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Rethinking the dynamics of woody vegetation in Uruguayan campos, 1800–2000

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Abstract

Simplistic interpretations of the impact of newcomers on South American ecosystems retain currency in the environmental history of the subcontinent. European settlement is almost invariably seen to produce a continuous and linear destruction of the environment. On the basis of several crisis narratives contained in historical documents, it is widely accepted that there was a severe decrease in the extent of woody vegetal formations in the Río de la Plata area during the 19th and 20th centuries. To test this perception, and to develop a more accurate and more complex analysis of the environmental consequences of European occupation, this article focuses on Uruguayan territory from c. 1800 to 2000. Changes in the shape and extent of forest lands in this broad area were assessed by comparing 251 land-survey charts, drawn between 1830 and 1860, with modern-day forest maps. Changes in shrubland abundance were assessed by comparing current distributions with those inferred from the accounts of five travellers who passed through this territory in the first half of the 19th century. Over 200 years, there is no evidence of major changes in forest distribution, extent or shape, and shrublands appear to be much more abundant today than in the early 19th century. These observations, although based on limited data, contradict the most common interpretation of regional environmental evolution. They confirm other claims that the idea of forest destruction in the early 19th century was created and manipulated by actors involved in land conflicts. Close examination of such socially-constructed crisis narratives, through the use of new archives, leads to a better understanding of recent changes in the South American environment.

Keywords: Environmental history; Crisis narratives; Land-survey charts; Grasslands; Forest dynamics; Campos; Uruguay; South America

Introduction

Catastrophist interpretations of the human occupation of South America still dominate the colonial and post-colonial environmental history of the subcontinent.[1] This view, that European settlement produced a continuous and linear destruction of the environment, criticized by historian John MacKenzie in an article on the British Empire,[2] has not been closely examined as far as South America is concerned. It therefore seems essential to re-examine the problem, not to rehabilitate the European conquest of the land, but to develop a more accurate and rigorous interpretation of the complex processes of society-environment co-evolution initiated by newcomers to the hemisphere. It seems unwise to interpret colonization merely as a reckless destruction of the environment. After all, Butzer and Helgren have demonstrated for South-Eastern Australia that catastrophist 'narratives' led to erroneous interpretations of the causes of erosion, and that these interpretations owed at least as much to the arguments of 19th-century historical texts as to material evidence of landscape transformation.[3] A re-examination of these narratives therefore offers interesting opportunities for studying environmental representations in post-colonial societies. It is possible to rethink the environmental history of South America in two ways: first, by socially contextualizing the historical sources used to reconstruct

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[1] We are mainly referring to historical interpretations developed by natural scientists, and not to studies conducted by historians.

[2] J.M. MacKenzie, Empire and the ecological apocalypse: the historiography of the imperial environment, in: T. Griffiths, L. Robin (Eds), *Ecology and Empire. Environmental History of Settlers Societies*, Keele, 1997, 215–228.

[3] K.W. Butzer, D.M. Helgren, Livestock, land cover and environmental history: the tablelands of New South Wales, Australia, 1820–1920, *Annals of the Association of American Geographers* 1 (2005) 80–111.

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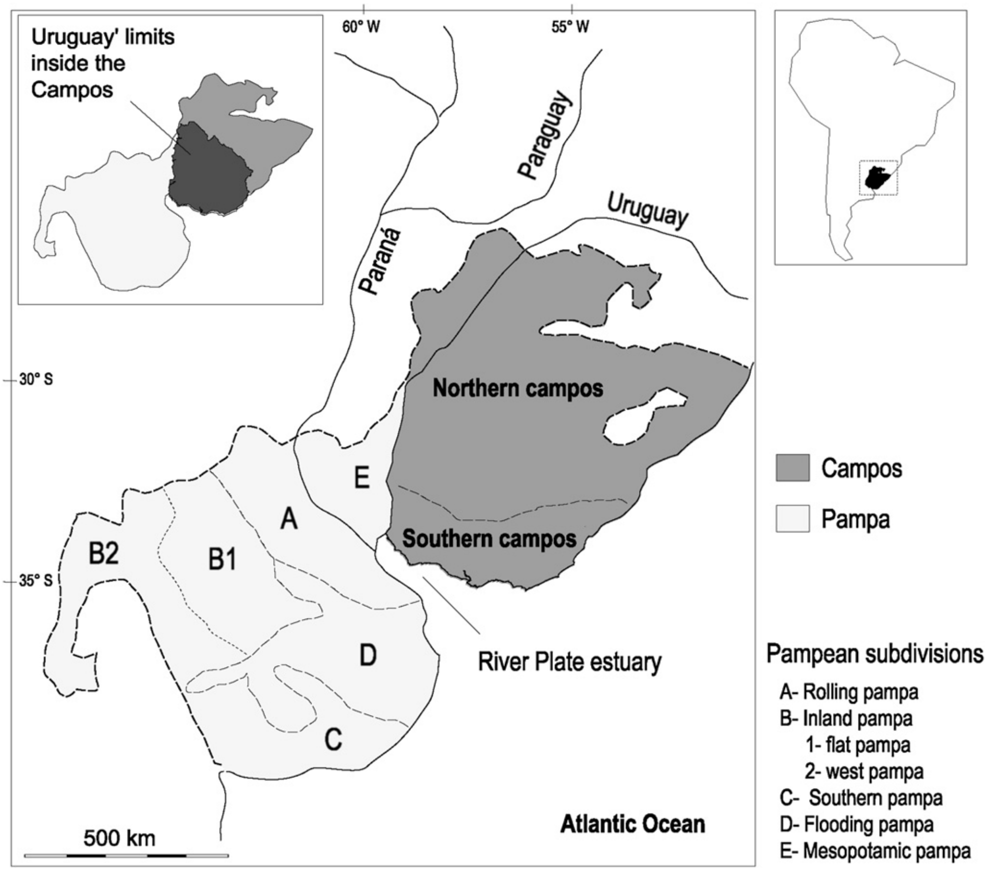

Fig. 1. Campos region according to Soriano et al., 1992 (see note 11)

long-term vegetation dynamics[4] and second, by seeking out documentary sources to assess environment dynamics at different scales in earlier times. In this article, we adopt the second approach to better understand the evolution of the Campos temperate grasslands landscapes during the past two centuries. We proceed by using hitherto untapped historical documents – 19th-century land-survey maps from Uruguay. This approach leads to a reinterpretation of a dominant narrative: the idea that in the Uruguayan part of the Rio de la Plata region (where grasslands are now dominant), forests, and woody formations in general, have suffered drastic reductions since the beginnings of the colonial period.

Uruguay lies in the Northern margin of the Río de la Plata estuary, occupying almost one-third of the huge transition zone of 'Campos' between the southernmost Brazilian forest and the treeless Buenos-Aires pampa (Fig. 1).[5] In Uruguay, forest is concentrated on the Eastern hilly zones of the Cuchilla Grande, the Northern zones of the Sierra de Haedo, and the Uruguay River valley (Fig. 2).[6] Shrublands have never been mapped nor scientifically defined, but they occur in all parts of the country, in highly variable abundance.[7] Uruguay's Campos is currently undergoing some of the land-use changes that have occurred in other grassy formations, mainly the development of planted prairies, the plantation of exotic trees, and the extension of the crop frontier.[8] But the major part of the country (approximately 70% of the total) is still covered by natural grasslands. This region is also locally concerned with the worldwide phenomena of shrub encroachment and local forest expansion.[9] As in grassland ecosystems worldwide, scientific awareness of the ecological importance of the Campos is very

[4] For an example of this kind of research and for a review of French works on this topic, see: P. Gautreau, Géographies d'une 'destruction' des forêts dans un territoire d'herbages. Récits de crise et résilience forestière dans les campos uruguayens du 18e au 20e siècle, PHD thesis, Lille: Université de Lille 1, 2006.

