Open Journal of Forestry, 2017, 7, 97-120
http://www.scirp.org/journal/ojf
ISSN Online: 2163-0437
ISSN Print: 2163-0429

Palm Forest Landscape in Castillos (Rocha, Uruguay): Contributions to the Design of a Conservation Area

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How to cite this paper: Rivas, M., Filippini, J. M., Cunha, H., Hernández, J., Resnichenko, Y., & Barbieri, R. L. (2017). Palm Forest Landscape in Castillos (Rocha, Uruguay): Contributions to the Design of a Conservation Area. *Open Journal of Forestry, 7,* 97-120.
https://doi.org/10.4236/ojf.2017.72007

Received: December 15, 2016
Accepted: March 17, 2017
Published: March 20, 2017

Abstract

Butia palm forests are considered unique due to their aesthetic value, high biodiversity level and historical, archaeological and cultural value. The lack of regeneration of butia palms caused by cattle overgrazing and natural grasslands replacement by agriculture endangers these palm forests. The aim of this work is to provide information for the proposal of a conservation area in this rural landscape within the framework of sustainable development. This work was developed within the context of a Geographic Information System with thematic information on palm forest density levels, soils, land use aptitude and rural registers. Field surveys were conducted to record the presence of plant species and genetic resources in different vegetation units. The main category of soil cover was natural grasslands, followed by native forests, wetlands and palm forests. Palm forests grow mainly on soil units with poor to rather poor drainage and on arable or non-arable lands under special conditions. We identified 212 farms where the palm forest is found, a high diversity of vegetation units, the presence of 302 native taxa of plants and a significant number of plant genetic resources for various uses. For the designation of a conservation area, we propose 20 priority farms that will ensure that palm forests are well represented regarding ecosystem diversity. We consider the creation of a Protected Landscape, a State Park or a GIAHS to be the best alternatives so as to protect this unique multifunctional landscape.

Keywords

Butia odorata, *In Situ* Conservation, Geographic Information Systems, Plant Genetic Resources

1. Introduction

Butia palms (*Butia odorata* (Barb. Rodr.) Noblick) are without a doubt a plant genetic resource with multiple uses that have shaped a biocultural and multifunctional landscape since pre-historical times (López Mazz & Pintos, 2001; Dabezies, 2011; Rivas & Barbieri, 2015), in the sense proposed by Agnoletti & Rotherham (2015). *Butia odorata* (*butia*) palm forests form a landscape characterized by the presence of butia palms with density levels of between 50 and 600 palms per hectare over natural herbaceous grasslands. These forests are found exclusively in the *Pampa* biome, in the south of Brazil and Uruguay. In the Department of Rocha (Uruguay is subdivided in 19 administrative regions known as *departments*), in the southeast of Uruguay, two large areas of palm forests are found: the palm forests of Castillos and San Luis, which cover an area of almost 70,000 hectares (Rivas, 2005). These palm forests are considered to be unique because of their landscape and biodiversity value, and also due to the associated historical, archaeological and cultural values (PROBIDES, 1995; López Mazz & Pintos, 2001; Geymonat & Rocha, 2009; Rivas & Barbieri, 2015). The Castillos palm forest is located in the middle plains of the *Laguna Negra* (Black Lagoon) basin, an area characterized by high environmental heterogeneity as a result of a topographic gradient from the hills to the lowlands (PROBIDES, 1999). This territory is part of the Biosphere Reserve of *Bañados del Este* (*Eastern Wetlands*) (MAB-UNESCO), with the presence of forests and bushes, natural fields or grasslands with varied physiognomies and a rich botanical composition as well as wetlands and coastal vegetation (PROBIDES, 1999; Pezzani, 2007).

While in Uruguay, the destruction of natural palm forests is forbidden (Law No. 9872 of 1939, as amended by Law No. 15,939 of 1987), this does not ensure their conservation. Most palms of the forest are more than two or three hundred years old, and there are almost no young plants to ensure the forest's survival. The lack of regeneration poses a serious threat to their preservation. These processes take place in lands which are owned exclusively by private owners for agricultural use. In the Castillos palm forest, the main activity is cattle farming on natural grasslands and, more recently, extensive agriculture. Overgrazing is a common practice in which cattle often eats and crushes young butia seedlings, causing their death. On the other hand, agriculture prevents seeds from germinating and seedlings from growing (Rivas, 2005; Rivas, 2013).

The Guidelines for Land Use Planning and Sustainable Development of the Government of Rocha state that "the aim of the development policy is to achieve a virtuous link between conservation and sustainable use of environmental values". In particular, "the conservation of palm forests in a production environment that makes its reproduction viable" is quoted as an expected result, while "promoting conservation actions for palm forests within productive land uses" appears as one of the plan's main actions.

In this sense, the concept of *in situ* conservation (United Nations, 1992, 2002; FAO, 1996, 2012) applies to the butia palm forest landscape. The framework for the establishment of a conservation area and the design of a management plan is that of sustainable use of biodiversity and their associated traditional knowledge (Hawkes et al., 1997; Maxted et al., 1997; Perrino et al., 2006; Iriondo et al., 2008; Rivas et al., 2010; Rajpurohit & Jhang 2015; Rivas & Condón, 2016). On the other hand, the multifunctional approach on landscapes (Cullotta & Maetzke, 2009; Taylor et al., 2010; Reyers et al., 2012; Dale et al., 2013) takes into consideration the advantages of landscape heterogeneity and allows us to meet specific ecological, productive and cultural objectives in order to improve the condition of the land and the quality of life of its inhabitants (Taylor et al., 2010, Brussaard et al., 2010).

The overall objective of this study is to contribute with recommendations for the establishment of a conservation area and the formulation of a management plan that helps to preserve butia forests within the context of a multifunctional rural landscape. The specific objectives are to identify and quantify the various categories of land cover, to survey plant communities, species and plant genetic resources, the characterization of the environmental conditions in which palm forests are found and their distribution within commercial farms. GIS (Geographic Information Systems) and ecogeographic surveys (Guarino, 1995; Magos Brehm et al., 2008; Parra-Quijano et al., 2012; Berlingeri & Crespo, 2012) are seen as appropriate tools so as to develop these objectives.

2. Materials and Methods

2.1. Area under Study

The studied territory was defined based on the distribution of the Castillos palm forest (Rocha, Uruguay) and its area of influence (**Figure 1**). The coordinates of the area are: 33˚53'14.29"S, 53˚59'14.69"W-northwest; 33˚52'38.67"S, 53˚36'25.65"W-northeast; 34˚23'28.65"S, 53˚58'10.05"W-southwest and 34˚22'52.36"S, 53˚35'12.89"W-southeast. It is bounded by the Atlantic Ocean on the south, by the *Laguna Negra (*Black Lagoon) on the east, by the *Laguna de Castillos* (Castillos Lagoon) on the west and by *Sierra de La Blanqueada* on the north.

2.2. Methodology for the Analysis of Thematic Information

A map produced by Zaffaroni et al. (2005) which states the palm density levels of the Castillos palm forest was used as base material. Five different density categories of the palm forest were determined by aerial photographic interpretation and field surveys (**Figure 2**). By using this methodology, an area of 11,611 hectares of palm forest was calculated and distributed according to the different density categories (**Table 1**).

The layers of digital information related to soil units and types, drainage, land aptitude and land cover were obtained from the database of the Department of Natural Resources of the Ministry of Farming, Agriculture and Fisheries of Uruguay (MGAP, 2013).

The classification of soil cover was carried out according to the Land Cover Classification System (LCCS FAO) using Landsat 5 TM 2007/2008 images of the whole country. It contains 45 classes including urban centers, water bodies, sand

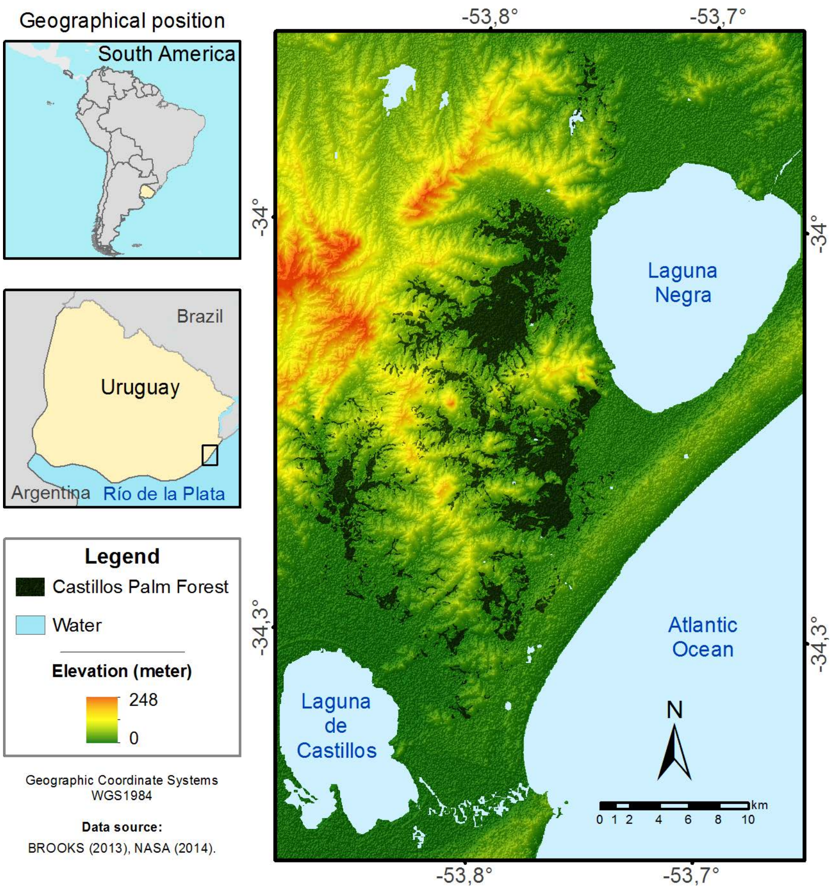

Figure 1. Map of South America, Uruguay and the Department of Rocha (left). Delimitation of the area of the Castillos palm forest (Rocha, Uruguay).

