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BOTANY

Unveiling neotropical serpentine flora: a list of Brazilian tree species in an iron saturated environment in Bom Sucesso, Minas Gerais

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ABSTRACT. Serpentine soils are those holding at least of 70% iron-magnesium compounds, which make life intolerable for many species. Although plant's adaptation to environmental toughness is widely studied in tropics, virtually nothing is known about Brazilian serpentine flora. Our aim was to bring up and characterize the serpentine flora in Bom Sucesso, Minas Gerais state, Brazil. We performed expeditions utilizing rapid survey sampling method to identify the arboreal compound in the area. Plants within circumference at breast high (CBH) up to 15,7 cm were included in our study. A specialist identified all the individuals to species level. We found 246 species located in 59 botanical families. Fabaceae, Myrtaceae and Melastomataceae were the most representative families in the area. Serpentine areas usually present a few species capable to survive to adverse conditions, contrasting the high number found in our study. To our knowledge, this is the first floristic survey in serpentine areas in the neotropics, reinforcing the need for more studies about plant diversity in those areas. It seems that serpentinites is not the key factor influencing plant diversity in the neotropics. The high diversity found in our study strengthens serpentine areas as a place for conservation concern.

Keywords: ultramafic vegetation; trace elements; heavy metals; serpentine soil.

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Introduction

Serpentine soils are those holding 70% or more iron-magnesium compounds, leading to rocky soils with many degrees of nutritional imbalance, containing high concentrations of weathered ultramafic rocks (Salihaj, Bani, & Echevarria, 2016). They are drifted from ultramafic rocks, shaping environments with low capacity to hold water, nutrient deficit and plenty of toxic materials such as nickel, chrome, magnesium and iron (Anacker, 2014). Although there some areas of serpentine soils in South America, they are scares around the globe, with the majority of them found in the Circum-pacific margin and Mediterranean Sea (Hseu, Zehetner, Fujii, Watanabe, & Nakao 2018), leading to a large gap of knowledge and only a few floristic surveys in Brazil and Central America (Almeda & Martins, 2015). Iron (Fe) and Magnesium (Mg) are known as trace elements because they are found at very small concentrations on plants, and when at higher concentrations, their presence can lead to leaf death, necrotic brown spotting on leaves, chlorosis, cellular damage, permutagenic damage, DNA strand breaks and DNA base modifications (Nagajyoti, Lee, & Sreekanth, 2010). Heavy metals are known to interfere directly on the physiological processes of the plants, playing an important role in the redox reactions, being an integral part of enzymes, interfering in CO_2 fixation, nutrient absorption, gaseous exchange and respiration (Nagajyoti et al., 2010). Altogether, those physical and chemical characteristics make serpentine soils a harsh environment for plants, hosting a reduced flora when compared to the neighboring areas (Brady, Kruckeberg, & Bradshaw Jr., 2005).

Serpentine plants need to endure harsh environmental conditions, and therefore understanding the ecological species that survive in those places is an important part of the serpentine problem (Kazakou et al., 2010). They are also known for the presence of extremely specialized habitats that hosts 'islands' of biodiversity and endemic flora (Chiarucci & Baker, 2007). In the tropics, flora associated with serpentine soil is a topic of concern for scientists (Cano, Cano-Ortiz, Del Río, Ramirez, & Ruiz, 2014), but despite the high endemism rates found on those places, floristic surveys exclusive from these locals on South America are scarce (Almeda & Martins, 2015).

Iron rich environments figure among the most threatened and less studied places in State Minas Gerais (Jacobi & Carmo, 2008). The state endured resource exploitation for livestock farming, wood harvest and anthropic fire, reducing its vegetation to a few. Mining in Brazil (from licenses to search for the ore to extractions) quadrupled between 2000 to 2009, reaching a 698.000 km^2 area in national territory (Jacobi, Carmo, & Campos, 2011). Despite all the measures that are being taken to preserve Brazilian biodiversity, few are those that intend to conserve mineral rich environments (Jacobi et al., 2011).

Due the high threaten to forest fragments and the advances on the mining industry in soils with high concentration of heavy metals (Hseu & Iizuka, 2013), it's urgent to understand vegetation distribution in serpentine environments and utilize those studies to help recover disturbed areas. Our study's aim was to characterize flora in a serpentine area in Bom Sucesso, Minas Gerais State, Brazil, by producing a species list that can further be used on conservation projects.

