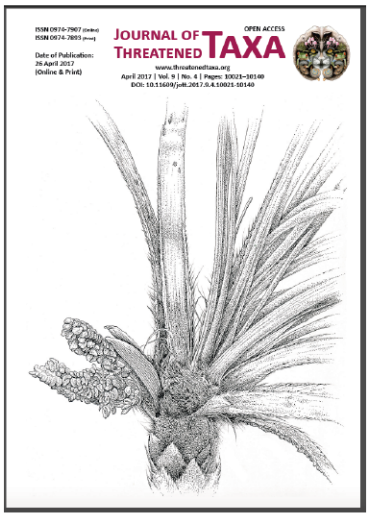

Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

ARTICLE

DISTRIBUTION AND POPULATION STATUS ASSESSMENT OF THE ENDEMIC GRASS-LIKE PALM *BUTIA MARMORII* (ARECALES: ARECACEAE) IN PARAGUAY

Irene Gauto, Fernando Palacios, Pamela Marchi, Nelson Silva & Gloria Céspedes

26 April 2017 | Vol. 9| No. 4 | Pp. 10021–10034
10.11609/jott.3085.9.4.10021-10034

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2017 | 9(4): 10021–10034

Distribution and population status assessment of the endemic grass-like palm *Butia marmorii* (Arecales: Arecaceae) in Paraguay

ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Irene Gauto[1], Fernando Palacios[2], Pamela Marchi[3], Nelson Silva[4] & Gloria Céspedes[5]

[1,3,4,5] Asociación Etnobotánica Paraguaya, Julia Miranda Cueto 795, 2160 San Lorenzo, Paraguay
[2] Asociación Guyra Paraguay, Av. Cnel. Carlos Bóveda, Parque Ecológico Capital Verde - Viñas Cué, Asunción, Paraguay
[1] igauto@gmail.com (corresponding author), [2] fernandolpd@gmail.com, [3] pamepy@gmail.com,
[4] nelsonsr92@gmail.com, [5] gloriacespedes@gmail.com

OPEN ACCESS

Abstract: The palm *Butia marmorii* Noblick was described in 2006 and has been found to date in only two populations in Paraguay. It is a species threatened mainly due to habitat loss and its ecology is largely unknown. Here we performed a potential distribution analysis, providing data about its distribution and ecology. This work was carried out in the Alto Paraná Department, eastern Paraguay, South America. We analyzed satellite images, in conjunction with a multi-temporal analysis using the sensors Landsat 1-MSS,5-TM,8-OLI, of the years 1973, 1984, 2002, 2012 and 2013; and a posterior visual interpretation of an ASTER ASTGTM2 radar image. The final step was an in situ visual verification. We registered 27 potential sites of distribution for *Butia marmorii*, finding it present in four sites, two of them with limited anthropogenic impacts. We found a density of 0.0054 to 0.11 individuals/m^2, and associations with the congener *B. paraguayensis*. These new Paraguayan populations of *Butia marmorii* provide verifiable data demonstrating that anthropogenic impact is the principal threat to the species. Here we found that the situation of *B. marmorii* is even worse than supposed before, and hence we consider the species to be Critically Endangered.

Keywords: *Butia paraguayensis*, Cerrado, conservation, deforestation, ecology, IUCN, Red List.

Spanish abstract: Resumen: La palmera *Butia marmorii* Noblick fue descrita en 2006 y hasta el momento se la encuentra únicamente en dos poblaciones en Paraguay. Es una especie amenazada principalmente debido a la pérdida de hábitat y su ecología es muy desconocida. Aquí realizamos un análisis de distribución potencial, proporcionando datos acerca de su distribución y ecología. Este trabajo se realizó en el Departamento de Alto Paraná, este de Paraguay, Sudamérica. Analizamos aquí, imágenes satelitales en conjunto con un análisis multi-temporal de sensores Landsat 1-MSS,5-TM,8-OLI de los años 1973, 1984, 2002, 2012 y 2013; y una posterior interpretación visual de imágenes de radar ASTER ASTGTM2. El paso final fue la verificación in situ. Registramos 27 sitios de distribución potencial para *Butia marmorii*, encontrándola presente en cuatro sitios, dos de ellos con limitados impactos antropogénicos. Encontramos una densidad de 0.0054 a 0.11 individuos/m^2, y asociaciones con la palmera congénere *B. paraguayensis*. Estas nuevas poblaciones de Paraguay de *Butia marmorii* proven datos verificables demostrando que los impactos antropogénicos son la principal amenaza para la especie. Aquí consideramos que la situación poblacional de *B. marmorii* es peor de lo anteriorment supuesto, y por lo danto la consideramos como una especie en Peligro Crítico.

DOI: http://doi.org/10.11609/jott.3085.9.4.10021-10034

Editor: Larry R. Noblick, Montgomery Botanical Center, Miami, USA. **Date of publication:** 26 April 2017 (online & print)

Manuscript details: Ms # 3085 | Received 03 October 2016 | Final received 12 April 2017 | Finally accepted 14 April 2017

Citation: Gauto, I., F. Palacios, P. Marchi, N. Silva & G. Céspedes (2017). Distribution and population status assessment of the endemic grass-like palm *Butia marmorii* (Arecales: Arecaceae) in Paraguay. *Journal of Threatened Taxa* 9(4): 10021–10034; http://doi.org/10.11609/jott.3085.9.4.10021-10034

Funding: Conservation Leadership Programme - CLP (Project ID: 02150413); Asociación Etnobotánica Paraguaya - AEPY; Guyra Paraguay.

Competing interests: The authors declare no competing interests.

For **Author Details** & **Author Contribution** see end of this article.

Acknowledgements: We thank the Conservation Leadership Programme for the financial support, the guidance and the training that made this project possible. We acknowledge the three institutions that support and facilitated our work: Asociación Etnobotánica Paraguaya, Guyra Paraguay and Itaipu Binacional. We thank Paraguayan authorities, especially the Secretary of the Environment (SEAM) for support and permission to collect plant material. We are grateful to the herbaria FCQ (Facultad de Ciencias Químicas) and to botanists Larry Noblick (Missouri Botanical Center) and Harri Lorenzi (Instituto Plantarum) for help in material identification. We thank IDEA WILD for donating field equipment used in the project. Special thanks go to Pier Cacciali to help in the preparation of the manuscript, to Paul Smith for English corrections, and to Nelson Pérez and Guillermo Caballero Marmori from Itaipu Binacional for advice and help in the field.

INTRODUCTION

Conservation status assessment is extremely useful in conservation biology as a planning tool for conservation actions, focusing the budget (always low) on specific targets that try to improve conservation outputs (Caro & O'Doherty 1999; Simberloff 1998). The most widely utilized assessment of conservation status is the method proposed by the International Union for Conservation of Nature (IUCN), and its website is one of the most popular references for citing the conservation status of different taxa; however, only 5% of the world's described species have been globally evaluated (IUCN 2016). The IUCN Red List of Threatened Species 2016 database shows 483 palm species assessed (IUCN 2016). This number represents only 19% of the total palm species recognized (2522 species) (Dransfield et al. 2008). Of the 483 palms assessed, 68% are in a threatened category (EW, CR, EN, and VU). This high proportion of threatened species may reflect the vulnerability of the palm family caused by the massive habitat loss that tropical ecosystems are facing (Myers et al. 2000). Typically each country also has its own national red list of threatened species and these often follow the guidelines of the IUCN (Llamozas et al. 2003; Calderón et al. 2005). In Paraguay the Secretariat of Environment (SEAM) updated the national list of threatened species in 2006 (Resolución 524/06) classifying the palm *Butia marmorii* as critically endangered. However the palm has not been yet included in the IUCN Red List as an assessed species.

Butia marmorii Noblick, 2006, is an acaulescent palm, with small grass-like leaves, and purple inflorescences at ground level (Images 1 & 2). The species is found in subtropical savanna like vegetation known as Cerrado. To date it is known only from two adjacent populations in the vicinity of Itakyry, Department of Alto Paraná, Paraguay, and a single Argentinean record (Noblick 2006) (Fig. 1), but its presence in Brazil (Três Lagoas, Mato Grosso do Sul) was postulated based on photographic records (Noblick 2006). Recent revisions however show that the Brazilian population is not the same species and the Argentinian population no longer exists (Lorenzi *et al.* 2010; Soares 2015). This makes the species endemic to Paraguay. Gauto et al. (2011) classified *Butia marmorii* as endangered due to its estimated area of occupancy highlighting other possible locations where the species may occur. Nevertheless, the threat of the loss of its natural habitat put the known population in high risk of extinction as eastern Paraguay has lost more than 50% of its natural vegetation cover in the last 50 years (Huang et al. 2009). In addition to this dramatic loss, the species occurs at low densities, is very inconspicuous, and inhabits isolated patches of Cerrado surrounded by soybean plantations. These characteristics make this species extremely vulnerable to any disturbance of its small area of remnant habitat. The areas where *Butia marmorii* occurred when it was described are not under legal protection (Noblick 2006).

