Swiss TPH
Swiss Tropical and Public Health Institute
Schweizerisches Tropen- und Public Health-Institut
Institut Tropical et de Santé Publique Suisse

Associated Institute of the University of Basel

arpae
emilia-romagna

The use of GIS in modelling exposure (practical)

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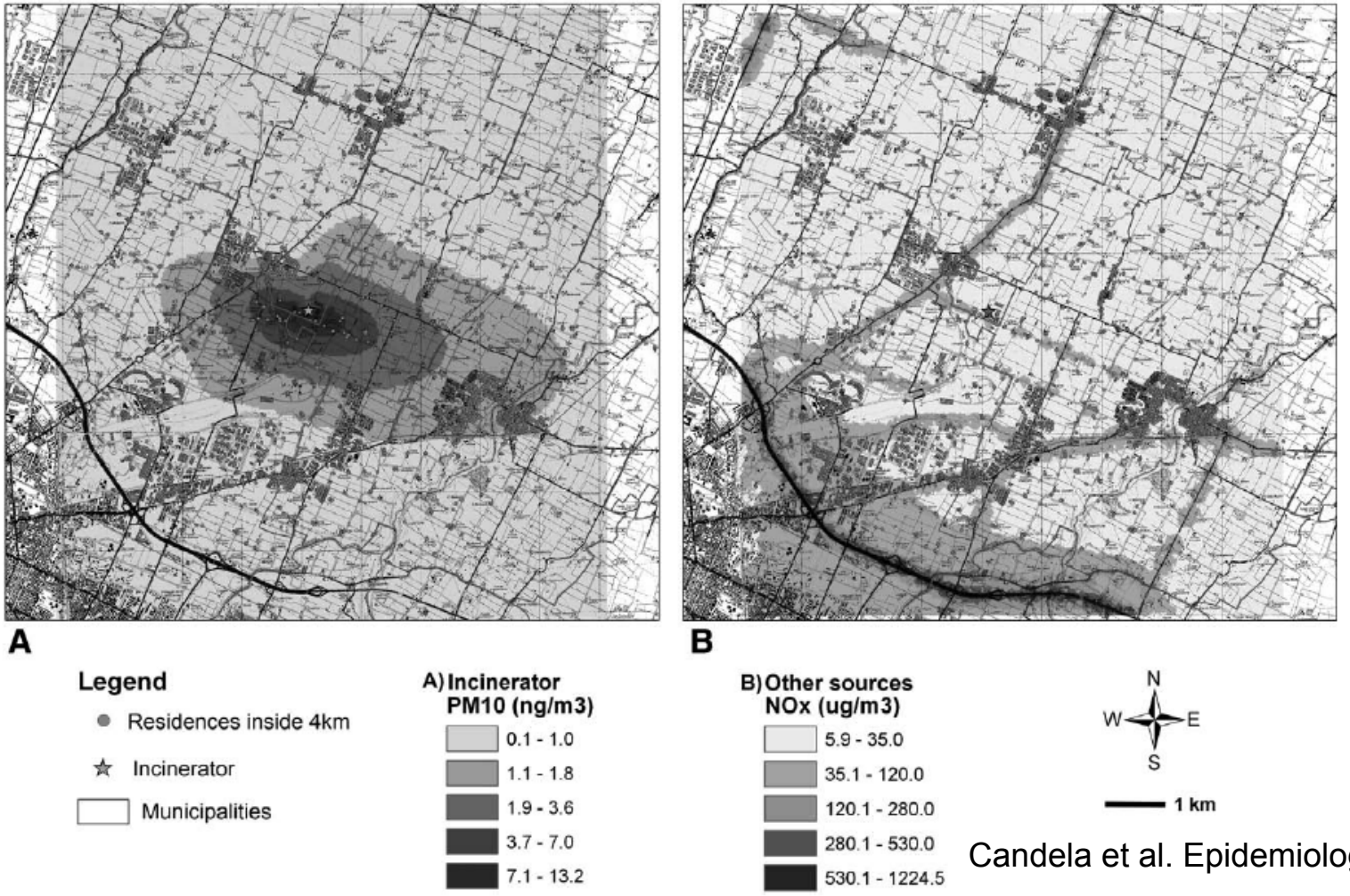
Learning outcomes

We will present practical examples on use of GIS for exposure assessment in epi studies and HIA

Air Pollution from Incinerators and Reproductive Outcomes

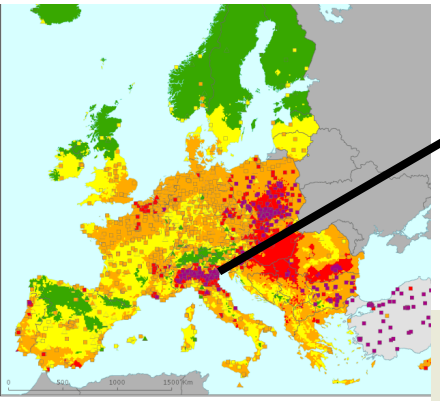


Candela et al. Epidemiology 2013

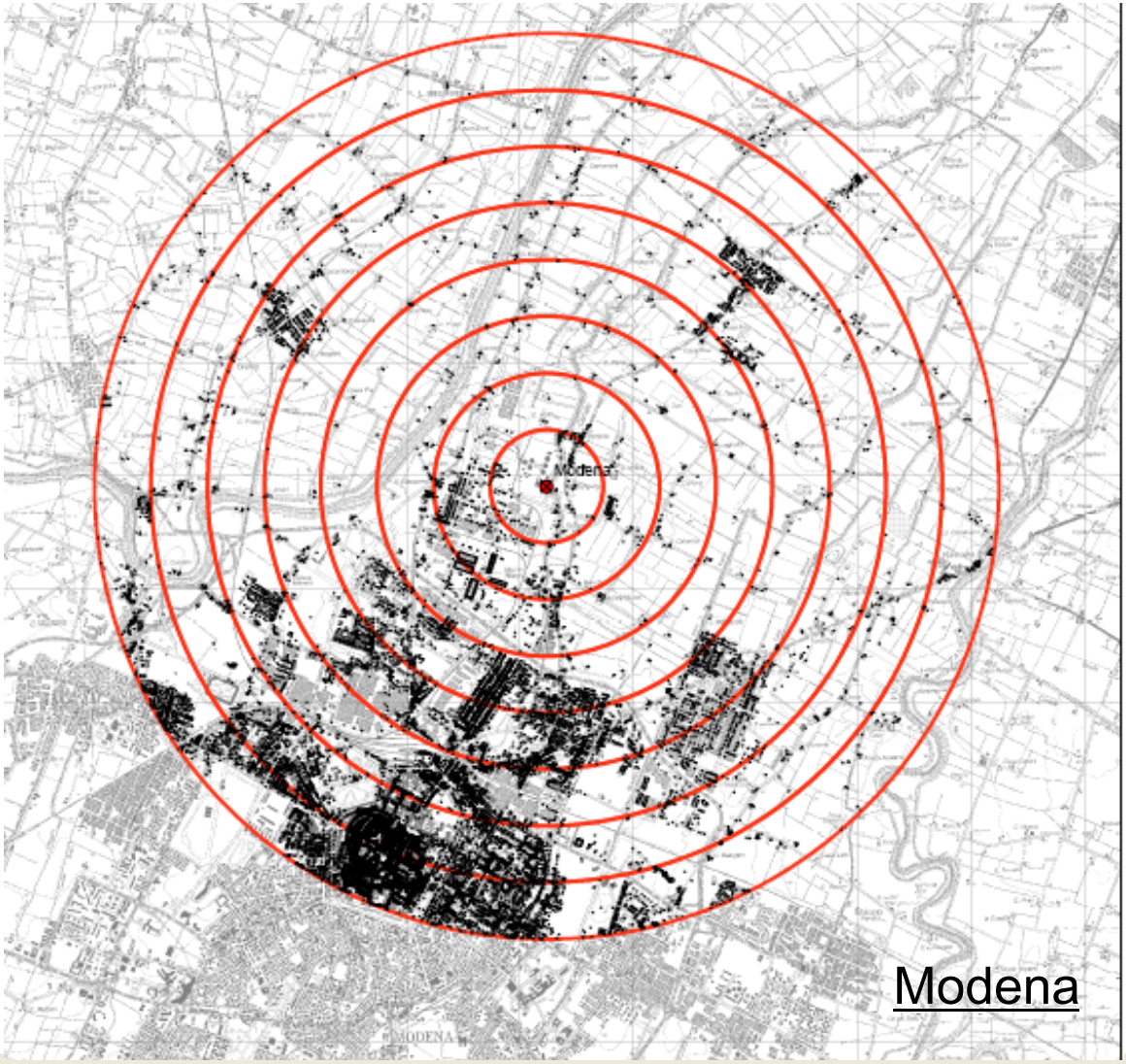
FIGURE 1. Pollutant dispersion map of Bologna site: A, PM_{10} (year 2006) for incinerator; B, NO_X for other sources.

Moniter Project

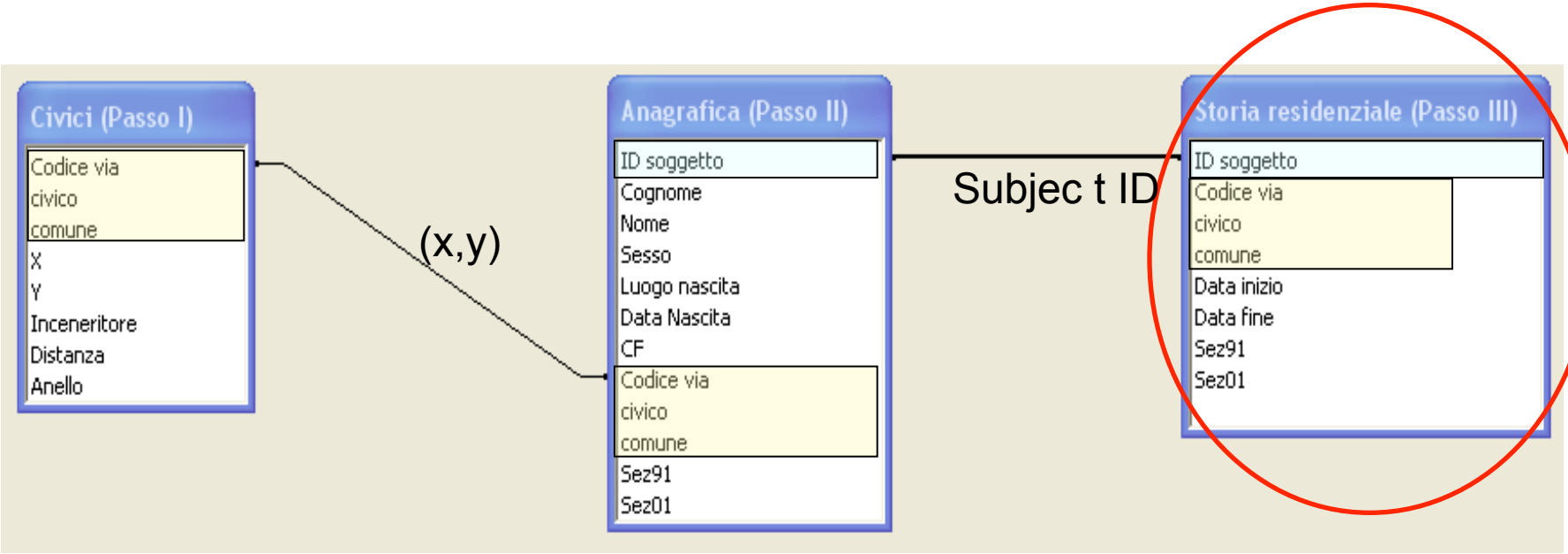
Monitoring incinerators in the territory of Emilia-Romagna



Study Population



Final Database



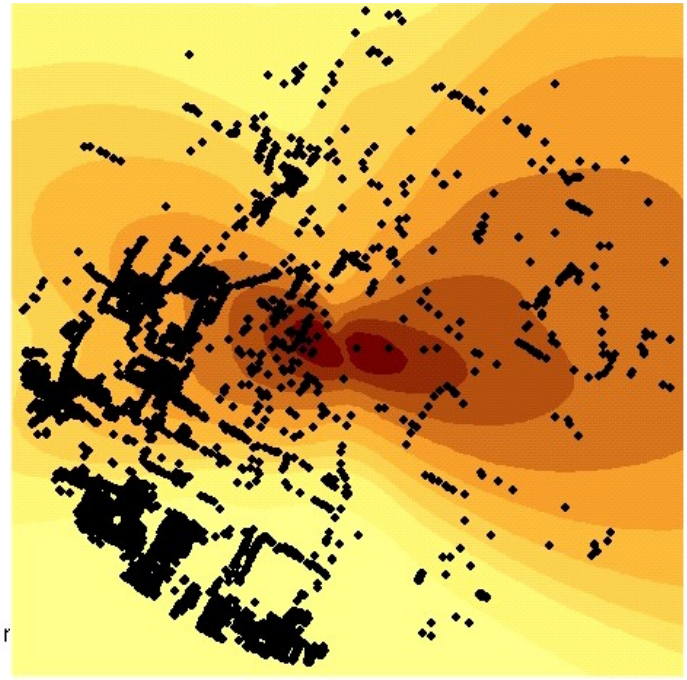
Database of gecoded addresses

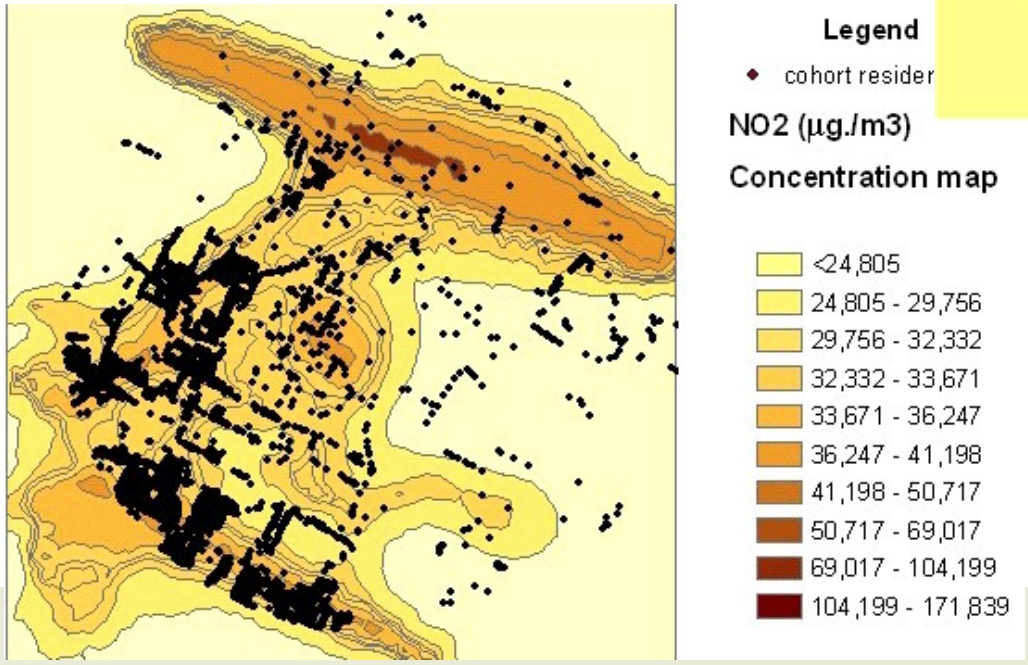
Database of population data

Database of residential history (i.e. a record for each subject residence)

Exposure assessment

Incinerator (PM10)





All sources (NOx)

