

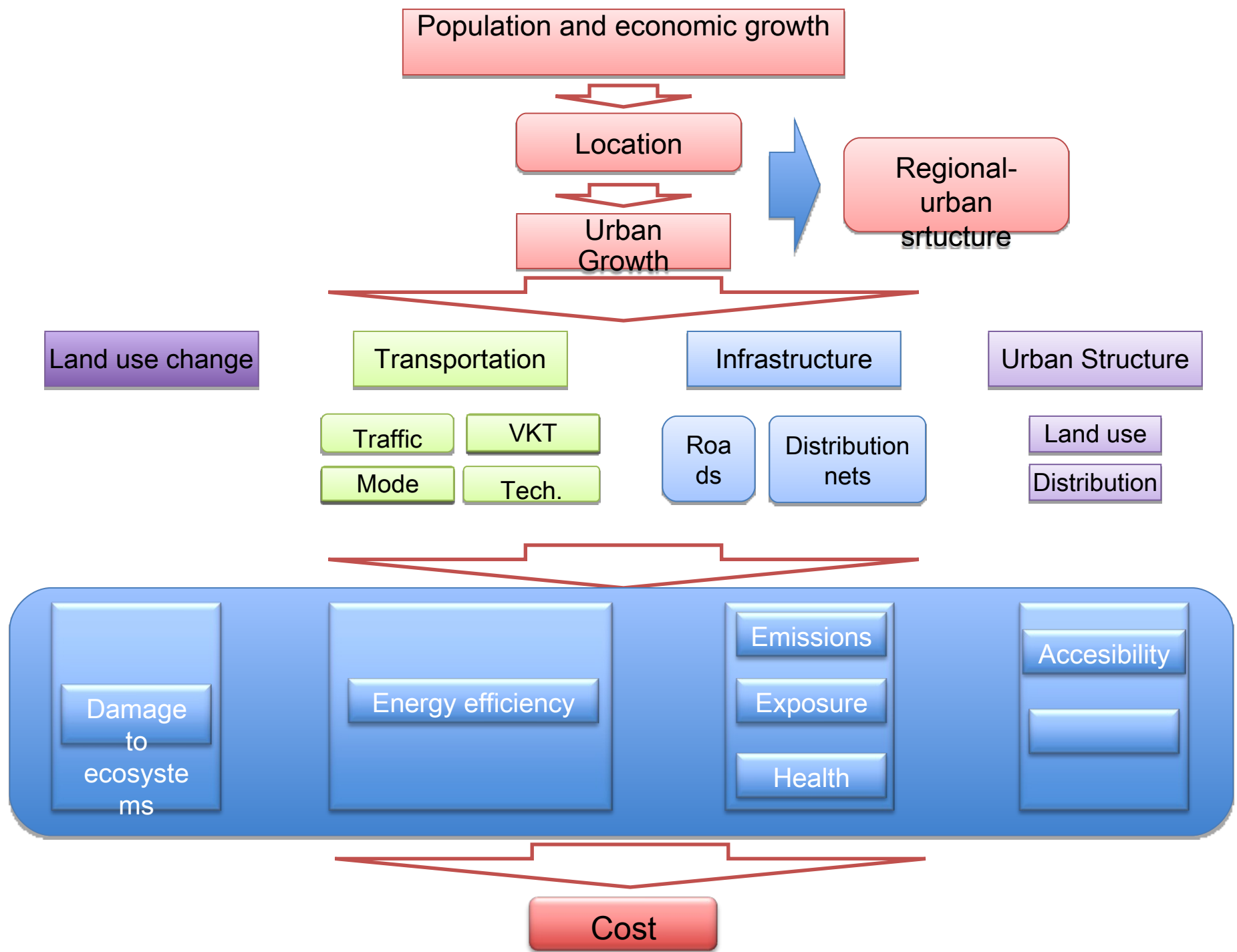
Urban Growth and Land-Use Change: An overview for air quality models

Manuel Suárez

Instituto de Geografía-UNAM

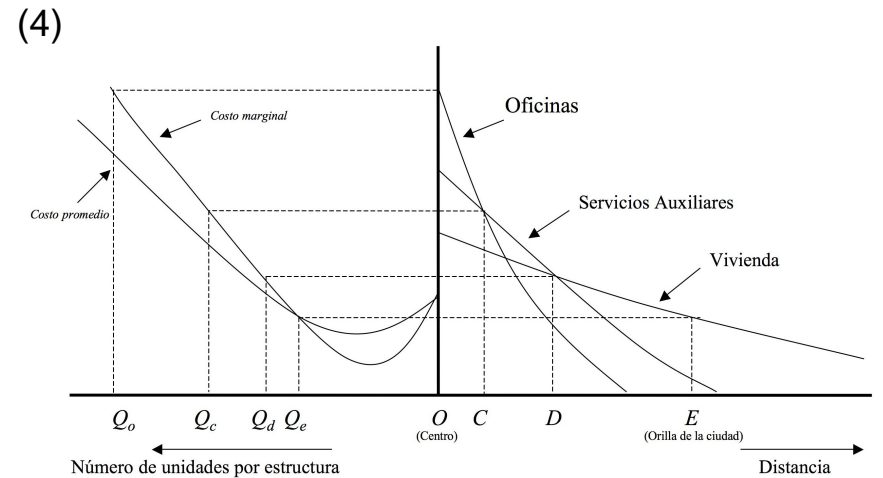
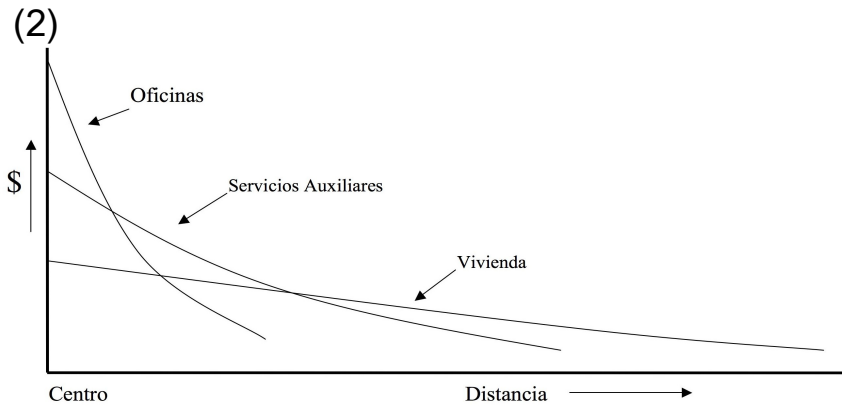
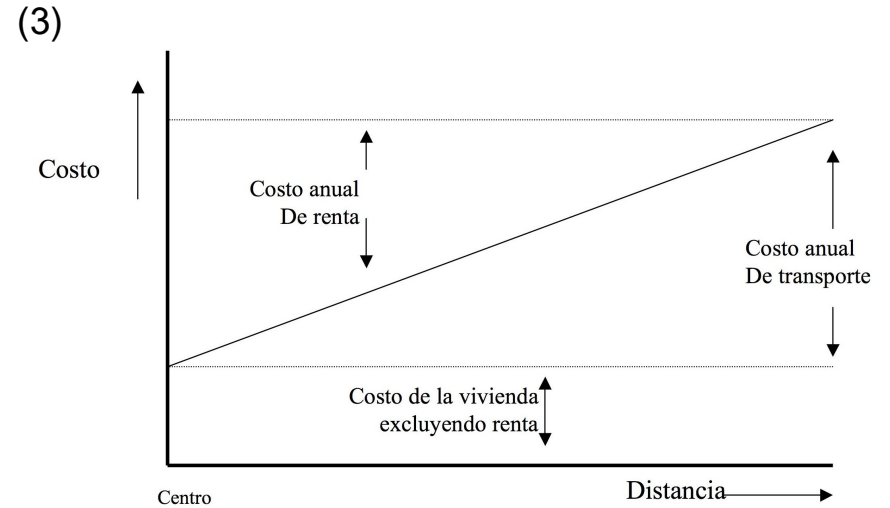
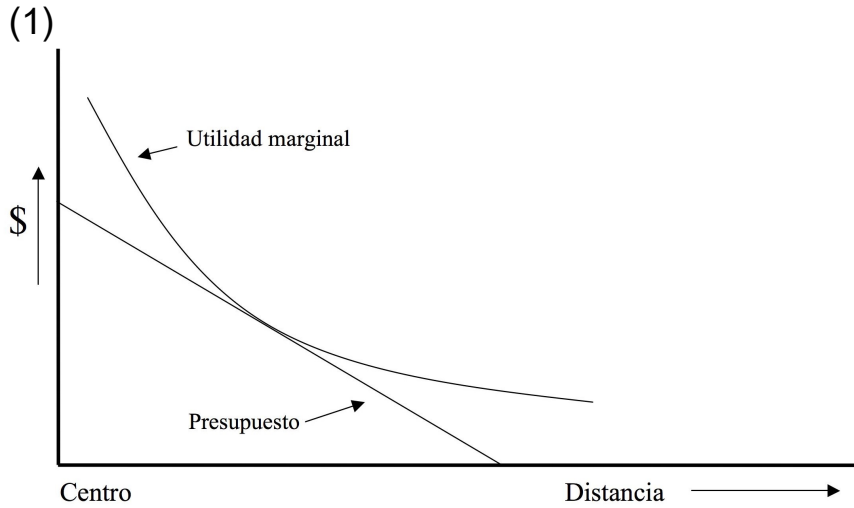
Contents

- Overview (Urban growth in AQ models)
- Why cities grow the way they do (Location theory)
- Growth implications on land use change and emissions
- Building urban growth scenarios
- Examples
- Summary