Images 1–2. *Butia marmorii*

Most of the biological traits of *B. marmorii* remain unknown, and the few scientific references that exist deal with descriptions and distribution (Pintaud et al. 2008; Stevens 2014; Soares 2015), and a historic anecdotal narration by Noblick (2014). Hoffmann et al. (2014) provided a summary of studies on the genus, highlighting the lack of information available for *B. marmorii*. The genus *Butia* itself, in fact, is poorly studied in general, as it is one of the less important palm genera from an economic point of view (Bernal et al. 2011). Soares (2015) made an important contribution to understanding the systematics of the genus, and mentioned the presence of *B. marmorii* only in Paraguay. No information about its rate of growth, its reproductive biology or its soil or nutrient requirements is available

Figure 1. Locality records of *Butia marmorii* based on Noblick (2006) highlighting Alto Paraná (in Pink) only department where this species is known in Paraguay. Triangles represent specimens from collections. Argentinean record is based on an extinct population. Circle illustrates a photographic record indicated by Noblick (2006) although currently recognized as a different species. See text for further details.

for the species, although cultivated specimens from the wild have been grown by institutions such as Montgomery Botanical Center (Griffith 2010), and Jardim Botânico Plantarum (http://www.plantarum.org.br/pagina/menus/125/Acervo_Vivo-Dezembro-2011.pdf), and Itaipu Binacional (Irene Gauto, pers. obs.), to ensure the survival of this evolutionary linage.

In order to better understand the threats that a species is facing, it is important to know its real distribution, the density of its populations, and its structure. Distribution models based on physical and ecological characteristics are a useful tool to highlight potential distribution areas of a species, as did Gauto et al. (2011) for *B. marmorii*. But more precise tools, such as small-scale satellite imagery classification of suitable habitat can show more accurate areas were a species could be found. These results can be verified in situ in order to better understand the real distribution of a species and its current threats in the wild.

In this work, we identify new areas of distribution for *Butia marmorii*, assessing the ecological status of each population recorded.

MATERIALS AND METHODS

Potential distribution assessment

Gauto et al. (2011) made an extensive analysis of the distribution of Paraguayan palms stating that based on a spatial prediction, *Butia marmorii* is the Paraguayan palm with the most limited distribution, after the almost extinct *Trithrinax brasiliensis* var *acanthocoma*. Working on the hypothesis that the distribution of this palm must be wider than is currently known, we performed a fine-scale analysis of satellite images. In order to accomplish this, we made a supervised classification and visual interpretation of satellite images, in conjunction with a multi-temporal analysis using the sensors Landsat 1-MSS,5-TM,8-OLI, for the years 1973, 1984, 2002, 2012 and 2013.

The analysis was limited to the "area of occupancy" proposed by Gauto et al (2011), in the Alto Paraná Department (eastern Paraguay). A key factor for the analysis was the identification of Cerrado ecoregion, with which the species is strongly associated. The natural habitats of Alto Paraná are, however, highly disturbed, and it can be difficult to distinguish between natural Cerrado and deforested areas. Consequently, images from 1973 and 1984 were used to identify the historical distribution of the Cerrado, and more recent images to assess changes. The satellite image processing for the years 1973–1984 (120m resolution) was performed employing unsupervised classification methods to identify the areas of the potential presence of the palm using the two sites of known presence as a reference point. We then made a visual interpretation to improve the quality of results, in conjunction with an ASTER ASTGTM2 radar image to eliminate areas located in potentially flooded areas since the palm only occurs in highlands (Fig. 2). Finally, we identified the remaining fragments of habitat with a high probability of housing additional populations, through analysis of Landsat Images from the 2012–2013 (30 m of resolution), along with IKONOS and QuickBird high resolution images from Google Earth.

Once the map of potential distribution areas was available, field verification was performed to confirm the species presence or absence.

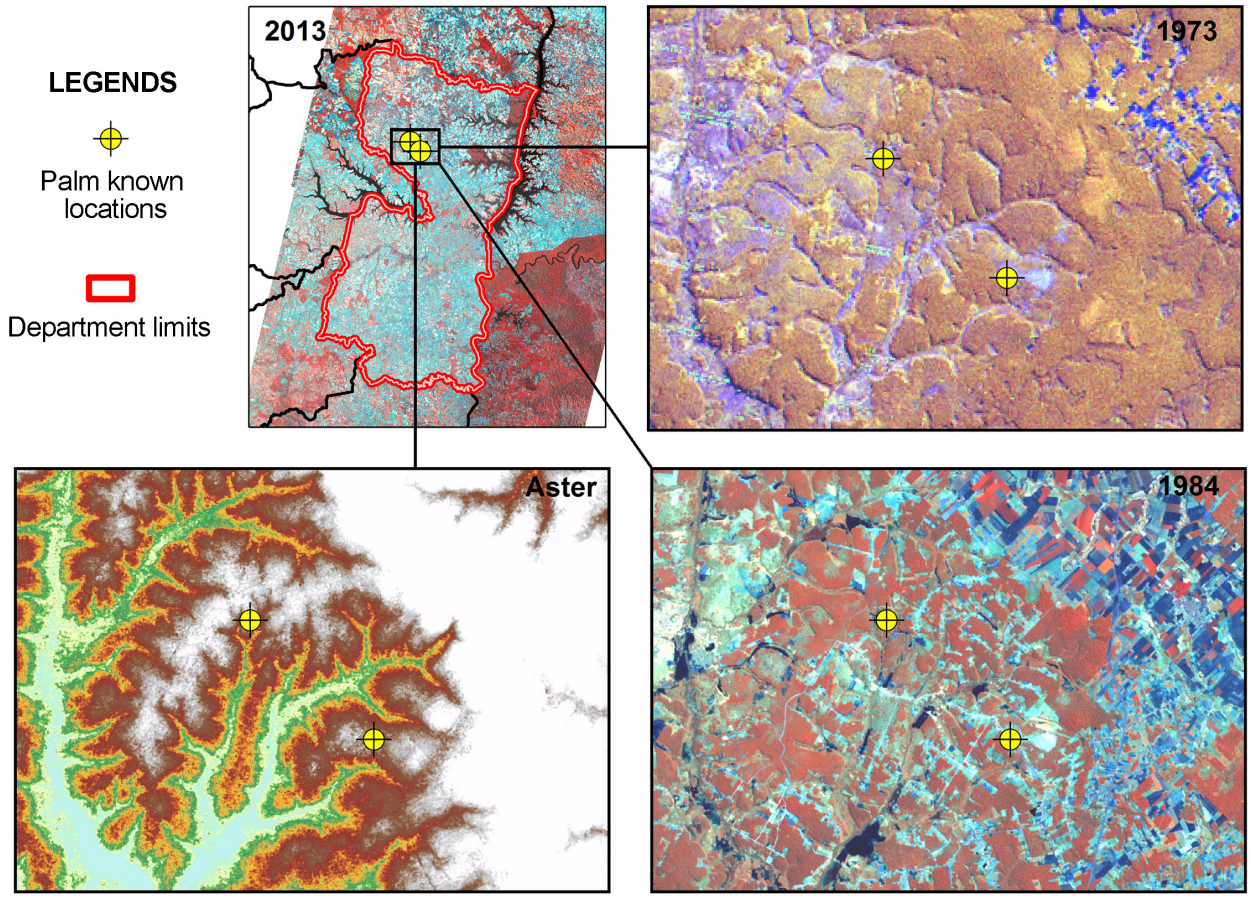

Figure 2. Top Left: sites of known presence of the palm in Paraguay. Top Right: Historical location of the Cerrado and Atlantic Forest in the year 1973. Bottom Left: Location of the two known sites in relation to the elevation of the terrain. Bottom Right: Historical location of the Cerrado and Atlantic Forest in the year 1984.

In situ population assessment

The verification of the presence of *Butia marmorii* in potential areas of occurrence was made with a series of fieldtrips. In localities where the palm was found to be present, we performed a survey to assess the population density and the ecological characteristics.

In each locality, 1ha plots were demarcated, divided into 25 sub-plots of 20×20 m (Dallmeier 1996). The spatial distribution of the 25 sub-plots was not necessarily squared (but maintaining the 400 m²), and the disposition was designed for the best fit with the spatial distribution of the palms and its environment. In each sub-plot, the following data were collected: GPS point, number of specimens, phenology status, soil type, soil coverage density, and associated plant species by surveys in the sub-plots.

RESULTS

Distribution assessment

A total of 27 polygons were suggested as potential areas of occurrence of the endangered palm *Butia marmorii* (Fig. 3). All of them were in the northern Alto Paraná Department. The total surface area of these areas was approximately 18.12km² (Table 1).

In situ verification confirmed that several of these localities had already been modified and cleared for crops (mostly soybean). In fact, most of the proposed localities were on farmlands, or in areas with severe environmental modification (Table 1). Thirty-five per cent of the suggested localities could not be closely visited because they were in private land and not authorization could be obtain. *Butia marmorii* populations were identified in sites 1, 8, 12, and 17 (Fig. 4). Of these four sites, only 1 and 8 showed ecological characteristics that could be analyzed, as they exhibited the lowest degree of environmental disruption. Site 12 corresponded to a growing area, where only a few isolated individuals were

Table 1. Surface areas of the polygons of potential presence of *Butia marmorii* (P*B*) with the centroid location of each area. Farmlands marked with asterisk (*) were not accessed.