[5] This 'Campos' landscape is dominated by grasslands, with scattered marginal woody patches: gallery forests, forest patches on slopes, or shrublands. For a review of current ecological knowledge on the Brazilian Campos, see: G.E. Overbeck, S.C. Müller, A. Fidelis, J. Pfadenhauer, V.D. Pillar, C.C. Blanco, I. Boldrini, R. Both, E.D. Forneck, Brazil's Neglected Biome: the South Brazilian Campos, *Perspectives in Plant Ecology, Evolution and Systematics* 9 (2007) 101–116.

[6] Forest cover estimates in the country vary between 590,000 and 811,000 hectares (MGAP, 2000 agronomical census). This represents from 3 to 5% of the country's total area.

[7] Here we use the term shrubland to describe continuous layers of woody vegetation, formed by shrubs, that cover more than 80% of the soil. Shrublands are dominated in the region by the Asteraceae family (genera *Baccharis, Eupatorium* and *Heterotalamus*) and Sapindaceae (*Dodonaea viscosa* (L.) Jacq.). Their height may vary from 50 cm to 4 m, more frequently reaching heights of 1–2 m. In this study, any formation dominated by trees, with a height superior to 4 m, is considered as 'wood'.

[8] M. Brossard, D. López-Hernández, Des indicateurs d'évolution du milieu et des sols pour rendre durable l'usage des savanes d'Amérique du Sud, *Sciences, Natures, Sociétés* 13 (2005) 266–278; MGAP, *Agronomical Census*, Montevideo, 1908, 1966, 1980, 1990, 2000, 2002.

[9] S. Archer, T.W. Boutton, K.A. Hibbard, Trees in Grasslands: biogeochemical Consequences of Woody Plant Expansion, in: E.D. Schulze (Ed), *Biogeochemical Cycles in the Climate System*, San Diego, 2001, 115–137.

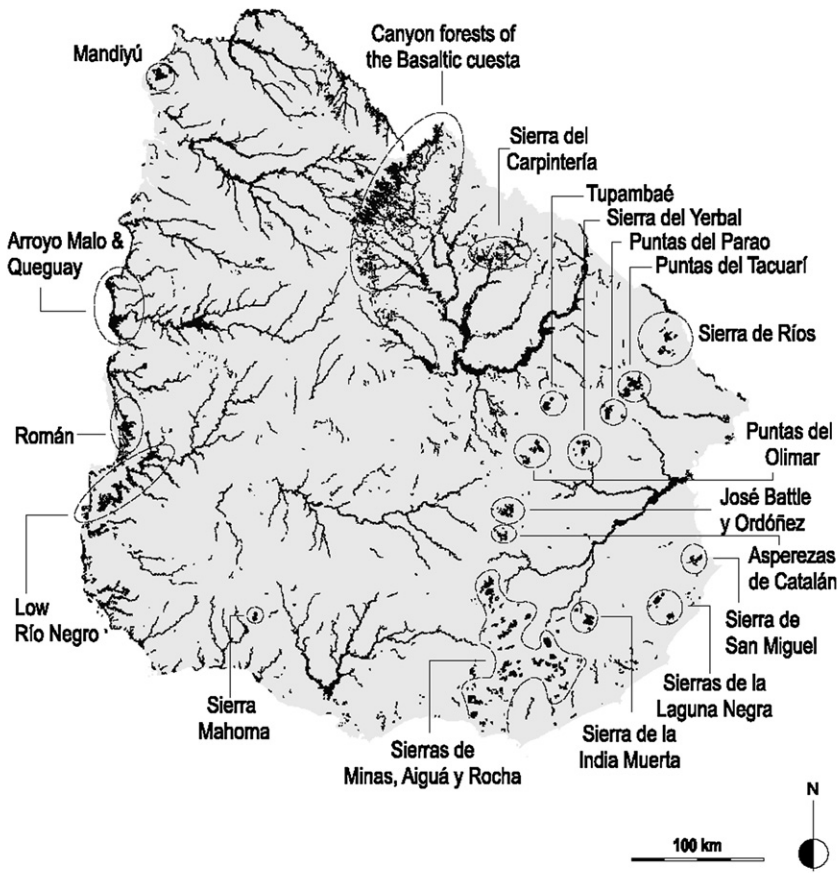

Fig. 2. Uruguayan forests. (From the 1980 "Carta Forestal" of the Agriculture Ministry, based on aerial photographs of 1966).

recent: previous studies of world grasslands hardly mentioned them and there are remarkably few ecological studies about Uruguay.[10] Bilenca and Miñarro, as well as Soriano, offer the most recent syntheses pertaining to the entire temperate grasslands region of the Río de la Plata, but they do not offer new data on fine-scale ecological patterns and vegetation communities in Uruguay.[11]

Paradoxically, paleoclimatic trends in the region are better documented than historical changes in vegetation from the beginnings of Spanish and Portuguese colonization in Argentina and Brazil.[12] It is often observed in present-day Uruguay that woody vegetation is very rapidly covering areas from which cattle are excluded. Scientific and occasional historical accounts tend to confirm this observation. The mid-20th-century botanist Rosengurtt concluded that shrubs were much more important in pre-colonial landscapes, before they were reduced by grazing and burning.[13] His colleague Del Puerto hypothesized that, before the 19th century, woody vegetation covered almost half the 176,220 km^2 of Uruguay's current territory, although it now accounts for less than 6%.[14] Various other authors uphold the idea of a drastic reduction of forest land from colonial times to the 20th century.[15] Wood cutting, fires set by ranchers, and agricultural expansion are adduced to explain this decline which is congruent

[10] G.M. Roseveare, The grasslands of Latin America, *Bulletin*, Cardiff: Imperial Bureau of Pastures and Field Crops, 36 (1945) 3–291. For example, the work of A.H. Clark made no mention of the Campos (The Impact of Exotic Invasions on the Remaining New World Mid-Latitude Grasslands, in: W.L. Thomas (Ed), *Man's Role in Changing the Face of the Earth*, Chicago, 1956, 737–762). For an historical analysis of the processes that led to ecological awareness of the grasslands' ecological importance, see: P. Gautreau, and C. Hinnewinkel, L'émergence d'un statut écologique pour les herbages: une vision croisée Inde (Nilgiri) – Río de la Plata, in: Paysage et environnement: de la reconstitution du passé aux modèles prospectifs, Colloque de Chilhac, 27–30.09.2006, 2006 (in press). Lately, there has been an increase in ecological publications (for an example, see: F. Lezama, A. Altesor, J.L. León, J.M. Paruelo, Heterogeneidad de la vegetación en pastizales naturales de la región basáltica de Uruguay, *Ecología Austral* 16 (2006) 167–182), that mark a clear break from the previous botanical and agronomical studies of grasslands by Rosengurtt (for an example from an abundant scientific production, see: B. Rosengurtt, B. Arillaga de Maffei, P. Izaguirre, *Gramíneas uruguayas,* Montevideo, 1970).

[11] D. Bilenca, F. Miñarro, *Áreas Valiosas de Pastizal en las Pampas y Campos de Argentina, Uruguay y Sur de Brasil (AVPs)*, Buenos-Aires, 2004; A. Soriano, The Río de la Plata grasslands, in: R.T. Coupland (Ed), *Natural Grasslands. Introduction and Western Hemisphere*, 1992, 367–407.