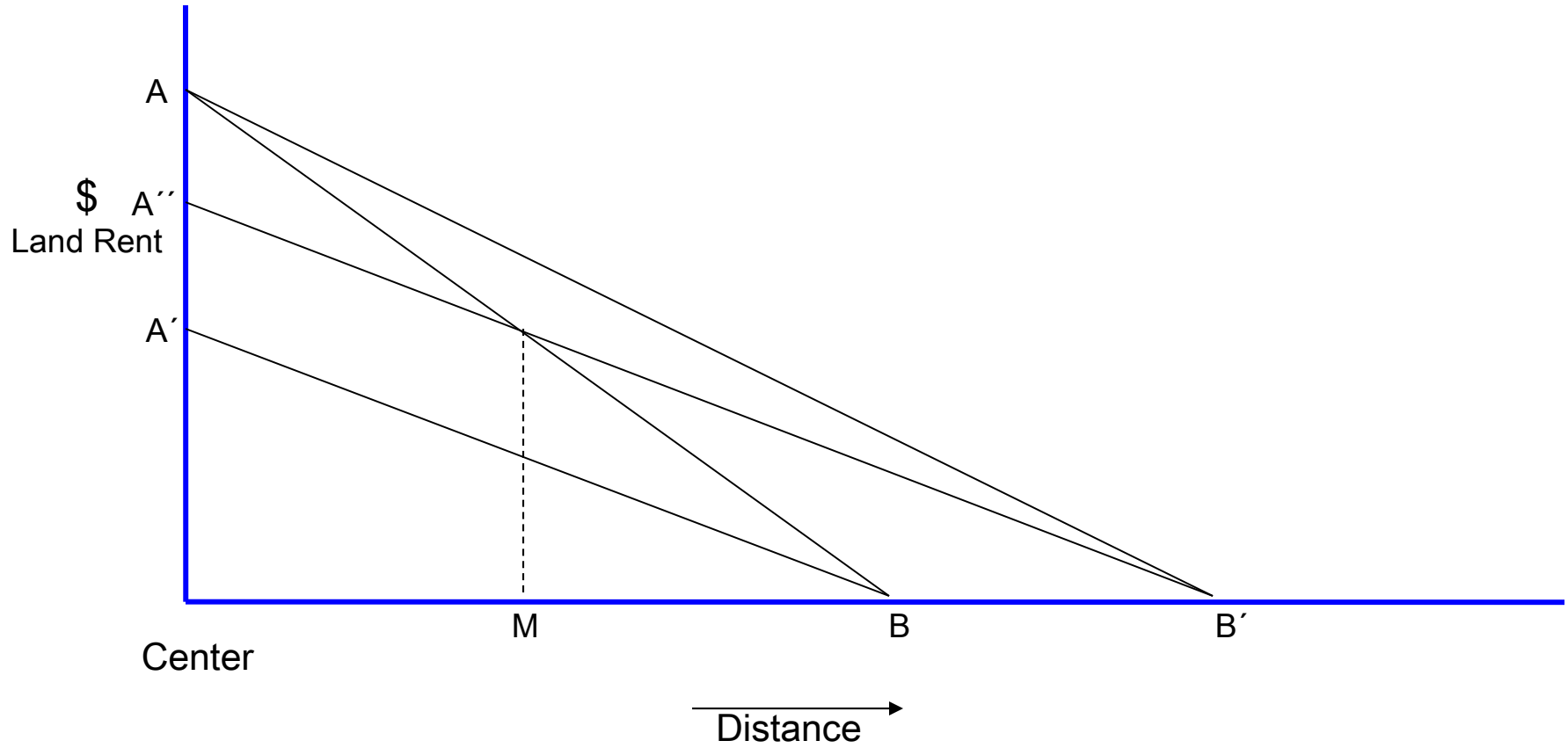


- Urban growth and urban structure determine:
 - Transportation emissions
 - VKT
 - Speed
 - Area emissions
 - City-wide population and employment densities (by type of economic activity)
 - Point emissions (Industrial location/permitted land use)

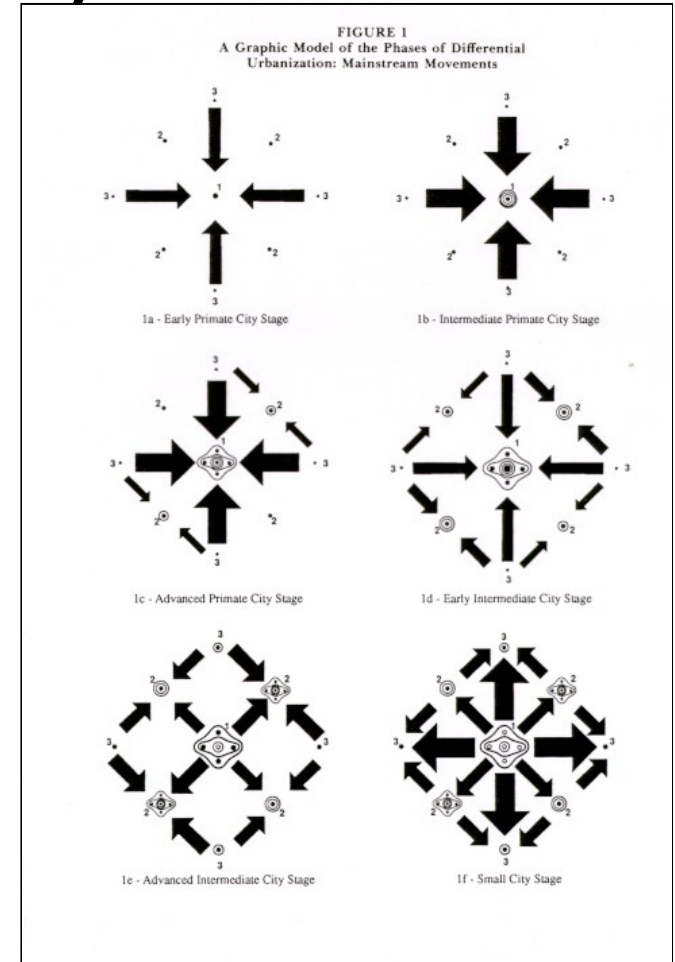
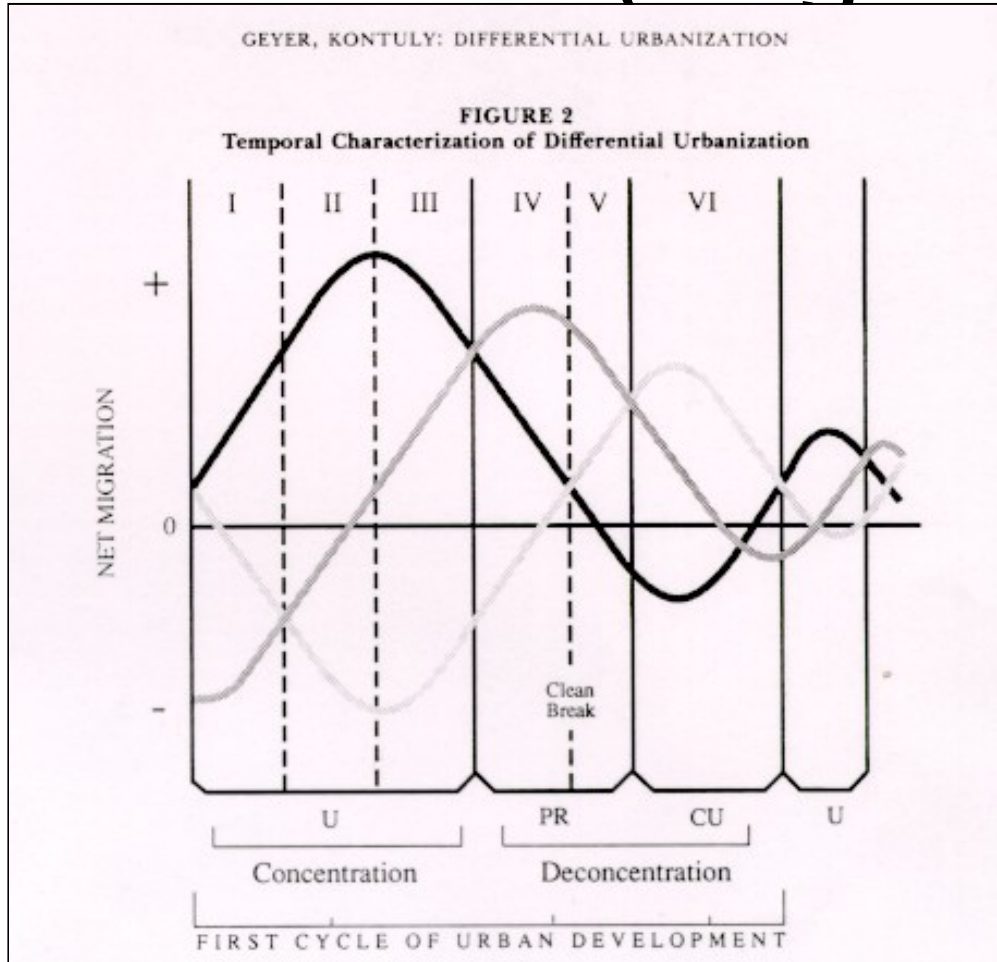
Urban location theory



City size theory



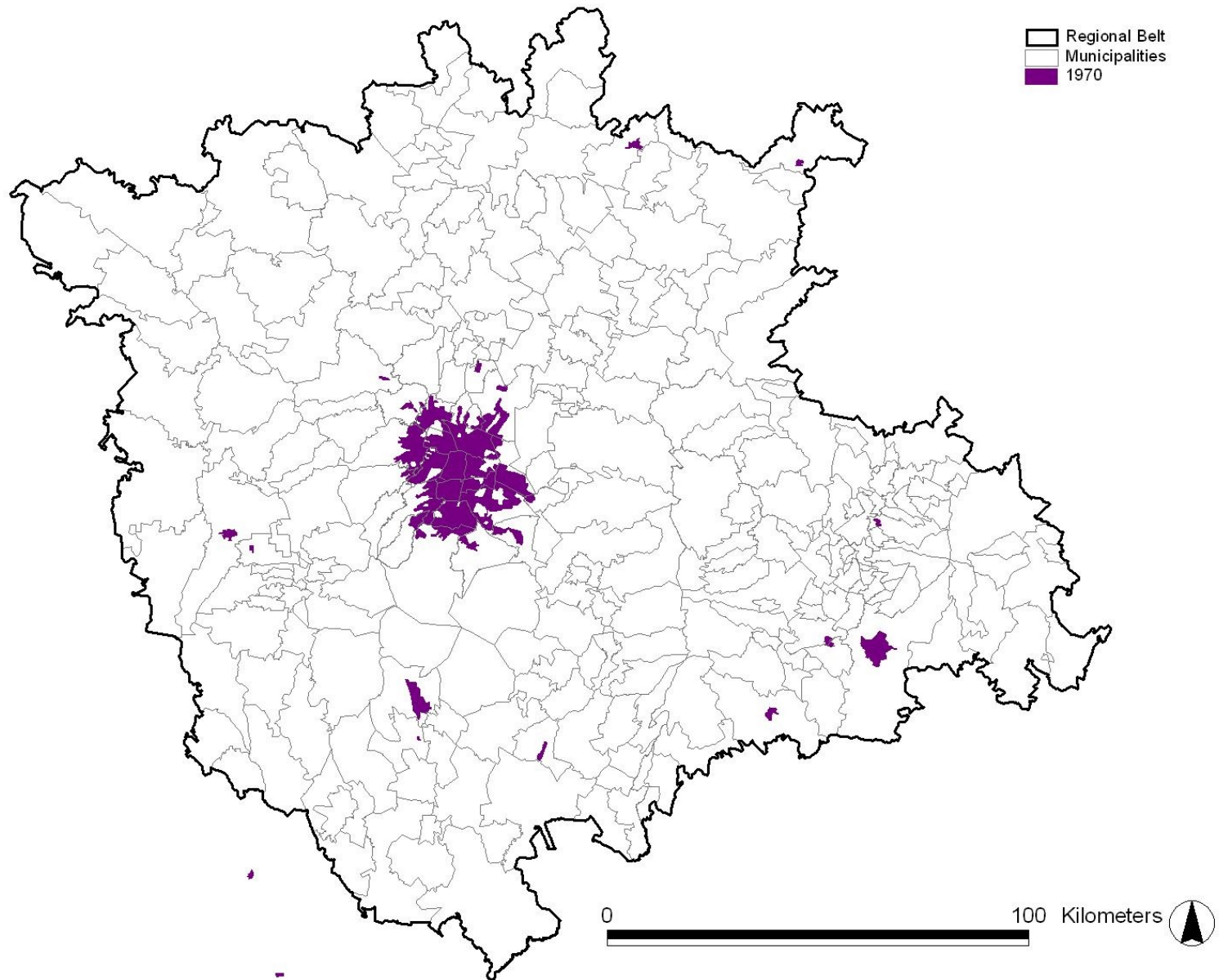
Differential Urbanization (Regional)