Site No.	Surface (km²)	Centroid		Status	P*B*
		Lat	Long		
1	1,258770	-25,0286⁰	-54,9878⁰	Mostly farmland with severe degradation.	+
2	1,807270	-25,0213⁰	-55,0482⁰	Farmland with degradation.	-
3	1,142490	-25,0049⁰	-55,0401⁰	Severe degradation.	-
4	0,729304	-24,9945⁰	-55,0442⁰	Mostly farmland with severe degradation.	-
5	0,616783	-24,9834⁰	-55,0502⁰	Severe degradation.	-
6	0,333371	-24,9769⁰	-55,0653⁰	Farmland.	-
7	0,612609	-24,9889⁰	-55,0709⁰	Farmland.	-
8	0,360043	-24,9823⁰	-55,0808⁰	Mostly farmland.	+
9	1,046410	-24,9912⁰	-55,0899⁰	Farmland with severe degradation.	-
10	1,689170	-25,0028⁰	-55,1007⁰	Farmland with degradation.	-
11	2,060710	-25,0172⁰	-55,1107⁰	Mostly farmland with severe degradation.	-
12	0,492106	-25,029⁰	-55,098⁰	Mostly farmland with severe degradation.	+
13	1,095350	-25,017⁰	-55,1283⁰	Farmland*.	-
14	0,157780	-24,993⁰	-55,0558⁰	Farmland.	-
15	0,005169	-24,9766⁰	-55,0734⁰	Farmland.	-
16	0,010207	-24,978⁰	-55,0741⁰	Farmland.	-
17	0,158209	-24,9777⁰	-55,0555⁰	Farmland.	+
18	0,031368	-24,9847⁰	-55,0572⁰	Severe degradation.	-
19	0,883487	-24,96⁰	-55,0726⁰	Farmland with severe degradation.	-
20	0,378927	-25,0782⁰	-55,027⁰	Farmland.	-
21	0,107612	-25,0981⁰	-55,0518⁰	Farmland.	-
22	0,144686	-25,098⁰	-55,0465⁰	Farmland*.	-
23	0,334212	-25,014⁰	-54,9694⁰	Farmland.	-
24	0,161656	-24,929⁰	-55,1662⁰	Farmland*.	-
25	2,128080	-24,9378⁰	-55,1476⁰	Farmland.	-
26	0,123344	-24,8458⁰	-55,1873⁰	Farmland*.	-
27	0,248713	-24,8522⁰	-55,1867⁰	Farmland.	-
Total	**18,117836**				

found, left by the owner of the establishment. Site 17 is a historical collection locality, with a marked reduction of original coverage caused by strong anthropogenic impact. Anthropogenic impacts through time are clearly visible through satellite analysis (Fig. 4) and are proof of habitat reduction for *Butia marmorii* (Table 2).

Population assessment

We observed an elevated degree of habitat alteration in Cerrado ecosystems where *Butia marmorii* occurs. Most of the original habitat had been converted into mechanized-agriculture or, to a lesser degree, forestry plantations of exotic species.

The parameters and characteristics of the two populations with less anthropogenic impacts are presented below; but given the lack of formal protection these do not have any greater chance of long term survival than any other localities.

- Site 1: Locality of first collections. Surface of vegetation = 5.8 hectares. Private property in disuse, with significant anthropogenic impact. Individuals = 1142 (density = 0.11 individuals/m²) (Appendix 1). Individuals reproductively active with flowers, fruits or both together. Mostly sandy soil, reddish, with formations of savannas, grasslands, or secondary forest. Figure 6 shows the composition and floristic diversity (at the family level) for the site. The list of associated species in this site is presented in Appendix 1.

- Site 8: Natural area with moderate anthropogenic impact. Surface of vegetation = 16.6 hectares. Individuals = 552 (54 *Butia marmorii*, 180 *B. paraguayensis*, and 318 *Butia* sp. (sterile specimens)). *Butia marmorii* density was 0.0054 individuals/m² (Appendix 1). Individuals reproductively active (with flowers/fruits) were found. Mostly clay soil, reddish, with formations of savanna associated shrubs. Figure 6 shows the floristic composition (at the family level) for the site. The composition of the flora and characteristics of this site are presented in Appendix 1.

Sites 12 and 17 held a very low population of *Butia marmorii* with the highest recorded population of just 20 individuals (Site 12), 15 of which were in a tilled area.

On sites 2, 7 and 12 were found specimens of *Butia paraguayensis* and some sterile specimens that could not be identified.

DISCUSSION

Species distribution models are powerful tools used in biological conservation, and can be used to predict not only the actual distribution of an organism, but also to infer distribution over time and assess how environmental change might affect that chorology (Theurillat & Guisan 2001; Williams et al. 2003; Thomas et al. 2004). The utility of these programs has been

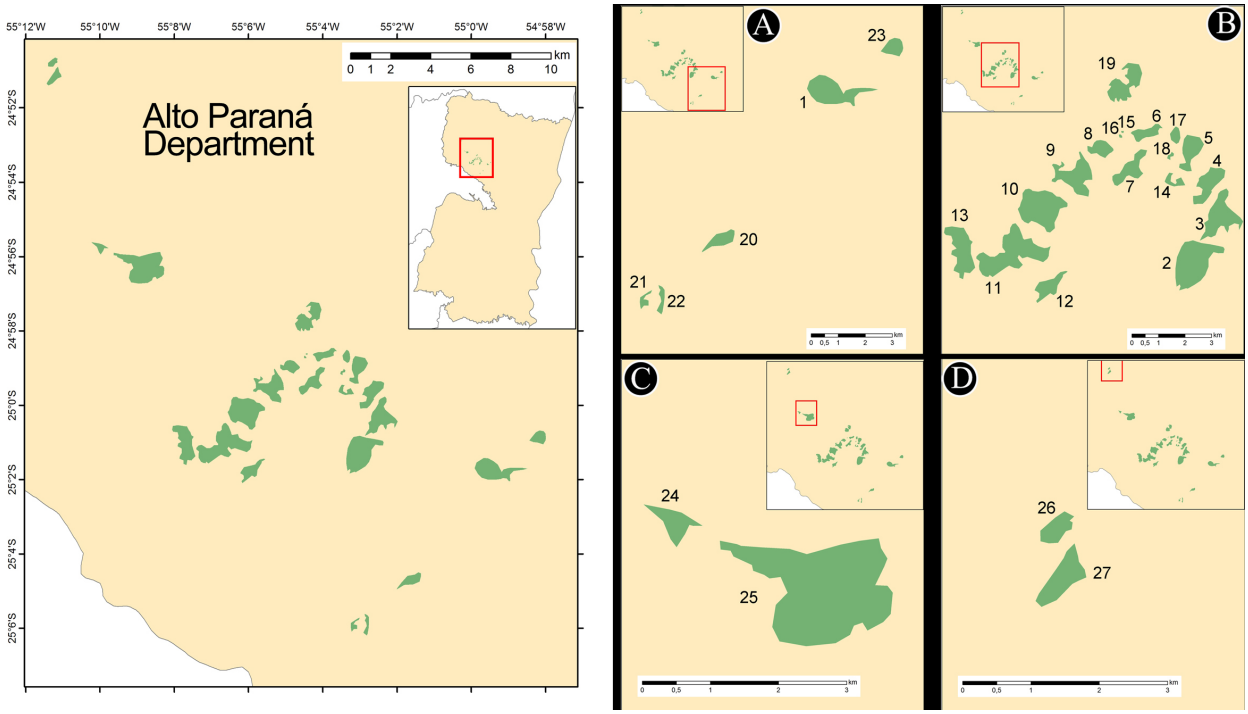

Figure 3. Location of proposed sites for field verification. Left: Overview map of the proposed sites. Right: Detailed numeric identification of the potential distribution sites.

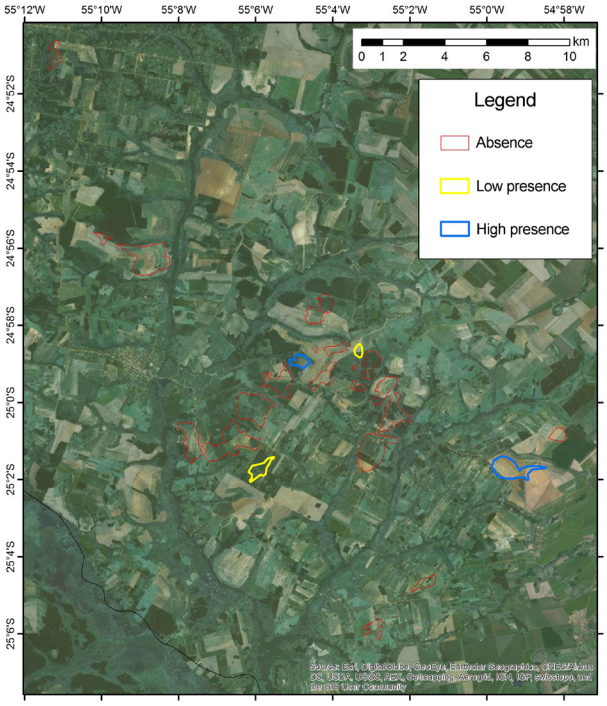

Figure 4. Potential distribution sites, on a satellite image showing presence status after in situ verification.

Table 2. Sites with presence of *Butia marmorii* and comparison of the natural vegetation cover between 1984 and 2014. See Figure 4 for visualization.