[12] For Rio Grande do Sul, see: H. Behling, L. De Patta Pillar, S. Girardi Bauermann, Late Quaternary Grassland (Campos), Gallery Forest, Fire and Climate Dynamics, Studied by Pollen, Charcoal and Multivariate Analysis of the São Francisco de Assis Core in Western Rio Grande do Sul (Southern Brazil), *Review of Palaeobotany and Palynology* 133 (2005) 235–248. For the Buenos-Aires Pampa, see: J. Deschamps, O. Otero, E. Tonni, Cambio climático en la Pampa bonaerense: las precipitaciones desde los siglos 18 al 20, *Documentos de trabajo de la Universidad de Belgrano* 109 (2003); L. Parodi, Distribución geográfica de los talares de la Provincia de Buenos-Aires, *Darwiniana* 4 (1940) 33–56.

[13] B. Rosengurtt, *Sucesión. Concepto de la tendencia climácica* (for internal University use), Montevideo: Facultad de Agronomía, Cátedra de forrajeras, bolilla 5, 12p. Rosengurtt pioneered the agronomical study of Uruguay's grasslands. He published abundantly from the 1940s to 1970s, and trained the major part of Uruguayan agronomists as Professor at the Facultad de Agronomía of Montevideo.

[14] O. Del Puerto, La extensión de la comunidades arbóreas primitivas en el Uruguay, *Notas técnicas* 1 (1987).

[15] G. Evia, E. Gudynas, *Ecología del Paisaje en Uruguay. Aportes para la conservación de la Diversidad Biológica*, Montevideo, Sevilla, 2000.

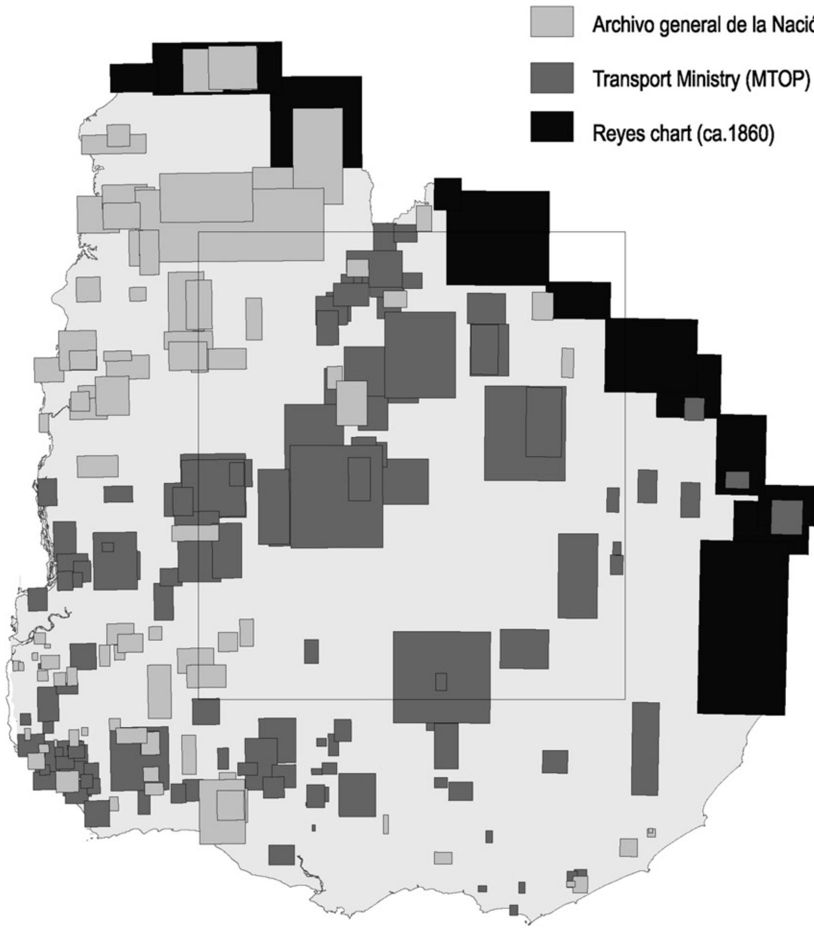

Fig. 3. Disposition of the charts selected for the analysis.

with (albeit on a scale different from) earlier theories that explain the formation of the Pampas by the destruction of woods.[16]

Textual archives from the colonial period and the 19th-century report the destruction of forests by European settlers. Some acknowledge the strong intensification of wood cutting in the region from the 16th century, but most of these narratives were produced by landowners who manipulated the idea of a crisis in an effort to abolish the forests' common property status under Spanish law (abolished in 1875). They attributed forest destruction to poor people – lumbermen, charcoal burners, peasants – in an attempt to persuade officials that common-pool resources were destroyed by public use and needed private owners, who would attend to their conservation. The ideological and political underpinnings of this argument cast doubt upon the accepted view, derived from it, that Uruguayan forests were destroyed by human greed. Arguably, the socially constructed idea of a 'forest crisis' influenced later scientific work on the development of the Campos, and guided common understandings of the evolution of the forests.[17] To provide a new perspective on these matters, this paper uses new historical data – hitherto largely neglected land-survey charts from Uruguay – to assess the spatial dynamics of vegetation change on the Campos.

Sources and methods for South American environmental history

The systematic production of land-survey charts began in Uruguay after Independence in 1830, with the creation of a 'Topographic Commission' on December 3, 1831 to develop a cadastral survey of public lands.[18] From this moment on, each person who wanted to own public lands had to submit an official request and a survey chart to the government. The Commission took on the task of cataloguing, standardizing and checking the technical quality of

[16] O. Schmieder, Alteration of the Argentine Pampa in the Colonial Period, Berkeley, *Publications in Geography* 2 (1927) 303–321; H. Ellenberg, Wald in der Pampa Argentiniens, Zürich: Veröffentlichungen des Geobotanischen Instituts der ETH, Stiftung Rübel 37 (1962) 39–56; J. Demangeot, *Les milieux 'naturels' du globe*, Paris, 1998.

[17] See note 10: Gautreau, Hinnewinkel.

[18] This process led to an original 'hybrid' cadastre: it mixed the drawing up of a list of the country's public lands by the Commission (without map production), and the collation of charts of public terrains that private individuals wished to lease from the State. Those maps were produced by authorized land surveyors, and then supervised and archived by the Commission (but not produced by it). The United Provinces (former Argentina), created a similar Topographic Commission in 1824. Most of the main land surveyors who integrated the former Uruguayan Topographic Commission were recognized experts in cartography and geodesy from other parts of the Río de la Plata countries – mainly Buenos-Aires – or from European countries like Spain, England, Italy, France, Sweden, Hungary (personal inquiry in progress, from the official list of Public Land surveyors: Ministerio de Transporte y Obras Públicas, Dirección de Topografía, Archivo Gráfico, N°de inventario DNT-AG-3+).

