
Spatiotemporal analysis of the grassland cover of the Pampa biome: reflections on its degradation

Análisis espacio-temporal de la cobertura de pastizales en el bioma Pampa: reflexiones sobre su degradación

Análise espaço temporal das coberturas campestres do bioma Pampa: reflexões sobre a sua degradação

Edvania Aparecida Corrêa Alves¹ <https://orcid.org/0000-0002-0712-5055>

¹ Universidade Federal de Pelotas, Pelotas, Rio Grande do Sul, edvania.alves@ufpel.edu.br

Received on: 08/27/2024

Accepted for publication on: 11/03/2024

Abstract

The areas with Grassland Formation present in the Pampa Biome are considered zones of high pressure for the advancement of agricultural frontiers, especially for agricultural commodities. The objective of this article was to evaluate the spatiotemporal dynamics (1985-2022) of the Grassland Formation coverage of the current Pampa Biome in the state of Rio Grande do Sul, identifying the agricultural frontiers and the degree of manipulation of this biome. Geoprocessing techniques and data from MapBiomas collection 8 were used. In the period from 1985 to 2022, there was a suppression of 56.3% of the remaining grassland vegetation that existed in 1985, leaving 31% of the remaining vegetation. The suppression of native vegetation occurred predominantly in favor of soybean farming.

Keywords: Geoprocessing. Land use and land cover dynamics; environmental legislation; agricultural commodities.

Resumen

Las áreas con Formación Campestre presentes en el Bioma Pampa son consideradas áreas de alta presión para el avance de las fronteras agrícolas, especialmente para los commodities agrícolas. En este sentido, el objetivo de este artículo fue evaluar la dinámica espacial y temporal (1985-2022) de

[Geopauta](#), Vitória da Conquista, V. 8, 2024, e15647

Este é um artigo de acesso aberto sob a licença Creative Commons da [CC BY](#)

la cobertura de la Formación Campestre del actual Bioma Pampa en el estado de Rio Grande do Sul, identificando las fronteras agrícolas y el grado de manipulación de este bioma. Se utilizaron técnicas de geoprocésamiento y datos de la colección MapBiomias 8. En el periodo de 1985 a 2022 se produjo una supresión del 56,3% de la vegetación de pastizal remanente que existía en 1985, quedando el 31% de la vegetación remanente. La supresión de la vegetación nativa se produjo, predominantemente, a favor del cultivo de soja.

Palabras clave: Geoprocésamiento. dinámica de uso y cobertura del suelo; legislación ambiental; productos agrícolas.

Resumo

As áreas com Formação Campestres presentes no Bioma Pampa são consideradas zonas de elevada pressão para o avanço das fronteiras agrícolas, especialmente por *commodities agrícolas*. Neste sentido, o objetivo do presente artigo foi o de avaliar a dinâmica espaço-temporal (1985-2022) das coberturas de Formação Campestre do Bioma Pampa presente no estado do Rio Grande do Sul visando identificar as fronteiras agrícolas e o grau de degradação deste bioma. Foram utilizadas técnicas de geoprocessamento e os dados provenientes da coleção 8 do MapBiomias. No período de 1985 a 2022 houve a supressão de 56,3% da vegetação Campestre remanescente que existia em 1985, restando 31% de vegetação remanescente. A supressão da vegetação nativa se deu, predominantemente, em prol da Sojicultura.

Palavras-chave: Geoprocessamento. dinâmica do uso e cobertura da terra; legislação ambiental; commodities agrícolas.

Introduction

Currently, Brazil holds a prominent position in global agricultural production, producing approximately 10% of the food consumed in the world (Contini; Aragão, 2021). Rio Grande do Sul is one of the states with the highest agricultural production in Brazil (Mapa, 2020), and the areas with Grassland Formation used for livestock farming are considered to be areas of high pressure for the expansion of agricultural frontiers.

