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The pre-Hispanic landscape of the Cerro de Montevideo (Uruguay) in the sixteenth century: first eco-historical study based on biogeography of vegetation and arachnids, historiography and other evidence

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ABSTRACT
The Cerro de Montevideo is a symbolic reference of Uruguay that currently presents an artificialised landscape with environmental deterioration. We used combined techniques including documentary analysis, cartography, remote sensing, biogeographical relict biota, digital recreation and estimated valuation of visual fragility to characterise its pre-Hispanic ecological landscape: a grassy matrix with large patches and corridors of grasslands and woody vegetation, with an estimated intermediate-level visual fragility. The physiognomic changes would have initiated since ca. 1520, much earlier than was formerly proposed (1851), due to supply of firewood from native forests to vessels and livestock introduction by Europeans. Landscape artificialisation by urbanisation and industrialisation was intensified since 1870. Environmental degradation has increased since 1930. For the first time, cryptozoic arachnofauna, visual fragility and digital satellite photographic recreations were included in an historical landscape study. In addition, Dorstenia brasiliensis was found to be the first known identified plant for the Uruguayan flora.

KEYWORDS
Ecological history; landscape; vegetation; arachnofauna; document; Montevideo; pre-Hispanic

1. Introduction

Landscapes are historical syntheses between natural and cultural elements resulting from interactions among abiotic, human and other biotic factors acting on the environment, and vary from fully natural states to totally cultural ones (Bengtsson et al., 2003; Buxó, 2006; Evia & Gudynas, 2000; Ode, Tveit, & Fry, 2008; Papadimitriou, 2010; Robredo & Arballo, 2011). To understand the landscape evolution of a given site, an historical analysis combining multiple types of evidence and using diverse techniques enables elucidation of its past complexity and identification of emergent qualities and the factors which have generated them (Bengtsson et al., 2003; Buxó, 2006; Ode et al., 2008). Detailed digital photograph-quality reconstructions of past states of a landscape contribute to a better understanding of its ecological trajectory to the present. The aim of this research to conduct a case study based on this approach applied to a hill considered as a historic reference of Uruguay and Latin America: the Cerro de Montevideo (CM; Figure 1). The CM was named by Magallanes in 1520 (Monte Vidi) and gives the...
name to the neighbouring capital of the country, Montevideo city, which was the last great foundation of the Spanish Empire in 1726, being disputed by Spain, Portugal and England during the eighteenth and nineteenth centuries (Barros-Lémez, 1992). The CM has been always a heraldic and numismatic reference in official shields and coins of Uruguay from the Hispanic period to the present (Figure 1(a)–(f)).

The first Uruguayan scientific document also refers to the height measurement of this hill (Larrañaga & Pérez Castellanos, 1809, in: Mañé-Garzón, 2005). Its present landscape is a remarkable element of Montevidean identity, involving both personal and social perceptions of its uniqueness, and a sense of belonging to the region (Stobbelaar & Pedroli, 2011). However, its pre-European physiognomy remains almost unknown. There are only a few available studies on the pre-Hispanic landscape of the CM, e.g. Berro (1946) and Gautreau (2006). Accordingly, the aim of this study was the characterisation of the pre-Hispanic landscape status of the CM based on a historical reconstruction of the vegetation (Prieto, Villagra, Lana, & Abraham, 2003).

Figure 1. (a)–(d) The Hispanic colonial coat, both first and current national badges of Uruguay and the coat of Montevideo. (e) and (f) Two Uruguayan official coins. The Cerro de Montevideo appears displayed in the centre or in the upper right corner (g) and (h) the two earliest known photographs of the hill (1870s).
2. Materials and methods

Selected samples of the pre-Hispanic landscape of the CM were digitally synthesised by incorporating the information obtained from a number of different sources including: satellite imagery, historical documentary data, and data of relict fauna and flora.
2.1. Study area