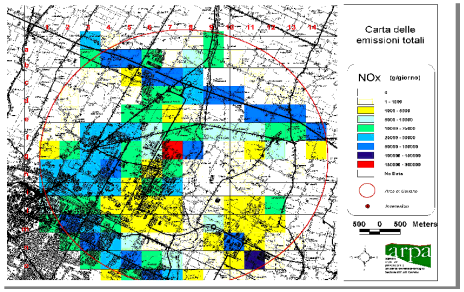
Environmental study

Traffic

Civil sources

Industry

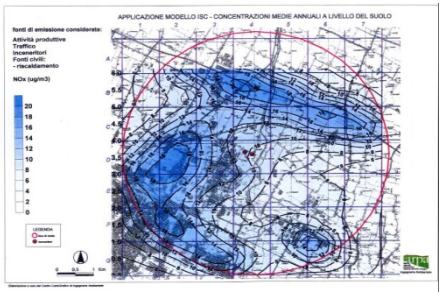
Incinerator



Emission map

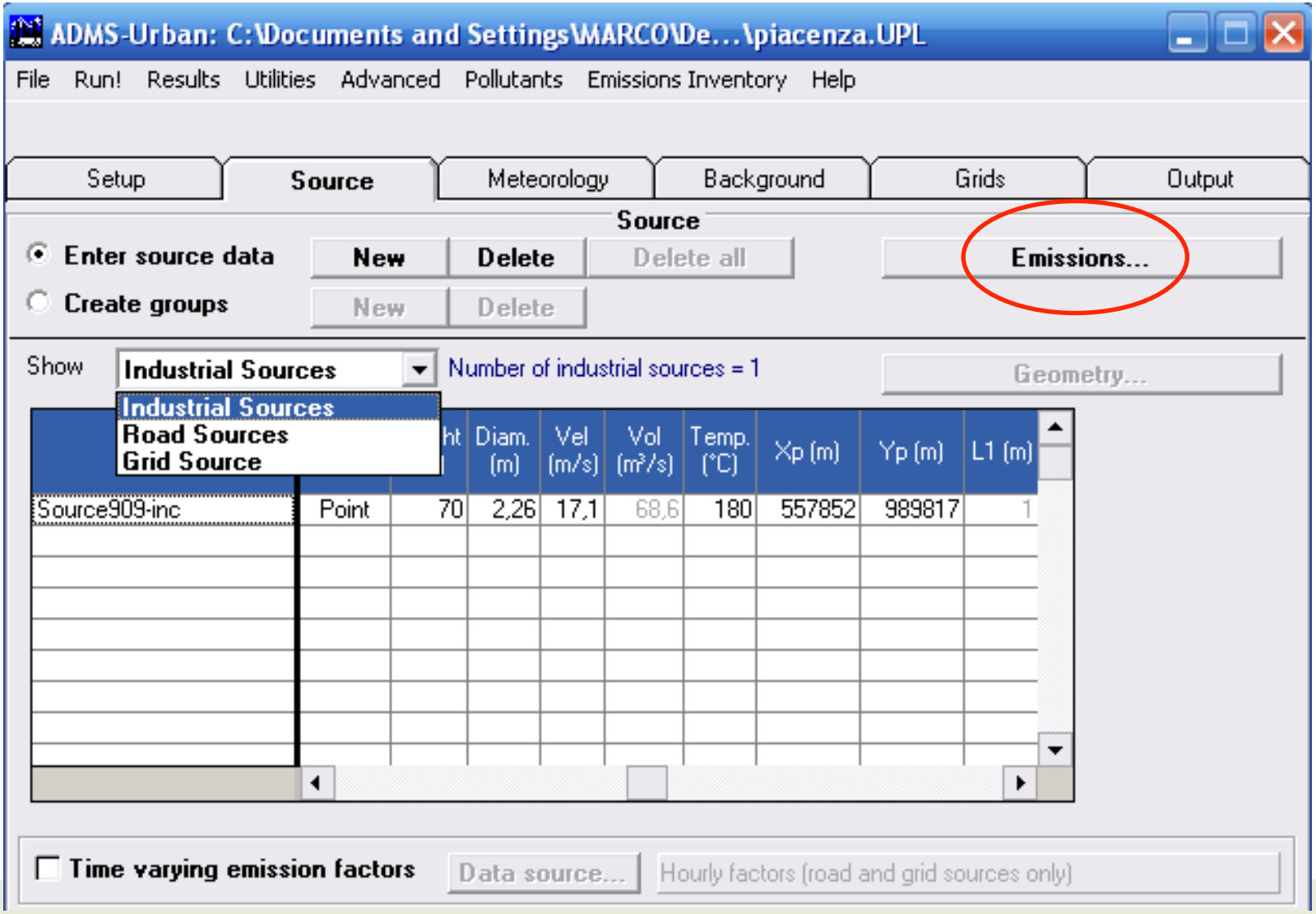
METEO DATA

Dispersion model



distribution of concentration at ground level

ADMS urban software



ADMS OUTPUT

CORINV.glt - Blocco note

File Modifica Formato Visualizza ?

X(m)	Y(m)	Z(m)	Conc|ug/m³|NO2|All sources|-|24hrs	Conc|ug/m³|VOC|All sources|-|24hrs	Conc|ug/m³|SO2|All sources|-| 1hr	Conc|ug/m³|SO2|All sources|-|24hrs	Con
742740.75	898740.75	0.00	0.162806E+02	0.186956E+01	0.712687E+01	0.712687E+01	0.168796E+02	0.975210E+01	
743000.00	898740.75	0.00	0.163769E+02	0.206153E+01	0.714985E+01	0.714985E+01	0.168998E+02	0.104943E+02	
743259.25	898740.75	0.00	0.164551E+02	0.214814E+01	0.715662E+01	0.715662E+01	0.169094E+02	0.111086E+02	
743518.50	898740.75	0.00	0.168953E+02	0.250100E+01	0.717245E+01	0.717245E+01	0.169443E+02	0.138787E+02	
743777.81	898740.75	0.00	0.168017E+02	0.243576E+01	0.718063E+01	0.718063E+01	0.169394E+02	0.132370E+02	
744037.06	898740.75	0.00	0.174305E+02	0.310619E+01	0.721237E+01	0.721237E+01	0.170075E+02	0.176134E+02	
744296.31	898740.75	0.00	0.171536E+02	0.286777E+01	0.721225E+01	0.721225E+01	0.169858E+02	0.155851E+02	
744555.56	898740.75	0.00	0.170664E+02	0.279174E+01	0.721189E+01	0.721189E+01	0.169797E+02	0.148987E+02	
744814.81	898740.75	0.00	0.170407E+02	0.276409E+01	0.720981E+01	0.720981E+01	0.169783E+02	0.146246E+02	
745074.06	898740.75	0.00	0.173141E+02	0.308421E+01	0.721950E+01	0.721950E+01	0.170109E+02	0.164575E+02	
745333.31	898740.75	0.00	0.173301E+02	0.308607E+01	0.722181E+01	0.722181E+01	0.170130E+02	0.164299E+02	
745592.62	898740.75	0.00	0.173631E+02	0.309391E+01	0.722696E+01	0.722696E+01	0.170153E+02	0.164924E+02	
745851.88	898740.75	0.00	0.174207E+02	0.310759E+01	0.723213E+01	0.723213E+01	0.170170E+02	0.166801E+02	
746111.12	898740.75	0.00	0.177251E+02	0.345429E+01	0.726626E+01	0.726626E+01	0.170562E+02	0.183953E+02	
746370.38	898740.75	0.00	0.179870E+02	0.367006E+01	0.728154E+01	0.728154E+01	0.170797E+02	0.200916E+02	
746629.62	898740.75	0.00	0.181249E+02	0.374118E+01	0.729775E+01	0.729775E+01	0.170919E+02	0.204251E+02	
746888.88	898740.75	0.00	0.182937E+02	0.384181E+01	0.731577E+01	0.731577E+01	0.171114E+02	0.207460E+02	
747148.19	898740.75	0.00	0.188668E+02	0.434201E+01	0.738627E+01	0.738627E+01	0.171824E+02	0.227829E+02	
747407.44	898740.75	0.00	0.202686E+02	0.522614E+01	0.742215E+01	0.742215E+01	0.173011E+02	0.294083E+02	
747666.69	898740.75	0.00	0.212786E+02	0.572660E+01	0.744811E+01	0.744811E+01	0.173856E+02	0.330672E+02	
747925.94	898740.75	0.00	0.191672E+02	0.454166E+01	0.742689E+01	0.742689E+01	0.172262E+02	0.235569E+02	
748185.19	898740.75	0.00	0.184544E+02	0.432663E+01	0.747619E+01	0.747619E+01	0.172009E+02	0.195372E+02	
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748703.69	898740.75	0.00	0.179958E+02	0.421953E+01	0.749624E+01	0.749624E+01	0.171880E+02	0.175027E+02	
748963.00	898740.75	0.00	0.178943E+02	0.423028E+01	0.750985E+01	0.750985E+01	0.171913E+02	0.169857E+02	
749222.25	898740.75	0.00	0.176853E+02	0.433784E+01	0.756316E+01	0.756316E+01	0.172079E+02	0.150240E+02	
749481.50	898740.75	0.00	0.176587E+02	0.435647E+01	0.757780E+01	0.757780E+01	0.172169E+02	0.147163E+02	
749740.75	898740.75	0.00	0.176423E+02	0.437675E+01	0.758977E+01	0.758977E+01	0.172255E+02	0.144626E+02	
750000.00	898740.75	0.00	0.175009E+02	0.435966E+01	0.763035E+01	0.763035E+01	0.172322E+02	0.128718E+02	
750259.25	898740.75	0.00	0.174934E+02	0.436348E+01	0.763887E+01	0.763887E+01	0.172370E+02	0.126822E+02	
742740.75	899000.00	0.00	0.189878E+02	0.443841E+01	0.721594E+01	0.721594E+01	0.171391E+02	0.282593E+02	
743000.00	899000.00	0.00	0.284101E+02	0.168194E+02	0.743353E+01	0.743353E+01	0.184290E+02	0.110632E+03	
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743518.50	899000.00	0.00	0.321879E+02	0.212444E+02	0.754154E+01	0.754154E+01	0.188546E+02	0.146388E+03	
743777.81	899000.00	0.00	0.339101E+02	0.234796E+02	0.760170E+01	0.760170E+01	0.190698E+02	0.164424E+03	
744037.06	899000.00	0.00	0.249559E+02	0.135921E+02	0.741226E+01	0.741226E+01	0.179833E+02	0.768739E+02	
744296.31	899000.00	0.00	0.245381E+02	0.131709E+02	0.741164E+01	0.741164E+01	0.179450E+02	0.732859E+02	
744555.56	899000.00	0.00	0.244228E+02	0.130538E+02	0.741340E+01	0.741340E+01	0.179356E+02	0.721894E+02	
744814.81	899000.00	0.00	0.243792E+02	0.130032E+02	0.741233E+01	0.741233E+01	0.179327E+02	0.716565E+02	
745074.06	899000.00	0.00	0.260419E+02	0.136627E+02	0.748304E+01	0.748304E+01	0.181328E+02	0.809106E+02	
745333.31	899000.00	0.00	0.260621E+02	0.136691E+02	0.748637E+01	0.748637E+01	0.181365E+02	0.808121E+02	
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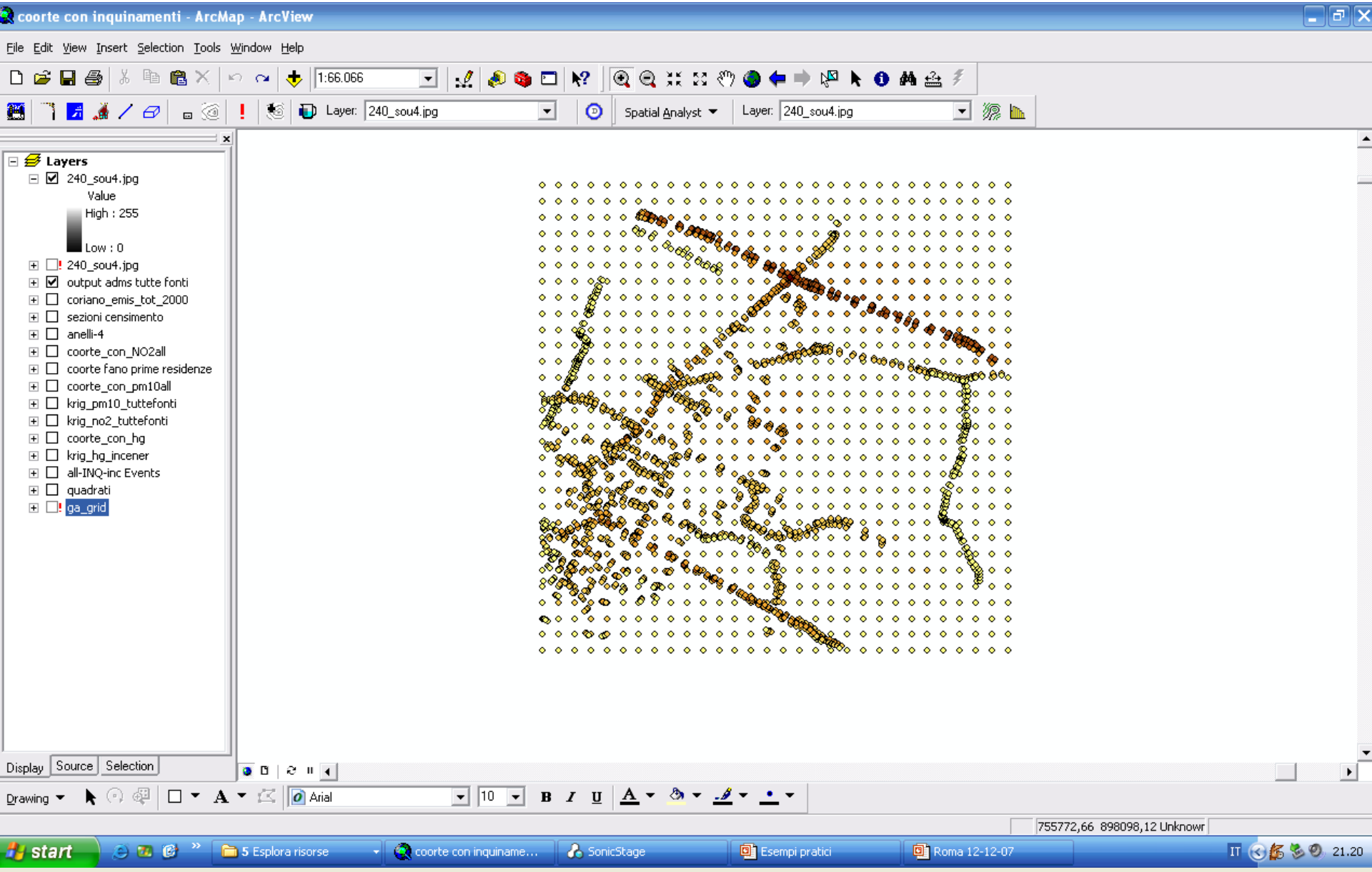
745851.88	899000.00	0.00	0.262051E+02	0.137454E+02	0.750073E+01	0.750073E+01	0.181511E+02	0.812505E+02	
746111.12	899000.00	0.00	0.265837E+02	0.134723E+02	0.758976E+01	0.758976E+01	0.181861E+02	0.813827E+02	
746370.38	899000.00	0.00	0.296959E+02	0.166267E+02	0.767372E+01	0.767372E+01	0.184933E+02	0.107022E+03	
746629.62	899000.00	0.00	0.276235E+02	0.142915E+02	0.764078E+01	0.764078E+01	0.182837E+02	0.878153E+02	
746888.88	899000.00	0.00	0.284728E+02	0.147423E+02	0.767250E+01	0.767250E+01	0.183591E+02	0.908510E+02	
747148.19	899000.00	0.00	0.448479E+02	0.230846E+02	0.808033E+01	0.808033E+01	0.199228E+02	0.152599E+03	
747407.44	899000.00	0.00	0.275393E+02	0.122608E+02	0.775844E+01	0.775844E+01	0.182030E+02	0.687066E+02	
747666.69	899000.00	0.00	0.240281E+02	0.101249E+02	0.771088E+01	0.771088E+01	0.179247E+02	0.515282E+02	
747925.94	899000.00	0.00	0.226001E+02	0.933811E+01	0.770009E+01	0.770009E+01	0.178243E+02	0.450520E+02	
748185.19	899000.00	0.00	0.201333E+02	0.897616E+01	0.778275E+01	0.778275E+01	0.176771E+02	0.286249E+02	