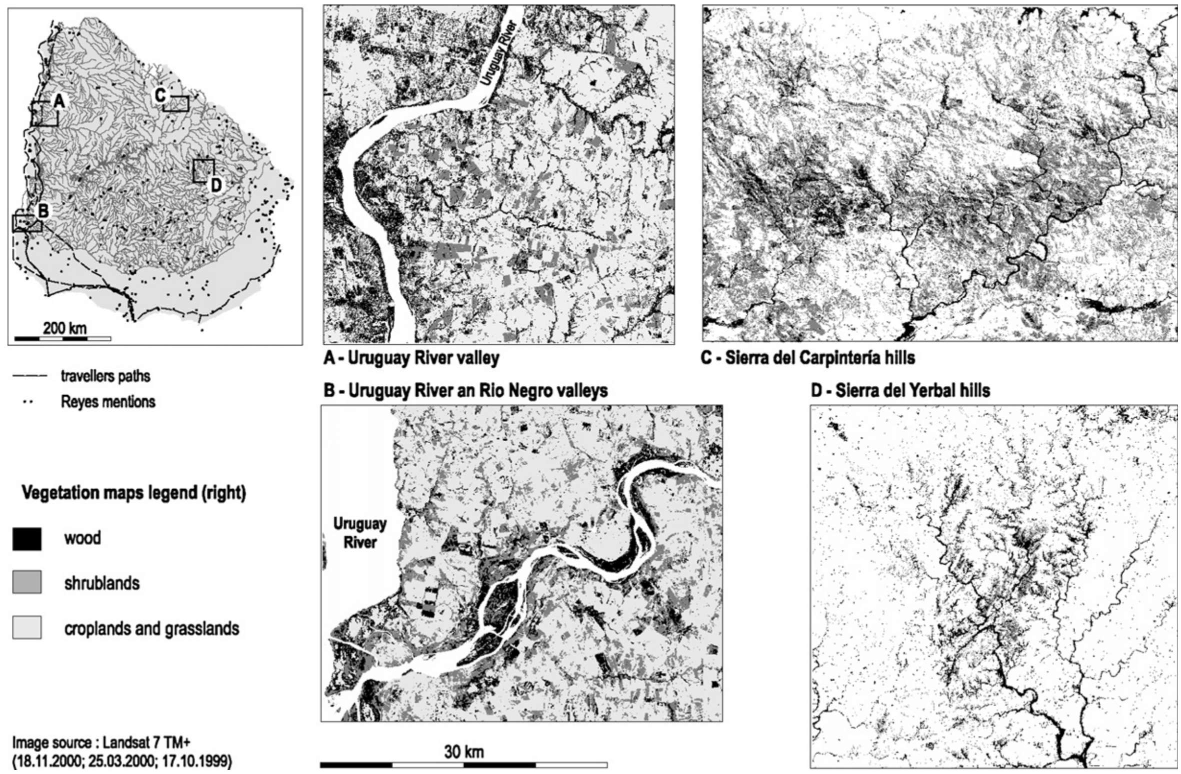

Fig. 4. Vegetation maps and field records of shrubland in the Uruguay valley (2000 and 2003), and paths of some naturalist travellers.

every survey.[19] Those surveys were made by land-surveyors authorized by the Commission ('agrimensores de número'), who produced almost 750 charts between 1830 and 1840. Although no written rules about cartographic representation were found in archives, the common elements in more than 400 charts make it clear that all the land surveyors used a standard cartographic language. Drawn in ink, then watercolored, these charts indicate rivers, dwellings ('estancias' or farms, 'puestos' or farm dependencies, 'ranchos' or huts), and some elements of the landscape (slope changes, cornices, main hilltops, rocky outcrops); many of them also indicate forests. The charts vary in scale between 1:20,000 and 1:100,000, but this does not influence the type of drawing used. Forests were probably mapped because of the natural fence function they fulfilled until wire fences were introduced on a massive scale during the 1880s.

This study began with an examination of 404 land-survey charts housed in two archives: the Archivo de la Nación (AGN) of Montevideo and the Archivo Topográfico of the Ministry for Transport (MTOP). Attention was limited to the 1833–1840 period so far as possible, but in zones where the data for this period were insufficient, the research was extended to the 1860s. Only the charts on which forests are represented were considered for the study of spatial change, because of the possibility that the absence of forest might reflect its systematic exclusion by the surveyor/cartographer (Figs. 7 and 8). Furthermore, only those charts in which interruptions of the galleries are observable, or those in which the drawing of forest islands is irregular – suggesting that the forests were not drawn for aesthetic purposes – were used for the final analysis. This analysis focused on 251 charts, selected according to this rule, which were scanned, georeferenced over pre-referenced satellite images and then incorporated into a Geographical Information System (Fig. 3).[20] The geometrical correction of charts was easy, thanks to the abundance of landmarks on these documents (mainly the hydrographic network). Spatial shifts ranged from a few hundred meters to less than 5 km, mainly due to paper deformations of the original charts. Taking into account the vastness of the area covered by the documents, generally several thousands of hectares, such errors were regarded as tolerable.

Changes in the spatial distribution of different forest types were assessed differently. Our approach distinguished between slope forests (uninfluenced by river dynamics) and gallery forests (located in floodplains). Charts with slope forests (61 charts) were compared with the 1966 chart of Uruguayan forests, compiled from air photographs at a scale of 1:20,000 (Fig. 2). Changes in gallery forests were assessed only longitudinally (149 charts were randomly chosen from the 251 initial chart sample): generally, these forests are less than several hundred meters wide, which makes it impossible to calibrate changes in their width with any accuracy, due to the scale of the land-survey charts. The longitudinal evaluation reveals changes due to fragmentation of the

[19] The decree of December 19, 1831 specifies the Commission's responsibilities: to create archives centralizing all cartographic documents; to determine the 'geographical positions' of the country's places; to prepare the development of a national map by collating earlier works; to define the mapping mode; to control the land surveyors. Article 2 specifies that all land surveyors who want to be registered officially have to pass an examination in 'geodesy, topography and descriptive drawing'. The decree of August 3, 1833 defines the role of the land-surveyor by giving him a role equivalent to that of a judge, in charge of settling possible disagreements between the applicant (who orders the measurement of land) and his neighbours. He is regarded as responsible for any errors in this work. Article 19 sets the fees payable to him for all the acts he carries out: commuting to the work place, devising and drawing the chart, fixing the tariff according to the land's size.

[20] Landsat TM+ coloured composition of 2000 and 2001, resampled at a 15 m resolution.

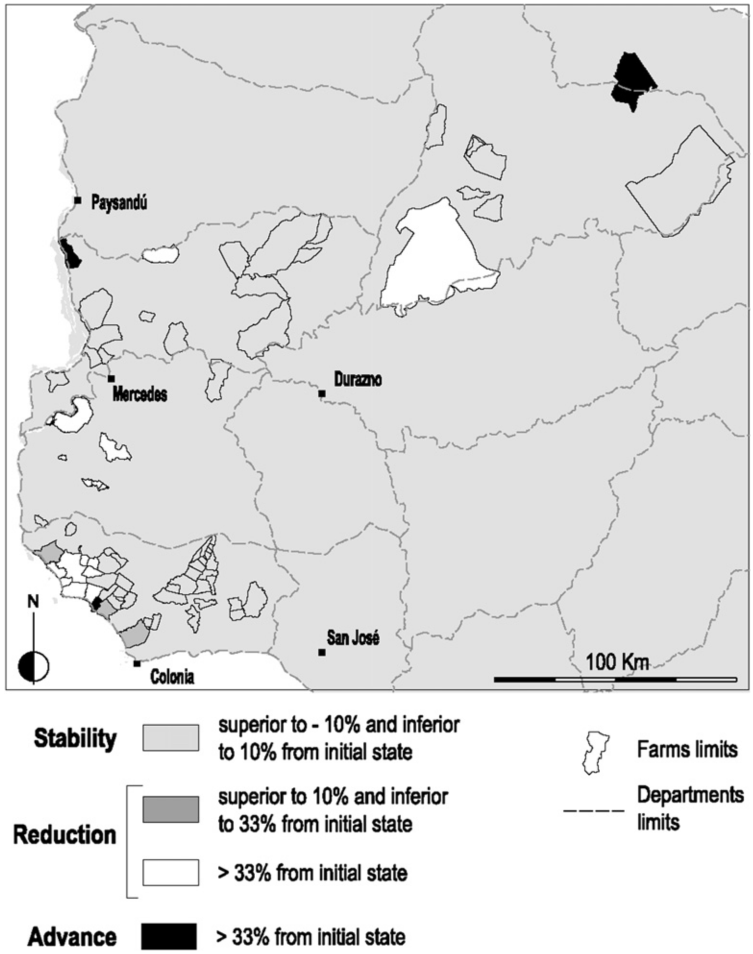

Fig. 5. Results of comparison for forests' surfaces evolution from 1830 to 1966.

