ES Mapping and Evaluation in Russia's Largest Cities: First Results (TEEB-Russia 2)

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The Global Agenda – Sustainable Development Goals

http://www.un.org/sustainabledevelopment/ru/sustainable-development-goals/

Aim and assessment objectives

Aim: to assess the volume of green infrastructure's ecosystem services (ES) on different spatial levels, and to form possible principles of ES knowledge integration into the federal documents on spatial planning and urban environment assessment of Russian Federation.

Objectives:

- to make define different GI elements on urban level for the largest cities of Russia;
- to define the main trend of GI area change during 2000-2016;
- to assess the supplied and demanded volumes of key ES groups: regulating, supporting, providing and cultural;
- to define the place of GI and its ES in the spatial planning documents of Russia.

Study Area

There are 1117 cities in Russia:

15 cities with population over 1 million people (2016)

City	City area, km^2	Population, thous. people
Moscow	2432	12381
Saint Petersburg	1439	5282
Novosibirsk	481	1603
Ekaterinburg	401	1456
Perm	806	1456
Nizhniy Novgorod	317	1262
Kazan	635	1232
Chelyabinsk	504	1178
Samara	543	1170
Rostov-na-Donu	355	1125
Ufa	667	1116
Krasnoyarsk	378	1083
Voronezh	601	1040
Omsk	580	1016
Volgograd	861	1015

Initial data for the supplied and demanded volumes of ecosystem services assessment

Inventory and dynamics

Landsat 5,7,8 - 2000 and 2016.
Tree-cover maps by M.C. Hansen
OpenStreetMap vectors

Raster Calculator
Select by attributes

NDVI – general vegetation cover
Tree-cover
Agricultural lands, selection of well-maintained GI elements

Verification
Wikimapia,
ArcGIS online

Green area of sanitary buffers

Selection of GI and residential/industrial zones with area > 1 ha, using OSM data

Buffer
Clip

300-800-m buffers
Share of residential area outside the 300-800 buffers and GI area inside the industrial buffers

Fragmentation

Hansen's tree-cover

Fragstats

Class metrics – 6 parameters

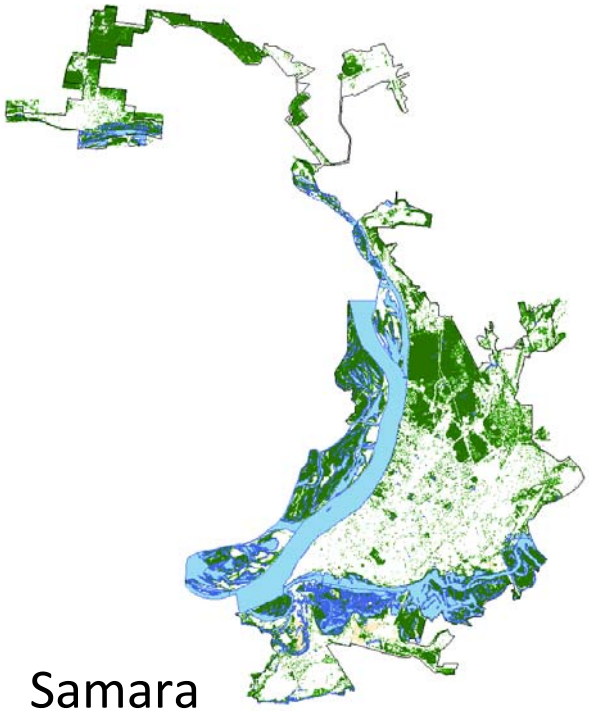
The demanded volume

Cities' and districts' population
Emissions

Passports of municipal settlements
www.gks.ru

Present-day State of Green Infrastructure in the Largest Cities of Russia

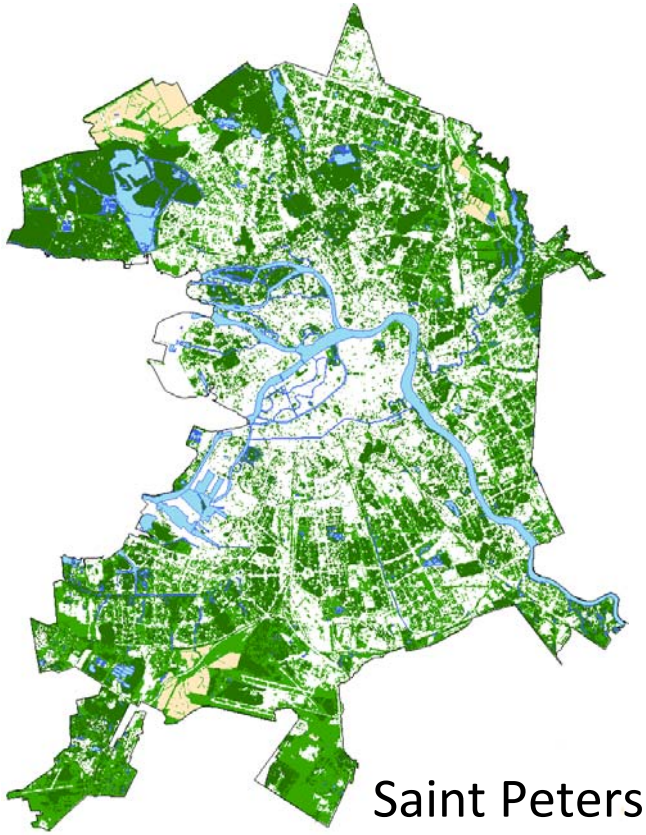
Share of green infrastructure from the city's area



Samara

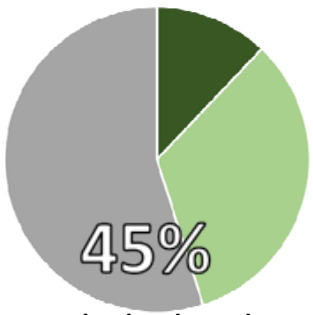
- *Tree vegetation*
- *Non-tree vegetation*
- *Non-vegetated area*

Agricultural lands
Tree vegetation
Non-tree vegetation
Water
Administrative borders