ADMS OUTPUT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Spatial Analyst
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Layers
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coorte_con_pm10all
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krig_no2_tuttefonti
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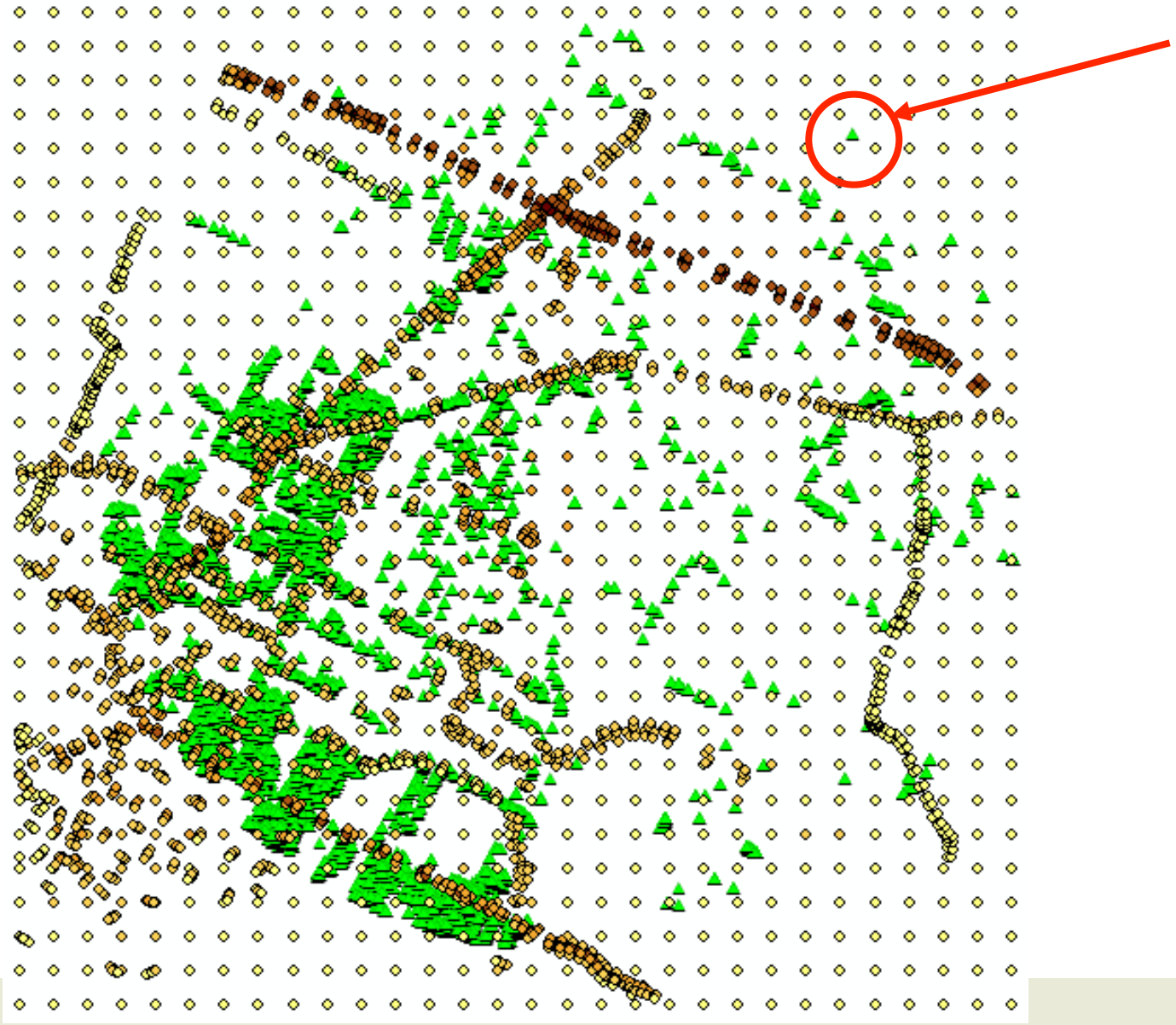
Residential cohort and ADMS output



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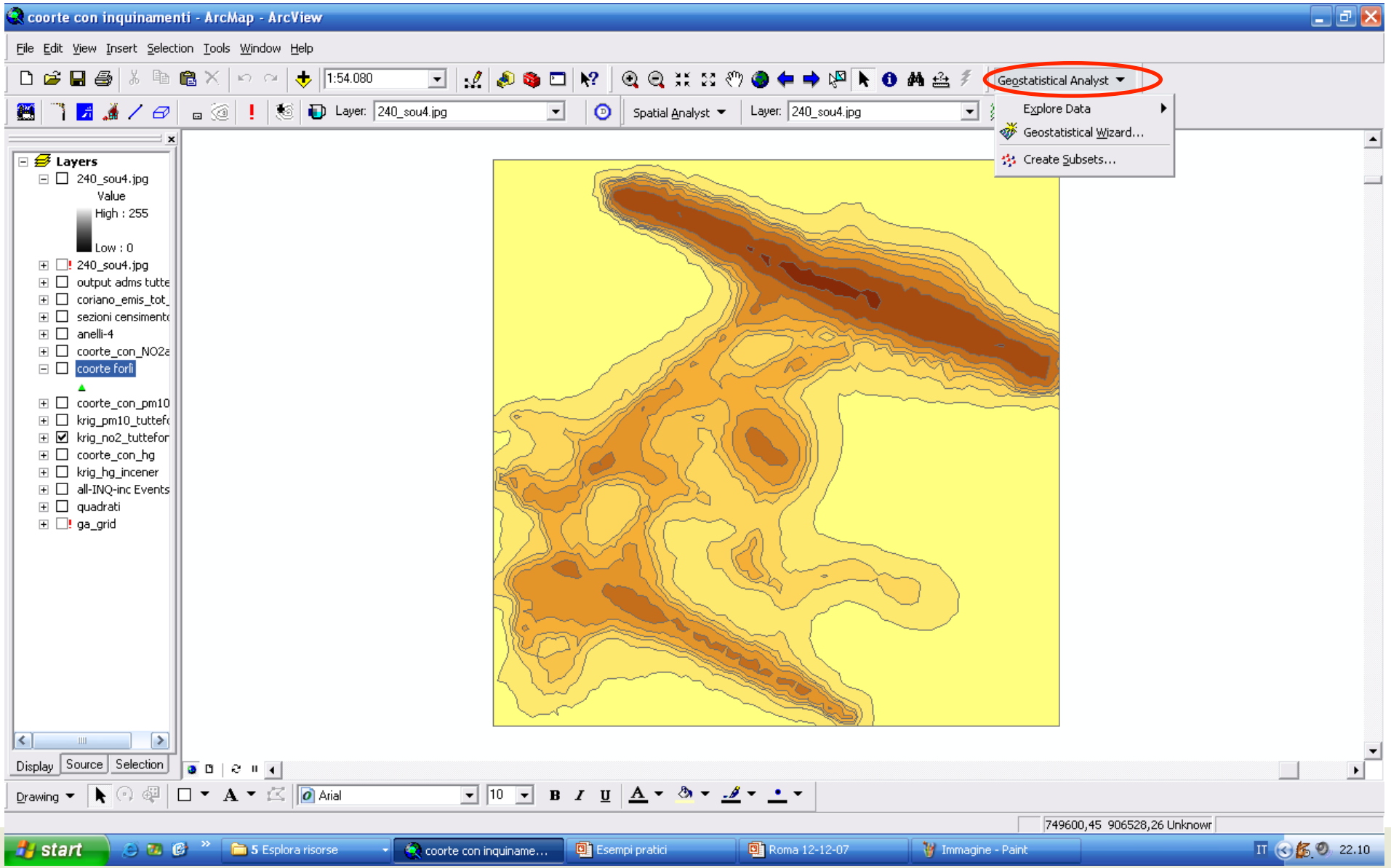
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Spatial Analyst
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Geostatistical Analyst
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output adms tutte
coriano_emis_tot_
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krig_pm10_tuttef
krig_no2_tuttefor
coorte_con_hg
krig_hg_incener
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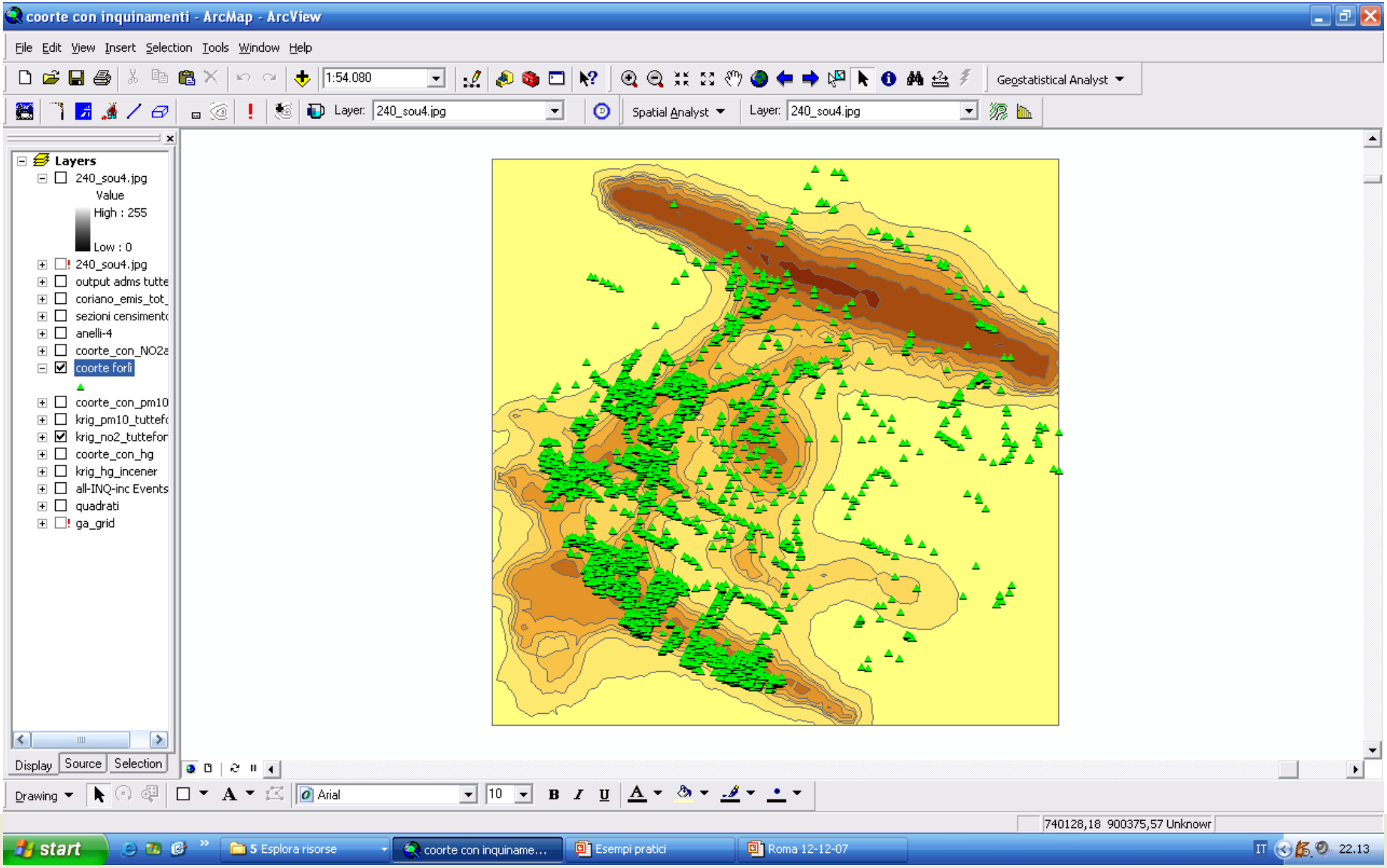
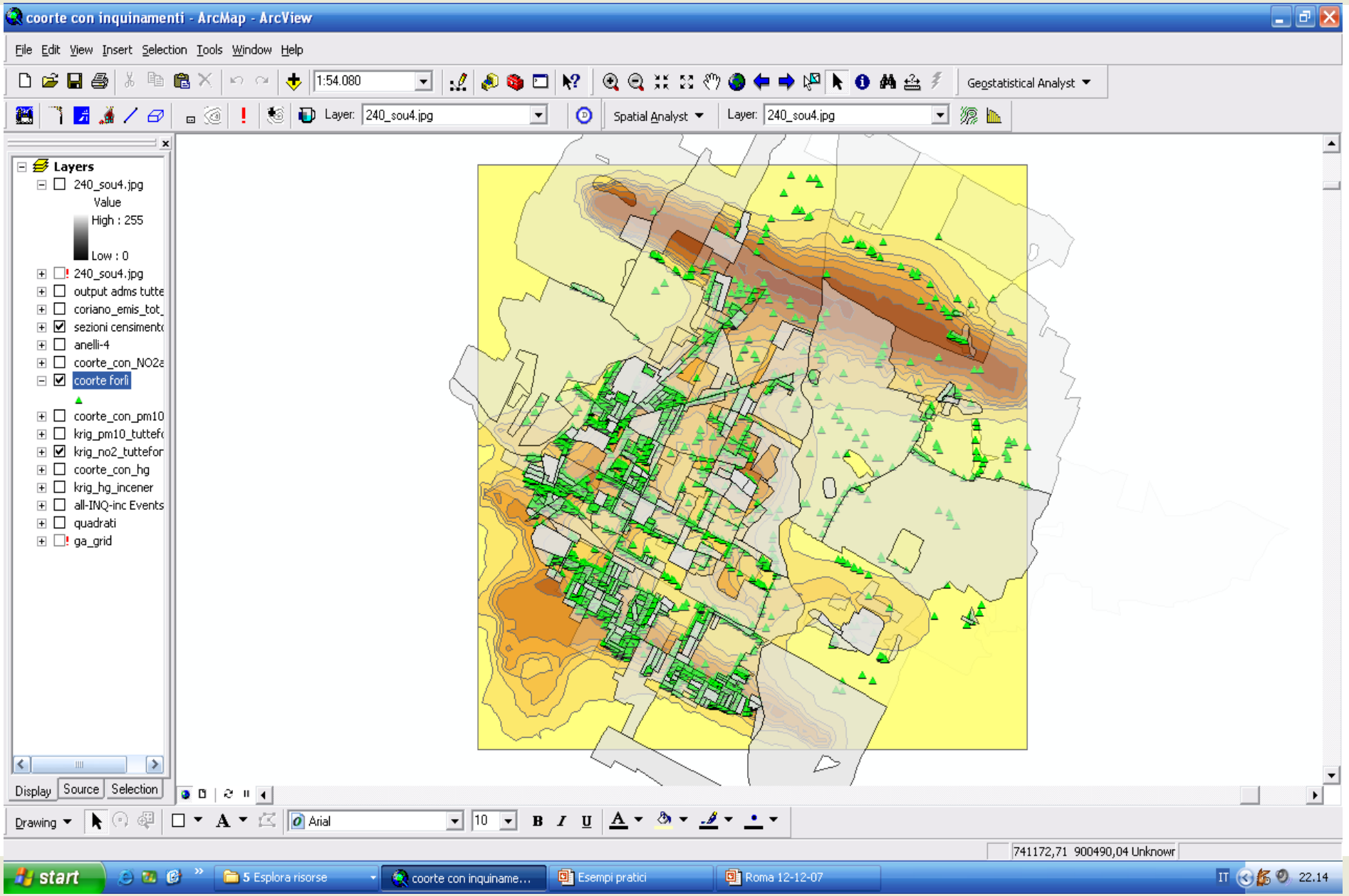
Esempi pratici
Roma 12-12-07
Immagine - Paint
IT
22.10