According to Kuplich; Capoane; Costa (2018), livestock farming on native fields is a traditional activity in the biome and, under adequate conditions, can enable its conservation, combining income generation with the sustainable use of natural resources (Echer et al., 2016). However, with the reduction of natural grassland areas,

there is overexploitation of the remaining areas due to the high density of animals per area, promoting the selection of specific and exotic plant species to the detriment of other native individuals (Overbeck et al. 2007; Echer et al., 2016), while at the same time degrading the soils through compaction by cattle trampling and the increase in erosion processes.

When the native areas of the Pampa Biome are not overexploited by livestock, there is suppression of native formations due to the expansion of cultivated areas, especially agricultural commodities such as soybean and rice farming (Sommer; Saldanha, 2012; Palazzi, 2018, Kuplich; Capoane; Costa, 2018; Oliveira, 2020; Palazzi, 2018). Some authors claim that in the general context, the native Pampa today represents only about 40% of its original vegetation (Overbeck et al., 2007; Ribeiro et al., 2021; Rolim; Rosenfield; Overbeck, 2022).

It is worth noting that the Pampa landscapes are naturally characterized by mountain ranges, hills, rocky hills and plains, in addition to the emblematic and dominant native fields and, to a lesser extent, riparian forests, hillside forests, shrub formations, among others (MMA, 2023; Rovedder, 2013). Although the grassland vegetation of the Pampa biome is a legacy of climate change associated with human actions over the last 12,000 years (Buriol et al., 2007), Boldrini (2009) and Kuplich et al. (2016) state that native grassland vegetation, when kept preserved, guarantees ecosystem services, such as the protection of water resources, soils and the maintenance of plant and animal species. However, it is observed that the Pampa biome, when compared to other Brazilian biomes, is the one with the smallest territorial quantity of Conservation Units (UC) (MMA, 2023; Kuplich; Capoane; Costa, 2018) and is the one that has shown the least progress in the creation of these in recent decades (Palazzi, 2018). Of the entire territory composed of the Pampa Biome, only 3.23% is allocated to Conservation Units, while the recommendation by the Convention on Biological Diversity (CBD, 2010) is that this percentage should be at least 17% (Bertzky, et al 2012; Conabio, 2013; Palazzi, 2018). Likewise, the Pampa

biome, together with the Cerrado and Caatinga biomes, are not considered natural heritage sites according to the Brazilian Federal Constitution (BRAZIL, 1988), and do not have guarantees for the preservation of their cultural, historical, biopatrimonial and geopatrmonial heritage.

Considering the above, the objective of this article was to evaluate the space-time dynamics (1985-2022) of the Campestre Formation coverage of the Pampa Biome present in the state of Rio Grande do Sul, aiming to identify the agricultural frontiers and the degree of degradation of this biome.

Methodology

The geospatial database was organized using the continuous vector cartographic base of Rio Grande do Sul (scale of 1:50,000) by Hasenack and Weber (2010) in addition to vector data provided by IBGE (2024), Ana (2024) and Fepam (2024).

