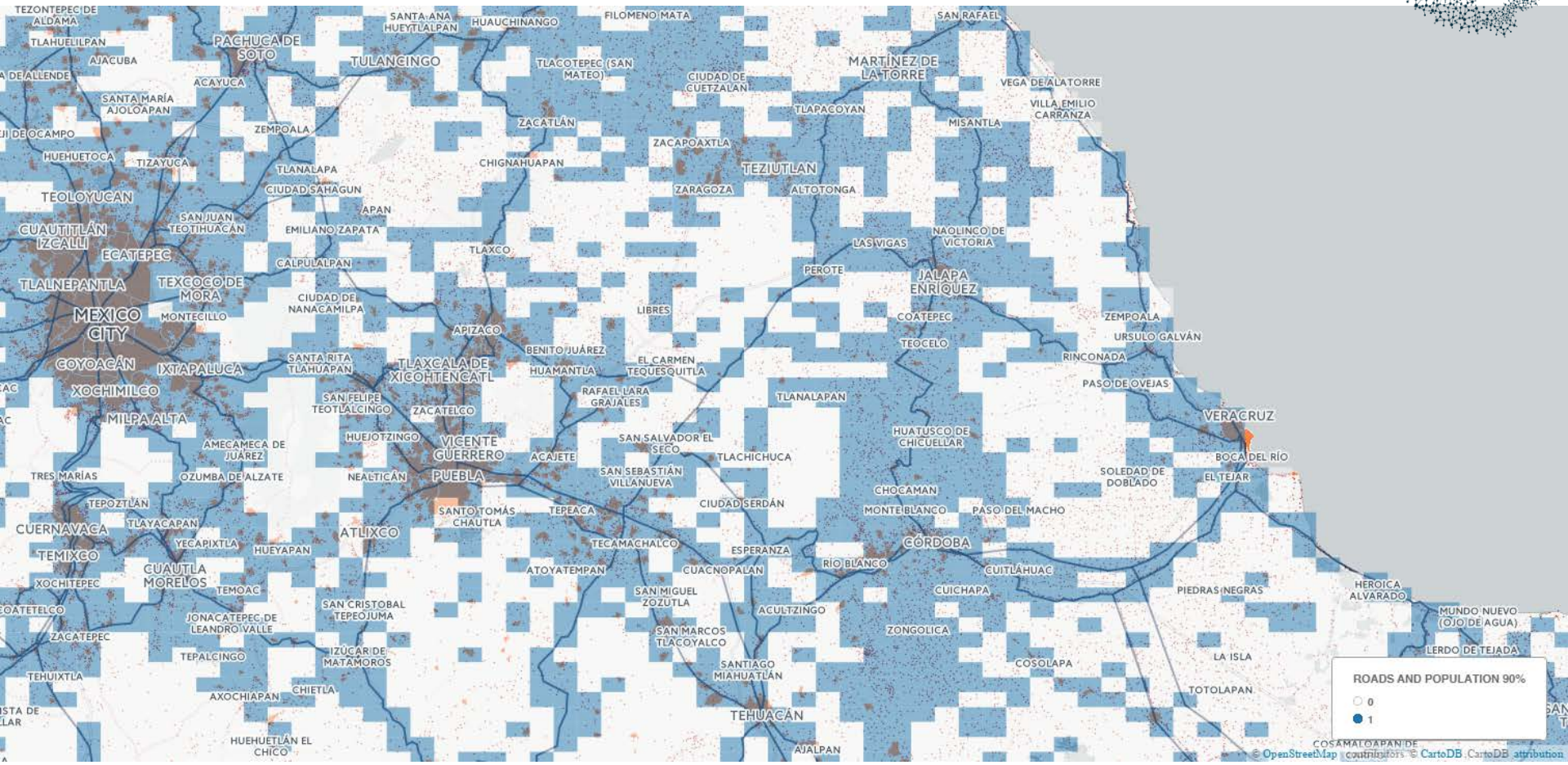
Minimum population per cell: 1,800 inhabitants

Covered population: 90%

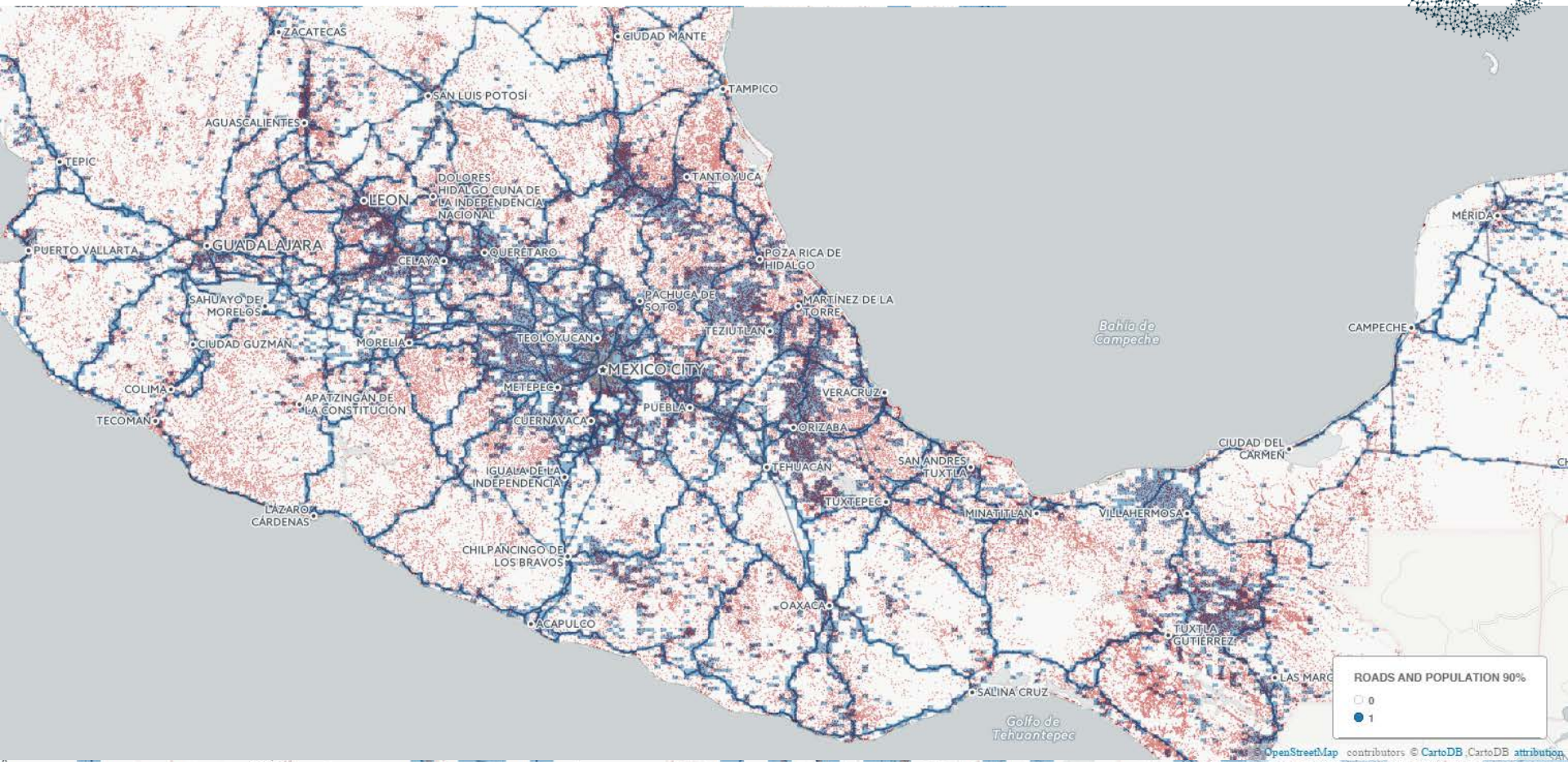
Surface (without highways): 174,333.2 km^2