Material and methods

Study area

We conducted this study in Minas Gerais State, Bom Sucesso municipality in an area known as *Morro das Almas*, located between the coordinates 21° 01' 58" South and longitude 44° 45' 28" West, in an altitude of 952 m above the sea level. The region presents a mosaic of phytophysiognomies, since the Minas Gerais State is an ecotone area (transitional areas between phytophysiognomies) *Instituto Brasileiro de Geografia e Estatística* (IBGE, 2012) with the main vegetation types belonging to the Cerrado (Brazilian savannah) and Mata Atlântica Domain IBGE (2013). Climate in the region is usually marked by two well defined seasons - wet and rainy summers, with dry cold winters IBGE (2013). The mean annual precipitation is 1776 mm concentrated in the months of October to March and mean temperature of 19°C (Figure 1). The area was previously studied by the *Departamento de Ciências do Solo* (Department of Soil Science) from *Universidade Federal de Lavras*, where they investigated the geology of the area and found that the flora from that locality stands upon soils holding high saturation of iron oxide (Fe_2O_3 on 72.33%), characterizing serpentine soils Araujo, Pedroso, Amaral, and Zinn (2014). Local landscape is surrounded by natural fields - a mosaic of Altitude and rocky fields), in which is usual the presence of livestock grazing.

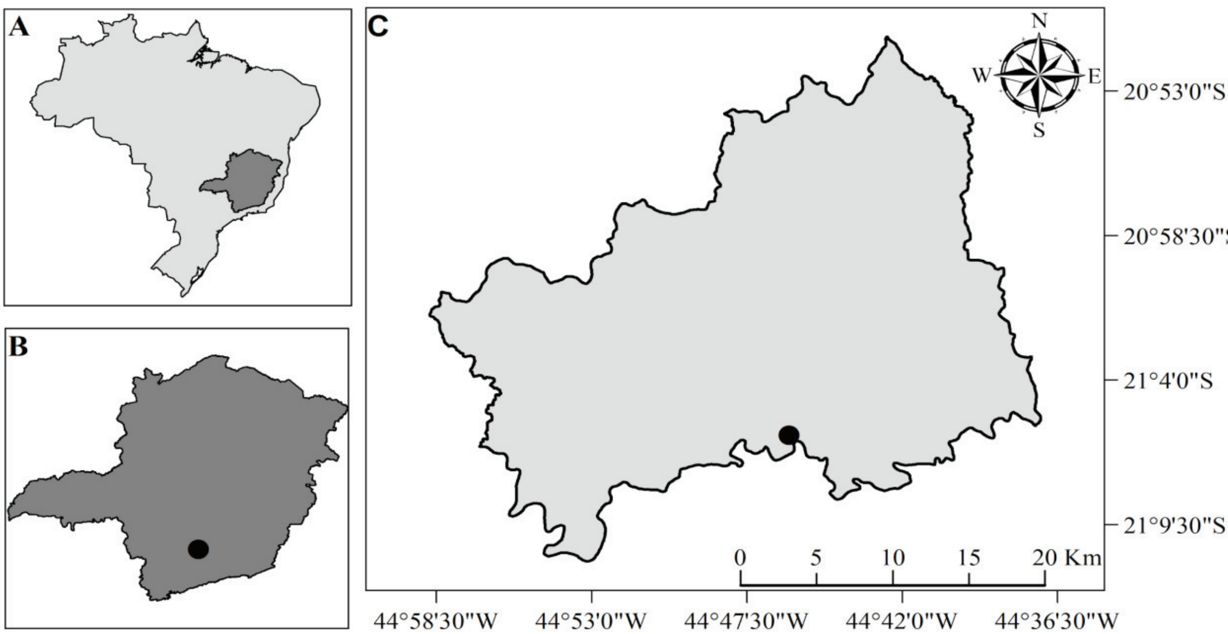

Figure 1. Map and coordinates of a serpentine soil area and the associated flora at Bom Sucesso municipality, Minas Gerais State, Brazil. A) Map of Brazil. B) Map from Minas Gerais State. C) Sampling area at Bom Sucesso municipality. The black dot in figures B and C represent where this study was carried, at *Morro das Almas*, Bom Sucesso, Minas Gerais, Brazil.

Floristic survey

We performed the floristic survey utilizing the rapid survey sampling method. This method consists in walking through an area and identifying the arboreal species, making a presence/absence list. When the same species appears several times in the same area, we continue to walk to try to find new species. Our sampling was complete when we covered the whole area of the *Morro das Almas* hill. We covered a 352 ha area and identified some species in the field. Species were sampled and identified by a dendrology specialist (Prof. Rubens Santos, from UFLA), since most of the species were not flourish. The plants which the specialist could not identify in the field were collected and checked using the Brazilian Flora Group (BFG, 2015) virtual herbarium. Plants were identified by using their vegetative characteristics and their names were checked in The Plant List (2018), Reflora 2015 virtual herbarium.