Site	Cover (ha)		Remanent (%)
	1984	2014	
1	125.9	5.8	4.6
8	36.0	16.6	46.2
12	49.2	9.8	19.9
17	15.8	0.4	2.8
Total	**226.9**	**32.7**	**14.4**

demonstrated numerous times (Carpenter et al. 1993; Loiselle et al. 2003; Naoki et al. 2006), but the predictions are never completely accurate as they work with climatic layers, and the programs do not distinguish the presence of cities or deforestation. Gauto et al. (2011) presented a distribution model for *Butia marmorii* that is extended northwards to Canindeyú and Amambay departments (Fig. 5c in Gauto et al. 2011). The technique employed here however identifies small and fragmented areas as potential localities of occurrence, as it also incorporates information on land use change.

Through an a posteriori and in situ verification, new records for *Butia marmorii,* at least two new sites (Sites 8 and 12), are documented. This is important for our understanding of the distribution of *B. marmorii* in the country. No additional populations of this rare species have been recorded since the species was described

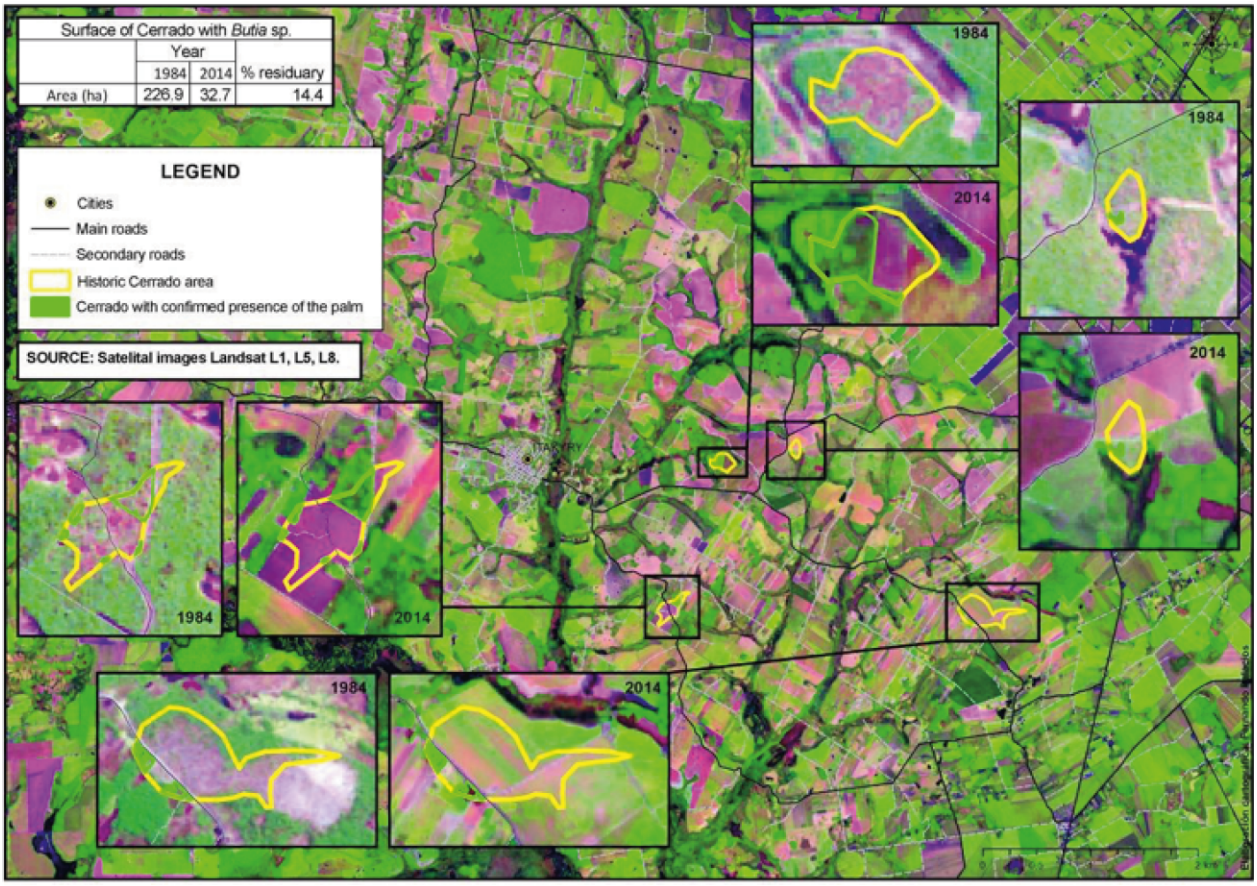

Figure 5. Comparison of the anthropogenic modifications to the landscape in the study area, in 1984 and 2014, showing the difference between the historic Cerrado areas, and current patches with presence of *Butia marmorii*. Top Left: Site 8. Top Right: Site 17. Bottom Left: Site 12. Bottom Right: Site 1. See Table 2 for specifications.

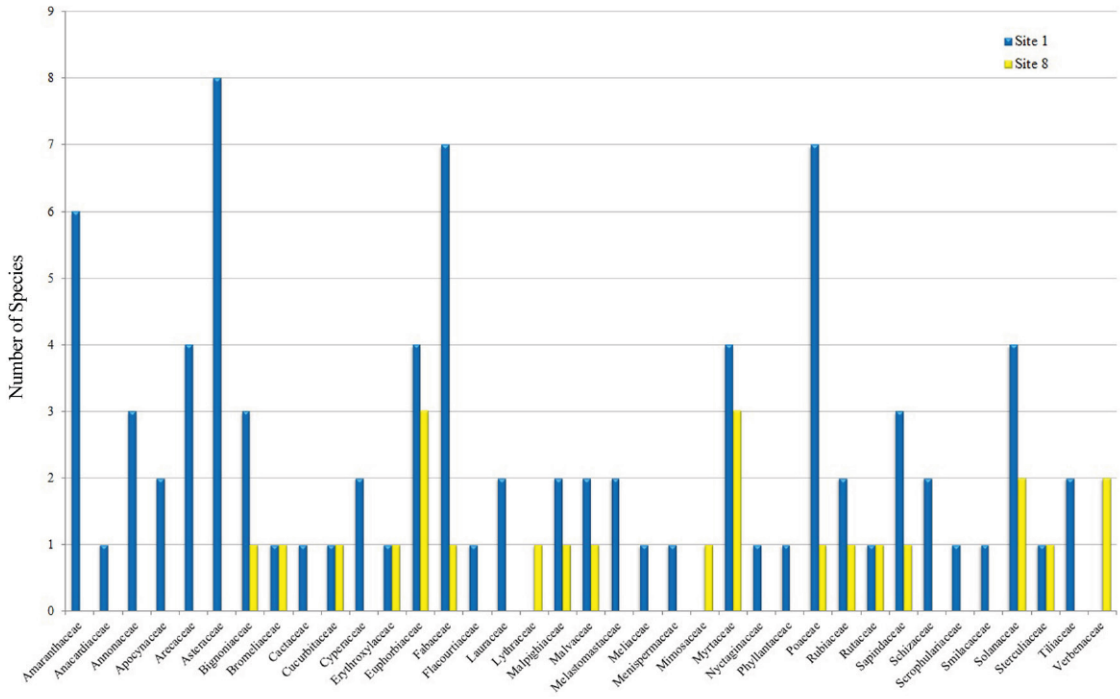

Figure 6. Floristic composition of the studied sites, at the family level.

