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MAPPING, EXTINCTION RISK ASSESSMENT AND IMPORTANCE FOR EPIPHYTE COMMUNITY OF *Vellozia gigantea* (VELLOZIACEAE), AN ENDEMIC GIANT DRACENOID PLANT FROM MINAS GERAIS, BRAZIL

Leonardo Cotta Ribeiro [1], Katia Torres Ribeiro [2], Daniela Campos De Filippo [3], Jaqueline Serafim do Nascimento[1] & João Augusto Madeira [2]*

[1] *Escola Estadual Dona Francisca Josina, Rua das Castanheiras 134, Serrra do Cipó, Santana do Riacho, MG – CEP 35847-000*
[2] *Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio. EQSW, 103/104, Complexo Administrativo, Sudoeste, Brasília-DF. CEP: 70.670-350.*
[3] *Instituto de Observação da Terra – INOT. Rua Teixeira Soares, 50, Floresta, Belo Horizonte – MG. CEP 31015-175.*
E-mails: leocottaribeiro@gmail.com, katia.ribeiro@icmbio.gov.br, danielacamposdefilippo@gmail.com, jjacknascimento@gmail.com, joao.madeira@icmbio.gov.br.

ABSTRACT

We investigated the geographic distribution and population size and structure of *Vellozia gigantea* (Velloziaceae) to assess its risk of extinction according to the IUCN criteria and categories, and to propose effective conservation actions for the species. *V. gigantea* is endemic to *campos rupestres* of Serra do Cipó (Minas Gerais, Southeast Brazil), a highly endemic species rich grassland vegetation associated to nutrient-poor, well drained, sandy soils. Locally very abundant, *V. gigantea* is phorophyte for many epiphytes, and its conservation contributes to the maintenance of a diverse array of species. Historically known from a single small patch (1 ha), our mapping efforts increased its known occurrence to a total of 44 patches (2,946 ha). Amidst, 21.4% of this area is within Serra do Cipó National Park (IUCN category II), 56.5% within a surrounding IUCN category V protected area, and 22.1% remain unprotected. We determined the area of occurrence (AOO, 196 km^2), the extent of occurrence (EOO, 443 km^2), and generation time (higher than 100 years) to define the species risk of extinction. Population size and structure were estimated using ten 5 ×50m transects, which were placed in five patches well apart from each other (two transects in each). Plant and epiphyte abundance were estimated and signs of fire were verified, since it was considered the main incident threat. Based on IUCN criteria B1 and B2 (geographic range, EOO and/or AOO) and subcriteria a and b (number of locations and inferred/projected continuing decline in area of occupancy, area, extent and/or quality of habitat), *V. gigantea* should be classified as a threatened species under the IUCN Vulnerable category (EEO: 442.86 km^2; AOO: 196.00 km^2 and seven locations - VU B1ab(iii) + 2ab(iii)). This status differs from the present official one – Endangered (EN). The whole population was estimated in 6 million plants with a proportion of ca. 75% of mature individuals, well above any threshold of concern. Nevertheless, a large portion of the population is outside any protected area and epiphytes are strongly pressured by gatherers. Fire management should be improved in order to avoid late season severe burnings that kill even old plants, and we reinforce the importance of increasing Serra do Cipó National Park limits towards eastern slopes, where *V. gigantea* prevail.

Keywords: conservation status; Espinhaço Chain; narrow endemism; phorophyte; Protected Areas.

INTRODUCTION

Assessing the extinction risk of a species is an essential step towards setting priorities for conservation in a scenario of habitat degradation and cascading extinctions (IUCN 2008). In highly bio diverse countries such as Brazil (Levinsohn & Prado 2005), linking conservation assessments of species or their surrogates (*e.g.* communities, ecosystems; Cowling *et al.* 2004), which result in official documents such as Red Lists and Action Plans (for target species, regions or categories of threat, Peres *et al.* 2011), aiming effective management and on-the-ground conservation is a challenge. There is an extra-large demand for research and conservation actions, besides conflicting decisions and small budgets (Murdoch *et al.* 2007).

In the last years a large assessment effort for Brazilian flora and fauna (4,617 and 12,256 species evaluated, respectively) resulted in impressive figures: 2,113 species of plants and 1,173 species of animals are officially recognized as threatened following IUCN categories and criteria (IUCN 2001). Among the 2,113 threatened plant species, 708 occur in Minas Gerais state, mainly along the vegetation known as *campos rupestres* or rupestrian grasslands, – associated mainly to quartzitic rock outcrops of *Serra do Espinhaço*, a mountain chain of ca. 1,000 km extending in N-S direction, in eastern Brazil (Giulietti *et al.* 1987, Pirani *et al.* 2003) (Figure 1). Rupestrian grasslands are characterized by high species richness and high numbers of narrow endemics.

Vellozia gigantea Mello-Silva & Menezes (Velloziaceae) is a narrow endemic plant from Southern portion of the Espinhaço Chain, associated to the rupestrian grasslands. Reproductive material of the species was first collected in 1989 and described in 1999 (Mello-Silva & Menezes 1999), despite being a conspicuous plant often reaching 6m height – the largest known Velloziaceae – growing in a graminoid landscape, and despite the strong botanical research effort in the region since 1970 (Giulietti *et al*. 1987, Madeira *et al.* 2008).

Although geographically restricted, *V. gigantea* may be considered a key species, due to the large number of epiphytes that densely cover its pseudo-trunks – many Orchidaceae, Bromeliaceae and ferns (Figure 2). Among the endemic species of the rocky fields of Serra do Cipó, *V. gigantea*, commonly known as "canela-de-ema-gigante", is remarkable, reaching the largest size reported for the family – 7.4 m. *Grobya cipoensis*, an endemic orchid classified as critically threatened (MMA 2014a), has only been observed on its branches (Barros & Lourenço 2004), but others are able to grow on branches of other dracenoid *Vellozia*, or even on treelets or on rock surfaces.

The epiphytes are still heavily harvested, due to the commercial trade of ornamental plants. In addition to that, *Vellozia* spp. branches have historically been a relevant source of fuel for domestic uses all along the Espinhaço Chain, due to its resin content. Orchids are usually collected attached to *Vellozia* spp. branches, resulting in an attractive flower arrangement. The same is observed for *V. piresiana* (Werneck & Espírito-Santo 2002), another dracenoid species found along the western neighboring valleys. Antropogenic wildfires are declining in frequency, but not in severity and extension, and still are a common threat in the region, with variable effects upon Velloziaceae species and on their epiphyte flora. Most wildfires are related to cattle ranching practices. However, cattle removal from some protected areas, like Serra do Cipó National Park, where *V. gigantea* occurs, is leading to high fuel accumulation and to catastrophic fire events in the driest months, in the absence of bold management practices (Figueira *et al*. 2016). It is also worth noting that natural burnings caused by lightening are becoming more common, probably another consequence of biomass/fuel accumulation.