Results

We recorded 249 arboreal species, located in 61 botanical families (Table 1). The most representative family in this study was Fabaceae, holding 31 species, an equivalent to 12.60% of the total richness in the community, followed by Myrtaceae with 33 species (11.38%) and Melastomataceae with 12 species (4.87%) (Figure 2). Those families hold 10.37% of the total floristic richness. *Copaifera* L. and *Bowdichia* Kunth were the most representative genera in Fabaceae, followed by *Myrcia* and *Eugenia* in Myrtaceae and *Miconia* and *Tibouchina* in Melastomataceae. *Myrcia splendens*, *Pera glabrata* and *Ocotea pulchella* were commonly found in all the area.

Table 1. List of the species from a neotropical serpentine site in Bom Sucesso, Minas Gerais State, Brazil.

Botanical Families/Species	Conservation Status (IUCN)	Endemic Species of Brazil	Protected by Law
Anacardiaceae			
Astronium fraxinifolium Schott	Low concern	No	No
Lithrea molleoides (Vell.) Engl.	Not evaluated	No	No
Schinus terebinthifolius Raddi	Not evaluated	No	No
Tapirira guianensis Aubl.	Not evaluated	No	No
Tapirira obtusa (Benth.) J.D.Mitch.	Not evaluated	No	No
Annonaceae			
Annona cacans Warm.	Low concern	No	No
Annona cornifolia A.St.-Hil.	Not evaluated	No	No
Annona emarginata (Schltdl.) H.Rainer	Low concern	No	No
Annona neolaurifolia H.Rainer	Not evaluated	Not evaluated	No
Annona sylvatica A.St.-Hil.	Not evaluated	Yes	No
Duguetia furfuracea (A.St.-Hil.) Saff.	Not evaluated	Yes	No
Duguetia lanceolata A.St.-Hil.	Low concern	Yes	No
Guatteria australis A.St.-Hil.	Low concern	Yes	No
Xylopia brasiliensis Spreng.	Near Threatened	Yes	No
Xylopia sericea A.St.-Hil.	Not evaluated	No	No
Apocynaceae			
Aspidosperma australe Müll.Arg.	Low concern	No	No
Aspidosperma cylindrocarpon Müll.Arg.	Low concern	No	No
Aspidosperma sp.	Not evaluated	Not evaluated	No
Aspidosperma spruceanum Benth. ex Müll.Arg.	Low concern	Yes	No
Aspidosperma tomentosum Mart. & Zucc.	Low concern	Yes	No
Aquifoliaceae			
Ilex cerasifolia Reissek	Not evaluated	Yes	No
Ilex conocarpa Reissek	Not evaluated	Yes	No
Araliaceae			
Dendropanax cuneatus (DC.) Decne. & Planch.	Low concern	No	No
Schefflera macrocarpa (Cham. & Schltdl.) Frodin	Not evaluated	Yes	No
Arecaceae			
Syagrus flexuosa (Mart.) Becc.	Not evaluated	No	No
Syagrus romanzoffiana (Cham.) Glassman	Low concern	Yes	No
Asteraceae			
Baccharis brachylaenoides DC.	Not evaluated	Not evaluated	No
Baccharis dentata (Vell.) G.M.Barroso	Not evaluated	No	No
Eremanthus erythropappus (DC.) MacLeish	Not evaluated	Yes	No
Gochnatia paniculata (Less.) Cabrera	Not evaluated	Not evaluated	No
Gochnatia polymorpha (Less.) Cabrera	Low concern	Not evaluated	No
Piptocarpha macropoda (DC.) Baker	Not evaluated	Yes	No
Vernonanthura divaricata (Spreng.) H.Rob.	Not evaluated	No	No
Vernonanthura fagifolia (Gardner) H.Rob.	Vulnerável	Yes	No