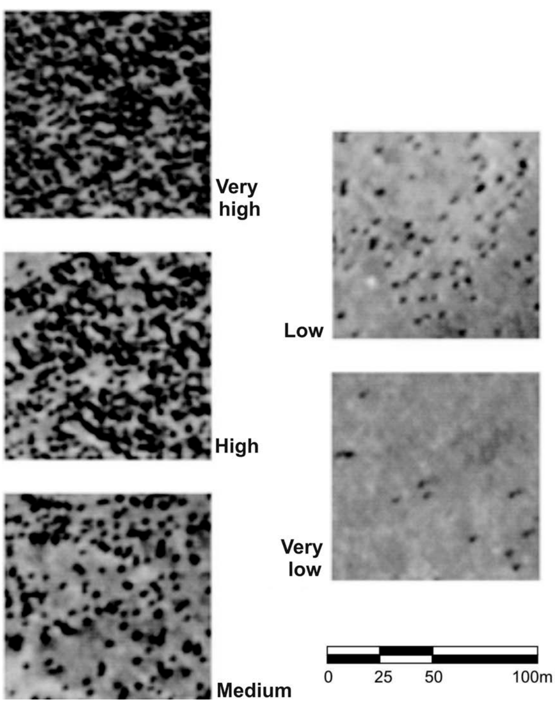

Figure 2. Density categories of the Castillos palm forest (Rocha, Uruguay) by photo-interpretation, according to Zaffaroni et al. (2005).

Table 1. Palm forest density categories and their respective areas in Castillos (Rocha, Uruguay), according to Zaffaroni et al. (2005).

Density category	Area (ha)	Area (%)
Very high (>351 palms/ha)	223.4	1.9%
High (251 - 350 palms/ha)	518.5	4.5%
Medium (151 - 250 palms/ha)	1458.2	12.6%
Low (51 - 150 palms/ha)	3890.1	33.5%
Very low (<50 palms/ha)	5520.2	47.5%
Total	11,611	100%

and rock formations, infrastructure and both cultivated and natural vegetation. These are standard procedures for digital processing in land management (Filippini et al., 2012). These levels of information were included in the GIS environment by cropping the portion corresponding to the area of study.

The "palm forest" class of the land cover layer was replaced by the "palm forest density classes" layer (Zaffaroni et al., 2005). Due to the different scales of the soil cover map (1:1,000,000) and the palm forest density layer (1:20,000), a surplus area was generated which was transformed into the "natural grassland" category. The resulting map included 13 soil cover classes: (1) infrastructure and urban areas, (2) water bodies, (3) wetlands, (4) natural grasslands, (5) rocky outcrops and quarries, (6) native forest, (7) cultivated forest, (8) sand formations, (9) very low density palm forest, (10) low density palm forest, (11) medium density palm forest, (12) high density palm forest; (13) very high density palm forest.

A vector layer of rural lots (basic administrative units in which the rural territory is organized) was overlapped (IDEuy, 2008). The area occupied by each class of land use in each lot was calculated using GIS.

As farms may be made up of one or more lots and this information is not officially digitalized in Uruguay, it was necessary to crosscheck the information on rural lots with registers from owners and tenants who manage cattle per lot from de Ministry of Farming, Agriculture and Fisheries. Registry units registered under the same name were grouped to form the different farms. This procedure allowed us to calculate the total area of each farm and of each land cover class in each farm.

During the springs of 2006 and 2007, seven surveys that lasted from 2 to 3 days were conducted *in situ* with the aim of mapping and geo-referencing vegetation units and other points of interest, using as support the 1:50,000 topographic maps and aerial photos at scale 1:20,000 obtained from the Military Geographic Service. Landscapes and plant communities were described by physiognomy. Samples of plant species of natural grasslands were obtained by using 50-meter transects every 50 centimeters. In the case of forests, wetlands and rocky outcrops, the most conspicuous species were recorded. Herbarium collections were made and photographs were taken for those cases in which it was necessary to make laboratory observations and use keys for correct identification. The correct names of the species were verified according to the Catalog of Vascular Plants of the Southern Cone (2016). 150 sites were sampled and the average size was of about one hectare. Subsequently, using the list of plant species that had been identified, wild plant genetic resources in the landscape of the palm forest were determined by literature review.

3. Results and Discussion

3.1. Soil Cover and Environmental Conditions in Which Palm Forests Are Found

The total area studied was of 197,107.43 hectares, 66,011.64 hectares (33.49%) of which corresponded to water bodies and 883.34 hectares (0.45%) to urban areas and infrastructure. The distribution of the remaining land cover categories identified and their area is presented in **Table 2**.

The overlapping of the layer of palm forest density with those corresponding to soil units and soil types, drainage and land use aptitude, led to the conclusion that most of the palm forest area is found on the San Luis (49.03%) and José Pedro Varela (31.18%) soil units, as identified in the chart of soil identification of Uruguay (MGAP, 1976). These units correspond to Typic Argiaquolls (49.03%) and Typic Argiudolls associated to Pachic Vertic Argiudolls (32.37%), with poor to rather poor drainage. With regard to their use aptitude, they are comprised within the category of arable land under special conditions (57.76%) or non-arable land, suitable for the production of pastures and with strong limitations for forest use (27.01%). The distribution of the different density levels within the palm forest was not associated to soil types or use aptitude.

3.2. Plant Community Diversity, Species and Plant Genetic Resources

In the set of 150 surveyed sites on field trips we recorded a total of 302 plant taxa, distributed in 87 families and 224 genera (**Table 3**). As the identification was made only at the genus level in some cases, the number of taxa is not equiv-

Table 2. Land cover categories and their respective areas in the palm forest territory of Castillos (Rocha, Uruguay).

Land cover category	Area (has)	Area (%)
Sand	3834.03	2.90%
Wetlands	16,431	12.60%
Natural grasslands (*campos*)	66,149.74	50.80%
Rocky outcrops and quarries	724.34	0.60%
Native forests	19,935.27	15.30%
Cultivated forests	11,523.36	8.80%
Palm forest	11,614.72	8.90%
TOTAL	130,212. 46	100%

Table 3. Plant native taxa, priority species for conservation and plant genetic resources surveyed in the palm forest territory of Castillos.

Family	Species	Environment	Priority for conservation	Genetic Resources
Fabaceae	*Acacia bonariensis* Gillies ex Hook. & Arn.	1		M
Asteraceae	*Acanthospermum australe* (Loefl.) Kuntze	4		OR
Myrtaceae	*Acca sellowiana* (O. Berg) Burret	1		F-M-OR
Asteraceae	*Achyrocline alata* (Kunth) DC.	2		M-OR
Asteraceae	*Achyrocline flaccida* (Weinm.) DC.	1.4		M
Asteraceae	*Achyrocline satureioides* (Lam.) DC.	1.4		M-OR
Fabaceae	*Adesmia bicolor* (Poir.) DC.	1		FO
Fabaceae	*Adesmia latifolia* (Spreng.) Vogel	2		FO
Pteridaceae	*Adiantopsis chlorophylla* (Sw.) Fée	1		OR
Pteridaceae	*Adiantum digitatum* Hook.	1		M-OR
Orobanchaceae	*Agalinis communis* (Cham. & Schltdl.) D'Arcy	1		OR
Sapindaceae	*Allophylus edulis* (A. St.-Hil., A. Juss. & Cambess.) Hieron. ex Niederl.	1		F-M-OR-T
Verbenaceae	*Aloysia gratissima* (Gillies & Hook.) Tronc.	1		M-OR
Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griseb.	2		M-T
Asteraceae	*Ambrosia tenuifolia*	3		M-OR
Violaceae	*Anchietea pyrifolia* (Mart.) G. Don	1		M
Poaceae	*Andropogon lateralis* Nees	1		OR
Cyperaceae	*Androtrichum trigynum* (Spreng.) H. Pfeiff.	2		OR
Pteridaceae	*Anogramma* sp.	2		OR
Poaceae	*Aristida* sp.	3		OR
Apocynaceae	*Asclepias mellodora* A. St.-Hil.	1		M
Asteraceae	*Aspilia montevidensis* (Spreng.) Kuntze	1.3		OR
Poaceae	*Axonopus fissifolius* (Raddi) Kuhlm.	3		FO
Salicaceae	*Azara uruguayensis* (Speg.) Sleumer	1		OR
Salviniaceae	*Azolla filiculoides* Lam.	2		OR
Asteraceae	*Baccharis aliena* (Spreng.) Joch. Müll.	1		OR
Asteraceae	*Baccharis articulata* (Lam.) Pers.	3		M-OR
Asteraceae	*Baccharis dracunculifolia* DC.	1		OR
Asteraceae	*Baccharis gnaphalioides* Spreng.	4		OR
Asteraceae	*Baccharis patens* Baker	1		M
Asteraceae	*Baccharis punctulata* DC.	2		OR
Asteraceae	*Baccharis spicata* (Lam.) Baill.	3		OR
Asteraceae	*Baccharis trimera* (Less.) DC.	1.3		M-OR
Asteraceae	*Baccharis vulneraria* Baker	2		M
Plantaginaceae	*Bacopa monnieri* (L.) Pennell	2		OR
Fabaceae	*Bauhinia forficata* Link	1		M-OR
Begoniaceae	*Begonia cucullata* Willd.	1		M-OR