gallery forest by wood cutting, or due to migration of the gallery's upstream margins. This assessment was made comparing the charts with recent satellite images, on which the continuity of the gallery forests can be determined accurately. Changes were calculated for 'segments' of the river – sections clearly demarcated by such discontinuities as stream junctions or meander lines with an acute angle (of less than 90°). In both cases, changes in the forest were categorized into 5 classes. Changes ranging between −10% and +10% of the initial state are regarded as non interpretable, and the forest dynamic is thus classified as 'stable'. Extensions in forest size or segment length were classified into categories of 10–33% expansion and more than 33% expansion. Reductions were similarly categorized.

To assess the evolution of shrublands during the same period, we collated references to these formations in the travellers' descriptions of the country during the 19th century. These references were located and compared with the spatial coverage of shrublands at the end of the 20th century, following the method used by Butzer and Helgren for the New South Wales region of Australia.[21] The analysis focused on references to shrublands (i.e. mentions of a continuous shrub layer) in the works of five travellers interested in vegetation or botanical issues, who travelled the country for several days: the travel diary of the catholic priest Dámaso Antonio Larrañaga, one of the foremost naturalists of Uruguay, who crossed the South–Western part of the country during the Independence conflict; the diary of Saint-Hilaire, a French botanist who walked along the South and West coasts of the territory in 1820–1821 and who left abundant and precise mentions of plants or vegetal formations; the memoirs of Arsène Isabelle, a French merchant who sailed northward on the Uruguay River in 1833; and the works of Lorentz, a German botanist who travelled along the right bank of Río Uruguay in 1876.[22] These descriptions, made along the Atlantic Ocean or the Uruguay river, were complemented by José María Reyes's 'Description of the territory of the Oriental Republic of Uruguay' (1860), which summarized his experience as director of the Topographic Commission and leading engineer during the mapping campaign on the frontier with Brazil.[23] An exhaustive analysis of his text identified 311 vegetation descriptions, which have been located on a national map (Fig. 4 shows the travellers' paths and Reyes's

[21] See note 2.

[22] D. Larrañaga, Diario de un viaje de Montevideo al pueblo de Paysandú, *Revista Histórica* (1910 edition) 7–8; Auguste de Saint-Hilaire, *Voyage à Rio Grande do Sul (Brésil)*, Orléans, 1887; A. Isabelle, *Voyage à Buenos-Ayres et à Porto Alegre, par la Bande Orientale, les Missions d'Uruguay et la Province de Rio Grande do Sul (de 1830 à 1834)*, Paris, 1835; P.G. Lorentz, *La vegetación del Nordeste de la Provincia de Entre-Ríos*, Buenos-Aires, 1878 (the Argentinean Entre-Ríos coast he visited is similar to the Uruguayan shore).

[23] J.M. Reyes, *Descripción geográfica del territorio de la República Oriental del Uruguay acompañada de observaciones geológicas y cuadros estadísticos*, Montevideo, 1860.

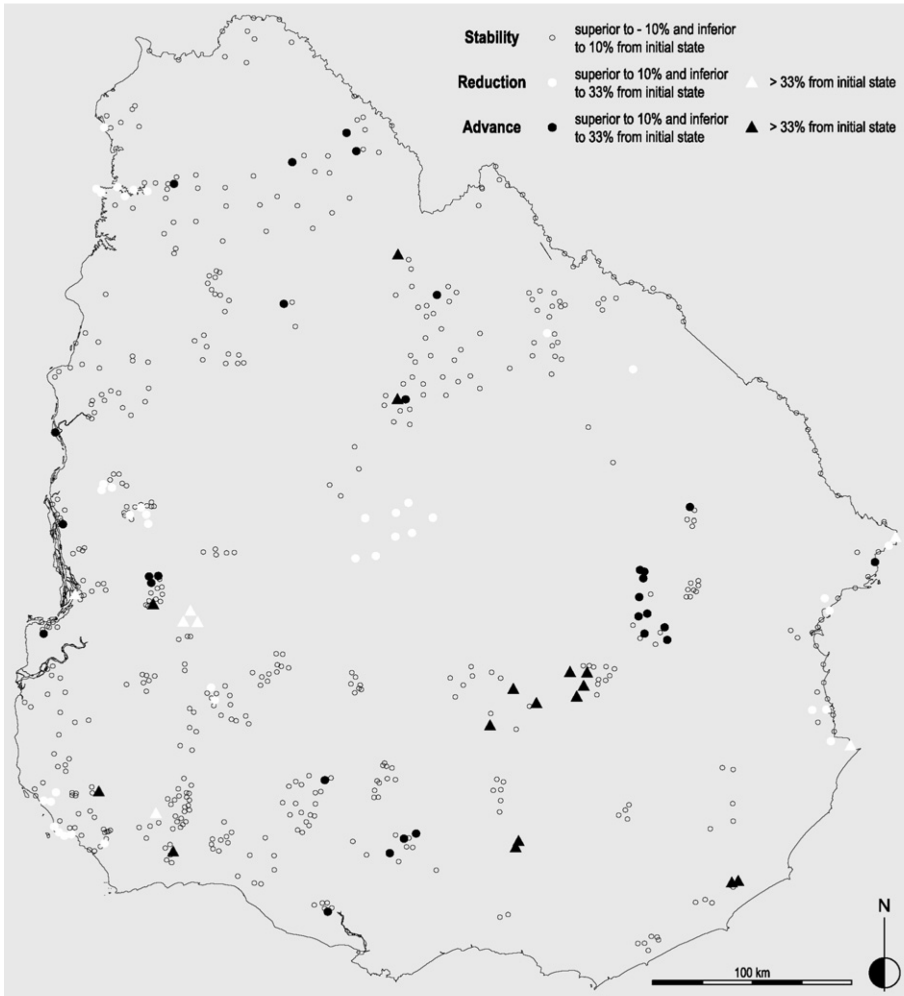

Fig. 6. Results of comparison for gallery forests' longitudinal variations from 1830 to 2000.

remarks). Those historical references are compared with vegetation maps built from remote sensing images interpreted with field data from 2003 (Fig. 4).

The inquiry suffers from the lack of intermediate temporal data, which could bring information about shorter-term fluctuations in the areas occupied by vegetal formations. These intermediate data are only available for the last decades of the 20th century. As a consequence, we are unable, here, to assess the probably diverse local trends of vegetation change: an increase in forest area observed by comparing documents produced 200 years apart might be the result of various shorter and alternate trends of reduction and extension. Another limit to the analysis lies in the differences in the scales at which we are able to assess spatial changes and posit the causes of these changes. Changes are assessed locally, at the farm level. But the lack of homogeneous and accurate historical data (texts) for all these localities forces us to resort to macro-scale factors (some operating at the national level) in order to provide tentative explanations for the changes we document. Thus the results and discussion presented below should be seen as a basis for further investigations rather than as definite conclusions.