Botanical Families/Species	Conservation Status (IUCN)	Endemic Species of Brazil	Protected by Law
Bignoniaceae			
Cybistax antisyphilitica (Mart.) Mart.	Not evaluated	No	No
Handroanthus aureus Mattos	Not evaluated	Not evaluated	No
Handroanthus ochraceus (Cham.) Mattos	Not evaluated	No	No
Handroanthus serratifolius (Vahl) S.O.Grose	Not evaluated	No	No
Jacaranda caroba (Vell.) DC.	Not evaluated	Yes	No
Jacaranda macrantha Cham.	Low concern	Yes	No
Boraginaceae			
Cordia sellowiana Cham.	Not evaluated	Yes	No
Cordia trichotoma (Vell.) Arrab. ex Steud.	Not evaluated	No	No
Burseraceae			
Protium spruceanum (Benth.) Engl.	Not evaluated	No	No
Protium widgrenii Engl.	Not evaluated	Yes	No
Trattinnickia ferruginea Kuhlm.	Endangered	Yes	Yes
Calophyllaceae			
Calophyllum brasiliense Cambess.	Not evaluated	No	No
Kielmeyera coriacea Mart. & Zucc.	Not evaluated	No	No
Kielmeyera speciosa A.St.-Hil.	Not evaluated	Yes	No
Cannabaceae			
Celtis brasiliensis (Gardner) Planch.	Not evaluated	No	No
Trema micrantha (L.) Blume	Not evaluated	No	No
Cardiopteridaceae			
Citronella paniculata (Mart.) R.A.Howard	Not evaluated	No	No
Caryocaraceae			
Caryocar brasiliense Cambess.	Low concern	No	No
Celastraceae			
Monteverdia evonymoides (Reissek) Biral	Not evaluated	No	No
Maytenus gonoclada Mart.	Not evaluated	No	No
Plenckia populnea Reissek	Not evaluated	No	No
Salacia elliptica (Mart. ex Schult.) G.Don	Not evaluated	No	No
Chrysobalanaceae			
Hirtella glandulosa Spreng.	Not evaluated	No	No
Clethraceae			
Clethra scabra Pers.	Low concern	No	No
Clusiaceae			
Garcinia brasiliensis Mart.	Not evaluated	Yes	No
Combretacea			
Terminalia argentea Mart.	Low concern	No	No
Terminalia glabrescens Mart.	Not evaluated	No	No
Cunoniaceae			
Lamanonia ternata Vell.	Not evaluated	Yes	No
Dilleniaceae			
Curatella americana L.	Not evaluated	No	No
Davilla rugosa Poir.	Not evaluated	No	No
Ebenaceae			
Diospyros burchellii Hiern	Not evaluated	Not evaluated	No
Erythroxylaceae			
Erythroxylum citrifolium A.St.-Hil.	Not evaluated	No	No
Erythroxylum cuneifolium (Mart.) O.E.Schulz	Not evaluated	No	No
Erythroxylum deciduum A.St.-Hil.	Not evaluated	No	No
Erythroxylum pelleterianum A.St.-Hil.	Low concern	No	No
Erythroxylum suberosum A.St.-Hil.	Not evaluated	No	No
Erythroxylum tortuosum Mart.	Not evaluated	No	No
Euphorbiaceae			
Croton floribundus Spreng.	Not evaluated	No	No
Pera glabrata (Schott) Baill.	Not evaluated	No	No
Sebastiania brasiliensis Spreng.	Not evaluated	No	No
Fabaceae			
Albizia polycephala (Benth.) Killip ex Record	Not evaluated	Yes	No
Andira anthelmia (Vell.) Benth.	Not evaluated	Yes	No
Andira fraxinifolia Benth.	Not evaluated	Yes	No
Bauhinia rufa (Bong.) Steud.	Not evaluated	No	No
Bowdichia virgilioides Kunth	Near Threatened	No	No
Copaifera langsdorffii Desf.	Not evaluated	No	No
Copaifera magnifolia Dwyer	Not evaluated	Yes	No
Dalbergia miscolobium Benth.	Not evaluated	Yes	No
Dalbergia villosa (Benth.) Benth.	Not evaluated	No	No
Enterolobium gummiferum (Mart.) J.F.Macbr.	Not evaluated	Yes	No
Hymenaea courbaril L.	Low concern	No	No
Hymenaea stigonocarpa Mart. ex Hayne	Not evaluated	No	No