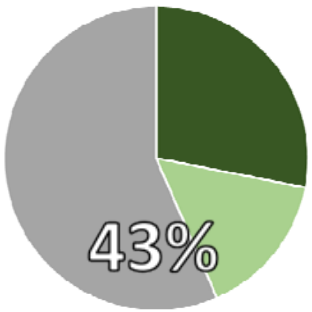


Saint Petersburg

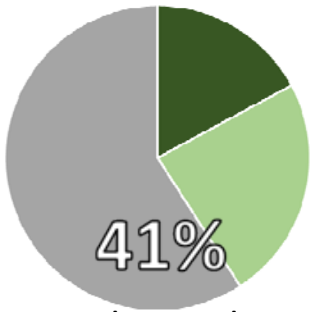
Less than 50%



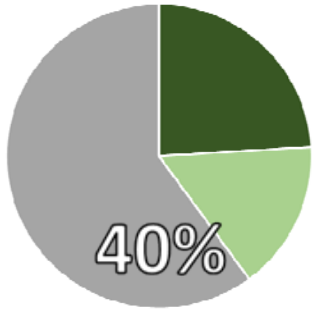
Chelyabinsk



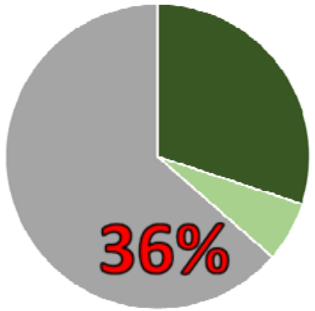
Kazan



Volgograd



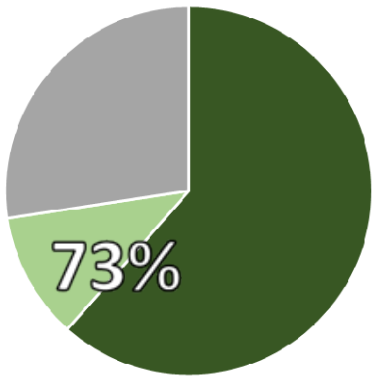
Samara



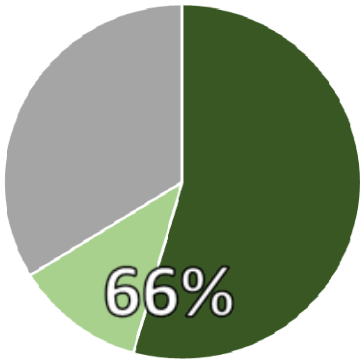
Saint Petersburg

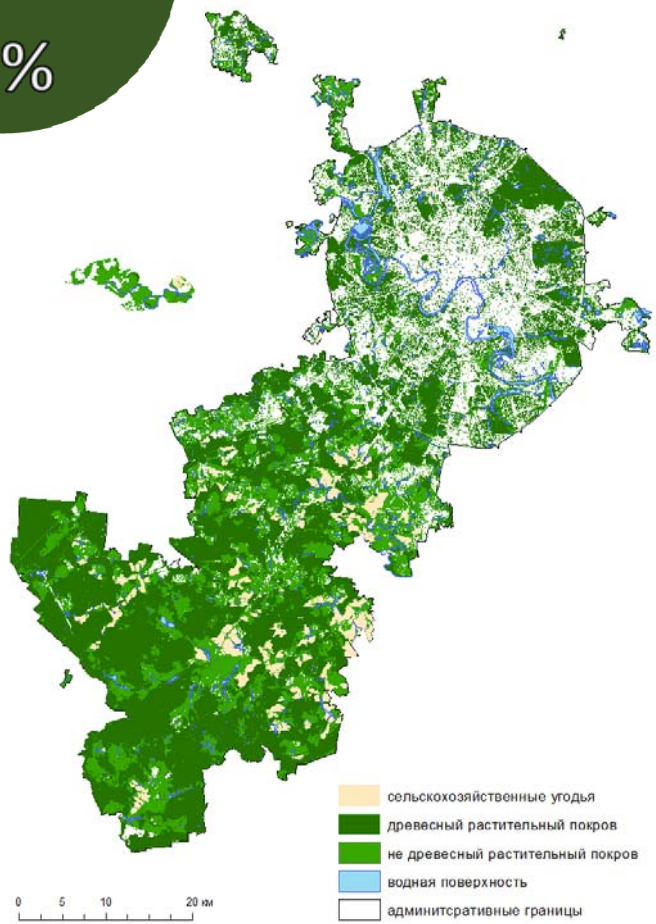
Relation between total share of GI and GI configuration

Perm



Moscow





Moscow and Perm: more than 50% of GI is concentrated in huge green massifs outside the limits of the most built-up urban core, but inside the administrative borders

GI Fragmentation Methods

«Basis» – tree vegetation
«**Background**» – water, non-vegetated area and non-tree vegetation

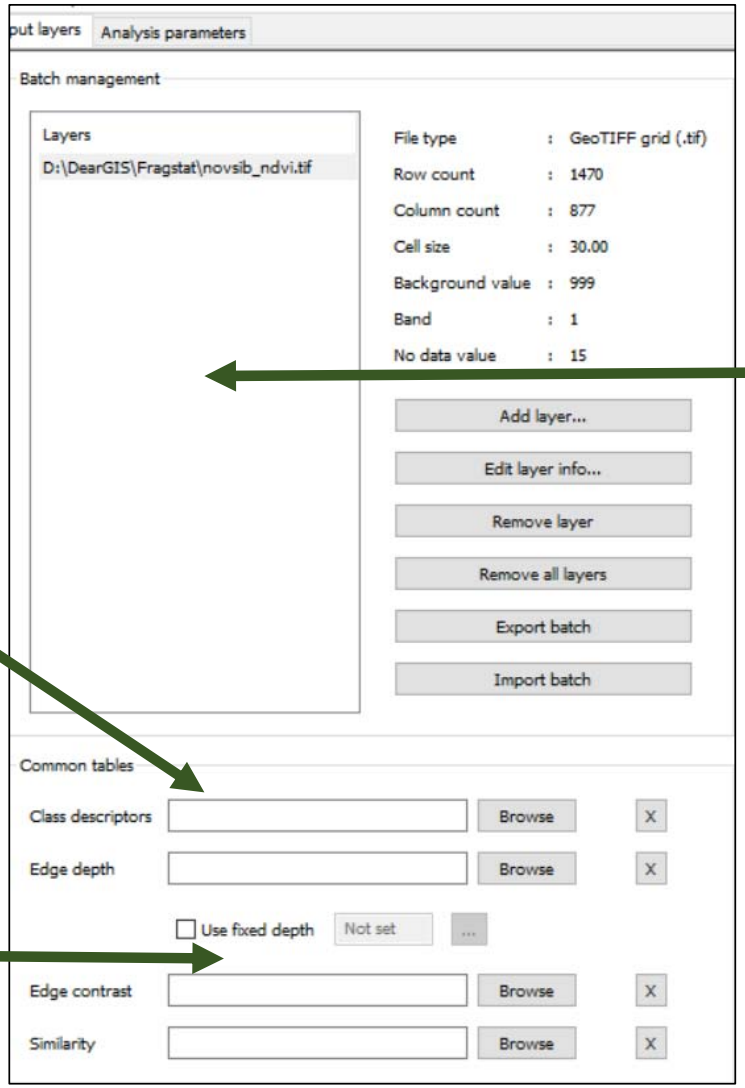
Basis and background table

```
ID, Name, Enabled, IsBackground
1, water, false, true
2, urban, false, true
3, grass, false, true
4, tree, true, false
```