Vellozia gigantea had not been yet described when the first regional assessment about threatened species was published (COPAM 1997) as well as the first national lists (IBDF 1968, IBAMA 1992). No Velloziaceae species were evaluated as threatened in official lists up to 1992, and IUCN world list yet does not include any species from this clearly vulnerable family (no entries for '*Vellozia*', '*Barbacenia*' or '*Pleurostima*' in February 2016). In 2005 *V. gigantea* was classified as endangered (EN B2ab ii, v), i.e. occupancy area smaller than 500km^2; severely fragmented/ number of locations and continuing decline in occupancy area and number of mature individuals (Biodiversitas 2005), according to IUCN notation, but the species was included in the large group of "data deficient" (DD) species in the 2008 Brazilian Red List (MMA 2008). The Biodiversitas' list (2005), that based the official one, included 10 Velloziaceae species, six from the genus *Vellozia*. From those, three were classified as vulnerable (VU) and three as critically endangered (CR). The 2014 Official List (MMA 2014a with details in Flora Red List - Martinelli & Moraes 2013) recognized 17 *Vellozia* species as threatened (16 EN and 1 CR) and *V. gigantea* was classified as EN B1ab(iii)+2ab(iii), based also on unpublished data. The notation means that the evaluation considered the geographic distribution (criteria B), either the extension of occurrence (B1), less than 5.000km^2, and area of occupancy (B2), less than 500m^2, and also less than 5 locations and decline in area, extension or habitat quality (IUCN 2001). Population size or number of mature individuals were not mentioned in analyses and reports.

When this study began, only one *V. gigantea* patch of ca. 1ha was known by field researchers, located within Serra do Cipó National Park, 2km away from a recently paved road, contiguous to the park limit (Menezes & Mello-Silva 1999). New information on the species occurrence (personal communication with locals) was the main drive for the present assessment, which is based in surveys that started in 2004. Results were disseminated in technical reports (ICMBio 2009) and based further studies (see Ribeiro *et al.* 2009, Lousada *et al.* 2011, Dutra 2012).

Here we bring more detailed data about the species, embracing its geographic distribution, estimations of population size and structure, an evaluation of its importance for the epiphyte community and some data about the effects of fire. The objectives are to contribute to a refinement of the species official extinction risk assessment (Brazilian government formally recognizes IUCN criteria and categories – MMA 2014b), and to develop recommendations for conservation actions and plans, also highlighting the importance of *V. gigantea* for the epiphyte community.

MATERIAL AND METHODS

Study site

The search for not registered *V. gigantea* patches was concentrated in the region of Serra do Cipó, the southernmost part of the long mountain chain called Serra do Espinhaço (Espinhaço Chain, Figure 1), that extends along ca. 1,000km in N-S (parallels 11ºS – 20ºS). "Serra do Cipó" is a progressively more generic name, for reasons related to tourism and marketing, but here we considered mainly the region comprised by two

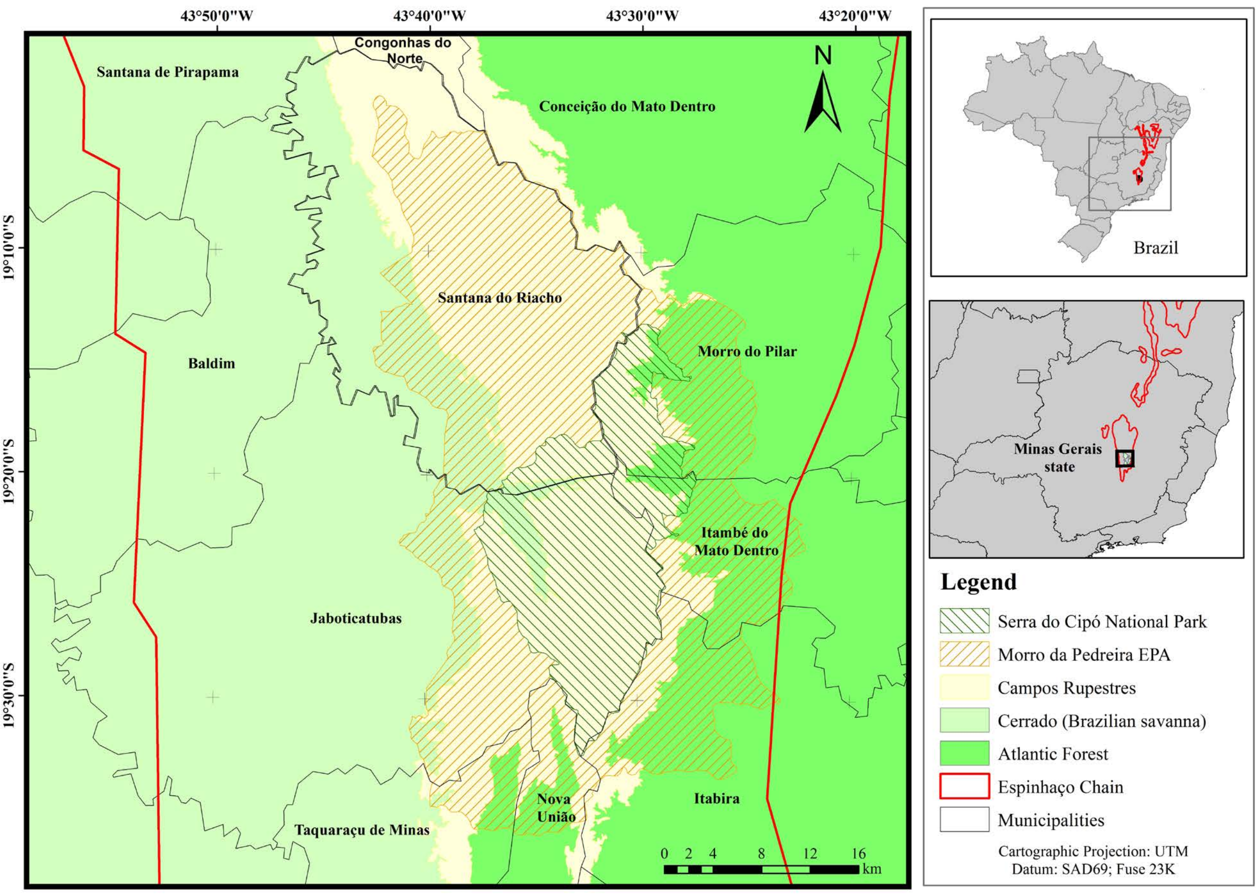

Figure 1. Region of the study area on Minas Gerais state, southeastern Brazil, with protected areas limits, vegetation domains, and municipal boundaries. Atlantic Forest limits shown here are those proposed for the region by Ribeiro *et al*. (2009), not the official ones (a downscaling process).

federal protected areas: Serra do Cipó National Park (SCNP, 31,639ha, well classified in IUCN category II) and Morro da Pedreira Environmental Protection Area (MPEPA, with 100,009ha, close to IUCN category V) distributed as a belt around the Park, like a buffer zone (Figure 1).