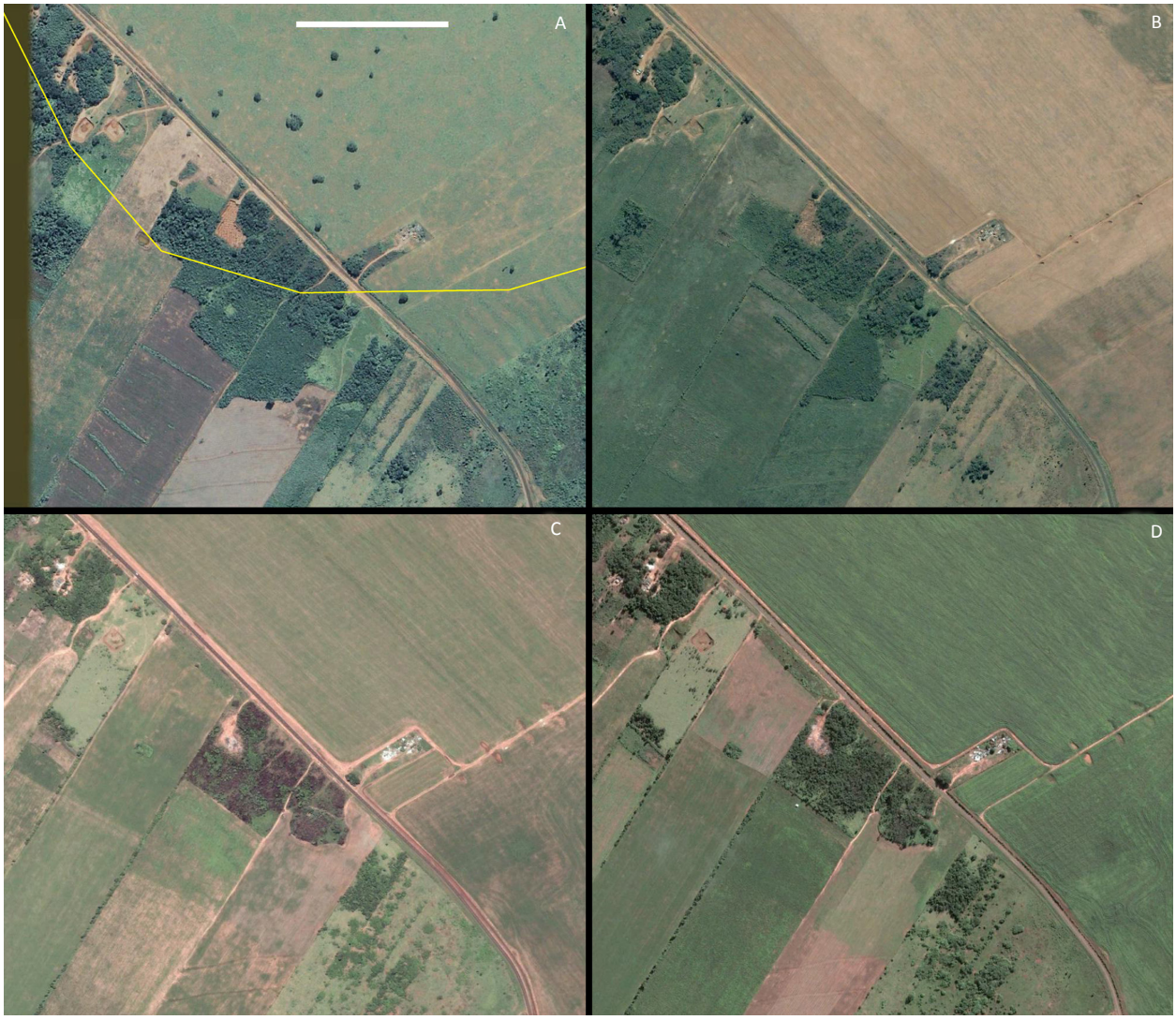

Figure 7. Changes through time in a spot of Cerrado, in Site 1. Yellow line, limit of the polygon of Site 1. White bar: 300m. A - 13-Apr-2003; B - 1-Aug-2006; C - 14-Nov-2014 (fire intervention); D - 4-May-2015. Images taken from Google Earth v. 7.1.2.2041, accessed on 25-Feb-2016.

(Noblick 2006; Gauto et al. 2011). Gauto et al. (2011) categorized this species as Endangered ("EN" following the IUCN criteria) given the reduced area of occupancy. In addition, here we confirm that the species is threatened by deforestation and rapid changes in land use, and that its distribution is fragmented and restricted to increasingly smaller patches. We quantified habitat loss, and just 14% of the original area of occurrence remains today (Table 2, Fig. 4). Such a decline is illustrated in Site 1, the type locality described by Noblick (2006), and which holds the highest number of individuals (Fig. 7). It is possible to see the patch of Cerrado (darker green area in the center of Fig. 7A) located in the southern extreme of Site 1, and its reduction through time due to anthropic intervention (Fig. 7B–D). Hence, we found that the situation of this palm is even worse than depicted by Gauto et al. (2011). In view of its extent of occurrence (EOO) of less than 100km^2, its severely fragmented distribution, and the continuing decline in the extent and quality of its habitat, now we consider *Butia marmorii* as Critically Endangered CR B1ab(i,ii,iii,iv,v) (Appendix 2) following IUCN categories and criteria (IUCN 2012).

In two places we were able to calculate the population density of the species, finding significant differences between the two sites. *Butia marmorii* density is significantly higher in Site 1, than in Site 8, even when in both sites the two *Butia* species share habitat. The density of *B. paraguayensis* in Site 1 was extremely low, whereas in Site 8 it had a higher density (180/ha) than *B. marmorii* (54/ha). This is a first approach to

the knowledge of the ecology of the species and their ecological relationships with other species. The next step is a detailed analysis of environmental conditions to infer the reasons behind the differing density. No previous studies have focused on the estimation of population density in *Butia* grass-like palms, but estimations of *Butia* palm trees (Guilherme & Oliveira 2010; V.V.F. Lima 2011, unpub. data) are predictably smaller than our results given the greater size of *Butia* palm trees.

In these localities some individuals show intermediate characteristics between *B. marmorii* and *B. paraguayensis*, making it difficult for identification in the field; thus specimens with fertile parts were collected and identified afterwards. More detailed taxonomic studies are thus recommended to better understand the systematics of the genus.

A future molecular approach should also be carried out. Given that the area where *B. marmorii* is present is being rapidly reduced, the chance of panmixis is also reduced, and populations are becoming more isolated. It is alarming that the palm tree *Butia eriospatha* has a low genetic diversity even in a panmitic population (Nazareno & dos Reis 2012), and that smaller populations are more vulnerable to genetic drift (Nazareno & dos Reis 2014). Needless to say populations of *B. marmorii* are extremely reduced and urgent and diverse actions are required in order to preserve this linage.

REFERENCES

Bernal, R., C. Torres, N. García, C. Isaza, J. Navarro, M.I. Vallejo, G. Galeano & H. Balslev (2011). Palm management in South America. *The Botanical Review* 77(4): 607–646; http://doi.org/10.1007/s12229-011-9088-6

Calderón, E., G. Galeano & N. García (2005). *Libro Rojo de Plantas de Colombia. Volumen 2: Palmas, Frailejones y Zamias*. Instituto Alexander von Humboldt - Instituto de Ciencias Naturales de la Universidad de Colombia - Ministerio de Ambiente, Vivienda y Desarrollo Territorial, Bogota, 454pp.

Caro, T.M. & G. O'Doherty (1999). On the use of surrogate species in Conservation Biology. *Conservation Biology* 13(4): 805–814; http://doi.org/10.1046/j.1523-1739.1999.98338.x

Carpenter, G., A.N. Gillison & J. Winter (1993). DOMAIN: a flexible modelling procedure for mapping potential distributions of plants and animals. *Biodiversity & Conservation* 2(6): 667–680; http://doi.org/10.1007/BF00051966

Dallmeier, F. (1996). From the forest to the user: a methodology update, pp. 43–51. In: Wilson, D.E. & A. Sandoval (eds.). *Manu: The biodiversity of Southwestern Peru*. Smithsonian Institute, Washington D.C., 672pp.

Gauto, I., R.E. Spichiger & F.W. Stauffer (2011). Diversity, distribution and conservation status assessment of Paraguayan palms (Arecaceae). *Biodiversity & Conservation* 20: 2705–2728; http://doi.org/10.1007/s10531-011-0100-6

Griffith, P. (2010). Plant exploration: New discoveries by the Montgomery team. *Montgomery Botanical News* 18: 1.

Guilherme, F.A.G. & A.S. Oliveira (2010). Estrutura populacional de *Butia purpurascens* Glassman (Arecaceae) en duas áreas de Cerrado *sensu stricto* no Estado de Goiás. *Revista de Biología Neotropical* 7(1): 37–45; http://doi.org/10.5216/rbn.v7i1.13853

Hoffmann, J.F., R.L. Barbieri, C.V. Rombaldi & F.C. Chaves (2014). *Butia* spp. (Arecaceae): An overview. *Scientia Horticulturae* 179: 122–131; http://doi.org/10.1016/j.scienta.2014.08.011

Huang, C., S. Kim, K. Song, J.R. Townshend, P. Davis, A. Altstatt, O. Rodas, A. Yanosky, R. Clay, C.J. Tucker & J. Musinsky (2009). Assessment of Paraguay's forest cover change using Landsat observations. *Global Planet Change* 67 (1–2): 1–12; http://doi.org/10.1016/j.gloplacha.2008.12.009

IUCN (2012). *IUCN Red List Categories and Criteria: Version 3.1*. Second edition. International Union of Conservation of Nature, Gland and Cambridge, 32pp.

IUCN Red List of Threatened Species (2016). Summary Statistics (http://www.iucnredlist.org/about/summary-statistics). Downloaded on 14 April 2016.

Llamozas, S., R.D. de Stefano, W. Meier, R. Riina, F. Stauffer, G. Aymard, O. Huber & R. Ortiz (2003). *Libro Rojo de la flora Venezolana*. Provita - Fundación Polar - Fundación Instituto Botánico de Venezuela Dr. Tobías Lasser - Conservación Internacional, Caracas, 555pp.

Loiselle, B.A., C.A. Howell, C.H. Graham, J.M. Goerck, T. Brooks, K.G. Smith & P.H. Williams (2003). Avoiding pitfalls of using species distribution models in conservation planning. *Conservation Biology* 17(6): 1591–1600; http://doi.org/10.1111/j.1523-1739.2003.00359.x

Lorenzi, H., L.R. Noblick, F. Kahn & E. Ferreira (2010). *Brazilian Flora*. Instituto Plantarum de Estudos da Flora, Nova Odessa, 384pp.

Naoki, K, M.I. Gómez, R.O. López, R.I. Meneses & J. Vargas (2006). Comparación de modelos de distribución de especies para predecir la distribución potencial de vida silvestre en Bolivia. *Ecología en Bolivia* 4(1): 65–78.

Nazareno, A.G. & M.S. dos Reis (2012). Linking phenology to mating system: exploring the reproductive biology of the threatened palm species *Butia eriospatha*. *Journal of Heredidy* 103(6): 842–852; http://doi.org/10.1093/jhered/ess070

Nazareno, A.G. & M.S. dos Reis (2014). At risk of population decline? An ecological and genetic approach to the threatened palm species *Butia eriospatha* (Arecaceae) of southern Brazil. *Journal of Heredity* 105(1): 120–129; http://doi.org/10.1093/jhered/est065

Noblick, L.R. (2006). The grassy *Butia*: Two new species and a new combination. *Palms* 50(4): 167–178.

