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Environment and Urbanization 2000; 12; 119
DOI: 10.1177/095624780001200210

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1. SAGyP (1995), *El deterioro de las tierras en la República Argentina. Alerta Amarillo (Deterioration of Land in the Argentine Republic. Yellow Alert)*, Secretariat of Agriculture, Livestock and Fishery, and Federal Agricultural Council, Buenos Aires.

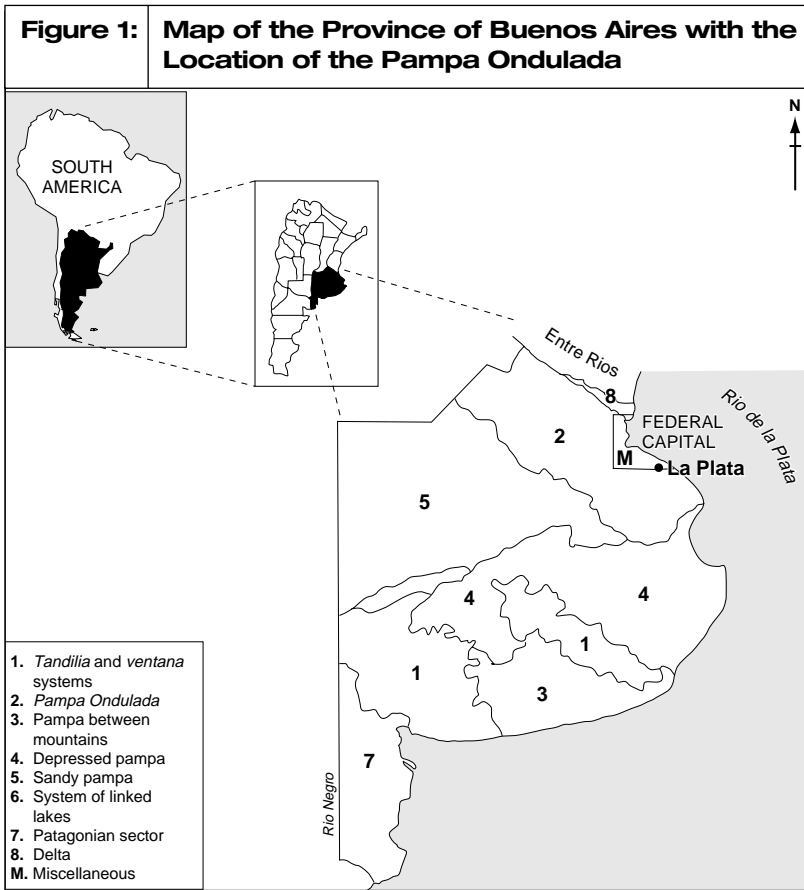
2. For example, 17.6 quintals per hectare of wheat, 45 quintals per hectare of maize and 22.1 quintals per hectare of soy; Scotta, E S (1996), *Estimación del valor económico de la erosión hídrica en la agricultura de Entre Ríos (Estimated Economic Value of Water Erosion in Agriculture - Entre Ríos)*, Research Paper, Experimental Agricultural Station, National Institute of Agricultural Technology, Paraná, Argentina.

SUMMARY: *This paper describes the conflict between agriculture and urban development in the Pampa Ondulada, the eco-region where the city of Buenos Aires is located and which is one of the world's richest and most productive agricultural areas. It describes and analyzes the ecological changes brought about by urban expansion in peri-urban and rural areas between 1869 and 1991 and the form that these have taken. It also includes an analysis of the soil types where this expansion has taken place. The paper ends with a discussion of the lack of control over the continued expansion of the urban agglomeration including that caused by the closed settlements now favoured by middle and upper-income groups and the speculative parcelling of land in advance of its development.*

I. INTRODUCTION

LA PAMPA ONDULADA (literally, the undulating or rolling Pampa) is one of the world's richest productive agricultural areas and occupies the central eastern portion of the province of Córdoba, north of Buenos Aires and south-west of Santa Fé.⁽¹⁾ Fertile soils, a low-energy relief and wide-spread powerful aquifers on which intensive exploitation has recently begun (to provide supplementary irrigation) provide an ideal medium for agricultural production. The region's climate is characterized by abundant annual precipitation (850-1,000 millimetres) which is distributed fairly uniformly throughout the year. There is only a short period during which there is a risk of frost, when average monthly temperatures fall below 10 degrees Celsius. As there is no snowfall in winter, the same plot of land can be used to grow two or three crops each year. The eco-region's agricultural wealth is attributable to its potential to alternate ranching with the cultivation of broad leaf (soy and sunflowers) and narrow leaf (wheat and maize) crops in space and time.

Average yields in this region⁽²⁾ show that this is the most richly endowed eco-region of the Argentine Pampa in terms of cereal biomass per unit of area – and it accounts for the bulk of Argentina's export grain production. Just under 400 kilometres of the rectangular *Pampa Ondulada* eco-region (see Figure 1) border the Paraná River, where agro-industries and ports specializing in direct loading of grain, pellets and oil onto trans-oceanic ships flourish. It also houses two of Argentina's major metropolitan areas – Buenos Aires and Rosario which, in 1991, had populations of 11.25 and 1.09 million, respectively. These cities are part of the country's



SOURCE: Modification of SAGyP (1995), *El deterioro de las tierras en la República Argentina Alerta Amarillo* (Deterioration of Land in the Argentine Republic; Yellow Alert), Secretariat of Agriculture, Livestock and Fishery, and Federal Agricultural Council, Buenos Aires.

most important urban-industrial axis. In this moderately sized eco-region of 44,000 square kilometres, competition between urban and rural land use is fierce. This paper focuses on this conflict which will be termed “geophagy”.

These two traditionally conflicting land uses assume uniquely dramatic proportions since the conflict is situated in Argentina's most important eco-region for agricultural production in an agro-exporting country, and because the change from rural to urban use is a permanent one – as permanent as the extinction of a species.