Continued

Berberidaceae	*Berberis laurina* Billb.	1		M-OR
Blechnaceae	*Blechnum brasiliense* Desv.	1		OR
Blechnaceae	*Blechnum* sp.	1		OR
Blechnaceae	*Blechnum tabulare* (Thunb.) Kuhn	2		OR
Myrtaceae	*Blepharocalyx salicifolius* (Kunth) O. Berg	1.2		M-OR-T
Poaceae	*Bothriochloa laguroides* (DC.) Herter *var. laguroides*	3		FO-OR
Bromeliaceae	*Bromelia antiacantha* Bertol.	1		OR
Poaceae	*Bromus catharticus* Vahl	3		FO-OR
Buddlejaceae	*Buddleja thyrsoides* Lam.	1.2		M-OR
Arecaceae	*Butia odorata* (Barb. Rodr.) Noblick	1.2	P	F-M-OR -Fi
Asteraceae	*Calea uniflora* Less.	1		M
Cannaceae	*Canna glauca* L.	1.2		M-OR
Sapindaceae	*Cardiospermum grandiflorum* Sw.	1		M
Cyperaceae	*Carex* spp.	23		OR
Salicaceae	*Casearia sylvestris* Sw.	1		M
Cucurbitaceae	*Cayaponia bonariensis* (Mill.) Mart.Crov.	1		M
Cannabaceae	*Celtis ehrenbergiana* (Klotzsch) Liebm.	1		M-OR-T
Cannabaceae	*Celtis iguanaea* (Jacq.) Sarg.	1		M
Apiaceae	*Centella asiatica* (L.) Urb.	2, 3, 4		M-OR
Rubiaceae	*Cephalanthus glabratus* (Spreng.) K. Schum.	2		M-OR
Cactaceae	*Cereus uruguayanus* R. Kiesling	1		OR
Solanaceae	*Cestrum parqui* L'Hér.	1		M
Asteraceae	*Chaptalia arechavaletae* Hieron. *Chascolytrum poomorphum* (J. Presl) Essi, Longhi-Wagner &	1		OR
Poaceae	Souza-Chies	3		FO
Poaceae	*Chascolytrum subaristatum* (Lam.) Desv.	3		FO-OR
Asteraceae	*Chevreulia sarmentosa* (Pers.) S.F. Blake	1.3		OR
Rubiaceae	*Chiococca alba* (L.) C.L. Hitchc.	1		M-OR
Sapotaceae	*Chrysophyllum gonocarpum* (Mart. & Eichler) Engl.	1		F
Vitaceae	*Cissus palmata* Poir.	1		OR
Vitaceae	*Cissus striata* Ruiz & Pav.	1.2		OR
Verbenaceae	*Citharexylum montevidense* (Spreng.) Moldenke	1		OR-T
Cardiopteridaceae	*Citronella gongonha* (Mart.) R.A. Howard	1		M
Ranunculaceae	Clematis *montevidensis*	1.3		M-OR
Linaceae	*Cliococca selaginoides* (Lam.) C.M. Rogers & Mildner	1		OR
Rhamnaceae	*Colletia paradoxa* (Spreng.) Escal.	1		M-OR
Commelinaceae	*Commelina diffusa* Burm. f. var. diffusa	4		M
Rhamnaceae	*Condalia buxifolia* Reissek	1		M

Continued

Asteraceae	*Conyza bonariensis* (L.) Cronquist	1.3	M-OR
Poaceae	*Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn.	2	M-OR-Fi
Asteraceae	*Criscia stricta* (Spreng.) Katinas	1	OR
Euphorbiaceae	*Croton lanatus* Lam.	1	OR
Euphorbiaceae	*Croton* sp.	1	OR
Lythraceae	*Cuphea fruticosa* Spreng.	2	M
Lythraceae	*Cuphea glutinosa* Cham. & Schltdl.	2	M-OR
Cyperaceae	*Cyperus giganteus* Vahl	1	Fi
Cyperaceae	*Cyperus sesquiflorus* (Torr.) Mattf. & Kük. ex Kük.	1.2	
Cyperaceae	*Cyperus* spp.	3	OR
Poaceae	*Danthonia montevidensis* Hack. & Arechav.	3	FO
Thymelaeaceae	*Daphnopsis racemosa* Griseb.	1.2	OR-Fi
Poaceae	*Deyeuxia alba* J. Presl	3	FO-OR
Poaceae	*Deyeuxia viridiflavescens* (Poir.) Kunth *Deyeuxia viridiflavescens* (Poir.) Kunth *var. montevidensis* (Nees)	2	FO-OR
Poaceae	Cabrera & Rúgolo	3	FO-OR
Convolvulaceae	*Dichondra microcalyx* (Hallier f.) Fabris	1, 2, 3	OR
Convolvulaceae	*Dichondra sericea* Sw.	4	OR
Rhamnaceae	*Discaria americana* Gillies & Hook.	1	M
Sapindaceae	*Dodonaea viscosa* Jacq.	1.4	M-OR
Moraceae	*Dorstenia brasiliensis* Lam.	1.3	M
Pteridaceae	*Doryopteris triphylla* (Lam.) Christ	1	
Droseraceae	*Drosera brevifolia* Pursh	2	OR
Bromeliaceae	*Dyckia remotiflora* Otto & A. Dietr.	1	OR
Alismataceae	*Echinodorus grandiflorus* (Cham. & Schltdl.) Micheli	2	M-OR
Asteraceae	*Eclipta elliptica* DC.	2.3	OR
Asteraceae	*Eclipta prostrata* (L.) L.	4	M
Pontederiaceae	*Eichhornia azurea* (Sw.) Kunth	2	M
Pontederiaceae	*Eichhornia crassipes* (Mart.) Solms	2	M
Ephedraceae	*Ephedra tweediana* Fisch. & C.A. Mey. emend. J.H. Hunz.	1	M-OR
Equisetaceae	*Equisetum giganteum* L.	2.3	M
Poaceae	*Eragrostis neesii* Trin.	1	FO
Poaceae	*Eragrostis retinens* Hack. & Arechav.	3	FO
Asteraceae	*Erechtites valerianifolius* (Link ex Spreng.) Less. ex DC.	4	OR
Poaceae	*Erianthus angustifolius* Nees	2.3	OR
Apiaceae	*Eryngium eburneum* Decne.	1.3	OR
Apiaceae	*Eryngium horridum* Malme	1, 3, 4	OR
Apiaceae	*Eryngium nudicaule* Lam.	3	M-OR
Apiaceae	*Eryngium pandanifolium* Cham. & Schltdl.	2	M-OR-Fi

Continued

Apiaceae	*Eryngium* spp.	3		M
Fabaceae	*Erythrina crista-galli* L.	1		M-OR-T
Myrtaceae	*Eugenia uruguayensis* Cambess.	1.3		OR
Asteraceae	*Eupatorium tweedianum* Hook. & Arn.	1		OR
Euphorbiaceae	*Euphorbia rochaensis* (Croizat) Alonso Paz & Marchesi	2	P	
Euphorbiaceae	*Euphorbia serpens* Kunth	1		M
Convolvulaceae	*Evolvulus sericeus* Sw.	1.3		OR
Moraceae	*Ficus cestrifolia* Schott	1	P	OR
Moraceae	*Ficus luschnathiana* (Miq.) Miq.	1.3		F-M-OR
Rubiaceae	*Galium* sp.	3		OR
Asteraceae	*Gamochaeta americana* (Mill.) Wedd.	3		M
Asteraceae	*Gamochaeta simplicicaulis* (Willd. ex Spreng.) Cabrera	1		M
Asteraceae	*Gamochaeta* sp.	4		M-OR
Verbenaceae	*Glandularia peruviana* (L.) Small	3		OR
Verbenaceae	*Glandularia selloi* (Spreng.) Tronc.	3.4		OR
Rubiaceae	*Guettarda uruguensis* Cham. & Schltdl.	1		OR
Orchidaceae	*Habenaria parviflora*	4		OR
Amaryllidaceae	*Habranthus gracilifolius* Herb.	3		OR
Lythraceae	*Heimia salicifolia* (Kunth) Link	3		M
Boraginaceae	*Heliotropium curassavicum*	2	P	M
Iridaceae	*Herbertia lahue* (Molina) Goldblatt	3		M-OR
Limnocharitaceae	*Hydrocleys nymphoides* (Willd.) Buchenau	2		OR
Apiaceae	*Hydrocotyle bonariensis* Lam.	1, 2, 3		M-OR
Apiaceae	*Hydrocotyle ranunculoides* L. f.	2		M-OR
Hypoxidaceae	*Hypoxis decumbens* L.	1.3		OR
Convolvulaceae	*Ipomoea alba* L.	1		OR
Convolvulaceae	*Ipomoea* sp.	1		M-OR
Poaceae	*Ischaemum minus* J. Presl	2.3		FO-OR
Isoetaceae	*Isoëtes weberi* Herter	2	P	OR
Asteraceae	*Jaegeria hirta* (Lag.) Less.	2.3		M
Malpighiaceae	*Janusia guaranitica* (A. St.-Hil.) A. Juss.	1		OR
Santalaceae	*Jodina rhombifolia* (Hook. & Arn.) Reissek	1		M-OR-T
Juncaceae	*Juncus acutus* L.	2		OR
Juncaceae	*Juncus* sp.	3		OR
Asteraceae	*Jungia floribunda* Less.	1.2		M
Verbenaceae	*Lantana camara* L.	1		M-OR
Verbenaceae	*Lantana megapotamica* (Spreng.) Tronc.	1		M-OR
Poaceae	*Leersia hexandra Sw.*	1.3		FO

