Diamonds and Daisies: Floristics and Conservation of Asteraceae in One of Brazil's Major Centers of Endemism

Authors: Chaves, Daniel Augusto, Ribeiro-Silva, Suelma, Rivera, Vanessa Lopes, Bringel, João Bernardo Azevedo, Nakajima, Jimi Naoki, et al.

Source: Tropical Conservation Science, 12(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/1940082919884292

Short Communication

Tropical Conservation Science
Volume 12: 1–18
© The Author(s) 2019
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/1940082919884292
journals.sagepub.com/home/trc
SAGE

Diamonds and Daisies: Floristics and Conservation of Asteraceae in One of Brazil's Major Centers of Endemism

Daniel Augusto Chaves[1], Suelma Ribeiro-Silva[2], Vanessa Lopes Rivera[3], João Bernardo Azevedo Bringel Jr.[4], Jimi Naoki Nakajima[5], Marcelo Brilhante de Medeiros[6], and Carolyn Proença[3]

Abstract

Brazilian rupestrian grasslands (campos rupestres) are old, climatically buffered infertile landscapes, which support many endemic species. Asteraceae show the high levels of plant endemism and contain more endangered species than any other family in Brazil. Here, we evaluated the complementarity of two protected areas for the conservation of endangered Asteraceae along the Espinhaço Mountain range, Southeast Brazil. Specifically, we investigated if the known endangered Asteraceae flora of the Diamantina District Plateau (38 species) occurs in two protected areas, Rio Preto State Park and Sempre Vivas National Park, and if these areas are complimentary or overlapping in protecting endangered Asteraceae species. To survey Asteraceae, we used a standardized RAPELD protocol (21 1 ha plots) and traditional floristic collecting (117 ha polygon/32 days/average team = 2.1 collectors) across different habitats and altitudes within both areas. RAPELD protocol recorded 115 species in a sample of 12,775 individuals of Asteraceae. Traditional floristic collecting recorded 172 species in a sample of 613 collections. Seventy-nine percent of endangered species known to occur within the Plateau were recollected by either RAPELD or traditional floristic collecting. Only 13% of endangered Asteraceae flora was common to both protected areas; 47% occur in Rio Preto State Park and 34% in Sempre Vivas National Park; combined, they recorded 68% of the endangered Plateau Asteraceae flora; only one critically endangered species was recorded. The two parks are complimentary but insufficient to protect the endangered Asteraceae flora of the Plateau; the uneven distribution of endangered species in the Diamantina District Plateau is a threat to their conservation.

Keywords

endangered species, Rupestrian grasslands, Espinhaço Mountain range, OCBIL, conservation in situ

Introduction

Floristic studies are fundamental for conservation planning (Prance, 1994; Zuquim et al., 2014). In one of the few country-level strategic studies where plants were included (Dobson, Rodriguez, Roberts, & Wilcove, 1997), the conservation of endangered plant species was found to maximize protection of endangered species of amphibians, arachnids, birds, clams, crustaceans, fish, insects, mammals, reptiles, and snails.

The campos rupestres (rupestrian grasslands) are old, climatically buffered infertile landscapes or OCBILs (Silveira et al., 2016) and, like other OCBILs in South Africa and southwestern Australia, support many

[1]Universidade de Brasilia, Brazil
[2]Centro Nacional de Avaliação da Biodiversidade e Pesquisa e Conservação do Cerrado, Brasília, Brazil
[3]Instituto de Ciências Biológicas, Universidade de Brasilia, Brazil
[4]Empresa Brasileira de Pesquisa Agropecuaria Recursos Geneticos e Biotecnologia, Brasilia, Brazil
[5]Universidade Federal de Uberlandia—Campus Umuarama, Brazil
[6]Empresa Brasileira de Pesquisa Agropecuaria Recursos Geneticos e Biotecnologia, Embrapa Cenargen, Brasilia, Brazil

Received 13 September 2019; Accepted 23 September 2019

Corresponding Author:
Carolyn Proença, ICB, Bloco D, Térreo, Universidade de Brasilia, Campus Darcy Ribeiro, Brasilia, Distrito Federal 70910-900, Brazil.
Email: cproenca@unb.br

endemic species of plants, animals, and arbuscular mycorrhizal fungi (Carvalho et al., 2012; Conceição et al., 2016; Rapini, Ribeiro, Lambert, & Pirani, 2008). Despite covering less than 1% of Brazil, the flora of the campos rupestres comprises at least 5,000 plant species (Silveira et al., 2016), and nearly 40% of them are endemic (BFG 2015).

The Espinhaço Mountain range (Cadeia do Espinhaço, hereafter CdoE), where campo rupestre dominates, runs c. 1,200 km from northern Bahia to southern Minas Gerais, in Southeastern Brazil. There is a major floristic discontinuity in the CdoE at c. 14° S (Arruda et al., 2008; Rizzini, 1979) corroborated by lithostructural contrast (Saadi, 1995), between the states of Bahia and Minas Gerais, so the northern portion is often referred to as the "Bahia" CdoE (also called the Septentrional Plateau; Saadi, 1995) and the Southern portion as the "Minas Gerais" CdoE (also called the Meridional Plateau; Saadi, 1995). This discontinuity was tested and 32.7% of species in the vascular flora were endemic to either the northern or southern CdoE (Conceição et al., 2016).. Some authors have claimed that because of the high frequency of narrow endemics, selection of priority areas for conservation would not be as effective as if the whole Espinhaço Range were protected (Echternacht, Trovó, Oliveira, & Pirani, 2011; Rapini, Mello-Silva, & Kawasaki, 2002). Monteiro et al. (2017) used distribution of 255 endangered species of the CdoE (as well as distribution of farming, mining, and fires) to suggest a conservation plan for these species and indicate priority areas for their conservation.

The Diamantina District Plateau (hereafter 'Plateau') is the largest continuous area in the "Minas Gerais" CdoE (Echternacht et al., 2011). Within this Plateau, there are two protected areas: Rio Preto State Park (PERP) and Sempre Vivas National Park (PNSV). Chaves et al. (2019) have shown that the main environmental predictors of Asteraceae distribution patterns in these two protected areas are either edaphic, that is, sum of bases and levels of aluminum (Al), clay, and sand, or associated with elevation and slope. Combined spatial and environmental components performed better at explaining Asteraceae floristic and relative abundance than either component by itself.

The Asteraceae was chosen for the study because (a) it is well represented in open and montane areas of the Neotropics and is the most species-rich family in campos rupestres vegetation (Silveira et al., 2016); (b) it represents almost 10% of the total angiosperm flora of Brazil (Flora do Brasil 2020 em construção, 2017a); (c) campos rupestres have the highest levels of Asteraceae endemism in Brazil (Flora do Brasil 2020 em construção, 2017b); (d) more species of Asteraceae face some level of threat than any other family in Brazil (Martinelli & Moraes, 2013; Ministério do Meio Ambiente, 2014).

We generated a list of the Asteraceae from PERP and PNSV to address two questions: (a) Is the known endangered Asteraceae flora of the Diamantina Plateau protected by these two protected areas? (b) Are these two protected areas complimentary or overlapping in protecting endangered species?

Methods

Study Area

Two protected areas and their surroundings within the Plateau were chosen for our study: PERP and PNSV (Figures 1 and 2). PERP has an area of 10,700 hectares and is in the municipality of São Gonçalo do Rio Preto (18°04′12″ to 18°14′15″ S, and 43°23′34″ to 43°18′18″ W). PNSV occupies an area of ca. 124,555 hectares in the municipalities of Olhos D'Água, Bocaiúva, Buenópolis, and Diamantina (17°44′11″ to 17°59′28″ S and 43°35'50″ to 43°59′33″ W).

Floristic Survey

Botanical collections were made (SISBIO Licence 40530–1 issued to the first author on August 6, 2013) using two different methods, the RAPELD protocol (Magnusson et al., 2005), with a reduction to 7 ha per module and some modifications to suit the campo rupestre environment (see Chaves et al., 2019), and traditional floristic collecting, between August 2013 and October 2014. For the RAPELD protocol, three sample modules were established, each of which with 21 sample units. Two sample modules were set up in PERP (PERP I and PERP II) and one in PNSV (PNSV I). Sample units were demarcated along two 5 km trails perpendicular to the isoclines (topographic contours) of the terrain. Sample units measured 250 m × 40 m (=10,000 m^2 = 1 ha) and were demarcated at 10 m increases in altitude in PNSV and 25 m increases in altitude in PERP (1,000, 1,025 m, etc.; Figure 1). Each 10,000 m^2 unit was subdivided into 25 subunits of that measures 10 m along the isocline × 40 m across that were easy to visualize and uniform in altitude, topography, and soil type. RAPELD collections were made within sample units, and both fertile and sterile specimens were collected. Even if additional specimens were added to the collection from the immediate vicinity of the unit, this was still considered a RAPELD collection since the motivation for the collection was its occurrence in the sample unit. Traditional floristic collecting (Mori et al., 1985; Ter Steege, Harispersaud, Bánki, & Schieving, 2011) was done in and out of the two protected areas, within a 117 ha polygon area of the Plateau whenever an Asteraceae was found either flowering or fruiting; sterile specimens were not collected. Total