The terrestrial surface of Uruguay is 176 215 km² (latitudinal extent: 30–35° S). The climate is temperate and humid with variable rainfall levels. The country belongs to the Biogeographical Neotropical Region Uruguayense District (Grela, 2004), where meadows occupy 70% of the lands whereas forests—associated with rivers, streams and chains of hills—occupy only 4.2–6% of the territory (Carrere, 1990; Gautreau, 2010; Grela, 2004). The Cerro de Montevideo is a hill (134.82 metres height; 34º53’19.04″S and 56º15’35.35″W) located at the NW coast of the Rio de la Plata in Montevideo Bay, (R.O.U., 1989) (Figure 2). This hill is an isolated outcrop of metamorphic hard rock (amphibolites; geological formation Montevideo, Inferior Precambrian Era; 2000 M.Y. before present) covered with very eroded soils (predominantly brunisols) with rocky outcrops (Cardellino & Ferrando, 1969; R.O.U., 1979). The hill is surrounded by Montevideo city (1 500 000 habitants). The landscape matrix is dominated by the anthropic component. The northern slope is completely urbanised while the southern one displays a very disturbed herbaceous matrix (Chebataroff, 1980) with patches of exotic tree species.

2.2. Image technologies and archaeological assessment of landscape fragility

The evaluation of the fragility of disappeared landscapes and their ecosystems would allow to infer the loss of valuable attributes, the intervening destructive agents and criteria for restoration; likely being equivalent to a comparison between current and ancient photographs of the site (Muñoz-Pedreros, 2004). Subsequent use of image technologies strengthens the analysis of the ecological history of landscapes (Sevenant & Antrop, 2011). They do not differ substantially from the in situ analyses, if techniques are adjusted for each situation maintaining the representative quality, minimising subjectivities and identifying appropriate indicators for qualitative inferences (Dee, 2004; Ode et al., 2008). In this study, we performed a comparative analysis between current photographies of landscapes and their digitally reconstructed pre-Hispanic versions. We also used Geographic Information Systems (IMM) and—as an innovation—satellite orthophotos (Google).

2.3. Historical documentary data on environment

One source of data for the study comprised historical documentary sources such as maps and the written observations of early naturalists. Specifically:

• Available literature on testimonial historical sources of the first order: facsimiles and correspondence (sixteenth and seventeenth centuries).
• Historiographical sources and reports of early naturalists (seventeenth, eighteenth and nineteenth centuries) and contemporary references (twentieth and twenty-first centuries).
• The first cartographies of Montevideo Bay (eighteenth century; Travieso, 1937) and the topographic map scale 1:25 000, K29-d (R.O.U., 1989).

2.4. Comparative biogeography and detection of relict biota

Another type of resource included the historical reconstruction of vegetation of the site by combining recognition of relict species in the study area (analysis in situ) and revision of available academic literature on this topic. Relict biotas can have a high indicative value about historical environmental disturbance or stability of a given site (Hayashida, 2005; Sheail, 1980). Considering the resilience of cryptozoic arachnids to anthropic impact (Ghione et al., 2007; Pérez-Miles et al., 1999), taxonomic and distributional data of these arthropods on the southern slope of the CM were included. Comparisons of taxonomic composition, spatial distribution and diversity of arachnids between the CM (with severe anthropogenic disturbance) and the less disturbed Sierra de las Animas, Maldonado (Costa, Pérez-Miles,
Gudynas, Prandi, & Capocasale, 1991) as well as between its vegetation physiognomy with other hills located at the South of Uruguay (Figure 2(c)) were conducted.

2.5. Imagery design

Digital image processors (Adobe Photoshop CS, Adobe Illustrator and Corel Photopaint 11) were used to perform re-synthesised photographic approaches to disappeared pre-Hispanic landscape states of this site in light of the information obtained by the techniques previously mentioned. In order to maintain consistence between resulting images and information, digital drawings were made directly from real photographs of current landscapes of the CM following the pattern of vegetation physiognomy of Uruguayan hills (Carrere, 1990).