The Buenos Aires Metropolitan Area⁽³⁾ is located on premium soil for agricultural production, with use capacities I-IV according to the classification of the US Soil Conservation Service (see Table 1). The process of urban growth in Greater Buenos Aires occurs at a bio-geographic crossroads. This territory, whose geodesic centre is the intersection of the 34°40' parallel and the 58°30' meridian, is home to interlocking ecosystems of bio-geographic domains of wet tropical lineage, such as the Amazon, and seasonal tropical/sub-tropical ones, such as Chaqueño.

At this bio-geographic crossroads, we find some woody species of tropical lineage, in the form of forests and savannahs, with patches of landscape occupied by typical high biodiversity jungle structures and

3. Greater Buenos Aires includes a total of 31 administrative jurisdictions (equivalent to *partidos*), covering a territory of 7,729 square kilometres of the *Pampa Ondulada*.

4. Matteucci, S D, J Morello, A Rodríguez, G Buzai and C Baxendale (forthcoming), “El crecimiento de las metrópolis y los cambios de biodiversidad” (“Growth in metropolises and changes in biodiversity”) in

Table 1: Cartographic Units of the Soil Map

Cartographic unit	Landform	Soil type	Use capacity	Productivity index
1	Delta Rolling surfaces Alluvial plains	Typical haplaquents, aquic udipluents Vertic argiudolls, aquic argiudolls Typical natraquolls, Typical natraqualfs	VII	30
2	Rolling surfaces Alluvial plains Headwaters	Typical argialbolls, typical argiudolls Typical argialbolls, typical argiudolls typical natraqualfs, typical natraqualfs Typical haplaqualfs, typical duraqualfs, typical haplaquolls	IV	50
3	Rolling surfaces Depressions Hills (lomas)	Vertic argiudolls, typical argiudolls Typical natraquolls, typical argiaquolls Thapto argic hapludolls	II	70
4	Hills (lomas) Alluvial plains Depressions	Thapto argic hapludolls Typical argiudolls Typical natrudalfs	II	70
5	Rolling surfaces Depressions	Typical argiudolls, thapto argic hapludolls Typical natraquolls, typical natraqualfs, typical natralbolls	II	70
6	Rolling surfaces Microhills Long slopes Depressions	Typical argialbolls Typical argiudolls Aquic argiudolls Vertic albaqualfs, typical natrudalf	III	65
7	Rolling surfaces Long slopes Depressions	Typical argiaquolls Typical natraqualfs Typical natralbolls	IV	42

SOURCES: Modification of Godagnone, R E and R R Casas (1996), *Los suelos del conurbano bonaerense* (Soils of the Buenos Aires Conurbation), research report, Soil Institute, Centre for Natural Resource Research, National Institute of Agricultural Technology, Castelar; also Palacio, M I (1996), *Cartas a color del conurbano bonaerense: suelos, capacidad de uso, índice de productividad* (Colour Maps of the Buenos Aires Conurbation: Soils, Use Capacity, Productivity Index), Soil Institute, Centre for Natural Resource Research, National Institute of Agricultural Technology, Castelar.

Matteucci, S.D. O T Solbrig, J Morello and G Halftter (editors), *Biodiversidad y uso de la tierra: conceptos y ejemplos de latiamérica. (Biodiversity and Land Use: Concepts and Examples in Latin America)*, UNESCO-EUDEBA, University of Buenos Aires Press, pages 549-580.

5. See reference 4.

low-biodiversity tropical riverside forests.⁽⁴⁾ Large areas of woody ecosystem, such as *Celtis spinosa* and *Prosopis alba*, and savannahs of *Acacia caven* have disappeared where the land offered potential for agricultural use. Ever shrinking patches of ecosystems, such as monospecific riverside forests of *Salix humboldtiana* and *Tessaria integrifolia*, high-diversity jungles of the Paraná Delta, and ridges of fertile land known as *monte blanco* and *selva marginal*, survive and are subjected to wet periods and flooding.⁽⁵⁾

The *Pampa Ondulada*'s landscape structure and urban geophagy are studied from different standpoints by the Landscape Ecology and Environment Team of the University of Buenos Aires Centre for Advanced Research, directed by Dr Jorge Morello.

II. CONCEPTUAL FRAMEWORK

SINCE THE SECOND half of the 1940s, the *Pampa Ondulada* has been Argentina's most important area for the conversion of very high quality agricultural land into urban-industrial land in the broadest sense – that is, including the landscape impression or footprint that an urban agglomeration makes on its environment, with the exploitation of low-cost, heavy natural resources (topsoil, B horizon, grass, turf, wood) and where transportation accounts for a substantial share of the costs. Urban agglomeration will be defined as the conversion of open land into city block-sized lots, whether or not they are built upon.

A distinction is drawn between a city's landscape footprint and what William E. Rees defines as its ecological footprint.⁽⁶⁾ A city's landscape footprint includes the ecologically productive land, water, and natural and semi-natural landscapes that the city consumes, permanently altering its traditional uses and cover.⁽⁷⁾ It is the imprint of the appropriations and permanent changes of ownership of contiguous territory that the city requires to grow, obtain mineral resources and dispose of waste materials. The landscape footprint is distinguished from the ecological footprint by contiguousness and border phenomena. The ecological footprint refers to the total area of productive land and bodies of water required on a permanent basis to produce all consumed resources and to absorb all waste materials produced by the agglomeration.

A city has two types of hinterland. The ecological hinterland – which is fragmented and whose fragments are not necessarily contiguous to or near the city – is the area required to sustain present levels of consumption. The landscape hinterland is the near or contiguous territory that is being consumed by the growth of the agglomeration, the development of residential settlements, and mining production (parent rock limestone, expansive clay and earth) and which, as a result, ceases to be agriculturally productive or to serve as media for natural and semi-natural ecosystems, with the relevant change of ownership and/or use.