Residential cohort



CENSUS DATA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Layer: 240_sou4.jpg
Spatial Analyst
Layer: 240_sou4.jpg
Layers
240_sou4.jpg
Value
High : 255
Low : 0
240_sou4.jpg
output adms tutte
coriano_emis_tot_
sezioni censiment
anelli-4
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krig_no2_tuttefor
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Esempi pratici
Roma 12-12-07
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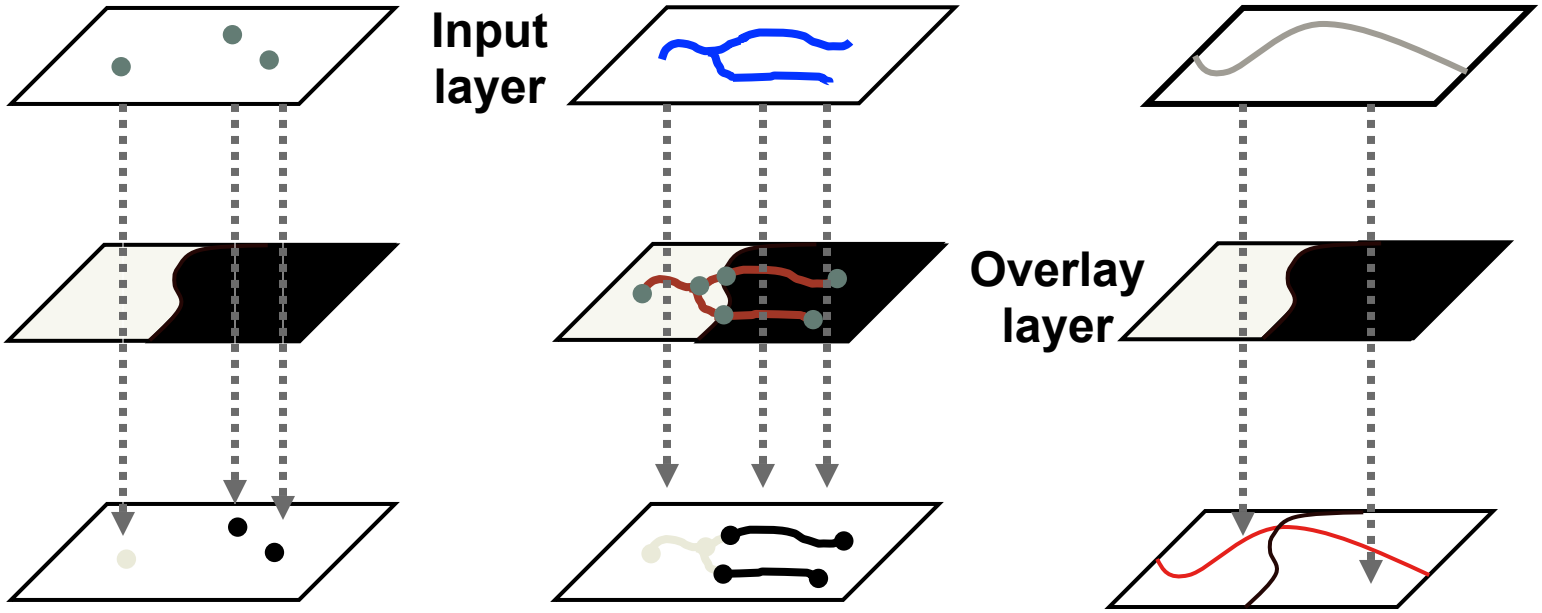
22.14

Application of Overlay analysis

Point-in-polygon | Line-in-polygon | Polygon-on-polygon



Output layer inherits overlay layer's attributes

Example 2: Use of large routine data

Example on Waste-related exposure:

how calculate EBD related to exposure to landfills in Europe

Today

Number of exposed people using European databases

- GIS approach to exposure assessment

Tomorrow (IEHIA lecture)

Use RR from literature and

Calculation of AC (Attributable Cases)

Combination of different health outcomes in one analysis using DALYs

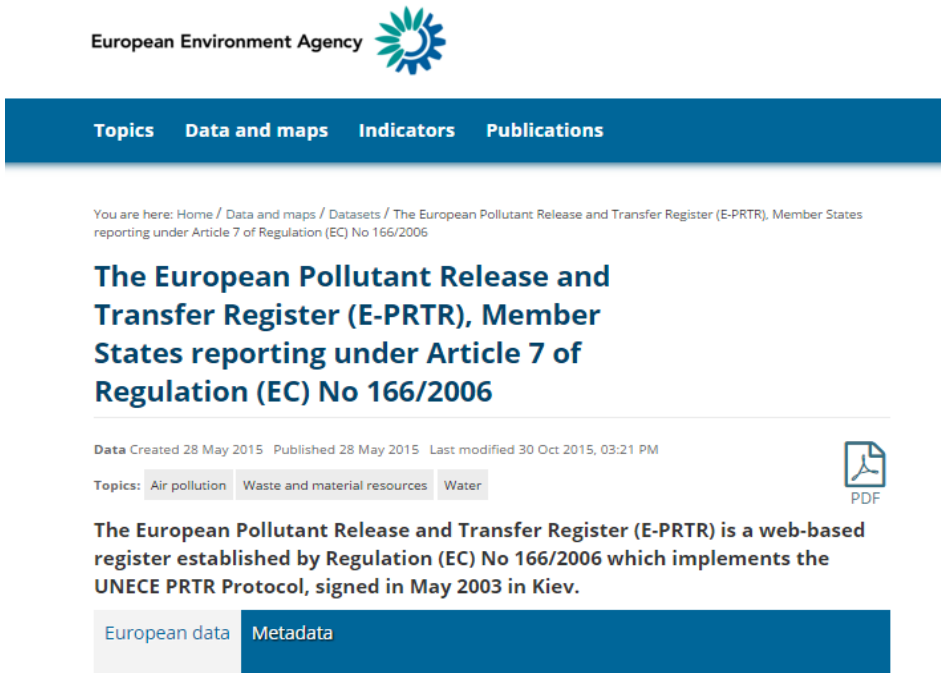
Data collection

Location of plants

Population database

European health statistics

Location of plants – E-PRTR register



http://www.eea.europa.eu/data-and-maps/data/member-states-reporting-art-7-under-the-european-pollutant-release-and-transfer-register-e-prtr-regulation-10

E-PRTR

- E-PRTR data covering reporting for 2007 to 2014 by EU Member States, Iceland, Liechtenstein, Norway, Serbia and Switzerland.
- Article 7 of the Regulation sets the requirements for the annual reporting by Member States which covers the releases to air and water for 91 substances, as well as the transfers of pollutants in water and the transfer of waste from industrial facilities across 65 sectors. The register includes information of more than 30.000 facilities in 32 countries.

E-PRTR (Sector 5.d – 2014 data)

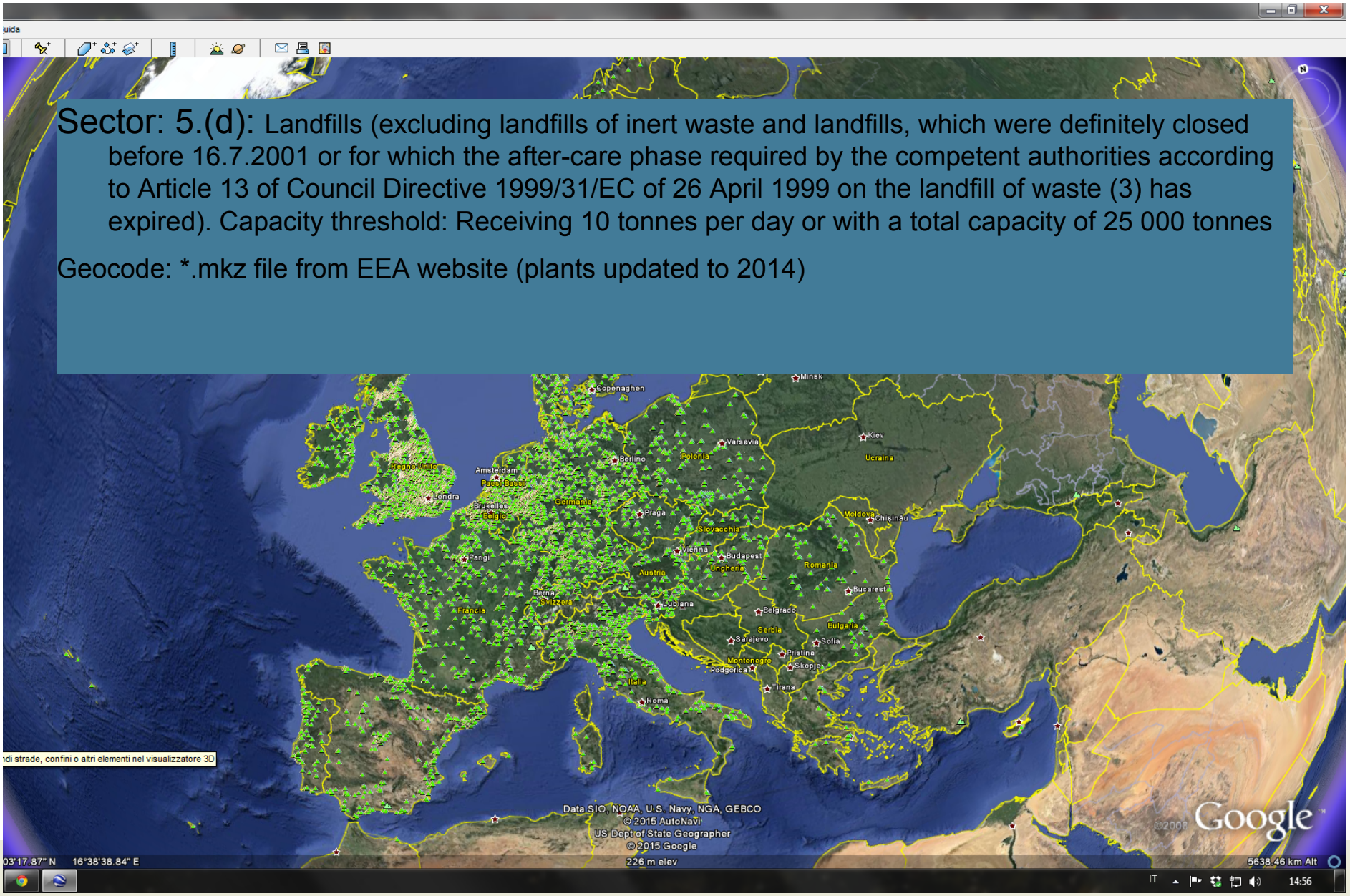
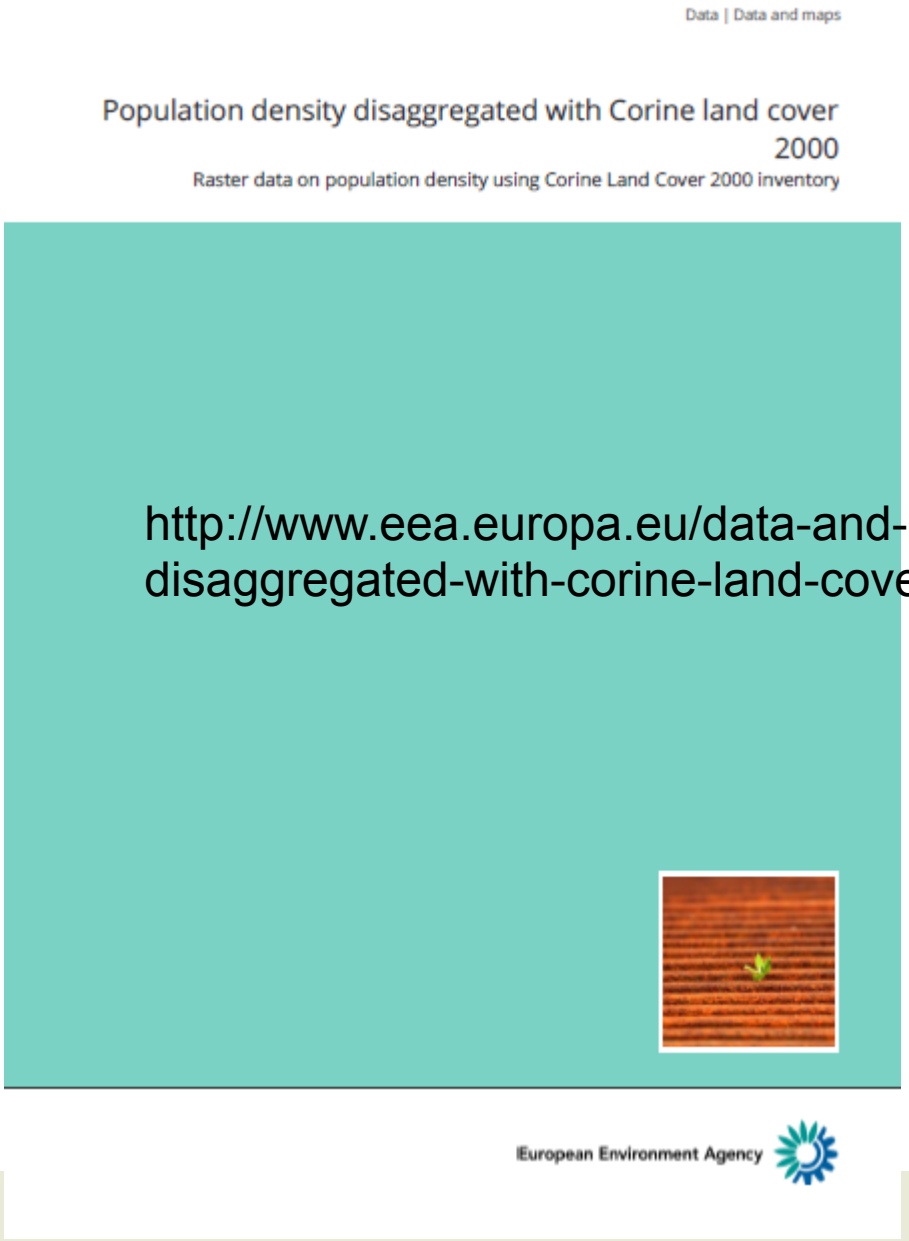


Table 1: Number of facilities reporting for each country by year.

	2007	2008	2009	2010	2011	2012	2013	2014
Austria	20	17	18	15	16	13	10	12
Belgium	22	23	23	17	17	20	17	16
Bulgaria	14	19	22	24	23	28	30	31
Croatia	0	0	0	0	0	0	0	6
Cyprus	0	0	0	0	1	1	1	1
Czech Republic	6	2	4	10	7	12	14	14
Denmark	52	39	27	23	15	27	24	22
Estonia	8	8	8	5	5	4	5	4
Finland	56	50	51	53	50	56	56	58
France	135	160	162	172	182	199	190	185
Germany	248	249	242	234	222	210	202	188
Greece	7	7	8	7	6	5	5	6
Hungary	14	16	17	14	15	8	11	20
Iceland	1	2	2	2	2	2	2	2
Ireland	30	31	33	33	34	33	34	33
Italy	100	115	118	128	128	120	149	163
Latvia	0	0	1	0	0	1	1	2
Liechtenstein	0	0	0	0	0	0	0	0
Lithuania	7	8	8	5	5	4	5	3
Luxembourg	2	2	2	2	2	2	2	2
Malta	2	2	0	2	2	2	2	0
Netherlands	26	25	29	29	26	26	27	27
Norway	48	58	59	60	66	65	55	56
Poland	77	78	78	77	68	72	74	67
Portugal	42	43	41	45	48	48	51	49
Romania	48	47	43	45	43	42	40	43
Serbia	0	0	0	0	0	0	0	1
Slovakia	9	13	16	8	7	6	9	10
Slovenia	20	35	39	32	29	23	26	24
Spain	121	123	139	143	151	155	153	149
Sweden	42	53	66	80	85	87	87	90
Switzerland	1	2	1	2	1	1	1	1
United Kingdom	250	261	251	253	254	258	245	259
Total	1408	1488	1508	1520	1510	1530	1528	1544