Visual attributes of Sierra de las Animas, e.g. colours, textures and constrasts, were carefully used to enable refinement in realistic recreations and enabling identification of possible indicators for estimating visual pre-Hispanic landscape fragility of the study area (Muñoz-Pedreros, 2004; Ode et al., 2008).

3. Results

3.1. Early descriptions

In 1501, the Cerro de Montevideo would be nominated as Pinachullo Detentio by Américo Vespucio, and also doubtfully indicated by Juan Díaz de Solis in 1516, as a determined hill … crowned by a group of old trees, whereas Fernando de Magallanes (1520) wrote: there is a mountain like a hat, which we nominated as Monte-Vidi (Arredondo, 1958; Azara, 1847; Barros-Lémez, 1992; Berro, 1946; Madero, 1902; Vespucio, 1986). In 1531, López de Sousa (Arredondo, 1958; Trías & de Sousa, 1958) gave important information: when the wind blows strong from the South East, I entered in a port located at the West of San Pedro hill, this hill has a port on the East and other on the West; here I landed and I went into land; I killed several ostriches and deer and I climbed together with all the people to San Pedro hill, from where we saw meadows up to where the eyesight could reach, as flat as the palm, and many rivers with trees along them. It is difficult to describe the beauty of this land. There is plenty of deer, gazelles, ostriches, and other animals of the size and aspect of newborn horses, the field is plenty of these game animals, I never saw so many sheep and goats in Portugal.

“San Pedro hill” was a former Portuguese name of the CM. In 1602, Díaz de Guzmán (in: Arredondo 1958; in: Mañé Garzón, 2000) refers to the Montevideo Bay as lands … of bread and grass for the cattle, plenty of animal games as deer, quails and ostriches.

3.2. Descriptions after human alterations

After introduction of cattle (end of seventeenth century), Fuillée (1708, in: Duprey, 1952; in: Mañé-Garzón, 2000) stated:

We saw from the top of the hill all the Southern portion, that ended in the river waters, confounded with the sky at the edge of the horizon. From the North, it was a wide plain enamelled of flowers of different colours which made a wonderful mixture. This plain was fused in the skyline … their habitants are countless oxen, cows and mules.

and also told:

The contra-hierba ordinarily growths in stony or sandy places and I only saw it in the slopes of the small hill of Montevideo, along my trip to the Western Islands. … During the morning we visited a small island, where they had found a lot of bird nests hiding among grasses as high as the waist ….

Mawe (1805; in: Mañé Garzón, 2005) wrote:

Near Montevideo, you can find deer and ostrich herds; the eagle is often seen as well as the tiger. After Artigas troops herded the cattle from the opposite hill, two tigers swam through the bay, entered in the town during the night and killed two or three inhabitants, possibly because they were hungry and looking for food…. In several parts of the hill you can observe clay beds, from which much water flows.
Saint Hilaire (1821, in: Mañé-Garzón, 2005) described:

The vegetation of the Cerro de Montevideo is almost artificial and is composed mainly by Echium, Miagriuna and Silene. This fact confirms what I said, regarding that these plants followed the steps of the Europeans, with which they have been introduced in the country.

In 1826, D’Orbigny (in: Mañé-Garzón, 2005) described the CM as a hill of monotonous flatlands. Coreal (1708, in: De Pena, 1892) was unable to find firewood in this site, evidencing the absence of arboreal vegetation on the hill. However, maps of 1719, 1781 and 1789 (Travieso, 1937), and a painting by William Gregory (1799) show presumed relict corridors of woody formations on its slopes (Figures 3 and 4).

The destruction of the Montevidean forest was mentioned by José M. Pérez Castellano in 1813 (Pérez Castellano, 1968): Fifty years (ago) it seemed impossible that it would be finished in centuries …
Figure 4. (a) A map of 1781 of the Bay of Montevideo and a detailed view (right) of the Cerro de Montevideo with presumed corridors of woody vegetation. (b) A map of 1789 of the same area with a detailed view (right) showing rocky slopes with presumed patches of dense vegetation. The island ‘Isla de la Libertad’ is visible in the west of the Bay, closely to the hill. (c) A painting of William Gregory (1799) picturing apparent woody vegetation corridors on the hill (inner circle: a detailed view).
their destruction is so fast that the city will soon run out of wood for consumption. Further environmental
degradation was reported by Diego de Alvear (1874):

Who knew Montevideo … thirty or forty years ago … saw, as we said, high dunes covered by reeds, well above to
the level of the beach: in the place now the reeds are destroyed by trampling, and most sand has been removed
by the wind and extracted for constructions in the town; the dunes had been reduced in such degree that they
are now at about the same level of the beach.