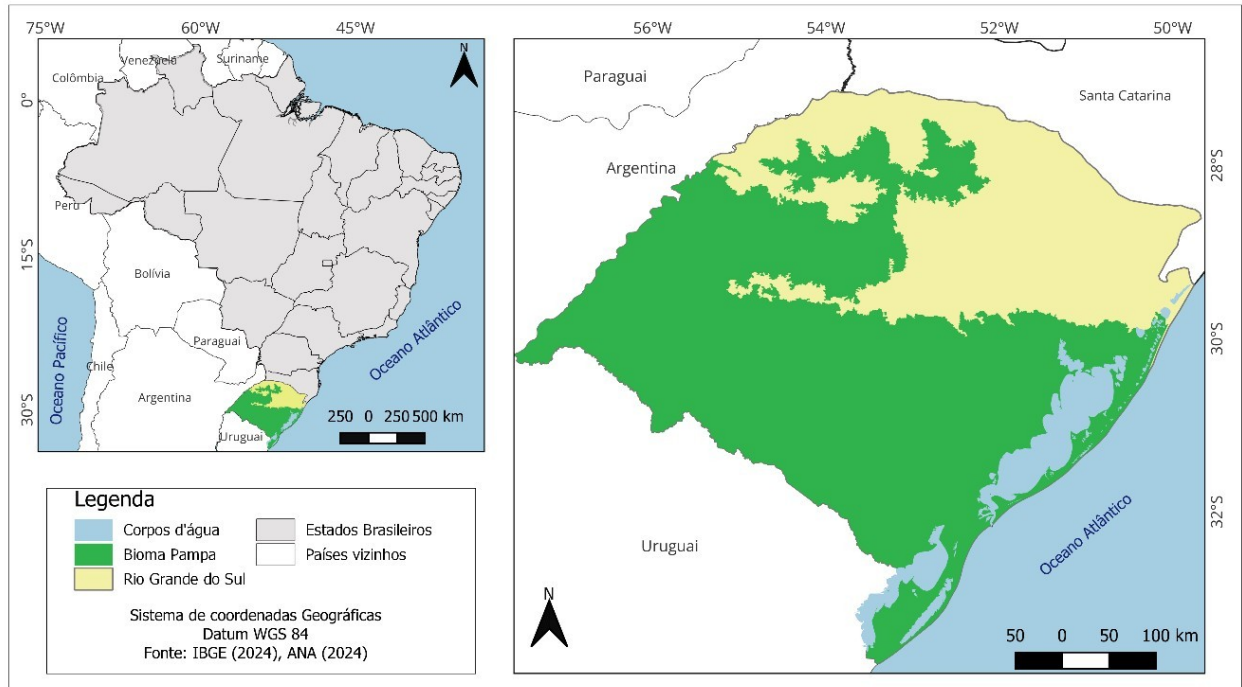
Data from MapBioma and the Google Enginee® platform (collection 8) were used. Land use and land cover data for the Pampa Biome section of the 1985 and 2022 scenarios were acquired. The 1985 scenario was considered as the initial scenario and this was compared to the 2022 scenario. After data acquisition, only the land cover with Campestre formation was analyzed. The collected scenarios were processed using QGis 3.28 and considering the geographic coordinate system, Datum WGS 84. Subsequently, considering the 1985 scenario, the areas that ceased to be native and were transformed into other anthropic uses were verified and quantified.

Results and discussion

Considering only its Brazilian portion, the Pampa is located exclusively in the southern and southeastern regions of the state of Rio Grande do Sul, corresponding to 63% of the state's area and 2.07% of the national territory (Rovedder, 2013). Despite its great importance to the region, the Pampa was only recognized as a biome in

Brazil in 2004 (IBGE, 2004) (Figure 1) due to negligence on the part of public biodiversity conservation policies (Overberck et al., 2009).