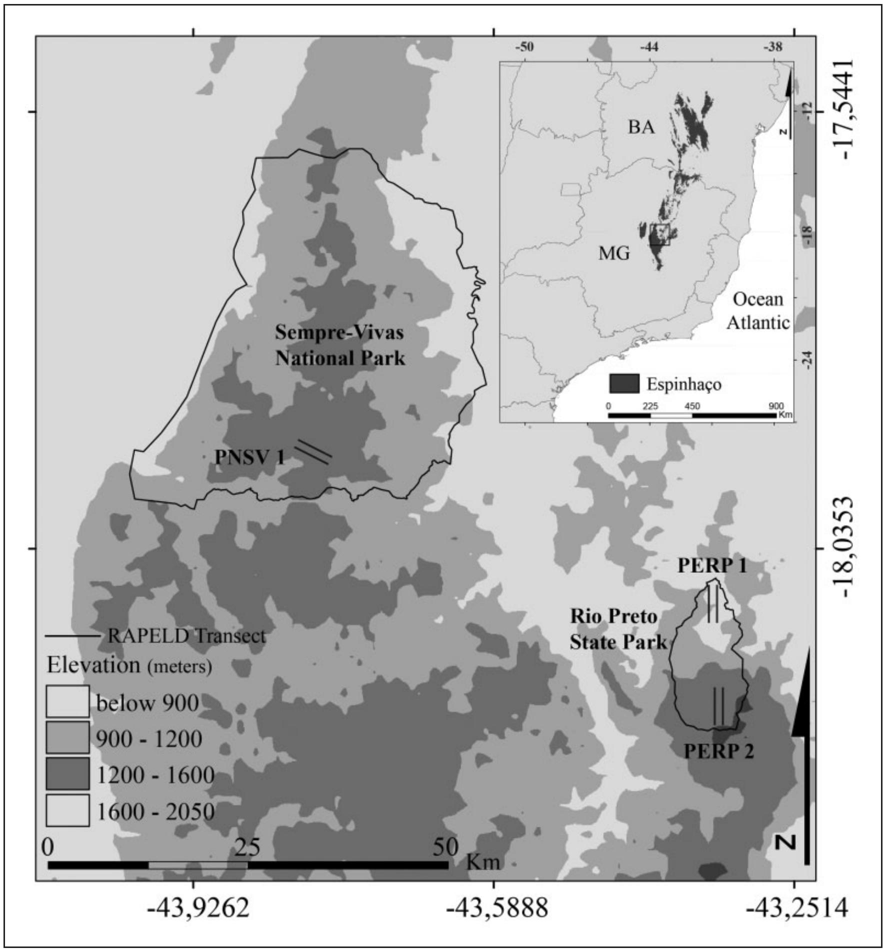

Figure 1. Study areas within the Cadeia do Espinhaço, Minas Gerais, Brazil. Larger inserted map: Espinhaço Mountain range (gray), Diamantina District Plateau (box), Parks (hatched). Smaller inserted map: Brazil (pale gray), Minas Gerais (dark gray), Bahia (black). PNSV = Sempre Vivas National Park; PERP = Rio Preto State Park.

collecting effort was 32 collecting days (1–5 collecting days per month) with teams of 1 to 4 collectors (average team = 2.1 collectors) between August 2013 and October 2014.

The PERP I module ran through savanna (cerrado) as well as campos rupestres, while the PERP II and PNSV I modules were in an area mainly of campos rupestres (Figure 2). All campos rupestres areas showed high heterogeneity of microhabitats with differences in soil, humidity levels, altitude, and floristic composition. In PERP I altitude varied between 760 and 940 m on poorly drained and well-drained soils, while in the savanna areas soils were deep with a high proportion of clay. In PERP II, altitude varied between 1,350 and 1,525 m, with prevalent rocky outcrops and some gallery forests, wet and well-drained fields (campos). In PNSV I, there was little variation in altitude (1,220–1,290 m), with campos rupestres dominating the vegetation but with pockets of savanna and gallery forest.

Principle of Analysis

Complementarity of areas (often considered the defining concept of spatial conservation prioritization; Kukkala & Moinen, 2013) was used to compare the two protected areas. Complementarity is a simple, iterative method of assessing the relative value of areas for conservation (Justus & Sarkar, 2002): one approach predicts that a set of areas that are species-rich for the surrogate taxon will be species-rich in general due to ecological complementary and habitat limitation (Faith & Walker, 1996; Williams, Faith, Manne, Sechrest, & Preston, 2006). Since many species have not yet been sampled phylogenetically in the CdoE, phylogenetic approaches would be very incomplete. Asteraceae, the chosen surrogate taxon, is suitable for the following reasons: (a) it presents a wide variety of growth forms, including some that are specific to campo rupestre (Clarke et al., 2013; Lusa, Appezzato-da-Glória, Loeuille, Bartoli, & Ciccarelli, 2014) and (b) it is species-rich, taxonomically diverse and responsive to environmental drivers (Chaves et al., 2019) making it a good

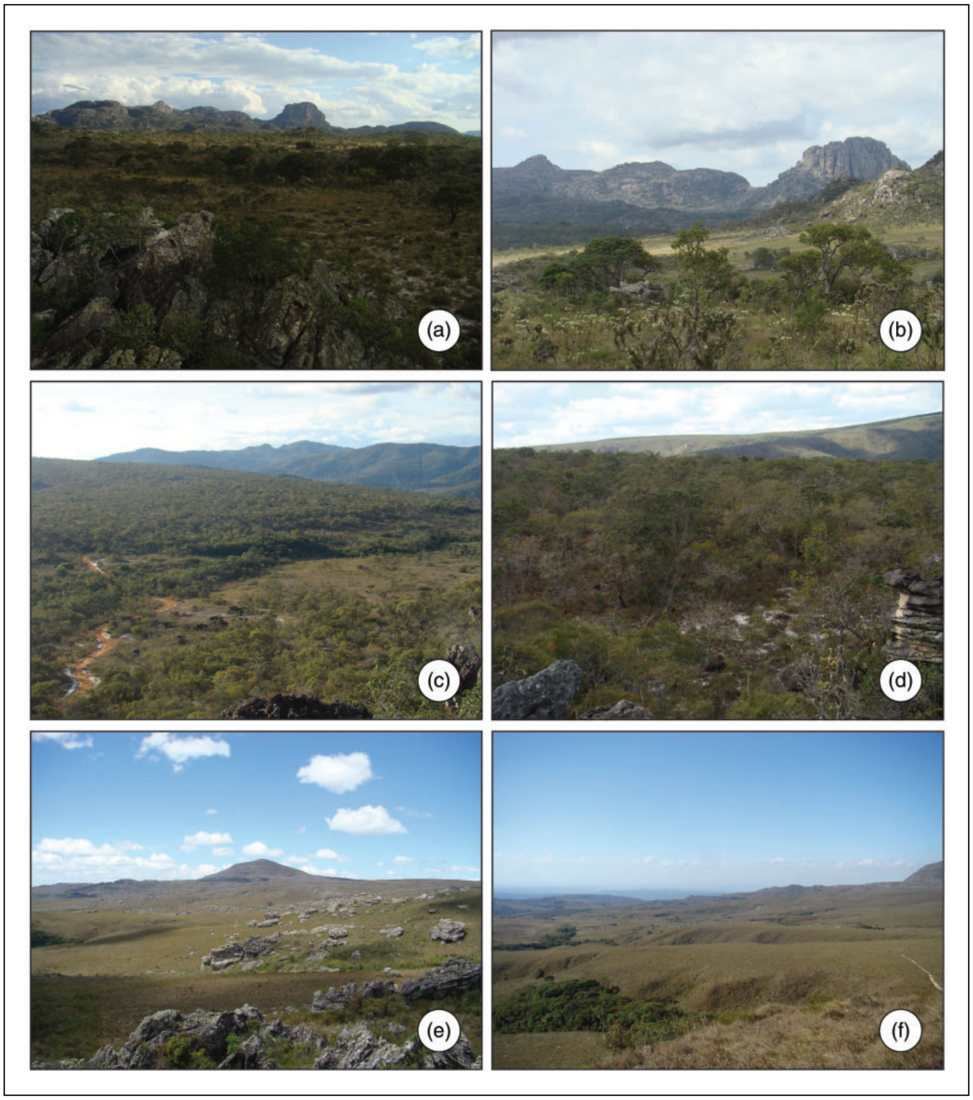

Figure 2. Habitats in the Diamantina Plateau. (a and b) Sempre Vivas National Park, RAPELD module area PNSV I with campos rupestres and cerrado savannas; (c and d) Rio Preto State Park, RAPELD module area PERP I with campos rupestres, cerrado savannas, and transitional areas; (e and f) Rio Preto State Park, RAPELD module area PERP II with campos rupestres and gallery forests.

surrogate of functional diversity, a highly informative biodiversity metric (Gallardo, Gascón, Quintana, & Comín, 2011). Asteraceae genera have been used to evaluate the efficiency of the conservation unit network in Mexico (Villaseñor, Ibarra, & Ocaña, 1998).

Taxonomic Identification

Authors J. B. A. B. Jr., J. N. N., and V. L. R. are Asteraceae specialists and identified most of the species but other specialists were consulted (see Acknowledgments). Herbarium vouchers were deposited in the Universidade de Brasília and in the Universidade Federal do Vale do Jequitinhonha e do Mucuri (see also Species Link 2017a, 2017b, 2017c, 2017d). Species with doubtful identifications (affinis or conferatum) and potential new species were listed in Table 1 but not counted and considered in the comparative analysis. Species' geographic distributions were compiled from the literature (Suppl. Information) and on-line databases (Herbário Virtual Reflora, 2017; Species Link, 2017a). Scientific names were updated following Flora do Brasil 2020 em construção (2017a).

Results

Richness and Endemism

A total of 613 collections of Asteraceae were made that resulted in 172 published, named species (Table 1); five morpho-species that are either undescribed species or

Table 1. List of Asteraceae Species Collected in Two Conservation Units and Their Surroundings in the Campos Rupestres of the Diamantina Plateau in the Espinhaço Mountain Range.