The Espinhaço Chain is predominantly composed by sedimentary and metamorphic rocks, which decomposes into nutrient-poor sandy soils with low water retention capacity. Quartzite rock outcrops, covered by a shrubby vegetation, are found everywhere, intermingled with graminoid sandy plains, gravelly slopes covered by a shrubby vegetation and forest patches associated to water drainages, more humid slopes or patches of soils of distinct geological origin (ICMBio 2009). Quartzitic outcrops prevail above 900-1,000m a.s.l., favoring open vegetation physiognomies, collectively known as 'rupestrian grasslands' (*campos rupestres*). In Serra do Cipó, rupestrian grasslands are distributed between the Atlantic Forest domain, to the East, and the *Cerrado* (Brazilian savanna) domain, to the west (Figure 1), two world biodiversity hotspots, considering species richness and incident threats (Myers *et al.* 2000).

The western portion of Serra do Cipó has been frequently included in botanic surveys under the leadership of University of São Paulo (USP) since the 1970's (Giulietti *et al.* 1987). Comparable results on species richness and endemism are being reported for other areas along the Espinhaço Chain (ex. Serra do Ambrósio, Grão Mogol and Chapada Diamantina; Pirani *et al.* 1994, Meguro *et al.* 1994, Mello-Silva 1995, Pirani *et al.* 2003, Conceição & Pirani 2005). This mountainous region has rainy summers and dry winters, when air humidity reaches below 25% during the day. Reported precipitation is around 1,500mm, but it is quite variable between eastern and western slopes, although this pattern is not formally described yet (Ribeiro *et al.* 2009).

The conspicuous presence of the families Velloziaceae, Eriocaulaceae and Xyridaceae largely characterize the rupestrian grasslands, amounting to ca. 800 species, out of which 90% are endemics to this vegetation complex (Giulietti *et al.* 2005). From the 58 Velloziaceae species found in Serra do Cipó, 46% are local endemics, 45% endemic to the Espinhaço Chain and only 8.5% have a broader documented distribution (Giulietti *et al.* 1987). The clumped pattern of very dense occurrence of individuals, associated to rocky environments and specific site conditions is very common for the family (Magalhães 1953). Rock outcrops are scattered along this type of landscape and constitute isolated environments which may act as barriers for fire and other disturbs, and potentially also for species dispersion and genetic exchanges between populations (Larson *et al.* 2000).

Geographic distribution

The search for new *V. gigantea* patches began in 2004. All trails within SCNP/MPEPA and those connecting the mountains to the closest villages within each valley were covered by 20 expeditions, summing 80 days of fieldwork. In the field, plants were easily found due to their distinctive size and appearance. Nevertheless, access difficulties due to the craggy relief led some plant patches to escape from our first search effort. Thus, other three groups of patches were discovered later and included in the extinction risk assessment. Determination was confirmed with the help of plates (Menezes & Mello-Silva 1999), and using exsiccate prepared with material from the population where the holotype was collected. Additional exsiccates were prepared with material from other three patches (BHMH 101421, 102620, 102622). Further, many other excursions were made, covering broad areas from Serra do Cipó up to Diamantina and, specifically, more detailed excursions were made to Conceição do Mato Dentro, near Serra do Cipó to the north, and to many sites within the "Iron Quadrangle", to the South, places where the transition from Atlantic forest to rupestrian grasslands is clear, with high density of clouds. However, since these surveys were mostly non-systematic, the number of days was not computed.

Boundaries of most *V. gigantea* patches were mapped in detail with the use of the GPS. In more dangerous places, sketches were drawn on topographic maps with the help of binoculars. Trails to populations were also mapped. All information was organized in GIS environment using the software Arcview©. The geographic distribution was determined based on two criteria (IUCN 2001): B1. extension of occurrence (EOO), calculated using a minimum convex polygon containing all known presence patches, and B2. area of occupancy (AOO), with a $4km^2$ cell grid used to calculate the resulting area of the cells with mapped patches (IUCN 2001).

Locations

The concept of location is considered under criteria B and D, by IUCN (2001). Here we shortly explain this concept in order to make clear our rationale when delimiting locations for *V. gigantea*, since it has a large degree of subjectivity. Location is conceptually quite different from sub-population. Whereas IUCN (2001) defines sub-populations as distinct groups within a population between which no genetic or demographic mixing occur; a location is an area where a single event can rapidly affect all members of a taxon, with clear emphasis on threats. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location definition should be based on the most serious plausible threat.

Although the delimitation of locations can be hard and imprecise, since inferences will vary greatly according to the source of threat considered, and the own choose of which source of threat is the worst is somewhat arbitrary and subjective, it may be useful when sources of impact are clear. For *V. gigantea* we considered the occurrence of wildfires as the most relevant incident threat, although individuals have shown to be quite resilient to its effects. Other threats are habitat conversion due to urbanization and mining, but most places where the species occur are relatively well protected by the rules of the two protected areas: the National Park, that completely prevent urbanization and mining, and MPEPA, with strong restrictions to land use and prohibition of mining on rupestrian grasslands sites, stated clearly since its decree.

Vellozia gigantea *population size and structure*

We described the population structure for sites from different locations (Figure 3). Population structure of *V. gigantea* was detailed for locations L1 (two sites), L3 (one site) and L4 (two sites). The other sites had too bad or dangerous local conditions for the establishment of transects.

Vellozia gigantea patches often have a sharp border, considering plant density. Few plants are found along the sandy plains, despite being the microhabitat where the tallest plants were found. Two transects were established at one patch per site, resulting in 10 transects, always beginning in the sandy plain near the outcrop edge, and going towards an imaginary center. Each transect was 50 meters long, composed by 10 adjacent 5x5m quadrats ($250m^2$ each one). All included individuals were counted and measured, considering height, diameter at the basis and number of dead and living branches. Signs of fire or lack of them were registered for each plant. Standing dead plants were also counted.

We considered that the lack of independence between quadrats within transects would be compensated by a better understanding of the transition from rock outcrops to sandy plains, a relevant information for conservation due to the quite different effect of fire over each habitat, with higher intensity in sandy plains than in rock outcrops. *V. gigantea* is visibly associated to rock outcrops, but we suspect, from field observations, that this strong association is largely derived from high fire intensity on open grasslands.

Population size was estimated multiplying the mean density of plants per pair of transects by the summed area of correspondent patches, per location. To estimate the number of mature individuals considering IUCN protocol, we made the same calculation considering density of plants above 40cm – we didn't observe flowering plants below this size, even in mass flowering after fire (see below). For locations where no detailed population structure counting have been performed we made inferences using the whole average density of *V. gigantea* among all transects.

Epiphytes

We also quantified the presence/absence of epiphytes on *V. gigantea* branches including alive and dead individuals. The structure of epiphyte community is not presented here. This information does not contribute to the assessment of conservation status of *V. gigantea* but stresses the risk associated to an eventual extinction of *V. gigantea*, putting it as a key species for this epiphyte community.