Surface (including highways): 287,711.2 km^2

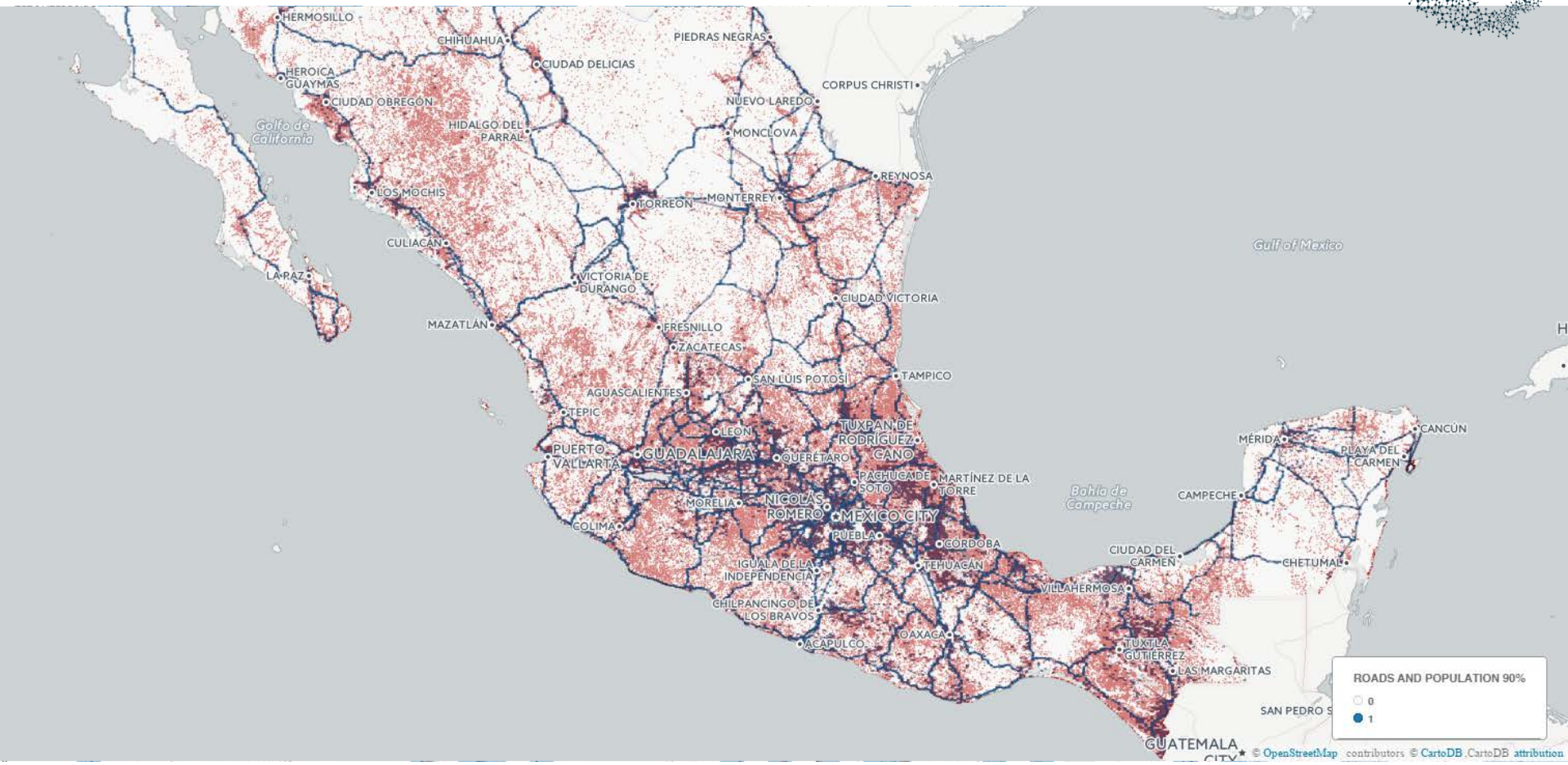
ii. Methodology



ii. Methodology



ii. Methodology



ii. Methodology

Third cut:

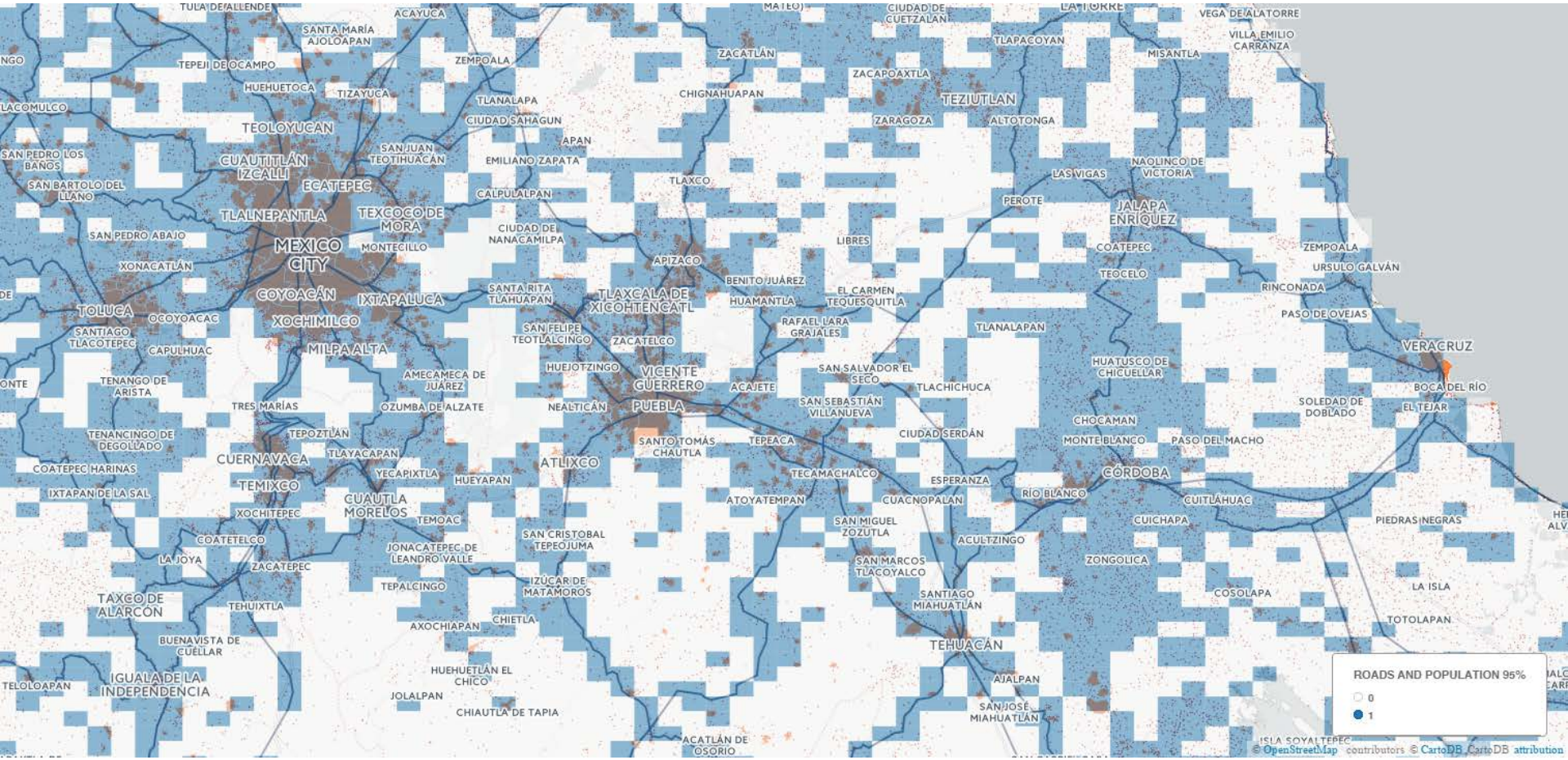
Minimum population per cell: 800 inhabitants