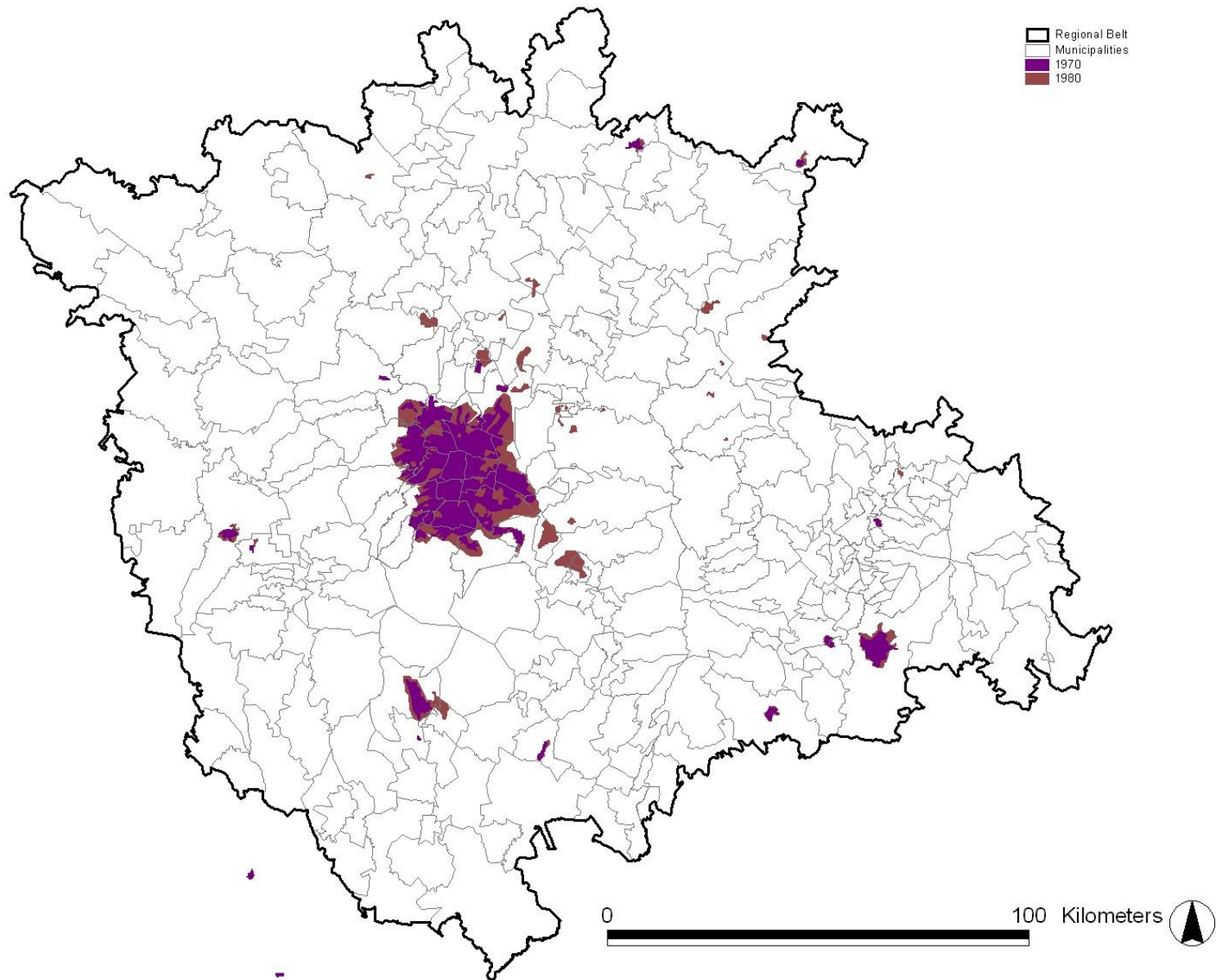
Possible impacts of types of urban growth on emissions

Population	Employment	Type	Effect on emissions
New urban areas	New / Existing urban areas	Sprawl	Exponential
Existing urban areas (zoned for housing)	Existing urban areas (zoned for employment)	Densification (Urban structure maintained)	Linear
Existing urban areas (Mixed use)	Existing urban areas (Mixed use)	Densification (More efficient urban structure)	Logarithmic (maybe linear with slope < 1)