Continued

Lemnaceae	*Lemna*	2		OR
Hydrocharitaceae	*Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine	2		M-OR
Anacardiaceae	*Lithraea brasiliensis* Marchand	1		M-OR
Anacardiaceae	*Lithraea molleoides* (Vell.) Engl.	1		M
Asteraceae	*Lucilia acutifolia* (Poir.) Cass.	1		OR
Asteraceae	*Lucilia nitens* Less.	1		OR
Onagraceae	*Ludwigia caparosa* (Cambess.) H. Hara	2		OR
Onagraceae	*Ludwigia peploides* (Kunth) P.H. Raven	2		M-OR
Poaceae	*Luziola peruviana* Juss. ex J.F. Gmel.	2		FO
Thelypteridaceae	*Macrothelypteris torresiana* (Gaudich.) Ching	2		
Apocynaceae	*Mandevilla coccinea* (Hook. & Arn.) Woodson	1		OR
Rosaceae	*Margyricarpus pinnatus* (Lam.) Kuntze	4		M-OR
Celastraceae	*Maytenus ilicifolia* Mart. ex Reissek	1		M-OR
Poaceae	*Melica macra* Nees	3		OR
Poaceae	*Melica sarmentosa* Nees	1		OR
Apocynaceae	*Metastelma difussum*	1		OR
Polypodiaceae	*Microgramma squamulosa* (Kaulf.) de la Sota	1		M
Asteraceae	*Mikania micrantha* Kunth	2.4		M
Poaceae	*Mnesithea selloana* (Hack.) de Koning & Sosef	3		FO
Asteraceae	*Mutisia coccinea* A. St.-Hil.	1		OR
Myrtaceae	*Myrceugenia glaucescens* (Cambess.) D. Legrand & Kausel	1		OR
Haloragaceae	*Myriophyllum aquaticum* (Vell.) Verdc.	2		OR
Myrtaceae	*Myrrhinium atropurpureum* Schott *var. octandrum* Benth.	1		OR-T
Primulaceae	*Myrsine coriacea* (Sw.) R. Br. ex Roem. & Schult.	1		OR
Primulaceae	*Myrsine laetevirens* (Mez) Arechav.	1.2		OR
Primulaceae	*Myrsine parvula* (Mez) Otegui	1		
Primulaceae	*Myrsine umbellata Mart.*	1	P	OR
Poaceae	*Nassella charruana* (Arechav.) Barkworth	3		OR
Poaceae	*Nassella mucronata* (Kunth) Pohl	3		FO
Alliaceae	*Nothoscordum gramineum* (Sims) Beauverd	1		
Asteraceae	*Noticastrum diffusum* (Pers.) Cabrera	1		OR
Menyanthaceae	*Nymphoides indica* (L.) Kuntze	2		M-OR
Onagraceae	*Oenothera affinis*	4		M-OR
Onagraceae	*Oenothera parodiana* Munz	4		OR
Poaceae	*Oplismenus hirtellus* (L.) P. Beauv.	1		OR
Cactaceae	*Opuntia arechavaletae* Speg.	1		OR
Osmundaceae	Osmunda *spectabilis* Willd.	1		OR
Oxalidaceae	*Oxalis* sp.	1		F-M-OR

Continued

Poaceae	*Panicum bergii* Arechav.	3		FO
Poaceae	*Panicum gouinii* E. Fourn.	3		FO
Poaceae	*Panicum prionitis* Nees	2		Fi
Poaceae	*Panicum racemosum* (P. Beauv.) Spreng.	2		OR
Poaceae	*Panicum sabulorum Lam.*	3		FO
Poaceae	*Paspalum denticulatum* Trin.	3		OR
Poaceae	*Paspalum dilatatum* Poir.	3		FO
Poaceae	*Paspalum notatum* Flüggé	3		FO-OR
Poaceae	*Paspalum plicatulum* Michx.	3		FO-OR
Poaceae	*Paspalum pumilum* Nees	1.3		FO-OR
Poaceae	*Paspalum quadrifarium* Lam.	2.3		OR-Fi
Poaceae	*Paspalum urvillei*	3		FO
Poaceae	*Paspalum vaginatum* Sw.	2.4		OR
Passifloraceae	*Passiflora caerulea* L.	1		F-M-OR
Piperaceae	*Peperomia catharinae* Miq.	5		
Solanaceae	*Petunia axillaris* (Lam.) Britton, Stern & Poggenb.	3		OR
Amaranthaceae	*Pfaffia tuberosa* (Spreng.) Hicken	3		OR
Poaceae	*Pharus lappulaceus* Aubl.	1	P	OR
Verbenaceae	*Phyla nodiflora* (L.) Greene *var. minor* (Gillies & Hook. ex Hook.) N. O'Leary & P. Peralta	3		M
Phytolaccaceae	*Phytolacca dioica*	1		M-OR
Asteraceae	*Picrosia longifolia* D. Don	1.3		M
Poaceae	*Piptochaetium montevidense* (Spreng.) Parodi	3		FO-OR
Poaceae	*Piptochaetium stipoides* (Trin. & Rupr.) Hack. ex Arechav.	3		FO
Araceae	*Pistia stratiotes* L.	2		M-OR
Plantaginaceae	*Plantago* sp.	1.3		M-OR
Polypodiaceae	*Pleopeltis lepidopteris* (Langsd. & Fisch.) de la Sota	1		OR
Asteraceae	*Pluchea sagittalis* (Lam.) Cabrera	13		M-OR
Poaceae	*Poa bonariensis* (Lam.) Kunth	3		FO-OR
Asteraceae	*Podocoma notobellidiastrum* (Griseb.) G.L. Nesom	1		M
Polygalaceae	*Polygala linoides* Poir. var. linoides	3		M-OR
Polygonaceae	*Polygonum acuminatum* Kunth	2.4		M
Polygonaceae	*Polygonum punctatum* Elliott	1.2		M-OR
Poaceae	*Polypogon elongatus* Kunth	3		M
Pontederiaceae	*Pontederia cordata* L.	2		M
Asteraceae	*Pseudognaphalium cheiranthifolium* (Lam.) Hilliard & B.L. Burtt	4		M
Myrtaceae	*Psidium cattleianum* Sabine	1	P	F-M-OR
Dennstaedtiaceae	*Pteridium arachnoideum* (Kaulf.) Maxon	1		OR
Asteraceae	*Pterocaulon lorentzii* Malme	1		OR

Continued

Ranunculaceae	*Ranunculus apiifolius* Pers.	2		
Marsileaceae	*Regnellidium diphyllum* Lindm.	2		OR
Amaryllidaceae	*Rhodophiala bifida* (Herb.) Traub	1		OR
Annonaceae	*Rollinia maritima* Záchia	1		
Dryopteridaceae	*Rumohra adiantiformis* (G. Forst.) Ching	1		M-OR
Alismataceae	*Sagittaria montevidensis Cham. & Schltdl.*	2, 4		M-OR
Salicaceae	*Salix humboldtiana* Willd.	1.2		M-OR-T
Lamiaceae	*Salvia guaranitica* A. St.-Hil. ex Benth.	1.2		
Lamiaceae	*Salvia procurrens* Benth.	2		OR
Salviniaceae	*Salvinia* sp.	2		M
Adoxaceae	*Sambucus australis* Cham. & Schltdl.	1		M
Euphorbiaceae	*Sapium glandulosum* (L.) Morong	1, 2, 3		OR
Anacardiaceae	*Schinus engleri* F.A. Barkley	1		OR
Anacardiaceae	*Schinus longifolius* (Lindl.) Speg.	1		M-OR
Poaceae	*Schizachyrium spicatum* (Spreng.) Herter	3		OR
Cyperaceae	*Schoenoplectus americanus* (Pers.) Volkart ex Schinz & R. Keller	2		OR
Cyperaceae	*Schoenoplectus californicus* (C.A. Mey.) Soják	2		M-OR-Fi
Cyperaceae	*Scirpus giganteus* Kunth	2		OR
Lamiaceae	*Scutellaria racemosa* Pers.	2.3		OR
Rhamnaceae	*Scutia buxifolia* Reissek	1.3		M-OR-T
Euphorbiaceae	*Sebastiania brasiliensis* Spreng.	1.2		M
Euphorbiaceae	*Sebastiania commersoniana* (Baill.) L.B. Sm. & Downs	1		M
Asteraceae	*Senecio brasiliensis* (Spreng.) Less.	2.3		OR
Asteraceae	*Senecio crassiflorus* (Poir.) DC.	4		OR
Asteraceae	*Senecio montevidensis* (Spreng.) Baker	1		OR
Asteraceae	*Senecio ostenii* Mattf.	4	P	OR
Asteraceae	*Senecio platensis* Arechav.	4		OR
Asteraceae	*Senecio selloi* (Spreng.) DC.	2.4		OR
Fabaceae	*Senna corymbosa* (Lam.) H.S. Irwin & Barneby	1.2		M-OR
Polypodiaceae	*Serpocaulon catharinae* (Langsd. & Fisch.) A.R. Sm.	1		OR
Fabaceae	*Sesbania punicea* (Cav.) Benth.	2		M-OR
Poaceae	*Setaria parviflora* (Poir.) Kerguélen	1.3		FO-OR
Malvaceae	*Sida rhombifolia* L.	2.3		M-OR
Sapotaceae	*Sideroxylon obtusifolium* (Roem. & Schult.) T.D. Penn.	1	P	M
Gesneriaceae	*Sinningia allagophylla* (Mart.) Wiehler	1		OR
Iridaceae	*Sisyrinchium platense* I.M. Johnst.	3		M-OR
Smilacaceae	*Smilax campestris* Griseb.	1		M
Solanaceae	*Solanum commersonii* Dunal ex Poir. ssp. *commersonii*	3		M-OR