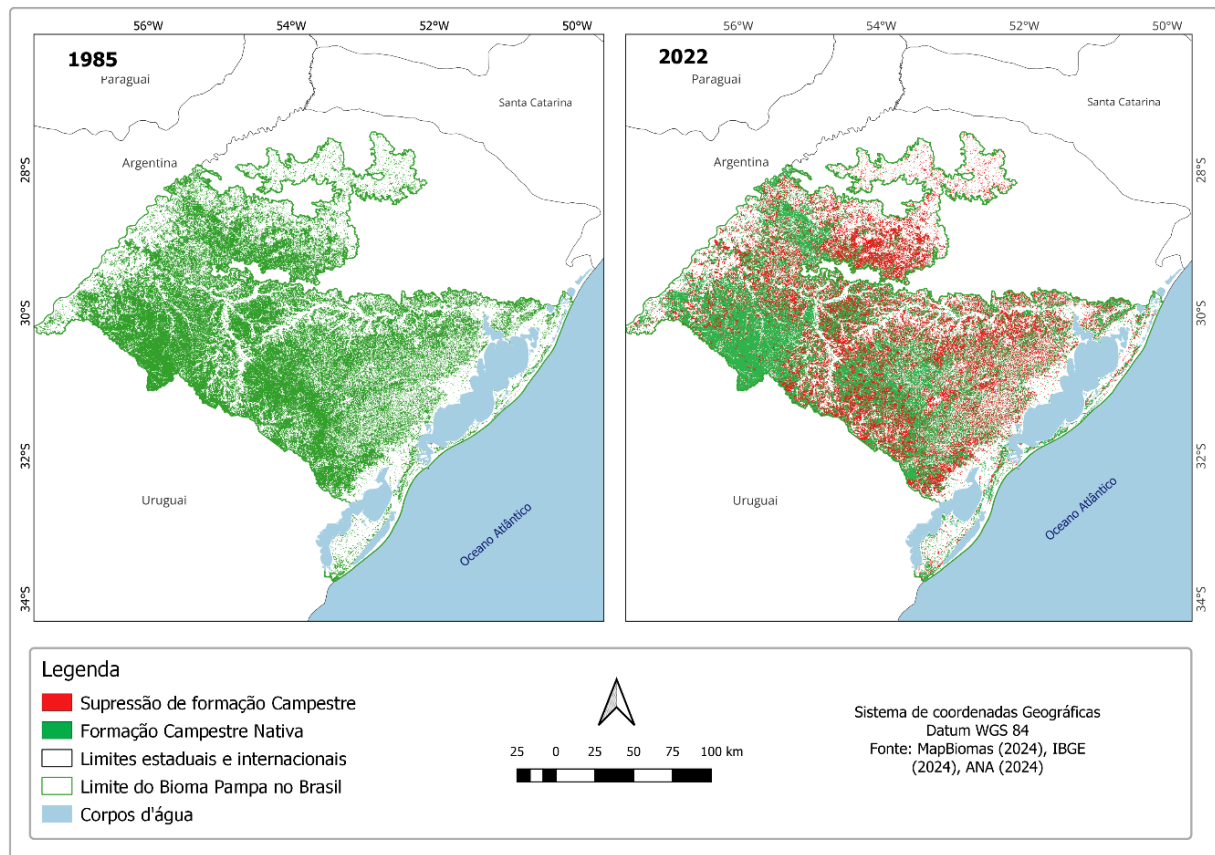
Map 1 - Location of the Pampa Biome in Brazilian territory.



Source: Prepared by Alves (2024)

The total area delimited by the Pampa biome and defined by the IBGE (2024), excluding the lagoon water bodies present in the coastal plain, is approximately 179,526 km². Studies indicate that before the insertion of industrial agricultural activities, the pampa biome's grassland areas were already in a process of degradation due to overcrowding by cattle and horses fenced in on properties. Before this process of overcrowding and degradation, the grasslands were composed of geophytes with creeping habits and a great biodiversity persisted (Cruz; Guadagnin, 2010). In 1985, the Campestre Formation coverage was 90,318.63 km², demonstrating a reduction in the original native coverage (Figures 2 and 3). In 2022, the Grassland Formations totaled 50,853.38 km², demonstrating that in a period of 37 years, 56.3% of the Grassland vegetation that existed in 1985 was suppressed.

Map 2 - Remnants of rural formation in 1985 and areas suppressed in 2022.