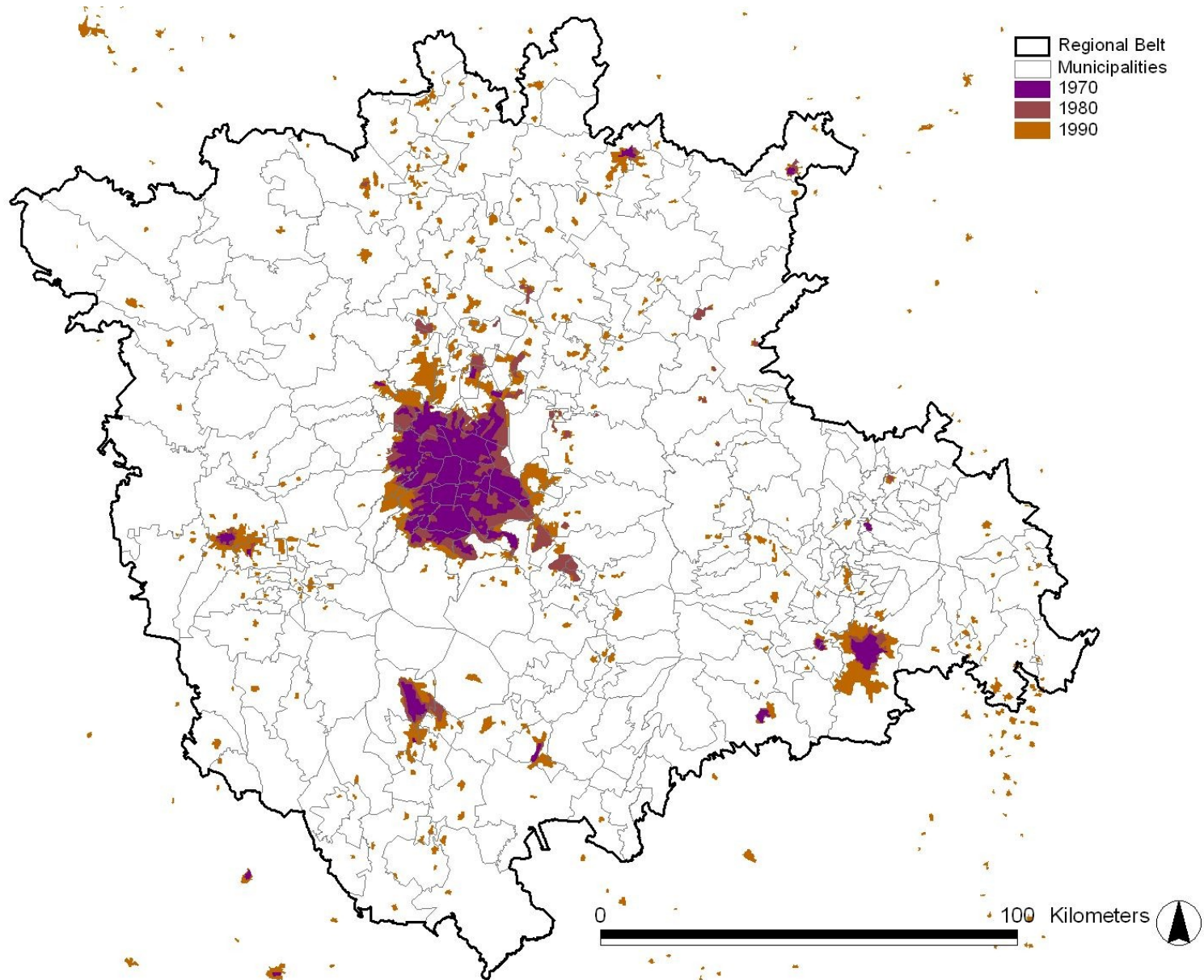
Urbanization 1970



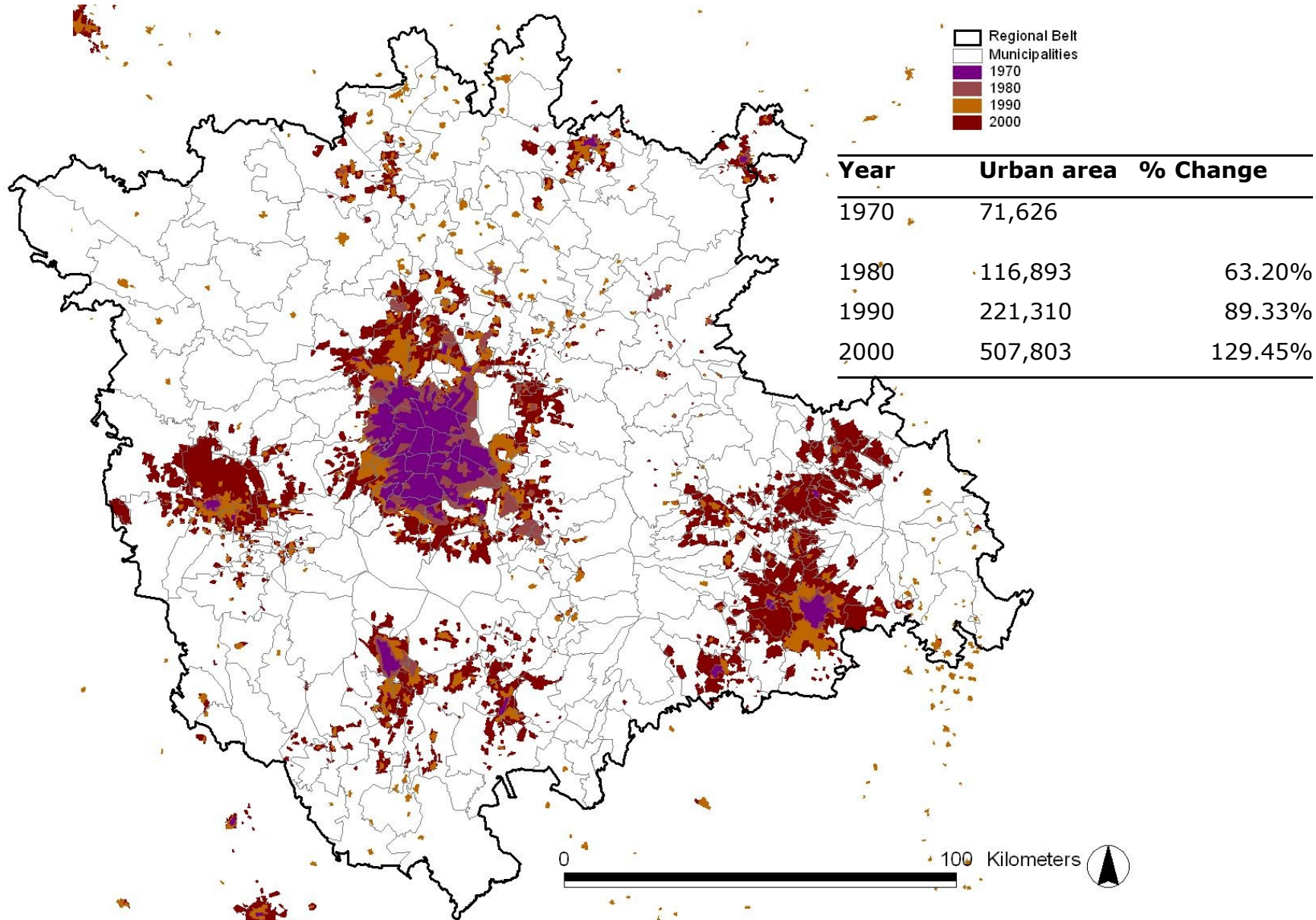
Urbanization 1970-1980



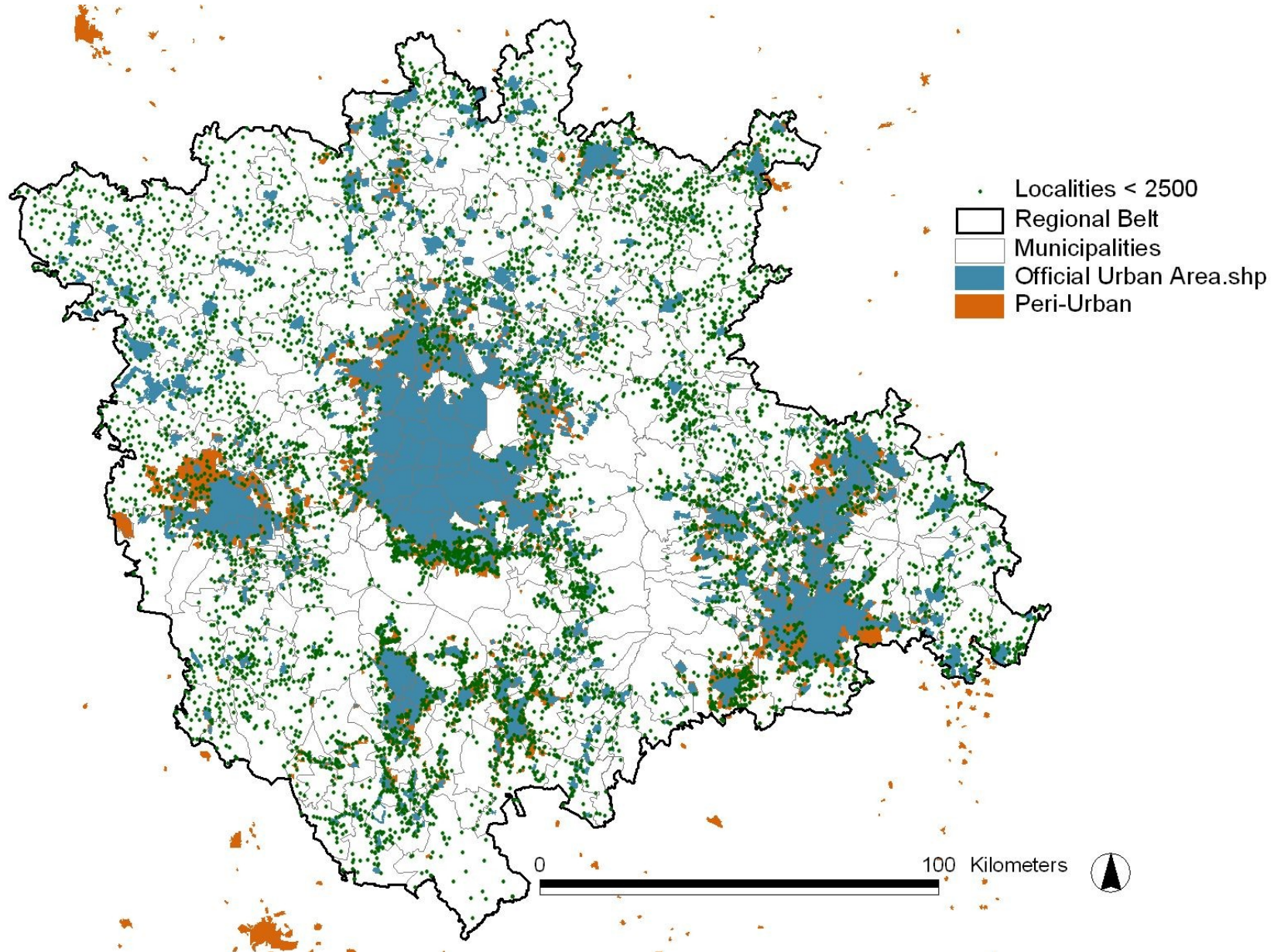
Urbanization 1980-1990

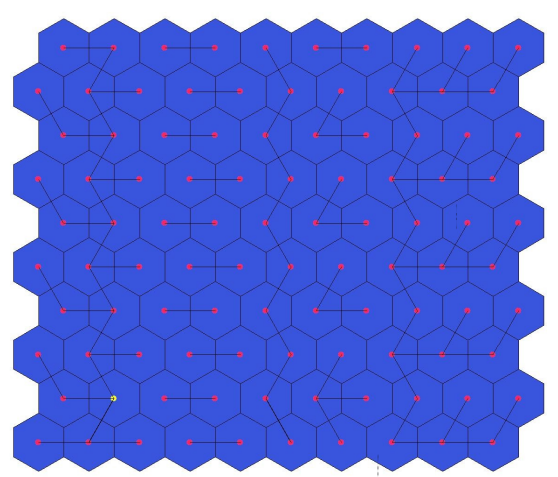
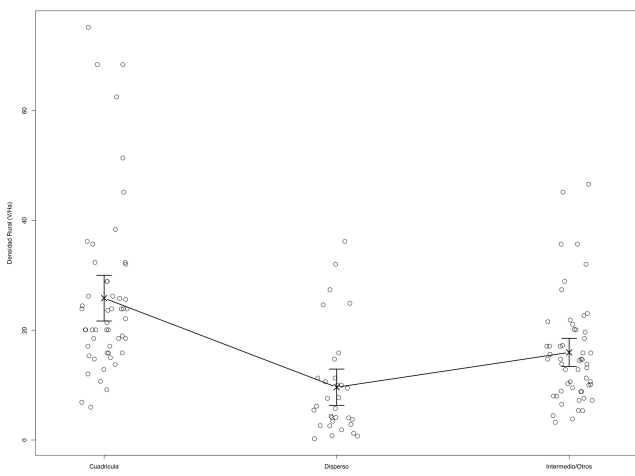
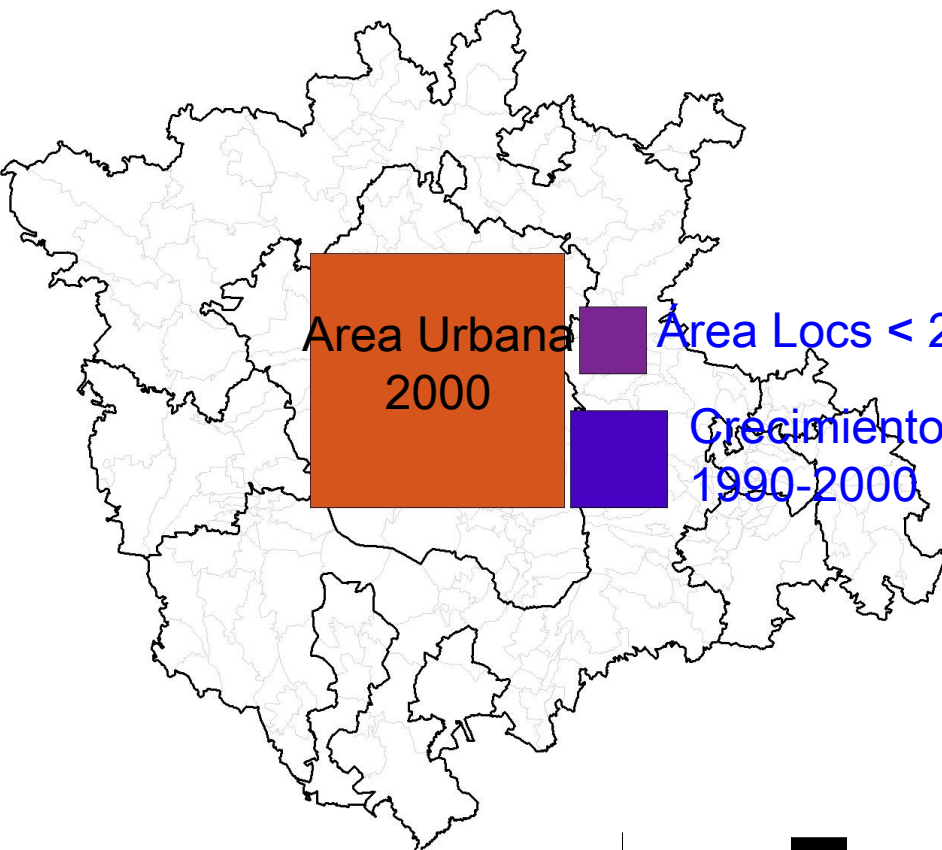


Urbanization 1990-2000



Peri-urban spaces 2000





Regresi—n de densidad de vivienda rural en funci—n de PEA primaria y terciaria

Residuals :

Min	1Q	Median	3Q	Max
-17,15		-6,73	-1,88	4,06
				34,01

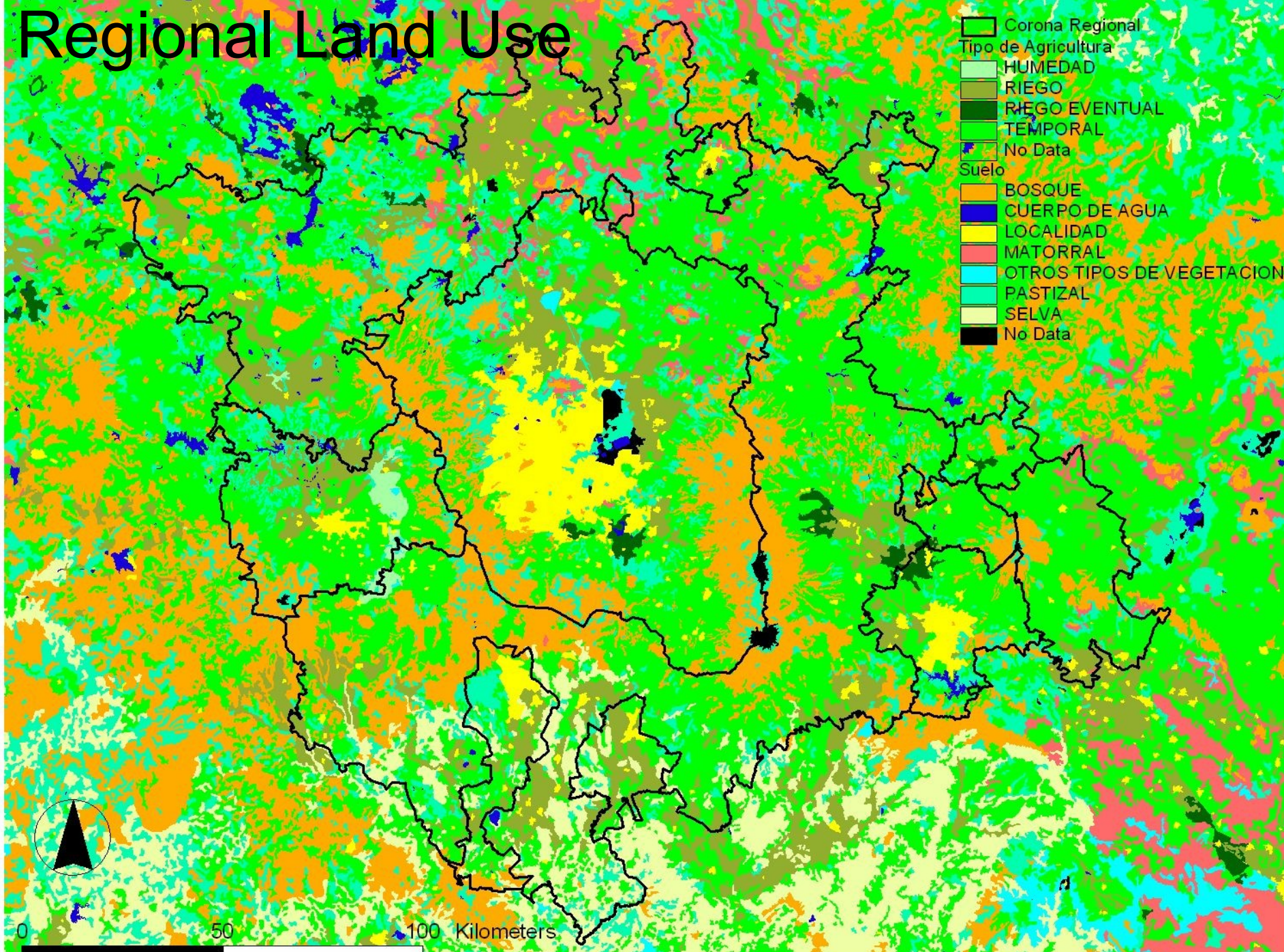
Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	14,5	3,13	4,63	9,50E-006***
log(PEAPRIM + 1)	-1,77	0,74	-2,38	0,02*
PEATER	0,05	0,01	8,14	5,17E-013***