Continued

Solanaceae	*Solanum glaucophyllum* Desf.	2		M-OR
Solanaceae	*Solanum mauritianum* Scop.	2		M-OR
Solanaceae	*Solanum sisymbriifolium* Lam.	3		M-OR
Asteraceae	*Solidago chilensis* Meyen var. *chilensis*	2		M-OR
Asteraceae	*Sommerfeltia spinulosa* (Spreng.) Less.	1	P	OR
Poaceae	*Sporobolus indicus* (L.) R. Br.	1.3		OR
Poaceae	*Steinchisma hians* (Elliott) Nash	3		FO-OR
Poaceae	*Stenotaphrum secundatum* (Walter) Kuntze	3		FO-OR
Asteraceae	*Stevia satureiifolia* (Lam.) Sch. Bip. ex Klotzsch var. *satureiifolia*	1		M-OR
Poaceae	*Stipa papposa* Nees	3		OR
Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	1		OR
Asteraceae	*Symphyotrichum squamatum* (Spreng.) G.L. Nesom	2		OR
Asteraceae	*Tessaria absinthioides* (Hook. & Arn.) DC.	2		OR
Thelypteridaceae	*Thelypteris* sp.	1		OR
Bromeliaceae	*Tillandsia aeranthos* (Loisel.) L.B. Sm.	5		M-OR
Bromeliaceae	*Tillandsia usneoides* (L.) *L.*	5		M
Commelinaceae	*Tradescantia fluminensis* Vell.	2		M-OR
Euphorbiaceae	*Tragia volubilis* L.	3		M
Fabaceae	*Trifolium polymorphum Poir.*	3		FO-OR
Loranthaceae	*Tripodanthus acutifolius* (Ruiz & Pav.) Tiegh.	1, 2		M-OR
Asteraceae	*Trixis praestans* (Vell.) Cabrera	1		OR
Typhaceae	*Typha domingensis* Pers.	2		M-OR-Fi
Typhaceae	*Typha* sp.	1.2		OR
Boraginaceae	*Varronia curassavica* Jacq.	1.2	P	OR
Verbenaceae	*Verbena bonariensis* L.	2		M-OR
Verbenaceae	*Verbena intermedia* Gillies & Hook. ex Hook.	3		M
Verbenaceae	*Verbena montevidensis* Spreng.	1		M
Fabaceae	*Vigna luteola* (Jacq.) Benth.	2		FO-OR
Poaceae	*Vulpia australis* (Nees ex Steud.) C.H. Blom	3		OR
Campanulaceae	*Wahlenbergia linarioides* (Lam.) A. DC.	4		OR
Lemnaceae	*Wolffia brasiliensis* Wedd.	2		OR
Salicaceae	*Xylosma tweediana* (Clos) Eichler	1		OR
Xyridaceae	*Xyris jupicai* Rich.	2		M
Rutaceae	*Zanthoxylum fagara* (L.) Sarg.	1		M-OR-T
Rutaceae	*Zanthoxylum rhoifolium* Lam.	1		M-OR
Rutaceae	*Zanthoxylum sp.*	1		
Amaryllidaceae	*Zephyranthes sp.*	3		OR
Poaceae	*Zizaniopsis bonariensis* (Balansa & Poitr.) Speg.	2		Fi

1: Forests, schrubs and rocky outcrops, F: Food; 2: Wetlands, FO: Fooder; 3: Rangelands, M: Medicinal; 4: Coast, OR: Ornamental; 5: Epiphyte, Fi: Fiber, T: Timber.

alent to the number of species. It must be noted, however, that the goal was not to complete an exhaustive floristic list but to identify the most relevant species which are structuring the landscape.

The two predominant families found are Poaceae (16.6% of the taxa) and Asteraceae (16.9% of the taxa). Such results are consistent with the fact that grasses form, along with asteraceas, the two largest families of Uruguayan and Brazilian natural grasslands (Lezama et al., 2006; Overbeck et al., 2006). The families that come next in number of taxa are Verbenaceae (3.3%), Fabaceae (3%), Apiaceae (2.7%), Euphorbiaceae (2.7%), Cyperaceae (2.7%), Myrtaceae (2%) and Solanaceae (2%). The other identified families are represented by 5 or fewer taxa. Among the 302 taxa, we found 11 species that had been previously identified by Marchesi et al. (2013) as of high priority for conservation in Uruguay based on endemism, rarity and limited distribution criteria, in addition to butia palms, which appear on the list of endangered species due to their lack of regeneration (**Table 3**). In terms of plant genetic resources, species for medicinal (130), ornamental (221), fodder (34), food (8), timber (12) and fiber (10) use were included in the group of 302 taxa (among many other uses). Among plant genetic resources, 106 multipurpose species stand out.

Natural grasslands or "campos" have the highest percentage of occupation in the studied area (**Table 2**), just as it happens throughout the Uruguayan territory. The geographic location of Uruguay in a subtropical–temperate climate transition zone, the geomorphological and soil diversity and the confluence of different floras have originated a wide diversity of "campos" types (Rosengurtt, 1943; Millot et al., 1987; Lezama et al., 2011), this being a typical feature of the *Pampa* biome. The natural grasslands of the palm forests are a particular case due to their botanical composition, which differs from that of the surrounding fields (Rivas et al., 2014). Within this context of species and ecosystem diversity, plant genetic resources have evolved, mainly grasses and legumes used for forage, which coexist in a network with herbaceous species used mainly for medicinal and ornamental purposes.

Wetlands, which occupy nearly 13% of the territory of the palm forest, include both permanently flooded lands and lands which are only flooded at certain times of the year. Among the typical environments, we distinguished marshes with floating and submerged rooted plants, watergrass or *gramales*, which are herbaceous formations consisting mainly of *Luziola peruviana*, a variety of monospecific groupings, including those of *Scirpus giganteus*, *Schoenoplectus californicus*, *Eryngium pandanifolium* and *E. eburneum*, *Typha domingensis*, *Erythrina crista-galli*, *Juncus acutus*, *Salix humboldtiana*, *Cephalanthus glabratus*, *Solanum glaucophyllum*, and panicgrass or *pajonales*, which are dense communities of *Panicum prionitis*, *Erianthus angustifolia* or *Paspalum quadrifarium* (Alonso, 1998; Rivas, 2013). Acid wetlands are yet another particular case found in this landscape (Alonso & Bassagoda, 2006). Among the best known plant genetic resources in wetland environments, we distinguish those that are used in construction, furniture making, basketry and handicrafts.

The proportion of native forests in this landscape is 3 - 4 times higher than the average for Uruguay of around 4% (**Table 2**). Different types of forests and scrublands were identified, which are named according to their topographical location: montane, coastal and riverine (Brussa & Grela 2007). Another very particular community called "*ombu* forest" (*Phytolacca dioica*) is found, being the largest grouping of this species in the country, which stretches along 20 kilometers by the shores of Laguna de Castillos (Castillos Lagoon) (Rodríguez-Gallego, 2006). Among the different plant genetic resources found in the forests, we may highlight those with food, timber, medicinal and ornamental use.

Within this context of ecosystem diversity, coastal communities (Fagúndez & Lezama, 2005) and vegetation accompanying rocky outcrops are also found.

Palm forests (**Figure 3**), as a specific type of forest, are mainly located on the middle plains, creating different landscapes not only due to their varying density levels, but also due to the differences in the accompanying vegetation and their associated anthropic uses (Rivas, 2013). Nowadays, butia palms are mainly used

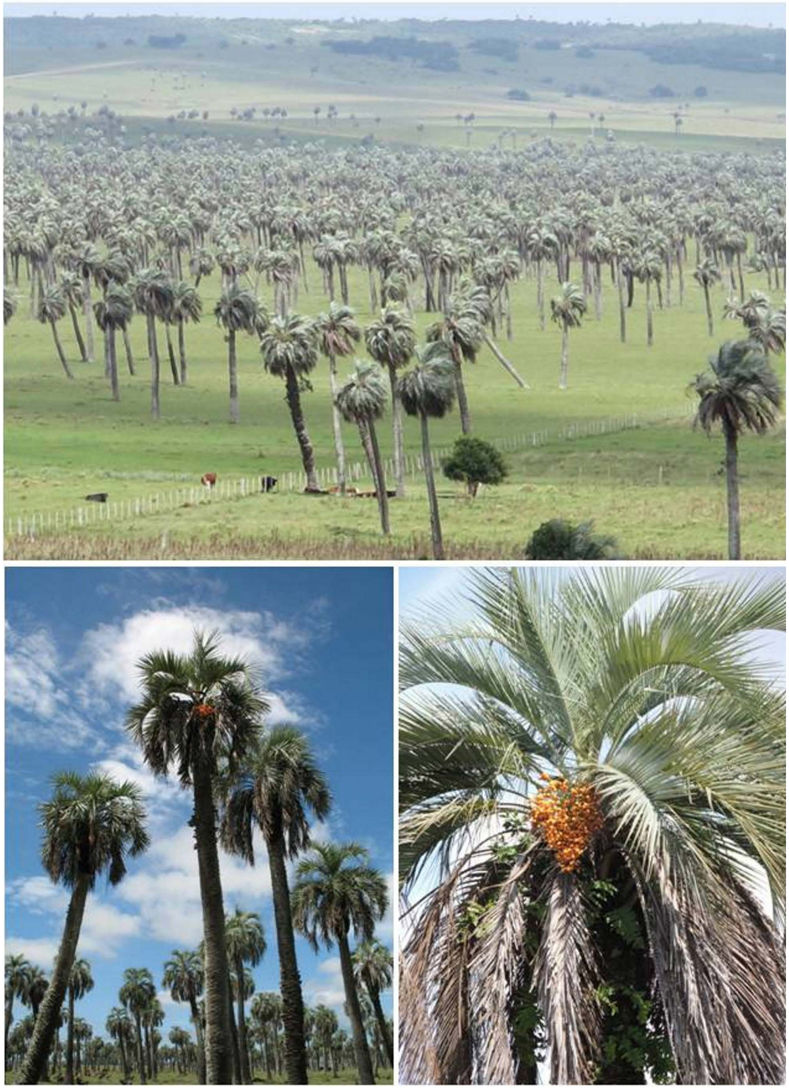

Figure 3. *Butia odorata*: Palm forest, palm and butia.

for food. Also, leaf fibers are used in handicrafts and the whole plant is used in landscaping projects with ornamental purposes. Sifted pulp, fiber and seeds of high nutritional value are obtained from fresh fruit products and used in the production of a wide range of foods such as ice cream, dessert sauce, jam and marmalade, sweet and sour sauce, stuffing for chocolates, cookies and pralines (Crosa et al., 2014), in addition to the typical and traditional butia liqueur.

