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# Adaptive strategies in burned subtropical grassland in southern Brazil

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## Abstract

Extensive parts of subtropical South America are covered by grassland vegetation, despite climatic conditions that allow for forest development, and fire may have been an important factor in the evolutionary history of these grasslands. In a regularly burned grassland area, situated in a forest–grassland-mosaic near Porto Alegre, RS, Brazil, life form spectrum and plant species' reaction to fire were examined, allowing for (1) a physiognomic description of the grassland, and (2) a functional classification of grassland species in relation to fire. Grassland sites with different time since the last fire occurred were compared between each other as well as to sites at the forest–grassland border. South Brazilian grassland is dominated by hemicryptophytic caespitose graminoids that resist fires, but contains a large number of geophytic or hemicryptophytic forbs, in general sprouting after fire. Shrubs, mostly sprouting species of the grassland community, were present with high cover values even in recently burned areas. In contrast to Central Brazilian Cerrado, trees were of little importance: most species found were forest pioneer species without the capacity to survive fires unless growing on sites protected from fire or at the forest border where burns stop. Non-sprouting species were of little importance in the community, and only two species found were therophytes. Lack of therophytes in South Brazilian grassland vegetation deserves further attention.


***Keywords:*** Campos; Fire; Life form; Plant functional type; Raunkiaer

## Introduction

While savanna ecosystems cover large parts of tropical South America (e.g., Sarmiento 1990 for an overview), wide parts of northern Argentina and Uruguay are characterized by grasslands, extending around the Río de la Plata and continuing in southern Brazil (Bilenca and Miñarro 2004; Soriano et al. 1992; Fig. 1). In southern Brazil, natural grasslands (''Campos'') can be found in the southermost state Rio Grande do Sul (RS; Fig. 2) and in the adjacent states of Santa Catarina (SC) and Paraná (PR). The total extension of the grasslands in those three states has been reduced from originally 218.700 $km^2$ (Longhi-Wagner 2003) to today appoximately 136.800 $km^2$ (Nabinger et al. 2000), principally due to expansion of agri- and silvicultural production. South Brazilian *Campos* grasslands, presenting a mixture of $C_4$ and $C_3$ grasses with $C_4$ dominance, are under subtropical humid climate (Köppen's Cfa) in southern RS state, and under warm-temperate humid climate on the highlands in northern RS and adjacent SC (Köppen's Cfb; Moreno 1961), in the latter climatic region in mosaics with Araucaria forests (see Fig. 1). Precipitation in southern Brazil ranges from 1200 (southern RS) to over 2200 mm $year^{-1}$ (highest part of the planalto in northern RS), with no dry season. Hydric deficits may occasionally occur in the

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**Fig. 1.** Location of temperate and subtropical grasslands in southern South America, between 25 and 38°S (both shades of gray). Grasslands south of the Río de la Plata commonly are considered to be *Pampas* grassland; those north of the Río de la Plata; *Campos*. *Campos* grasslands in Brazil depicted in darker shade gray (sources: Soriano et al. 1992 for Argentina and Uruguay; Leite 2002 for distribution of grasslands in Brazil, modified).

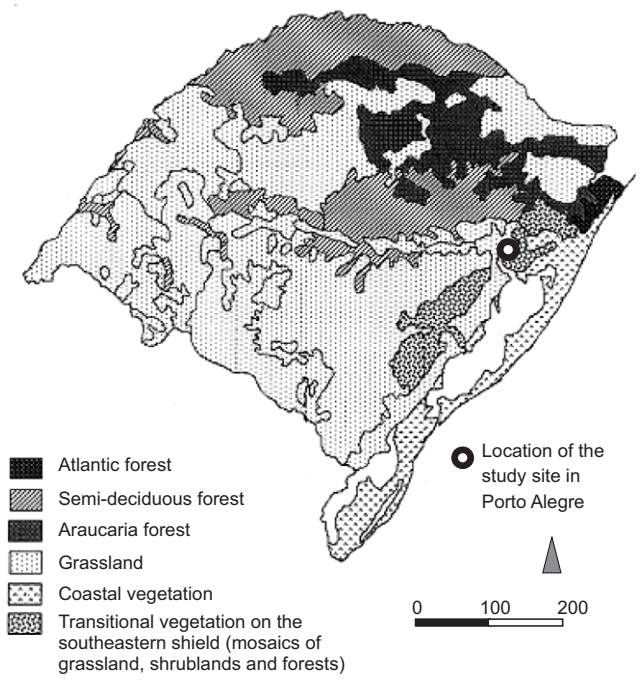


**Fig. 2.** Vegetation types in Brazil's southernmost state, Rio Grande do Sul (from Pillar and Quadros 1997, modified).

summer months, but current climatic conditions allow for forest development (Lindman 1906; Rambo 1956). Already Lindman (1906) had noted the contradiction between the presence of grassland vegetation in southern Brazil and humid climatic conditions that allow for forest development. Similarly, the presence of grasslands in a climate apparently supporting forest vegetation has led to intense debate of the so-called "Pampas problem" in the Río de la Plata region (e.g., Box 1986; Eriksen 1978; Walter 1967). Discussion, however, focused on relations between climate and vegetation in a rather static view, neglecting vegetation history and the possibility of rather recent climatic changes. Phytogeographical and paleoecological data suggest that grasslands in southern Brazil are relicts of drier and cooler conditions during the last glacial and post-glacial periods, stabilized by herbivory and fire and subject to forest invasion only relatively recently (Behling 2002, 2004; Bigarella 1971; Klein 1975; Pillar and Quadros 1997; Rambo 1953, 1956). In contrast to South African savannas and grasslands, large native herbivores are largely missing: they became extinct as the result of climatic changes between the end of the last glaciation and 8000 years BP (Kern 1994), coninciding with the arrival of human populations in the region. The fire history of southern Brazil is poorly known. Palynological studies indicate that fire was rare during early post-glacial times, but became frequent about 7400 years ago (Behling et al. 2004), possibly as it may have been used as a tool for hunting by indigeneous people (Kern 1994). In Cerrado (Central Brazilian savannas), fire is considered to have been present long before human occupation, but frequency most probably has increased with anthropogenic use (Hoffmann and Moreira 2002; Miranda et al. 2002); the effect has been a stabilization of open vegetation formations by impeding establishment of forest species, and thus a change in physignomy (Hoffmann 1996, 2000; Mirelles et al. 1997). Recent modelling of the distribution of vegetation types in southern Africa in relation to climatic parameters and fire has shown that in regions above a certain limit of precipitation (approx. 650 mm for southern Africa), not climatic conditions, but presence of fire determines vegetation physiognomy, independent of historic human action (Bond et al. 2003). While less data are available for southern Brazil, the situation likely is similar.

Few studies have been conducted on the effect of fire on grassland communities in southern Brazil. Single fire events do not invoke major overall compositional changes (Eggers and Porto 1994), and fire has been shown to increase small-scale and short-term diversity (Overbeck et al. 2005). Adaptations of South Brazilian *Campos* species have not been studied explicitly so far. A number of classification systems for plant adapations exist, including some specifically related to fire. Noble and Slatyer (1980) have presented a general model of plant strategies in respect to fire, focusing on regeneration or colonization attributes; application of this model to a community, however, requires detailed information