Reproduction after wildfire

Since intense wildfires were considered the main threat to *V. gigantea* in the present, we used the occurrence of two not natural wildfires to observe the exposition of plants to fire and its response in terms of mass flowering. Patches from L3 burned unequally in October 2005, and from L5 in February 2006. In L3 we quantified the number of blossoms, flowers and fruits on all surveyed individuals within the population structure transects. In L5, where population structure was not described in detail, flowering and fruiting plants after fire were counted along a single 10x100m transect in N-S direction, with no subdivisions. Each plant was classified according to presence or absence of recent fire signs (these are very clear – the very flammable stems become covered by charcoal). In both sites, these counts were performed three months after fire. Differences between populations in proportion of flowering/fruiting plants, in proportion of plants with fire signs, or in plants size were tested by multifactorial ANOVA, with reproductive event as dependent variable, fire and plant height as factors and populations as cofactor.

Defining generation time

Estimation of generation time is an important step to go across IUCN criteria, defining the time scale of many analyses (it is considered the period of at least 10 years of the generation time, the larger one, up to a maximum of 100 years). To obtain a very conservative estimate of generation time for *V. gigantea* we considered the height of the smallest plant class with fruits sampled across the transects, and calculated the minimum age for reproduction based on a rough estimate of *V. gigantea* growth rate proposed by Alves & Kolbek (1994): ca. 1cm per year. With this approach we estimated the minimum reproductive age to be 40 years old, and the minimum time for 3 generations as 120 years. Considering that plants reproduce continuously from 40cm up to 6m height, and that a reasonable form of calculating mean generation time is considering the mean parent age of a whole offspring (Harper 1977), *V. gigantea* mean generation time would easily pass the 100 years reference limit proposed by IUCN criteria. So, we employed the period of 100 years. We had not been able to model any change in distribution or population size beyond this time scale, due to the lack of long data series, but the calculation was important to show which criteria we could really use to evaluate *V. gigantea* extinction risk, and to orientate future researches. We had enough data to run the analyses using criteria B and C, i.e., geographic distribution and population size.

RESULTS

Geographic distribution

We found and mapped 44 *V. gigantea* main patches, from 1,100 to 1,300m a.s.l.. Table 1 shows the coordinates of the centroid of the pool of patches of each location (see location definition above) and the summed area of patches per location. Only L1 is mostly inside SCNP limits; L2, L3, and L4 are partially inside SCNP, but mostly inside MPEPA; L6 is entirely within MPEPA; L5 is partially inside MPEPA, but mostly unprotected, and L7 is entirely unprotected (Table 1). The whole population occupies 2,943.6 hectares (summed area of the 44 patches): 21.4% inside SCNP, 56.5% inside MPEPA and 22.1% unprotected (Table 1). The first known *V. gigantea* patch, part of L1, previously supposed to have 1ha, has actually more than 19ha.

Fire signs were found in 70.7% of the sampled plants (Table 2). Only eight out of 44 patches had no signs of fire, and these were places where juxtaposed rock plates protected plants from flames (Figure 2). Some patches, mainly those outside the park, had many cut plants, due to the use as firewood or to epiphyte harvesting for commerce. Most patches showed clear signs of cattle presence, except L1, situated quite near to a surveillance post of SCNP.

V. gigantea extent of occurrence (EOO) is 44,285.72 ha (Figure 3). The area of occupancy

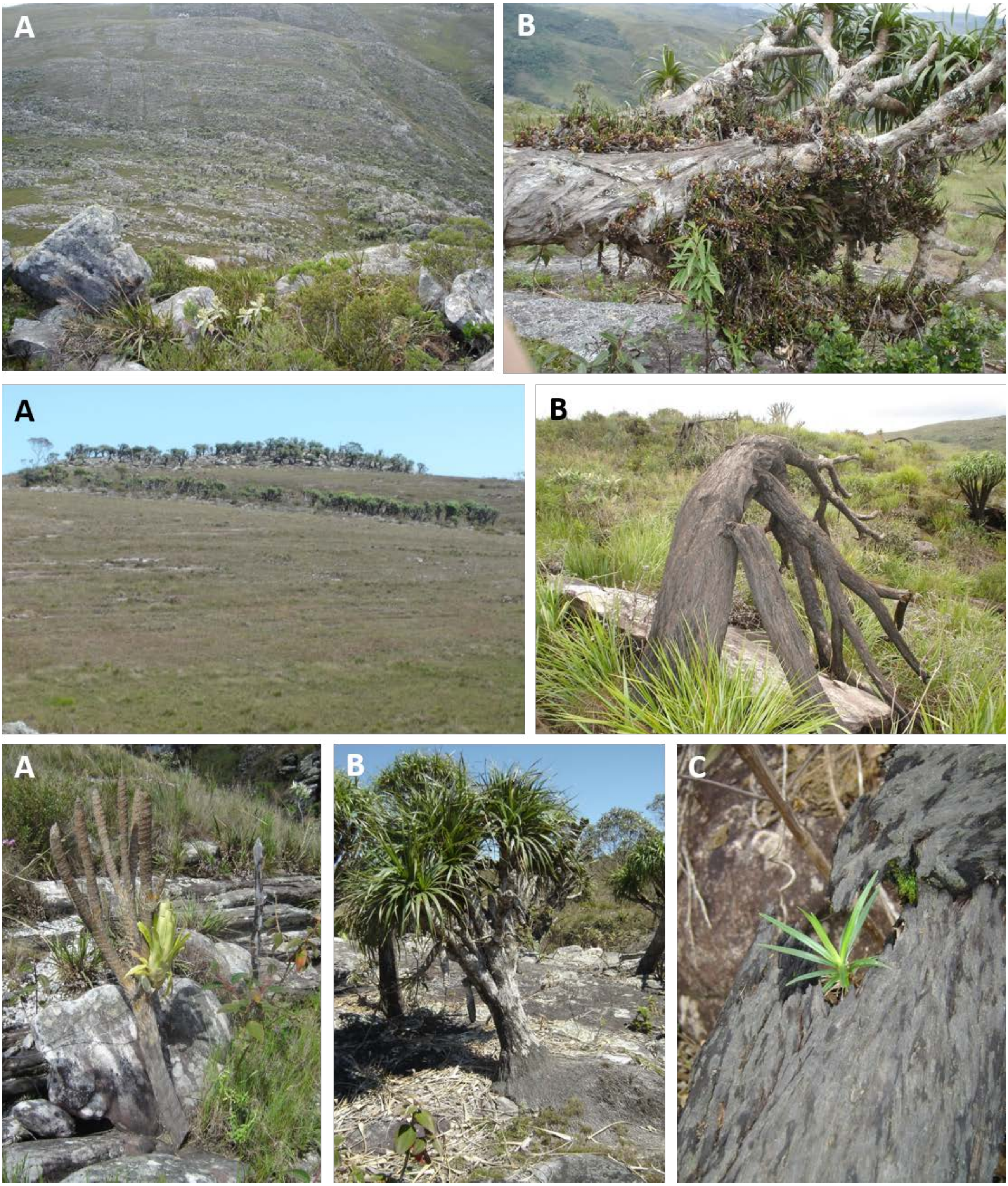

Figure 2. A. Mist reaching a *Vellozia gigantea* patch, within Serra do Cipó National Park (photo by Guilherme Freitas); B. A *V. gigantea* branch covered with epiphytes; C. A *V. gigantea* patch molded by fire, with plants as refugees on the rock outcrops; D. A tall plant killed by fire within the severely burned grasslands; E. A plant intentionally cut, probably for commerce of epiphytes; F. A site clearly protected from fire, with a deep layer of dead leaves; G. Seedling growing on a burned dead plant (B-F photos by Katia Torres Ribeiro).