Covered population: 95%

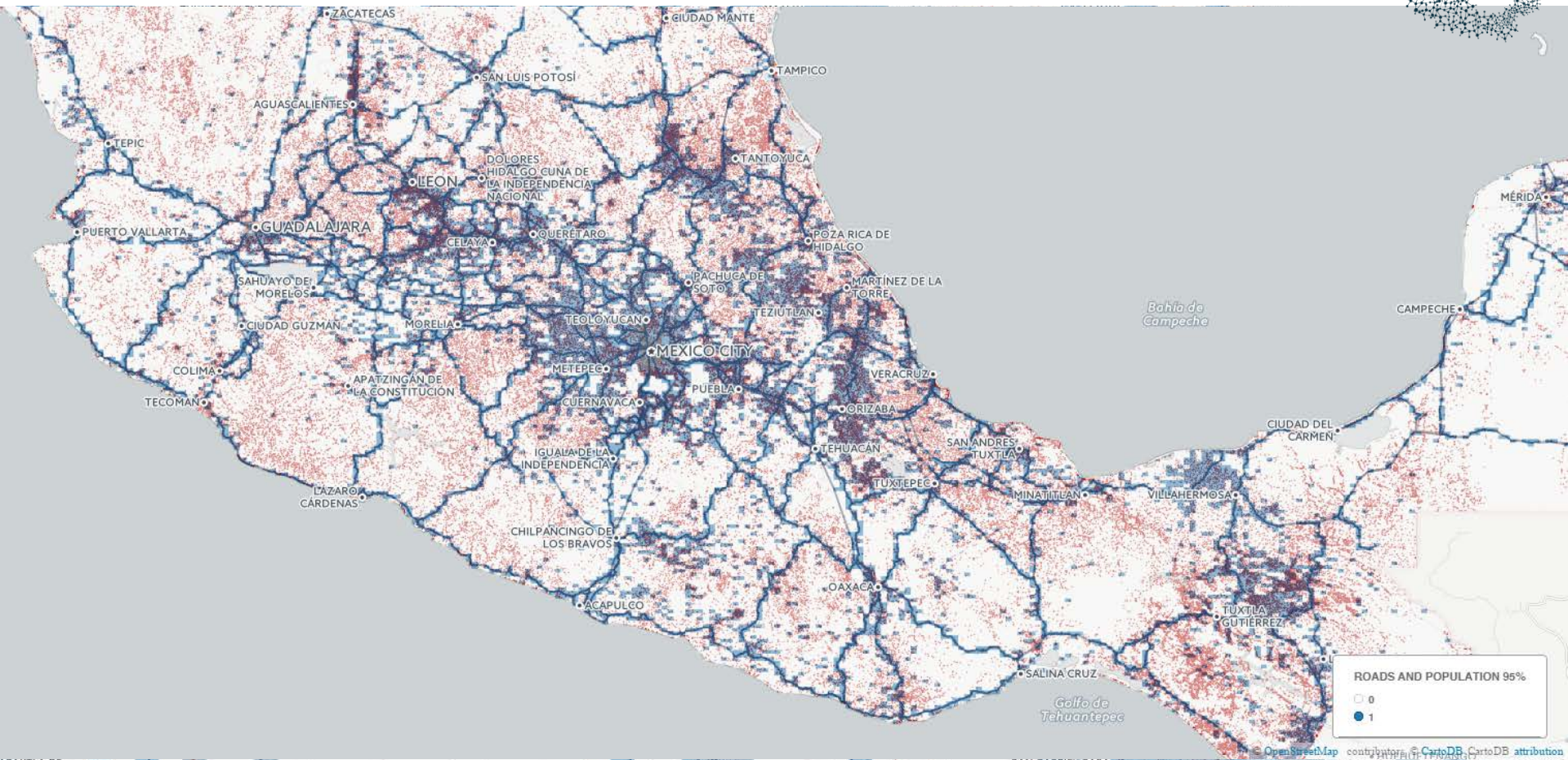
Surface (without highways): 305,966.6 km^2