Noblick, L.R. (2014). *Butia*: what we think we know about the genus. *The Palm Journal* 208: 5–24.

Pintaud, J.C, G. Galeano, H. Balslev, R. Bernal, F. Borchsenius, E. Ferreira, J.-J. de Granville, K. Mejía, B. Millán, M. Moraes, L. Noblick, F. W. Stauffer & F. Kahn (2008). Las palmeras de América del Sur: diversidad, distribución e historia evolutiva. *Revista Peruana de Biología* 15(1): 7–29.

Simberloff, D. (1998). Flagships, umbrellas, and keystone species: is single-species management passé in the landscape era? *Biological Conservation* 83(3):247–257; http://doi.org/10.1016/S0006-3207(97)00081-5

Soares, K.P. (2015). Le genre *Butia*. *Princeps* 1: 12–57.

Stevens, J. (2014). Let's get reacquainted with *Butia* palms. *Southeastern Palms* 21(3): 14–31.

Theurillat, J.-P. & A. Guisan (2001). Potential impact of climate change on vegetation in the European Alps: a review. *Climate Change* 50(1): 77–109; http://doi.org/10.1023/A:1010632015572

Thomas, C.D, A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F. N. Erasmus, M.F. de Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. van Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips & S.E. Williams (2004). Extinction risk from climate change. *Nature* 472: 145–148; http://doi.org/10.1038/nature02121

Williams, S.E., E.E. Bolitho & S. Fox (2003). Climate change in Australian tropical rainforests: an impending environmental catastrophe. *Proceedings of the Royal Society of London, Biological Sciences* 270: 1887–1892; http://doi.org/10.1098/rspb.2003.2464

Appendix 1. Data obtained during fieldwork sampling

PARCEL 1 - Site 1 (Fieldwork: 23–25 October 2013)

SP	*Bm*	*Bp*	*B*sp	Light	Soil	Vegetation	Associated species
1	1	0	0	Medium	Sandy, abundant leaflitter	Secondary forest	*Luehea candicans*, *Syagrus romanzoffiana*, *Guadua* sp., *Guarea* sp., *Triumfeta semitriloba*, *Casearia silvestris*, *Urochloa brizantha*, *Allophylus edulis*, *Solanum sisymbriifolium*, *Ocotea* sp., *Desmodium tortuosum*, *Helietta apiculata*, *Smilax campestris*, *Froelichia procera*, *Anemia tometosa*, *Campomanesia adamantium*, *Solanum americanum*, *Sida rhombifolia*, *Cenchrus echinatus*.
2	3	0	0	Medium	Sandy, reddish	Secondary forest	*Ocotea* sp., *Gochnatia polymorpha*, *Acosmium* sp., *Astronium urundeuva*, *Solanum sisymbriifolium*, *Coniza bonariensis*, *Calliandra brevicaulis*, *Helietta apiculata*, *Phyllanthus orbiculatus*, *Gomphrena macrocephala*, *Smilax campestris*, *Borreria verticillata*, *Allophylus edulis*.
3	15	0	0	Medium	Sandy, reddish	Savanna	*Gochnatia polymorpha*, *Gomphrena macrocephala*, *Astronium urundeuva*, *Acosmiun* sp., *Anemia tomentosa*, *Mandevilla pohliana*, *Alternanthera hirtula* var. *nitens*, *Campomanesia adamantium*, *Campomanesia pubescens*, *Cnidoscolus* sp.
4	1	1	0	Medium	Sandy, abundant leaflitter	Savanna	*Gochnatia polymorpha*, *Acosmium* sp., *Allophylus edulis*, *Nectandra lanceolata*, *Anemia tomentosa*, *Campomanesia adamantium*, *Cnidoscolus* sp., *Urochloa brizantha*, *Ocotea* sp.., *Byrsonima psilandra*, *Andira humilis*, *Serjania* sp., *Heteropteris angustifolia*, *Dyckia* aff. *tuberosa*, *Campomanesia pubescens*.
5	43	0	0	Abundant	Sandy, reddish	Savanna	*Helietta apiculata*, *Gochnatia polymorpha*, *Ocotea* sp., *Astronium urundeuva*, *Dyckia* aff. *tuberosa*, *Gomphrena macrocephala*, *Smilax campestris*, *Cnidoscolus* sp., *Urochloa brizantha*, *Arrabigdaea* sp., *Anemia tomentosa*, *Desmodium* sp., *Calea verticillata*, *Campomanesia adamantium*, *Andira humilis*, *Luehea candicans*, *Galactia* sp., *Campomanesia pubescens*, *Hibiscus* sp., *Allophylus edulis*, *Solanum lycocarpum*, *Tabernaemontana catharinensis*, *Cayaponia* sp.
6	51	1	0	Abundant	Sandy, half covered with leaflitter	Savanna	*Gochnatia polymorpha*, *Gomphrena macrocephala*, *Acosmiun* sp., *Dyckia* aff. *tuberosa*, *Cnidoscolus* sp., *Calea verticillata*, *Campomensia pubescens*, *Solanum sisymbriifolium*, *Croton garckeanus*, *Hibiscus* sp., *Froelichia procera*, *Solanum lycocarpum*, *Smilax campestris*, *Astronium urundeuva*, *Pfaffia* sp., *Coniza bonariensis*, *Alternanthera hirtula* var. *nitens*.
7	62	1	0	Abundant	Sandy, abundant leaflitter	Savanna	*Acosmium* sp., *Gochnatia polymorpha*, *Dyckia* aff. *tuberosa*, *Erythroxylum* sp., *Luehea candicans*, *Byttneria* sp., *Byrsonima psilandra*, *Scoparia dulcis*, *Calea verticillata*, *Froelichia procera*, *Cissampelos* sp., *Anemia tomentosa*, *Urochloa brizantha*.
8	191	0	0	Abundant	Sandy, redish	Savanna	*Gochnatia polymorpha*, *Dickya* sp., *Campomanesia pubescens*, *Solanum lycocarpum*, *Campomanesia guazumaefolia*, *Froelichia procera*, *Pisonia aculeata*, *Smilax campestris*, *Bromelia balansae*, *Serjania erecta*, *Eugenia uniflora*.
9	36	1	0	Medium	Sandy, abundant leaflitter	Savanna	*Solanum lycocarpum*, *Calea verticillata*, *Dyckia* aff. *tuberosa*, *Gochnatia polymorpha*, *Ocotea* sp., *Helietta apiculata*, *Astronium urundeuva*, *Pennisetum* sp., *Porophyllum ruderale*, *Casearia sylvestris*, *Senecio grisebachii*, *Bromelia balansae*, *Urochloa brizantha*, *Cnidoscolus* sp., *Guibouchia chodatiana*, *Luehea candicans*, *Cissampelos* sp., *Pyrostegia venusta*, *Gomphrena* sp., *Tibouchina* sp., *Mimosa* sp..
10	21	0	0	Medium	Sandy, abundant leaflitter	Savanna	*Astronium urundeuva*, *Erythroxylum* sp., *Campomanesia guazumaefolia*, *Adenocalymma marginatum*, *Gochnatia polymorpha*, *Acosmium* sp., *Dyckia* aff. *tuberosa*, *Cayaponia* sp., *Annona* sp., *Cnidoscolus* sp, *Calea verticillata*, *Campomanesia pubescens*, *Cissampelos* sp, *Mimosa* sp, *Scoparia dulcis*, *Tabernaemontana catharinensis*, *Andira humilis*.
11	77	0	0	Abundant	Sandy, redish	Savanna	*Solanum lycocarpum*, *Pyrostegia venusta*, *Urochloa brizantha*, *Acosmium* sp., *Smilax campestris*, *Erythroxilum* sp., *Bromelia balansae*, *Astronium urundeuva*, *Andira humilis*, *Eugenia uniflora*, *Calea verticillata*, *Dyckia* aff. *tuberosa*, *Croton* sp., *Coniza bonariensis*, *Cayapona* sp., *Duguetia furfuracea*.
12	39	0	0	Medium	Sandy, abundant leaflitter	Savanna	*Urochloa brizantha*, *Acosmium* sp., *Gochnatia polymorpha*, *Campomanesia guazumaefolia*, *Campomanesia pubescens*, *Cissampelos* sp., *Senecio grisebachii*, *Eugenia uniflora*, *Tabernaemontana catharinesis*.
13	6	0	0	Abundant	Sandy, redish	Degraded grassland	*Coniza bonariensis*, *Borreria verticillata*, *Pyrostegia venusta*, *Gomphrena macrocephala*, *Urochloa brizantha*, *Bulbostylis capillaris*, *Tabernaemontana catharinensis*, *Gochnatia polymorpha*, *Sonchus oleraceus*, *Gamochaeta* sp.
14	25	0	0	Abundant	Sandy, redish	Degraded grassland	*Astronium urundeuva*, *Annona dioica*, *Rhynchospora corimbosa*, *Tabernaemontana catharinensis*, *Cnidoscolus* sp., *Coniza bonariensis*, *Sonchus oleraceus*, *Allagoptera leucocalyx*, *Solanum americanum*, *Pyrostegia venusta*, *Gomphrena celosioides*, *Scoparia dulcis*, *Solanum palinacanthum*, *Calea verticillata*.
15	26	0	0	Abundant	Sandy, redish	Degraded grassland	*Tabernaemontana catharinensis*, *Baccharis* sp., *Solanum sisymbriifolium*, *Sonchus oleraceus*, *Coniza bonariensis*, *Annona dioica*, *Calea verticillata*, *Dyckia* aff. *tuberosa*, *Pyrostegia venusta*, *Richardia brasiliensis*, *Gamochaeta* sp., *Allagoptera leucocalyx*, *Acisanthera* sp.