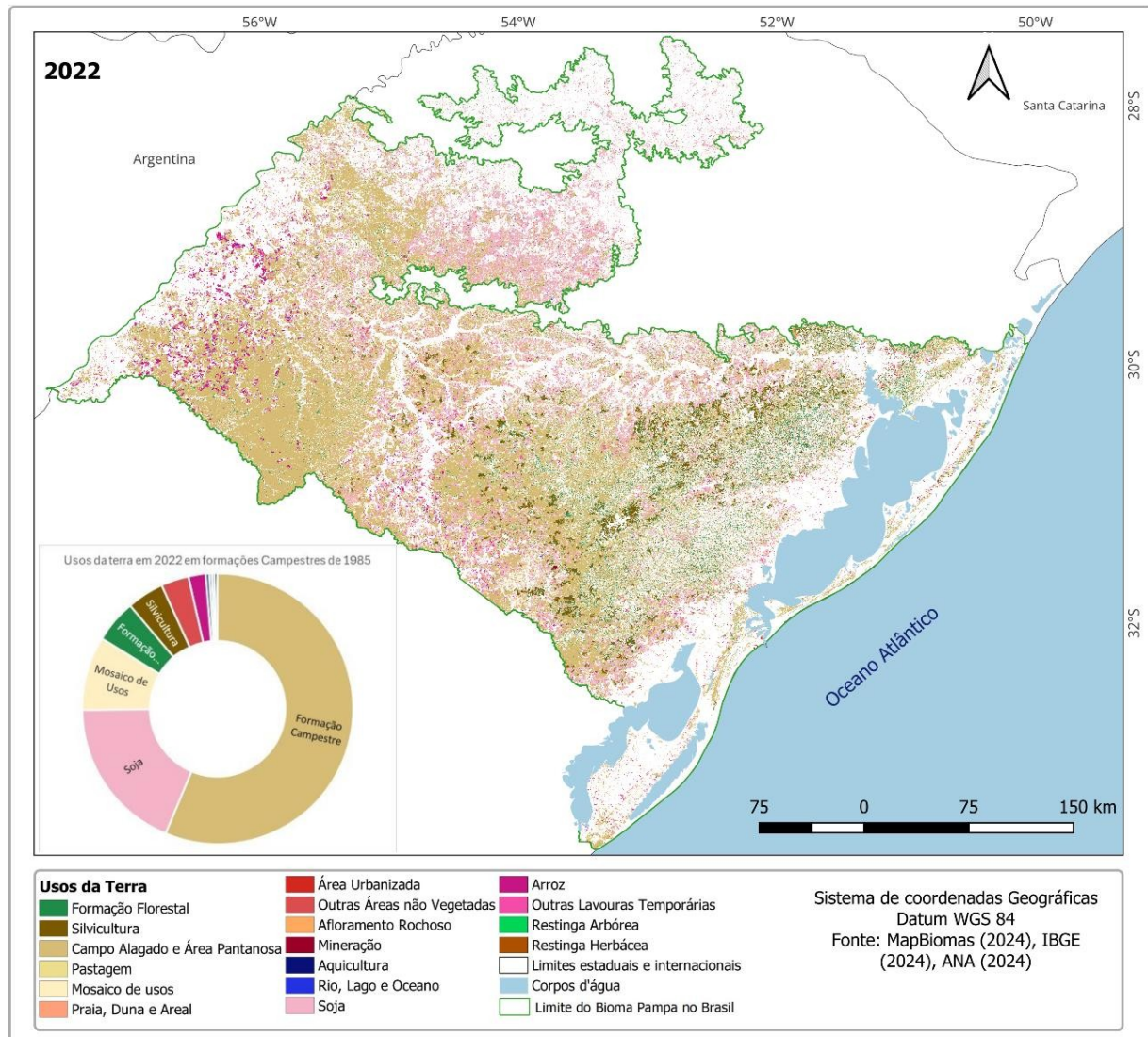
Source: Prepared by Alves (2024)

When comparing all native coverage of the Pampa biome (classes called Forest Formation, Grassland Formation, Flooded Field and Marshy Area, and Arboreal and Herbaceous Restingas) there is a total of 55,806.77 km² in 2022, which results in only 31% of the vegetation of the Pampa biome remaining, demonstrating that 69% of the Pampa Biome areas (according to the limit proposed by IBGE, 2024) were suppressed by 2022.