Peri-urban will be defined as the area of urban and rural interaction where the landscape footprint is made. It is a space contiguous to the city, that is affected favourably or unfavourably by that contiguousness.⁽⁸⁾ The peri-urban system is neither rural nor urban. As Figure 2 shows, it is an interface, where there is increasingly less provision for the various services provided within the urban agglomeration such as drinking water, electricity, storm sewers, pavements and rubbish collection. When compared to the rural system, there is also increasingly less provision of the ecological services such as the capacity to absorb carbon dioxide; to harness solar energy as chemical energy and convert it to food; to break down organic matter; to recycle nutrients; to control the animal and plant population balance; to prevent pest outbreaks; to regulate water flows; to absorb, store, and distribute short-term river flooding; and to form soils.

Buenos Aires' peri-urban area's landscape footprint includes:

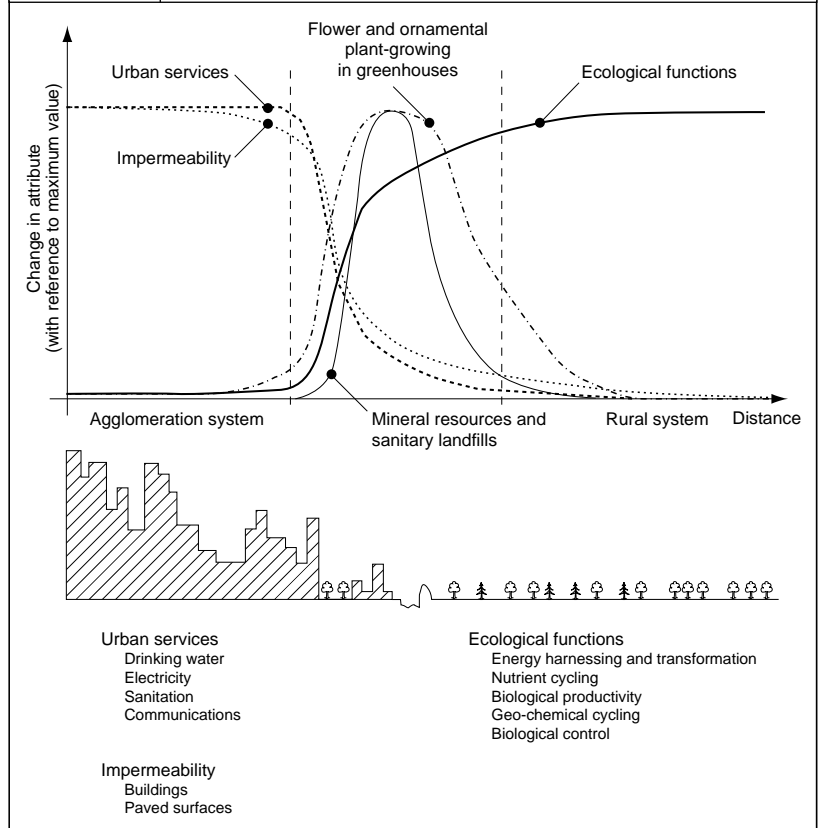
- land parcelling in city block-sized lots;
- soil removal through extraction (A, B, and C horizon) for building embankments, for brickworks and for urban development landfills on land prone to flooding in order to raise the elevation;
- extraction of sections of turf;
- consumption of soil for nurseries and similar operations;
- legal and illegal disposal of refuse and industrial waste;
- urban wastelands;

6. Rees, W (1992), "Ecological footprints and appropriated carrying-capacity: what urban economics leaves out", *Environment and Urbanization* Vol 4, No 2, London.

7. Morello, J, S D Matteucci, G D Buzai, C Baxendale and A F Rodríguez (1998), "Aplicación de la tecnología SIG para el análisis del soporte biofísico en áreas metropolitanas como herramienta de planificación. El caso de Buenos Aires" ("Application of geographic information system GIS technology to the analysis of the biophysical support in metropolitan areas as a planning tool. The case of Buenos Aires) in Matteucci, S D and G D Buzai (editors), *Sistemas ambientales complejos: herramientas de análisis espacial. (Complex Environmental Systems: Tools for Spatial Analysis)*, University of Buenos Aires Press (EUDEBA), Buenos Aires, pages 409-424.

8. Gutman, P, G Gutman and A Dascal (1987), *El campo en la ciudad: la producción agrícola en el Gran Buenos Aires (Field in the City: Agricultural Production in Greater Buenos Aires)* Centre for Urban and Regional Studies (CEUR), Buenos Aires.

Figure 2: The Change in Attributes along the Urban-Rural Gradient



SOURCE: Based on Rodríguez, A F (1997), Cambios de uso de suelos en el entorno periurbano del Gran Buenos Aires. Estudio de usos de neoeosistemas y ecosistemas residuales en el área no urbana del partido de Berazategui (Changes in Soil Use in the Peri-urban Environment of Greater Buenos Aires. Study of the Use of Neo-ecosystems and Residual Ecosystems in the Non-urban Area of the District of Berazategui), Licenciatura thesis, School of Philosophy and Literature, University of Buenos Aires.

- spontaneous settlements (including squatter settlements);
- country clubs, *barríos cerados* (closed settlements), rustic clubs (*clubes campestres*);
- industries;
- heavy infrastructure equipment;
- storage or dumping grounds;
- water purification facilities;
- automobile salvage and junkyards;
- clandestine pig farms and farm abattoirs, greenhouse and aviary complexes;
- road construction yards; and
- garden cemeteries and neo-ecosystems, that is, semi-natural landscapes where the dominant or most frequently occurring species are not native but accompanying and subordinated species.