Surface (including highways): 397,068.3 km^2

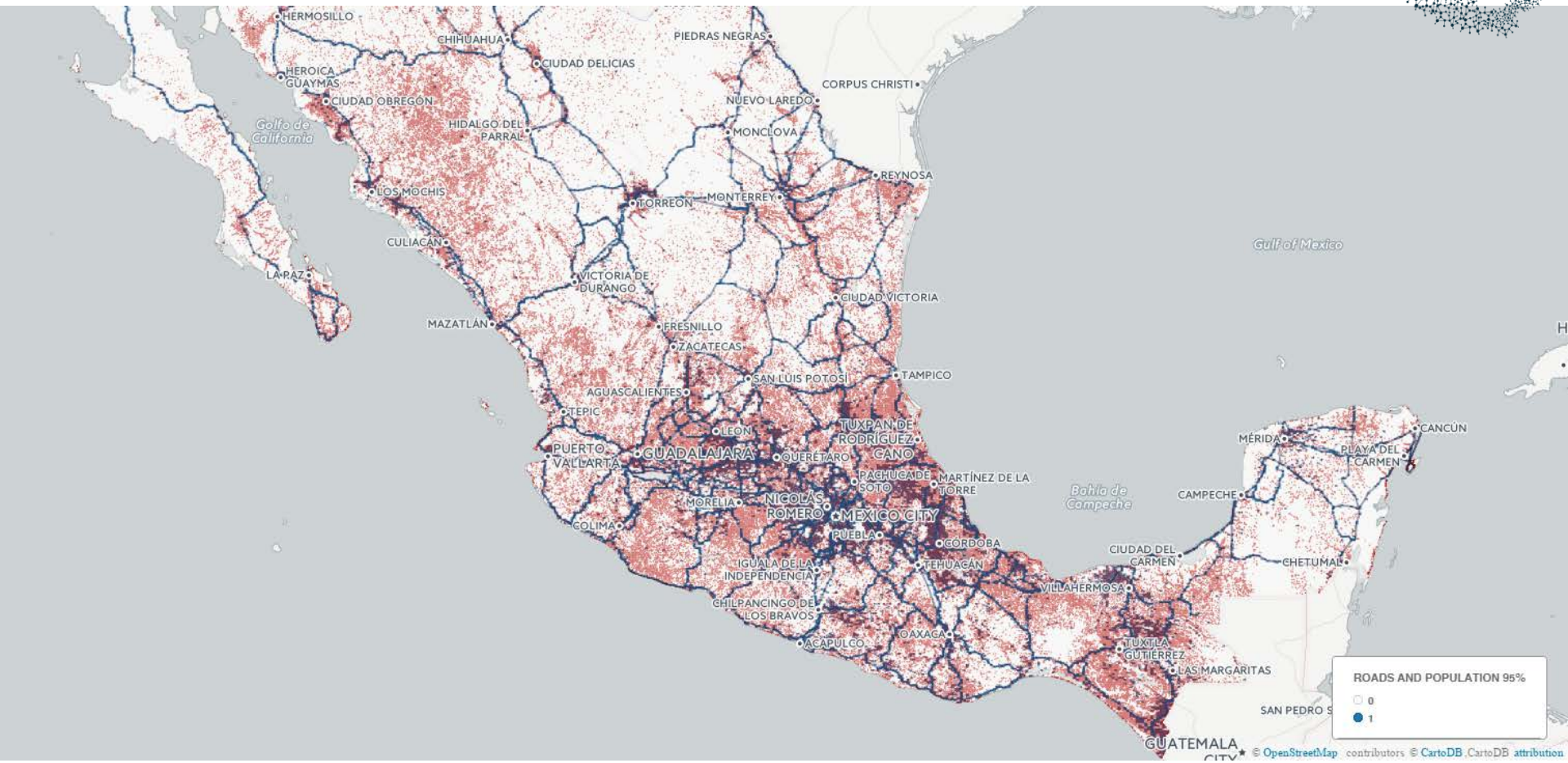
ii. Methodology



ii. Methodology



ii. Methodology



ii. Methodology

Fourth cut:

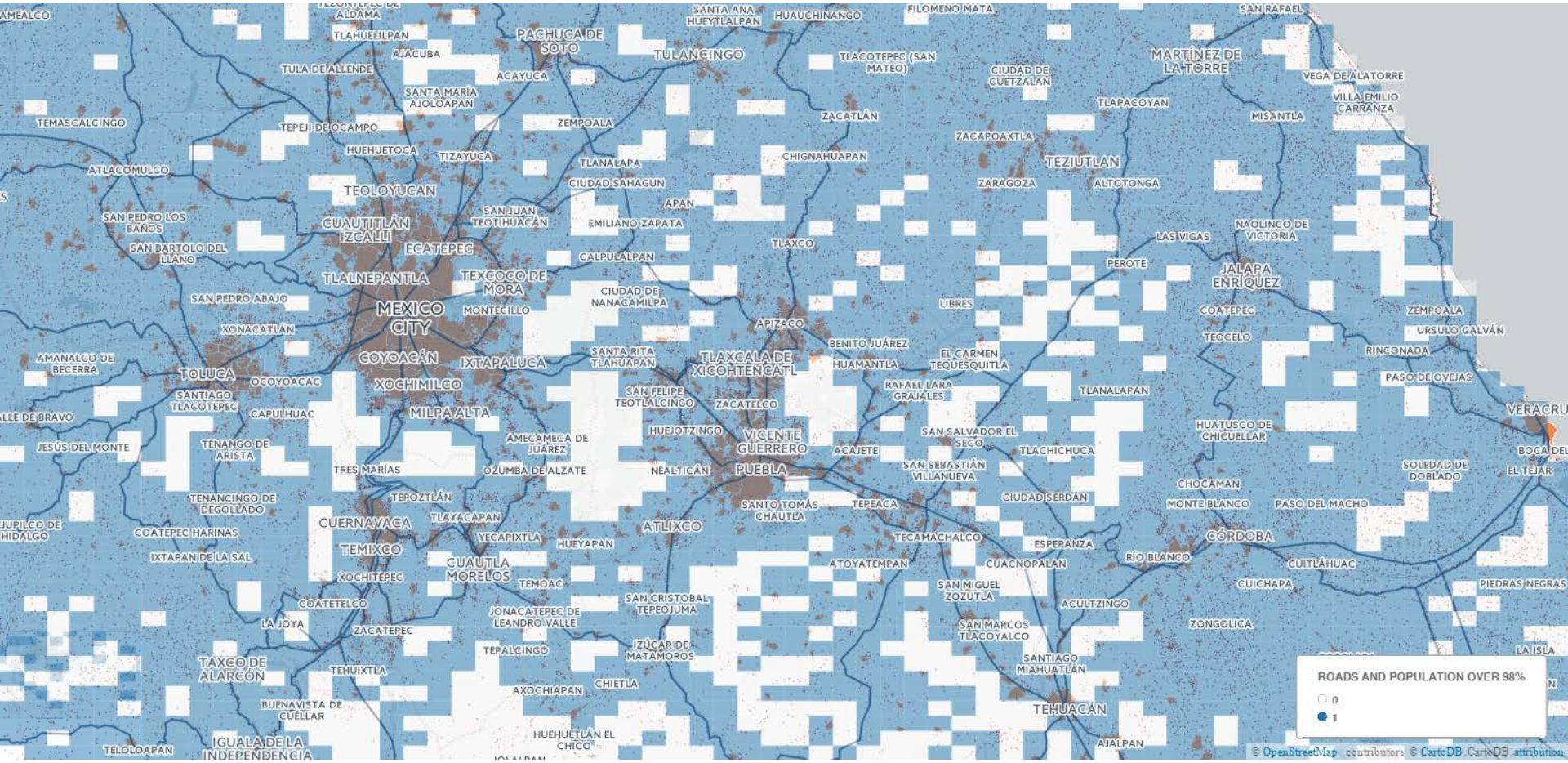
Minimum population per cell: 350 inhabitants