Regarding the Grassland Formation coverage, map 2 shows the changes in uses between the 1985 and 2022 scenarios. It is possible to observe that the agricultural frontiers are found especially in the north/northwest and central/south portions of the state. In the north and northwest portions of the state, there is suppression of Grassland Formation in favor of soybean farming and other temporary crops (map 3). In this region, there were few remnants of Campestre Formation in 1985 (map 2) and almost total elimination of these in 2022. It is in this region that the Alto and Médio

Jacuí and Ijuí hydrographic basins are located, basins that since 2023 have been suffering from processes of intense rainfall and major floods and that have caused environmental, social and economic losses to the entire state of Rio Grande do Sul.

Map 3 - Land use and land cover (2022 scenario) present in the remnants of Campestre Formation existing in 1985.



Fonte: Elaborado por Alves (2024)

In the central/southern portion of the state, the suppression of the Campestre formation was also observed in place of soybean cultivation and forestry, the latter being a crop that grew rapidly among the scenarios evaluated (map 3).

Regarding the changes in the remaining Campestre formations from 1985, it is possible to observe in map 3 that, in general, there was a high growth in Soybean

cultivation, Mosaics of Uses and Forestry, with these expanding by 18.5% and 8.8% and 4.4% respectively over the areas of remaining *Campestre* Formation from 1985. Although there is environmental legislation that aims to protect other natural vegetation that has been useful to the lands that cover it since 1965 in Brazil (Brasil, 1965, 2012), it is noted that the Pampa Biome has no political or economic importance for its conservation. In this context, Overbeck et al. (2015) report that in Brazil there is little attention to the conservation and monitoring of non-forest covers, which is the reason behind the devastation of biomes such as the Pampa, Pantanal, Cerrado and Caatinga.

Final Considerations

Between 1985 and 2022, 56.3% of the remaining grassland vegetation that existed in 1985 was removed. In relation to the existing limit of the Pampa biome delimited by the IBGE (2024), 31% of the remaining vegetation remains. It can be seen that in the temporal and spatial cut-off evaluated, the removal of native vegetation was in favor of temporary crops, with emphasis on soybean farming, which is linked to the agricultural commodities market. It can also be seen that the areas of greatest degradation are located in the North/Northwest and Center/South portions, with native vegetation being practically absent in the North/Northwest portion. This region contains important river basins that have been undergoing climate emergency processes since 2023, with the occurrence of intense rains and extreme flooding. It is worth noting that, despite the existence of federal environmental legislation aimed at protecting natural vegetation of relevant importance, the Pampa biome stands out for its lack of compliance with the legislation as well as for the proposal of new environmental legislation at the state level (Law 15434, of 09/01/2020) that allows the suppression of native fields for use with temporary crops. Thus, the climate emergency currently experienced by Rio Grande do Sul is also the result of the misuse of land associated with local political will.

References

ANA. Agência Nacional de Águas e Saneamento Básico. **Dados Abertos da Agência Nacional de Águas e Saneamento Básico**. Disponível em <https://dadosabertos.ana.gov.br/>. Acesso em 01 de junho de 2024.

BERTZKY, B., CORRIGAN, C., KEMSEY, J., KENNEY, S., RAVILIOUS, C., BESANÇON, C., BURGESS, N. **Protected Planet Report 2012: Tracking progress towards global targets for protected areas**. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK, 2012.

BOLDRINI, I. I. A flora dos campos do Rio Grande do Sul. In: PILLAR, V. P.; MÜLLER, S. C.; CASTILHOS, Z. M. S.; JACQUES, A. V. A. (Eds.). **Campos Sulinos: conservação e uso sustentável da biodiversidade**. Ministério do Meio Ambiente, Brasília, 2009. pp. 63- 77.