Edge depth table

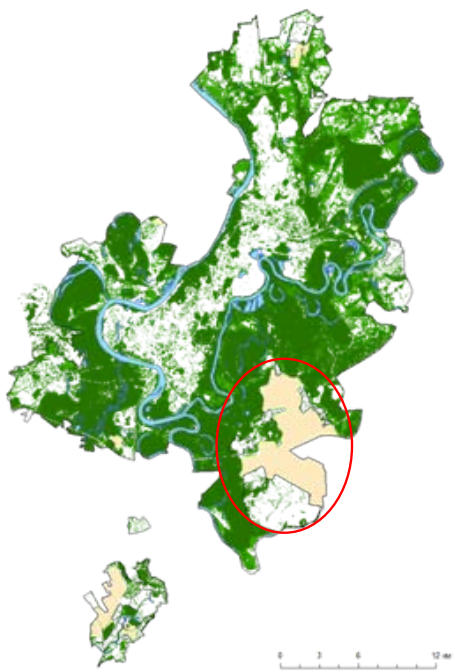
```
FSQ_TABLE
CLASS_LIST_LITERAL (water, urban, grass, tree)
0,0,0,0
0,0,0,0
0,0,0,0
120,120,0,0
```

«**Edge effect**» - is set for borders with each class. For tree vegetation – 120 m.



Classified and generalized NDVI
Basing on Landsat 7-8, 30 x 30 m
(+verification by tree-cover raster)
(+ manual classification and OSM for agriculture)

Min. patch – pixel size
«Cleaned» raster – **1 ha**



Green Infrastructure Fragmentation

	Parameter	*Fragmentation*
1. (NP): **Number of Patches**	↑	↑
2. (PD): **Patch Density** – patches per 100 ha	↑	↑
3. (ED): **Edge Density** – m/ha – a ratio between the total length of patches' edges and class area	↑	↑
4. (LPI): **Largest Patch Index**	↑	↓
5. (TCA): **Total Core Area** – area, not influenced by edge effect - 120 m	↑	↓
6. (ENN): **Euclidian Nearest Neighborhood Distance** – m	↑	↑

GI Fragmentation Indicators

Indicator	Unit of measurement	Mean values	Worst results	Best results
Number of Patches	patch	**5000**	17 000 – Moscow 7 500 – Saint Petersburg	3 600 – Rostov-na-Donu 3 900 – Omsk
Patch Density	patch / km^2	**9**	11,5 – Saint Petersburg 11,0 – Krasnoyarsk	5,7 – Ufa
Edge Density	km/ km^2	**5**	8,9 – Perm	3,2 – Omsk
Largest Patch Index	%	**7**	0,5 – Omsk 2,1 – Saint Petersburg	23,6 – Perm 19,3 – Moscow
Total Core Area	km^2	**13**	0,9 – Omsk 1,6 – Volgograd 1,8 – Saint Petersburg	56,1 – Moscow 23,0 – Chelyabinsk
Euclidean distance	M	**85**	110 – Nizhniy Novgorod	79 – Kazan

Together fragmentation indicators characterize GI sustainability and resistance

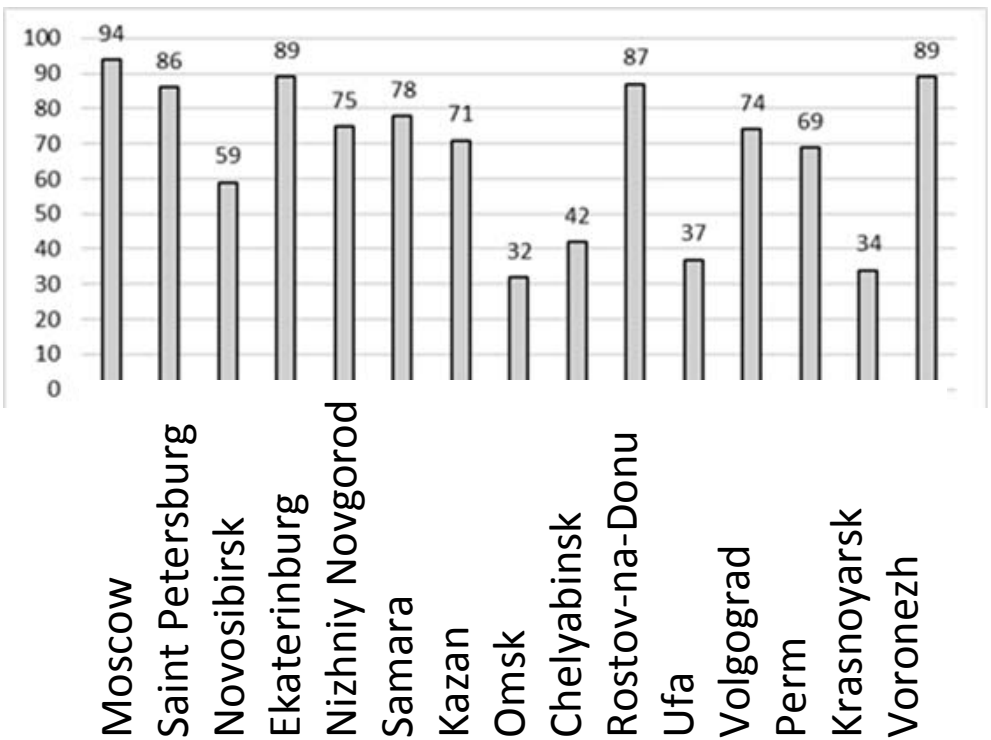
The Supplied and Demanded volumes of the Ecosystem Services