Population



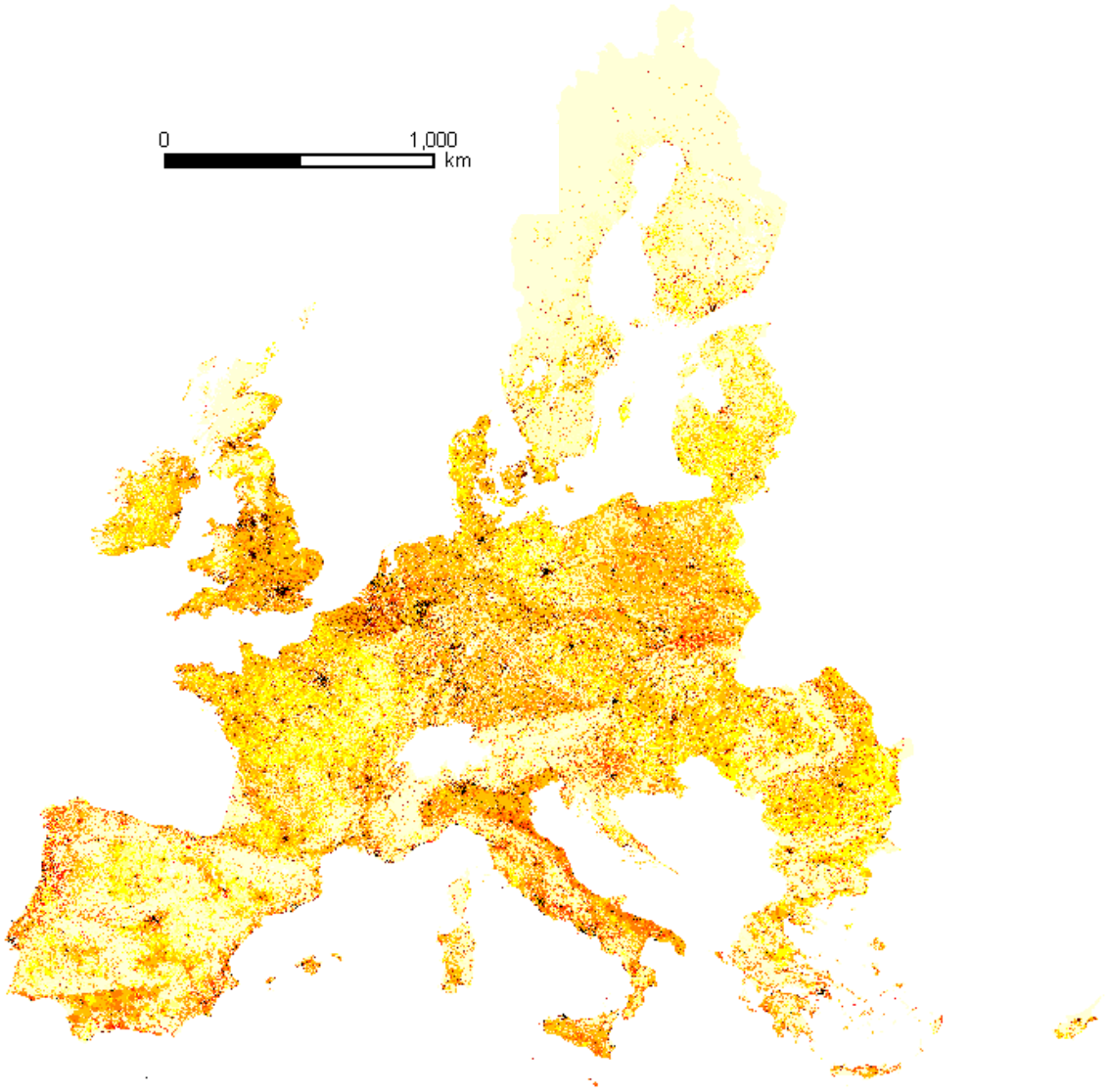
Data are available at 100 meters resolution.
Population by municipality correspond to Census 2001 (Eurostat).
Owners and Processors: Joint Research Centre (JRC)

http://www.eea.europa.eu/data-and-maps/data/population-density-disaggregated-with-corine-land-cover-2000-2

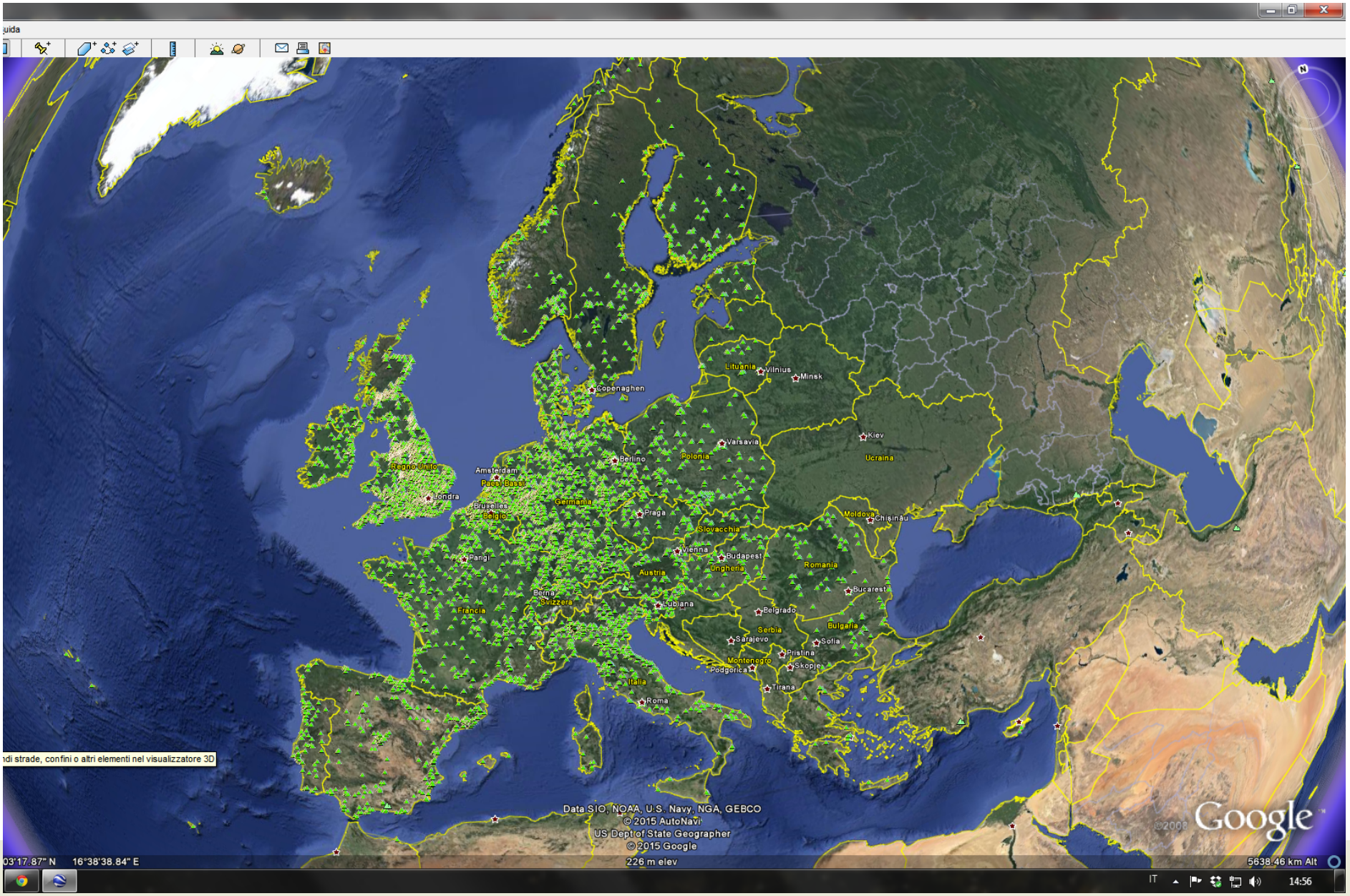
Reference:

Gallego F.J., 2010, A population density grid of the European Union, Population and Environment. 31: 460-473
http://www.springerlink.com/content/h22617v812p51014/?p=a5de0fad279b474187e630362f4f2fc8&pi=3

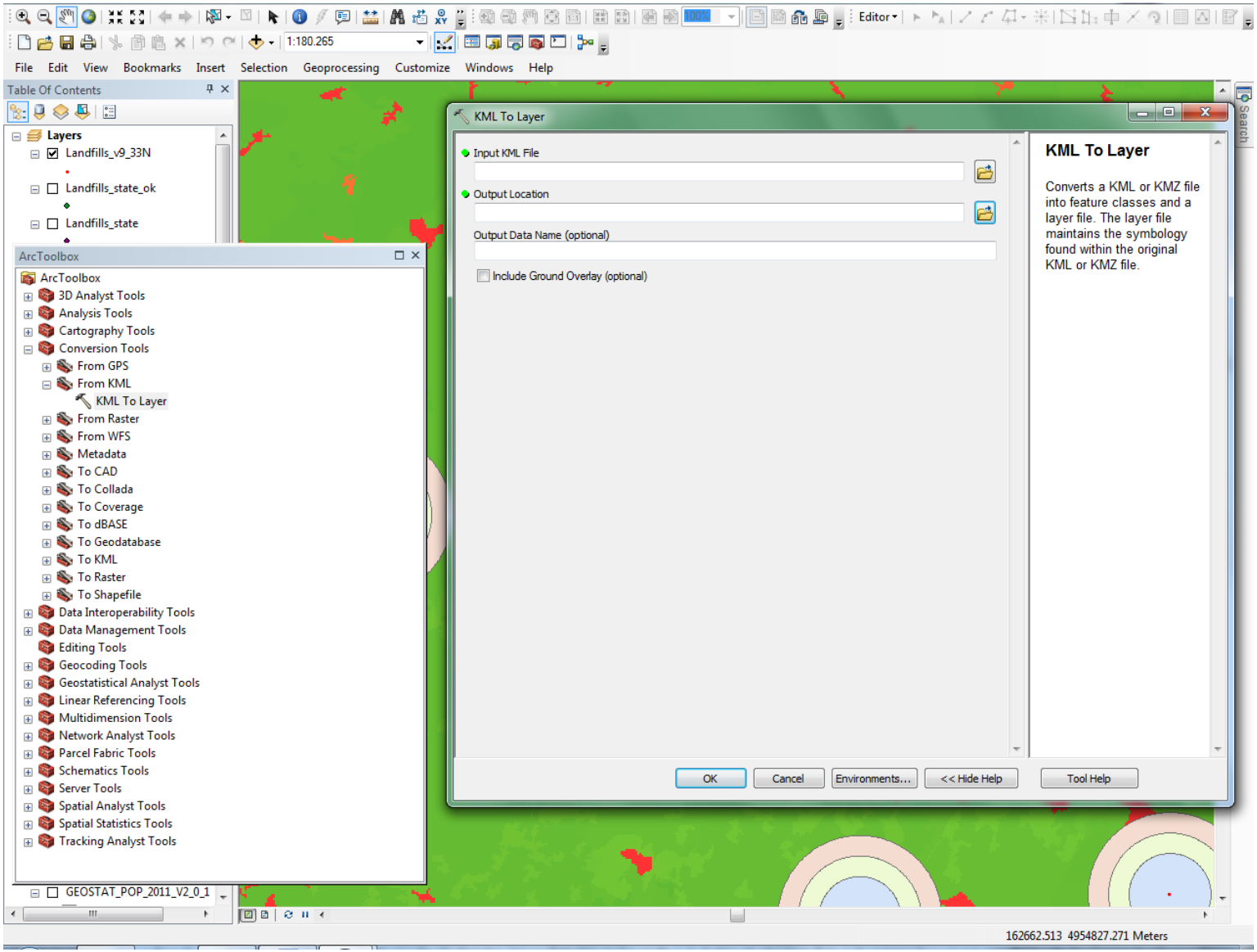
Population



E-PRTR data – Kmz file



KMZ to layer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Landfills_state
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ArcToolbox
3D Analyst Tools
Analysis Tools
Cartography Tools
Conversion Tools
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From KML
KML To Layer
From Raster
From WFS
Metadata
To CAD
To Collada
To Coverage
To dBASE
To Geodatabase
To KML
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Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Parcel Fabric Tools
Schematics Tools
Server Tools
Spatial Analyst Tools
Spatial Statistics Tools
Tracking Analyst Tools
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Output Location
Output Data Name (optional)
Include Ground Overlay (optional)
KML To Layer
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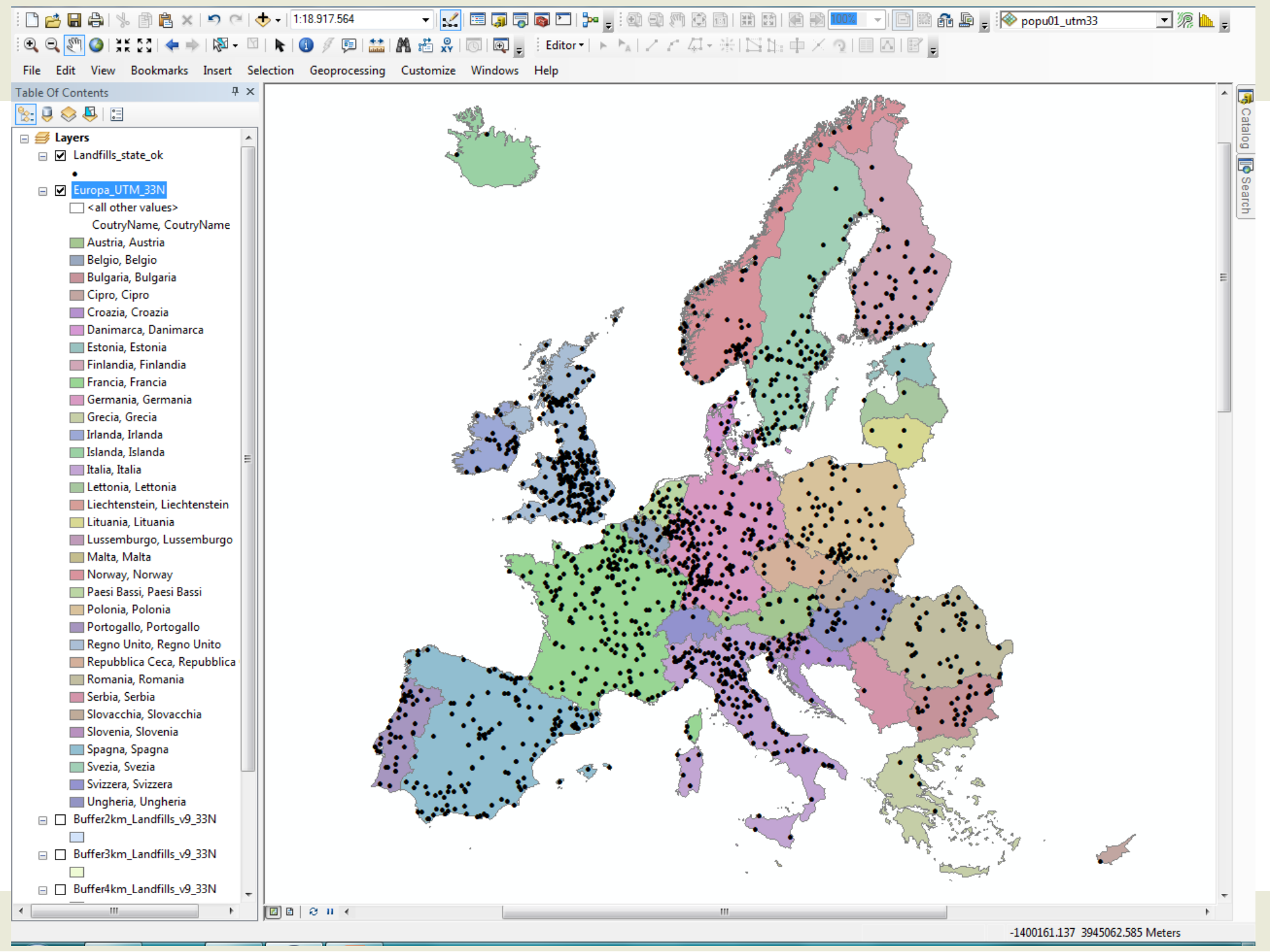
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Svizzera, Svizzera
Ungheria, Ungheria
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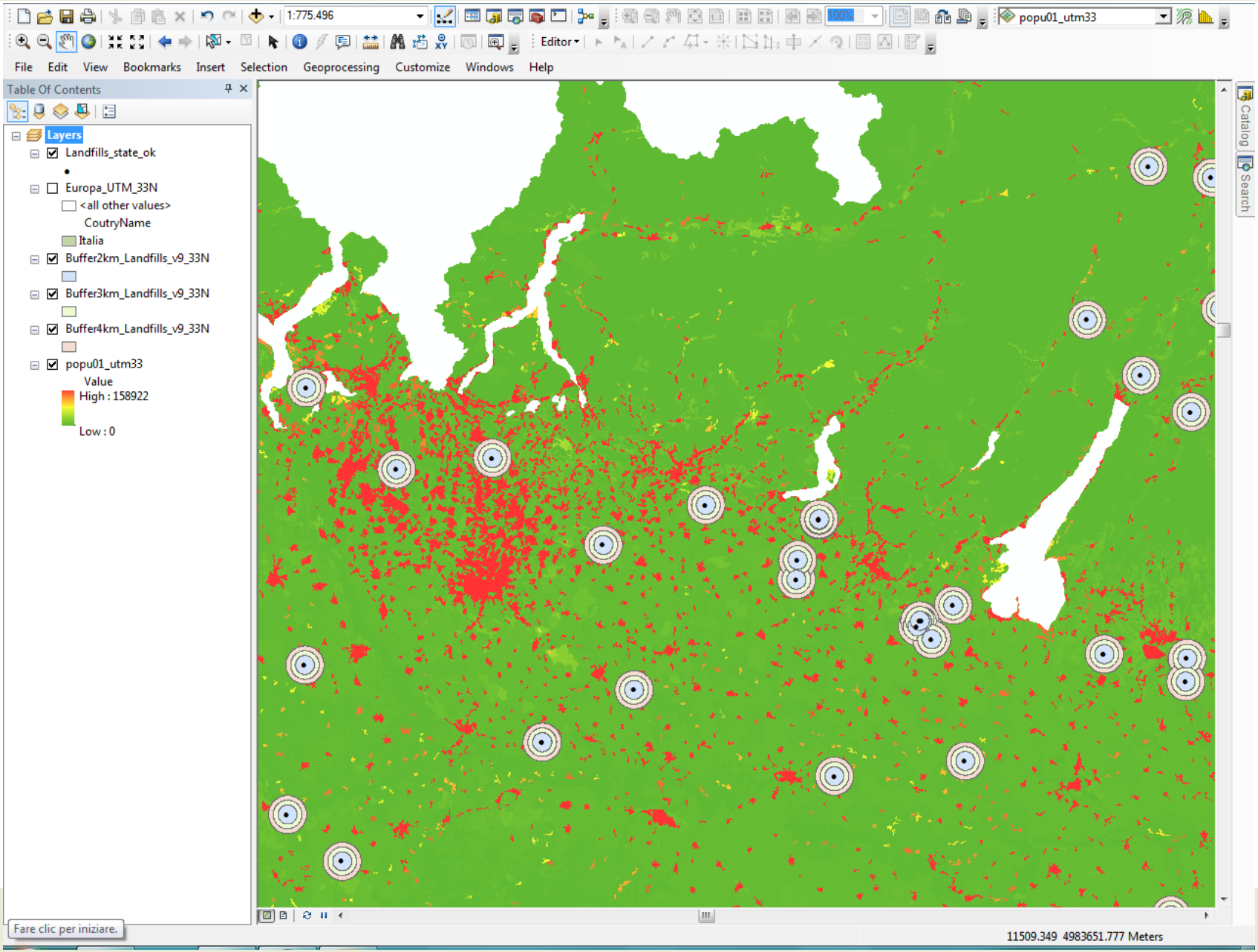
Buffering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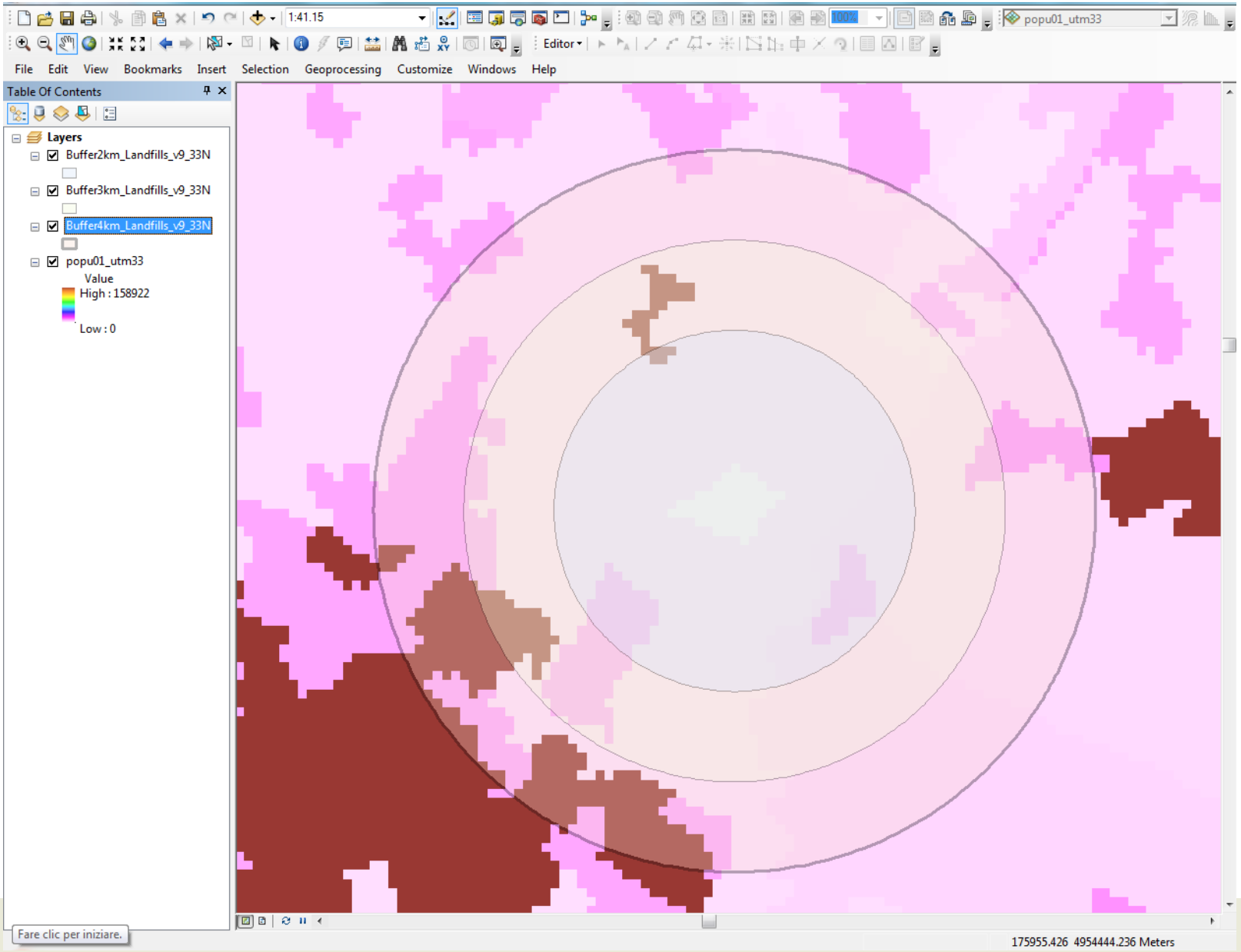
Population data



