# Wetlands of Rio Grande do Sul, Brazil: a classification with emphasis on plant communities.

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**ABSTRACT: Wetlands of Rio Grande do Sul, Brazil: A classification with emphasis on plant communities.** Wetland classification is particularly important for conducting inventories, watershed planning, biodiversity assessment and evaluating wetland functions. The type of vegetation has been one of the most used criteria in wetland classification systems. The objectives of this paper were: 1. to propose a hierarchical classification of the palustrine wetlands in the state of Rio Grande do Sul with emphasis on the structure of their plant communities and 2. to test the proposed classification in 146 wetlands distributed over the state of Rio Grande do Sul. Vegetation survey was carried using the Aqua-Rap Program. In order to test the classification, a total of 146 palustrine wetlands was sampled within the four geomorphologic units. The wetland classification proposed for the state of Rio Grande do Sul is hierarchical and it is divided into four levels based on hydrogeomorphologic and biologic factors (subsystems, types, classes and subclasses). The 146 analyzed wetlands of Rio Grande do Sul was distributed in two systems: "palustrine" (95.9%) and "man-made" (4.1%). The palustrine system was divided in three subsystems: "palustrine" (62.8%), "lacustrine" (28.6%) and "floodplain" (8.6%). A total of 17 wetland classes were identified, which "palustrine palustrine permanent emergent (18.5%) and "palustrine palustrine permanent aquatic bed" (11.6%) were the most frequent. We hope that this classification can generate some discussion among limnologists, wetland ecologists and hydrologists and that it will gradually establish an acceptable classification system for the wetlands in the State of Rio Grande do Sul.

**Key-words:** wetlands, classification, vegetation, conservation, Brazil.

**RESUMO: Áreas úmidas do Rio Grande do Sul, Brasil: Uma classificação com ênfase nas comunidades de plantas.** A classificação de áreas úmidas é particularmente importante para a elaboração de inventários, planejamento de bacias hidrográficas, avaliação da biodiversidade e reconhecimento de suas funções. O tipo de vegetação tem sido um dos critérios mais utilizados nos sistemas de classificação de áreas úmidas. Os objetivos desse trabalho foram: 1. propor uma classificação hierárquica das áreas úmidas palustres do estado do Rio Grande do Sul com ênfase na estrutura de suas comunidades de plantas e; 2. testar a classificação proposta em 146 áreas úmidas distribuídas ao longo do estado do Rio Grande do Sul. O levantamento da vegetação foi realizado utilizando o Programa Aqua-Rap. Com a finalidade de testar a classificação, foi amostrado um total de 146 áreas úmidas, distribuídas em quatro unidades geomorfológicas. A classificação das áreas úmidas proposta para o estado do Rio Grande do Sul é hierárquica e se divide em quatro níveis baseados em fatores hidrogeomorfológicos e biológicos (subsistema, tipos, classes e subclasses). As 146 áreas úmidas estudadas estão distribuídas em dois sistemas: "palustre" (95,9%) e "artificial" (4,1%). O sistema palustre foi dividido em três subsistemas: "palustre" (62,8%), "lacustre" (28,6%) e "planícies de inundação" (8,6%). Um total de 17 classes de áreas úmidas foi identificado, sendo "palustre palustre permanente emergente" (18,5%) e "palustre palustre permanente herbácea" (11,6%) as mais freqüentes. Nós esperamos que esta classificação gere algumas discussões entre limnólogos, ecólogos de áreas úmidas e hidrólogos e que estabeleça gradualmente um sistema de classificação aceitável para áreas úmidas do Rio Grande do Sul.

**Palavras-chave:** áreas úmidas, classificação, vegetação, conservação, Brasil.

## Introduction

The process of inventory and classification of wetlands influences our perception of an important and natural resource (Pressey & Adam, 1995). While wetlands inventories provide an indication of the location of land with the highest biological diversity and productivity (Taylor et al., 1995), wetlands classification groups habitats into categories with similar characteristics, properties, or functions (Tiner, 1999). This information is particularly important for conducting inventories, watershed planning, assessing biodiversity and evaluating wetlands functions (Tiner, 1999).

The classification is a useful tool for wetland conservation and it should achieve three aims: 1. to arrange units that have similar natural attributes, 2. to provide units for inventory and mapping; and 3. to provide uniformity in concepts and terminology throughout in the entire country (Cowardin & Golet, 1995). However, several proposed classifications have national or regional wetland terminology, and differs in the criteria used in their classification. For instance, some wetlands have been classified solely on their vegetation structure ("salt marshes" and "meadows"), some according to their vegetation combined with associated soil/substrate and water types ("peatlands" and "bogs"), and some on their water permanence in association with vegetation ("swamps") (Semeniuk & Semeniuk, 1995). This situation difficults the use of some classifications in areas outside where they were first defined, as well as the understanding and publication of the results of an inventory.

The classification of wetlands can be carried out using different categories of data (biological, physical-chemical, hydrological, etc), which vary according to the necessities identified by managers, the objectives of the inventories or by the available information (Tiner, 1999). The type of vegetation has been one of the most used criteria in wetlands classification systems (Tiner, 1999). Tiner (1984) regarded the existence of two wetland classification models: horizontal and hierarchical. Horizontal classification systems divide habitats into a series of classes, in contrast, hierarchical classification system provides a wetlands distribution into different levels, starting from a more generalized division, the systems (using criteria like water origin and landscape position) to a more detailed division, the classes (according to dominant vegetation, substrate types, hydrology and other criteria).