Botanical Families/Species	Conservation Status (IUCN)	Endemic Species of Brazil	Protected by Law
Inga vera Willd.	Not evaluated	No	No
Leptolobium dasycarpum Vogel	Not evaluated	No	No
Leptolobium elegans Vogel	Not evaluated	No	No
Leucochloron incuriale (Vell.) Barneby & J.W.Grimes	Not evaluated	Yes	No
Machaerium hirtum (Vell.) Stellfeld	Not evaluated	No	No
Machaerium nyctitans (Vell.) Benth.	Low concern	No	No
Machaerium villosum Vogel	Low concern	No	No
Ormosia fastigiata Tul.	Not evaluated	Yes	No
Piptadenia gonoacantha (Mart.) J.F.Macbr.	Low concern	No	No
Platypodium elegans Vogel	Not evaluated	No	No
Senna aversiflora (Herbert) H.S.Irwin & Barneby	Not evaluated	Yes	No
Senna macranthera (DC. ex Collad.) H.S.Irwin & Barneby	Not evaluated	No	No
Senna multijuga (Rich.) H.S.Irwin & Barneby	Not evaluated	No	No
Stryphnodendron adstringens (Mart.) Cov.	Low concern	Yes	No
Stryphnodendron obovatum Benth.	Not evaluated	Not evaluated	No
Stryphnodendron occhionianum E.M.O.Martins	Not evaluated	Yes	No
Tachigali denudata (Vogel) Oliveira-Filho	Near Threatened	Yes	No
Tachigali rugosa (Mart. ex Benth.) Zarucchi & Pipoly	Near Threatened	Yes	No
Vatairea macrocarpa (Benth.) Ducke	Not evaluated	No	No
Hypericaceae			
Vismia guianensis (Aubl.) Choisy	Not evaluated	No	No
Lacistemaceae			
Lacistema hasslerianum Chodat	Not evaluated	No	No
Lamiaceae			
Aegiphila lhotzkiana Cham.	Not evaluated	Not evaluated	No
Hyptidendron asperrimum (Spreng.) Harley	Low concern	Yes	No
Hyptidendron canum (Pohl ex Benth.) Harley	Not evaluated	No	No
Hyptidendron sp.	Not evaluated	Not evaluated	Not evaluated
Vitex megapotamica (Spreng.) Moldenke	Not evaluated	No	No
Vitex polygama Cham.	Not evaluated	Yes	No
Lauraceae			
Aniba canelilla (Kunth) Mez	Not evaluated	Yes	No
Aniba firmula (Nees & Mart.) Mez	Not evaluated	Yes	No
Endlicheria paniculata (Spreng.) J.F.Macbr.	Not evaluated	No	No
Nectandra grandiflora Nees	Low concern	Yes	No
Nectandra megapotamica (Spreng.) Mez	Not evaluated	No	No
Nectandra nitidula Ness	Not evaluated	Yes	No
Nectandra oppositifolia Ness	Not evaluated	No	No
Ocotea corymbosa (Meisn.) Mez	Not evaluated	No	No
Ocotea odorifera (Vell.) Rohwer	Endangered	Yes	Yes
Ocotea pulchella (Nees & Mart.) Mez	Low concern	No	No
Persea major (Meisn.) L.E.Kopp	Not evaluated	Yes	No
Lecythidaceae			
Cariniana estrellensis (Raddi) Kuntze	Not evaluated	No	No
Lythraceae			
Lafoensia pacari A.St.-Hil.	Low concern	No	No
Malpighiaceae			
Byrsonima coccolobifolia Kunth	Low concern	No	No
Byrsonima intermedia A.Juss.	Not evaluated	Yes	No
Byrsonima sericea DC.	Not evaluated	No	No
Byrsonima verbascifolia (L.) DC.	Not evaluated	No	No
Heteropterys byrsonimifolia A.Juss.	Not evaluated	Yes	No
Malvaceae			
Eriotheca candolleana (K.Schum.) A.Robyns	Not evaluated	Yes	No
Luehea candicans Mart. & Zucc.	Low concern	No	No
Luehea divaricata Mart.	Not evaluated	No	No
Luehea grandiflora Mart. & Zucc.	Not evaluated	No	No
Luehea paniculata Mart. & Zucc.	Not evaluated	No	No
Pseudobombax grandiflorum (Cav.) A.Robyns	Low concern	Yes	No
Pseudobombax longiflorum (Mart. & Zucc.) A.Robyns	Not evaluated	No	No
Pseudobombax tomentosum (Mart.) A.Robyns	Low concern	No	No
Melastomataceae			
Miconia albicans (Sw.) Triana	Not evaluated	No	No
Miconia burchellii Triana	Not evaluated	Yes	No
Miconia pepericarpa DC.	Not evaluated	Yes	No
Miconia sellowiana Naudin	Not evaluated	Yes	No
Miconia trianae Cogn.	Not evaluated	Yes	No
Miconia tristis Spring	Not evaluated	No	No
Miconia willdenowii Klotzsch ex Naudin	Low concern	Yes	No
Pleroma candolleanum (Mart. ex DC.) Triana	Not evaluated	Yes	No
Tibouchina estrellensis (Raddi) Cogn.	Not evaluated	Yes	No

