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Policy Forums

# Challenges for the conservation of vanishing megadiverse rupestrian grasslands

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The Espinhaço Mountains comprise a mountain range that stretches more than 1200 km in the east of South America. In these mountainous environments occur the rupestrian grasslands, a complex mosaic of vegetations influenced primarily by relief and ancient geological history. Far from being homogeneous, rupestrian grasslands show different grassy and shrubby vegetation types on rock outcrops (quartzite, sandstone or ironstone), stony to sandy soils, peat bogs, and other transitional physiognomies such as altitudinal cerrado, gallery forests, remnants and hillside Atlantic Rain Forests (e.g. Medina and Fernandes, 2007; Carvalho et al., 2012). In grassland physiognomies the main factor of environmental stress is greatly associated with sandy-stony soils, often very shallow, with low nutrient levels, extreme aluminum toxicity, and low water holding capacity (Carvalho et al., 2012; Negreiros et al., 2014). High radiation incidence and a long period of annual water deficit (Lüttge et al., 2007) confer additional harshness to this singular ecological system. Plants exhibit several types of physiological, biochemical, morphological, structural and phenological adjustments to survive to environmental stresses (Lüttge et al., 2007; Negreiros et al., 2009, 2014). Like other ancient ecosystems with extremely poor soils (see Hooper, 2009), rupestrian grasslands are among the most species-rich vegetations in the World. Approximately one-third of its species are endemic, with varying degrees of rarity and life strategies (Giulietti et al., 1997; Rapini et al., 2008).

Predictive models suggest a catastrophic future for this ecosystem in new climatic scenarios (e.g. IPCC, 2007). Models indicate that the regions which are likely to remain climatically stable until the end of this century will be just the south of the Espinhaço Mountains in Minas Gerais, including the region of the Iron Quadrangle and Serra do Cipó, and other regions as Serra da Canastra and part of the Chapada Diamantina in northern Espinhaço (Fig. 1). These regions therefore represent an invaluable resource for the conservation of rupestrian grasslands. The remaining smaller mountains in central Brazil (which also harbors rupestrian grasslands) as well as the mountains located in the north of Minas Gerais state (e.g. in Diamantina and Grão Mogol municipalities) also are highly endangered. According to our models, by the end of the century rupestrian grasslands might lose up to 95% of the current suitable area (which corresponds to values of approximately 66,500 $km^2$).

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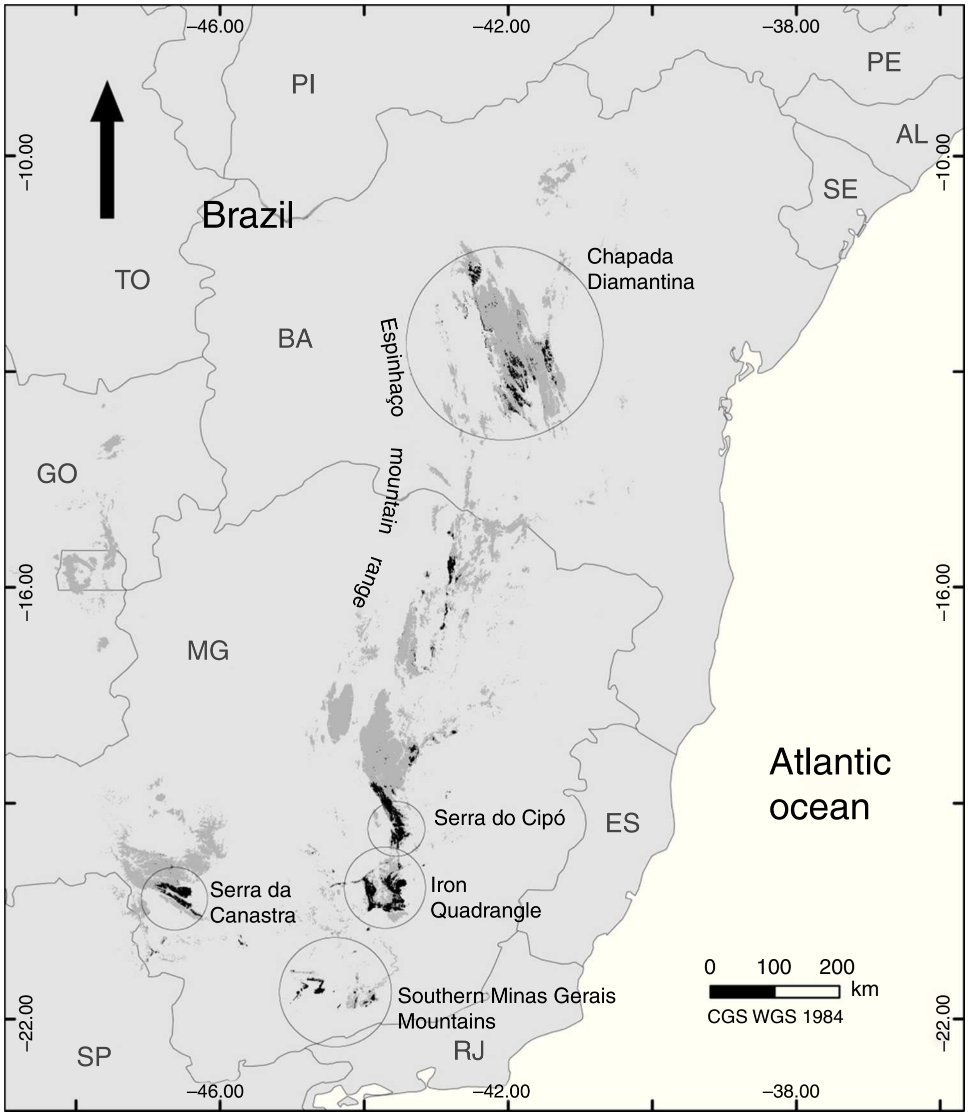