1. Removal of air pollutants from vehicles

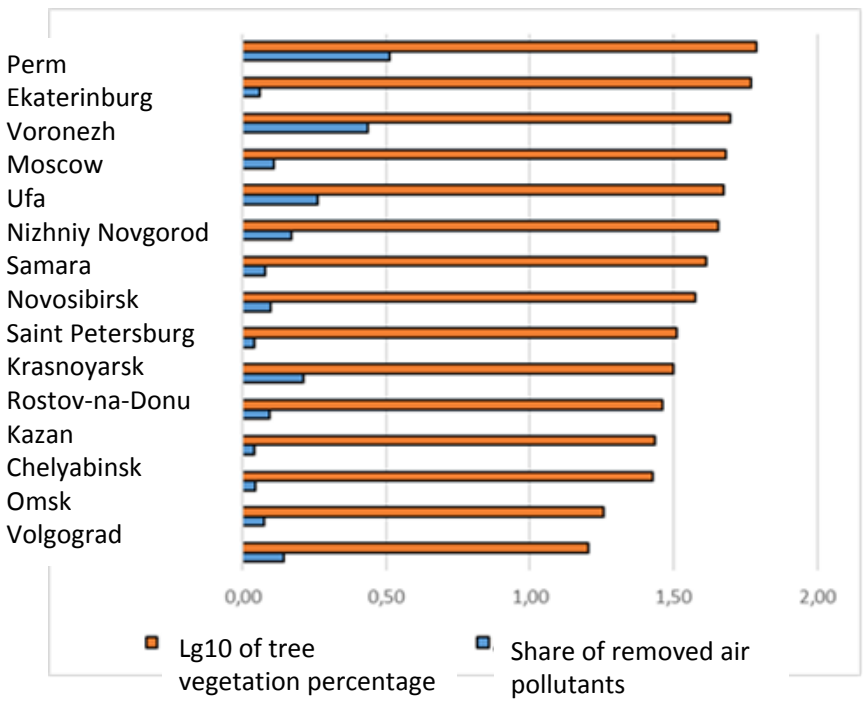
The supplied volume = area of tree vegetation X coefficient of mean absorption by main forest types

The demanded volume = vehicles (automobile transport) emissions (total and separately for SO2 + NOx + CO) (Rosgidromet, 2016)

Share of automobile emissions in the structure of total gaseous emissions, %



Relation between the forest area and the share of removed air pollutants

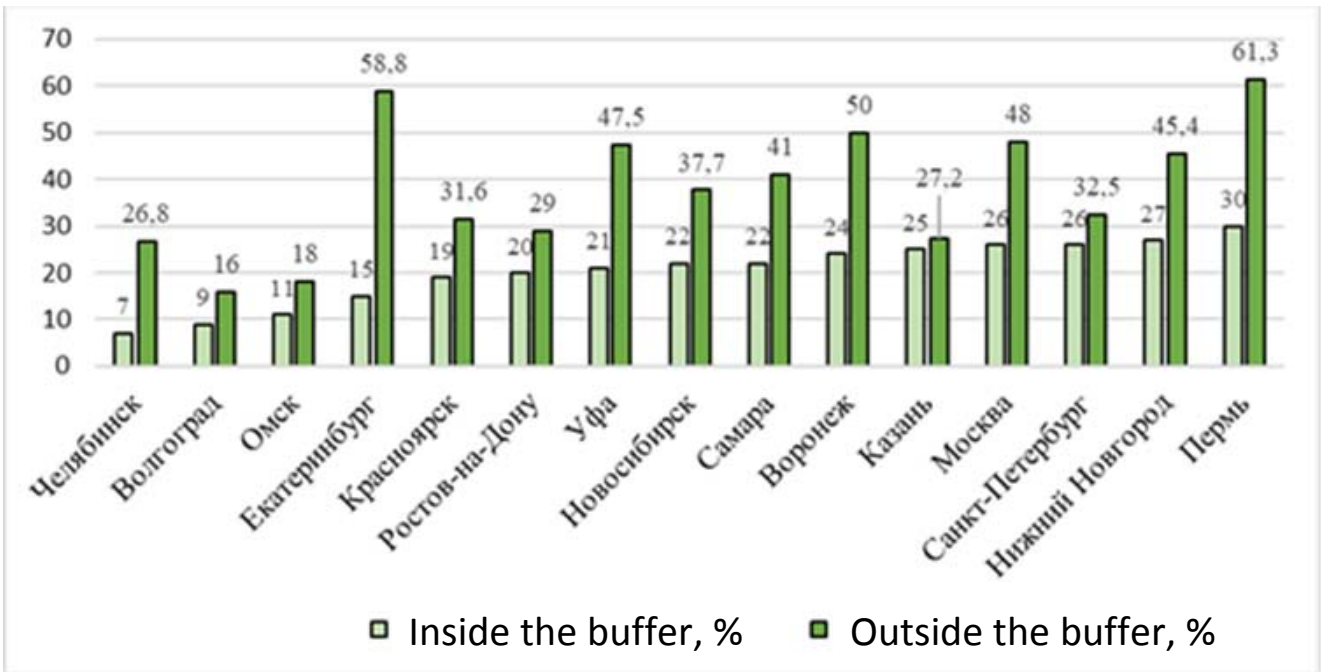


2. Removal of air pollutants from point sources

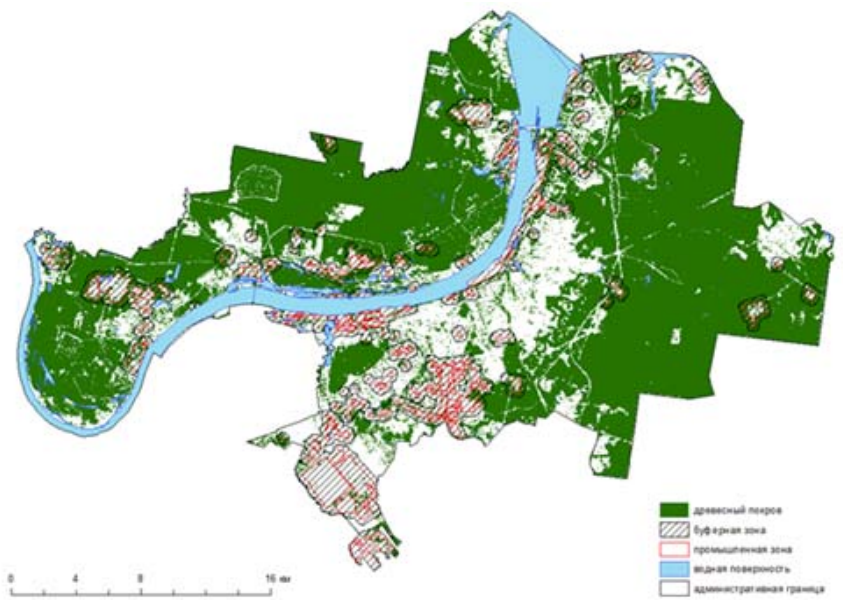
The supplied volume = area of tree vegetation inside sanitary zones X coefficient of mean absorption by main forest types

Необходимый объем = emissions from point sources (total and separately for SO2 + NOx + CO) (Rosgidromet, 2016) (Rosgidromet, 2016)