The Argentine Pampa is considered a classic example of a highly vulnerable bio geographic unit in terms of the establishment of introduced species and the formation of ecosystems that are partially or totally stable

under certain conditions. In the peri-urban area of the metropolitan region, human activities such as selective tree-felling, interference with the hydro-periodic pulse through infrastructure construction, and water and soil contamination have all stimulated the successful establishment of neo-ecosystems. Overexploited forests, deprived of flood pulses, have been replaced with *Ligustrum lucidum* and *Ligustrum sinensis* woods, both exotic species introduced as ornamental plants for streets and gardens. Land flooded episodically by water contaminated with heavy metals and hydrocarbons now harbours ecosystems in which the dominant cover species is *Rubus ulmifolius*; and the dominant species in damp soil borders of flat areas is now *Iris pseudacorus* – another species introduced into gardens for ornamental purposes.⁽⁹⁾ These three neo-ecosystems now occupy larger territories than the ones that they replaced or are in the process of replacing, as in the case of the iris.

III. ASSESSMENT OF LAND CONVERSION

LAND PARCELLING IS one of the indicators that can be used to assess the conversion of rural landscapes into urban ones and is one of the easiest to assess as it can be viewed on maps, aerial photographs and satellite images. Information about parcelling, and available census and cartographic information, was used to study the advancement of parcelling using the peripheral area of metropolitan Buenos Aires as an example. The pilot area included the federal capital and the 23 sections surrounding it, an area of 3,880 square kilometres, 60 per cent of which corresponded to agglomeration in 1991. The information came from a variety of sources, including the eight national population and housing censuses conducted in Argentina between 1869 and 1991; historical cartography for the first four censuses; official agency cartography for the period 1970-1980; and satellite images for 1991.⁽¹⁰⁾

Eight thematic maps were produced using the Geographic Information System (OSU Map for the PC, version 4.0). These maps show the size and location of the parcelled areas at each point in time (1869, 1895, 1914, 1947, 1960, 1970, 1980, and 1991). The maps are like snapshots and pairs of them can be compared to identify the advancement of parcelling.

The soil map of the study area was prepared by the soil institute of INTA-Castelar (Instituto de Suelos, INTA-Castelar) with extrapolation of information from systematic soil surveys by INTA in the areas surrounding the Buenos Aires conurbation and in the areas of native vegetation and non-waterproofed soils that perforate the urban matrix. The ninth thematic layer is soil units, with seven soil association categories (see Table 1). A relief map with four altitude categories was also used.

The Geographic Information System was used to overlay thematic layers to obtain agglomeration maps for each cartographic soil and relief unit for each point, and to calculate the areas occupied by each category on each map.⁽¹¹⁾

IV. RESULTS

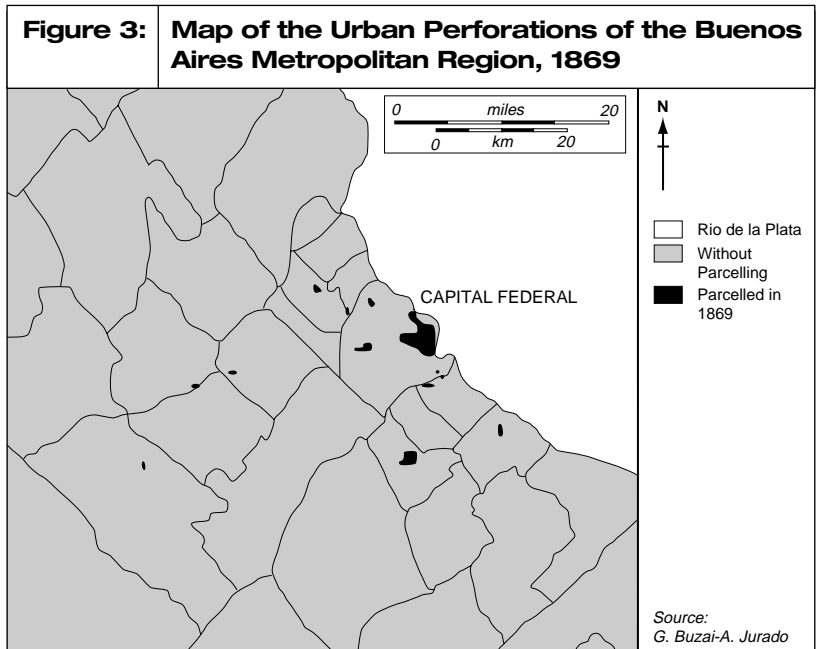
IN 1869, THE *Pampa Ondulada* appeared to be perforated⁽¹²⁾ with 11 plots of parcelled land (see Figure 3). The largest agglomeration was in the centre of the city of Buenos Aires which had developed as a port settle-

9. See reference 4.

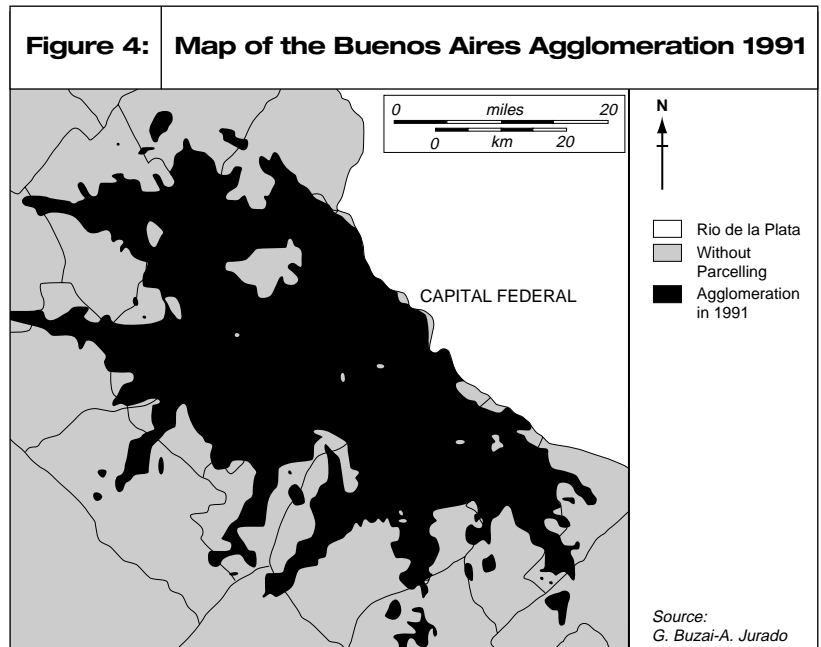
10. Buzai, G D (1993), "Buenos Aires 1869-1991. Análisis SIG de su evolución espacial" ("Buenos Aires 1869-1991. GIS analysis of its spatial development"), Anais, Fourth Latin American Conference on Geographic Information Systems, and Second Brazilian Symposium on Geoprocessing, São Paulo, pages 333-351.