Genus/species	Endemism	Campo rupestre specialist	PNSV	PERP	Other DD localities	Voucher
Acanthospermum	W					
1. *Acanthospermum australe* (Loefl.) Kuntze	W		x	x		93, 328
Achyrocline	W					
2. *Achyrocline satureioides* (Lam.) DC.	W		x		x	83, 172
Acritopappus	BR					
3. *Acritopappus irwinii* R.M.King & H.Rob. (E)	BR, CdoE		x			90
4. *Acritopappus longifolius* (Gardner) R.M.King & H.Rob.	BR		x	x		188, 229, 451
Ageratum	W					
5. *Ageratum fastigiatum* (Gardner) R.M.King & H.Rob.	W		x		x	22, 372
Aldama	W					
6. *Aldama bracteata* (Gardner) E.E.Schill. & Panero	BR		x	x	x	285, 214, 340
Apopyros	W					
7. *Apopyros* aff. *corymbosus* (Hook. & Arn.) G.L. Nesom	BR			x	x	565
Aspilia	W					
8. *Aspilia andersonii* H. Rob.	BR, CdoE, DD				x	139
9. *Aspilia diamantinae* J.U. Santos (E)	BR, CdoE, DD	Yes		x	x	241
10. *Aspilia foliosa* (Gardner) Baker	BR		x	x		101
11. *Aspilia fruticosa* (Gardner) Baker	BR				x	62
12. *Aspilia riedelii* Baker	BR		x		x	169, 320
13. *Aspilia subpetiolata* Baker	BR			x		388
Ayapana	W					
14. *Ayapana amygdalina* (Lam.) R.M.King & H. Rob.	W			x	x	31, 531
Baccharis	W					
15. *Baccharis aphylla* (Vell.) DC.	W			x		525
16. *Baccharis brevifolia* DC.	W			x		555, 587
17. *Baccharis claussenii* Baker	BR	Yes		x		576
18. *Baccharis calvescens* DC.	BR				x	369
19. *Baccharis crispa* Spreng.	W			x	x	557
20. *Baccharis elliptica* Gardner (E)	BR	Yes			x	148
21. *Baccharis ligustrina* DC.	BR			x		558
22. *Baccharis linearifolia* (Lam.) Pers.	W			x		414
23. *Baccharis lychnophora* Gardner (E)	BR			x	x	599, 333
24. *Baccharis minutiflora* Mart. ex Baker	BR	Yes		x		507, 568
25. *Baccharis perlata* Sch.Bip. ex Baker	BR		x		x	99, 200, 319, 363
26. *Baccharis platypoda* DC.	W		x	x	x	89, 386, 63
27. *Baccharis pseudoalpestris* Malag. (E)	BR	Yes		x		574
28. *Baccharis reticularia* DC.	BR		x	x	x	313, 488, 164
29. *Baccharis retusa* DC.	BR		x	x	x	84, 264, 329

(continued)

Table 1. Continued.

Genus/species	Endemism	Campo rupestre specialist	PNSV	PERP	Other DD localities	Voucher
30. Baccharis serrulata (Lam.) Pers.	BR			x		219, 412
31. Baccharis subdentata DC.	BR			x		474
Bidens	W					
32. Bidens flagellaris Baker	BR		x			206
33. Bidens sp. 1[a]	?			x		223, 447
Calea	W					
34. Calea ferruginea Sch. Bip. ex Baker	W			x		231
35. Calea graminifolia Sch.Bip. ex Krasch.	BR		x		x	109, 577
36. Calea nitida Less.	BR			x		569
37. Calea oxylepis Baker	BR, CdoE			x		545
38. Calea sp. 1[a]	?			x		266
Campuloclinium	W					
39. Campuloclinium campuloclinioides (Baker) R.M. King & H. Rob.	BR		x			195
Chaptalia	W					
40. Chaptalia integerrima (Vell.) Burkart	W			x		559
Chresta	W					
41. Chresta pycnocephala DC.	BR				x	30
42. Chresta sphaerocephala DC.	BR		x		x	20, 36
Chromolaena	W					
43. Chromolaena barrosoae R.M. King & H. Rob.	BR, CdoE		x	x	x	184, 424, 322
44. Chromolaena chaseae (B.L. Rob.) R.M. King & H. Rob.	BR			x	x	411, 147
45. Chromolaena horminoides DC.	BR		x	x	x	207, 230, 358
46. Chromolaena multiflosculosa (DC.) R.M. King & H. Rob.	BR		x	x	x	86, 166, 48
47. Chromolaena pedalis (Sch.Bip. Ex Baker) R.M. King & H.Rob.	BR				x	352
48. Chromolaena pungens (Gardner) R.M. King & H.Rob.	BR		x	x	x	297, 359
49. Chromolaena maximiliani (Schrad. ex DC.) R.M.King & H.Rob.	W			x		392
50. Chromolaena squalida var. *martiusii* (DC.) Baker	W			x		505
51. Chromolaena squalida var. *squalida* DC.	W		x			277
52. Chromolaena squalida var. *subvelutinum* (DC.) Baker	W			x	x	448
Chronopappus	W					
53. Chronopappus bifrons (DC. ex Pers.) DC. (E)	BR, CdoE			x		600
Chrysolaena	W					
54. Chrysolaena obovata (Less.) Dematt.	W		x	x		92, 431
55. Chrysolaena simplex (Less.) Dematt.	W			x		549
Dasyphyllum	W					
56. Dasyphyllum sprengelianum (Gardner) Cabrera	BR		x	x		309, 265
Dimerostemma	W					
57. Dimerostemma brasilianum Cass.	W		x	x		192
58. Dimerostemma oblongum (Gardner) G.M.Barroso	BR, CdoE			x		395

(continued)

Table 1. Continued.

Genus/species	Endemism	Campo rupestre specialist	PNSV	PERP	Other DD localities	Voucher
Disynaphia	W					
59. *Disynaphia praeficta* (B.L.Rob) R.M.King & H.Rob. (E)	BR, CdoE	Yes	x	x	x	283, 382, 71
Echinocoryne	BR					
60. *Echinocoryne schwenkiifolia* Mart. ex DC.	BR		x	x	x	301, 409, 365
Erechtites	W					
61. *Erechtites hieraciifolius* (L.) Raf. ex DC.	W		x	x	x	79, 250, 51
62. *Erechtites valerianifolius* (Link ex Spreng.) DC.	W				x	327
Eremanthus	W					
63. *Eremanthus crotonoides* (DC.) Sch.Bip.	BR		x			198
64. *Eremanthus elaeagnus* (Mart. ex DC.) Sch.Bip	BR		x	x	x	95, 175, 162
65. *Eremanthus erythropappus* (DC.) MacLeish	BR		x		x	267
66. *Eremanthus glomerulatus* Less.	BR		x	x	x	275, 177, 343
67. *Eremanthus incanus* (Less.) Less.	BR			x	x	464, 163
68. *Eremanthus polycephalus* (DC.) MacLeish (E)	BR			x	x	468, 41
Eupatorium	W					
69. *Eupatorium lineatum* Sch. Bip. ex Baker[b]	BR				x	427
Grazielia	W					
70. *Grazielia bishopii* R.M.King & H.Rob.	BR		x			125, 194
Heterocoma	BR					
71. *Heterocoma erecta* (H. Rob.) B. Loeuille, J.N. Nakaj. & Semir	BR	Yes		x		427
72. *Heterocoma* sp. 1 (sp. nov.?)	BR, CdoE, DD			x		615
Heterocondylus	W					
73. *Heterocondylus alatus* (Vell.) R.M. King & H. Rob.	BR			x	x	58
74. *Heterocondylus pumilus* (Gardner) R.M. King & H. Rob.	BR			x		589
Hoehnephytum	W					
75. *Hoehnephytum trixoides* (Gardner) Cabrera	BR			x		592
Ichthyothere	W					
76. *Ichthyothere terminalis* (Spreng.) S.F.Blake	W			x		482
Inulopsis	W					
77. *Inulopsis camporum* (Gardner) G.L. Nesom	W			x		603
78. *Inulopsis scaposa* (DC.) O.Hoffm.	W			x		605
Koanophyllon	W					
79. *Koanophyllon adamantium* (Gardner) R.M. King & H. Rob.	BR			x		499
Lepidaploa	W					
80. *Lepidaploa argyrotricha* (Sch. Bip. ex Baker) H. Rob.	BR			x		380
81. *Lepidaploa lilacina* (Mart. ex DC.) H. Rob.	BR		x	x		292, 467
82. *Lepidaploa rufogrisea* (A. St.-Hil.) H. Rob.	BR		x	x	x	57, 100, 253
83. *Lepidaploa sororia* (DC.) H.Rob.	BR			x		544
84. *Lepidaploa spixiana* (Mart. ex DC.) H. Rob. (E)	BR	Yes		x	x	616, 38

(continued)

Table 1. Continued.