Many testimonies endorse the presence of marshes with shrubs of *Cortaderia selloana* (Schult. & Schult.f.)
Asch. & Graebbn, associated with jaguars *Panthera onca* L. at the west of the CM (Figures 7, 9, and 10)
in 1813, 1829 and 1831 De María (2006).

### 3.3. Relictual flora

Relict woody individuals of *Celtis ehrenbergiana* (Klotzch) Liebm., *Myrsine laetevirens* Arechav., *Daphnopsis
racemosa* Griseb., *Ephedra tweediana* C.A. Mey., *Colletia paradoxa* (Spreng.) Escal., *Mimosa* sp., have been
found in the CM until relatively recent times (Berro, 1946; Chebataroff, 1980; Figure 5; Table 1). Other
woody species occur in the present near the CM (5–15 Km West): *Vachellia caven* (Molina) Seigler &
longifolius* Speg., *Dodonaea viscosa* Mart. and *Scutia buxifolia* Reissek (Bernardi, 2007). Predominantly
heliophyte herbaceous native species currently occur in the rocky slopes of this site (Table 1), e.g. *Pavonia
cymbalaria* St.Hil., *Dorstenia brasiliensis* Lam. (the ‘contra-hierba’ mentioned by Feuillée in 1708), the orchids
*Bipinnula* sp. and *Chloraea* sp. Chebataroff (1980), the fern *Selaginella sellowii* Hieron. and the
Table 1. List of past and present botanical indicator biota.

<table>
<thead>
<tr>
<th>Species</th>
<th>Taxonomic Classification</th>
<th>Main habitat Vegetational type</th>
<th>Source (AIS: analysis in situ)</th>
<th>Reported location related (0–15 km) to the study area (CM: Cerro de Montevideo; NA: neighbouring area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schoenoplectus</td>
<td></td>
<td></td>
<td>AIS</td>
<td></td>
</tr>
<tr>
<td>californicus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spartina ciliata</td>
<td></td>
<td>Saline, flooding, clay or sandy coastal soils. Herbaceous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorea sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Parodia concinna</td>
<td></td>
<td>Heliophyte. Rocky slopes. Herbaceous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parodia mammulosa</td>
<td></td>
<td>Heliophyte. Rocky slopes. Herbaceous</td>
<td></td>
<td></td>
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<tr>
<td>Opuntia aurantiaca</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Parodia selloii</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pavonia cymbalaria</td>
<td>Malvaceae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dorstenia brasiliensis</td>
<td>Moraceae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selaginella sellowii</td>
<td>Selaginellaceae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celtis ehrenbergiana</td>
<td>Cannabaceae</td>
<td>Hilly, coastal and riparian forests. Woody arboreal</td>
<td>Berro (1946) Bulterro (1990)</td>
<td></td>
</tr>
<tr>
<td>Myrsine laetevirens</td>
<td>Myrsinaceae</td>
<td>Hilly, coastal and riparian forests. Woody arboreal</td>
<td>Berro (1946)</td>
<td></td>
</tr>
<tr>
<td>Daphnopsy racemosa</td>
<td>Thymelaeaceae</td>
<td>Hilly, coastal and riparian forests. Woody shrubby</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ephedra tweediana</td>
<td>Ephedraceae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coelletia paradoxa</td>
<td>Rhamnaceae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scutia buxifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schinus longifolius</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dodonaea viscosa</td>
<td>Sapindaceae</td>
<td>Hilly, coastal and riparian forests. Woody shrubby</td>
<td>Chebataroff (1980)</td>
<td></td>
</tr>
<tr>
<td>Mimosa sp.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
3.4. Relictual fauna: cryptozoic arachnids and land snails