**Fig. 1 – Estimated losses of areas with environmental suitability for rupestrian grasslands calculated through the use of the CCCma-CGCm2 (Canadian Centre for Climate Modelling and Analysis, Coupled Global Climate Model, second generation) climatic model under an optimistic scenario (B2A). In gray the original area and in black areas predicted to the end of the century.**

This scenario becomes even more disturbing considering the intensification of current human impacts (e.g. Barbosa et al., 2010; Jacobi et al., 2011). For example, data for mining processes on rupestrian grasslands, available at SIGMINE/DNPM (www.http://sigmine.dnpm.gov.br/webmap), indicate intense pressure on grasslands in the Iron Quadrangle, which is not well covered by the existing network of strictly protected areas (Fig. 2). Some proposals for prioritizing areas for conservation in the Espinhaço (Drummond et al., 2005; Silva et al., 2008) have been done, and in the last decade, ten protected areas under strict protection were created in rupestrian grasslands in Minas Gerais State protecting about 116,000 ha. However, unique elements of biodiversity and endemism are underrepresented in the protected area system, rupestrian grasslands like ironstone outcrops (i.e. Cangas). In this context, Canga vegetation can be considered one of the most threatened community types in the country.

Mountain ecosystems will be the first places to suffer the impacts of global climate change (IPCC, 2007). Anthropogenic factors, such as extensive cattle ranching, uncontrolled tourism, highly frequent of intense burning episodes and the entry of invasive species (Barbosa et al., 2010; Hilário et al., 2011), are still elements that precludes the conservation of these systems and can act synergistically with climate change, causing unpredictable or even catastrophic results. In 2005, this region was named a Biosphere Reserve by UNESCO to ensure adequate visibility for their conservation. On the other hand, there are still many challenges to be faced by the civil society and the government so that conservation plans can be really effective for the preservation of this very fragile ecosystem (Domingues et al., 2012). Although there is a great interest in the preservation of this unique ecosystem, many species of rupestrian grasslands are endangered, due to the small area they occupy and strong human impacts that have