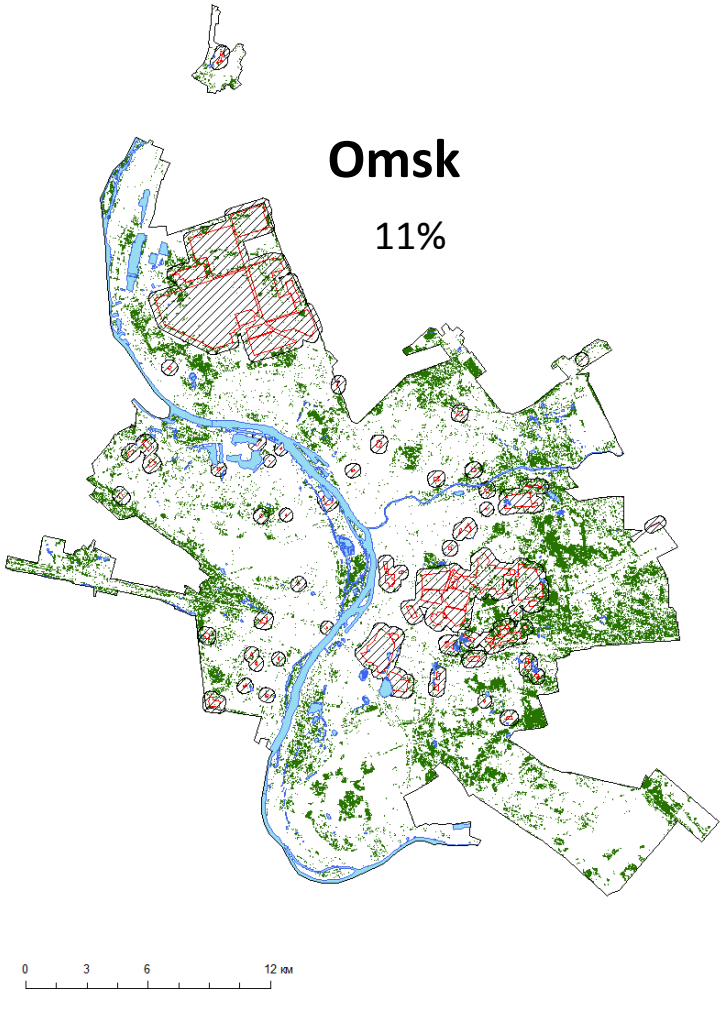
Share of green area inside the sanitary buffers, %

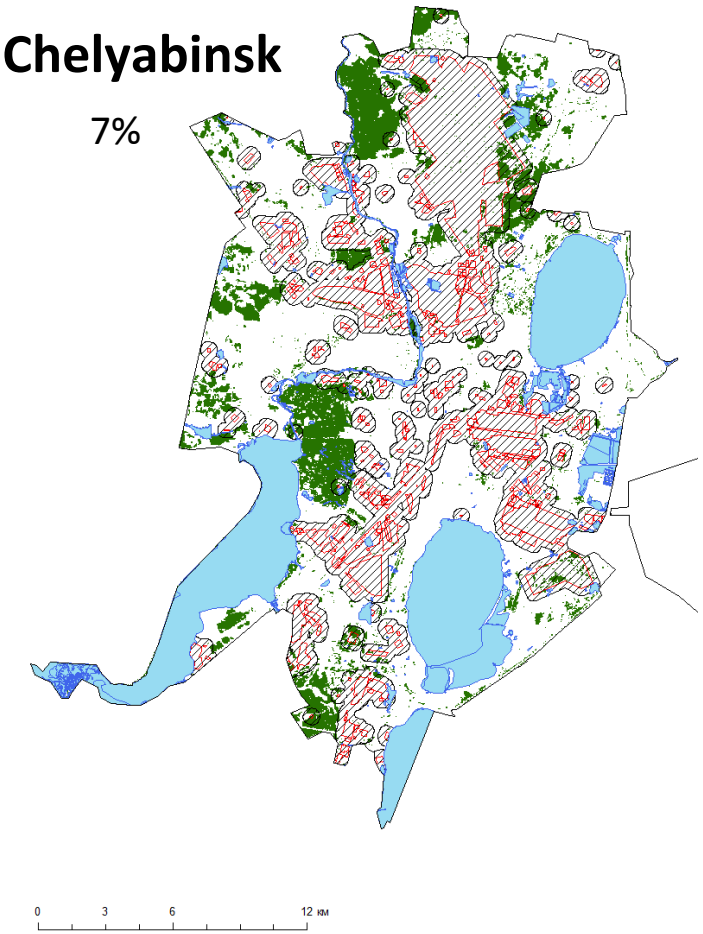


Best results – Perm (30%)



Green infrastructure of sanitary zones





Not enough tree vegetation in 300-m buffers around industrial zones.

Perm, Moscow, Nizhniy Novgorod:
The best results – **25-30%**

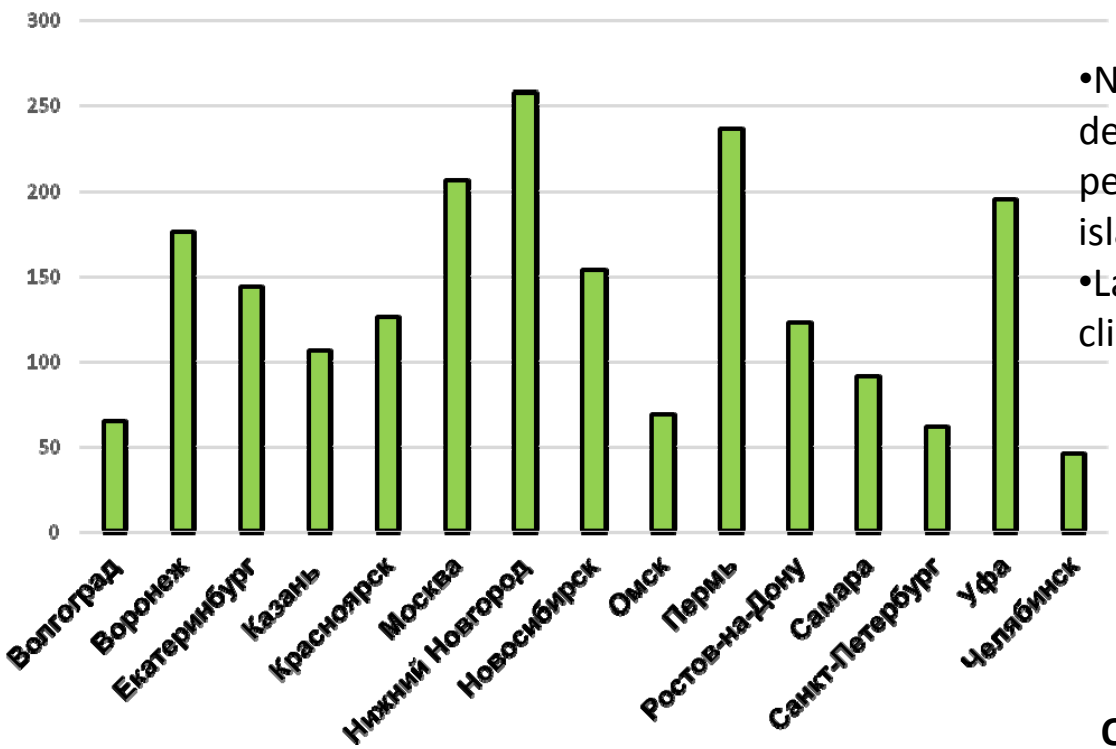
Omsk, Ufa, Chelyabinsk, Krasnoyarsk:
The biggest emissions from point sources: (171–129 thous. tonnes in 2016)