SP	*Bm*	*Bp*	*Bsp*	Light	Soil	Vegetation	Associated species
16	16	0	0	Abundant	Sandy, redish	Degraded grassland	*Gomphrena macrocephala*, *Coniza bonariensis*, *Sonchus oleraceus*, *Solanum sisymbriifolium*, *Rhynchelitrum repens*, *Tabernaemontana catharinensis*, *Borreria verticillata*, *Pyrostegia venusta*, *Digitaria* sp.
17	58	1	0	Abundant	Sandy, redish	Degraded grassland	*Tabernaemontana catharinensis*, *Coniza bonariensis*, *Urochloa brizantha*, *Pyrostegia venusta*, *Richardia brasiliensis*, *Annona* sp., *Borreria verticillata*, *Campomanesia pubescens*, *Sonchus oleraceus*, *Mimosa* sp., *Baccharis* sp.
18	18	0	0	Abundant	Sandy, redish	Degraded grassland	*Pyrostegia venusta*, *Coniza bonariensis*, *Digitaria* sp., *Paspalum* sp., *Sonchus oleraceus*, *Panicum* sp., *Calea verticillata*, *Solanum lycocarpum*, *Campomanesia guazumaefolia*, *Annona dioica*, *Baccharis* sp., *Gomphrena celosioides*, *Mimosa* sp.
19	25	0	0	Medium	Sandy, abundant leaflitter	Degraded forest	*Urochloa brizantha*, *Gochnatia polymorpha*, *Luehea candicans*, *Ocotea* sp., *Cnidoscolus* sp., *Cereus stenogonus*, *Acosmium* sp., *Guarea* sp., *Baccharis* sp., *Erythroxylum* sp., *Allophylus edulis*, *Mimosa* sp., *Bromelia balansae*, *Dyckia* aff. *tuberosa*, *Anemia phyllitidis*, *Pyrostegia venusta*, *Cayaponia* sp., *Allagoptera leucocalyx*, *Smilax campestris*, *Eugenia* sp., *Helietta apiculata*, *Cissampelos* sp., *Gomphrena macrocephala*, *Senecio grisebachii*, *Calea verticillata*.
20	2	0	0	Medium	Sandy, abundant leaflitter	Degraded forest	*Urochloa brizantha*, *Acosmium* sp., *Gochnatia polymorpha*, *Tabernaemontana catharinensis*, *Casearia sylvestris*, *Nectandra lanceolata*, *Baccharis* sp., *Alternanthera hirtula* var. *nitens*, *Bromelia balansae*, *Allophylus edulis*, *Senecio grisebachii*, *Cnidoscolus* sp., *Guarea* sp., *Eugenia* sp., *Campomanesia guazumaefolia*.
21	8	0	0	Abundant	Sandy, redish	Savanna	*Urochloa brizantha*, *Baccharis* sp., *Tabernaemontana catharinensis*, *Mimosa* sp., *Calea verticillata*, *Solanum sisymbriifolium*, *Cnidoscolus* sp., *Pyrostegia venusta*, *Scoparia dulcis*, *Gomphrena macrocephala*, *Senecio grisebachii*.
22	148	0	0	Abundant	Sandy, redish	Savanna	*Bromelia balansae*, *Smilax campestris*, *Acosmium* sp., *Ocotea* sp., *Allophylus edulis*, *Tabernaemontana catharinensis*, *Cissampelos* sp., *Solanum lycocarpum*, *Senecio grisebachii*, *Dyckia* aff. *tuberosa*.
23	254	0	0	Abundant	Sandy, redish	Savanna	*Pennisetum* sp., *Allagoptera leucocalyx*, *Gomphrena celosioides*, *Calea verticillata*, *Coniza bonariensis*, *Duguetia furfuracea*.
24	15	0	0	Abundant	Sandy, redish	Savanna	*Bromelia balansae*, *Smilax campestris*, *Acosmium* sp., *Ocotea* sp., *Allophylus edulis*, *Tabernaemontana catharinensis*, *Cissampelos* sp., *Solanum lycocarpum*, *Senecio grisebachii*, *Dyckia* aff. *tuberosa*.
25	1	0	0	Medium	Sandy, redish	Savanna	*Luehea candicans*, *Syagrus romanzoffiana*, *Guadua* sp., *Guarea* sp., *Triumfeta semitriloba*, *Casearia silvestris*, *Urochloa brizantha*, *Allophylus edulis*, *Solanum sisymbriifolium*, *Ocotea* sp., *Desmodium tortuosum*, *Helietta apiculata*, *Smilax campestris*, *Froelichia procera*, *Anemia tometosa*, *Campomanesia adamantium*, *Solanum americanum*, *Sida rhombifolia*, *Cenchrus echinatus*.

PARCEL 2 - Site 8 (Fieldwork: 28–30 December 2013)

SP	*Bm*	*Bp*	*Bsp*	Light	Soil	Vegetation	Associated species
1	9	16	27	Abundant	Reddish, clayish loam	Savanna	*Solanum sisymbriifolium*, *Campomanesia* sp., *Calea verticilata*, Verbenaceae.
2	1	1	10	Medium	Reddish, clayish loam	Savanna	*Schinnus weinmannifolius*, *Bromelia balansae*, *Campomanesia* sp., *Urochloa brizantha*.
3	0	2	5	Medium	Reddish, clayish loam	Savanna	*Baccharis frenguelli*, *Syagrus romanzoffiana*, *Eugenia uniflora*, *Campomanesia* sp., *Solidago chilensis*, *Macrosiphonia petraea*.
4	0	2	2	Medium	Reddish, clayish loam	Savanna	*Calea verticilata*, *Solanum sisymbriifolium*, *Gomphrena macrocephala*, *Hibiscus striatus*, *Macrosiphonia petraea*, *Solidago chilensis*, *Bromelia balansae*, *Acrocomia aculeata*, *Allophylus edulis*, *Baccharis frenguelli*.
5	0	1	8	Medium	Reddish, clayish loam	Savanna	*Solanum lycocarpum*, *Campomanesia pubescens*, *Hibiscus striatus*, *Macrosiphonia petraea*, *Macrosiphonia petraea* var. *pinifolia*, *Baccharis frenguelli*, *Eryngium* sp.
6	1	2	8	Medium	Reddish, clayish loam	Savanna	*Baccharis frenguelli*, *Hibiscus striatus*, *Campomanesia pubescens*, *Solanum sisymbriifolium*, *Calea verticilata*, Verbenaceae, *Gomphrena macrocephala*, *Baccharis trimera*, *Mimosa dolens*, *Heteropterys angustifolia*, *Bromelia balansae*, *Erytroxylum* sp.
7	0	3	4	Abundant	Reddish, clayish loam	Savanna	*Baccharis frenguelli*, *Campomanesia pubescens*, *Campomanesia guazumaefolia*, *Solanum sisymbriifolium*, *Lippia alba*, *Macrosiphonia petraea*, *Mimosa dolens*, *Bromelia balansae*, *Tabebuia* aff. *ochraceae*, *Julocroton solanaceus*.
8	4	2	0	Low	Reddish, clayish loam	Shrubland	*Eugenia uniflora*, *Tabebuia* cfr. *ochraceae*, *Baccharis frenguelli*, *Allophylus edulis*, *Bromelia balansae*, *Solanum sisymbriifolium*, *Macrosiphonia longiflora*.
9	0	1	8	Medium	Reddish, clayish loam	Savanna	*Campomanesia guazumaefolia*, *Baccharis frenguelli*, *Heteropterys angustifolia*, *Gomphrena macrocephala*, *Baccharis articulata*, *Melochia* sp., *Eugenia uniflora*, *Allophylus edulis*.