Residual standard error: 10.18 on 116 degrees of freedom
 Multiple R-Squared: 0.3832, Adjusted R-squared: 0.3726
 F-statistic: 36.03 on 2 and 116 DF, p-value: 6.738e-13

Regional Land Use

- Corona Regional
- Tipo de Agricultura
 - HUMEDAD
 - RIEGO
 - RIEGO EVENTUAL
 - TEMPORAL
 - No Data
- Suelo
 - BOSQUE
 - CUERPO DE AGUA
 - LOCALIDAD
 - MATORRAL
 - OTROS TIPOS DE VEGETACION
 - PASTIZAL
 - SELVA
 - No Data



0 50 100 Kilometers

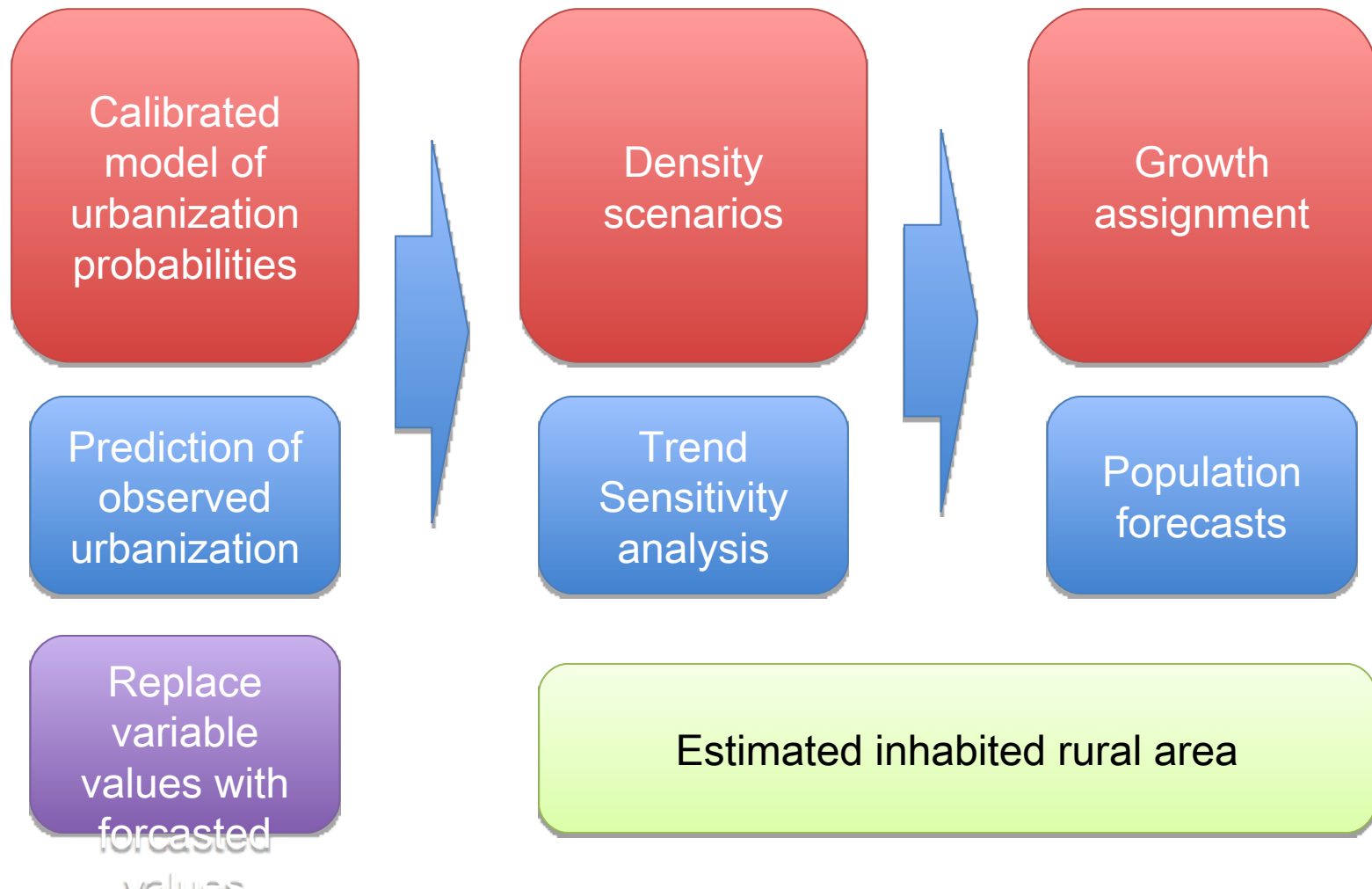
Regional Land Use Change (Remote sensing)

Land-use change (Official urbanization)

Previous Land use	Area (Ha)	%
Agriculture	56,993	81.4
Pasture	4,510	6.5
Forest	1,535	2.1
Others	6,935	10.0
<hr/>		
TOTAL	69,973	100

Mean urban population density: 80 p/Ha
Mean urbanization density 1990-2000 (official): 25 p/Ha
Mean urbanization density 1990-2000 (periurban): 8.2 p/Ha

Scenario based urban growth forecast - 3 step model



Data sources

- Population census data tract (AGEB) level
- Economic census data tract (AGEB) level
- Land use (remote sensing)
- Main transportation infrastructure (Roads)
- Population forecasts
- Employment forecasts (Shift-share analysis)
 - Data should be available for at least two time periods

Urbanization probabilities

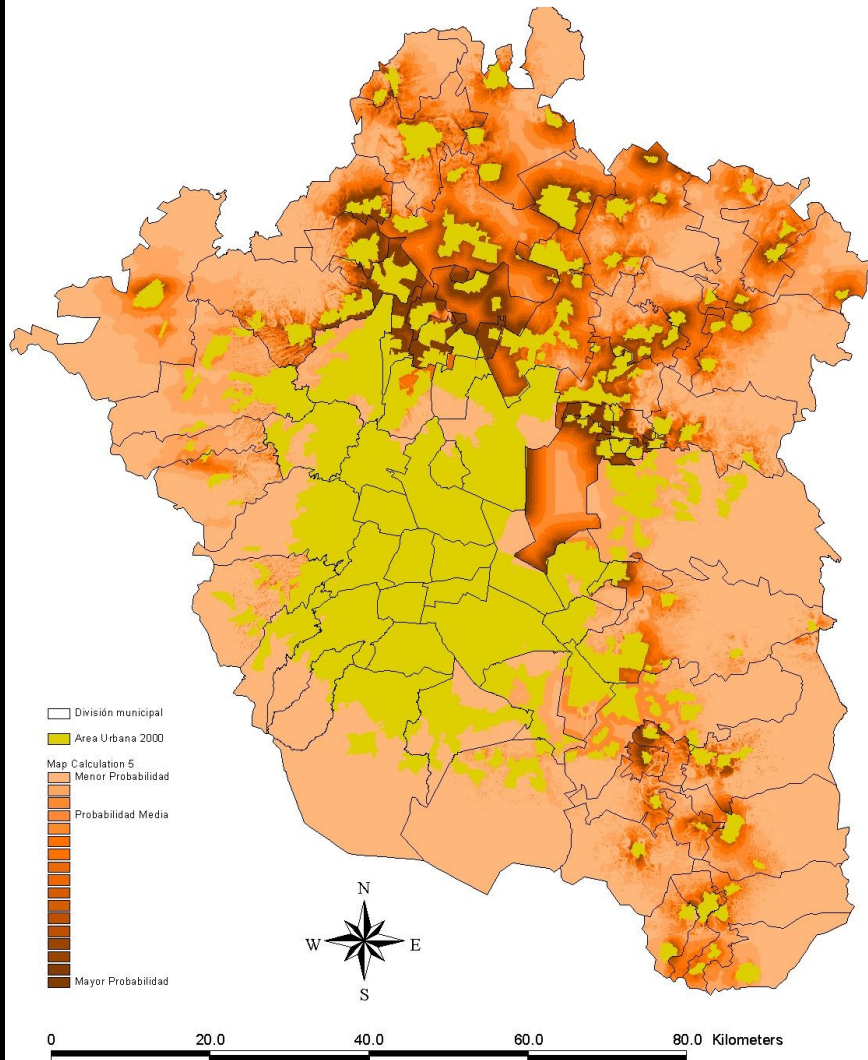


Table1: Variables in the calibrated model

No.	Alias	Name	Source
X_1	[DISTRKCM]	Distance to highways (Km)	Información topográfica Vectorial escala 1:1000,000, (INEGI, 2000a)*
X_2	[DISTLOC]	Distance to the closest urban locality (m)	Catálogo de Integración territorial, (INEGI, 2000b)*
X_3	[LOCSIZE]	Population of the closest locality (thousands)	Censo General de Población y Vivienda (INEGI, 1990)
X_4	[SLOPE]	Terrain slope (%)	Geography Institute, UNAM*
X_5	[MANUFAC]	Number of manufacturing jobs in a 6 km radius (thousands of jobs)	Censo Económico (INEGI, 1989)*
X_6	[SERVS]	Number of service jobs in a 6 km radius (thousands of jobs)	Censo Económico (INEGI, 1989)*
X_7	[INCOME]	Median income of the closest existing tract	Censo General de población y Vivienda (INEGI, 1990a)
X_8	IRRIG	Proportion of agricultural municipal irrigated terrain	Censo Agrícola ganadero*

* Value calculated with GIS with inputted data from the source

Table 2: Calibrated Binomial Logit model of urbanization probabilities in MCMA 1990-2000

Variable	B	Std. Error
DISTRKCM	-0.005	0.031
INCOME	0.841*	0.091
LOCSIZE	0.003*	0
IRRIG	1.12*	0.008
MANUFAC	0.086*	0.035
SERVS	-0.389*	0.008
SLOPE	-0.069*	0
DISTLOC	-0.001*	0.197
CONSTANT	-1.141*	