Pérez-Miles et al. (1999) observed a similar familiar richness in cryptozoic spiders between the Cerro de Montevideo and a small hill with low anthropic modification near Sierra de las Animas described by Costa et al. (1991): 23 and 26 families, respectively. Toscano-Gadea (2002) found that the 32% of collected scorpions in CM were *Bothriurus buecherli* San Martín (Bothriuridae) (Table 2). In addition, the Gastropod *Habroconus paraguayanus* Pfeiffer was found in the vicinity of the hill (Scarabino, 2003; Lista sistemática de los Gastropoda terrestres vivientes de Uruguay, Comunicaciones de la Sociedad Malacológica del Uruguay 8; 78–79, pp. 203–214).

### Table 2. List of past and present zoological indicator biota.

<table>
<thead>
<tr>
<th>Species</th>
<th>Taxonomic classification</th>
<th>Main habitat</th>
<th>Source (AS: analysis in situ)</th>
<th>Reported location related (0–15 km) to the study area (CM: Cerro de Montevideo; NA: neighbouring area)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ozotoceros bezoarticus</em></td>
<td>Mammalia: Cervidae</td>
<td>&quot;Pampean&quot; meadows</td>
<td>López de Sousa (1531; in: Arredondo, 1958; Trías &amp; de Sousa, 1958)</td>
<td>NA</td>
</tr>
<tr>
<td><em>Panthera onca</em></td>
<td>Mammalia: Felidae</td>
<td>Forests and dense vegetation areas near to water currents</td>
<td>(De María, 2006)</td>
<td>NA</td>
</tr>
<tr>
<td><em>Nothura maculosa</em></td>
<td>Aves: Tinamidae</td>
<td>Meadows</td>
<td>López de Sousa (1531; in: Arredondo, 1958; Trías &amp; de Sousa, 1958)</td>
<td>NA</td>
</tr>
<tr>
<td><em>Bothriurus buecherli</em></td>
<td>Scorpiones: Bothriuridae</td>
<td>Cryptozoic refuges on hills with native and compact forest</td>
<td>San Martín (1963)</td>
<td>CM</td>
</tr>
<tr>
<td><em>Habroconus paraguayanus</em></td>
<td>Mollusca: Gastropoda, Euconulidae</td>
<td>Native forest and nearby zones</td>
<td>Toscano-Gadea (2002)</td>
<td>NA</td>
</tr>
</tbody>
</table>

3.5. Analysis of images

The deep urban impact displayed in Figure 6(a)—orthophoto—contrasts sharply with its pre-Hispanic recreation in which it can be seen a meadow matrix with patches and corridors of marshes and woody vegetation. Sandy and rocky coasts, water courses and the Río de la Plata are also visible. Such a 'satellite' landscape recreation enabled preliminary estimates of woody vegetation coverage (c.a. 30–40%) of the hill. These patches and corridors of hilly forest would be located at protected concavities at the basis of the slopes, along water currents. They performed as contrasting elements with the meadow...
matrix, contributing strongly to the inferred intermediate level of fragility of this landscape (Figures 6–8, Table 3). Large patches of marshes of Cortaderia and reeds were also occurring in nearby riparian and coastal areas (Figure 6). All these vegetational formations together with the occurrence of mesofauna elements (Ozotoceros, Rhea) performed as attributes of perceptual heterogeneity and diversity (Figures 6 and 7) observable from ‘satellite’ views (Figure 6(b)) and from the Bay of Montevideo (East) or from the Rio de la Plata (South; Figure 8). The remarkable seasonal whitish flowering of Cortaderia marshes (Robredo & Arballo, 2011) of pre-Hispanic neighbouring of the CM (Figure 7) presumably conferred a memorable phenologic visual impression which decreased in the following centuries due to human impact although several communities of Cortaderia survived until the present.