SP	*Bm*	*Bp*	*B*sp	Light	Soil	Vegetation	Associated species
10	5	13	21	Medium	Reddish, clayish loam	Savanna	*Cuphea* sp., *Hibiscus striatus*, *Pfaffia glomerata*, *Campomanesia pubescens*, *Campomanesia guazumaefolia*, *Solanum sisymbriifolium*.
11	3	3	16	Medium	Reddish, clayish loam	Savanna	*Campomanesia pubescens*, *Aloysia gratissima*, *Bromelia balansae*, *Solanum lycocarpum*, *Solanum sisymbriifolium*, *Baccharis trimera*.
12	0	5	11	Low	Reddish, clayish loam	Savanna	*Solanum lycocarpum*, *Solanum sisymbriifolium*, *Campomanesia pubescens*, *Bromelia balansae*, *Allophylus edulis*, *Aloysia gratissima*, Fabaceae.
13	0	3	2	Medium	Reddish, clayish loam	Savanna	*Aloysia gratissima*, *Lippia alba*, *Campomanesia pubescens*, *Campomanesia guazumaefolia*.
14	16	11	19	Abundant	Reddish, clayish loam	Savanna	*Bromelia balansae*, *Hibiscus striatus*, *Campomanesia pubescens*, *Solanum sisymbriifolium*, *Solanum lycocarpum*, *Allophylus edulis*, *Tabebuia* aff. *ochraceae*, Fabaceae.
15	2	35	25	Abundant	Reddish, clayish loam	Savanna	*Hibiscus striatus*, *Campomanesia guazumaefolia*, *Solanum lycocarpum*, *Aloysia gratissima*, *Aloysia gratissima*, *Cayaponia* sp., Verbenaceae, Fabaceae.
16	0	3	9	Medium	Reddish, clayish loam	Savanna	*Campomanesia pubescens*, *Campomanesia guazumaefolia*, *Solanum sisymbriifolium*, *Bromelia balansae*, *Hibiscus striatus*, *Calea verticilata*, *Allagoptera leucocalyx*, *Macrosiphonia petraea*, *Fagara* sp., *Lychnophora salicifolia*.
17	1	16	25	Abundant	Reddish, clayish loam	Savanna	*Calea verticilata*, *Campomanesia pubescens*, *Baccharis frenguelli*, *Baccharis articulata*, *Lychnophora salicifolia*, Verbenaceae.
18	0	11	5	Medium	Reddish, clayish loam	Savanna	*Calea verticilata*, *Solanum sisymbriifolium*, *Campomanesia pubescens*.
19	6	5	28	Abundant	Reddish, clayish loam	Grassland	*Vernonia* sp., *Pfaffia glomerata*, *Gomphrena macrocephala*, *Aloysia gratissima*, *Bromelia balansae*, *Mimosa dolens*.
20	5	12	25	Abundant	Reddish, clayish loam	Grassland	*Sapium longifolium*, *Vernonia* sp., *Calea verticilata*, *Aspilia* sp.
21	0	2	11	Abundant	Reddish, clayish loam	Grassland	*Lippia alba*, *Aloysia gratissima*, *Gomphrena macrocephala*, *Bromelia balansae*, *Vernonia* sp., *Solanum sisymbriifolium*, *Cnidosculus* sp.
22	0	13	13	Abundant	Reddish, clayish loam	Grassland	*Vernonia* sp., *Gomphrena macrocephala*, *Aloysia gratissima*, *Solanum lycocarpum*, *Baccharis frenguelli*, *Baccharis articulata*.
23	0	3	4	Abundant	Reddish, clayish loam	Grassland	*Macrosiphonia petraea*, *Vernonia* sp., *Aloysia gratissima*, *Solanum lycocarpum*, *Gomphrena macrocephala*, *Calea verticilata*.
24	0	12	5	Abundant	Reddish, clayish loam	Grassland	*Gomphrena macrocephala*, *Macrosiphonia petraea*, *Julocroton solanaceus*, *Cuphea* sp, *Alibertia sesilis*, *Melochia* sp., Verbenaceae.
25	1	3	27	Abundant	Reddish, clayish loam	Grassland	*Lychnophora salicifolia*, *Vernonia* sp., Fabaceae.

SP - Sub-parcel (20m^2); *Bm* - Individuals of *Butia marmori* per sub-parcel; *Bp* - *Butia paraguayensis*; Bsp - *Butia* sp.

Appendix 2. IUCN Red List Assessment: *Butia marmorii* Noblick, 2006

Kingdom: Plantae
Division: Magnoliophyta
Class: Liliopsida
Order: Arecales
Family: Arecaceae
Genus: *Butia*
Species: *B. marmorii*
Authority: Noblick 2006

Common name:
Taxonomic notes: The palm *Butia marmorii* was described by Noblick (2006) based on two close populations in eastern Paraguay. Currently, Gauto et al. (2011) discovered additional populations in close related areas.

Assessment Information

Red List Category and Criteria (Version 6.2): Critically Endangered B1ab(i,ii,iii,iv,v).
Justification: *Butia marmorii* is assessed as Critically Endangered as its distribution is severely fragmented but restricted to a range of less than 100km^2 in the eastern part of Paraguay, which is impacted by anthropogenic factors such as agriculture resulting in a continuing decline in the extent of occurrence, area of occupancy, number of mature individuals, and locations. The original patch from where the holotype was extracted was reduced to half its size in a span of 10 years.

Geographic Range / Distribution information

Range description: The species is restricted to a small area in the eastern part of Paraguay, in patches of Cerrado in association with Alto Parana Atlantic Forest (Fig. 1).
Countries of occurrence: Paraguay (Alto Paraná Department).
Extent of Occurrence (EOO): Its EOO is estimated in less than 100km^2 in a severely fragmented area, which is still currently under a severe anthropogenic impact.
Area of Occupancy (AOO): AOO was not estimated.
Number of locations: This species is known from four severely fragmented locations, where the main threat is the modification of the original environment.
Range map: The known distribution of this species is shown in Fig. 1.

Population information

Population: The species was estimated to have a density of 0.0054–0.11 individuals/m^2 depending on the environmental conditions of the site. Then, if we consider a mean of ~0.06 individuals/m^2, the estimation would be approximately 600 individuals (including matures and offspring).
Population trend: The population is in constant decline, given the reduction of its area of distribution. In fact, in Fig. 7 is shown how a single patch (type locality and patch with higher density) was reduced to the half of its size in 10 years.

Habitat and Ecological information

Habitat and ecology: The species is found in subtropical savanna like vegetation known as Cerrado, in association with Alto Parana Atlantic Forest. The original environment (now modified to crop farming) was a tessellation of forests and savannas established on reddish sandy soils. The climate in that area is warm temperate with a marked seasonality of dry and cold season (June–August) with mean temperatures between 10 and 24 ºC and precipitations of 80–120 mm per month, and a humid and warm season (October–February) with mean temperatures between 18 and 32 ºC and precipitations of 140–200 mm per month.
The exact flowering period is not known, although specimens with flowers and fruits were seen from November to March. A high rate of the seeds are predated by beetles.

Information on Threat

Threats: Habitat modification is the main threat of the species. In the area where the species occurs there are several crop farms, and every year farmers clear new areas of natural cover for plantation of cereals (primarily soy bean).
Additional threats: No additional threats are known so far.

Use and Trade information

Use: Local people do not collect the species since no uses are known.
Livelihoods and sustenance: Local communities are not dependent on this species for their livelihoods or sustenance.
Trend in off take from the wild: The survivorship of transplanted specimens is low (about 20%).
Trend in off take from cultivation: Not yet observed.
Commercial value: The species has no known local, domestic, national or international commercial value.

Information on Conservation Actions

Conservation actions: Ex situ conservation actions were taken by the Missouri Botanical Center. That institution kept a collection of *Butia marmorii* for 10 years. Currently, none of the specimens survive in that collection. More recently, the nonprofit Paraguayan organization Asociación Etnobotánica Paraguaya together with the Botanical Garden of the capital city of the country, and the institution Itaipú Binacional, performed a project to maintain specimens in different botanical gardens with low rate of success. Some specimens are kept by the Instituto Plantarum in Brazil. All the specimens came from the same site (type locality) shown in Fig. 7.

Research in place: The first research carried out in place was at the moment of the original description. Later Gauto et al. (2011) studied the population for the second time, and in this work we present the first data about ecological aspects of the species.
Research needed: Detailed taxonomic and genetic studies are recommended to better understand the systematics of the genus.
Monitoring in place: There is no monitoring of the species, population or habitat in place.
Monitoring needed: Population and site monitoring are urgently required.
Education in place: While we carried this work, we accomplished some educational activities with local communities. Nevertheless, no other education action was made in the past.
Education needed: It is important to perform educational activities in the place where this species is present, so people can learn about the scientific value of the species.

Author Details: I. Gauto holds a master degree in botany, specialized in palm conservation; she worked in conservation projects for the NGO Guyra Paraguay and was Executive Director of the Asociación Etnobotánica Paraguaya (AEPY), being currently linked as an active member of the AEPY. F. Palacios by the time of the study he was working as a consultant at the geo-processing department of the Guyra Paraguay, with focus on change detection, climate change, natural resources management, modeling of forestry scenarios; and currently he's finishing a master in Photogrammetry and Geoinformatics at the Hochschule für Technik-Stuttgart, Germany. P. Marchi was the coordinator of the project "Paraguayan Ethnobotany" of AEPY; and currently doing a master degree in environmental science and ecology at the Universita de Pisam Italy. N. Silva is technician in agroecology who worked as curator of the botanical garden kept by AEPY. G. Céspedes is the current Executive Director of the AEPY, professor at the National University of Concepción, Paraguay, associate researcher of the Centro para el Desarrollo de la Investigación Científica (CEDIC), and is an active researcher (PRONII, level I) of the Consejo Nacional de Ciencia y Tecnología (CONACYT).

Author Contribution: IG and GC designed the study; IG obtained financial support; fieldwork carried out by all the authors; FP analyzed satellite images; IG, PM, and GC analyzed fieldwork data; IG wrote the manuscript; FP and GC revised the manuscript.

Journal of Threatened Taxa

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

April 2017 | Vol. 9 | No. 4 | Pages: 10021–10140
Date of Publication: 26 April 2017 (Online & Print)
DOI: 10.11609/jott.2017.9.4.10021-10140
www.threatenedtaxa.org

zooh! ZÜRICH

WILD ZOO Threatened Taxa