11. See reference 10.

12. A "perforation" is defined as an isolated patch with clearly defined limits which is different from and contrasted with the homogeneous matrix surrounding it.



SOURCE: GEPAMA (Landscape Ecology and Environment Team), Centre for Advanced Research, University of Buenos Aires.



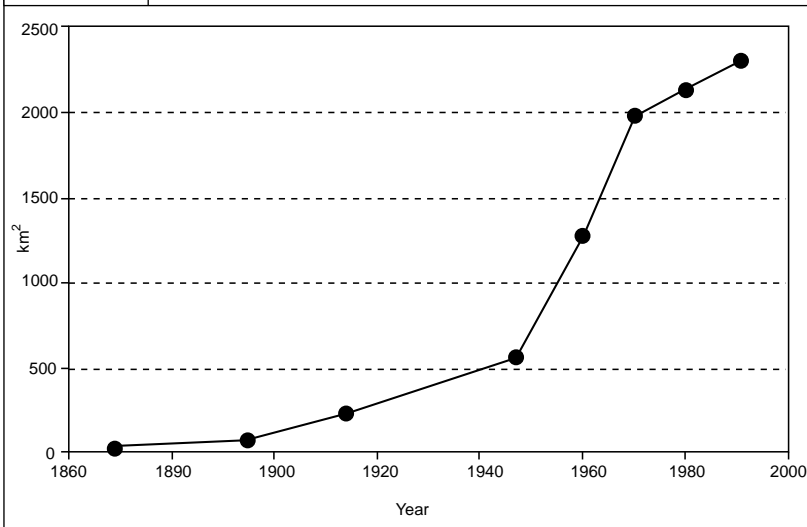
SOURCE: GEPAMA (Landscape Ecology and Environment Team), Centre for Advanced Research, University of Buenos Aires.

ment on the estuary of the Rio de la Plata. Corridors of perforation could already be observed: three along the path of the Sarmiento railroad to the west, and five more along the Roca railroad to the south. The most remote perforation, now the district of Marcos Paz, was located on one of the branches of the Sarmiento railroad. Between 1869 and 1895, most growth

occurred in the central agglomeration although it did not combine with the neighbouring perforations. During this period, three new perforations began on the future path of the North Belgrano railroad, which was built along the coast at the beginning of the twentieth century. Nine lines of dissection were already visible in 1960, the last two of which (highway routes) appeared between 1947 and 1960. New perforations continued to appear until 1991, all along transportation corridors, although the number of agglomerations started to decrease substantially, beginning in 1960, when the existing ones began to grow and combine. The Buenos Aires city centre grew steadily and the agglomerations on its border combined to produce a dissection of the grasslands, savannahs, pampas and riverside copses in primitive river valleys, along diverging radii from the city centre. Fragmentation, however, is not perceived at the scale of the study. The diverging radii, rather, continued to widen and combine and, by 1970, they all appeared to be forming continuous corridors. The process in general can be described as a creeping fungal growth of agglomeration into the grasslands, savannahs and elongated patches of copses. Between 1970 and 1991, no appreciable expansion occurred; the radii widened and combined, and a few new perforations appeared (see Figure 4).

Surprisingly, during the last period the growth in land parcelling decelerated (see Figure 5), with an initial phase of slow growth between 1869 and 1947 (approximately seven square kilometres per year), a phase of rapid linear growth from 1947 until 1970 (61 square kilometres per year) and a decrease in the growth rate during the period 1970-1991 (16 square kilometres per year). The widening of the radii indicates that the agglomeration was advancing into virtually isolated land between areas that had

Figure 5: The Growth in Land Parcelling in Buenos Aires Agglomeration, 1869 to 1991