Digital recreations of the physiognomy of the CM during the founding period of the City of Montevideo based on maps and paintings of the eighteenth century (Figures 3, 4 and 8(c)) show scarce corridors of woody vegetation indicating the scale of loss of landscape’s heterogeneity and diversity elements. The predominance of meadows has increased since the seventeenth century (Figures 6–8) displaying a long historical continuity in the scenic perception of the CM (Figures 1(g)–(h) and 8) at least since 1708, taking the observer to the foundation of Montevideo in 1726.

Figure 6. A current satellite image of the study area (a) and its pre-Hispanic simulation (b). Scale bar = 250m.
A presumed wooden cross located in the hilltop in 1719 would be barely visible in the distance (Figures 3(d) and 8(c)). Fortress General Artigas—currently surrounded with herbaceous vegetation modified with exotic species and artificially planted native trees—is an iconic element added in 1811.
to the hilltop conferring a current scenic prevalence sharply contrasting with the simulated pre-Hispanic hilltop presumably covered with a rocky meadow of *Nassella*, scattered shrubs of, e.g. *Colletia* and *Daphnopsis*, and diverse Cactaceae (Figure 10(b)). Other areas also evidence a pre-Hispanic natural physiognomy deeply contrasting with the current anthropised one, e.g. a watercourse named as ‘Cañada del Tala’ (Western CM) displays severe urban impact whereas its digitally inferred pre-Hispanic landscape (Figures 9(a) and (b)) shows riparian forest, marshes of *Schoenoplectus* and *Cortaderia* and a specimen of *Panthera onca*. In addition, a sandy coast located at the southern part of the hill currently displays anthropic modifications, e.g. foreign flora, and the city of Montevideo in the background. Instead, its inferred pre-Hispanic recreation shows predominant dune vegetation with coastal populations of *Cortaderia* and *Dodonaea* (Figures 9(c) and (d)).

Digital reconstructions of the landscapes of the CM from the late nineteenth century—based on Figure 1 (g) and (h)—to the present show a gradual decline in the herbaceous matrix area due to the advance of urbanisation and exotic tree crops, which today dominate many landscapes of the CM (Figures 6–8 and 10). The current presence of low shrubby vegetation at the southern slope and the
irregular urbanisation at the northern slope evidence a low sense of care and order as an acquired visual character (Figures 6–8). The wide panoramic perception including the CM and Bahía de Montevideo performs as a highly conserved attribute, and has been memorably impressing most observers since the 1500s to the present (Barros-Lémez, 1992; Mañé-Garzón, 1996; Vespucio, 1986). However, we infer a higher visibility of the CM in the sixteenth century with respect to the present (Figures 7, 8 and 10(a)) due to the increase of visual obstacles, e.g., buildings and exotic tree crops. Accordingly, a panoramic view from the southern slope of the hill (Figure 10(a)) reveals anthropic incidence: modified hillside flora, artificially extended coast lines and the city of Montevideo in the background. Instead, its digital-simulated pre-Hispanic version displays an herbaceous matrix of *Nassella* with patches of native forest, and a higher observational deepness.

4. Discussion

The ecological impact after European colonisation in the temperate regions of America was more severe in zones with nomadic cultures than in sedentary ones (Torrejón & Cisternas, 2002). The pre-Columbian Uruguayan population was 5000–6000 nomad hunters–collectors, inhabitants who produced low environmental impact (Carrere, 1990).