Covered population: 98%

Surface (without highways): 454,081.8 km^2

Surface (including highways): 525,093.3 km^2

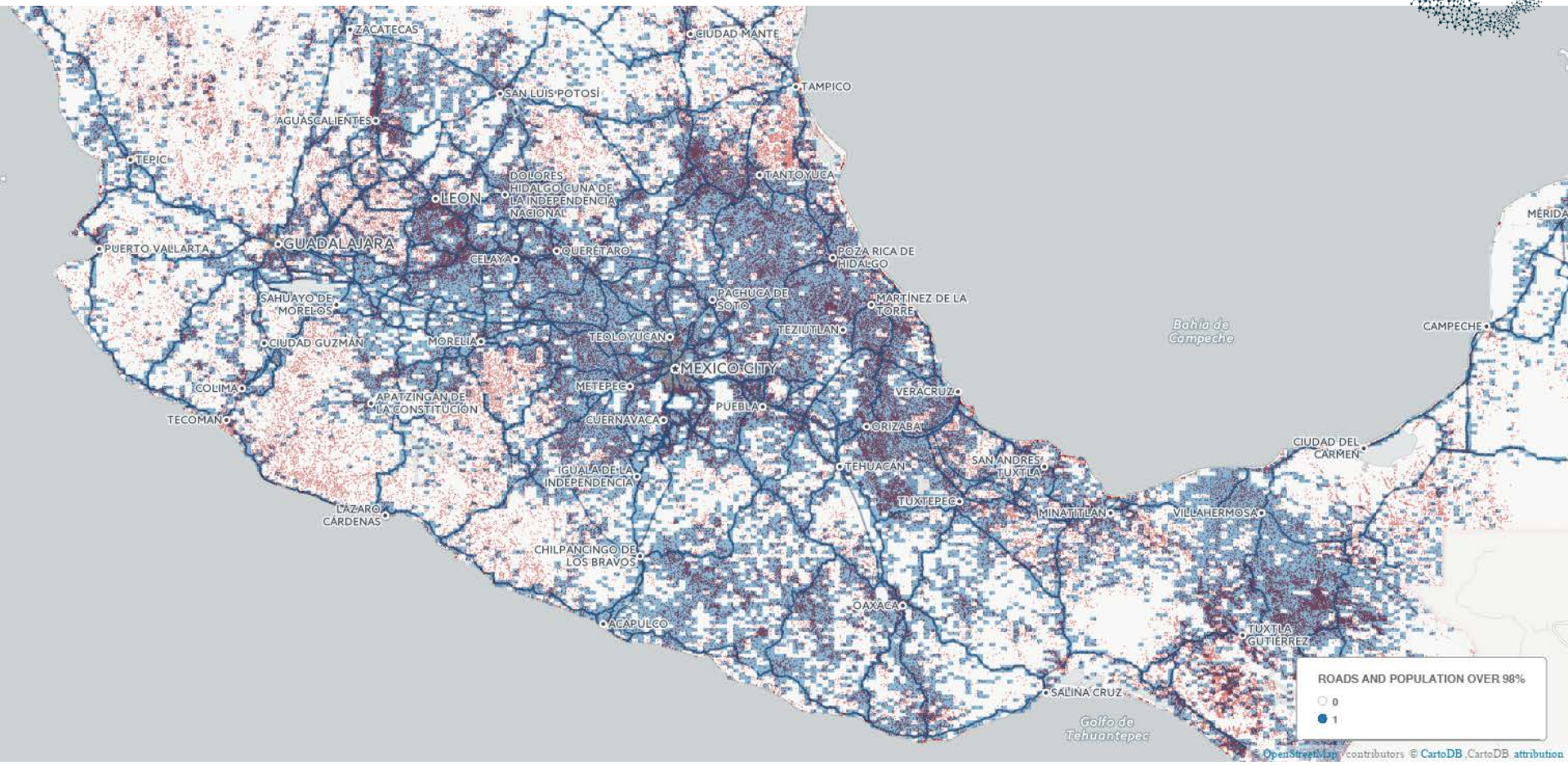
ii. Methodology



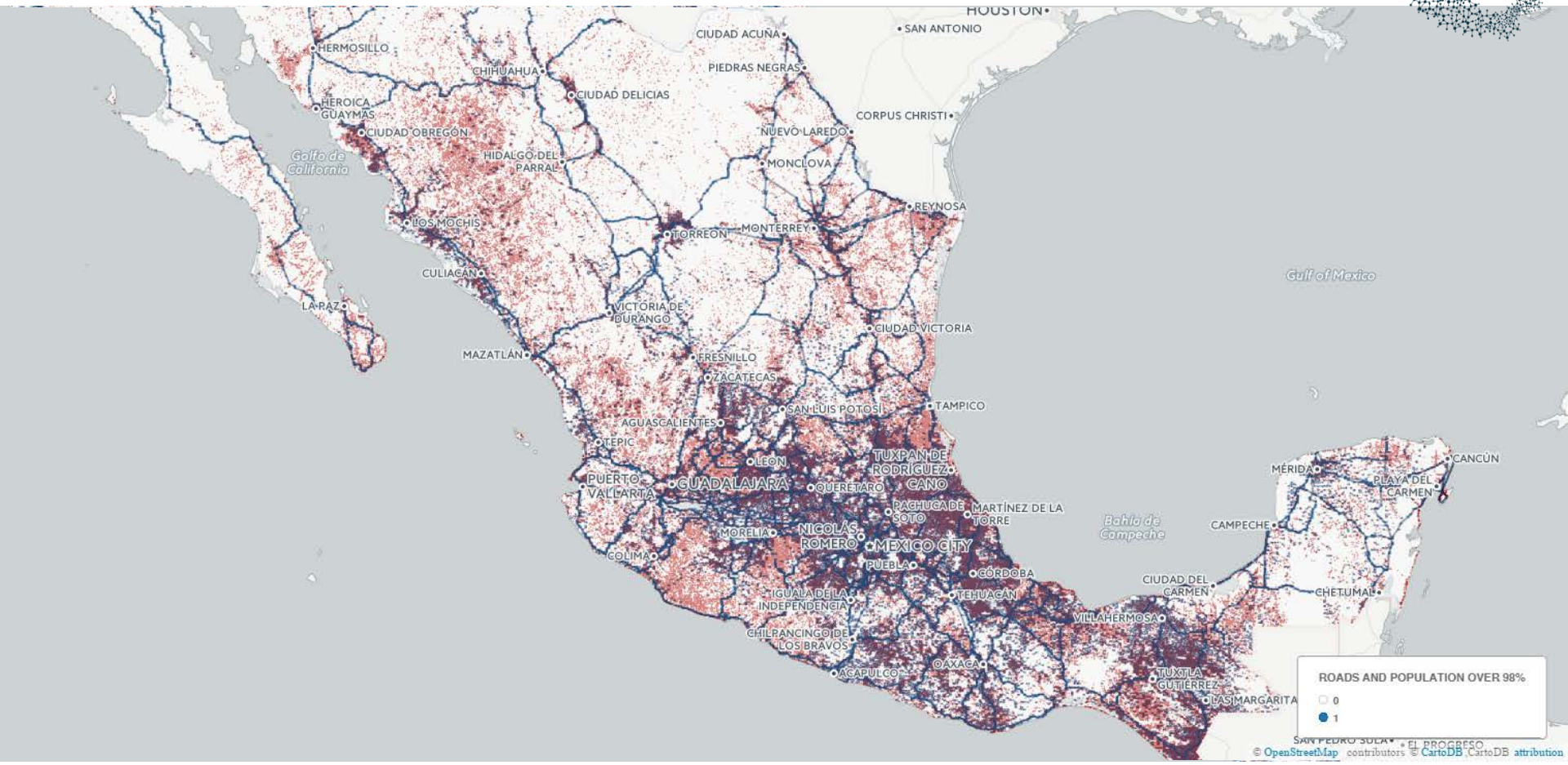
1 2 3 4

Territory-population estimation

ii. Methodology



ii. Methodology



ii. Methodology

Fifth cut:

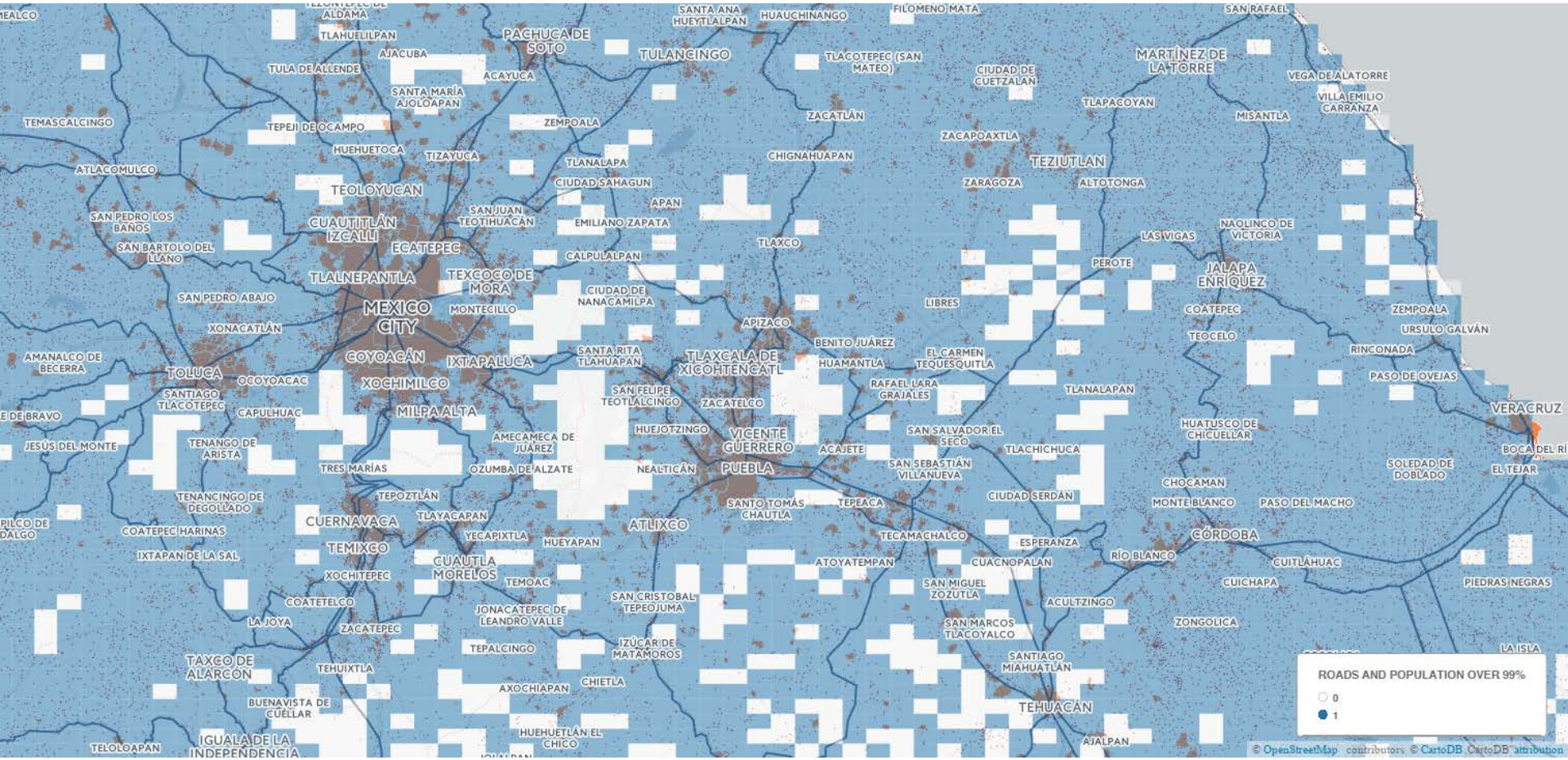
Minimum population per cell: 100 inhabitants