Genus/species	Endemism	Campo rupestre specialist	PNSV	PERP	Other DD localities	Voucher
Lessingianthus	W					
85. Lessingianthus adenophyllus (Mart. ex DC.) H. Rob. (E)	BR, CdoE	Yes	x	x		98, 385
86. Lessingianthus ammophilus (Gardner) H. Rob.	BR			x		487
87. Lessingianthus bardanoides (Less.) H. Rob.	W			x		220
88. Lessingianthus brevipetiolatus (Sch. Bip. ex Baker) H. Rob.	BR			x		238
89. Lessingianthus carduoides (Baker) H. Rob.	BR			x		423
90. Lessingianthus cordiger (Mart. ex DC.) H. Rob.	BR, CdoE	Yes		x		390
91. Lessingianthus coriaceus (Less.) H. Rob.	BR		x	x		186, 226
92. Lessingianthus laevigatus (Mart. ex DC.) H. Rob.	W			x		242
93. Lessingianthus psilophyllus (DC.) H. Rob.	BR		x	x	x	293, 418, 37
94. Lessingianthusscaposus(G.M. Barroso) H. Rob.	BR, CdoE, DD			x		547, 604
95. Lessingianthus stoechas (Mart. ex Baker) H. Rob. (E)	BR		x			24
96. Lessingianthus tomentellus (Mart. ex DC.) H. Rob.	BR			x	x	612
97. Lessingianthus vepretorum (Mart. ex DC.) H. Rob.	BR	Yes	x	x	x	124, 70, 404
98. Lessingianthus warmingianus (Baker) H. Rob.	BR			x	x	228, 144
Lucilia	W					
99. Lucilia lycopodioides (Less.) S.E. Freire	W			x		537–9, 590
Lychnophora	BR					
100. Lychnophora diamantinana Coile & Jones (E)	BR, CdoE, DD	Yes			x	133
101. Lychnophora ericoides Mart.	BR	Yes			x	34
102. Lychnophora gardneri Sch. Bip. (E)	BR, CdoE, DD	Yes			x	3
103. Lychnophora cf. *humillima* Sch. Bip.[a]	BR	Yes				597
104. Lychnophora martiana Gardner (E)	BR, CdoE	Yes		x		442
105. Lychnophora passerine (Mart. ex DC.) Gardner	BR	Yes		x		455
106. Lychnophora pinaster Mart.	BR	Yes	x			26
107. Lychnophora pohlii Sch. Bip.	BR, CdoE	Yes			x	6
108. Lychnophora reticulata Gardner	BR	Yes			x	153
109. Lychnophora rosmarinifolia Mart.	BR	Yes			x	16
110. Lychnophora rupestris Semir & Leitão	BR	Yes			x	7
111. Lychnophora salicifolia Mart.	BR	Yes			x	152
112. Lychnophora sellowii Sch. Bip.	BR, CdoE	Yes			x	44
113. Lychnophora staavioides Mart.	BR, CdoE, DD	Yes		x	x	479, 17
114. Lychnophora syncephala (Sch. Bip.) Sch. Bip.	BR		x		x	199, 134
115. Lychnophora tomentosa (Mart. ex DC.) Sch. Bip.	BR, CdoE	Yes	x	x	x	97, 437, 2
116. Lychnophoratriflora (Mattf.) H. Rob.	BR, CdoE		x			25, 103, 118
117. Lychnophora uniflora Sch. Bip.	BR	Yes			x	149
*118. Lychnophora villosissim*a Mart. (E)	BR, CdoE	Yes	x		x	315, 149
119. Lychnophora sp. 1 (sp. nov. ined. "cryptomerioides")	BR, CdoE, DD	Yes		x		428
120. Lychnophora sp. 2 (sp. nov.)	BR, CdoE, DD	Yes	x			197

(continued)

Table 1. Continued.

Genus/species	Endemism	Campo rupestre specialist	PNSV	PERP	Other DD localities	Voucher
Lychnophoriopsis	BR					
121. *Lychnophoriopsis candelabrum* (Sch. Bip.) H. Rob. (E)	BR, CdoE, DD	Yes			×	39
Mikania	W					
122. *Mikania glauca* Mart. (E)	BR	Yes		×		530
123. *Mikania luetzelburgii* Mattf.	BR		×	×	×	272, 64
124. *Mikania microphila* Sch.Bip. Ex Baker	BR					367
125. *Mikania neurocaula* DC. (E)	BR		×			82, 685
126. *Mikania nummularia* DC.	BR			×		593
127. *Mikania officinalis* Mart.	BR		×		×	123, 154
128. *Mikania ramosissima* Gardner	BR		×	×		76, 529
129. *Mikania reticulata* Gardner	BR			×	×	65, 561, 566
130. *Mikania sessilifolia* DC.	BR	Yes		×	×	383, 355
131. *Mikania parvifolia* Baker	BR, CdoE			×		506
132. *Mikania* aff. *phaeoclados* Mart.	?			×		476
133. *Mikania* sp. 1	?			×		239, 410, 457
Minasia	BR					
134. *Minasia alpestris* (Gardner) H. Rob. (E)	BR, CdoE, DD	Yes	×	×		110, 438
135. *Minasia pereirae* H. Rob. (E)	BR, CdoE	Yes	×			23
136. *Minasia scapigera* H.Rob. (E)	BR, CdoE	Yes		×		444
Moquinia	W					
137. *Moquinia racemosa* DC.	BR		×	×		113, 512
Moquiniastrum	W					
138. *Moquiniastrum blanchetianum* (DC.) G. Sancho	BR		×	×		312, 224
139. *Moquiniastrum floribundum* (Cabrera) G. Sancho	W			×		453
140. *Moquiniastrum hatschbachii* (Cabrera) G. Sancho (E)	BR, CdoE			×		415
141. *Moquiniastrum paniculatum* (Less.) G. Sancho	BR		×	×		19, 540
Paralychnophora	BR					
142. *Paralychnophora glaziouana* Loeuille	BR, CdoE	Yes	×	×		104, 284
Piptolepis	BR					
143. *Piptolepis buxoides* (Less.) Sch. Bip. (E)	BR, CdoE	Yes		×		379
144. *Piptolepis campestris* Semir & B. Loeuille	BR, CdoE, DD	Yes		×	×	591, 344
145. *Piptolepis ericoides* (Less.) Sch. Bip.	BR, CdoE	Yes	×			189
146. *Piptolepis leptospermoides* (Mart. ex DC.) Sch. Bip. (E)	BR, CdoE, DD	Yes	×		×	117, 75
Porophyllum	W					
147. *Porophyllum angustissimum* Gardner	W		×	×	×	128, 471, 72
Praxelis	W					
148. *Praxelis decumbens* (Gardner) A. Teles & R. Esteves	BR			×	×	419, 326
Proteopsis	BR					
149. *Proteopsis argentea* Mart. & Zucc. ex Sch. Bip. (E)	BR	Yes	×			190

(continued)

Table 1. Continued.

Genus/species	Endemism	Campo rupestre specialist	PNSV	PERP	Other DD localities	Voucher
Pseudobrickellia	BR					
150. Pseudobrickellia angustissima (Spreng. ex Baker) R.M. King & H. Rob.	BR		x	x	x	274, 258, 156
151. Pseudobrickellia brasiliensis (Spreng.) R.M. King & H. Rob.	BR		x	x	x	108, 456, 29
Pterocaulon	W					
152. Pterocaulon rugosum (Vahl) Malme	W			x	x	585, 33
Richterago	BR					
153. Richterago angustifolia (Gardner) Roque (E)	BR, CdoE	Yes	x			111
154. Richterago arenaria (Baker) Roque (E)	BR, CdoE	Yes	x	x	x	282, 510, 47
155. Richterago discoidea (Less.) Kuntze	BR	Yes		x	x	263, 347
156. Richterago elegans Roque (E)	BR, CdoE, DD	Yes	x	x	x	281, 519, 325
157. Richterago polyphylla (Baker) Ferreyra (E)	BR, CdoE, DD	Yes		x	x	571, 141
Riencourtia	W					
158. Riencourtia oblongifolia Gardner	W			x		496
Senecio	W					
159. Senecio brasiliensis (Spreng.) Less.	W			x	x	514, 12
160. Senecio macrotis Baker	BR	Yes		x		436
Stenocephalum	W					
161. Stenocephalum megapotamicum (Spreng.) Sch. Bip.	BR		x	x	x	211, 260, 321
Stenophalium	W					
162. Stenophalium gardneri (Baker) D.J.N.Hind	BR, CdoE	Yes			x	74
Stomatanthes	W					
163. Stomatanthes polycephalus (Sch. Bip. ex B.L. Rob.) H. Rob.	BR			x	x	32
Symphyopappus	W					
164. Symphyopappus brasiliensis (Gardner) R.M. King & H. Rob	BR		x		x	187, 66
165. Symphyopappus cuneatus (DC.) Sch.Bip. ex Baker	BR		x		x	116, 180
166. Symphyopappus decussatus Turcz.	BR		x	x	x	107, 465, 53
167. Symphyopappus reitzii (Cabrera) R.M.King & H.Rob.	BR		x	x		119, 611
Trichogonia	W					
168. Trichogonia hirtiflora (DC.) Sch. Bip. ex Baker	BR		x	x	x	88, 583, 336
169. Trichogonia salviifolia Gardner	BR				x	138
170. Trichogonia villosa Sch. Bip. ex Baker	BR		x	x	x	276, 433, 5
Trixis	W					
171. Trixis glutinosa D. Don	BR			x		478
172. Trixis nobilis (Vell.) Katinas	BR		x			130, 191
173. Trixis vauthieri DC.	BR		x	x	x	21, 449, 14
Verbesina	W					
174. Verbesina macrophylla (Cass.) S.F. Blake	W			x		389
Vernonanthura	W					
175. Vernonanthura laxa (Gardner) H. Rob.	BR		x	x		303, 493

(continued)

Table 1. Continued.

Genus/species	Endemism	Campo rupestre specialist	PNSV	PERP	Other DD localities	Voucher
176. Vernonanthura mariana (Mart. Ex Baker) H. Rob.	BR		×	×	×	77, 243, 68
Vernonia	W					
177. Vernonia adamantium Gardner[c]	BR, CdoE		×	×	×	96, 511, 50
Wunderlichia	BR					
178. Wunderlichia mirabilis Riedel ex Baker	BR			×		237
179. Wunderlichia senae Glaz. ex Maguire & G.M. Barroso (E)	BR, CdoE, DD	Yes		×		430

BR = Brazil; CdoE = Cadeia do Espinhaço; DD = Diamantina Plateau; E = endangered, see Table 2; PNSV = Sempre Vivas National Park; PERP = Rio Preto State Park; W = Widespread, weedy or naturally occurring out of Brazil.
[a]Sterile collection. Voucher numbers refer to Chaves et al.'s collection numbers.
[b]Will be transferred to genus *Chromolaena* (Nakajima, in prep.).
[c]Will be transferred to genus *Lepidaploa* (Nakajima, in prep.).

doubtful identifications are not included in this tally. The RAPELD survey recorded 115 species in a sample of 12,775 individuals of Asteraceae. Forty-seven species (27%) are endemic to campo rupestre vegetation, and 38 species (22%) are found only in the southern "Minas Gerais" region of the CdoE mountain range (Figure 1; Table 1). Furthermore, 13 of these species (7.5%) are endemic to the Plateau. The true number of endemic species of the Plateau may be even higher as collections of three possible new species were made. *Lychnophora* sp. 1 (Table 1) is an unpublished species recognized by Semir (1991).