Share of GI in sanitary zones is less than 10% in the most industrious cities with the biggest emissions

3. Urban microclimate regulation

The supplied volume - $S_3 = S_1 + S_2$, with S_2 – influenced area,
S_1 – 500 ha, S_3 – total area of park (GI element) and area under its influence

The demanded volume – all city's area

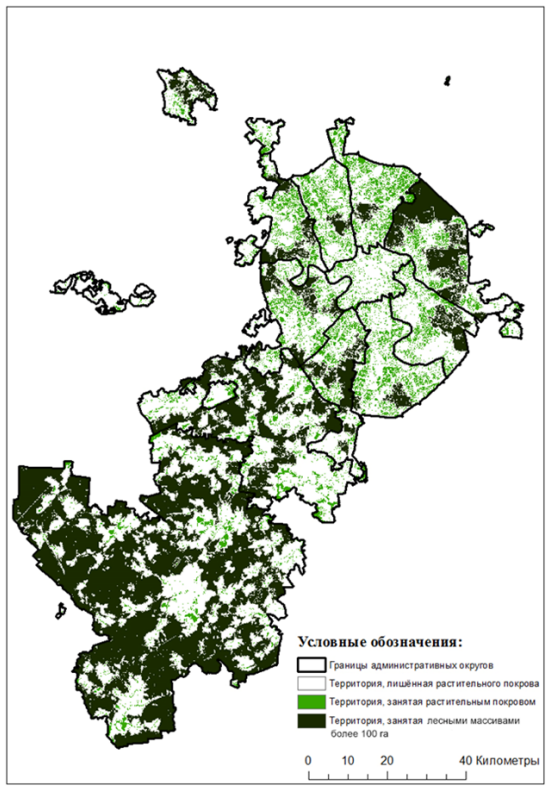


Problems:

- Not enough standards to define the optimum of GI percentage for reducing heat island effect in the city
- Lack of empirical data and climate models

Optimal structure???

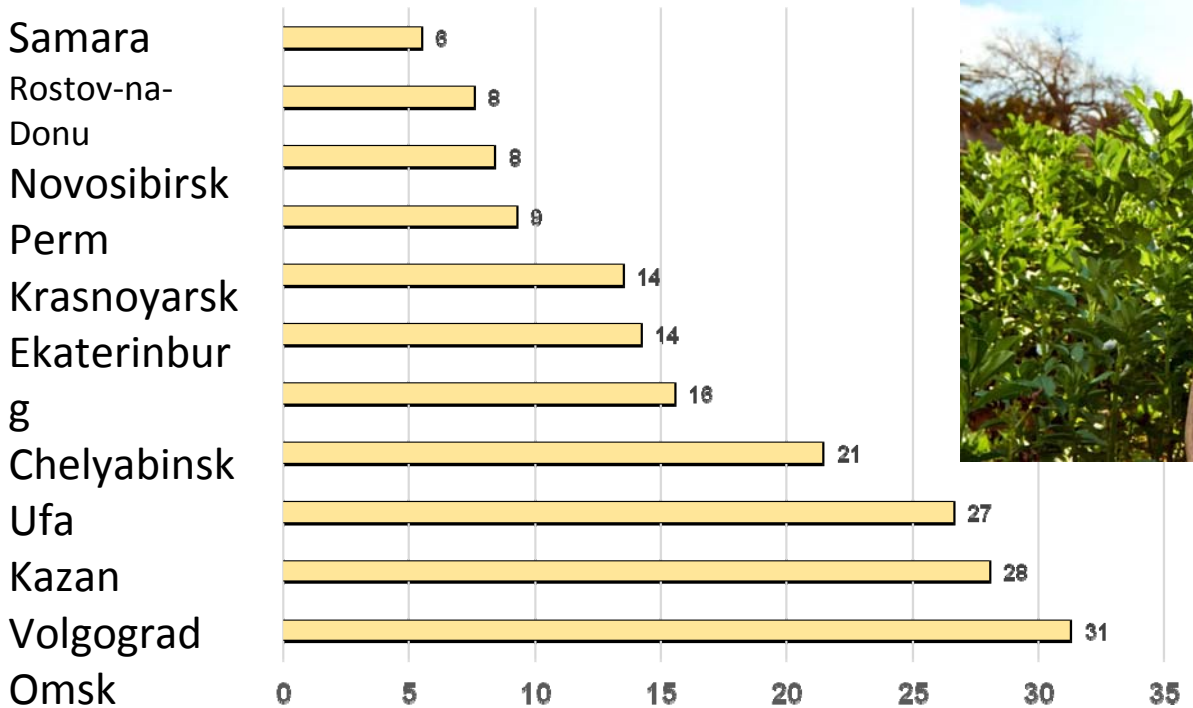
«Cool islands» in Moscow



4. Providing ecosystem services

The supplied volume – gross agricultural yield of private holdings per year. Among cultivated crops – potatoes, fruit and vegetables.

The demanded volume – the standard of vegetables consumption multiplied by population.