Covered population: 99%

Surface (without highways): 664,676.2 km^2

Surface (including highways): 715,813.0 km^2

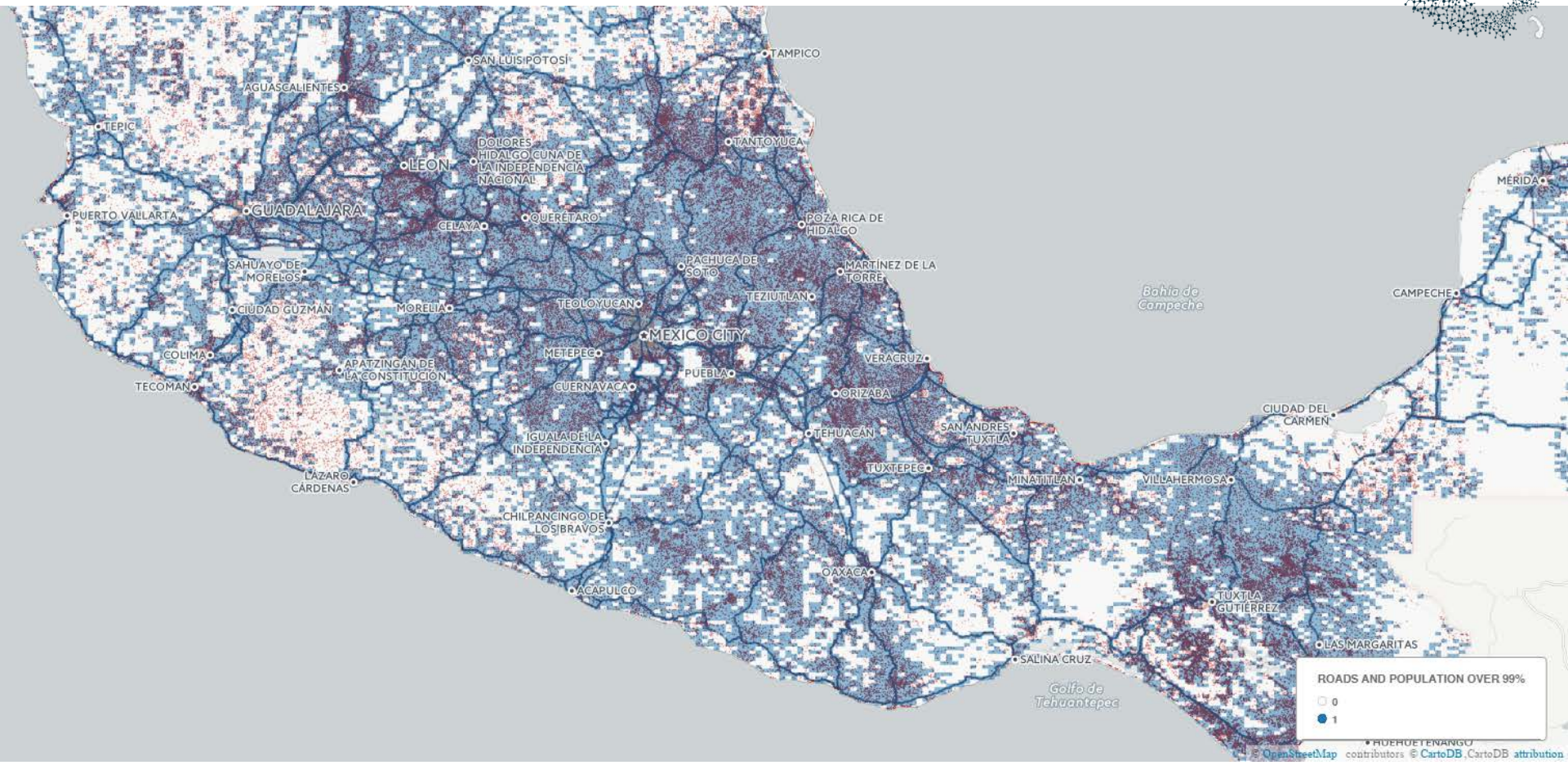
ii. Methodology



1 2 3 4

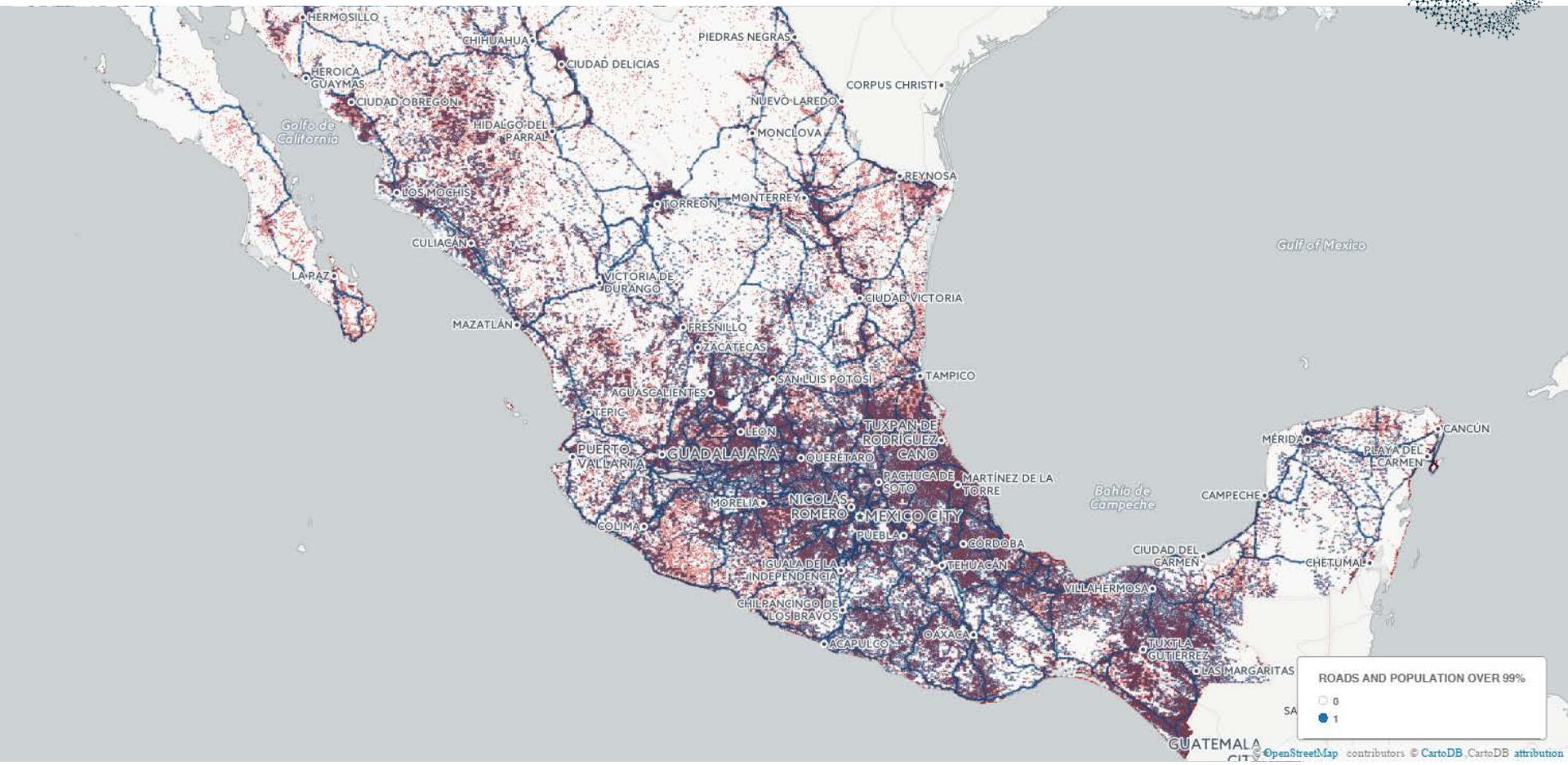
Territory-population estimation

ii. Methodology



1 2 3 4 Territory-population estimation

ii. Methodology



ii. Methodology

Sixth cut:

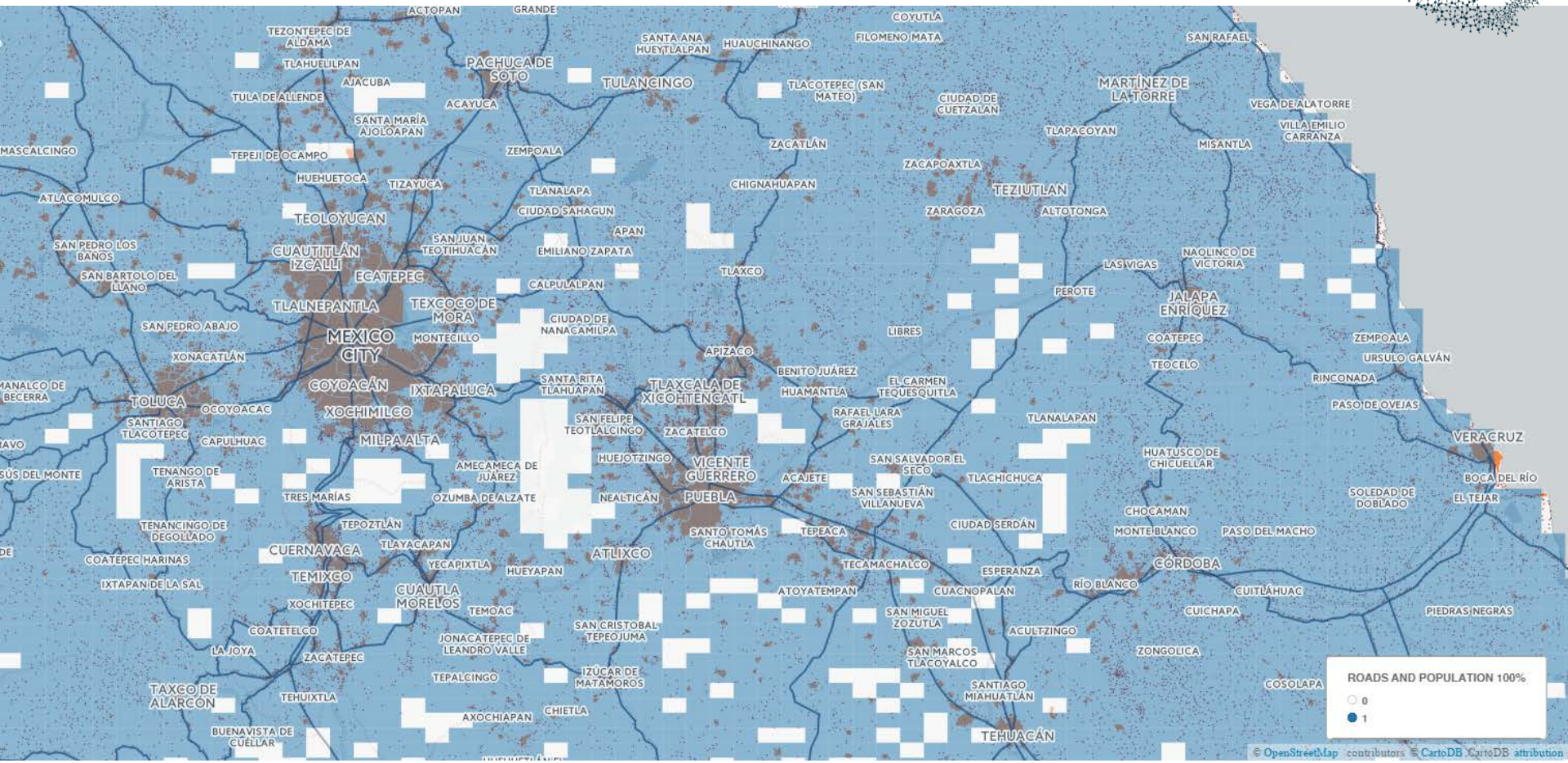
Minimum population per cell: 10 inhabitants