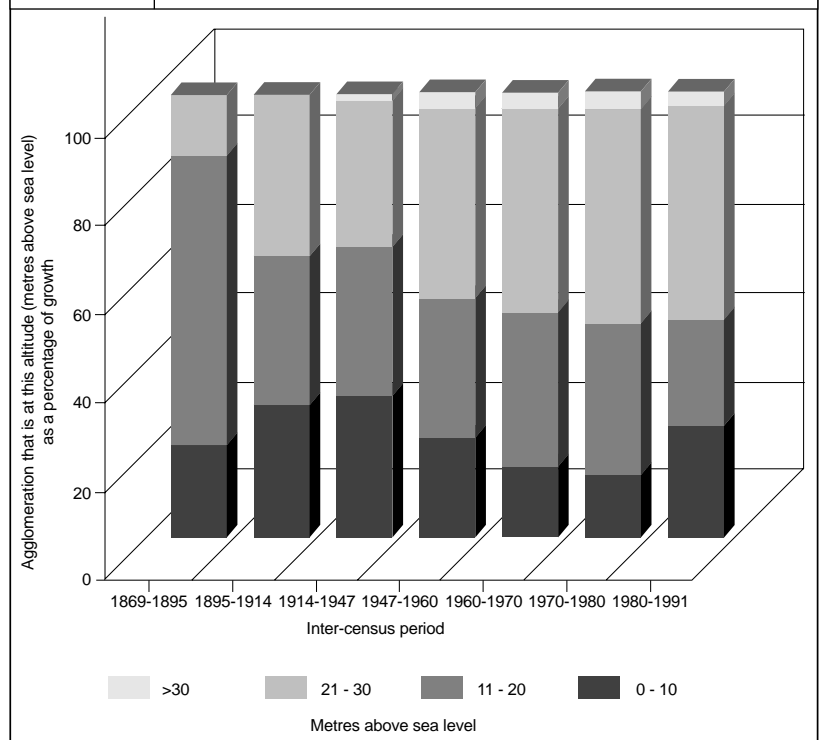


SOURCE: Morello, J S, D Matteucci, G D Buzai, C Baxendale and A F Rodríguez (1998), "Aplicación de la tecnología SIG para el análisis del soporte biofísico en áreas metropolitanas como herramienta de planificación. El caso de Buenos Aires" ("Application of geographic information system GIS technology to the analysis of the biophysical support in metropolitan areas as a planning tool; the case of Buenos Aires") in Matteucci, S D and G D Buzai (editors), *Sistemas ambientales complejos: herramientas de análisis espacial. (Complex Environmental Systems: Tools for Spatial Analysis)*, University of Buenos Aires Press (EUDEBA), Buenos Aires, pages 409-424.

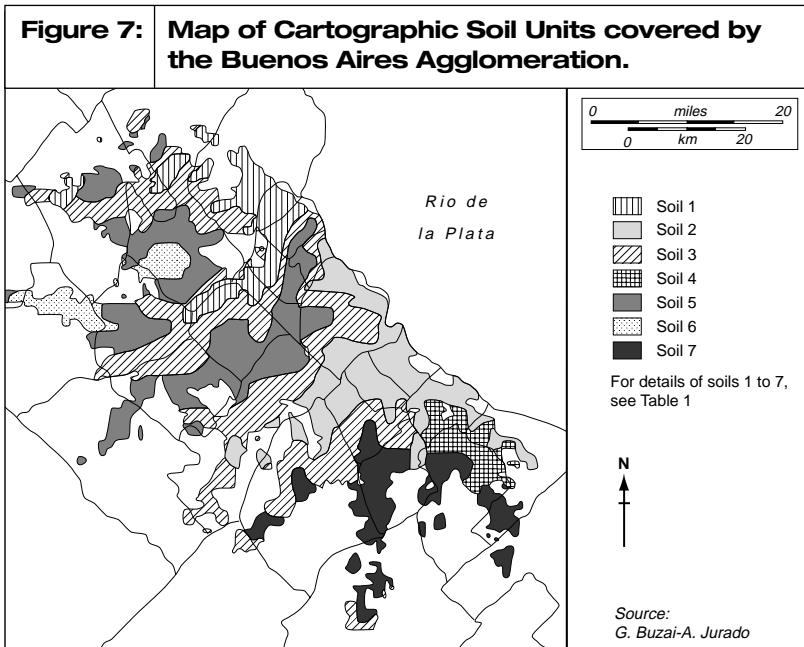
already been parcelled.

Given the low energy and scope of relief, there is no evident association between hypsometry and the growth in parcelling – in other words, no clear preference for any particular relief has affected expansion in a particular cartographic unit of relief at the scale of study. At the first three points in time, agglomeration had moved into land situated 10-20 metres above sea level, probably as the result of this cartographic unit's proximity to the coast. Substantial amounts of land below 10 metres (such as the present sites of the Palermo Hippodrome, the airport and the promenade) was later reclaimed from the river and was therefore not available during the initial stages of growth in the city centre. From 1960 onwards, most of the growth occurred at the 20-30 metre level (see Figure 6). Land above 30 metres occupies a small fraction of the area studied and is situated far from the coast, with the exception of one peninsula of high ground in the section of San Isidro which leads to the bank of the estuary. Accordingly, this area might be expected to include the smallest proportion of parcelled land at all points in time. Of course, the risk of flooding has consistently been the key determinant in space occupied by the elite and low-income

Figure 6: The Proportion of the Growth in Agglomeration in each Cartographic Unit by Altitude for each Period between 1869 and 1991



SOURCE: Morello, J S, D Matteucci, G D Buzai, C Baxendale and A F Rodríguez (1998), "Aplicación de la tecnología SIG para el análisis del soporte biofísico en áreas metropolitanas como herramienta de planificación. El caso de Buenos Aires" ("Application of geographic information system GIS technology to the analysis of the biophysical support in metropolitan areas as a planning tool. The case of Buenos Aires) in Matteucci, S D and G D Buzai (editors), *Sistemas ambientales complejos: herramientas de análisis espacial*. (Complex Environmental Systems: Tools for Spatial Analysis), University of Buenos Aires Press (EUDEBA), Buenos Aires, pages 409-424.