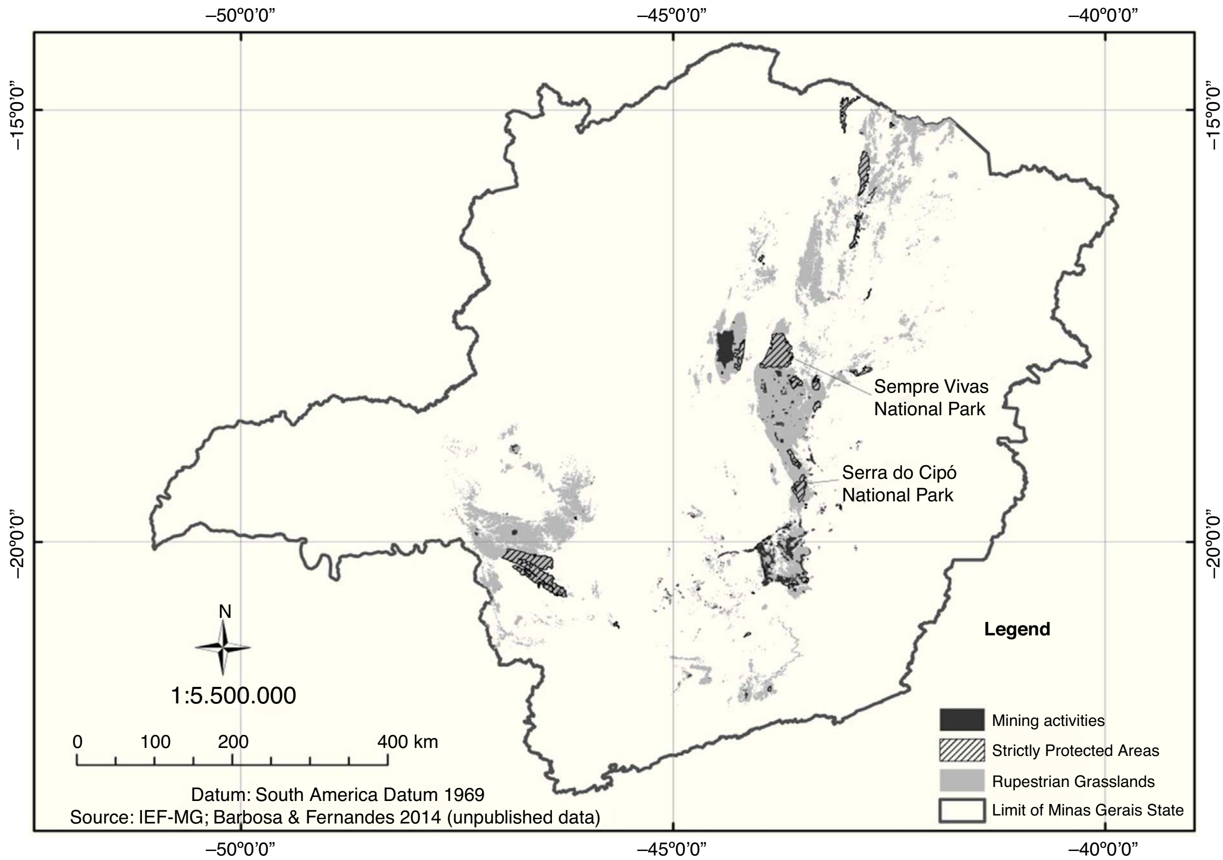


**Fig. 2 – Mining activities and strictly protected areas in rupestrian grasslands in Minas Gerais State. The information about mining activities was obtained from Geographic Information System Mining (SIGMINE) provided by National Department of Mineral Production (DNPM). We use data of current, required and granted mining concession.**

been intensifying in recent years, coupled with the general lack of knowledge about the biology and ecology these species (Moreira et al., 2010; Le Stradic et al., 2014a).

From the 1980s, tourism has intensified in both south of Belo Horizonte city (dominated by ironstone rupestrian grasslands) and northeast (dominated by quartzitic rupestrian grasslands). This growth was primarily driven by the improvement in the road system. The Serra do Cipó (a mountain range full of rupestrian grasslands) is only 100 km away from Belo Horizonte and is a classic example. After paving the MG-010 highway, the tourism multiplied uncontrollably. Currently, the region no longer supports the growing number of tourists, without the infrastructure and education needed for the conservation of natural resources, causing various types of impacts. This floating population is responsible for the deposition of a huge amount of waste, contaminating rivers and aquifers. This picture is further compounded by the critical lack of sanitation in these areas.

Common to rupestrian grasslands, fires caused both by tourists and outdated agricultural practices are enhanced by the presence of invasive exotic grasses, brought to the region primarily for livestock feed (Kolbek and Alves, 2008) as well as to revegetation of degraded areas. The livestock activity, rooted in the history of the regional occupation often under small farmsteads, is responsible for land degradation in many areas and also contributes to the spread of weed plants of great invasive potential, as *Urochloa* spp. P. Beauv. and *Melinis minutiflora* P. Beauv. These grasses are highly combustible, far surpassing the native species, which have a much lower biomass. Unfortunately, instead of increasing the degree of protection and conservation of this rich environment, the situation has actually worsened in the face of erroneous strategies from public officials and the lack of support from regulatory agencies. A clear example is the deliberate introduction of exotic species in still pristine environments. Many plant species have become invasive in the region after being mistakenly used for revegetation purposes, such as *Urochloa* spp., *Melinis minutiflora*, *Cajanus cajan* (L.) Huth, among others (Oliveira et al., 2009; Hilário et al., 2011). Further aggravating this situation, other exotic plants have established along new highways due to the introduction of exogenous soils containing weed propagules (Barbosa et al., 2010). This situation has exacerbated the threat to native species, altering the natural food chain of the region and bringing exotic species of fungi and insects, which can cause disease in the species present there, and thus, cause a series of extinctions (Fernandes and Barbosa, 2013).

Mining now settles heavily on rupestrian grasslands between the Serra do Cipó National Park and Sempre Vivas National Park (Fig. 2). Besides the visual impact, other problems occur as the fragmentation of the environment, extinction of populations and species, pollution and siltation of water bodies, and the introduction of invasive alien species. The rupestrian grassland is extremely fragile and has almost no resilience (Le Stradic et al., 2014a,b). Once the link is broken in this delicate vegetation to the environment, there seems little chance of spontaneous regeneration to occur (Negreiros et al., 2011). Ravines, ridges and gullies can be observed in large numbers across rupestrian grasslands. Areas resulting from the historical use processes remain devoid of vegetation, even having been abandoned for decades (e.g. Giulietti et al., 1997; Negreiros et al., 2011).

Despite advances, knowledge generated in recent decades is insufficient given the enormous diversity and importance of rupestrian grasslands (Resende et al., 2013). There is a need for a major effort to broaden and deepen observational and experimental knowledge on the ecology of native and invasive species and land use change. This will enable robust conservation and management strategies, like control of biological invasion and creation of new protected areas considering future climate scenario, helping the conservation of perhaps the more singular natural vegetation of Brazil.

## Conflicts of interest

The authors declare no conflicts of interest.

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