The earliest visitors to the CM report a clear abundance of the currently threatened Pampa deer (*Ozotocerus bezoarticus* L.), rheas (*Rhea americana* L.) and patridges (*Nothura maculosa* Temminck and
Rhynchotus rufescens Temminck (Table 2), evidencing a meadow matrix (González & Martínez-Lanfranco, 2010; Olmos, 2011; Piñeiro et al., 2004). They also suggested the occurrence of several corridors of riparian forest (De Sousa: many rivers with trees along them) presumably inhabited by capybaras (Hydrochoerus hydrochaeris L.) (De Sousa: newborn horses). Experimental evidence arising from the geographic regional context (Río de la Plata) of the CM (Cayssials, 2010; Loydi & Distel, 2010; Piñeiro et al., 2004) suggests that incidence of introduced cattle grazing on the herbaceous communities in the study area would have increased the richness of the species, consistent with the intermediate disturbance hypothesis, suggesting a possible explanation for the colourful diversity of flowers observed by Feuillée (1708, in: Duprey, 1952; in: Mañé-Garzón, 2000). This visitor had also referred to the vegetation of the small island ‘Isla de la Libertad’, located in Montevideo Bay close to the CM. These descriptions refer to the antique extension in Montevideo of coastal herbaceous halophyte and psammophyte vegetation of 1–2 m high (Fagúndez & Lezama, 2005, Figures 6–9), which in the present still remains in coastal surroundings of the CM and the Isla de la Libertad. It is also present now along the Uruguayan coast, in association with saline, flooding, clay or sandy soils, in beaches, water current mouths where reeds such as

Figure 10. (a) A panoramic view from the southern slope of the hill. (b) A digital simulation of the site during 1500s. (c) The rocky hilltop. (d) Its simulated pre-Hispanic appearance.
*Juncus acutus* (L.) Torr. Ex Retz., *Spartina ciliata* Brongn. and *Schoenoplectus californicus* (C.A. Mey) Steud. predominate (Table 1) (Alonso & Bassagoda, 1999, 2002; Cabrera, 1968; Fagúndez & Lezama, 2005). The so-called ‘tiger’, actually the jaguar, has been extinct in Uruguay since 1904 and inhabits forests and dense vegetation areas near water courses (González & Martínez Lanfranco (2010); Prigioni et al., 2003). The marshes of *Cortaderia* are now located in large relictual patches in the environment of the CM, which used to be much extended in the past (Del Puerto, 1969; Figure 7).

All relict woody species reported for the CM (Table 1) have widespread distribution throughout the country in hilly forests, being independent of dendrofloristic regions (Grela, 2004). In Uruguay, many of these species also integrate the woody coastal sub-xerophyte communities, with a maximum height of 3 m (Alonso & Bassagoda, 1999, 2002, 2003; Cabrera, 1968; Fagúndez & Lezama, 2005). Rather than primary forest relicts, the forest corridors represented in maps and paintings of the late eighteenth century probably could be considered as successional stages of woody vegetation along the springs that flowed down the slopes of the hill. Significantly, either native (*Eupatorium*) or foreign shrubs, currently observed in the present at the hill’s southern slope, suggest its ability to support native woody vegetation in the past.

The vegetation architecture of hilly zones of Uruguay presents a consistently structurally homogeneous pattern (Carrere, 1990; Gautreau & Lezama, 2009; Grela & Brussa, 2003) which does not determine any physiognomic difference. In low slopes, the forest has great development (7–8 m high) due to protecting topography and more water availability. In areas of intermediate altitude of the slopes, the forest occupies humid zones in topographic concavities with springs (Figure 2(d)). The sub-xerophyte scrub shrubs occur towards the top of the hill. These convexities of the slopes and the top are exposed to the winds, have low water availability and have herbaceous vegetation as dominant (Carrere, 1990). Then, it is possible to infer the state of the pre-Hispanic landscape of the CM through comparative analysis with the Sierra de las Animas hills located about 100 km to the east of Montevideo (Figure 2(c)): they show less anthropic impact and similar vegetation structure. On the contrary, coastal hills around Piriápolis city have suffered more anthropic and eolic modifications that have generated the predominance of shrubby vegetation.

A lost meadow graminous matrix with a predominance of *Nassella* was proposed for our study area Chebataroff (1980) and evidenced by experimental data (Piñeiro et al., 2004) (Figure 10). All native species found in convexes zones of the slopes of the CM probably constitute relicts of herbaceous original vegetation, e.g., *Pavonia cymbalaria*, an endemic heliophyte of the hilly zones of Buenos Aires (Argentina) and Uruguay (Torres et al., 2008). Documentary evidence (Feouillée, 1708, in: Duprey, 1952) suggests that another relict—*Dorstenia brasiliensis*—is the first known plant identified for the Uruguayan flora since the pre-Linnean times (Figure 5).