Forest stability and shrubland expansion

Our analyses suggest that forests were spatially stable, and that shrublands expanded between the 19th and 20th centuries. Slope forest variations were studied along a SW–NE transect (Fig. 5). Except for a narrow littoral fringe in the current district of Colonia (SW) and in an area of the lower Río Negro valley, stability was more common than reduction in the forest area between the beginning of the 19th and the end of the 20th centuries.[24] For gallery forests (Fig. 6), stability largely dominates (empty dots): generally, neither longitudinal fragmentation of the galleries, nor variation of the upstream limit of the forest in the valley can be seen. As with slope forests, our evaluation suggests that there was little change in the gallery forest cover of the Uruguayan landscape. Again we note that our findings are limited by the scope of our evidence (Fig. 3), and that we cannot draw any conclusions regarding the South–Eastern shores of the country, or the central area of Uruguay.

Evidence for the expansion of shrublands can be found by comparing travellers' texts with current landscapes. The travellers' accounts seldom mention shrubs, or forms which resemble them; they contain even fewer references to shrub formations. Nowadays,

[24] Three places indicate area growth. On the northernmost chart (Ministerio de Transporte y Obras Públicas Archive, Montevideo, chart N° 102817), the few small forest islands that existed in 1832 were replaced by a massive forest in 1966. Overall, however, slope forests were strikingly stable.

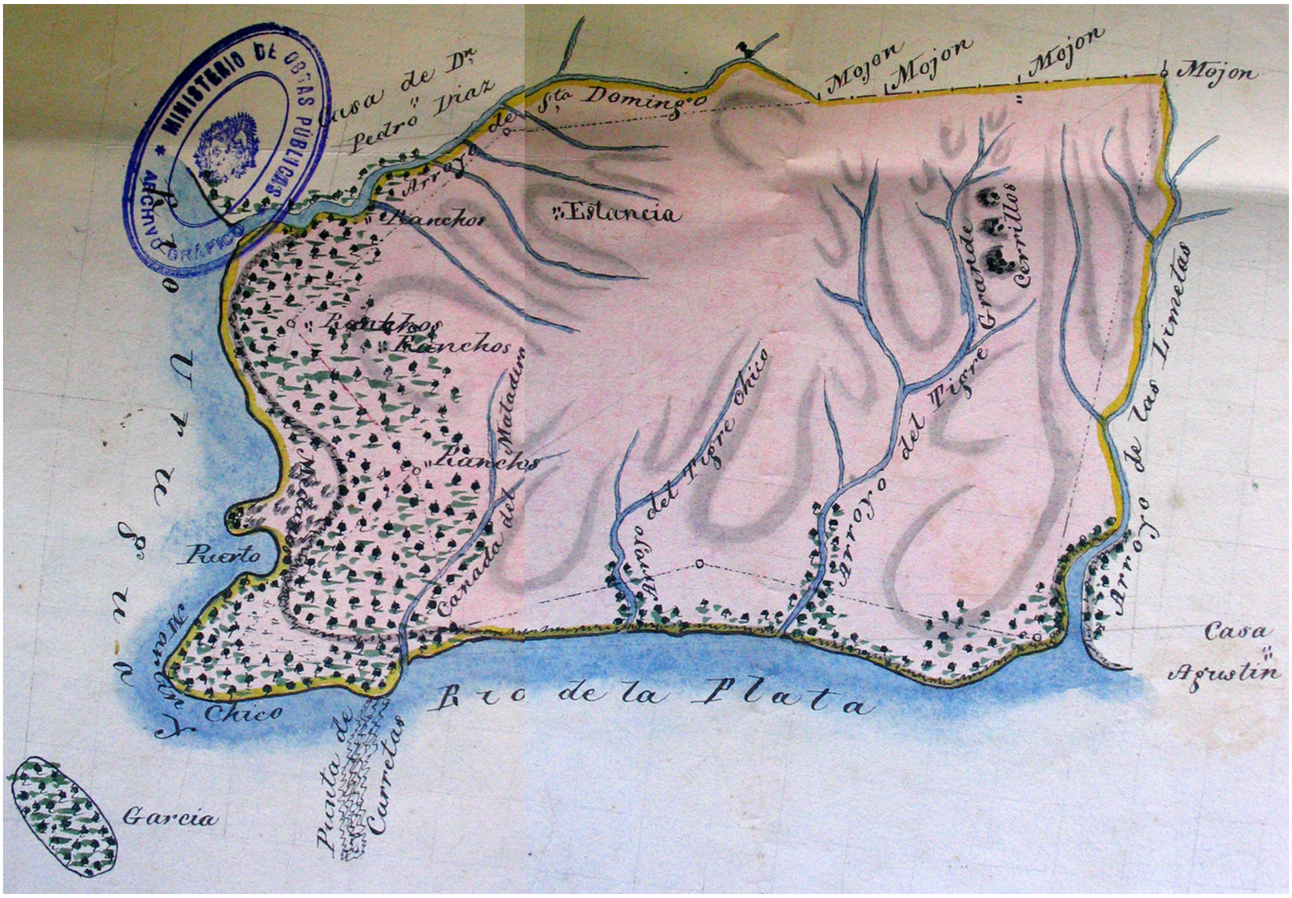

Fig. 7. Example of land-survey chart with slope forest in South–Western Uruguay, Colonia Region. The slope forest occupies the left third of the mapped property. Short gallery forests can be seen in the right part (1833, Land-surveyor Juan Christison, Archivo Topográfico of the Ministry for Transport, N° 30538).

by contrast, shrub formations are frequent in several parts of the country (Fig. 4). The travellers who went along Uruguay's river (Western) and oceanic (Southern) coasts mention isolated shrubs occasionally, and never mention shrubland formations. In one month of travel, Larrañaga described only one place 'densely covered with shrublands (*chircales*), eastwards of the Cufré river, in the South of the country'.[25] In 1820–1821, Saint-Hilaire almost never described shrubs, and when he did they were isolated plants.[26] In 1833, Isabelle underlined the absence of shrubs in the grasslands near Paysandú, where they are frequent today: '…all surrounding hills are naked and deprived even of shrubs'.[27] Lorentz mentioned shrubs or woody species on several occasions, but they never formed the continuous layer that can be observed today on the Uruguayan side of the river.[28] In his 'Description' of 1860, Reyes mentioned shrub plants 21 times out of 311 references to Uruguayan vegetation. His work is a dense overview of the country, and the scarcity of references to shrubs and shrublands confirms that they were infrequent at the time.[29] His failure to mention shrublands in the hilly part of the country is noteworthy, and contrasts with the current situation of the landscape.

These results challenge dominant ideas about the recent history of vegetation in the Río de la Plata, which state that the increasing density of human occupation from the 18th-century onward would have been accompanied by a reduction of shrubs in Campos landscapes, and by a great reduction of forested areas. Our hypothesis is that neither territorial transformations nor the ecological qualities of the woody species have been taken into sufficient account to elaborate an appropriate model of the long-term evolution of woody vegetation on the Campos.

Rethinking the historical dynamics of campos vegetation

Our core hypothesis is that increased human occupation of the territory during the period under study created spatial gaps in the grassland that facilitated woody vegetation encroachment, unless it was accompanied by a more intense use of the vegetation by ranchers. These spatial gaps occurred where fire – the main regulator of woody seedlings – was reduced in frequency and intensity. A parallel instance of this phenomenon has been described for the North-American prairie by Scanlan.[30]

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[25] 23.06.1815, see note 22.