BRASIL, **Lei nº 4.771, de 15 de setembro de 1965**. Institui o novo Código Florestal, 1965. Disponível em: http://www.planalto.gov.br/ccivil_03/leis/l4771.htm. Acesso em: 03 nov. 2021.

BRASIL. **Lei nº 12.651, de 25 de maio de 2012**. Dispõe sobre a proteção da vegetação nativa; altera as Leis nºs 6.938, de 31 de agosto de 1981, 9.393, de 19 de dezembro de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nºs 4.771, de 15 de setembro de 1965, e 7.754, de 14 de abril de 1989, e a Medida Provisória nº 2.166-67, de 24 de agosto de 2001; e dá outras providências. Brasília: Presidência da República, 2012. Disponível em: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm. Acesso em: 03 nov. 2021.

BRASIL. **Constituição da República Federativa do Brasil**: texto constitucional promulgado em 5 de outubro de 1988, com as alterações determinadas pelas Emendas Constitucionais de Revisão nos 1 a 6/94, pelas Emendas Constitucionais nos 1/92 a 91/2016 e pelo Decreto Legislativo no 186/2008. – Brasília: Senado Federal, Coordenação de Edições Técnicas, 2016. 496 p.

BURIOL, G. A.; ESTEFANEL, V; CHAGAS, A. C.; EBERHARDT, D. Clima e vegetação natural do estado do Rio Grande do Sul segundo o diagrama climático de Walter e Lieth. **Ciência Florestal**, Santa Maria, v. 17, n. 2, p. 91-100, 2007.

CBD, 2010. **Decision X/2**. <https://www.cbd.int/decision/cop/?id=12268> (acesso em 19/06/2024).

CONABIO. **Resolução no 6 - Dispõe sobre as Metas Nacionais de Biodiversidade para 2020**. Disponível em: http://www.mma.gov.br/images/arquivo/80049/Conabio/Documentos/Resolucao_06_03set2013.pdf. Acesso em 20/12/2023.

CONTINI, E.; ARAGÃO, A. **O Agro Brasileiro alimenta 800 milhões de pessoas**. Online. 2021. Disponível em: <https://neomundo.org.br/2021/02/26/o-agro-brasileiro-alimenta-800-milhoes-de-pessoas/>. Acesso em: 21 fev. 2024.

CRUZ, R. C., GUADAGNIN, D. L. Uma pequena história ambiental do Pampa: proposta de uma abordagem baseada na relação entre perturbação e mudança In: **A sustentabilidade da**

Região da Campanha-RS: Práticas e teorias a respeito das relações entre ambiente, sociedade, cultura e políticas públicas. Ed. Santa Maria, RS.: UFSM, PPG Geografia e Geociências, Dep. de Geociências, 2010, p. 155-179.

ECHER, R. et al. Usos da terra e ameaças para a conservação da biodiversidade no bioma Pampa, Rio Grande do Sul. **Revista Thema**, Pelotas, v. 12, n. 2, p. 4-13, 2016.

FEPAM. **Dados Geoespaciais.** Disponível em <https://www.sema.rs.gov.br/si-dados-geoespaciais>. Acesso em 01/06/2024.

HASENACK, H.; WEBER, E. (org.) **Base cartográfica vetorial contínua do Rio Grande do Sul** - escala 1:50.000. Porto Alegre: UFRGS Centro de Ecologia. 2010. 1 DVD-ROM.

IBGE, Instituto Brasileiro de Geografia e Estatística. **Mapa de Biomas do Brasil.** IBGE, 2004. Online. Disponível em: <https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html?=&t=downloads>. Acesso em: 12 fev.2024.

KUPLICH, T. M. et al. **Algumas aplicações de sensoriamento remoto em estudos de vegetação campestre no RS.** Instituto Nacional de Pesquisas Espaciais - INPE, Brasil, 2016. Disponível em: <http://mtc-m21b.sid.inpe.br/col/sid.inpe.br/mtc-m21b/2016/06.02.13.31/doc/publicacao.pdf>. Acesso em: 19 de junho de 2024.