PERP had two RAPELD modules located at different altitudes, one through campos rupestres and one through campos rupestres grading into savanna (cerrado); PNSV had only one module mainly through campos rupestres. This resulted in 226 RAPELD collections in PERP versus 83 RAPELD collections in PNSV. In PERP, with two sample modules, there was more diversity (127 vs. 76 species in PNSV) and 57 species collected were exclusive to PERP and were not found in PNSV or the park's surrounding areas. On the other hand, in PNSV, only 16 exclusive species were found. Interestingly, 21 species were collected in the surroundings of both parks but recorded in neither of them (Table 1).

Endangered Species and Conservation Status

A total of 38 endangered species of Asteraceae, representing 16% of the Asteraceae on Brazil's official list (Ministério do Meio Ambiente, 2014), are known to occur in the Plateau (Table 2). We recollected 30 of these (Figure 3; Tables 1 and 2), of which 26 species were recorded in one or both parks and 4 species were only recorded by traditional floristic collecting out of the park areas. The status of the recollected species was one critically endangered, 19 endangered, and 10 vulnerable (Martinelli & Moraes, 2013; Ministério do Meio Ambiente, 2014; Table 2). The number of endangered species recorded in PERP (18 spp.) and in PNSV (13 spp.) was similar but only five species were common to both parks (Table 1). Eight endangered species with known distribution within the Plateau were not recollected. Only one of the six critically endangered species from the Plateau was found (*Piptolepis leptospermoides* recollected from PNSV by traditional floristic collecting).

Discussion

Endangered Species and Conservation Status

For 20 Diamantina Plateau endangered species (53% of the known total of 38 species), our study has brought qualitative gain: they are now known to occur in one or

Table 2. List of Endangered Asteraceae Species (numbered) From the DD Plateau and Species Whose Distributions Expanded (Not Numbered).

Species	IUCN[a] status	IUCN[a] criteria	Collecting method	Previous situation	Present situation
***1. Acritopappus irwinii* R.M.King & H.Rob.**	**VU**	**B1ab(iii)**	**TRAD**	**NCUC**	**(3)**[b]
***2. Aspilia diamantinae* J.U. Santos**	**EN**	**B1ab(iii)**	**TRAD, RAPELD**	**NCUC**	**(4)**[b]
3. Aspilia egleri J.U. Santos	CR	B2ab(i,ii,iii,iv)	NC	ODUC[c] (Montes Claros)	ODUC[c] (Montes Claros)
4. Aspilia jugata H. Rob.	CR	B2ab(i,ii,iii,iv)	NC	NCUC	NCUC
5. Aspilia ovalifolia (DC.) Baker[d]	CR	B2ab(i,ii,iii,iv)	NC	NCUC	NCUC
6. Baccharis elliptica Gardner	EN	B1ab(i,ii,iii,iv)	TRAD	(2)	(2)
7. Baccharis lychnophora Gardner	VU	B2	TRAD, RAPELD	(1, 4)	(1, 4)
***8. Baccharis pseudoalpestris* Malag.**	**VU**	**B1ab(i,iii)**	**RAPELD**	**NCUC**	**(4)**[b]
9. Chronopappus bifrons (DC. ex Pers.) DC.	VU	B1ab(iii,iv); B2	RAPELD	(1, 2, 4)	(1, 2, 4)
***10. Disynaphia praeficta* (B.L.Rob.) R.M.King & H.Rob.**	**EN**	**B2ab(i,ii,iii)**	**TRAD, RAPELD**	**(2)**	**(2, 3, 4)**
11. Eremanthus polycephalus (DC.) MacLeish	VU	B2	TRAD, RAPELD	(1, 2, 4)	(1, 2, 4)
Heterocoma erecta (H. Rob.) B. Loeuille, J.N. Nakaj., & Semir			TRAD	(4)	DE (4)[e]
***12. Lepidaploa spixiana* (Mart. ex DC.) H. Rob.**	**EN**	**B1ab(iii)+2ab(iii)**	**TRAD, RAPELD**	**(2)**	**(2, 4)**
***13. Lessingianthus adenophyllus* (Mart. ex DC.) H. Rob.**	**EN**	**B2ab(iii)**	**TRAD, RAPELD**	**(2)**	**(2, 3, 4)**
***14. Lessingianthus stoechas* (Mart. ex Baker) H. Rob.**	**VU**	**B2ab(iii)**	**TRAD, RAPELD**	**ODUC** [f] **(Veadeiros)**	**(3)**
15. Lychnophora albertinioides Gardner	CR	B2ab(iii)	NC	(4)	(4)
16. Lychnophora diamantinana Coile & Jones	EN	B1ab(iii)+2ab(iii)	TRAD	(2)	(2)
17. Lychnophora gardneri Sch. Bip.	EN	B1ab(iii)+2ab(iii)	TRAD	(2)	(2)
***18. Lychnophora martiana* Gardner**	**EN**	**B1ab(iii)+2ab(iii)**	**TRAD**	**NCUC**	**(4)**[b]
19. Lychnophora souzae H.Rob.	CR	B2ab(iii)	NC	(2)	(2)
Lychnophora triflora (Mattf.) H.Rob.			TRAD	ODUC (Chapada Diamantina)	DE (4)[e]
***20. Lychnophora villosissima* Mart.**	**EN**	**B2ab(iii)**	**TRAD, RAPELD**	**(2)**	**(2, 3)**
21. Lychnophoriopsis candelabrum (Sch. Bip.) H. Rob.	EN	B1ab(iii)+2ab(iii)	TRAD	ODUC (Cabral)	ODUC (Cabral)
22. Lychnophoriopsis hatschbachii H. Rob.	EN	B1ab(iii)+2ab(iii)	NC	NCUC	NCUC
23. Lychnophoriopsis heterotheca Sch. Bip.	EN	B2ab(iii)	NC	NCUC	NCUC
24. Mikania glabra D.J.N. Hind	EN	B2ab(iii)	NC	NCUC	NCUC
***25. Mikania glauca* Mart.**	**EN**	**B2ab(iii)**	**TRAD, RAPELD**	**ODUC (Itacolomi)**	**(4)**
***26. Mikania neurocaula* DC.**	**EN**	**B2ab(iii)**	**TRAD, RAPELD**	**(2)**	**(2, 3)**
***27. Minasia alpestris* (Gardner) H. Rob.**	**EN**	**B1ab(iii)+2ab(iii)**	**TRAD**	**(2, 4)**	**(2, 3, 4)**
***28. Minasia pereirae* H. Rob.**	**EN**	**B1ab(iii)+2ab(iii)**	**TRAD**	**(2)**	**(2, 3)**
29. Minasia scapigera H.Rob.	EN	B1ab(iii)+2ab(iii)	TRAD	(2, 4)	(2, 4)
***30. Moquiniastrum hatschbachii* (Cabrera) G. Sancho**	**VU**	**B1ab(i,ii,iii)**	**TRAD**	**(2)**	**(2, 4)**

(continued)

Table 2. Continued.

Species	IUCN[a] status	IUCN[a] criteria	Collecting method	Previous situation	Present situation
***31. Piptolepis buxoides* (Less.) Sch. Bip.**	**EN**	**B1ab(i,ii,iii,v)+ 2ab(i,ii,iii,v)**	**TRAD**	**NCUC**	**(4)**[b]
32. Piptolepis leptospermoides (Mart. ex DC.) Sch. Bip.	CR	B2ab(i,ii,iii)	TRAD	(3)	(3)
***33. Proteopsis argentea* Mart. & Zucc. ex Sch. Bip.**	**VU**	**B2ab(i,iii)**	**RAPELD**	**(2)**	**(2, 3)**
***34. Richterago angustifolia* Gardner) Roque**	**EN**	**B1ab(i,ii,iii)+ 2ab(i,ii,iii)**	**TRAD**	**(2)**	**(2, 3)**
***35. Richterago arenaria* (Baker) Roque**	**VU**	**B1ab(i,ii,iii)+ 2ab(i,ii,iii)**	**TRAD, RAPELD**	**(2)**	**(2, 3, 4)**
***36. Richterago elegans* Roque**	**VU**	**B1ab(i,ii,iii)+ 2ab(i,ii,iii)**	**TRAD, RAPELD**	**(2)**	**(2, 3, 4)**
***37. Richterago polyphylla* (Baker) Ferreyra**	**EN**	**B1ab(i,ii,iii,v)+ 2ab(i,ii,iii,v)**	**TRAD, RAPELD**	**(2)**	**(2, 4)**
Verbesina macrophylla (Cass.) S.F.Blake			TRAD		DE[e]
38. Wunderlichia senae Glaz. ex Maguire & G.M. Barroso	EN	B1ab(i,ii,iii,v)+ 2ab(i,ii,iii,v)	TRAD	(2, 4)	(2, 4)

Note. New records from one or both parks (this study) are indicated in bold. CR = critically endangered; DE = distribution expansion; EN = endangered; NC = not collected in our study; NCUC = not collected in any conservation unit; IUCN = International Union for Conservation of Nature; ODUC = collected in a conservation unit outside of the DD plateau, identified by name; RAPELD = collected with frequency and environmental data; TRAD = traditional collecting; VU = vulnerable. Voucher numbers refer to Chaves et al.'s collection numbers. (1) Recorded in Itambé State Park in the DD plateau. (2) Recorded in Biribiri State Park in the DD plateau. (3) Recorded in Sempre Vivas National Park in the DD plateau. (4) Recorded in Rio Preto State Park in the DD plateau.

[a]Fide Martinelli and Moraes (2013).

[b]First collection in a Conservation Unit.

[c]More commonly collected in the Northern "Bahia" CdoE.