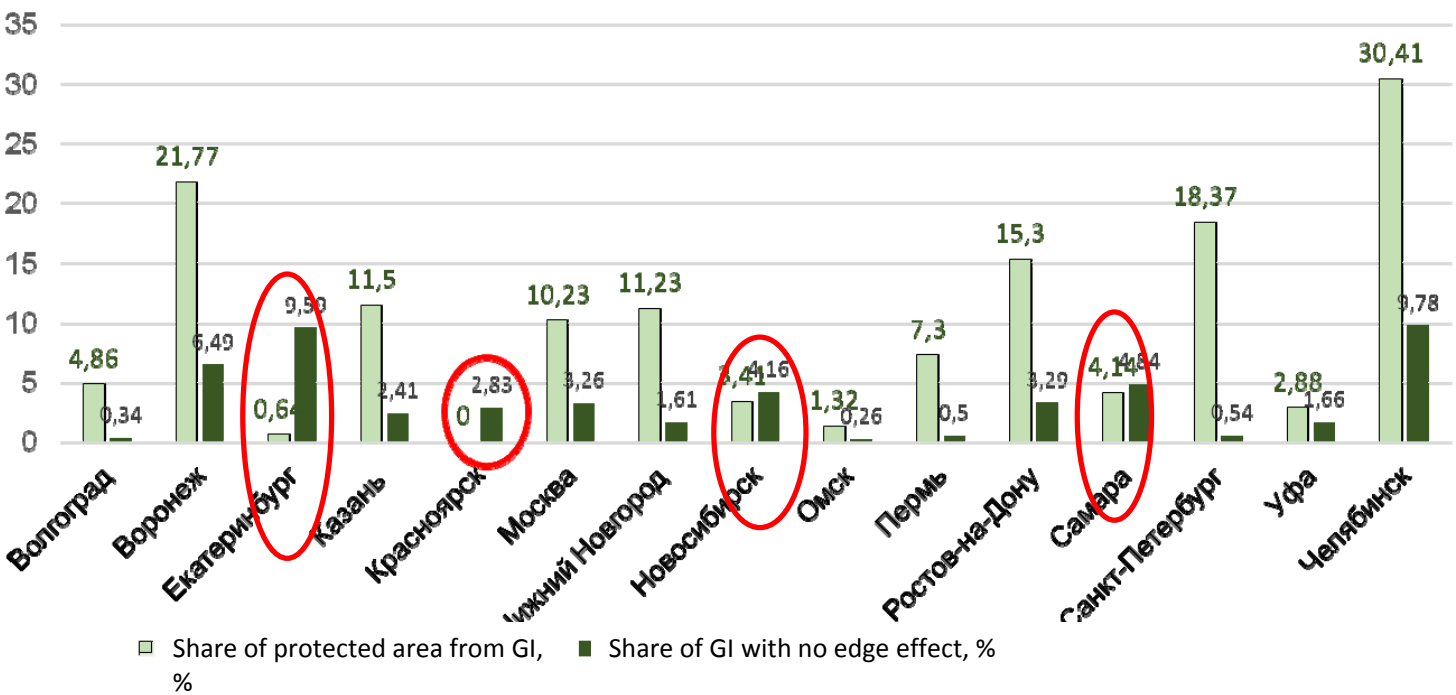
5. Natural Habitats Conservation

A possible indicator of ES supplied volume – share of protected area from the total area of urban GI;

Additionally – share of GI, not influenced by edge effect (using Fragstat)

The demanded volume - *???*

Protected areas and zones with no edge effect



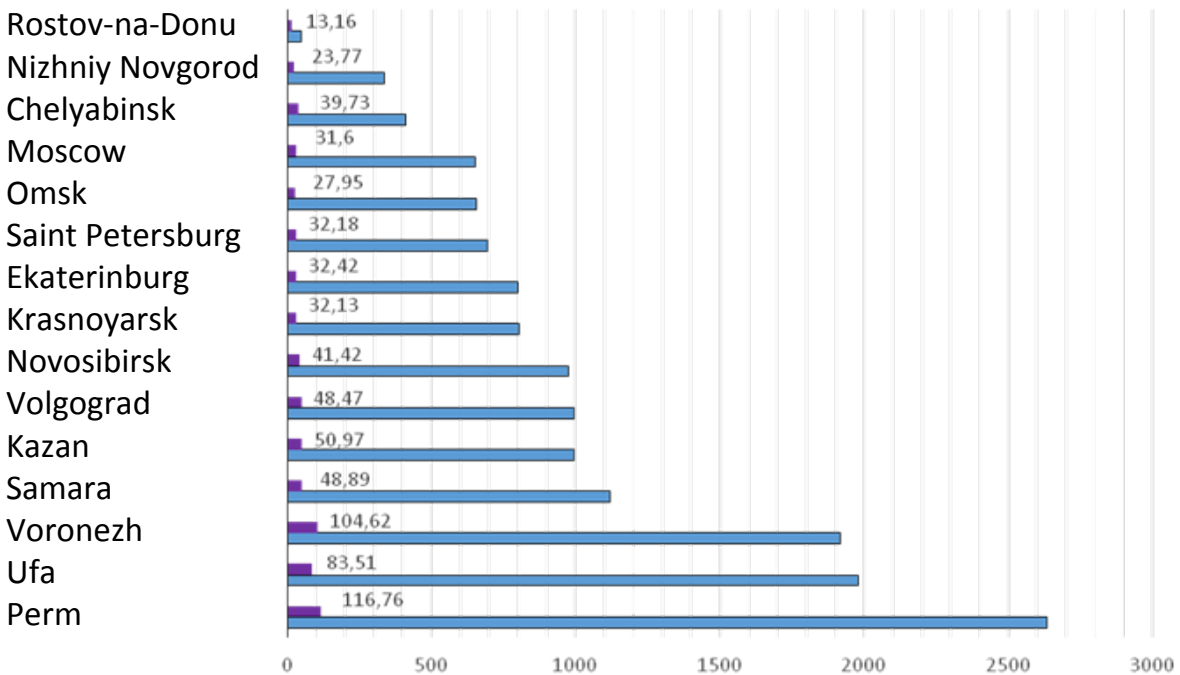
Problems:

- Need more accurate indicators of habitats conservation than a number of rare and red-book species
- Additional indicators of GI fragmentation
- Area of green infrastructure

6. Everyday recreation

The supplied volume – maximum affordable number of people that can have a comfortable walk in GI element at the same time, considering different statuses of these elements.
The demanded volume – a simultaneous visit of 5% of city's population

The ratio between the supplied and the demanded volumes, considering different standards of simultaneous visits capacity, %