Botanical Families/Species	Conservation Status (IUCN)	Endemic Species of Brazil	Protected by Law
Pleroma fissinervium Schrank et Mart. ex DC.	Not evaluated	Yes	No
Pleroma fothergillii (Schrank et Mat. ex DC.) Triana	Not evaluated	Yes	No
Pleroma granulosum (Desr.) D. Don	Not evaluated	Yes	No
Meliaceae			
Cabralea canjerana (Vell.) Mart.	Not evaluated	No	No
Cedrela fissilis Vell.	Vulnerável	No	No
Trichilia pallens C.DC.	Low concern	Yes	No
Monimiaceae			
Mollinedia argyrogyna Perkins	Low concern	Yes	No
Moraceae			
Brosimum gaudichaudii Trécul	Not evaluated	No	No
Ficus pertusa L.f.	Not evaluated	No	No
Ficus adhatodifolia Schott ex Spreng.	Not evaluated	No	No
Maclura tinctoria (L.) D.Don ex Steud.	Not evaluated	No	No
Myrtaceae			
Blepharocalyx salicifolius (Kunth) O.Berg	Low concern	No	No
Calyptranthes clusiifolia O.Berg	Not evaluated	No	No
Campomanesia guazumifolia (Cambess.) O.Berg	Not evaluated	No	No
Campomanesia velutina (Cambess.) O.Berg	Not evaluated	Yes	No
Campomanesia xanthocarpa (Mart.) O.Berg	Low concern	No	No
Eugenia bimarginata DC.	Not evaluated	No	No
Eugenia discolorans C.Wright	Not evaluated	Not evaluated	No
Eugenia florida DC.	Low concern	Yes	No
Eugenia hiemalis Cambess.	Low concern	No	No
Eugenia sonderiana O.Berg	Not evaluated	Yes	No
Eugenia verticillata (Vell.) Angely	Not evaluated	Yes	No
Eugenia discolorans C. Wright & Sauvalle	Not evaluated	Not evaluated	No
Myrceugenia miersiana (Gardner) D.Legrand & Kausel	Low concern	Yes	No
Myrcia guianensis (Aubl.) DC.	Low concern	No	No
Myrcia hebepetala DC.	Not evaluated	Yes	No
Myrcia multiflora (Lam.) DC.	Not evaluated	No	No
Myrcia obovata (O.Berg) Nied.	Low concern	Yes	No
Myrcia subcordata DC.	Not evaluated	Yes	No
Myrcia retorta Cambess.	Not evaluated	Yes	No
Myrcia splendens (Sw.) DC.	Not evaluated	Yes	No
Myrcia tomentosa (Aubl.) DC.	Not evaluated	No	No
Myrcia variabilis DC.	Low concern	Yes	No
Myrcia venulosa DC.	Low concern	Yes	No
Pimenta pseudocaryophyllus (Gomes) Landrum	Not evaluated	Yes	No
Plinia cauliflora (Mart.) Kausel	Not evaluated	Yes	No
Psidium rufum Mart. ex DC.	Not evaluated	Yes	No
Siphoneugena densiflora O.Berg	Low concern	Yes	No
Siphoneugena widgreniana O.Berg	Low concern	Not evaluated	No
Nyctaginaceae			
Guapira opposita (Vell.) Reitz	Not evaluated	No	No
Ochnaceae			
Ouratea castaneifolia (DC.) Engl.	Not evaluated	No	No
Pentaphylacaceae			
Ternstroemia brasiliensis Cambess.	Low concern	Yes	No
Phyllanthaceae			
Hieronyma alchorneoides Allemão	Not evaluated	Not evaluated	No
Piperaceae			
Piper gaudichaudianum Kunth	Not evaluated	No	No
Polygonaceae			
Ruprechtia laxiflora Meisn.	Not evaluated	No	No
Primulaceae			
Myrsine coriacea (Sw.) R.Br. ex Roem. & Schult.	Not evaluated	No	No
Myrsine gardneriana A.DC.	Not evaluated	No	No
Myrsine guianensis (Aubl.) Kuntze	Not evaluated	No	No
Myrsine lineata (Mez) Imkhan.	Not evaluated	Yes	No
Myrsine umbellata Mart.	Not evaluated	No	No
Proteaceae			
Euplassa rufa (Loes.) Sleumer	Not evaluated	Yes	No
Roupala montana Aubl.	Not evaluated	No	No
Rubiaceae			
Amaioua guianensis Aubl.	Not evaluated	No	No
Amaioua intermedia Mart. ex Schult. & Schult.f.	Not evaluated	No	No
Chomelia sericea Müll.Arg.	Not evaluated	Yes	No
Cordiera concolor (Cham.) Kuntze	Not evaluated	No	No
Cordiera sessilis (Vell.) Kuntze	Not evaluated	No	No