How to calculate exposed people

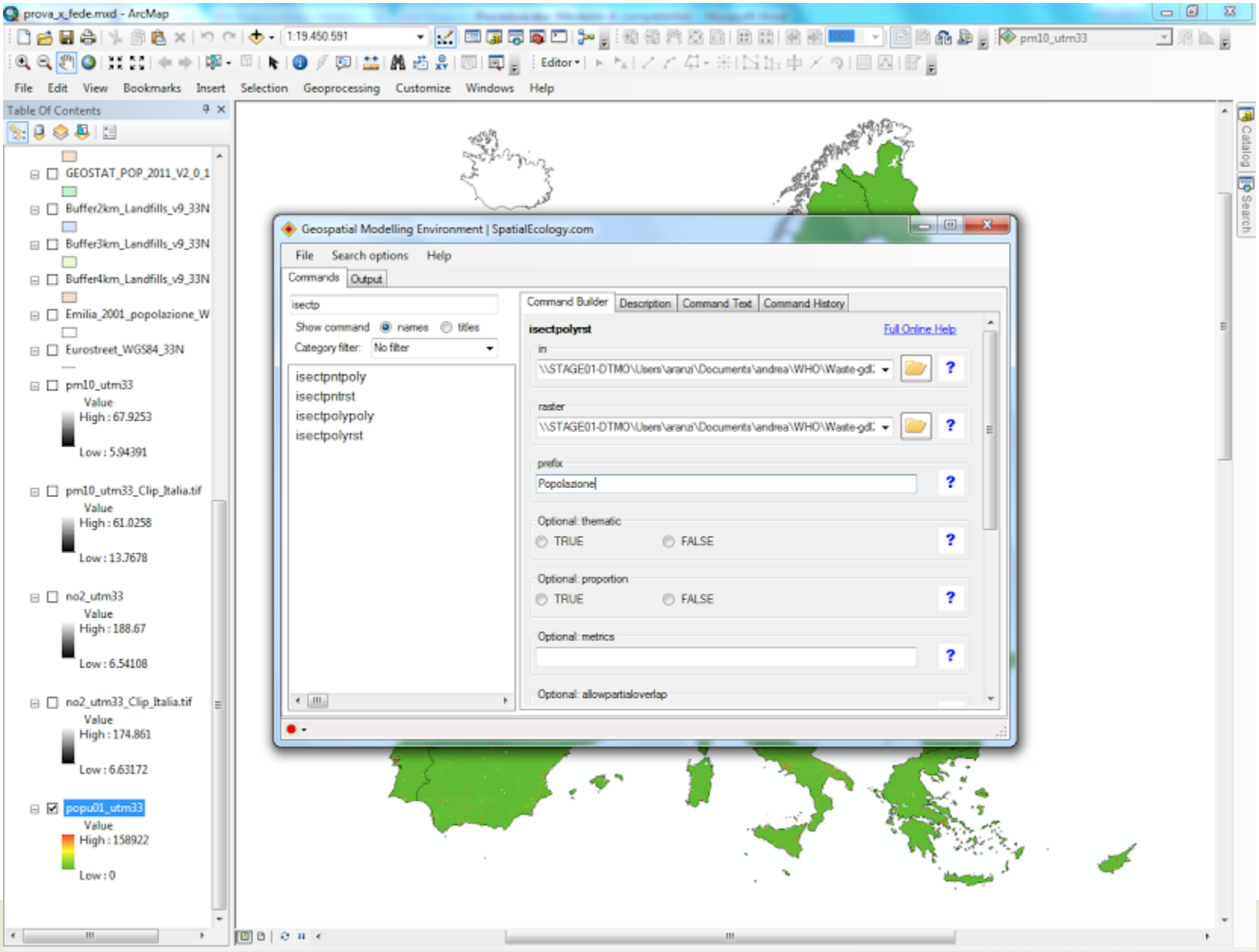
ArcGIS function: “Clip” raster to select squares, then calculation of sum of values

GME free package (http://www.spatialecology.com/gme/, ArcGIS and R are required in your PC)

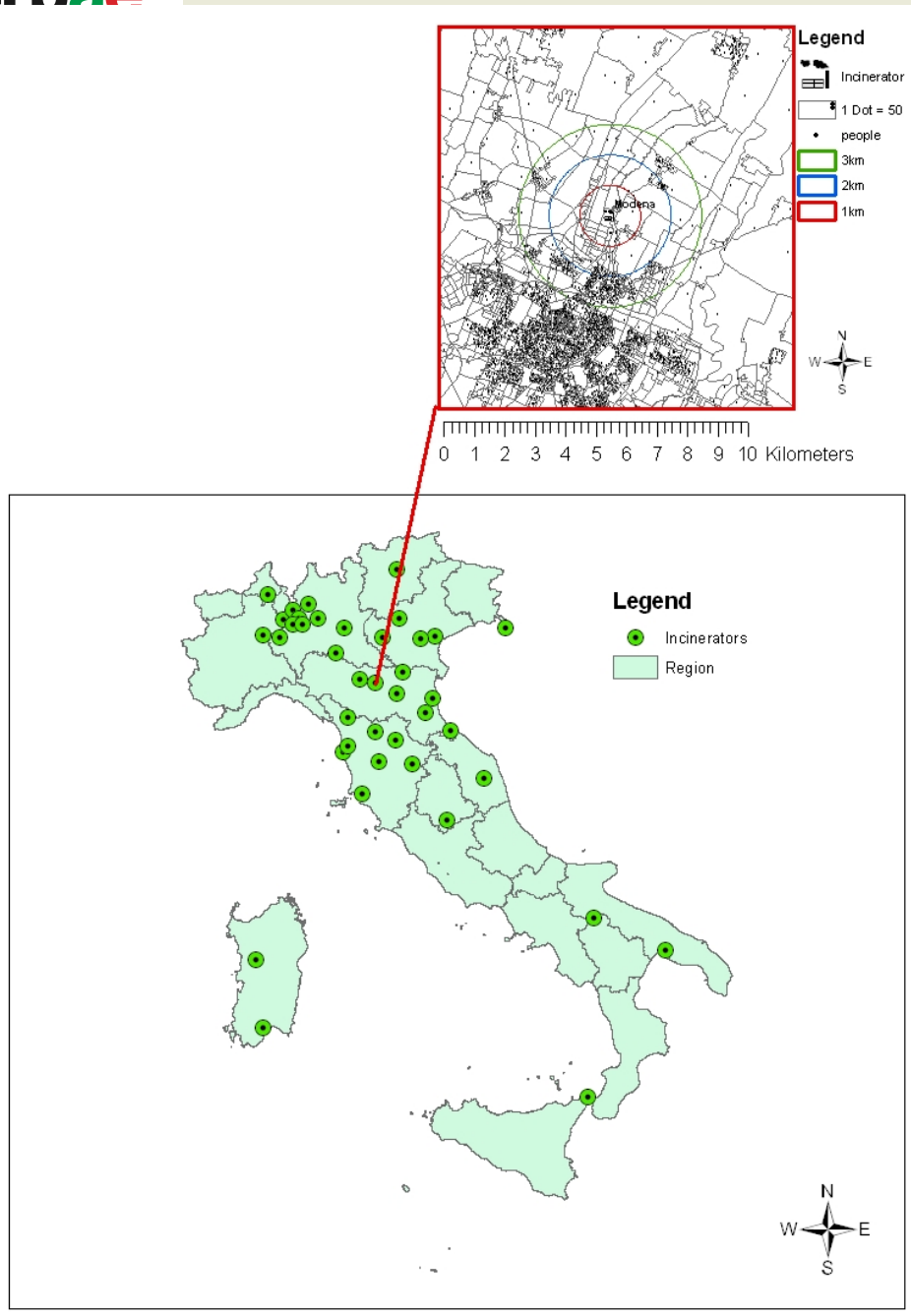
1. Function: isectpolyrst(in=*polygon shapefile with buffers*, raster=*rasterfile with population*, prefix="Pop", metrics=c("CNT","SUM","MEAN","STD"), allowpartialoverlap=TRUE);

At the end, each population number has to be divided by 100 (as it represents 1x1 km density on 100x100 m, see Gallego et al.)

GME free package



Italy

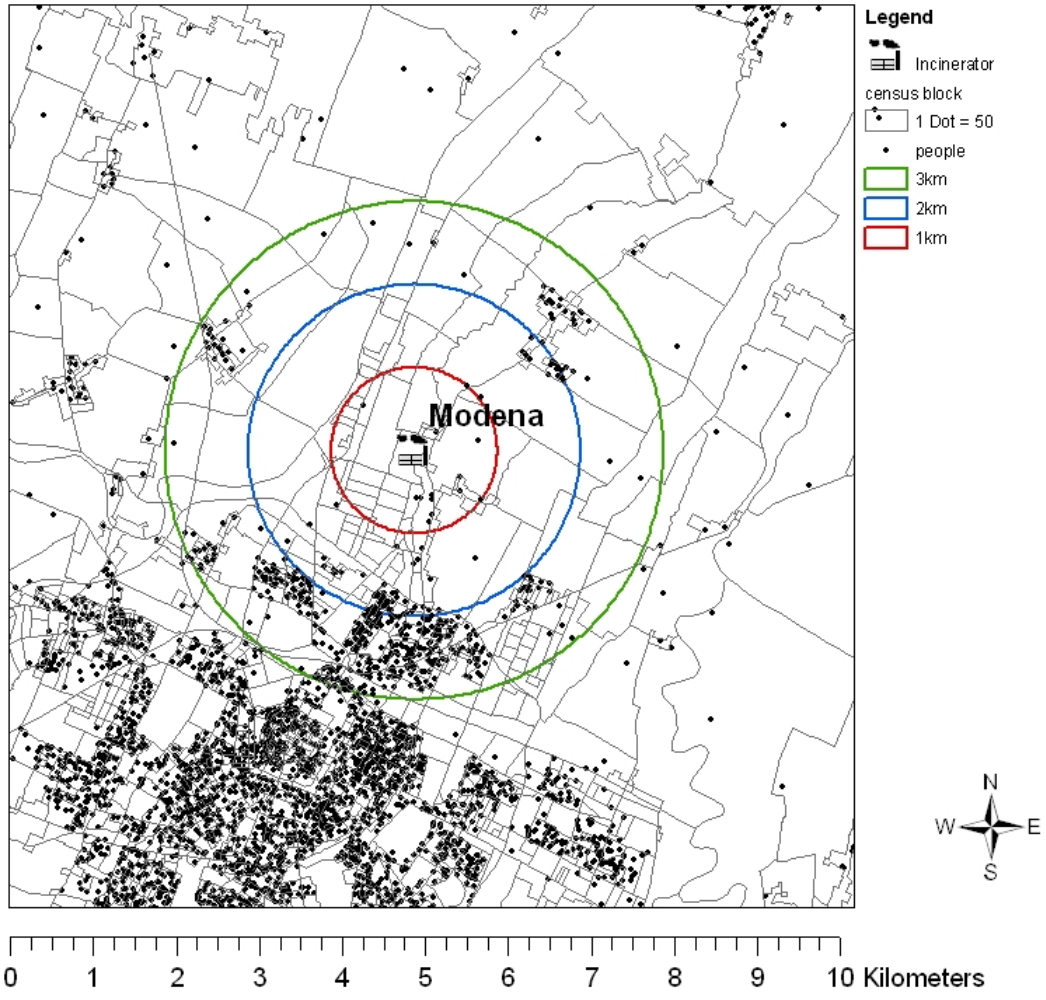


DATA

The geographic coordinate of waste management site

The population distribution in the census block by gender and by age

Modena Incinerator: Selection criteria



Step 1

Use the proximity analysis tool to create buffer to a specific distance around the site of study.