KUPLICH, T. M.; CAPOANE, V; COSTA, L. F. F. O avanço da soja no bioma Pampa. **Boletim Geográfico do Rio Grande do Sul**, Porto Alegre, n. 31, p. 83- 100, 2018.

MAPA, Ministério da Agricultura, Pecuária e Abastecimento. **Agropecuária brasileira em números.** Online. Disponível em: <https://www.gov.br/agricultura/pt-br/assuntos/politica-agricola/todas-publicacoes-de-politica-agricola/agropecuaria-brasileira-em-numeros/abn-02-2022.pdf/view>. Acesso em: 05 mar. 2024.

MAPBIOMAS. **Mapa de usos e cobertura da terra do Bioma Pampa.** Coleção 8. Disponível em [projects/mapbiomas-workspace/public/collection8/mapbiomas_collection80_integration_v1](https://projects.mapbiomas-workspace/public/collection8/mapbiomas_collection80_integration_v1). Acesso em 2024;

MMA. **Pampa.** Ministério do Meio Ambiente, Brasília, 31 mar. 2022. Acessado em 23 set. 2023. Online. Disponível em: <https://antigo.mma.gov.br/biomas/pampa.html>.

OLIVEIRA, C. V. de. **Análise de mudanças da cobertura e uso do solo no Bioma Pampa com matrizes de transição.** 2020. Dissertação (Mestrado em Sensoriamento Remoto) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2020.

OVERBECK, G.; VÉLEZ-MARTIN, E.; SCARANO, F.; LEWINSOHN, T.; FONSECA, C.; MEYER, S.; MÜLLER, S.; CEOTTO, P.; DADALT, L.; DURIGAN, G. Conservation in Brazil Needs to Include Non-Forest Ecosystems. **Divers. Distrib.** 2015, 21, 1455–1460.

OVERBECK, G. E. et al. Brazil's neglected biome: The South Brazilian Campos. Perspectives in Plant Ecology, **Evolution and Systematics** v.9, p. 101-116, 2007.

OVERBECK, G. E., et. al. Os campos Sulinos: um bioma negligenciado. In: PILLAR, V. D.P., et. al. **Campos Sulinos: conservação e uso sustentável da biodiversidade.** Brasília. MMA, 2009. p. 26-41. Disponível em: Acesso em: 02 abr. 2024

PALAZZI, GIOVANNA. **A meta para o sistema de áreas protegidas no Bioma Pampa: como estamos e para onde vamos?** Dissertação de Mestrado em Ecologia. Universidade Federal do Rio Grande do Sul, Porto Alegre, 2018.

RIBEIRO, S. et al. Protected Areas of the Pampa biome presented land use incompatible with conservation purposes. **Journal of Land Use Science**, v. 16, n. 3, p. 260-272, 2021.

ROLIM, R. G.; ROSENFELD, M. F.; OVERBECK, G. E. Are we ready to restore South Brazilian grasslands? Plant material and legal requirements for restoration and plant production. **Acta Botanica Brasilica**, v. 36, 2022.

ROVEDDER, A. P. M. Bioma Pampa: relações solo-vegetação e experiências de restauração. In: **XIV Congresso Nacional De Botânica: botânica sempre viva**. Belo Horizonte, 2013, Anais... Belo Horizonte: Sociedade Botânica do Brasil, 2013, p. 46-53.

SOMMER, J.; SALDANHA, D. Análise Temporal do Uso e Cobertura dos Solos no Município de São José dos Ausentes, Rio Grande do Sul, Brasil. **Revista Brasileira de Geografia Física**, v. 1, p. 18-32, 2012.

Acknowledgements

To the Rio Grande do Sul Research Support Foundation (FAPERGS) for research funding (grant term: 24/2551-0001151-0).