[d]Sensu Santos (2001).

[e]First record of distribution expansion southwards from the Northern "Bahia" CdoE crossing the major barrier and into the "Minas Gerais" CdoE.

[f]Also collected in highland areas of Goiás.

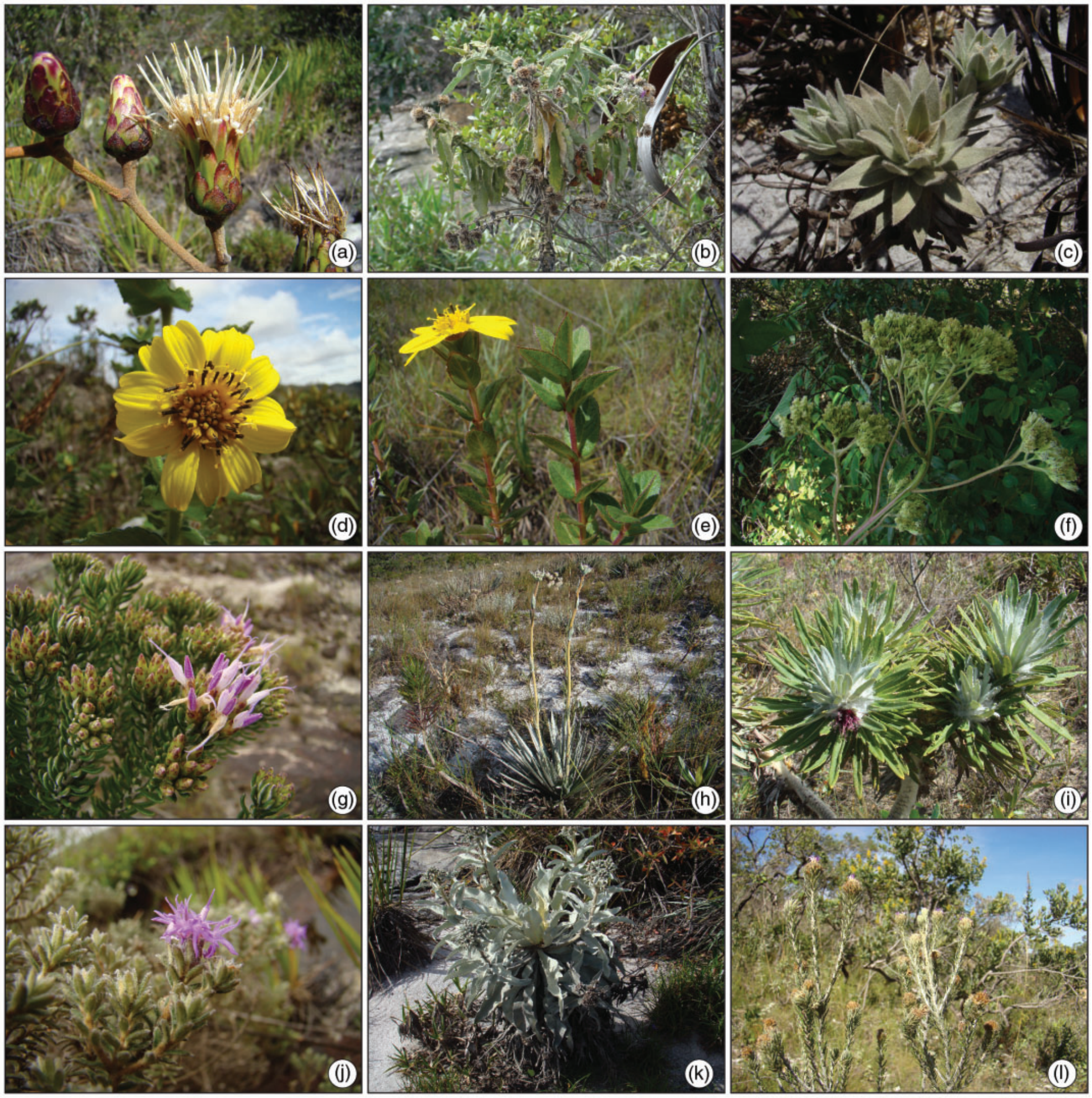

Figure 3. Asteraceae from the Diamantina Plateau. (a) *Wunderlichia senaeii* Glaz. ex Maguire & G.M. Barroso 'E'; (b) *Heterocoma erecta* (H. Rob.) B. Loeuille, J.N. Nakaj. & Semir 'E'; (c) *Lychnophora* cf. *humillima* Sch. Bip.; (d) *Aspilia andersonii* H. Rob.; (e) *Aspilia diamantinae* J.U. Santos 'E'; (f) *Verbesina macrophylla* (Cass.) S.F. Blake; (g) *Lychnophora triflora* (Mattf.) H. Rob.; (h) *Minasia scapigera* H. Rob. 'E'; (i) *Lychnophora martiana* Gardner 'E'; (j) *Piptolepis leptospermoides* (Mart. ex DC.) Sch. Bip. 'E'; (k) *Minasia alpestris* (Gardner) H. Rob. 'E'; (l) *Lychnophora uniflora* Sch. Bip. 'E.' 'E' = endangered species, for category see Table 2.

both parks, and in many cases, frequency data have been obtained from RAPELD modules (see Chaves et al., 2019). Five such endangered species have been recorded from protected areas for the first time (species marked with [b] in Table 2). For the other 18 species (47%), there has been no qualitative change in conservation unit occurrence. However, only for five species does this 'no change' represent continued failure to record the species in a conservation unit. Most qualitative 'no change' means the species had already been recorded from the parks by previous collectors.

Our negative results from the three RAPELD modules, which sampled 12,775 individuals of Asteraceae and found only 27% of endangered species known to occur in the Plateau, are possibly as significant as the positive results (recollections of endangered species known to occur there). If endangered species were uniformly distributed in different habitats, a high percentage of endangered species recovery might have been expected from the RAPELD modules. Closer investigation of the endangered species that were not collected showed that two of them are common either in the northern "Bahia" CdoE or in the more westerly Serra Geral de Goiás. For species where wide-scale distributional data could not explain absence, microdistributional differences or microhabitat specialization, as proposed by Chaves et al. (2019), stochastic distribution, or a combination of these are the most likely explanations. Percentages of gravel, sand, and silt in the soil explained 67% of the difference between mycorrhizal communities (Carvalho et al., 2012). Substrate (quartzitic, arenitic, or ironstone) was the most important campo rupestre driver of floristic diversity (Zappi, Moro, Meagher, & Nic Lughadha, 2017). These findings suggest that these endangered species were absent because they are restricted to unsampled, microhabitat communities. *Dimmerostema oblonga*, collected by us and only three times in 175 years in widely separate campo rupestre areas, could be such a specialist—or simply a very rare species. Another possibility is extreme geographic narrow endemism, such as has been recorded for the charismatic, unmistakable *Vellozia gigantea* Mello-Silva whose nine known populations are within 27 km of each other (Lousada, Borba, Ribeiro, Ribeiro, & Lovato, 2011).

Conservation strategies and the choice of priority areas are usually based on the presence of red-listed endangered species, but abundance, persistence, geographic distribution, and level of threats should also be quantified (Kakkala & Moinen, 2013; Nakajima, Junqueira, Freitas, & Teles, 2012). Campo rupestre lineages show high phylogenetic conservatism and low dispersal and colonization capabilities and are thus highly deserving of conservation priority (Conceição et al., 2016). Knowledge of species abundance allows for safer decision-making during management of protected areas (Brandon, Fonseca, Rylands, & Silva, 2005). CdoE alpha-taxonomic knowledge remains incomplete and more collecting is needed (Madeira, Ribeiro, Oliveira, Nascimento, & Paiva, 2008; U. Oliveira et al., 2016).

Although many endangered species found in this study may appear protected, the protected areas often lack effective management and physical infrastructure. National and state parks are threatened by mining, criminal fires, invasive species, and habitat destruction as population and tourism grows (Echternacht et al., 2011; Silveira et al., 2016). It has been estimated under various climate change scenarios that between 40% and 82% of the CdoE's area of campo rupestre will be lost or fragmented and practically disappear in the northern region by 2070 (Bitencourt, Rapini, Damascena, & De Marco, 2016; Fernandes, Barbosa, Negreiros, & Paglia, 2014; Fernandes, et al., 2018). Such area reduction could mean mass extinction of endemic species, even in current protected areas, that could shrink by up to 40% in area by 2050 (Bitencourt et al., 2016; Fernandes et al., 2018). Species distribution models that predict current as well as future species-range distribution patterns under climate change are essential so conservation planning can adapt to novel scenarios.

Conservation Implications

The answer to our first question is that the two protected areas are not sufficient to protect the endangered Plateau Asteraceae flora, since 29% of endangered species of Asteraceae have not yet been recorded in either park. For the CR species, 66% have not yet been recorded in either park. The answer to our second question is that the two parks are complimentary in preserving the endangered flora of the Plateau. Only five endangered species (13% of the 38 known endangered Asteraceae flora) were common to both parks; PERP is known to protect 47% of the endangered Asteraceae flora and PNSV to protect 34% of that flora; combined, the parks protect 68% of the endangered Asteraceae flora. Complementarity methods have been criticized for being data-hungry (Redford et al., 1997), but the large dataset generated by RAPELD undermines this criticism. Asteraceae endangered species at least are neither common nor uniformly distributed in the Plateau, a pattern that might be applicable to other families and OCBILs. Results support Monteiro et al.'s (2018) guidelines for campo rupestre conservation, which includes a recommendation that detailed in situ and ex situ studies of endangered species be done.