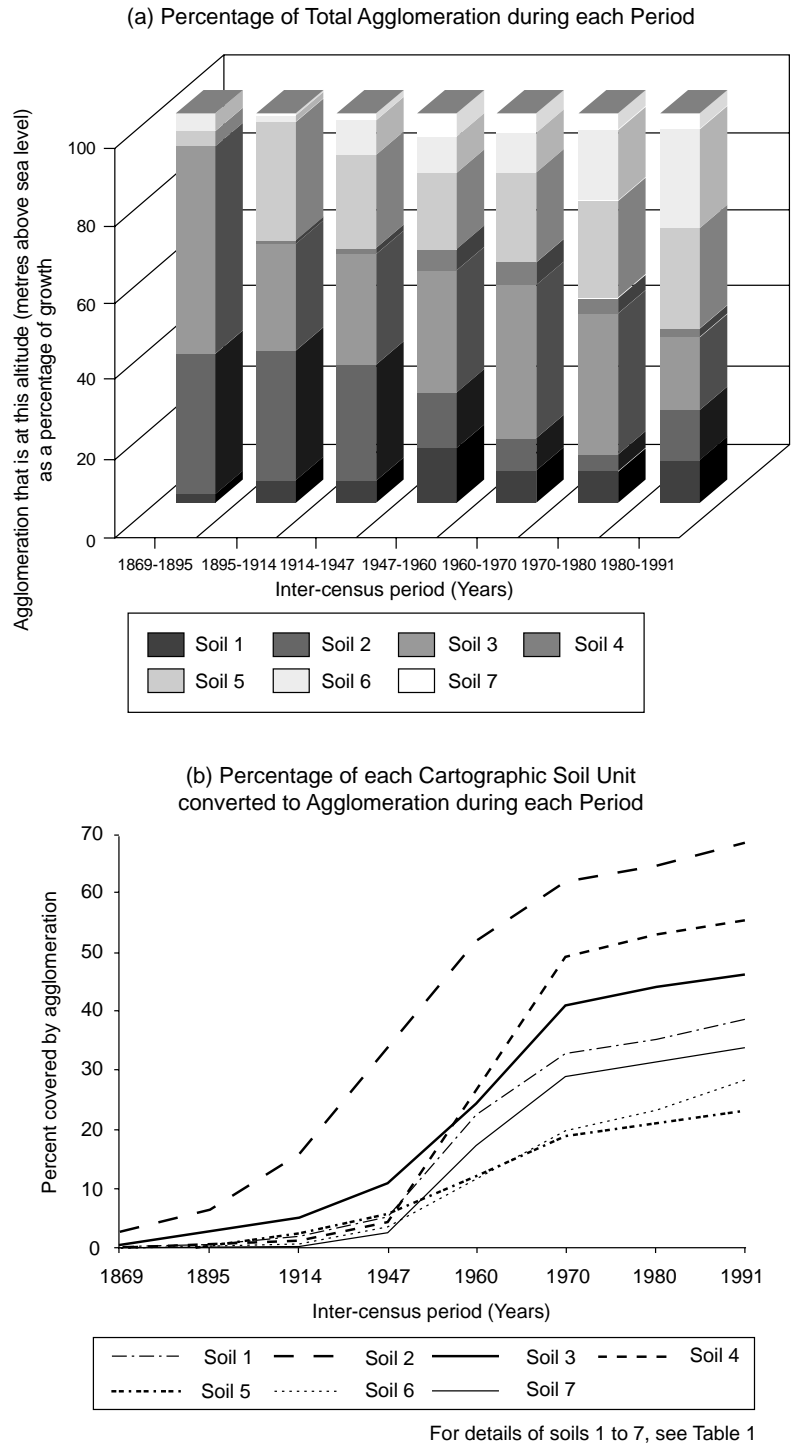
SOURCE: Morello, J S, D Matteucci, G D Buzai, C Baxendale and A F Rodríguez (1998), "Aplicación de la tecnología SIG para el análisis del soporte biofísico en áreas metropolitanas como herramienta de planificación. El caso de Buenos Aires" ("Application of geographic information system GIS technology to the analysis of the biophysical support in metropolitan areas as a planning tool. The case of Buenos Aires) in Matteucci, S D and G D Buzai (editors), *Sistemas ambientales complejos: herramientas de análisis espacial*. (Complex Environmental Systems: Tools for Spatial Analysis), University of Buenos Aires Press (EUDEBA), Buenos Aires, pages 409-424.

populations. The social map of the city prepared by Torres,⁽¹³⁾ using indicators such as the number of persons employed or holding university degrees by census area, shows clear socio-environmental segregation in 1999 with relation to flooding. The same has been true for the growth of agglomeration on lower ground. The only choice was probably to rule out the coastal beach, in those sites where it existed, and the Matanza and Reconquista river valleys. In 1960, the Matanza river valley appeared to be totally parcelled along the middle and coastal sections, and the Reconquista river valley seemed to be fragmented by parcelling in sections along its path. In 1991, most of the land between 0 and 20 metres was already occupied. One might expect all subsequent growth to be on land in the 20-30 metre range, corresponding to higher areas more valuable for agricultural production.

Despite the importance of agricultural production to the national economy and the soil's suitability for this activity, since the beginning of Argentina's urban history, cartographic Unit 3 – with rolling relief cut by ravines, streams and rivers, and a predominance of soils suitable for agricultural activities typical of the *Pampa Ondulada* – has been a preferred expansion area for agglomeration (see Figure 7). In 1869, 37 per cent of the 3,321 parcelled hectares were situated in Unit 3 and 10 per cent in Unit 5 – another section of the *Pampa Ondulada* endowed with deep, rich soil. Forty-nine per cent of the parcelled land was classified as Category 2, corresponding to the terraces of the River Plate, and only 4 per cent were in Categories 1 (depressed coastal fringe) and 6 which are less suited to agricultural production. Beginning in 1895, movement into Units 2 and 3 decreased, while they increased into Units 5 and 6 (see Figure 8). Unit 9

13. Torres, HA (1992), "Cambios en la estructura socioespacial de Buenos Aires a partir de la década de 1940" ("Changes in the sociospatial structure of Buenos Aires from the 1940s on") in Jorrot, J and R Sautu (compilers), *Después de Germani. Exploraciones de la estructura social en Argentina (After Germani. Explorations in the Social Structure of Argentina)*, Paidós, Buenos Aires, pages 158-175.

Figure 8: Growth of the Buenos Aires Agglomeration on the Cartographic Soil Units, 1869 to 1991



is also part of the *Pampa Ondulada* and is suitable for agricultural use, although with some limitations (see Table 1). The soil type was clearly not a factor in planning growth in agglomeration.