Covered population: 100%

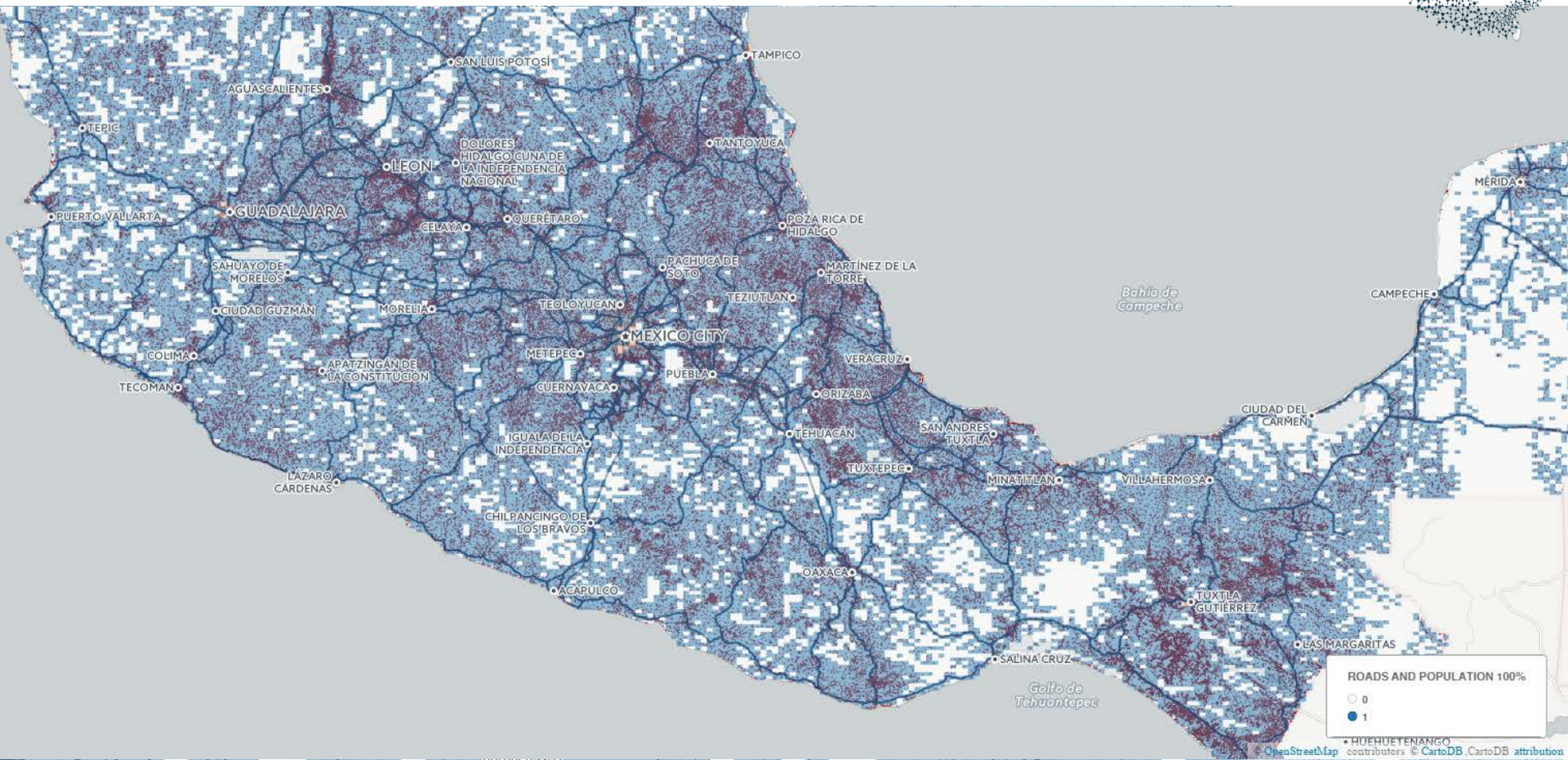
Surface (without highways): 1,121,144 km^2

Surface (including highways): 1,129,679 km^2

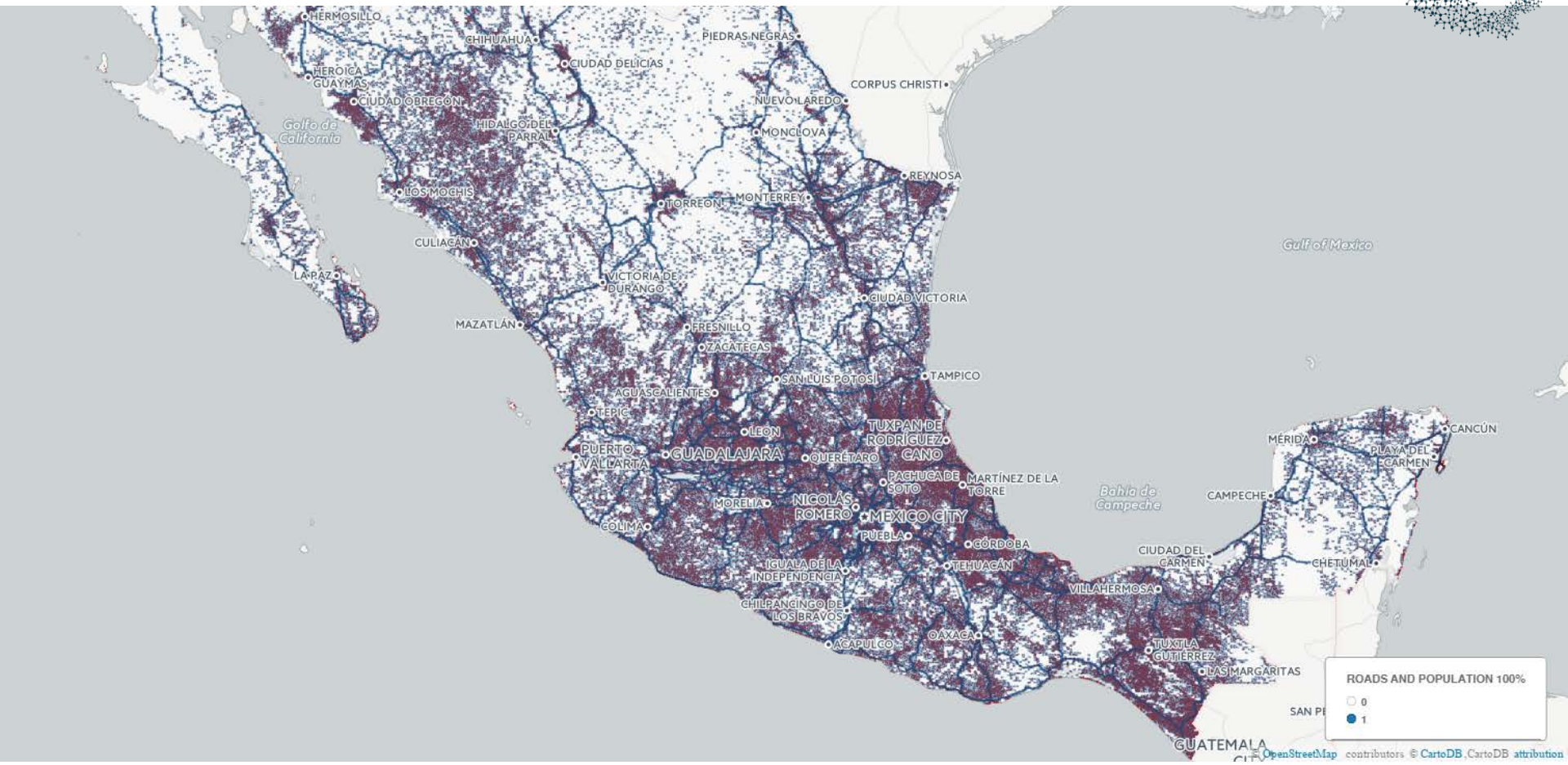
ii. Methodology



ii. Methodology



ii. Methodology



iii. Results

% Population	Km²	Km² including highways	Minimum population per quadrilateral
100%	1,121,144	1,129,679	10 inhabitants
99%	664,676	715,813	100 inhabitants
98%	**454,081**	**525,093**	**350 inhabitants**
95%	305,966	397,068	800 inhabitants
90%	174,333	287,711	1,800 inhabitants
85%	111,723	239,139	3,000 inhabitants
80%	67,159	205,906	4,900 inhabitants