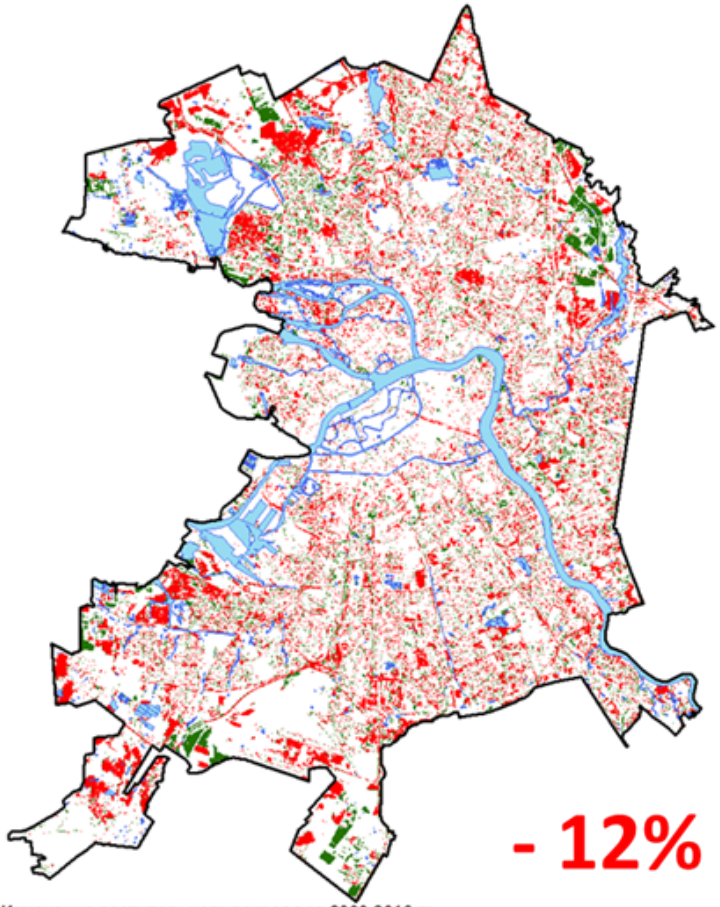


Standards of simultaneous visiting capacity –
2 per./ha (forests),
50 per./ha (urban forests and parks)

Problems:
- Capacity of simultaneous visiting
- Different standards for different recreatin activities
- Elaboration of the supplied volume of recreation activities by different GI elements

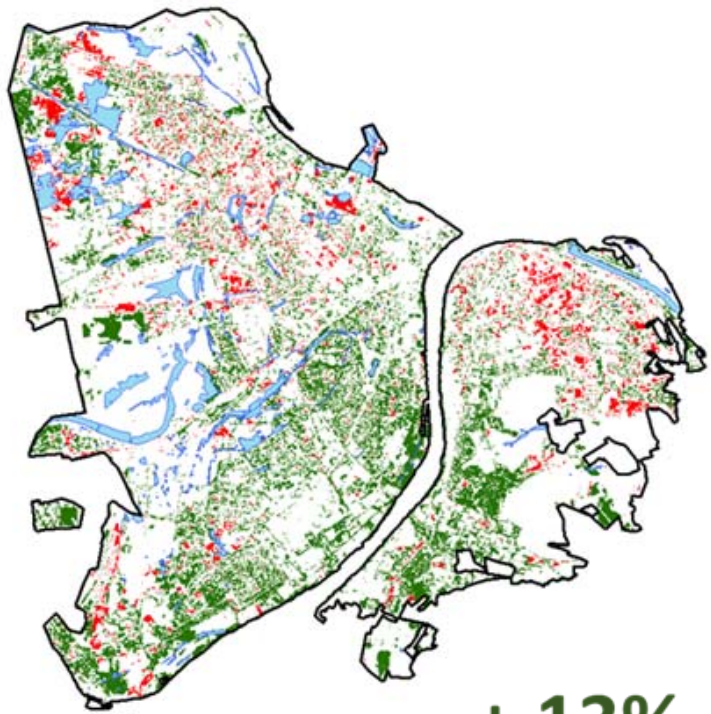
Prerequisites of gain/loss of ecosystem services during 2000-2016

Saint Petersburg



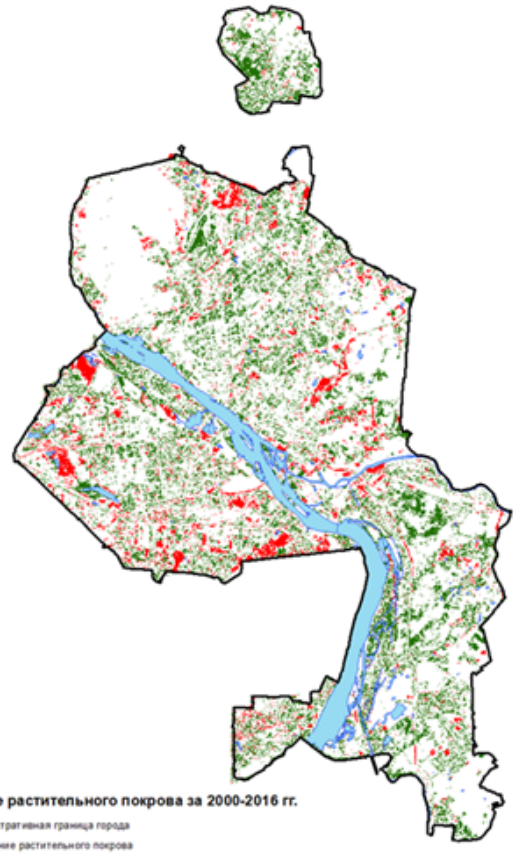
- 12%

Nizhniy Novgorod



+ 13%

Novosibirsk



+ 11%

Change of vegetation during 2000-2016

- Administrative borders
- Vegetation gain
- Vegetation loss
- Water

0 2 4 8 км

Mean monetary value of GI ecosystem services in different cities of temperate climate

Ecosystem service	Mean value (US$/ha/yr)	Values range
1. Air pollutants removal	647 (*n* = 9)	*60–2106*
2. Carbon sequestration (year cycle)	395 (*n* = 5)	*58–702*
3. Rainwater runoff reduction	922 (*n* = 6)	*615–2540*
4. Energy saving /temperature regulation	1412 (*n* = 4)	*34–1908*
5. Recreation	6325 (*n* = 2)	*2133–10 517*
Total	9701	3212–17 772

Источник: http://www.sciencedirect.com/science/article/pii/S1877343515000433#bib0510

Conclusions and perspectives

1. There is data on SPATIAL LOCALIZATION, but it lacks data on QUALITY (and as a result on the SUPPLIED VOLUME of GI services)

2. Natural and climatic factors do play role, but are not entirely responsible for GI state and quality…

3. The most supplied services are recreational, services on air purification are in deficit.

4. ES decrease takes place both in the center and at the outskirts, but what is worse?

5. Official spatial planning documents should take into account the QUALITY of regulating ES via standards of GI spatial differentiation and fragmentation.