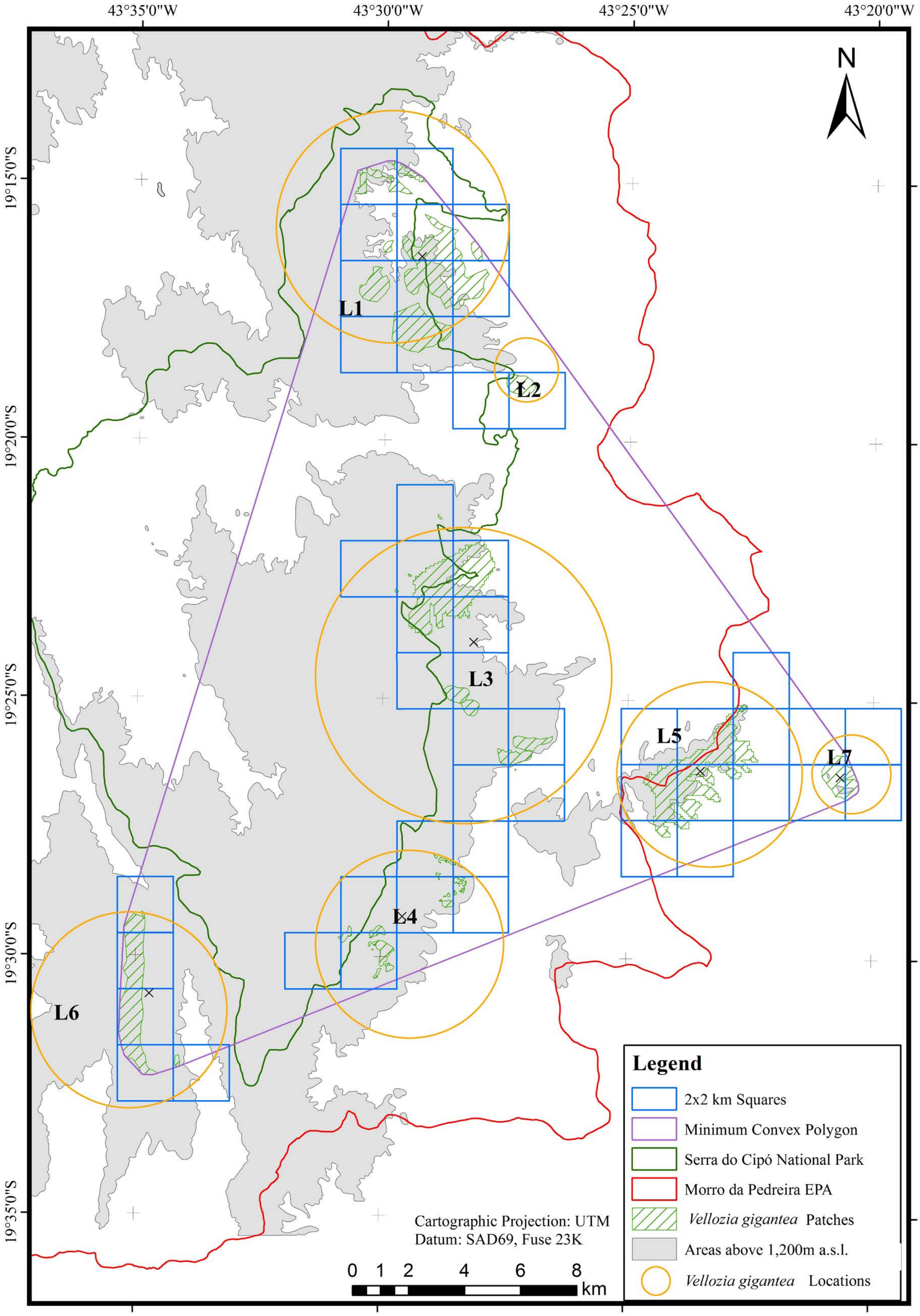

Figure 3. Distribution of *Vellozia gigantea* patches and illustration of parameters used to determine the species conservation status, according to IUCN criteria – area of occurrence (AOO), given by the number of 4km^2 squares with *V gigantea* presence, and extent of occurrence (EOO), given by the minimum convex polygon (MCP) that covers all the species patches.

(AOO), here considered as the sum of all individual patches areas, resulted in 2,946.2 ha (Table 1).

Locations

We proposed seven locations (L1 – L7, Figure 3), considering patches along the landscapes that could often be affected by a single fire event, using França & Ribeiro (2008) mapping of burnt areas between 1984-2007. In Serra do Cipó, fire propagation is usually strongly reduced in deep valleys, so the recognized groups are separated by V-shaped valleys.

Population size

Along the 2,500 m^2 of sampled area, 788 individuals were found and measured. From those, 475 (60.3%) were alive. Abundance of living plants in 500 m^2 varied from 61 to 159 (Table 2). Population structure among transects varied a lot, from an inverted J structure to sites with clear predominance of large plants, but small plants were found anywhere, suggesting effective recruitment along all the distribution area (Figure 4). Although even small plants can be many decades old, field observation reinforce the idea of effective recruitment in the last years – seedlings were found near dead carbonized plants laid on the ground, most probably victims of a severe wildfire occurred in 1999 (França & Ribeiro 2008). The proportion of mature (above 40cm) individuals within the sample was 78.4%.

Proportion of living plants within locations varied between 41.7 and 83.5% (Figure 4), and mean proportion of living plants was 60.3 for the whole sample, 55.3% between plants with fire signs and 72.2% between plants with no fire signs. Absolute and relative numbers of living, standing dead and burned individuals are in Table 2.

The total number of plants, including living and dead ones, was estimated in ca. 10.7 million plants, being 6 million alive and 4.7 million dead. The mean population density (plants/m^2) was 0.190 (0.315 with standing dead plants). Living and dead *V. gigantea* plants were functional phorophytes for epiphytes and, in one location (L1a), dead plants harbored higher abundance and richness of epiphytes than living ones. The importance of dead plants for the epiphyte community is evident (Table 3).

Reproduction after fire

In L3, 350 individuals were sampled, and 65.1% had recent fire signs. From the 228 burned individuals, 72.8% had flowers and/ or fruits, versus 4.1% among the 122 unburned plants. In L5, from the 201 sampled individuals, 47.2% had fire signs. From those 95 recently burnt plants,

Table 1. Coordinates of the centroid of each location proposed for *Vellozia gigantea;* summed area of *V. gigantea* patches; area of patches inside Serra do Cipó National Park (SCNP); area of patches inside Morro da Pedreira Environmental Protected Area (MPEPA) and area of patches under no protection (Outside).