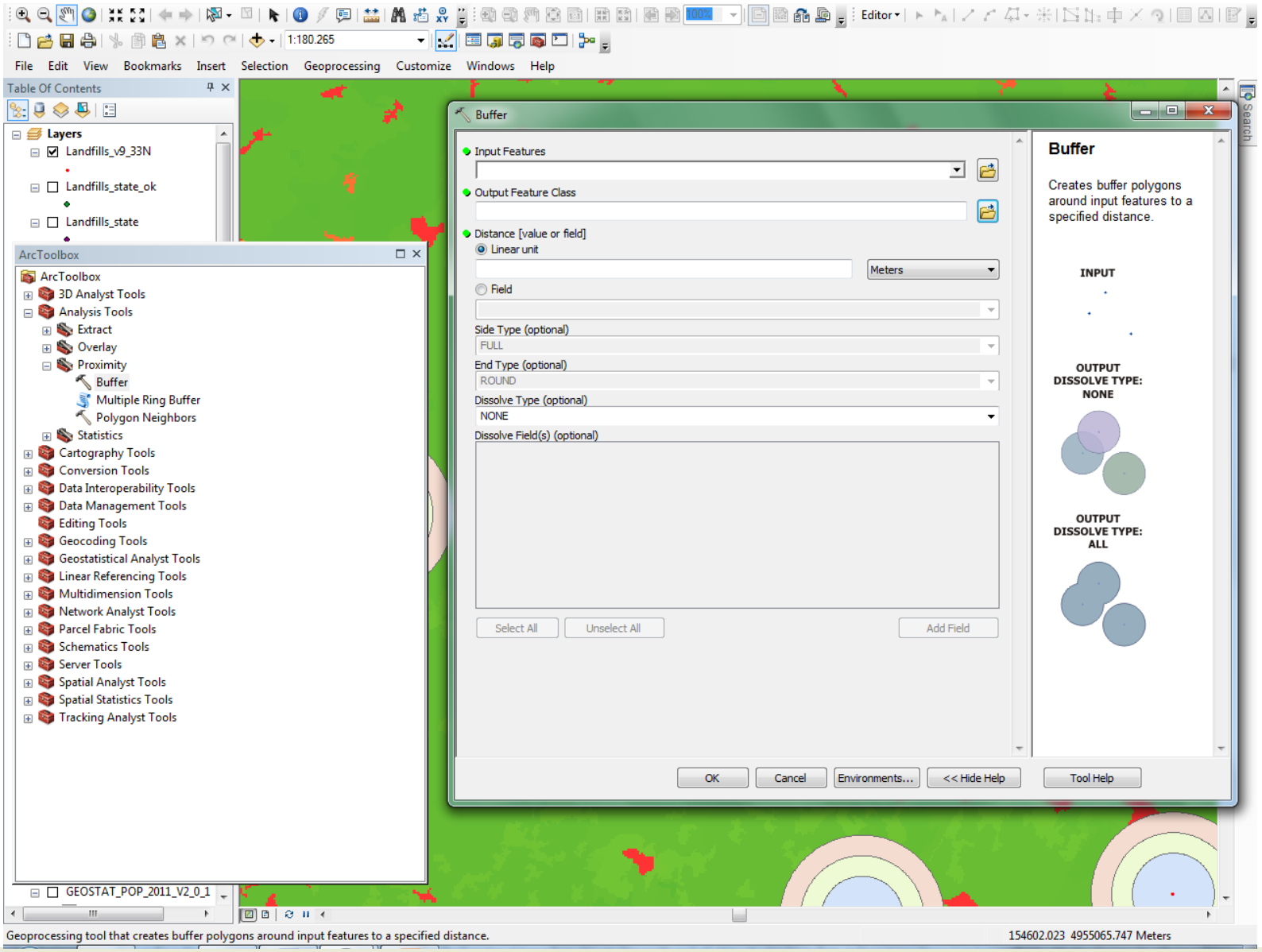
in the present example case:

1km

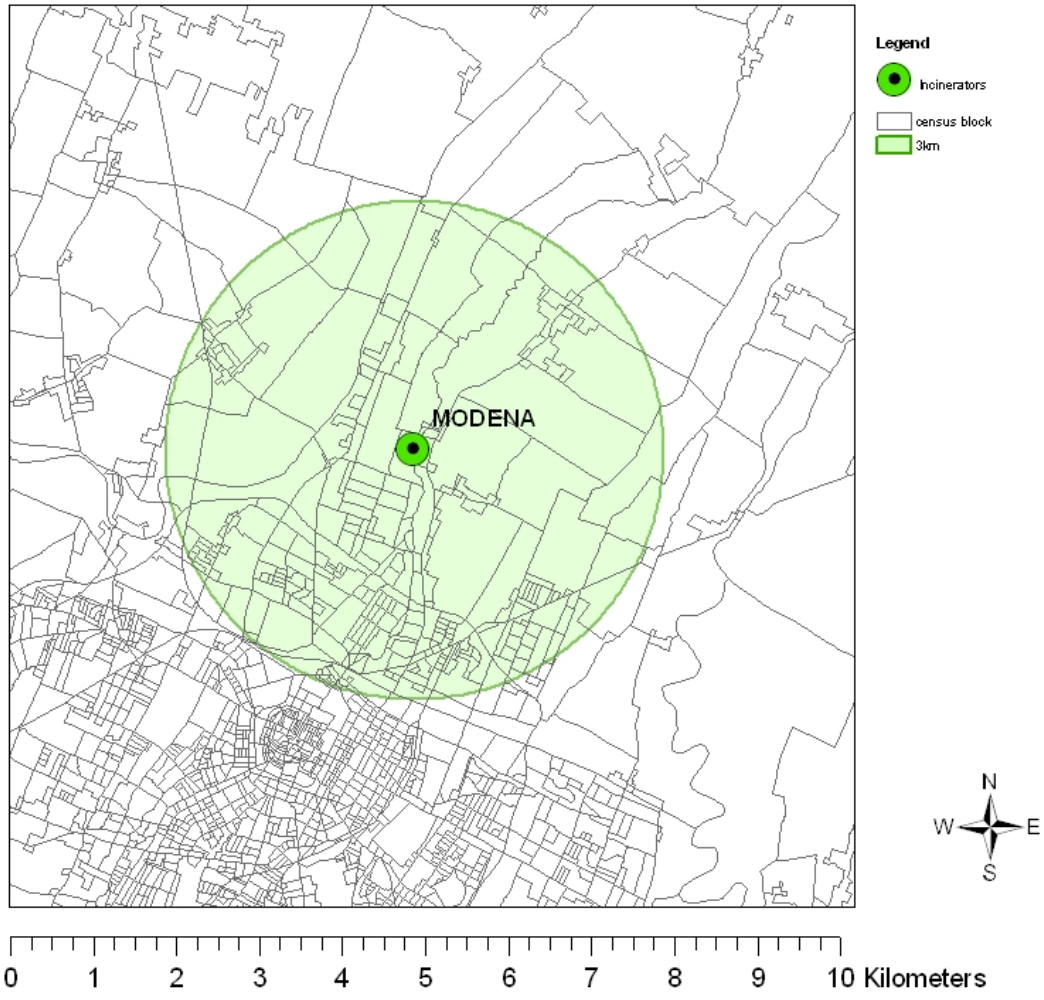
2km

3km

ARCMAP – BUFFER window



Modena Incinerator: Selection criteria



3 KM buffer

Some census block are completely within the buffer

Some others intersect the buffer

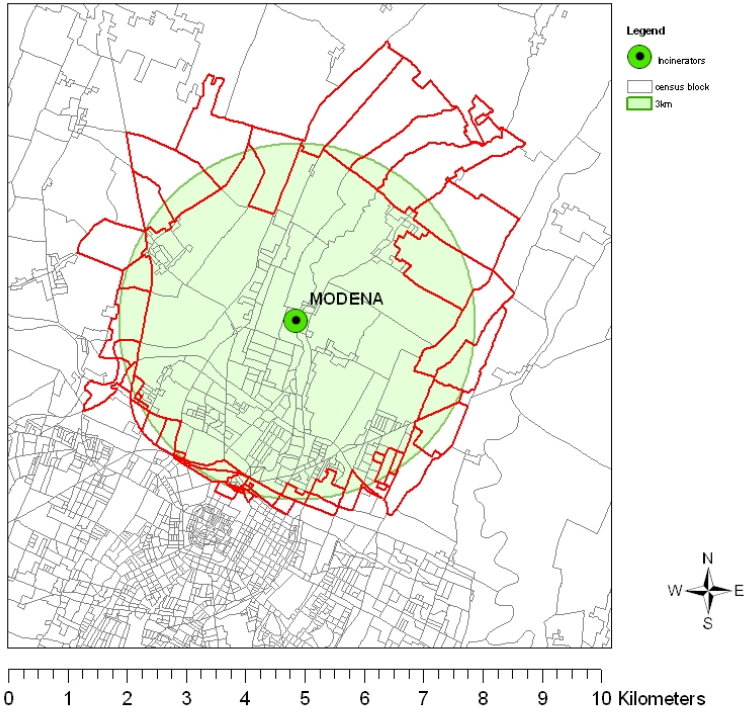
Step 2

Chose the selection criteria

Modena Incinerator: Selection criteria

completely within the buffer

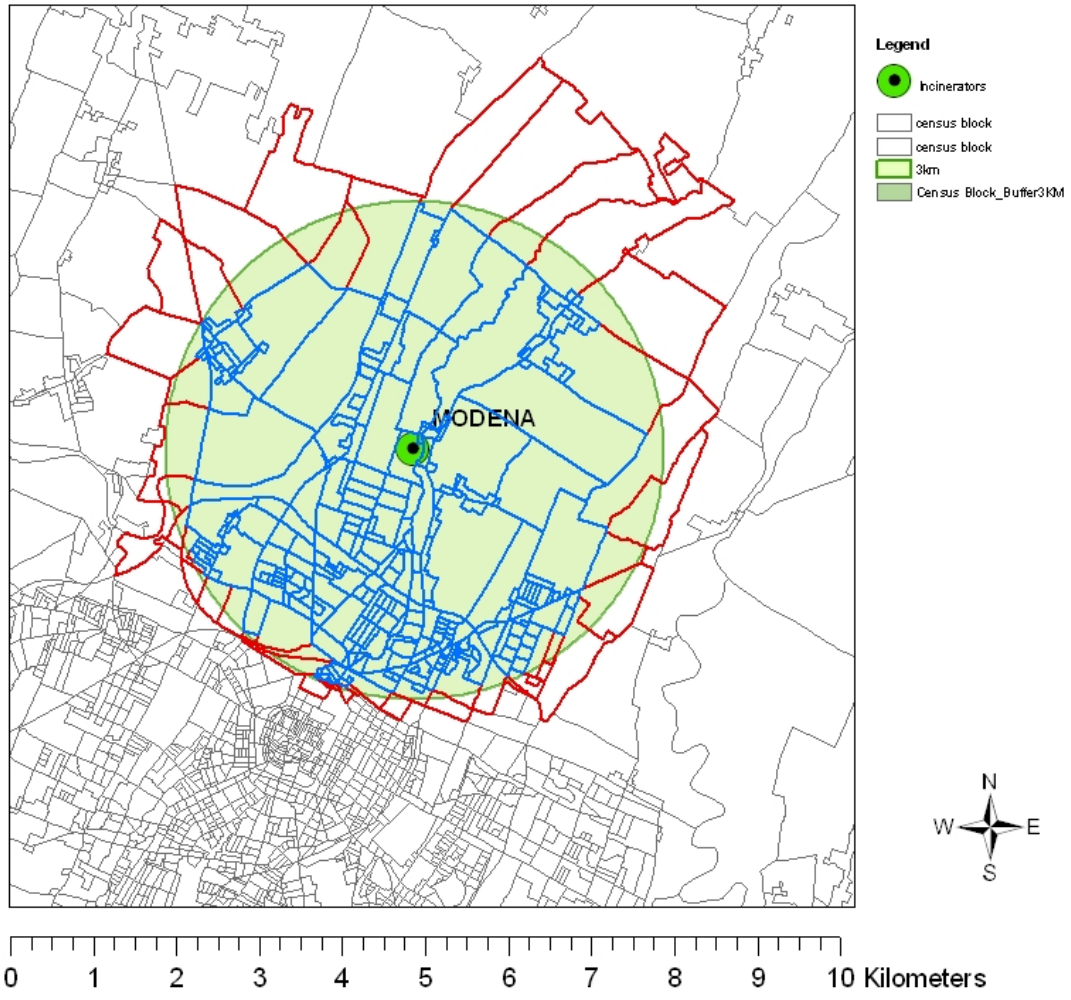
intersect the buffer



Question ..

How can we estimate people living in the “red” census block?

Estimating population exposure



we assume an homogeneous distribution of population in a census block

Step 3

Intersect buffer and census block to extract the real area at 3km from incinerator