Botanical Families/Species	Conservation Status (IUCN)	Endemic Species of Brazil	Protected by Law
Faramea latifolia (Cham. & Schltdl.) DC.	Not evaluated	Yes	No
Guettarda uruguensis Cham. & Schltdl.	Not evaluated	No	No
Guettarda viburnoides Cham. & Schltdl.	Not evaluated	Yes	No
Ixora brevifolia Benth.	Not evaluated	Not evaluated	No
Machaonia brasiliensis (Hoffmanss. ex Humb.) Cham. & Schltdl.	Not evaluated	No	No
Rudgea viburnoides (Cham.) Benth.	Not evaluated	No	No
Rutaceae			
Zanthoxylum caribaeum Lam.	Not evaluated	No	No
Zanthoxylum fagara (L.) Sarg.	Not evaluated	No	No
Zanthoxylum rhoifolium Lam.	Not evaluated	No	No
Zanthoxylum riedelianum Engl.	Not evaluated	No	No
Salicaceae			
Casearia arborea (Rich.) Urb.	Not evaluated	No	No
Casearia decandra Jacq.	Not evaluated	Yes	No
Casearia lasiophylla Eichler	Low concern	Yes	No
Casearia sylvestris Sw.	Not evaluated	No	No
Sapindaceae			
Allophylus edulis (A.St.-Hil. et al.) Hieron. ex Niederl.	Not evaluated	No	No
Cupania zanthoxyloides Radlk.	Not evaluated	Yes	No
Matayba guianensis Aubl.	Not evaluated	No	No
Sapotaceae			
Chrysophyllum marginatum (Hook. & Arn.) Radlk.	Not evaluated	No	No
Pouteria gardneri (Mart. & Miq.) Baehni	Not evaluated	No	No
Siparunaceae			
Siparuna brasiliensis (Spreng.) A.DC.	Low concern	Yes	No
Siparuna guianensis Aubl.	Not evaluated	No	No
Smilacaceae			
Smilax brasiliensis Spreng.	Not evaluated	Yes	No
Solanaceae			
Cestrum axillare Vell.	Not evaluated	No	No
Solanum bullatum Vell.	Low concern	Yes	No
Solanum cernuum Vell.	Not evaluated	Yes	No
Solanum lycocarpum A.St.-Hil.	Not evaluated	No	No
Styraceae			
Styrax camporum Pohl	Not evaluated	No	No
Styrax ferrugineus Nees & Mart.	Not evaluated	No	No
Styrax latifolius Pohl	Not evaluated	Yes	No
Styrax pohlii A.DC.	Not evaluated	No	No
Symplocaceae			
Symplocos pubescens Klotzsch ex Benth.	Not evaluated	No	No
Symplocos sp.	Not evaluated	No	No
Thymelacaceae			
Daphnopsis coriacea Taub.	Not evaluated	Yes	No
Urticaceae			
Cecropia pachystachya Trécul	Not evaluated	No	No
Verbenaceae			
Aloysia virgata (Ruiz & Pav.) A.Juss.	Not evaluated	No	No
Vochysiaceae			
Qualea grandiflora Mart.	Not evaluated	No	No
Qualea multiflora Mart.	Not evaluated	No	No
Vochysia magnifica Warm.	Not evaluated	Yes	No
Vochysia rufa Mart.	Not evaluated	Yes	No
Vochysia thyrsoidea Pohl	Not evaluated	Yes	No
Vochysia tucanorum Mart.	Not evaluated	No	No
Zygophyllaceae			
Kallstroemia minor Hook.f.	Not evaluated	Not evaluated	No

From the 249 species recorded in our study, 91 are native from Brazil. Four of the species are recorded as Near Threatened, two are Vulnerable and two are Endangered according to the IUCN Red List (International Union for Conservation of Nature [IUCN], 2019).

Discussion

Serpentine environments provide peculiar conditions, resulting in a strong selective pressure, specialized flora to adverse conditions and holding many degrees of soil toxicity and endemism (Cano et al., 2014). Due to the many degrees of nutritional imbalance and inhospitable physicochemical conditions on soils, it is usual to find a depauperate flora on serpentine areas (Branco & Ree, 2010). In some surveys regarding flora associated to serpentine soils in the tropics, it is usual to find a low number of species (Cano et al., 2014), counterpointing the high species number found in our survey. The highest species number found for the Americas in a serpentine soil area was 219 species in Dominican Republic (Cano et al., 2014) and recently 135 species in Philippines (Sarmiento, 2018), reinforcing the importance of the *Morro das Almas* area as one of the most diverse serpentine areas from the Tropics.