3.3. Palm Forest Distribution in Agricultural Land

Within the surveyed area there were a total of 2153 lots, which added up to an area of 158,450.8 hectares. This number is different to the total area of the surveyed territory (**Table 2**) as some rural lots are not entirely located within the surveyed area.

There are 700 rural lots where palm forests are found (32.5%), with varying proportions that range from less than 1% to 100% of the total area. Moreover, a relatively low proportion of these lots have a high percentage of palm forest coverage. A total of 117 lots have more than 50% of their area covered by palm forest that could be considered relevant to the conservation plan. However, in order to effectively determine the importance of these lots in the design of the conservation area, it is necessary to link this information to the area which is indeed occupied by each of them as well as to identify the farms and their location within the general context of distribution of the palm forest and its different density levels.

By comparing the information on lots and the database of owners and tenants who manage cattle we were able to sort into farms 77% of the cases (539/700 lots), a relatively satisfactory scenario considering they cover 87% of the area of the Castillos palm forest.

We managed to configure a total of 212 farms where the palm forest is found, 101 of which have all lots covered by palm forest and 111 of which have lots where the palm forest may or may not be found. Farms where palm forest is found have a size that ranges from 5.15 to 3848 hectares and a modal value of 78 hectares. The majority of them, more specifically 86.8%, have less than 500 hectares, a slightly higher proportion than the average for the department of Rocha (78.5%) (DIEA, 2013). These farms are considered units of family agriculture according to Uruguayan law, which states that farmers can not exploit an area of more than 500 hectares with CONEAT 100 (an index related to the average production capacity of the country) and they must live within 50 km of the property, have no more than two employees and that agriculture has to account for their main source of income (MGAP, 2009). The group of farmers with less than 20 hectares (11.3%) is also slightly above the average for the department of Rocha (9.5%).

Out of the 10,094.3 hectares of land covered by palm forest, 9241 hectares are located in farms of more than 100 hectares and 7174.11 hectares in farms of more than 500 hectares (**Figure 4**). The Pearson correlation coefficient between farm size and palm forest area is of 0.70. This result becomes a crucial element

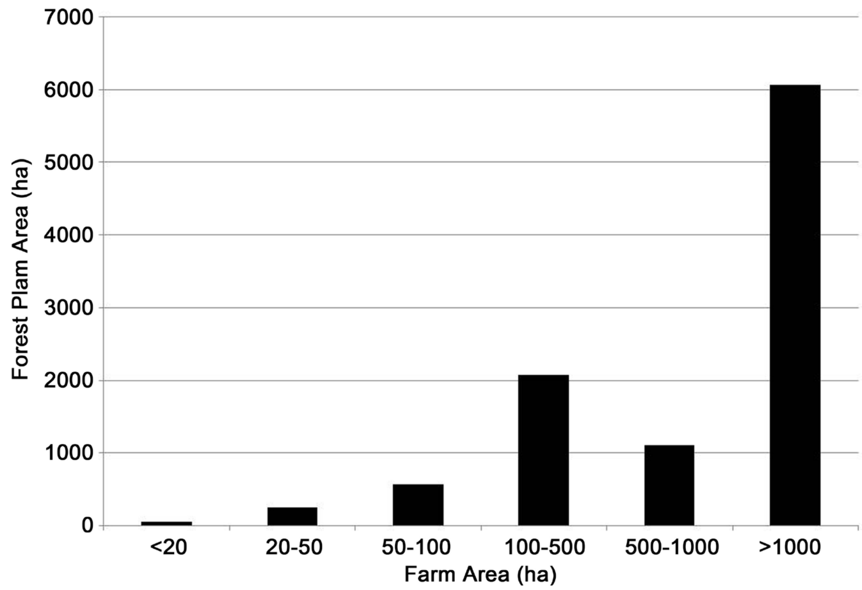

Figure 4. Forest palm area (ha) by size of farms (ha).

for the design of a conservation plan for the palm forest. Larger farms are of higher priority, while in Uruguay policies to support farmers within the framework of environmental conservation and climate change mitigation programs are usually directed at family farmers with smaller farms.

By overlapping layers of farms and palm forest we noticed that 18 farms (**Figure 5**), all of which are characterized by having more than 100 hectares of palm forest, have a total of 6952.40 hectares of palm forest (68.9% of the palm forest is located within farms) and account for 45.5% of the total area of the farms. This situation had not been previously quantified, so it becomes an important element in the planning and formulation of a management plan for palm forest conservation. These 18 producers own substantial areas of palm forest of very low density, while 6 producers own areas of more than 100 hectares of low density. The importance of these low and very low density palm forests is that, under monitored grazing conditions, regeneration can take place (Rivas & Barbieri 2015). In the palm forest area with the highest density, hardly any new butia plants can be found under conditions of exclusion or low stocking rates of grazing, probably due to the creation of an environment with greater humidity and less luminosity. Palm forests of medium density are also well represented by all these farmers.

Areas of palm forest with high and very high density levels occupy, in general terms, a relatively low area (**Table 1**) for this group of 18 properties. However, in a second group of farms where there are between 50 and 100 hectares of palm forest, two farms stand out for having areas of dense and very dense palm forest. By including these two farms as part of the proposed conservation area, palm forests of all density levels are represented. It would also promote the development of ecotourism and the marketing of butia by-products, which are particularly found in this area of high aesthetic value and easy access known as "Vuelta del Palmar".

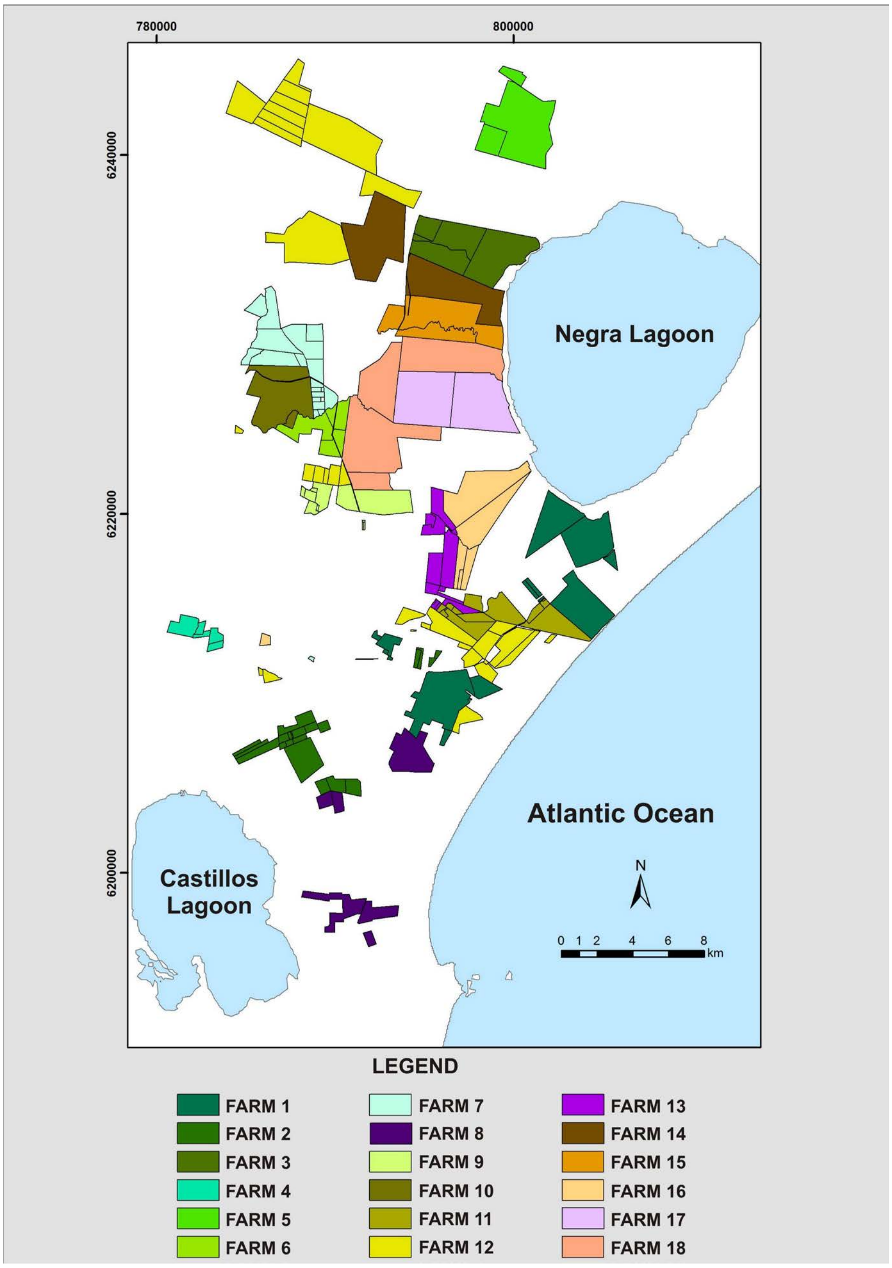

Figure 5. Map showing the location of the 18 priority properties to integrate the conservation area.