Model Fit

-2 Log likelihood = 6748.227

Cox & Snell R Square = 0.213

Nagelkerke R Square = 0.434

N = 15670

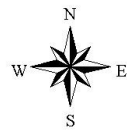
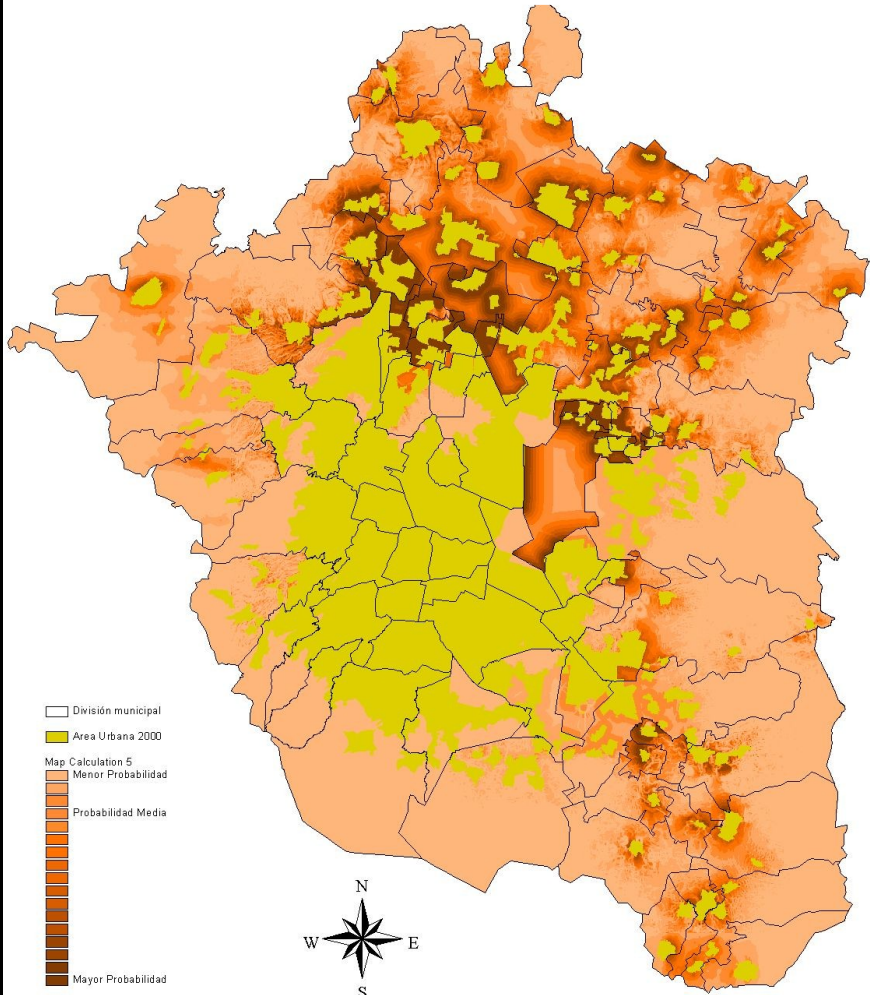
% of correctly classified cases: 0 = 83%; 1 = 80%;

Total = 83%

(Cut value= 0.15)

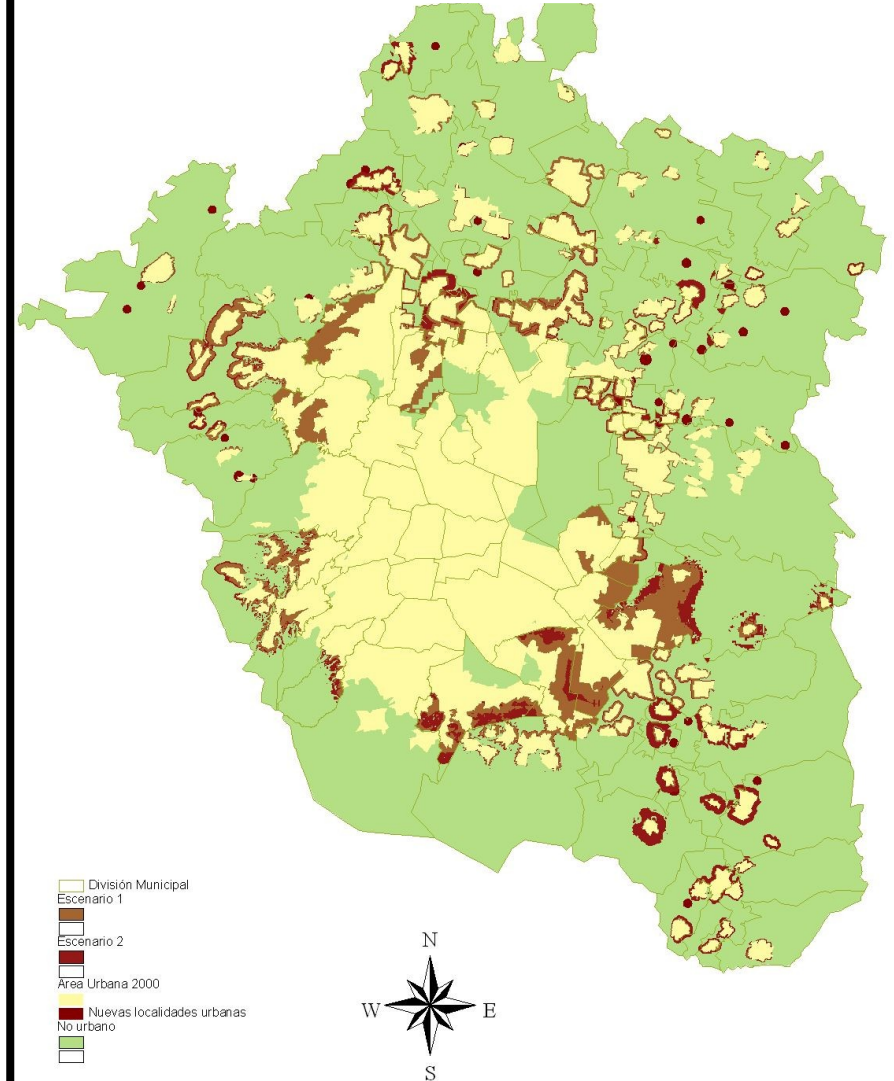
* Sig. at 0.001 or better

Urbanization probabilities



0 20.0 40.0 60.0 80.0 Kilometers

Urban expansion scenarios

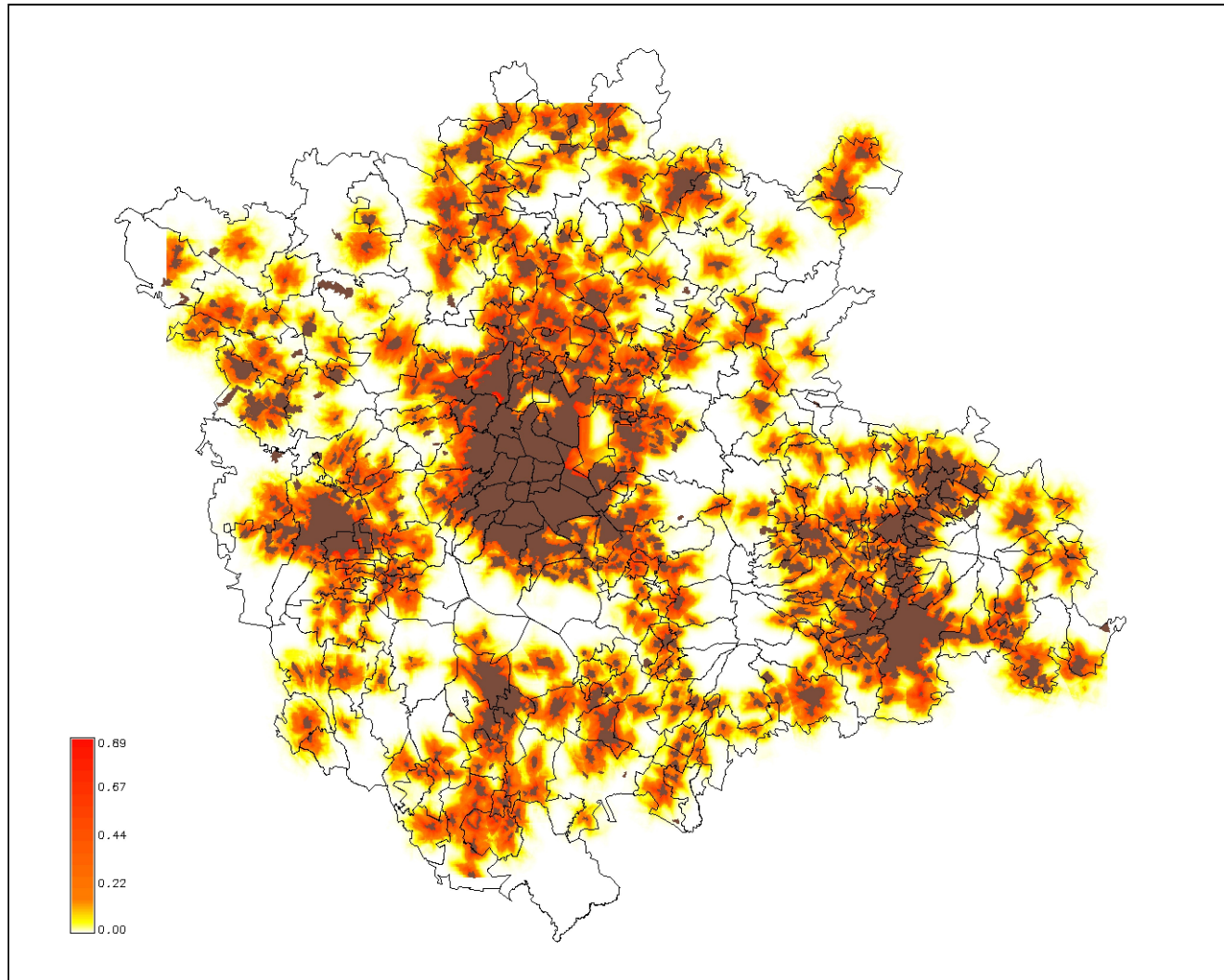


0 20.0 40.0 Kilometers

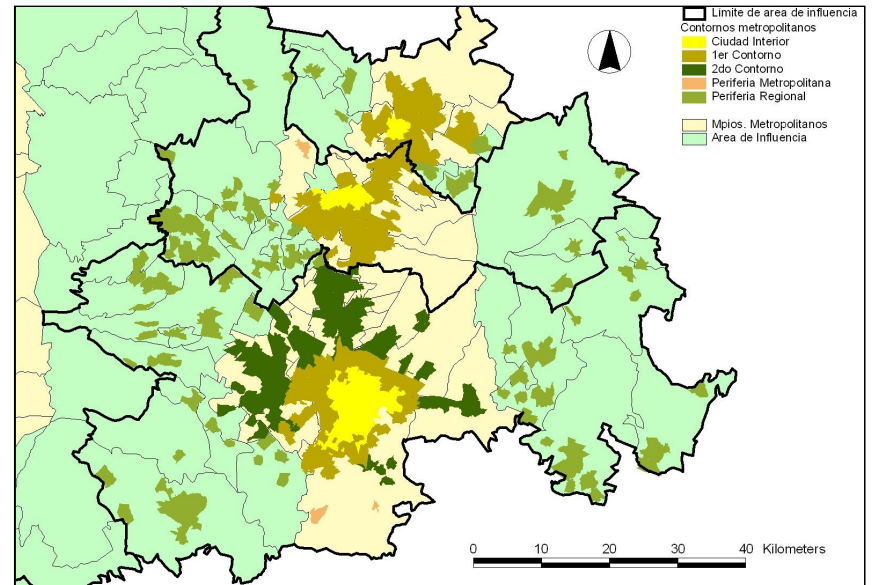
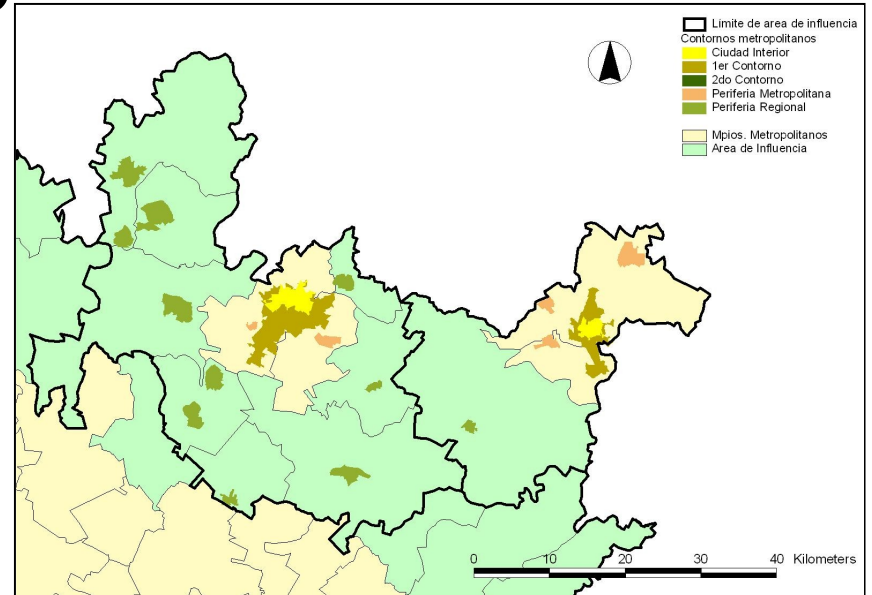
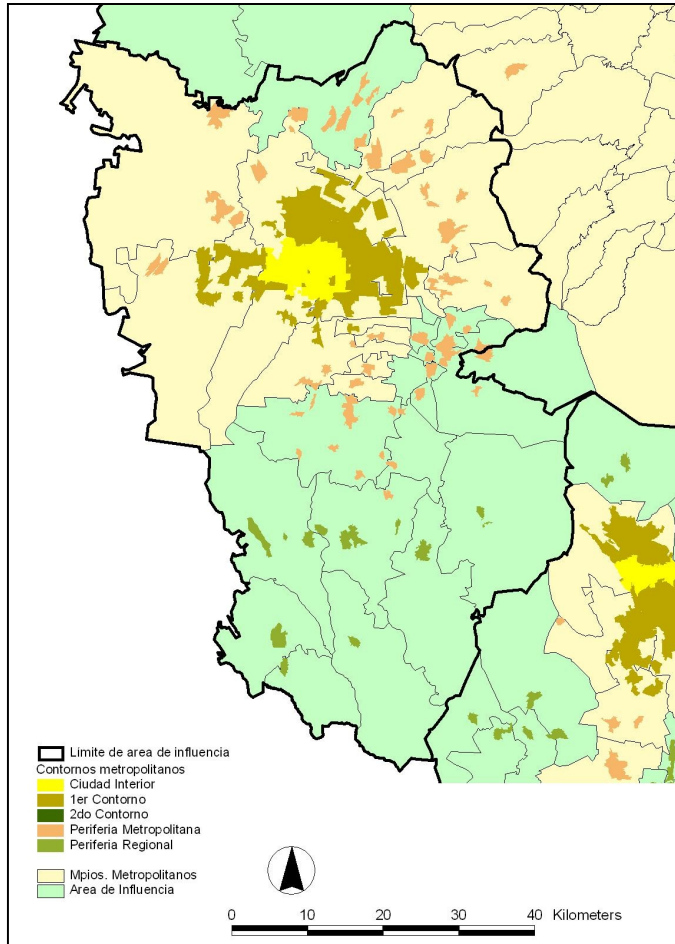
Dinámicas regionales de expansión urbana