The percentage occupation of each cartographic soil unit shows that in 1947, 50 per cent of Unit 2 was covered by agglomeration, while Unit 4 reached the same percentage in 1960 (see Figure 8b). Rather than a pref-

Table 2: Area Occupied by each Cartographic Soil Unit, in Square Kilometres and as a Percentage of Continental Area		
	Surface	
Soil	Km ²	(%)
1	570.57	9.00
2	547.23	8.63
3	1,651.92	26.06
4	176.95	2.79
5	2,235.19	35.26
6	858.93	13.55
7	292.04	4.61

Cartographic Soil Units are Described in Table 1.

SOURCE: GEPAMA (Landscape Ecology and Environment Team), Centre for Advanced Research, University of Buenos Aires

erence for soil type, these developments reflect Unit 2's location and the small proportion that it occupies of the area studied (see Table 2). The same is true for cartographic Unit 4. Units 3, 5 and 6, which are of most interest as they are larger in size and have the greatest use capacity, register low occupation levels, implying that all future growth in agglomeration will occur on agricultural land.

V. FINAL COMMENTS

THIS STUDY HAS shown the process of spread of urbanization to agricultural land in a pilot area with an analysis based on one of many possible indicators, namely, agglomeration. Before land is occupied by urban plots, the resources in the vicinity of the urban perforations begin to deteriorate. Any forward-looking model capable of assessing the consequences of future urbanization should use indicators that reflect the landscape footprint. In other words, there is a need for indicators that reflect the effects of agglomeration on the contiguous areas.

Among the many negative impacts shaping the landscape footprint is "geophagy", a term coined by Morello to identify the consumption of land for urban activities, including brickworks, extraction of soil for gardens and other forms of soil decapitation (loss of the fertile horizon). GEPAMA is now conducting a study to assess the soil requirements of agglomeration, and changes in this indicator over time, as well as the peri-urban area whose soil cover is shown in satellite images to be decapitated.

It is alarming to observe how, and to what extent, urban perforations are being created within crop, pasture and woodlands in the province of

14. Matteucci, S D (1998), "El análisis regional desde la ecología" ("Regional analysis from the ecological standpoint") in Matteucci and Buzai (see reference 7), pages 117-150.

15. Campanario, S (1998), "El nuevo mapa del boom inmobiliario" ("New map of the real estate boom") in *Clarín, Suplemento económico* (Clarín, Economic Supplement), Sunday 9 August, Buenos Aires.

16. Tella, G and F Aguilar (1999), "Barrios cerrados" ("Closed settlements") in Aguilar, M and A Pusio (editors), *Estudio de la ciudad de Buenos Aires en el Sistema Metropolitano (Study of the City of Buenos Aires in the Metropolitan System)*, Conference of the School of Architecture and Urbanization, UBA-Secretariat of Urban Planning of the City of Buenos Aires, Buenos Aires, unpublished.

17. See reference 16

18. See reference 15.

Buenos Aires without any consideration for the potential consequences. The process of expansion of the urban frontier, at the expense of the natural or semi-natural ecosystems and the services that they provide to society, are widely acknowledged. Landscape ecology applied to changes in spatial patterns shows that perforations will inevitably be followed by (and from time to time, preceded by) dissections connecting the perforations. These corridors widen and branch out, while the perforations grow and aggregate, so that the original matrix becomes fragmented, shrinks and eventually disappears.⁽¹⁴⁾ All conservation efforts in rural areas should acknowledge these phenomena of mosaic spatial sequences in planning the location of new urban centres and in projecting growth and uncontrolled uses of natural or agricultural ecosystems. This approach is used in other parts of the world.

An estimated 60 per cent of housing demand, corresponding to the middle and upper-classes, is moving to peripheral areas, indicating a potential demand for land of approximately 800 hectares per year.⁽¹⁵⁾ Since 1985-1990, highways have been the preferred axes for the advancing urban frontiers and, with the necessary expressways, have defined new forms of occupation with various types of *barrios cerrados* (closed settlements) which, by April 1990 covered more than 20,000 hectares and housed 250,000 persons at very high living standards.⁽¹⁶⁾ More remote closed urbanistic developments have produced perforations in the matrix of agricultural and natural ecosystems, many of which reconcile accessibility with sparse or concentrated occupation of the surrounding area, and have eliminated patches of native vegetation, including ecosystems vital to the country's natural heritage such as jungles on the banks of the River Plate estuary. The recent phenomenon is beginning to be analyzed, and we now know that most wooded surfaces that have been destroyed are exceptionally valuable riverbank plots of *Celtis spinosa* and *Prosopis alba*. New attractions, ranging from private universities to shopping malls primarily involving the leisure industry, have been created. Tella and Aguilar⁽¹⁷⁾ consider that 2 per cent of the population of Greater Buenos Aires live in closed settlements whose total area equals half the area of the federal capital. The effects of this advancement into productive agricultural space on the productive agricultural belt are not fully understood. Furthermore, this involves individual development efforts that are not coordinated – and there are no direct plans to connect these settlements to the sewer and drinking water systems. Unfortunately, there is no direct relationship between the advancement of parcelling and direct need. This is attributable primarily to real estate speculation, as a lead time of as much as five years is required for an area to be ready for acquisition by a business venture.⁽¹⁸⁾

Thousands of hectares have been taken out of productive agricultural use for such purposes, and have been turned into wastelands awaiting development – attributable, *inter alia*, to the fact that Argentina still has no master plan for urban/suburban land management to regulate this type of situation. The loss of agricultural land directly through landscape conversion, or indirectly as the result of the landscape footprint, and the impact of these activities on the national economy has yet to be studied and is not being considered by the official agencies responsible for environmental management. While the abundant current legislation addressing the environmental problems that result from urbanization does not address the problem of loss of agricultural land, this factor should be reflected in regional planning.