Given the need to prioritize some properties, the different density levels of palm forest and/or the strong presence of other plant communities, some factors that would increase the value of conservation proposals are considered. As proposed by Zimmerman & Runckle (2010), conservation priorities should focus on the representation of plant communities within a context of landscape conservation. In that sense, 5 of these farms have large areas of wetlands, yet another landscape at conservation risk due to the drainage works carried out by some farmers. Coastal forests near *Laguna Negra* (Black Lagoon) as well as montane forests add an extra value to the palm forest conservation sites.

A reserve comprising these 20 farmers is considered appropriate, taking into account the heterogeneity of the environments, the quality of the available habitat, a low edge effect and the concept of minimum viable population (Van Dyke, 2008; Hodgson et al., 2011). Although there are no studies that define the need for a certain population size of butia palms, it would be large enough so as to ensure the conservation of the palm forest. The connectivity of the area, which depends on the potential spread of the species and on habitat fragmentation (Luque et al., 2012), can be considered appropriate, although studies on the spread of pollen and seeds of butia palms are scarce (Rodríguez-Mazzini & Molina, 2000). Nor is there information on gene flow or on whether palm forests are a single population or they are structured in more subpopulations. The observed fragmentation is mainly explained by natural environmental conditions such as the presence of hills and wetlands, which are unsuitable environments for butia palms.

4. Conclusion

The main contributions of this work for the establishment of a conservation area within the butia palm forest of Castillos are the set up of a Geographic Information System (GIS) and the survey of plant communities, species and genetic resources. This GIS allowed us to determine the environmental conditions and the distribution of the palm forest and its density levels in each farm. By analyzing this information, we concluded there are 212 farms in which the palm forest is found, the larger ones having greater proportions of palm forest. The presence in the forest palm landscape of a high ecosystemic, specific and genetic richness values the territory for its conservation. Valuable plant resources with current and potential uses stand out among the 302 surveyed taxa as well as 11 species of high conservation priority apart from butia palms.

As this is an agricultural area that belongs to private owners, the focus of any proposal should be based on the coexistence of production practices with management techniques that can be adapted to conservation strategies and the inclusion of farmers and local dwellers in the definition and management of the area (Bridgewater, 2016). In this sense, the focus of Biosphere Reserves (PROBIDES, 1999; Pezzani, 2007; Ozyavuz & Yazgan, 2010), some categories of IUCN protected areas such as Protected Landscapes (IUCN, 2008), the Regional Natural Parks (SNAP, 2010) and the GIAHS (Globally Important Agricultural Heritage Systems) (Koohafkan & Cruz, 2011) are valid options to implement the conservation of Butia palm forests within the framework of integrated biocultural landscape conservation alternatives. Management plans and conservation policies should be framed within a context of sustainable agricultural systems (Dale et al., 2013; Benoit et al., 2012; Baiamonte et al., 2015).

Acknowledgements

We thank the Sectorial Committee for Scientific Research (CSIC-University of the Republic) and the National Agency for Research and Innovation (ANII) of Uruguay for the financing of various projects that made this work possible. We are also grateful to the Federal University of Pelotas (Brazil), Embrapa Temperate Climate (Brazil) and CAPES (Brazilian Agency for the Improvement of Higher Education Personnel) for their valuable cooperation and contribution to the conservation and sustainable use of Butia. We especially thank Martin Jaurena, César Fagúndez, Maria Puppo, Inés Espasandín and Jerónimo Pardiñas for their support in field work, Patricia Mai for her collaboration in the organization of taxonomic information, Federico Condón, Laura del Puerto and Mariana Viladó for their assistance in writing this paper and the farmers and organizations for their cooperation and permission to have access to their lands.

References

Agnoletti, M., & Rotherham, I. D. (2015). Landscape and Biocultural Diversity. *Biodiversity and Conservation, 24,* 3155-3165. https://doi.org/10.1007/s10531-015-1003-8

Alonso, E. (1998). Aquatic Plants in the Eastern Wetlands. Montevideo: PROBIDES.

Alonso, E., & Bassagoda, M. J. (2006). Flora and Vegetation along the Uruguayan Atlantic Coast and the River Plate. In R. Menafra, L. Rodríguez-Gallego, F. Scarabino, & D. Conde (Eds.), *In Guidelines for the Conservation and Management of Uruguayan Coastal Areas* (pp. 71-88). Montevideo: Vida Silvestre Uruguay (Uruguayan Wildlife).

Baiamonte, G., Domina, G., Raimondo, F. M., & Bazan, G. (2015). Agricultural Landscapes and Biodiversity Conservation: A Case Study in Sicily (Italy). *Biodiversity and Conservation, 24,* 3201-3216. https://doi.org/10.1007/s10531-015-0950-4

Benoit, M., Rizzo, D., Marraccini, E., Moonen, A. C., Galli, M., Lardon, S., Rapey, H., Thenail, C., & Bonari, E. (2012). Landscape Agronomy: A New Field for Addressing Agricultural Landscape Dynamics. *Landscape Ecology, 27,* 1385-1394. https://doi.org/10.1007/s10980-012-9802-8

Berlingeri, C., & Crespo, M. B. (2012). Inventory of Related Wild Species of Priority Crops in Venezuela. *Genetic Resources and Crop Evolution, 59,* 655-681. https://doi.org/10.1007/s10722-011-9709-2

Bridgewater, P. (2016). The Anthropocene Biosphere: Do Threatened Species, Red Lists, and Protected Areas Have a Future Role in Nature Conservation? *Biodiversity and Conservation, 25,* 603-607. https://doi.org/10.1007/s10531-016-1062-5

Brussa, C. A., & Grela, I. A. (2007). *Uruguayan Tree Flora, Mainly in Rivera and Tacuarembó*. Montevideo: COFUSA.

Brussaard, L., Caron, P., Campbell, B., Morgan, B., Lipper, L., Mainka, S., Rabbinge, R., Babin, D., & Pulleman, M. (2010). Reconciling Biodiversity Conservation and Food Security: Scientific Challenges for a New Agriculture. *Current Opinion in Environmental Sustainability, 2,* 34-42. https://doi.org/10.1016/j.cosust.2010.03.007

Catalog of Vascular Plants of the Southern Cone (2016). http://www2.darwin.edu.ar/Proyectos/FloraArgentina/fa.htm

Crosa, M. J., Burzaco, P., Irisity, M., Gioscia, D., Sosa, J., & Ayres, C. (2014). Valorization of Butia Fruits and Their Manufacture. In P. Betancurt, & M. J. Crosa (Eds.), *Native Fruit Appreciation as a Way of Promoting Local Development. Food and Agricultural Exploitation of Butia Palms in Rocha* (pp. 25-40). Montevideo: FPTA.

Cullotta, S., & Maetzke, F. (2009). Forest Management Planning at Different Geographic Levels in Italy: Hierarchy, Current Tools and Ongoing Development. *International Forestry Review, 11,* 475-489. https://doi.org/10.1505/ifor.11.4.475

Dabezies, J. M. (2011). Plant Processing, Yesterday and Today: An Approach to Some of the Current Uses of *Butia capitata* Palms in Order to Understand Some of Its Past Uses. *Trama. Revista de Cultura y Patrimonio, 2-3,* 10-21.

Dale, V. H., Kline K. L., Kaffka, S. R., & Langeveld, J. W. A. (2013). A Landscape Perspective on Sustainability of Agricultural Systems. *Landscape Ecology, 28,* 1111-1123. https://doi.org/10.1007/s10980-012-9814-4

Fagúndez, C., & Lezama, F. (2005). *Spatial Distribution of Coastal Vegetation along the River Plate and the Uruguayan Atlantic Coast*. Montevideo: Freplata.

FAO (1996). *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture*. Rome: FAO.

FAO (2012). *Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture*. Rome: FAO.

Filippini Alba, J. M., Schroder, V. F., & Nobrega, M. R. (2012). Land Cover Change Detection in Southern Brazil through Orbital Imagery Classification Methods. In B. Escalante (Ed.), *Remote Sensing: Applications* (pp. 99-116). Rijeka: Intech. https://doi.org/10.5772/36940

Geymonat, G., & Rocha, N. (2009). *Mbotia; A Unique Ecosystem in the World*. Castillos: Casa Ambiental.

Guarino, L. (1995). Mapping the Ecogeographic Distribution of Biodiversity. In L. Guarino, V. Ramanatha Rao, & R. Reid (Eds.), *Collecting Plant Genetic Diversity: Technical Guidelines* (pp. 287-314). Roma: IPGRI.

Hawkes, J. G., Maxted, N., & Zohary, D. (1997). Reserve Design. In N. Maxted, B.V. Ford-Lloyd, & J.G. Hawkes (Eds.), *Plant Genetic Conservation. The in Situ Approach* (pp. 132-143). London: Chapman & Hall.

Hodgson, J. A., Moilanen, A., Wintle, B. A., & Thomas, C. D. (2011). Habitat Area, Quality and Connectivity: Striking the Balance for Efficient Conservation**.** *Journal of Applied Ecology, 48,* 148-152. https://doi.org/10.1111/j.1365-2664.2010.01919.x

IDEuy (2008). *Temporary Data Array (Conjunto de Datos Provisorios-CDP)*. http://descarga-cdp-ide.agesic.gub.uy/

Institute of Agricultural Statistics (DIEA) (2013). *General Agricultural Census 2011*. Preliminary Report, Montevideo: DIEA.

International Union for Conservation of Nature (IUCN) (2008). *Directrices para la aplicación de las categorías de gestión de áreas protegidas*. Gland: IUCN.