Acknowledgments

Authors thank the Universidade de Brasilia for institutional support. C. P. thanks CNPq for her Level 2 Research grant. V. L. R. thanks FAPDF for her postdoctoral grant. J. N. N. thanks FAPEMIG for his research grant (PPM-00385 -14). Thanks are also due to the National and State park authorities. The following individuals provided much appreciated help in setting up RAPELD sample units and in the collecting of data and specimens: G. Braga, P. Duarte, M. F. Ferreira, J. Galves, V. F. Gomes, F. Hiago, P. H. Moreira, M. A. Pacheco, M. Pinheiro, and T. Rocha. Finally, our deepest gratitude to the Asteraceae specialists who were invaluable in helping us to achieve correct identification of their speciality groups: G. Heiden (*Baccharis*), B. Loueille (*Lychnophora*), C. T. Oliveira (*Mikania*), and A. M. Teles (Astereae). S. A. Harris and two anonymous reviewers provided comments that improved the quality of the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: CNPq/CAPES/FAPs –Edital REFLORA 56/10 –Processo 193.000.455/2011 provided funding and a scholarship to D. A. C. PROBIO II/GEF Cerrado/ICMBio/EMBRAPA Recursos Genéticos e Biotecnologia and Instituto Biotropicos funded field work (2013 -2015).

ORCID iD

Carolyn Proença https://orcid.org/0000-0002-8924-2692

Supplemental Material

Supplemental material for this article is available online.

References

Arruda, M. B., Proença, C. E. B., Rodrigues, S. C., Campos, R. N., Martins, R. C., & Martins, E. S. (2008). Ecorregiões, Unidades de Conservação e Representatividade Ecológica do Bioma Cerrado [Ecoregions, conservation units and ecological representation of the Cerrado Biome]. In S. M. Sano, S. P. Almeida, & J. F. Ribeiro (Eds.), *Cerrado: Ecologia e Flora* (pp. 229–272). Brasília, Brazil: Embrapa-Cerrados.

Bautista, H. P. (2000). *Sistemática e filogenia de um gênero endêmico do Brasil Acritopappus R. M. King & H. Rob. (Asteraceae, Eupatorieae)*. [Systematic and phylogeny of a genus endemic to Brazil Acritopappus R. M. King & H. Rob. (Asteraceae, Eupatorieae)] (Doctoral Thesis). Universidad de Santiago de Compostela, Santiago de Compostela, Spain.

Bitencourt, C., Rapini, A., Damascena, L. S., & De Marco, P., Jr. (2016). The worrying future of the endemic flora of a tropical mountain range under climate change. *Flora*, *218*, 1–10.

Brandon, K., Fonseca, G. A. B., Rylands, A. B., & Silva, J. M. C. (2005). Conservação brasileira: Desafios e oportunidades [Brazilian conservation: Challenges and opportunities]. *Megadiversidade*, *1*, 7–13.

Carvalho, F., de Souza, F. A., Carrenho, R., Moreira, F. M., de, S., Jesus, E. D C., & Fernandes, G. W. (2012). The mosaic of habitats in the high-altitude Brazilian rupestrian fields is a hotspot for arbuscular mycorrhizal fungi. *Applied Soil Ecology*, *52*, 9–19.

Chaves, D. A., Ribeiro-Silva, S., Proença, C. E. B., Oliveira, W. L., Bringel, J. B. A., Jr., & Medeiros, M. B. (2019). Geographic space, relief, and soils predict plant community patterns of Asteraceae in rupestrian grasslands, Brazil. *Biotropica*, *51*, 1–10.

Clarke, P., Lawes, M., Midgley, J., Lamont, B., Ojeda, F., Burrows, G., … Knox, K. (2013). Resprouting as a key functional trait: How buds, protection and resources drive persistence after fire. *New Phytologist*, *197*, 19–35.

Conceição, A. A., Rapini, A., do Carmo, F. F., Brito, J. C., Silva, G. A., Sâmia, … Jacobi, C. M. (2016). Rupestrian grassland vegetation, diversity, and origin. In G. W. Fernandes (Ed.), *Ecology and conservation of mountaintop grasslands in Brazil* (pp. 105–127). New York, NY: Springer.

Costa, F. N., Trovó, M., & Sano, P. T. (2008). Eriocaulaceae na Cadeia do Espinhaço: Riqueza, endemismo e ameaças [Eriocaulaceae in the Espinhaço Chain: Wealth, endemism and threats]. *Megadiversidade*, *4*, 89–97.

Deble, L. P. (2007). O gênero *Achyrocline* (Less.) DC. (Asteraceae, Gnaphalieae) no Brasil. [The genus Achyrocline (Less.) DC. (Asteraceae, Gnaphalieae) in Brasil] (Doctoral thesis).Universidade Federal de Santa Maria, Santa Maria, Brazil.

Dobson, A. P., Rodriguez, J. P., Roberts, W. M., & Wilcove, D. S. (1997). Geographic distribution of endangered species in the United States. *Science*, *275*, 550–553.

Echternacht, L., Trovó, M., Oliveira, C. T., & Pirani, J. R. (2011). Areas of endemism in the Espinhaço Range in Minas Gerais, Brazil. *Flora*, *206*, 782–791.

Faith, D. P., & Walker, P. A. (1996). How do Indicator Groups Provide Information about the Relative Biodiversity of DifferentSets of Areas?: On Hotspots, Complementarity and Pattern-Based Approaches. *Biodiversity Letters*, *3*, 18–25.

Fernandes, G. W., Barbosa, N. P. U., Alberton, B., Barbieri, A., Dirzo, R., Goulart, F., … Solar, R. R. C. (2018). The deadly route to collapse and the uncertain fate of Brazilian rupestrian grasslands. *Biodiversity and Conservation*, *27*, 2587–2603.

Fernandes, G. W., Barbosa, N. P. U., Negreiros, D., & Paglia, A. P. (2014). Challenges for the conservation of vanishing megadiverse rupestrian grasslands. *Natureza e Conservação*, *12*, 162–165.

Flora do Brasil 2020 em construção. (2017a). *Jardim Botânico do Rio de Janeiro*. Search: Family = Asteraceae + Ocorre no Brazil = sim. Retrieved from http://floradobrasil.jbrj.gov.br/reflora/listaBrasil/ConsultaPublicaUC/BemVindoConsultaPublicaConsultar.do?invalidatePageControlCounter=1&idsFilhosAlgas=%5B2%5D&idsFilhosFungos=%5B1%2C10%2C11%5D&lingua=&grupo=5&familia=55&genero=&especie=&autor=&nomeVernaculo=&nomeCompleto=&formaVida=null&substrato=null&ocorreBrasil=QUALQUER&ocorrencia=OCORRE&endemismo=TODOS&origem=TODOS&regiao=QUALQUER&estado=QUALQUER&ilhaOceanica=32767&domFitogeograficos=QUALQUER&bacia=QUALQUER&vegetacao=TODOS&mostrarAte=SUBESP_VAR&opcoesBusca=TODOS_OS_NOMES&loginUsuario=Visitante&senhaUsuario=&contexto=consulta-publica

Flora do Brasil 2020 em construção. (2017b). *Jardim Botânico do Rio de Janeiro*. Search: Family = Asteraceae + Ocorre no Brazil = sim + Vegetação = campo rupestre. Retrieved from http://floradobrasil.jbrj.gov.br/reflora/listaBrasil/ConsultaPublicaUC/BemVindoConsultaPublicaConsultar.do?invalidatePageControlCounter=1&idsFilhosAlgas=%5B2%5D&idsFilhosFungos=%5B1%2C10%2C11%5D&lingua=

&grupo=5&familia=55&genero=&especie=&autor=&nomeVernaculo=&nomeCompleto=&formaVida=null&substrato=null&ocorreBrasil=SIM&ocorrencia=OCORRE&endemismo=TODOS&origem=TODOS&regiao=QUALQUER&estado=QUALQUER&ilhaOceanica=32767&domFitogeograficos=QUALQUER&bacia=QUALQUER&vegetacao=CAMPO_RUPESTRE&mostrarAte=SUBESP_VAR&opcoesBusca=TODOS_OS_NOMES&loginUsuario=Visitante&senhaUsuario=&contexto=consulta-publica

Gallardo, B., Gascón, S., Quintana, X. & Comín, F. A. (2011). How to choose a biodiversity indicator – Redundancy and complementarity of biodiversity metrics in a freshwater ecosystem. *Ecological Indicators*, *11*, 1177–1184.

Guilietti, A. M., Harley, R. M., de Queiroz, L. P., Wanderley, M. G. L., & Van den Berg, C. (2005). Biodiversity and conservation of plants in Brazil. *Conservation Biology*, *19*, 632–639.

Herbário Virtual Reflora. (2017). Retrieved from http://reflora.jbrj.gov.br/reflora/herbarioVirtual/Consulta PublicoHVUC/ConsultaPúblicoHVUC.do

Hind, D. J. N. (1993). New compositae from the Serra do Grão-Mogol (Mun. Grão-Mogol, Minas Gerais, Brazil) and the surrounding area. *Kew Bulletin*, *49*, 511–522.

Hind, D. J. N. (2003). Flora of Grão-Mogol, Minas Gerais: Compositae (Asteraceae). *Boletim de Botânica da Universidade de São Paulo*, *21*, 179–234.

ICMBio. (2016). Plano de manejo do Parque Nacional das Sempre vivas (Unpublished report).

Justus, J., & Sarkar, S. (2002). The principle of complementarity in the design of reserve networks to conserve biodiversity: a preliminary history. *Journal of Bioscience* (Suppl. 2), *27*, 421–435.

Kukkala, A., & Moinen, A. (2013). Core concepts of spatial prioritisation in systematic conservation planning. *Biological Reviews*, *88*, 443–464.

Loeuille, B., Semir, J., Hind, N. D. J., & Pirani, J. R. (2012b). Three new species of Piptolepis (Compositae: Vernonieae) from Minas Gerais, Brazil. *Kew Bulletin*, *67*, 1–8.

Loeuille, B., Semir, J., & Pirani, J. R. (2012a). A new species of Paralychnophora (Asteraceae: Vernonieae), and comments on the identity of Paralychnophora bicolor. *Brittonia*, *64*, 289–295.