[26] Mentions that he crossed grasslands 'without a single shrub' (02.12.1820) are more frequent. Over the course of four months of travel, he only mentioned three places in which shrubs grew outside of small valleys, in Santa Teresa, Maldonado and Guardia del Cuareim.

[27] 04.10.1833, see note 22.

[28] The only exception was a single mention of an area where *Baccharis notosergila* Grisebach abounded.

[29] Only once, in the surroundings of Rosario (South–West of the country), did he evoke with precision the *Dodonaea viscosa* (L.) Jacq. shrub, 'which is abundant in Campos, adjacent [to forests]'.

[30] M.J. Scanlan, Biogeography of Forest Plants in the Prairie-Forest Ecotone in Western Minnesota, *Ecological Studies* 41 (1981) 67–95.

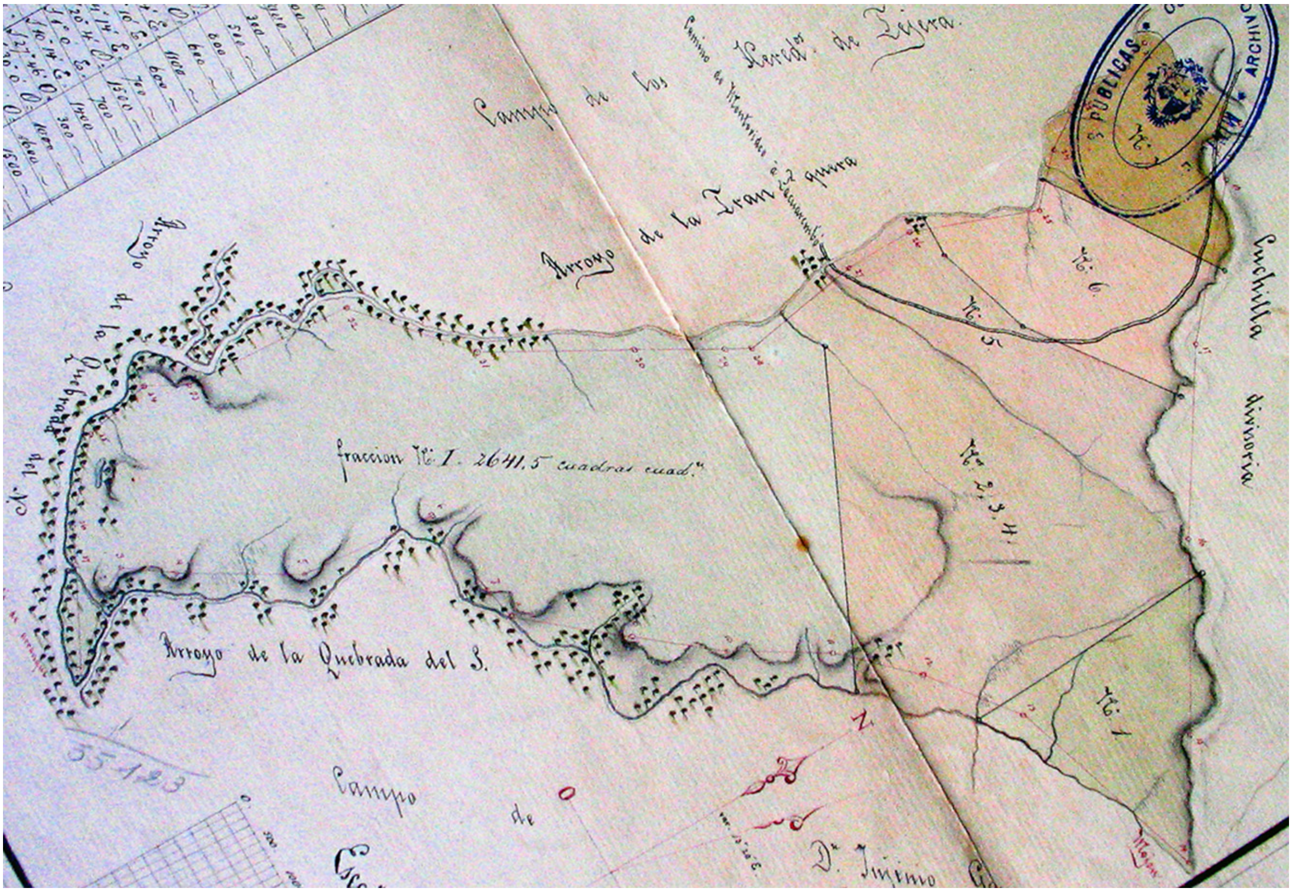

Fig. 8. Example of land-survey chart with gallery forests in Northern aUruguay, Tacuarembó Region. The mapped property is limited by a drainage divide (*cuchilla*) on its East side, and by two confluent rivers on its South and North sides, both flowing westward. The lower part of these rivers is occupied by gallery forests, continuous in the Northern river, discontinuous in the Southern one (1855, Land-surveyor Adolfo Conring, Archivo Topográfico of the Ministry for Transport, N° 82335).

In our estimate, fire has been the main driver of landscape dynamics and the main controller of woody vegetation on the Campos, perhaps more than water availability.[31] There are several indications of its ancient importance in the Campos. Palynological records from Behling *et al.* indicate an increase in the frequency of anthropomorphic fires from the beginning of the Holocene period, for an area close to Northern Uruguay.[32] The Spanish and Portuguese settlers intensified the use of fire to produce new tender grass and to gather together wild cattle, an action that led to frequent conflicts between cultivators and cattle breeders.[33] Even more frequent after droughts, burning seems to have been a common rural practice in the entire country during the 19th century.[34] Isabelle and Saint-Hilaire described it as a 'habit', and Lorentz explained the existence of treeless sectors in the open forest of Entre-Ríos by the frequent fires set by a dispersed rural population.[35] Burning continued to be a general pastoral practice until the second half of the 20th century. The authorities of the District of Florida tried to prohibit it in the 1880s, but they faced much opposition and conflict, because the Rural Code defined burning as a right, and their efforts were unsuccessful.[36] Teodoro Berro, the author of an article in the *Review of Rural Association* in 1895, and a rancher himself, deplored the extent of burning by 'ignorant people' and great landowners.[37]

Changes in the management of pastoral territories meant that livestock densities rose from 10–50 to 40–80 sheep/km^2 and from 30 to 50–70 bovines/km^2 across the country between 1860 and 2000.[38] These changes reduced the herbaceous biomass, as well as – to a significant extent – the fuel available for fires. Fires gradually

[31] See note 4, Overbeck *et al.*
[32] See note 11.
[33] P. Deffontaines, Contribution à la géographie pastorale de l'Amérique latine, Rio de Janeiro, 1964. Repeated decrees by the citizen assembly of the 'Cabildo de Buenos-Aires' in the second half of the 17th century, or by that of Montevideo between 1748 and 1775, insist on prohibiting 'the burning of fields', which proves that this practice was frequent.
[34] G.G. Politis, Climatic Variations During Historical Times in Eastern Buenos-Aires Pampas, Argentina, *Quaternary of South America and Antartic Peninsula* 2 (1984) 133–161; C.L. Leonhardt, Documentos inéditos relativos a los antiguos jesuitas en la actual R.O del Uruguay sacados de los archivos de Buenos-Aires por el P. Carlos L., S.J. Colegio del Salvador de Buenos-Aires, in: *Revista del Instituto histórico y Geográfico del Uruguay* 2 (1927) 505–556; reference to the burning of marshes in a land-surveying chart (MTOP, chart N° 82277).
[35] Mentions by Saint-Hilaire: 09.10.1820; Isabelle: 20.10.1833.
[36] *Código Rural reformado de la República Oriental del Uruguay*, Montevideo, 1879.
[37] T. Berro, Quemazones de campo, *Revista de la Asociación Rural del Uruguay* (1900) 714.
[38] J.P. Barrán, B. Nahum, *Historia Rural del Uruguay Moderno. 1886–1894*, Montevideo: Ediciones del a Banda Oriental, 1971; J.P. Barrán, B. Nahum, *Historia Rural del Uruguay Moderno. 1851–1885*, Montevideo: Ediciones del a Banda Oriental, 1967, 329–330; MGAP (note 7).