Zona Metropolitana	Población urbana 1990	Población urbana 2000	Cambio población urbana	Área urbana 1990	Área urbana 2000	Densidad 1990	Densidad 2000	Cambio Densidad
ZMCM	14,998,978	18,000,442	20.0%	193,846	211,881	77.375722	84.955308	7.579586624
Pachuca	176,640	267,293	51.3%	5,437	6,595	32.488744	40.527247	8.038503352
Tulancingo	91,905	124,057	35.0%	3,651	4,560	25.17228	27.202559	2.030279695
Toluca	791,032	1,208,702	52.8%	23,735	34,232	33.328053	35.308641	1.980588439
Cuernavaca	522,028	724,743	38.8%	16,784	18,349	31.101957	39.497813	8.395855839
Cuautla	135,120	186,182	37.8%	4,439	4,779	30.440522	38.962191	8.52166882
Puebla	1,372,547	1,793,416	30.7%	43,362	47,141	31.653448	38.043761	6.390313169
Tlaxcala	146,977	235,632	60.3%	11,642	15,697	12.624808	15.011506	2.386697967
Apizaco	74,470	122,263	64.2%	8,228	11,331	9.0504172	10.790352	1.739935133
Periferia	1,540,297	2,140,596	39.0%	100,319	126,906	15.354026	16.867547	1.513521377
TOTAL	19849994	24803326	25.0%	411,443	481,472	48.244853	51.515646	3.270792709