Loca-tions	Geographical coordinates		Total area of patches (ha)	Absolute area (ha)			Percent area		
	Latitude S	Longitude W		SCNP	MPEPA	Outside	SCNP	MPEPA	Outside
L1	19º16’26.8”	43º29’16.2”	931.9	475.6	456.2	0	51.0	49.0	0
L2	19º30’44.5”	43º34’42.9	58.9	2.5	56.4	0	4.2	95.8	0
L3	19º23’54.0”	43º28’9.5”	720.9	140.9	580.0	0	19.6	80.4	0
L4	19º29’13.2”	43º29’33.9”	97.8	11.2	84.0	0	11.8	88.2	0
L5	19º26’21.8”	43º23’30.7”	621.4	0	103.2	518.2	0	16.6	83.4
L6	43º34’42.9”	19º30’44.5”	383.8	0	383.8	0	0	100	0
L7	43º34’42.9”	19º30’44.5”	131.5	0	0	131.5	0	0	100
	Total population area		2,946.2	630.3	1,663.6	649.7	21.4	56.5	22.1

Table 2. Number of living and dead *Vellozia gigantea* plants with or without fire signs, found within 500m^2 at each sampled site, per location.

Locations	Plants			Fire signs		With fire signs		No fire signs	
	All	Alive	Dead	Yes	No	Alive	Dead	Alive	Dead
L1a	172	89	83	106	66	31	75	58	8
L1b	168	70	98	105	60	41	64	27	33
L3	251	159	92	194	57	124	70	35	22
L4a	115	96	19	84	31	66	18	30	1
L4b	82	61	21	66	16	45	21	16	0
Total	788	475	313	555	230	307	248	166	64
Percent		60.28	39.72	70.7	29.3	55.32	44.68	72.17	27.83

57.9% had flowers and/or fresh fruits, contrasting with the 6.6% among unburned plants (Table 4). Probability of flowering is also influenced by plant size (fire effect: F=169.84, p<0,001; plant height effect: F=9.68, p<0.001; fire*height: F=5.75, p<0.01; site effect: F=13.31 p<0.001; R^2=0.502). All factors together had significant effect, suggesting that flowering is induced by fire occurrence, but the effect is also related to plant height and environmental characteristics that in turn affect fire intensity.

Defining conservation status

Considering the available data, we were able to run the analyses using criteria B and C (IUCN 2001). *i.e.*, considering geographic distribution and number of mature individuals. For geographic distribution we considered B1 - extension of occurrence (EOO) and B2 - area of occupancy (AOO), and also the number of locations, a further issue for either choice. The results were respectively 442.86km^2 EOO; 196.00km^2 AOO and 7 locations.

Table 5 shows that in relation to B1 and B2 the figures are a little above the threshold for CR (critically threatened) category and well below the threshold for EN (endangered). According to the method, at least two other conditions must be met to classify the species into a category – the number of locations is one of the conditions to be observed – we proposed the number of seven, above the limit for EN and compatible to Vulnerable status (VU). In relation to population numbers (mature individuals, total number of individuals), estimated values are well above any threshold for threatened categories (78.4% of the sample individuals – in a simple proportion for a 6 million plants, ca. 4.6 million), and successful reproduction is occurring, as shown by high proportion of reproducing individuals and recruitment of new individuals. The other met condition is a degradation in habitat quality (iii). So, we understand that the species could be reclassified as VU B1ab(iii) + 2ab(iii).

DISCUSSION

Vellozia gigantea is highly associated to rock outcrops along eastern humid slopes and may be seen as equivalent to dwarf trees along cloud forest mountain belts. Only 21.4% of its population is inside SCNP, 56.5% inside MPEPA and 22.1% outside any protected area, in places well pressured by urban expansion/ habitat degradation (around Belo Horizonte metropolitan region). *V. gigantea* is an endemic but locally dominant plant, as shown by the estimated number of individuals alive (ca. 6 millions) – these are rough numbers, but communicate well the dominance and the importance of the species for a rich epiphyte community, with large number of individuals (estimated 51 million individuals) growing on branches of living (ca. 60%) and standing dead (40%) plants. Some of these epiphytes are the orchid *Grobya cipoensis*, a critically threatened species, and *Hadrolaelia coccinea*, classified as LC – Least Concern, but strongly pressured by illegal harvesting. Other common species are the orchids