declined in amplitude, frequency, and caloric intensity and destroyed fewer woody plants. Around the same time, grasslands were fragmented by the extension of transportation networks, in ways similar to those reported for the North-American prairie by Briggs *et al.*[39] Before properties were enclosed with wire fences during the 1880s, only gallery forests formed a barrier to fires in the grassland; when the whole territory became divided into paddocks, the maximum size of burnt surfaces decreased gradually.[40] The reduction in the average size of paddocks was spectacular and continuous over the 1908–2000 period, and it was probably the main cause of grassland fragmentation.[41] These changes were accompanied by the decrease of fire-setting in some regions of Uruguay (SW) at the end of the 20th century; in regions where it is still a common practice (N and E), it is generally used biannually, over small surfaces.[42] These convergent factors explain part of the spatial expansion of shrublands on a national scale. At the regional scale, the formation, in the years 1980–2000, of many waste lands by loss of agricultural surfaces in marginal fields, mainly in the Uruguay River valley (W), was a second contributing factor.

To understand why forests have not suffered dramatic reduction at a national scale, in spite of wood cutting intensification due to population growth, it is necessary to identify a number of convergent factors. First, the physical factors controlling the grassland–forest boundary seem to be very stable over this period. Explanations of the current distribution of forests at the national scale generally stress water availability as the main driver. But this does not account for the pattern of slope forests which generally do not occupy areas with greater water availability than grasslands. Forest geography is explained mainly by fire. Most forests are found where fire is absent or less frequent or less intense than on the grassland. This is true of both gallery and slope forests. The analysis of the land-survey charts from the Uruguay River valley shows that in the 19th century, forests occupied predominantly marshy areas with a gleyic horizon and gentle slopes with alkaline soils, and not those seemingly more fertile slopes where brunosols dominate. In these places, soil characteristics lead to a major scarcity in grass cover, which weakens the intensity of fires, and reduces their frequency, allowing forests to thrive. In addition, the increase in rainfall observed in several meteorological stations of Uruguay during the 20th century, and noted in historical records for the 19th century, may have improved conditions for forest growth.[43] Also, the ecological capacity of forests to recover from high rates of wood cutting seems to have been underestimated. In the past, as today, the forests of the Uruguay River valley were probably dominated by *Prosopis spp*. and *Acacia caven* which have a high re-growth rate and are thus resistant to long-term wood cutting.[44]

An increasing number of recent investigations have confirmed the earlier observations of Lindman and Rambo that the area of the Río de la Plata region occupied by woody formations has increased during the 20th century.[45] Behling *et al.* proved that for the Holocene period in South–Western Rio Grande do Sul, forest islands started to appear on slopes after 1550 BP. Before this time, landscapes were occupied only by grasslands.[46] For the 20th century, a great number of studies show a spatial extension of forests, even in places where fires are set.[47] Therefore, the convergence of climate change, modification of pastoral practices and the ability of regional wood species to encroach on grasslands and re-grow after cutting or burning could explain forest stability at a national level, in spite of a denser human settlement of the country. These conditions would have maintained the general pattern of forest–grasslands boundaries during the past two centuries, despite local forest removal to allow for the expansion of agriculture and the submergence of substantial areas by major storage reservoir lakes.[48]

Conclusion

These observations point to the long-term stability of forest vegetation features in the Campos landscape since the 19th century. This, added to the manifest expansion of shrubland areas, tends to throw doubts on the idea that current Campos landscapes were formed by a drastic reduction of forest and shrubland formations during the last two centuries. Ecological and spatial factors played a central part in the matter: the native woody species of the region are generally adapted to high levels of perturbation, enabling them to withstand fires and cutting. The fragmentation of grasslands by wire fences and transportation networks offered spatial gaps in which woody vegetation could encroach and develop. All of this reaffirms the importance of territorial analysis for biogeographical studies with a historical perspective.

This interpretation of the evolution of the Uruguayan Campos during the colonial and post-colonial periods needs to be confirmed by further investigations. Two areas deserve more accurate analysis on a local scale: the Western part of Uruguay, where interactions between ranching and agriculture rendered territorial evolution highly complex during the 20th century (there was an intensification of cropping in some places, while others were semi-abandoned and colonized by woods); and the North–Eastern hills (*sierras del este*), which may have experienced the most intense expansion of woody vegetation in the country during the 20th century. Further work is also needed to interpret the articulation between long-term trends – the tendency of forests to expand over grasslands since the late Holocene – and short-term ones, especially European colonization. Did the latter merely amplify a long-term trend of changes on the land? The most striking effect is possibly am increased spatial differentiation of landscapes that were once relatively homogeneous. In some areas, fire, grazing, or cropping limited woody encroachment. Other areas

39 J.M. Briggs, An Ecosystem in Transition: causes and Consequences of the Conversion of Mesic Grassland to Shrublands, *BioScience* 55 (2005) 243–254.

40 The Rural Code (see note 39) compelled farmers to close their property.

41 National trend in average size of paddocks for the years 1908, 1966 and 2000 (in ha): 248, 66, 54 (source: see note 7).

42 See note 3.

43 Rainfall average for the 1931–1961 and 1971–2001 periods (in mm), and variations between these two series, for six meteorological stations: Mercedes (953, 1197, 25.6%); Paysandú (1154, 1254, 8.7%); Prado-Montevideo (1063, 1157, 8.8%); Rivera (1479, 1620, 9.6%); Rocha (997, 1224, 22.8%); Treinta-y-Tres (1112, 1410, 26.8%). Data source: Dirección Nacional de Meteorología, Montevideo; see also: Deschamps *et al.* (note 11).

44 M. Rolfo, *Estudio del género Prosopis en el Uruguay*, Montevideo, 1970.

45 C.A.M. Lindman, *A vegetacão do Rio Grande do Sul* (*Brasil Austral*), Porto Alegre, 1906; B. Rambo, *A fisionomia do Río Grande do Sul. Ensaio de monografia natural*, Porto Alegre, 1956.

46 See note 11, Behling *et al.*, 2005.

47 Extension of forest patches borders generally occurs when the fire-setting frequency is superior to two years. For Rio Grande do Sul, see (note 4) (Müller); for Uruguay, see (note 3).

48 The few areas of forest loss (see Fig. 6) can be explained by the agricultural development of the Uruguay River and Río de la Plata banks at the end of the 19th and the beginning of the 20th century (SW), by rice crop extension on the banks of the Merín lagoon (SE), or by the creation of storage reservoirs (centre and North–West of Uruguay).

became marginal for agricultural and pastoral production and experienced more rapid encroachment. From this perspective, European colonization would have deeply differentiated woody vegetation dynamics.

This work also shows that novel spatial sources still lie in South American archives for those wishing to deepen their understanding of the environmental histories of European colonization. The critique raised against the environmental crisis narratives of the last centuries also opens the door to reinterpretation of known sources. This reinterpretation shows the complexity and non-unilinearity of society-environment relations after the conquest of South America: it is necessary to be cautious about catastrophist interpretations in order to elaborate more accurate analyses of socio–environmental systems.

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