Urban expansion probabilities in Mexico City's Regional Belt 2020

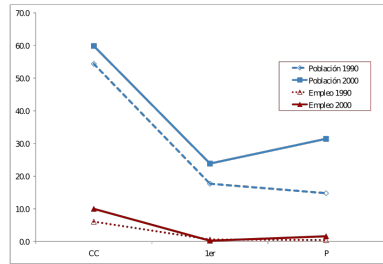


Urban ring structures

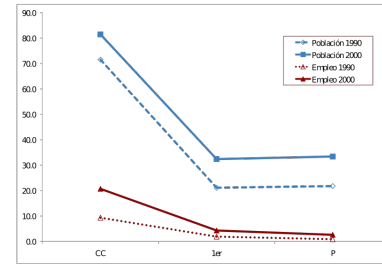


Employment and population density by urban ring

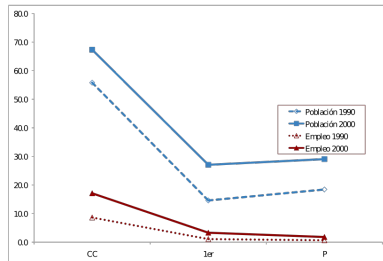
Cuatla



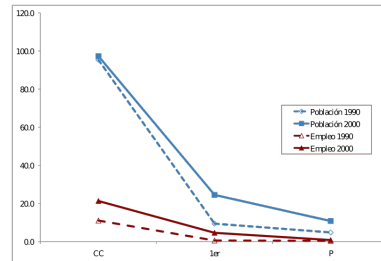
Cuernavaca



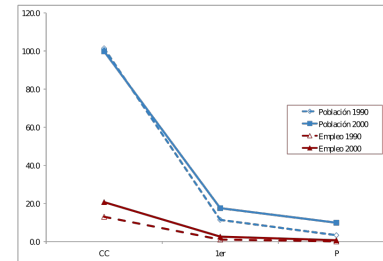
Toluca



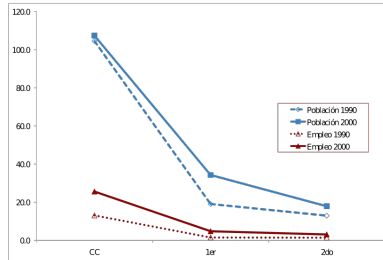
Pachuca



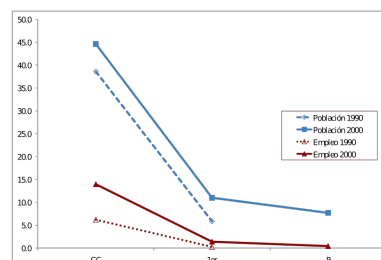
Tulancingo



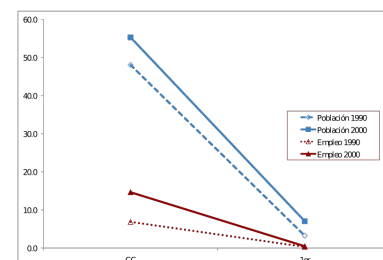
Puebla



Tlaxcala

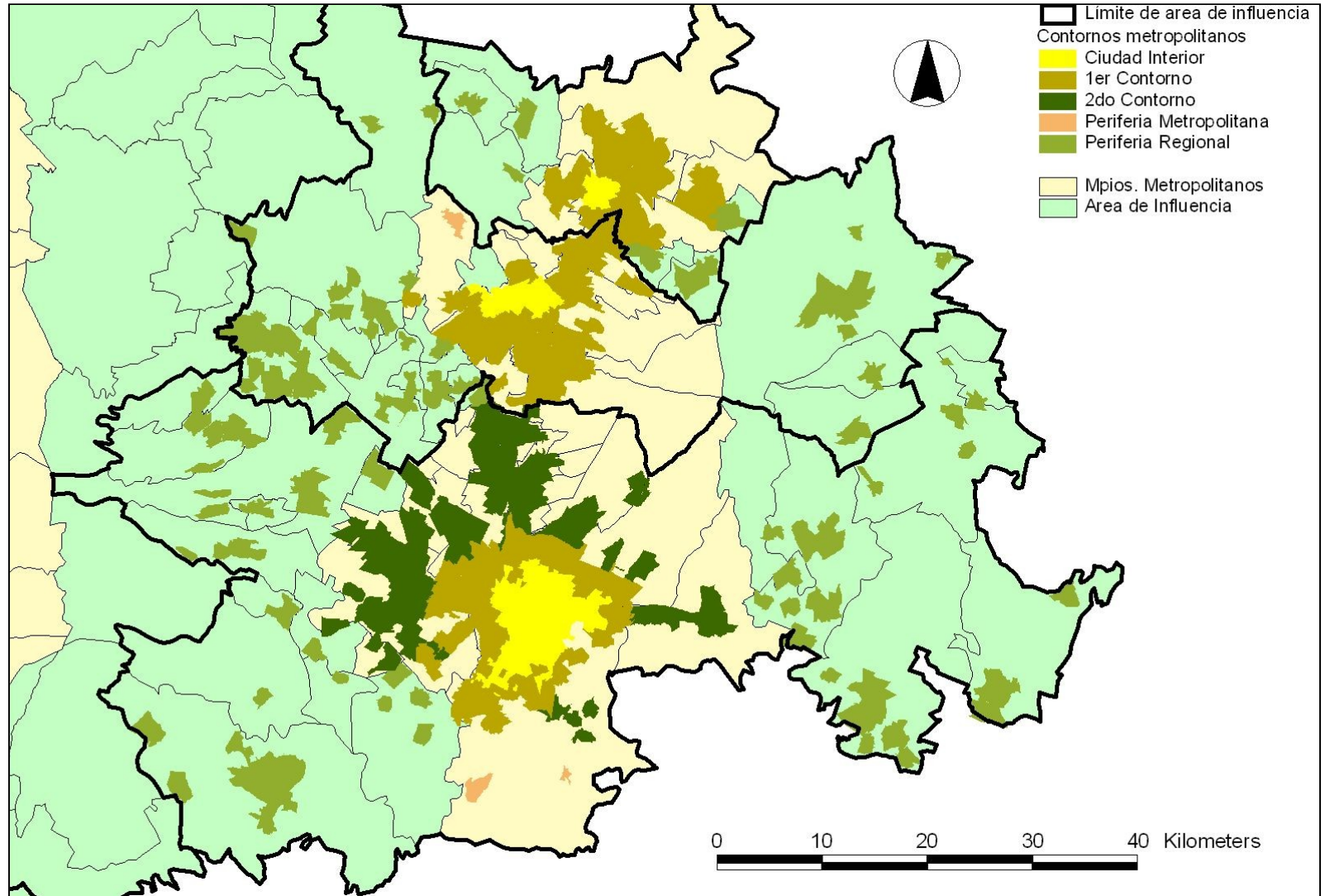


Apizaco

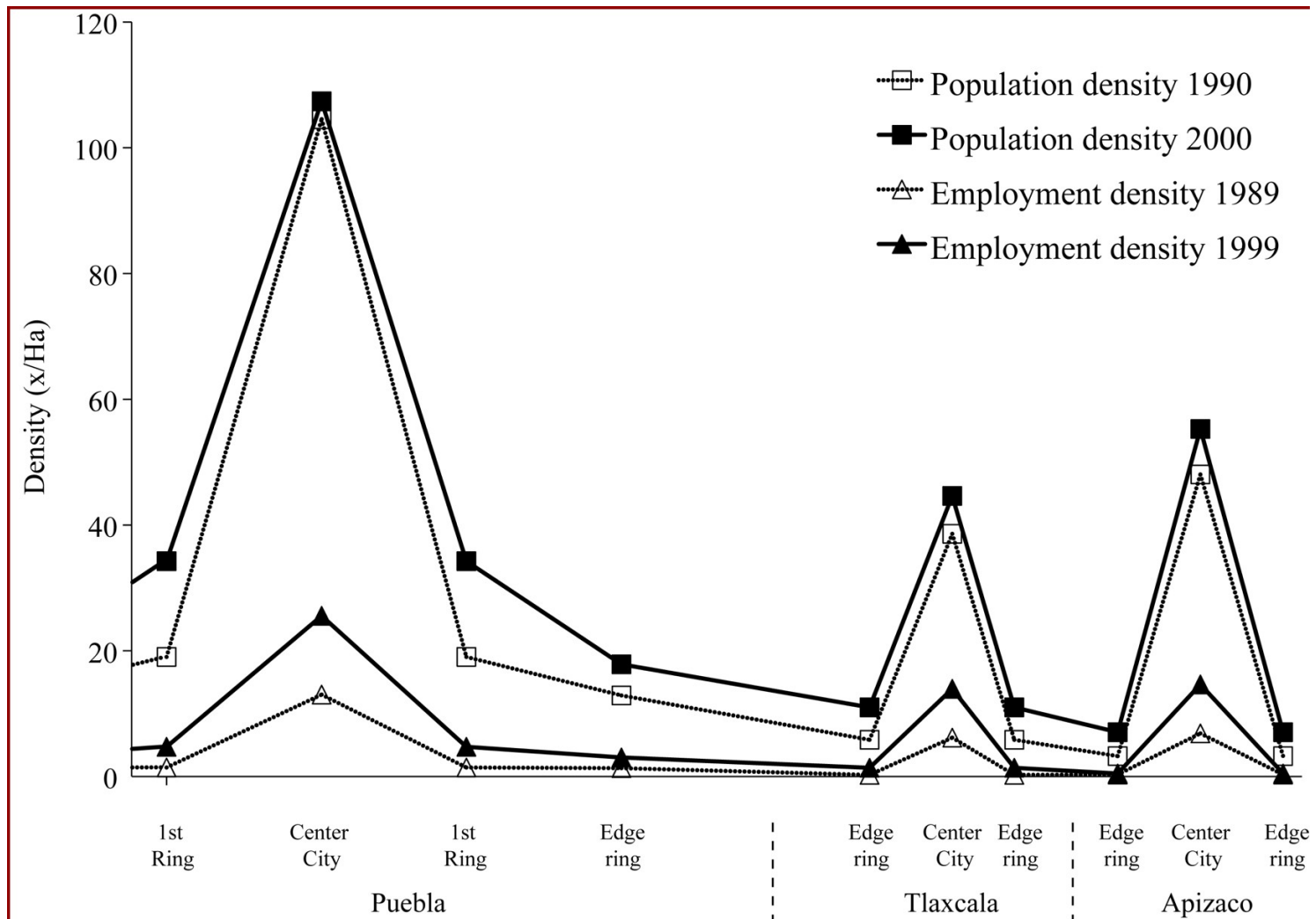


Puebla-Tlaxcala urban ring configuration

Puebla-Tlaxcala-Apizaco



Population and employment density profile by urban ring



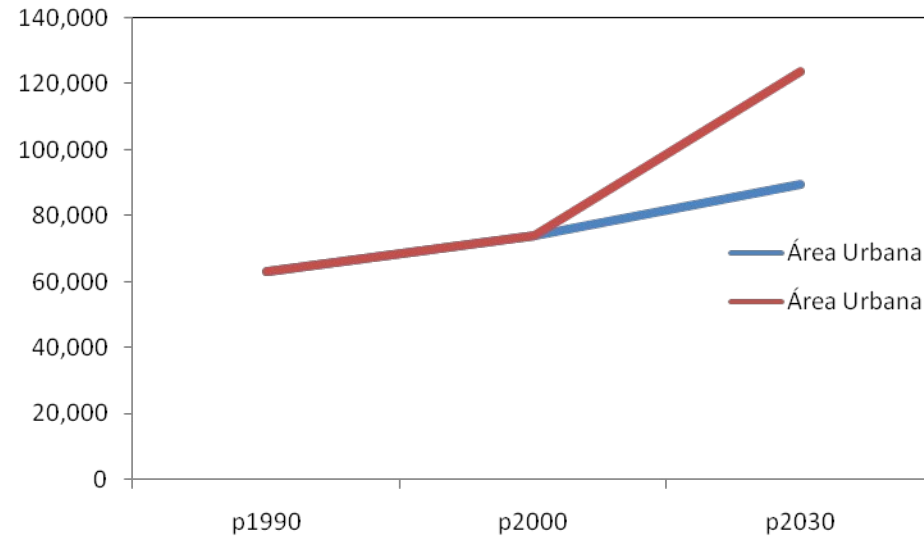
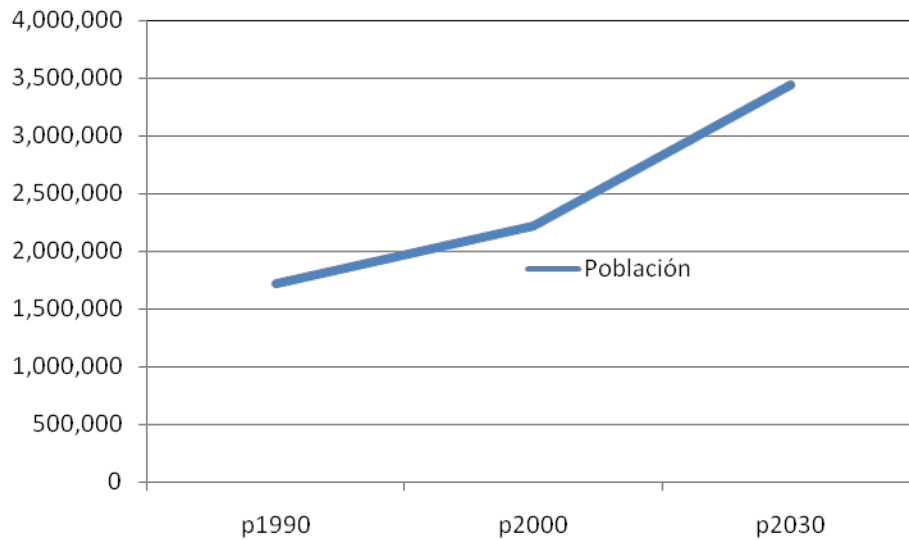
Logit model: urban growth probability

Importance of variables in expansion probabilities

	Puebla	Tlaxcala	Apizaco
Distance to transportation	0.408	0.007	0.749
Distance to closest urban area	0.115	0.603	0.004
Population size of closest urban area	1.012	0.859	0.856
Local income	1.746	1519.876	23.844
Agricultural land (dummy)	1.37	1.569	1.57E+010
Non irrigated (dummy)	1.244	23.136	9.055
Slope	0.919	0.598	1.121
Number of jobs	1.01	1.256	0.001
Number of service jobs	0.66	21.63	4.33E+012
Manufacturing : Services Ratio	0.997	1.053	1.163
Constant	1.016	0	0

$$\hat{Y}_i = \frac{e^u}{1+e^u} \quad u = A + B_1X_1 + B_2X_2 + \dots + B_nX_n$$

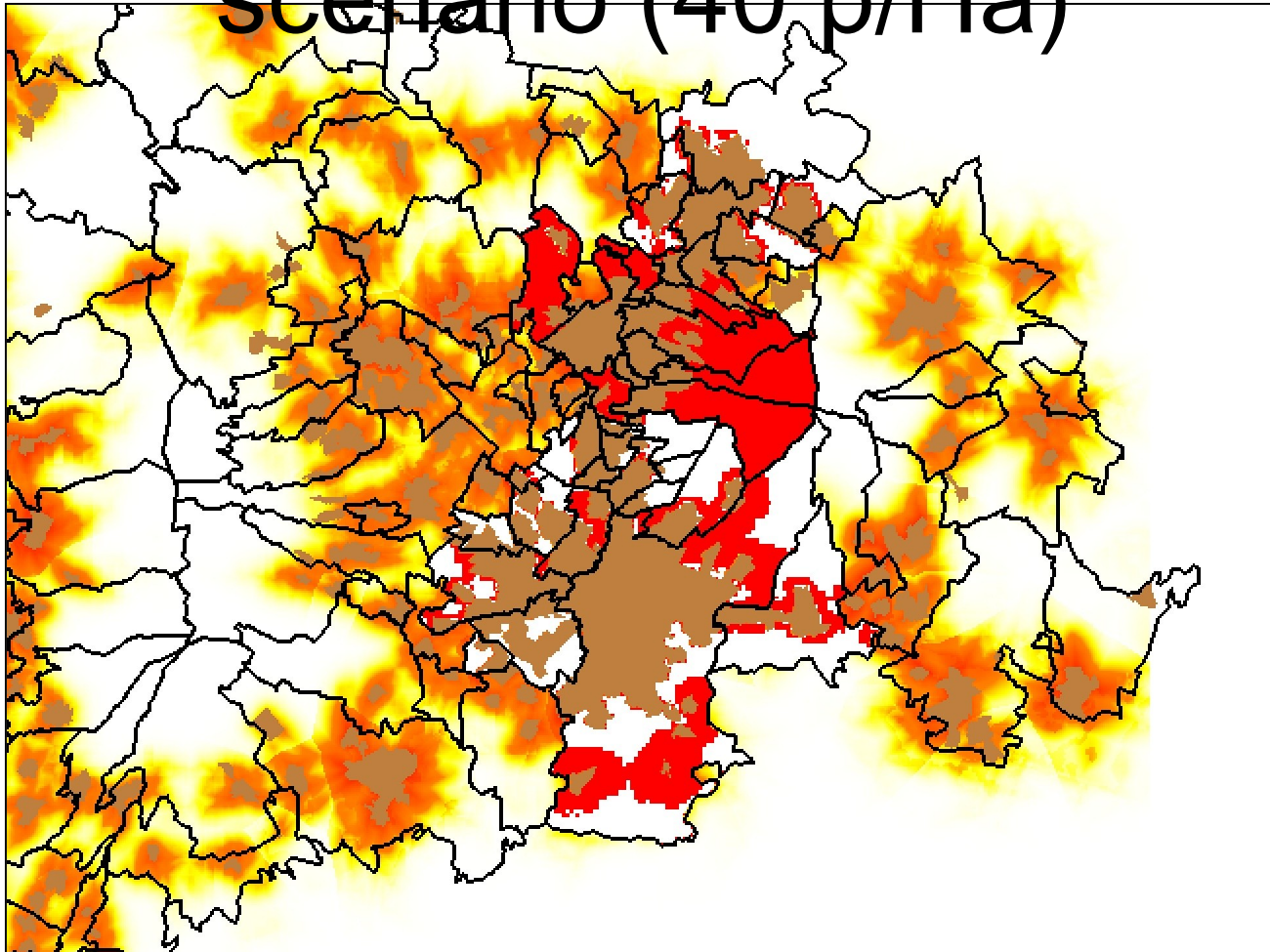
Urbanization density scenarios



Cambio poblacional y de área urbana 1990-2030				
Año	p1990	p2000	p2030	Cambio
Población	1,721,876	2,220,827	3,439,322	1,218,495
Área Urbana	63,231	74,168	89,627	15,458
Área Urbana	63,231	74,168	123,635	49,466

Growth assignment

Urbanization in Puebla-Tlaxcala 2030, [preliminary] optimistic scenario (40 p/Ha)



Summary

- Urban growth models can help:
 - Forecast emissions
 - Area emissions through estimated/planned population density data
 - Transportation emissions with Mobile 6 or other (better) transportation models (i.e. 4 step transportation model)
 - Guide planning policies through sensitivity analyses of AQ models

Thanks for your attention!