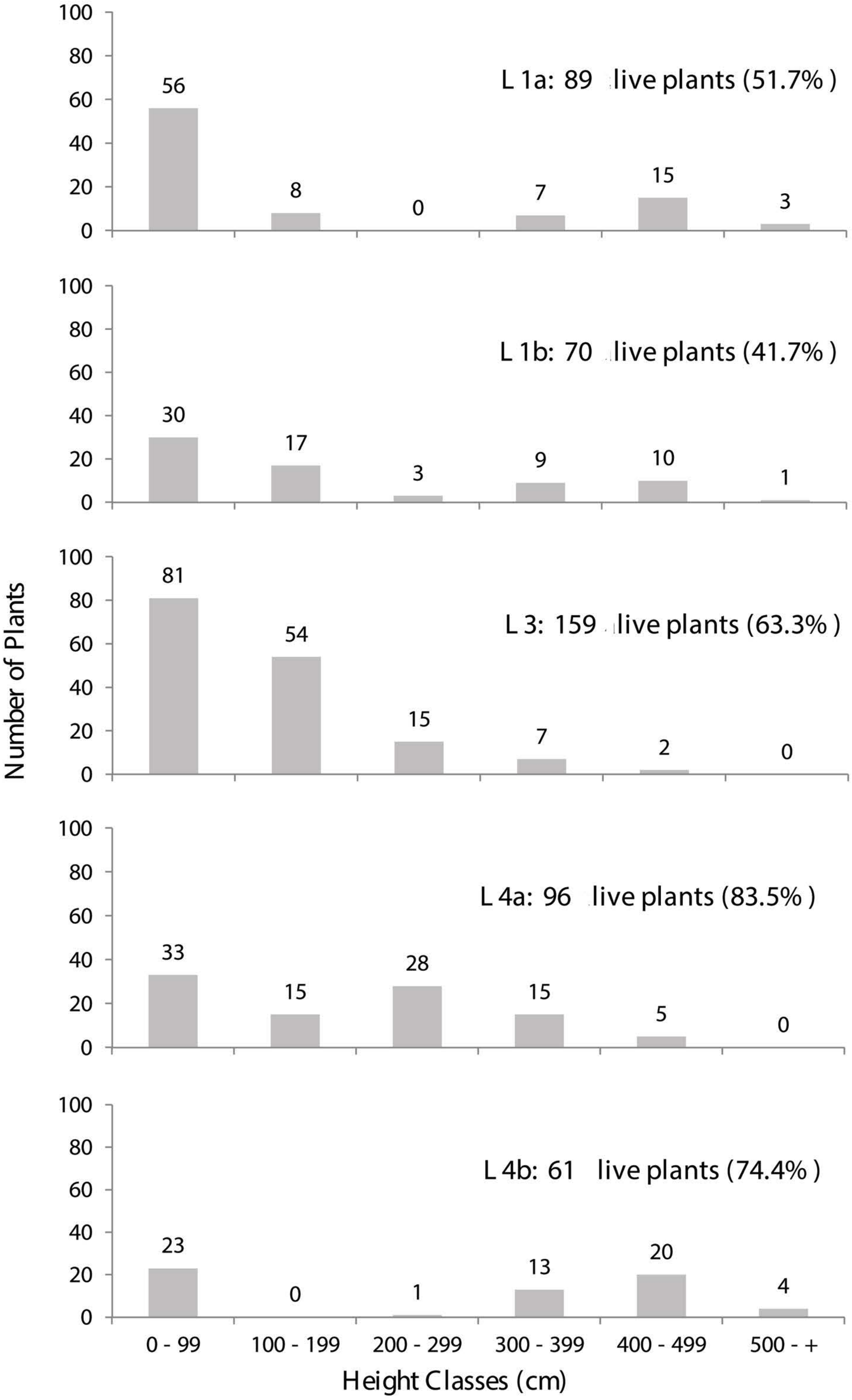

Figure 4. Population structure of *Vellozia gigantea* along five transects.

Maxillaria madida and *Prosthechea pachysepala*, and the bromeliad *Vriesea oligantha* – they have not been evaluated yet, according to JBRJ (2016).

Here we propose the classification of *V. gigantea* as Vulnerable, differently from the current official classification (MMA 2014a), this one following the broad assessment reported in Martinelli & Moraes (2013), where it has been

Table 3. *Vellozia gigantea* density (plants/m^2) per transect and estimated total abundance, obtained by density x patches summed area; estimated abundance of epiphytes.

Location	Summed area of patches (ha)	Density		*V. gigantea* estimated abundance			Estimated abundance of epiphytes		
		Living plants/ m^2	Standing dead plants/ m^2	Living plants	Standing dead plants	Total	On living plants	On dead plants	Total
L1a	85.3	0.178	0.166	151,834	141,598	293,432	178,847.8	215,706.9	394,555
L1b	846.6	0.140	0.196	1,185,240	1,659,336	2,844,576	5,009,679.8	3,188,102.4	8,197,782
L2	58.9	0.190	0.125	111,910*	73,743*	185,653*	429,426.2*	200,185.7*	629,612*
L3	720.9	0.318	0.182	2,292,494	1,312,056	3,604,550	19,706,354.4	2,187,467.8	21,893,822
L4a	68.7	0.192	0.038	131,904	26,106	158,010	668,269.4	14,725.5	682,995
L4b	29.1	0.122	0.042	35,526	12,230	47,757	244,271.5	56,410.5	300,682
L5	621.4	0.190	0.125	1,180,660*	777,993*	1,958,653*	8,543,383.6*	2,011,410.0*	10,554,794*
L6	383.8	0.190	0.125	729,220*	480,518*	1,209,738*	5,277,304.7*	1,247,173.7*	6,524,478*
L7	131.5	0.190	0.125	249,850*	164,638*	414,488*	1,807,955.3*	427,270.1*	2,235,225*
Total	2,946.2	0.190	0.125	6,068,638	4,648,218	10,716,856	41,865,493	9,548,453	51,413,945

* For L2, L5, L6 and L7 the count was not performed, so we used a mean value based on all the other groups. For L1 and L4 two counts were performed.

Table 4. Presence or absence of flowers and/or fresh fruits on burned and unburned *Vellozia gigantea* plants after wildfire events occurred in Locations 3 and 5.

	Height class (cm)	Burnt				Unburnt				Total per class
		reproducing		vegetative		reproducing		vegetative		
		N	%	N	%	N	%	N	%	
Location 3	1 – 50	2	20	8	80	0	0	28	100	38
	51 – 100	38	55.1	31	44.9	3	6.7	42	93.3	114
	101 – 150	47	75.8	15	24.2	1	3.0	32	97.0	95
	151 – 200	20	95.2	1	4.8	0	0	9	100	30
	201 – 250	17	89.5	2	10.5	1	25.0	3	75.0	23
	251 – 300	18	81.8	4	18.2	0	0	3	100	25
	301 – 350	14	93.3	1	6.7	0	-	0	-	15
	351 – +	10	100	0	0	0	-	0	-	10
	Total/Mean	166	72.8	62	27.2	5	4.1	117	95.9	350
Location 5	1 – 50	0	0	8	100	1	5	19	95	28
	51 – 100	2	25	6	75	1	11.1	8	88.9	17
	101 – 150	3	75	1	25	0	0	4	100	8
	151 – 200	11	84.6	2	15.4	3	25	9	75	25
	201 – 250	19	63.3	11	36.7	1	3.8	25	96.2	56
	251 – 300	12	57.1	9	42.9	0	0	22	100	43
	301 – 350	7	77.8	2	22.2	0	0	10	100	19
	351 – +	1	50	1	50	1	33.3	2	66.7	5
	Total/Mean	55	57.9	40	42.1	7	6.6	99	93.4	201

Table 5. Thresholds for extension of occurrence (EOO), area of occurrence (AOO), locations, and number of mature individuals for the categories CR - critically threatened; EN – endangered and VU – vulnerable and the values obtained for *Vellozia gigantea* both in Valente *et al*. (2013) and by the present study.

Category	EEO	AOO	Locations	Mature individuals
CR	< 100 km^2	< 10 km^2	1	< 50
EM	< 5,000 km^2	< 500 km^2	5	< 2500
VU	< 20,000 km^2	< 2,000 km^2	10	< 10,000
V. gigantea – 2013	232.66 km^2	16 km^2	2	551
V. gigantea – here	442.86 km^2	196.00 km^2	7	> 4 million*

* Based on proportions after sampling.

classified as Endangered. Indeed, for the variables extension of occurrence and area of occurrence the values are below the threshold values for the endangered category. The difference is related to complementary data and also to the explicit consideration of the location concept in our approach – we propose seven locations for *V. gigantea*, considering wildfires as the current main threat (see Figueira *et al*. 2016) since large portion of the populations (77.9%) are within protected areas. Morro da Pedreira EPA is not a strict use protected area but rupestrian grasslands receive special protection, officially, and good control of habitat conversion.

For the big challenge of assessing conservation status for a large set of Brazilian flora, under the leadership of Rio de Janeiro Botanic Garden, there was an investment in data cleaning and organization and automation of pre analyses, before appreciation by specialists. Three basic information were used in most assessments: taxonomic literature, electronic herbarium specimen data and spatial cover data (Raimondo *et al.* 2013). Valente *et al*. (2013), for this large assessment effort, report the following numbers: EOO – 232 km^2 and AOO – 16 km^2. They mention that studies raised the number of 551 mature individuals, for two sites – a population within SCNP and one in Serra do Lobo – probably the assessment considered the existence of two locations. *V. gigantea* is badly represented in herbaria, what can partially explain the disparity in results in relation to the present analysis.