Iriondo, J. M., Maxted, N., Dulloo, M. E. (2008). *Conserving Plant Genetic Diversity in Protected Areas. Population Management of Crop Wild Relatives*. London: CAB International. https://doi.org/10.1079/9781845932824.0000

Koohafkan, P., & de la Cruz, M. J. (2011). Conservation and Adaptive Management of Globally Important Agricultural Heritage Systems (GIAHS). *Journal of Resources and Ecology, 2,* 22-28.

Lezama, F., Altesor, A., León, R. J., & Paruelo, J. M. (2006). Vegetation Heterogeneity of Natural Grasslands in the Uruguayan Basaltic Region. *Ecología Austral, 16,* 167-182.

Lezama, F., Altesor, A., Pereira, M., & Paruelo, J. M. (2011). Description of Vegetation Heterogeneity of Natural Grasslands in the Main Geomorphologic Regions of Uruguay. In A. Altesor, W. Ayala, & J. M. Paruelo (Eds.), *Ecological and Technological Guidelines for Pasture Management* (pp. 15-32). Montevideo: FPTA.

López Mazz, J. M., & Pintos, S. (2001). *The Archaeological Landscape of Laguna Negra (Black Lagoon). In Uruguayan Archaeology towards the Turn of the Millennium* (Vol. 1). Montevideo: AVA.

Luque, S., Saura, S., & Fortin, M. J. (2012). Landscape Connectivity Analysis for Conservation: Insights from Combining New Methods with Ecological and Genetic Data. *Landscape Ecology, 27,* 153-157. https://doi.org/10.1007/s10980-011-9700-5

Magos Brehm, J., Maxted, N., Ford-Lloyd, B. V., & Martins-Louçao, M. A. (2008). Natural Inventories of Crop Wild Relatives and Wild Harvested Plants: Case-Study for Portugal. *Genetic Resources and Crop Evolution, 55,* 779-796. https://doi.org/10.1007/s10722-007-9283-9

Marchesi, E., Alonso, E., Delfino, L., García, M., Haretche, F., & Brussa, C. (2013). Vascular Plants. In A. Soutullo, C. Clavijo, & J. A. Martínez-Lanfranco (Eds.), *Priority Conservation Species in Uruguay. Vertebrates, Continental Mollusks and Vascular Plants* (pp. 27-71). Montevideo: SNAP.

Maxted, N., Guarino, L., & Dulloo, M. E. (1997). Management and Monitoring. In N. Maxted, B. V. Ford-Lloyd, & J. G. Hawkes (Eds.), *Plant Genetic Conservation. The in Situ Approach* (pp. 144-159). London: Chapman & Hall. https://doi.org/10.1007/978-94-009-1437-7

Millot, J. C., Methol, R., & Risso, D. (1987). *Survey on Natural Grasslands and Extensive Improvements in Farming Areas in Uruguay.* Montevideo: FUCREA-CHPA.

Ministry of Farming, Agriculture and Fisheries (MGAP) (1976). *Classification Chart of Uruguayan Soils*. Montevideo: MGAP.

Ministry of Farming, Agriculture and Fisheries (MGAP) (2009). *Decree 527/008 of 29/07/09. Defining Family Farmers*. Montevideo: MGAP.

Ministry of Farming, Agriculture and Fisheries (MGAP), & Institute of Natural Resources (2013). http://www.renare.gub.uy

National Network of Protected Areas (SNAP) (2010). *Protected Areas and Natural Regional Parks. An Insight to the Uruguayan Context. Discussion Document. Strengthening the Implementation Process of the National Network of Protected Areas. Project*. Montevideo: SNAP.

Overbeck, G. E., Muller, S. C., Pillar, V. D., & Pfadenhauer, J. (2006). Floristic Composition, Environmental Variation and Species Distribution Patterns in Burned Grassland in Southern Brazil. *Brazilian Journal of Biology, 66,* 1073-1090. https://doi.org/10.1590/S1519-69842006000600015

Ozyavuz, M., & Yazgan, M. E. (2010). Planning of Igneada *Longos* (Flooded) Forests as a Biosphere Reserve. *Journal of Coastal Research, 26,* 1104-1111. https://doi.org/10.2112/JCOASTRES-D-09-00065.1

Parra-Quijano, M., Iriondo, J. M., & Torres, E. (2012). Ecogeographical Land Characterization Maps as a Tool for Assessing Plant Adaptation and Their Implications in Agrobiodiversity Studies. *Genetic Resources and Crop Evolution, 59,* 205-217. https://doi.org/10.1007/s10722-011-9676-7

Perrino, P., Laghetti, G., & Terzi, M. (2006). Modern Concepts for the Sustainable Use of Plant Genetic Resources in the Mediterranean Natural Protected Areas: The Case Study of the Alta Murgia Park (Italy). *Genetic Resources and Crop Evolution, 53,* 695-710. https://doi.org/10.1007/s10722-004-3942-x

Pezzani, F. (2007). *Biosphere Reserve of the Eastern Wetlands, Uruguay.* Work Document No. 37, Montevideo: PROBIDES, South-South Cooperation Plan, UNESCO.

PROBIDES (1995). *Palm Forests, Palms and Butiá. Didactic Index 4*. Montevideo: PROBIDES.

PROBIDES (1999). *Management Plan. Biosphere Reserve of the Eastern Wetlands/Uruguay.* Montevideo: PROBIDES.

Rajpurohit, D., & Jang, T. (2015). *In Situ* and *ex Situ* Conservation of Plant Genetic Resources and Traditional Knowledge. In R. K. Salgotra, & B. B. Gupta (Eds.), *Plant Ge-*

netic Resources and Traditional Knowledge for Food Security (pp. 137-161). Berlin: Springer. https://doi.org/10.1007/978-981-10-0060-7_8

Reyers, B., O'Farrell, P. J., Nel, J. L., & Wilson, K. (2012). Expanding the Conservation Toolbox: Conservation Planning of Multifunctional Landscapes. *Landscape Ecology, 27,* 1121-1134. https://doi.org/10.1007/s10980-012-9761-0

Rivas, M. (2005). Challenges and Alternatives for the *in Situ* Conservation of *Butia capitata* Palm Forests (Mart.) Becc. *Agrociencia, 9,* 161-168.

Rivas, M. (2013). *Conservation and Sustainable Utilization of Butia odorata Palm Forests (Barb. Rodr.) Noblick*. Doctorate Thesis, Pelotas: Pelotas Federal University.

Rivas, M., & Barbieri, R. L. (2015). *Good Practices for the Sustainable Management of Butia Palm Forests*. Brasilia: Embrapa.

Rivas, M., & Condón, F. (2016). Plant Domestication and Utilization: The Case of the Pampa Biome. In J. M. Al-Khayri, S. M. Jain, & D. V. Johnson (Eds.), *Advances in Plant Breeding Strategies: Breeding, Biotechnology and Molecular Tools* (pp. 3-24, Vol. 1). Cham: Springer International Publishing.

Rivas, M., Clausen, A., &, León-Lobos, P. (2010). *In Situ* Conservation of Plant Genetic Resources of Importance for Food and Agriculture. In *Strategies on Plant Genetic Resources for the Southern Cone Countries* (pp. 59-74). Montevideo: IICA-PROCISUR.

Rivas, M., Jaurena, M., Gutiérrez, L., & Barbieri, R. L. (2014). Plant Diversity of Natural *Butia odorata* Grasslands (Barb. Rodr.) Noblick in Uruguay. *Agrociencia, 18,* 14-27.

Rodríguez-Gallego, M. G. (2006). Structure and Regeneration of *Ombú* Forests (*Phytolacca dioica*) in Laguna de Castillos (Castillos Lagoon) (Rocha, Uruguay). In R. Menafra, L. Rodríguez-Gallego, F. Scarabino, & D. Conde (Eds.), *Guidelines for the Conservation and Management of Uruguayan Coastal Areas* (pp. 503-511). Montevideo: Vida Silvestre Uruguay.

Rodríguez-Mazzini, R., & Molina, B. (2000). *The Forest Fox (Cerdocyon thous) as a Palm Seed Spreading Agent*. Work Document No. 30, Rocha: PROBIDES.

Rosengurtt, B. (1943). *Studies on Uruguayan Natural Grasslands: Third Contribution*. Montevideo: Barreiro y Ramos.

Taylor Lovell, S., DeSantis, S., Nathan, C. A., Olson, M. B., Méndez, V. E., Kominami, H. C., Erickson, D. L., Morris, K. S., & Morris, W. B. (2010). Integrating Agroecology and Landscape Multifunctionality in Vermont: An Evolving Framework to Evaluate the Design of Agroecosystems. *Agricultural Systems, 103,* 327-341. https://doi.org/10.1016/j.agsy.2010.03.003

United Nations (1992). *Convention on Biological Diversity*.

United Nations (2002). *The Global Strategy for Plant Conservation*. La Haya: GSPC, CDB.

Van Dyke, F. (2008). The Conservation of Habitat and Landscape. In F. Van Dyke (Ed.), *Conservation Biology. Foundations, Concepts, Applications* (pp. 279-311, 2nd ed.). Berlin/Heidelberg: Springer Science and Business Media. https://doi.org/10.1007/978-1-4020-6891-1_10

Zaffaroni, C., Rivas, M., Resnichenko, Y., & Hernández, J. (2005) A Contribution for the Conservation of Unique Landscapes: *Butia capitata* Palm Forests (Mart.) Becc., in the Department of Rocha, Uruguay. In *10th Annual Report-Conference of Latin American Geographers* (pp. 116611-16622). Sao Paulo: EGAL.

Zimmerman, C. L., & Runkle, J. R. (2010). Using Ecological Land Units for Conservation Planning in a Southwestern Ohio Watershed. *Natural Areas Journal, 30,* 27-38. https://doi.org/10.3375/043.030.0104