The cryptozoic arachnofauna is capable of resisting severe environmental impacts, e.g., fire and deforestation, with a remarkable ability to persist (Ghione et al., 2007) suggesting that such communities are good indicators of earlier biotas (Ruzicka, 1987). The scorpion *Bothriurus buecherli* predominates in humid topographic concavities of both the CM and Sierra de las Animas (Costa & Pérez-Miles, 1994; Toscano-Gadea, 2002). In pristine hills, these concavities show native forest (Carrere, 1990). San Martín (1963) & San Martín & Gambardella (1967/1975) stressed the extreme selectivity of *B. buecherli* on habitat, inhabiting exclusively cryptozoic refuges on hills with native and compact forest. Costa and Pérez-Miles (1994) found that this species can also occupy open slopes without trees but predominates in woody environments, being almost absent in meadows. Several species of scorpions are diggers and their habitat preference is related to soil granulometry and humidity. These factors are associated to different climatic and floristic conditions (Polis, 1990; Prendini, 2001). Scorpions have poor dispersal mechanisms and constitute good subjects for historical, biogeographical and ecological studies (Lourenço 1986, 1991, 1994a, 1994b, Polis, 1990; Peretti 1997, 2001, Prendini, 2001). Acosta (1993) yielded the dispersal characteristics of scorpions to explain the distribution of the *B. prospicuus* species group, which involves several species from Argentina and Uruguay, including *B. buecherli*. The extreme habitat selectivity of *B. buecherli*, the relative isolation of the CM regarding other hills (more than 60 km apart) and the poor dispersal abilities suggest the relict condition of this species (Toscano-Gadea, 2002).
Relict land snails are well known to reflect environmental changes of the past (Hayashida, 2005). The Gastropod Habroconus paraguayanus, found in the surroundings of the CM, currently inhabits native forests and nearby zones (Scarabino, 2003; Lista sistemática de los Gastropoda terrestres vivientes de Uruguay. Comunicaciones de la Sociedad Malacológica del Uruguay 8; 78–79, pp. 203–214). In summary, both the invertebrate species suggest the presence of pre-Hispanic forest in this hill.

In summary, available evidence shows no apparent environmental disturbance in the CM until the eighteenth century. Introduction of cattle and invasive flora during the seventeenth century, along with the use of the easily accessible trees of the CM as a source of firewood for ships, would have been the most influential impact factors on the former pre-Hispanic landscape of this hill. Woods would have mostly disappeared before 1708 (Carrere, 1990; Duprey, 1952; Gautreau, 2006) though some remaining corridors would have persisted until the nineteenth century (Figure 8(b) and (c)). This historical reconstruction of the vegetation could be used as a basis for historical-floristic landscape reconstructions using phytoliths and palynomorphs (Hayashida, 2005).

The estimated intermediate-level visual fragility of the pre-Hispanic landscape of the CM (Table 3) would evidence its considerable vulnerability to the deep floristic changes that have occurred (Cayssials, 2010; Del Puerto, 1969; Piñeiro et al., 2004). Since the foundation of Montevideo to the present, agriculture, urbanisation and industrialisation have increased the artificialisation of the CM landscape (Gautreau, 2006).

5. Final remarks and conclusions

For the first time, we have demonstrated the applicability of archaeological evaluation of the fragility of disappeared landscapes based on computer simulations of photos and—as an original innovation—orthophotos of past centuries. The use of data from cryptozoic arachnid community constitutes an original approach and novelty for landscapes studies. We conclude that long-standing human alterations of the ancestral landscape of the CM (Figures 6–8) initiated three centuries before previous estimations which dated in 1851 (Fernández-Saldaña & García de Zúñiga, 1939; Gautreau, 2006) and their intervening main influential factors, were identified.

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