We are completely aware that such a detailed characterization of a species population like the present shown here is not a feasible goal for a megadiverse country like Brazil with a high proportion of endemic species. But, as emphasized by Raimondo *et al.* (2013), many endemic and threatened species occur together and are suffering from the same main pressures and drivers, and a deeper study of a species may contribute for the assessment of other species, this is clear in the case of *V. gigantea* due to the high number and abundance of associated epiphytes.

Despite the presentation of a less severe classification in relation to Valente *et al*. (2013) and the official list, we stress that, for conservation purposes, it should be registered that geographic distribution numbers are close to EN category, that the summed area of patches where the species really occur is only 29 km^2 and that 22.1% of the described patches, in terms of area, have no specific protection. The high genetic or holotypic structure between populations of this species (and other in rupestrian grasslands) (Lousada *et al.* 2011) points to a justified concern with the whole species distribution, in order to maintain its genetic diversity. Further, we highlight its importance for the epiphyte community – for example, we estimated the number of 21 million epiphyte individuals for L3 patches – they are in a region rarely surveyed by the park staff, and very susceptible to illegal harvesting.

We made an estimation of the generation time for the species since some criteria consider the fluctuations in geographic distribution, population size, number of locations, and so on, in the period correspondent to three generations or ten years (the larger one). Yet, we did not use this information in the evaluation since there is no documentation about the distribution, small scale habitat prevalence or number of individuals 100 years ago, remembering that the species has been described recently. Nevertheless, habitat degradation outside the park limits and mainly outside MPEPA is evident as well as the elimination of individuals from the flat sandplains and marshes due to catastrophic fires related to fuel accumulation and anthropic ignition sources at the late dry season. On the other hand, we may consider that the population is already severely limited to the rock outcrops, not due exclusively to habitat specificity but clearly due to fire (see Figure 2C), and even in this context it has a very high number of mature individuals successfully reproducing.

Rupestrian grassland areas appear to be more arid than they really are. Humidity tends to be higher at this altitude than in the lower surroundings, even in more arid microhabitats. It is noticeable the availability of moisture over these rocky outcrops, if compared to the surrounding environments, due to orographic condensation and frequent fogs (Alves & Kolbek 1994). In Serra do Cipó, there is a striking contrast between the savannah physiognomy (Cerrado), to the west, and the more humid slopes towards the Atlantic Forest domain (Ribeiro *et al.* 2009). Velloziaceae pseudo trunks, composed by old leaves sheaths and adventitious roots with velamen, are able to capture nebular water (Giulietti *et al.* 2000).

Alves & Kolbek (1994) argue that the mountain ranges with rupestrian grasslands may have acted as refuges during adverse drier periods, believing that confinement of xerophytic species in these mountain ranges (and its relative scarcity all around) nowadays is mainly due to soil conditions. In the case of *V.gigantea*, we believe that in addition to edaphic specificity, mist dew and orographic rain play a fundamental role in the spatial distribution of the species and also of some associated epiphytes, clearly related to the Atlantic forest domain (ex. *Grobya cipoensis* and *Hidrolaelia coccinea*).

Based partially on the data presented here, Dutra (2012) run predictive analyses in order to assess the potential distribution of *V. gigantea* (and *V. auriculata*, that occurs to the north), using climatic, topographic and vegetational (ex. NDVI) spatial data. The model using points obtained directly from previously known patches of the plant resulted in a potential area of occurrence of 750 km^2 (nearly twice the reported EEO of 442.86 km^2). The resulting region cover areas along the Eastern and also Western slopes of the mountains – both at the region known as Serra do Cipó and at the Iron Quadrangle, to the South. Yet, the author confirms that the real distribution is clearly related to the regions where orographic rain and moisture condensation are observed, as already proposed by Ribeiro *et al*. (2009), with a single exception in relation to the available maps of cloud prevalence. Recently, a small *V. gigantea* patch was found at the Iron Quadrangle (M. Dutra 2015, personal communication), specifically at Caraça, a private protected area also influenced by the ocean humidity (see Ribeiro *et al.* 2009), in a search driven by the mentioned model.

It is interesting to note that *V. piresiana*, another tall *Vellozia* species, also dominant across rock outcrops, is found in the Western portions of the map derived from Dutra's analyses, for *V. gigantea*. *Vellozia piresiana* harbors another significant array of epiphytes (Werneck & Espírito-Santo 2002), like *Constantia cipoensis* Porto & Brade, a CR species, severely pressured by the illegal trade of ornamental species (Neto 2012).

As said above, current wildfire regime is a clear threat. Wildfires are still associated to cattle ranching, but, independently of the proximal cause, we must be aware that a high accumulation of biomass is taking place, due to the absence of cattle in the Park and lack of fuel management - any source of ignition can lead to a severe wildfire as is being observed in Serra do Cipó National Park and in many other protected areas within the Cerrado domain, where the zero fire policy is still being adopted (Figueira *et al*. 2016). In the last decades, intense fires carbonized a very large number of tall *V. gigantea* plants (see Figure 2D and G), whereas some of these recently killed plants had probably survived to centuries of European human occupation. This fact must be considered in the debates about fire management – in 2015 the SCNP staff began to use prescribed burnings in the early dry season in order to protect some of the *V. gigantea* aggregations. It is probable that more audacious fire management will be needed since many patches of the plant are at difficult access places. On the other hand, plants on rock outcrops seem not to be severely damaged by fire – although also reached by flames in most cases. Mass flowering and fruiting are stimulated and seed release may eventually occur in inadequate periods – Garcia & Diniz (2003) demonstrated that germination of three species of *Vellozia* seeds, including *V. gigantea*, occurs easily, but its establishment is sensitive to slight environmental variations. Seed dispersal in a bad season may have strong effects, but most plants survive and reproduce again. Effects on the epiphyte community should be considered, since many of them are associated to the Atlantic forest domain and possibly sensitive to fire.

We suggest some conservation actions for this endangered species and its associated epiphytic community based on the current knowledge. SCNP work on fire prevention and management should explicitly consider *V. gigantea* distribution, as a main target. The use of prescribed fires, in order to protect some populations or to create mosaics of burned areas, dealing with biomass accumulation and having the heterogeneity in fire regimes, avoiding severe fires, should be explicitly discussed as a management alternative to the current zero fire police (see details in Figueira *et al.* 2016).

In addition, *V. gigantea* distribution may be considered as a surrogate for a highly diversified associated community, and its distribution must be considered in proposals of expanding SCNP boundaries to the East, towards still uninhabited slopes, in order to include nowadays weakly protected *V. gigantea* patches. Serra do Lobo, outside MPEPA, also deserves further attention.

In conclusion, adequate and bold fire management associated to a research program and further protection through the expansion of SCNP and MPEPA limits are required to cope with increasing pressures.

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