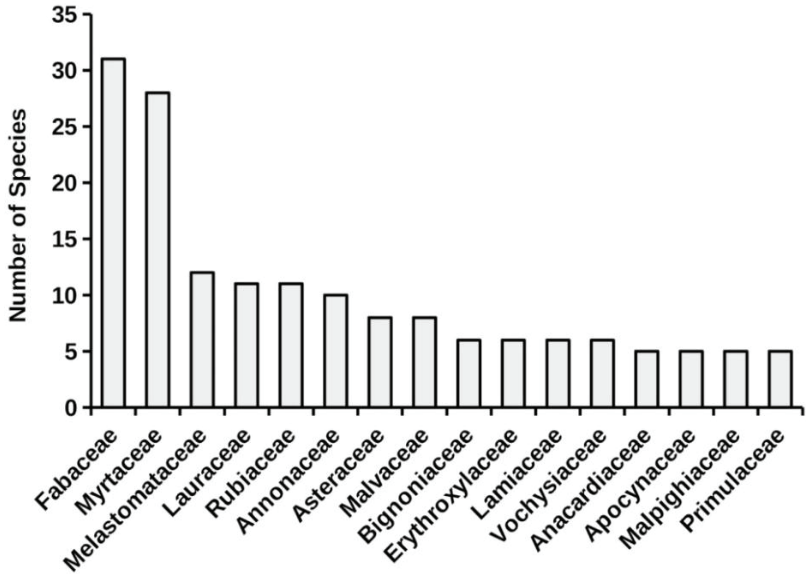

Figure 2. Most representative families (> than 5 species) in a serpentine soil area in Bom Sucesso, Minas Gerais State, Brazil.

The amount of species found in our study points to the existence of some kind of adaptation by the plants present in *Morro das Almas*, making explicit that despite the stress caused by toxic metals in soil, vegetation might present morphological and anatomical adaptations to deal with those effects. Despite the proposal that serpentine soils are limiting factors to vegetation diversification, in our study it doesn't seem to be the key factor influencing this community's plurality, as the high species number can evidence. Fabaceae, Myrtaceae and Melastomataceae, the families with higher species richness, also characterize the neighboring region flora (Guimarães, Almeida, Carneiro, Souza, & Siqueira, 2012; Terra et al., 2018), foregrounding its adaptive power facing edaphic variations.

Fabaceae is frequently associated with nodule systems that benefit not only the plants from this family, but also induces changes in the soil fertility, nitrogen fixation and enhances the variability of microbes (Saad, Kobaissi, Amiaud, Ruelle, & Benizri, 2018), characteristics that might explain the higher representativeness of this family in our study. It is also possible that the soil microbes found in the area might be highly adapted to the excess of toxic heavy metals, as the soil microbes activity can affect the fertility, carbon storages and growth patterns from the plants (Malik et al., 2018).

From the 249 species recorded, two (*Trattinnickia ferruginea* and *Ocotea odorifera*) are classified as endangered according to the IUCN Red List (IUCN, 2019) and protected by the Brazilian law as priority for the conservation in the country (Brasil, 2008). The fact that we could found species that are protected by law at *Morro das Almas* reinforces the need to pay better care for this area. *Morro das Almas* hill has already been studied by MMX *Mineração e Metálicos S.A.*, a company from the Eike Batista group, as a possible location to exploit minerals, but the business didn't continue due to the fact that the company experienced a bankrupt. The fact that a mining company already had the license to exploit this region makes the need to study this place urgent. Since the State of Minas Gerais is already dealing with a series of environmental contamination due to the disrupts of the damn in Mariana and Brumadinho that killed two important rivers for the state (*Rio Doce* and *Rio Paraopeba*), it is vital to study and comprehend the flora from places with natural excess of heavy metal, using them as potencial phytoremediators and vegetation management projects for areas impacted by ore extractions (Ali, Kahn, & Sajad, 2013).

As our results demonstrate from the high number of species found on the area, it seems that the presence of serpentine soil is not enough to restrict the local flora biodiversity, which reinforces that there might be some anatomical and physiological adaptations on the plants from the studied community to deal with the environmental adversity provided by the high levels of iron-magnesium compounds found on the local soil. As those soils are only found in less than 1% of the Earth's exposed surface (Vithanage, Rajapaksha, Oze, Rajakaruna, & Dissanayake, 2014), further investigations on the area might explore the biochemical, ecological and resistance to stress aspect of the plants (Echevarria et al., 2018) to help understand the functioning aspect of this single community. Investigating the relationships between the plants from serpentine areas and the soil might assist on phytostabilization projects, as it's been successfully used in other countries (Boisson et al., 2018; Mizuno, Nakahara, Fujimori, & Yoshida, 2018).

Conclusion

Species substitution and environmental heterogeneity found in this study reinforce serpentine environments importance to conservation as they act as refugee to those species providing a specific habitat for the vegetation.

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