Step 4

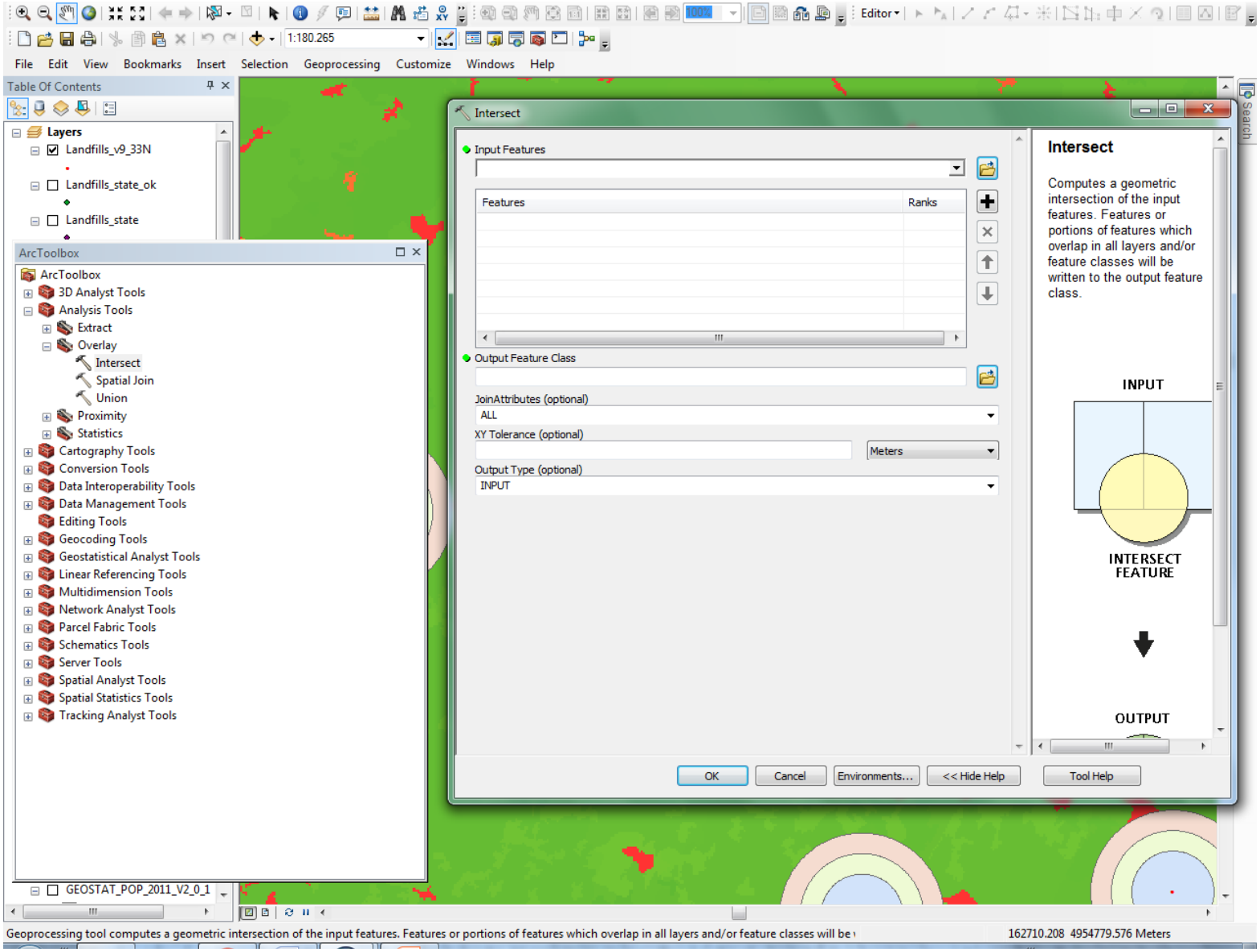
Calculate the area within the buffer

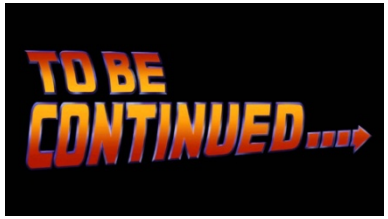
Step 5

Calculate the population proportionally of square meters

$$\sum \left(\frac{Pop}{TOTarea\_CensusBlock} \right) * (area\_i)$$

ARCMAP – INTERSECT window

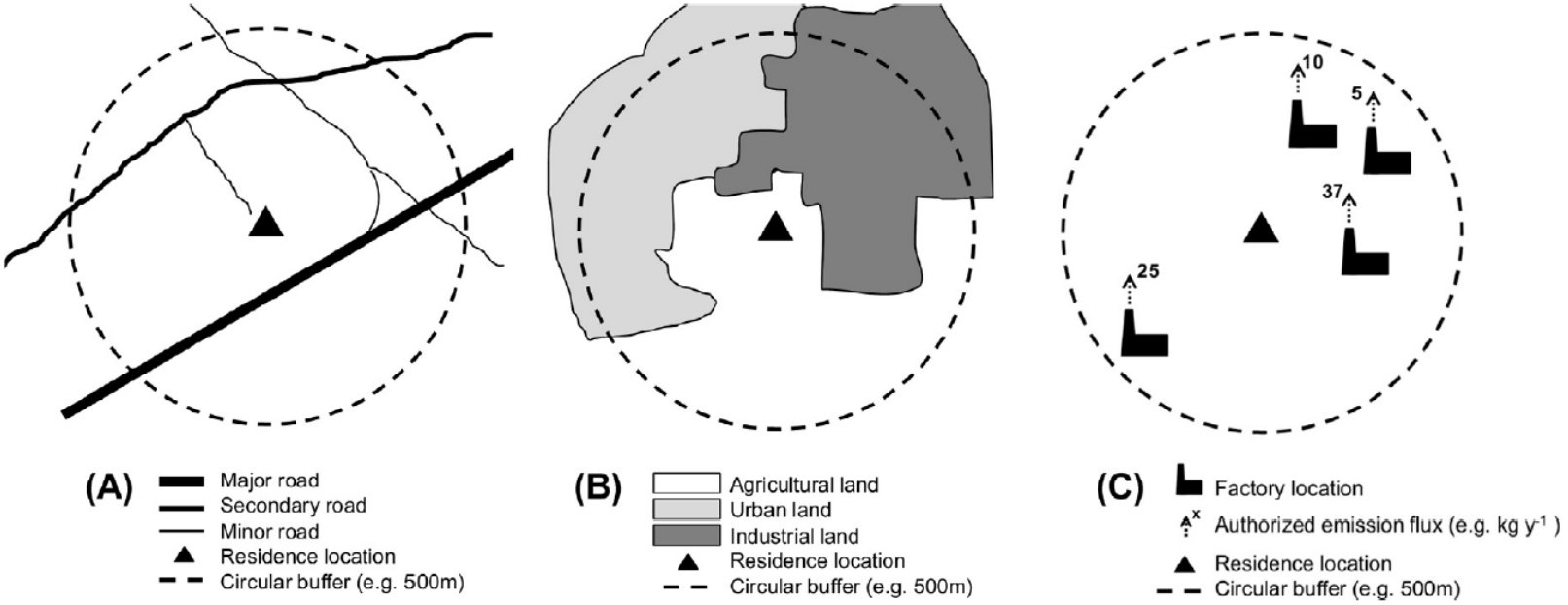




tomorrow with health data and HIA calculations…

LUR models - predictor variables

- Predictor variables:
  1. Land use (CORINE)
  2. Road length, distance to road (Eurostreets)
  3. Population density/household density
  4. Altitude, Longitude, Latitude
  5. Traffic intensity, distance to road (Local road network)
  6. Local variables



A comparison between self-reported and GIS-based proxies of residential exposure to environmental pollution in a case–control study on lung cancer

M. Cordioli et al. / Spatial and Spatio-temporal Epidemiology 9 (2014) 37–45

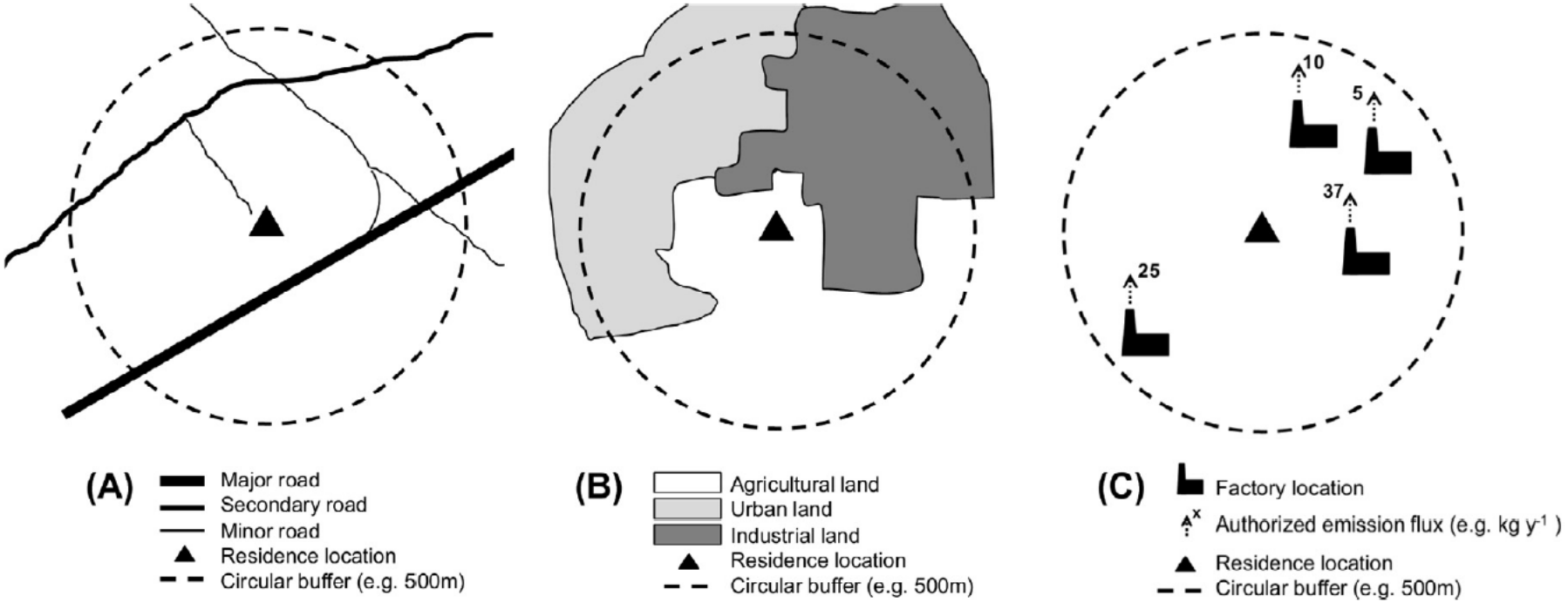
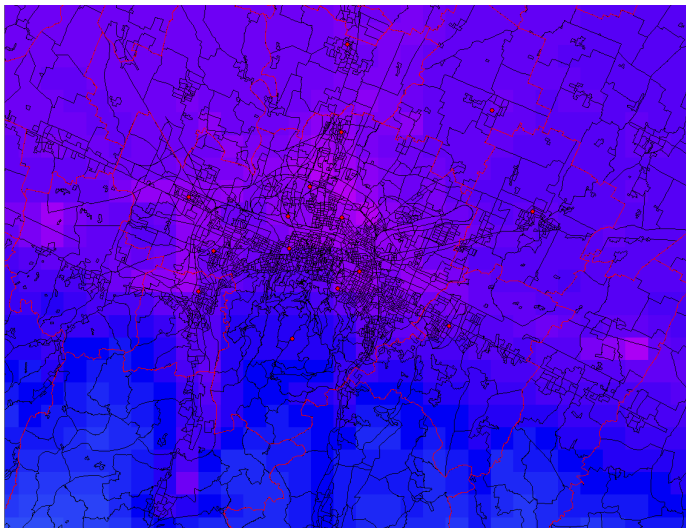


Fig. 1. Schematic representation of GIS exposure assessment: (A) length of roads by typology inside a buffer around the residence, (B) percentage of buffe area covered by different land uses, (C) tons of pollution emitted inside a buffer.

Example 3: PM2.5 at urban level

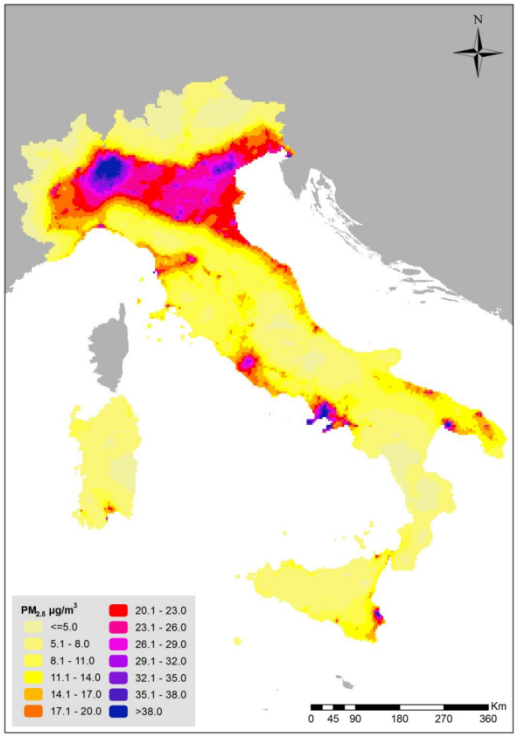
Example on exp ass on pm2.5 or pm10 for burden of disease
-VIIAS italian project (info at regional level)
-Regional air quality plan (info at municipality level)

- Calculate mean of values of PM and total population that fall into a region (i.e. census block)

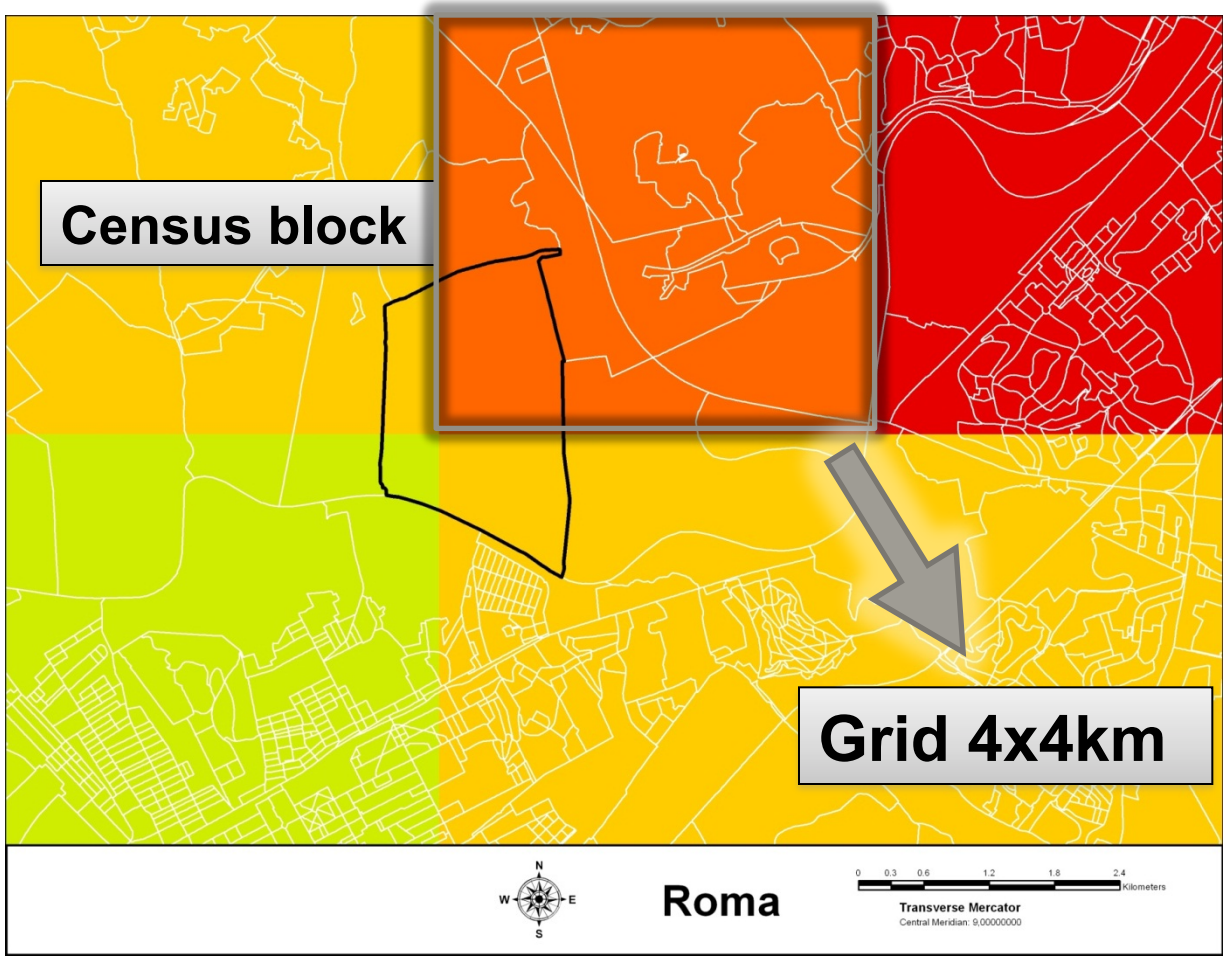


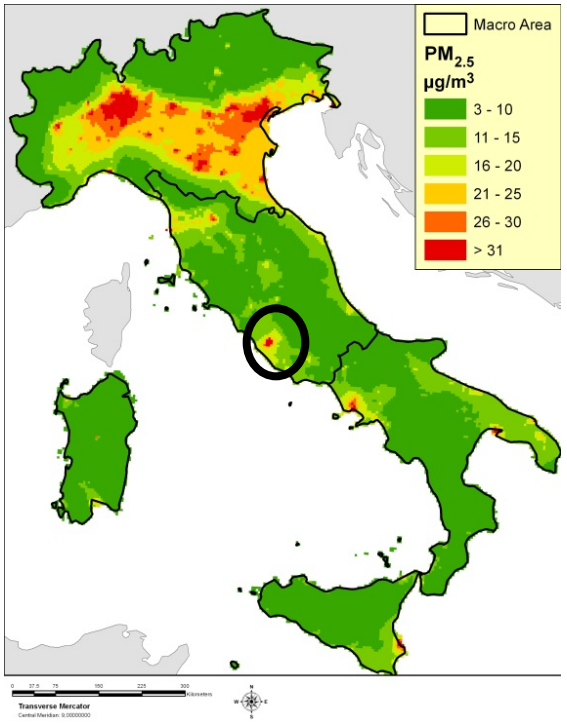
Bologna, with census block and pm2.5 dispersion model

Italy (2005)



Methods: estimating population exposure





$$\sum \frac{Pop \times areaInt}{areaCensusBlock}$$

- Intersect grid and census block to extract the area in each cell 4x4km
- Calculate the area within each cell
- Calculate the population proportionally of square meters