Lousada, J. M., Borba, E. L., Ribeiro, K. T., Ribeiro, L. C., & Lovato, M. B. (2011). Genetic structure and variability of the endemic and vulnerable Vellozia gigantea (Velloziaceae) associated with the landscape in the Espinhaço Range, in southeastern Brazil: Implications for conservation. *Genetica*, *139*, 431–440.

Lusa, M. G., Appezzato-da-Glória, B., Loeuille, B., Bartoli, G., & Ciccarelli, D. (2014). Functional groups in Lychnophorinae (Asteraceae: Vernonieae) based on morphological and anatomical traits. *Australian Journal of Botany*, *62*, 150–163.

Madeira, J. A., Ribeiro, K. T., Oliveira, M. J. R., Nascimento, J. S., & Paiva, C. L. (2008). Distribuição espacial do esforço de pesquisa biológica na Serra do Cipó, Minas Gerais: Subsídios ao manejo das unidades de conservação da região [Spatial distribution of the biological research effort in Serra do Cipó, Minas Gerais: Subsidies for the management of protected areas in the region]. *Megadiversidade*, *4*, 257–271.

Magnusson, W. E., Lima, A. P., Luizão, R., Luizão, F., Costa, F. R., Castilho, C. V. D., & Kinupp, V. F. (2005). RAPELD: A modification of the Gentry method for biodiversity surveys in long-term ecological research sites. *Biota Neotropica*, *5*, 19–24.

Martinelli, G., & Moraes, M. (2013). *Livro vermelho da flora do Brasil [Red book of Brazil flora]*. Rio de Janeiro, Brazil: Centro de Conservação da Flora.

Ministério do Meio Ambiente. (2014). *Lista de Espécies da Flora Ameaçadas de Extinção. Portaria MMA no 443 de 17 de dezembro de 2014 (Diário Oficial da União, Seção 1, no 245, 18 de dezembro de 2014)*. Retrieved from http://www.icmbio.gov.br/cepsul/images/stories/legislacao/Portaria/2014/p_mma_443_2014_lista_esp%C3%A9cies_amea%C3%A7adas_extin%C3%A7%C3%A3o.pdf

Monteiro, L., Machado, N., Martins, E., Pougy, N., Verdi, M., Martinelli, G., & Loyola, R. (2018). Conservation priorities for the threatened flora of mountaintop grasslands in Brazil. *Flora*, *238*, 234–243. doi:10.1016/j.flora.2017.03.007

Moraes, M. D., & Semir, J. (2009). A revision of Brazilian *Dimmerostema* (Asteraceae, Heliantheae, Ecliptinae), with a new species and taxonomic adjustments. *Brittonia*, *61*, 341–365.

Mori , S. A. , Silva, L. A. M. , Lisboa, G. & Coradin, L. (1985). *Manual de Manejo do Herbário Fanerogâmico*. Ilhéus, Brazil: Centro de Pesquisas do Cacau.

Nakajima, J. N., Junqueira, T. V., Freitas, F. S., & Teles, A. M. (2012). Comparative analysis of red lists of the Brazilian flora: Asteraceae. *Rodriguésia*, *63*, 39–54.

Oliveira, U., Paglia, A. P., Brescovit, A. D., de Carvalho, C. J. B., Silva, D. P., Rezende, D. T., ... Santos, A. J. (2016). The strong influence of collection bias on biodiversity knowledge shortfalls of Brazilian terrestrial biodiversity. *Diversity and Distribution*, *22*, 1232–1244.

Prance, G. T. (1994). The use of phytogeographic data for conservation planning. In P. I. Forey, C. J. Humphries, & R. I. Vane-Wright (Eds.), *Systematics and conservation evaluation* (pp. 145–163). Oxford, England: Clarendon Press.

Rapini, A., Mello-Silva, R., & Kawasaki, M. L. (2002). Richness and endemism in Asclepiadoideae (Apocynaceae) from the Espinhaço Range of Minas Gerais, Brazil—A conservationist view. *Biodiversity and Conservation*, *11*, 1733–1746.

Rapini, A., Ribeiro, P. L., Lambert, S., & Pirani, J. R. (2008). A flora dos campos rupestres da Cadeia do Espinhaço. *Megadiversidade*, *4*, 15–23.

Rivera, V. L. (2006). *Estudos fitogeográficos em Vernonia Schreb. (sensu lato) no bioma Cerrado* [Phytogeographic studies in Vernonia Schreb. (sensu lato) in the Cerrado biome] (Master of Science thesis). Universidade de Brasília, Brasília, Brazil.

Rizzini, C. T. (1979). *Tratado de fitogeografia do Brasil [Phytogeography treaty of Brazil]*. São Paulo, Brazil: Hucitec/EDUSP.

Roque, N., & Pirani, J. R. (1997). Flora da Serra do Cipó, Minas Gerais: Compositae—Barnadesieae e Mutisieae [Flora of Serra do Cipó, Minas Gerais: Compositae—

Barnadesieae and Mutisieae]. *Boletim de Botânica da Universidade de São Paulo*, *16*, 151–185.

Saadi, A. (1995). A Geomorfologia da Serra do Espinhaço em Minas Gerais e de suas margens [The Geomorphology of Serra do Espinhaço in Minas Gerais and its margins]. *Geonomos*, *3*, 41–63.

Santos, J. U. M. (2001). *O gênero Aspilia Thou (Asteraceae—Heliantheae) no Brasil* [The genus Aspilia Thou (Asteraceae—Heliantheae) in Brazil]. Belém, Brazil: Museu Paraense Emílio Goeldi.

Semir, J. (1991). *Revisão taxonômica de Lychnophora Mart (Vernonieae: Compositae) [Taxonomic revision of Lychnophora Mart (Vernonieae: Compositae)] (Doctoral thesis)*. Universidade Estadual de Campinas, Campinas, Brazil.

Semir, J., Rezende, A. B., Monge, M., & Lopes, N. P. (2011). *As arnicas endêmicas das serras do Brasil. Uma visão sobre a Biologia e a química das espécies de Lychnophora (Asteraceae)* [The endemic arnicas of the mountains of Brazil. An insight into the biology and chemistry of Lychnophora (Asteraceae) species]. Ouro Preto, Brazil: UFOP.

Silva, J. A., Machado, R. B., Azevedo, A. A., Drumond, G. M., Fonseca, R. L., Goulart, M. F., … , Neto, M. B. R. (2008). Identificação de áreas insubstituíveis para conservação da Cadeia do Espinhaço, estados de Minas Gerais e Bahia, Brasil [Identification of irreplaceable areas for conservation of Espinhaço Chain, states of Minas Gerais and Bahia, Brazil]. *Megadiversidade*, *4*, 1–2.

Silveira, F. A. O., Negreiros, D., Barbosa, N. P. U., Buisson, E., Carmo, F. F., Carstensen, D. W., … Lambers, H. (2016). Ecology and evolution of plant diversity in the endangered Campo Rupestre: A neglected conservation priority. *Plant and Soil*, *403*, 129–152.

Souza-Buturi, F. O. (2013). *Taxonomia, Palinologia e Anatomia de Wunderlichia, Asteraceae [Taxonomy, palynology and anatomy of Wunderlichia, Asteraceae] (Doctoral thesis)*. Universidade Estadual de Campinas, Campinas, Brazil.

Species Link. (2017a). *Search: ((any = [diamantina])) and ((stateprovince = [minas] and stateprovince = [gerais]))*. Retrieved from http://www.splink.org.br/index?lang=pt

Species Link. (2017b). *Search: ((family = [asteraceae])) and ((any = [parque] and any = [estadual] and any = [do] and any = [biribiri]) or (any = [parque] and any = [estadual] and any = [do] and any = [itambé])) and ((stateprovince = [minas] and stateprovince = [gerais]))*. Retrieved from http://www.splink.org.br/index?lang=pt

Species Link. (2017c). *Search: ((genus = [heterocoma] and species = [erecta]))*. Retrieved from http://www.splink.org.br/index?lang=pt

Species Link. (2017d). *Search: ((genus = [verbesina] and species = [macrophylla]))*. Retrieved from http://www.splink.org.br/index?lang=pt

Teles, A. M., & Stehmann, J. R. (2016). A tribo Senecioneae (Asteraceae) em Minas Gerais, Brasil [The Senecioneae (Asteraceae) tribe in Minas Gerais, Brazil]. *Rodriguésia*, *67*, 455–487.

Ter Steege, H., Harispersaud, P. P., Bánki, O. S., & Schieving, F. (2011). A model of botanical collectors behavior in the field: Never the same species twice. *American Journal of Botany*, *98*, 31–37.

Urbatsch, L. E., Zlotsky, A., & Pruski, J. F. (1986). Revision of Calea sect. Lemmatium (Asteraceae: Heliantheae) from Brazil. *Systematic Botany*, *11*, 501–504.

Villaseñor, J. L., Ibarra, G. & Ocaña, D. (1998). Strategies for the Conservation of Asteraceae in Mexico. *Conservation Biology*, *12*, 1066–1075.

Williams, P., Faith, D., Manne, L., Sechrest, W., & Preston, C. Complementarity analysis: Mapping the performance of surrogates for biodiversity. *Biological Conservation*, *128*, 253–264.

Zappi, D. C., Moro, M. F., Meagher, T. R., & Nic Lughadha, E. (2017). Plant biodiversity drivers in Brazilian Campos Rupestres: Insights from phylogenetic structure. *Frontiers in Plant Science*, *8*, 2141. doi:10.3389/fpls.2017.02141

Zuquim, G., Tuomisto, H., Jones, M. M., Prado, J., Figueiredo, F. O. G., Moulatlet, G. M., … Emilio, T. (2014). Predicting environmental gradients with fern species composition in Brazilian Amazonia. *Journal of Vegetation Science*, *25*, 1195–1207.