Numerous classifications were proposed in the United States (Wilen & Bates, 1995). The first classifications were regional and associated with land use, mainly agricultural interests which sought to convert wetlands to croplands. The first nationwide classification carried out in the United States of America was proposed by Martin et al. (1953), in order to gather important waterfowl habitats. In 1974, the "U.S. Fish and Wildlife Service" (FWS) elaborated the first hierarchical classification in USA (Cowardin et al., 1979). Later, Canada (Zoltai et al., 1975; Tarnocai, 1980), Australia (Paijamans et al., 1985) and the Convention of Ramsar (Ramsar Convention Bureau, 1990) elaborated other hierarchical classifications for wetlands.

Scott & Carbonell (1986) elaborated a wetland inventory in South America, employing a broader system classification. This classification had three expectations: 1. to have the basic framework for sound conservation actions for wetlands and waterfowl; 2. to expand the number of Neotropical countries signataries of the Ramsar convention; 3. to establish a network of people and institutions responsible for wetland monitoring. This inventory identified that approximately 95% of South American inventoried wetlands belong to six countries, and Brazil had 50% of the total wetland area (Naranjo, 1995). However, this inventory is not updated, remaining with a small number of inventoried wetlands (368 areas), when compared to some inventories more recently developed in Brazil (Maltchik et al., 1999; Maltchik et al., 2003a; Maltchik et al., 2003b).

In Brazil, the climatic and physiographic variations originated a large diversity of wetlands. Differences in soil type, water origin, geology and altitude influence the composition of aquatic communities in wetlands. However, the majority of the national classifications (from the Ministry of Defence, SUDENE and IBGE) are direct translations from English and they are not supported by any ecological criteria differentiating wetland classes.

The objectives of this paper were: 1. to propose a hierarchical classification of palustrine wetlands in the state of Rio Grande do Sul with emphasis on the structure of plant communities and 2. to test the proposed classification in 146 wetlands distributed over the state of Rio Grande do Sul.

### Study area

The state of Rio Grande do Sul is located in southern Brazil and has an area of 282.184 km². The Moist Subtropical Mid-Latitude Climate prevails in this region. The annual precipitation varies between 1200-1800 mm, and is relatively well distributed along the year, without a dry period (Cf - Koeppen's climate classification). The mean temperature varies between 15 and 18 ºC. The minimum temperature is lower than 10 ºC in Winter and the maximum temperature is higher than 32 ºC in Summer (RADAMBRASIL, 1986).

The vegetation is represented by small fragments of forest and temperate and tropical grassland areas. The forest is represented by different major types: temperate summergreen deciduous forest, mixed evergreen-deciduous forest, and temperate mountainous coniferous forest. The grasslands are represented by savanna, steppe, and pioneering formations. The main rivers of the state are Uruguai, Jacuí, Taquarí, Ibicuí, Ijuí, Pelotas and Camaquã distributed along the three hydrological watersheds (Guaíba, Uruguai and Coastal Plain). The State presents four geomorphologic units: Highlands, Central Depression, Cristaline Shield and Coastal Plain (Hausman, 1995).

Wetland distribution in the State of Rio Grande do Sul is quite heterogeneous, with higher density in the Central Depression, Coastal Plain and in the West of the Highlands (Maltchik et al., 2003a). Palustrine wetlands constitute great percentage of wetlands in southern Brazil (~90%) (Maltchik et al., 2003a), and they may be permanently, periodically, or never flooded, but saturated for extended periods during the annual cycle. They include marshes, swamps, shallow and oxbow lakes and floodplains (Maltchik et al., 2003a). The hydrology of the majority of palustrine wetlands is affected by precipitation, surface water runoff and groundwater discharge, in different combinations.

The Highlands are located in the Northern region of Rio Grande do Sul with altitudes between 1200 (E) and 50 (W) meters. The Central Depression is located in the central area of the State with altitudes between 250 and 300 meters. The Jacuí and Ibicuí rivers are the largest of the Central Depression. The Cristaline Shield is located in Southeastern of Rio Grande do Sul with altitude below than 600 meters. The Coastal Plain extends for 600 km along Atlantic Ocean, and the main hydrologic characteristic of this province is the lack of big rivers and the presence of several lagoons distributed over its extension (Rambo, 2000)

## Material and methods

The proposed classification for the wetlands of Rio Grande do Sul is an adaptation of the models developed by U.S. Fish and Wildlife Service (Cowardin et al., 1979) and by Ramsar Convention Bureau (1990). The first considers five systems: marine (open ocean and its associated high-energy coastline), estuarine (salt and brackish marshes, mangrove swamps, nonvegetaded tidal shores, and brackish waters of coastal rivers and embayments), riverine (rivers and streams), lacustrine (lakes, reservoirs and large ponds) and palustrine (marshes, bogs, swamps, and small shallow ponds). Each system, with exception of the palustrine, is divided into subsystems. The next level – class – describes the general physiognomy of the wetland in terms of the dominant vegetative life form or the nature and composition of the substrate (Tiner, 1999). The classification of Ramsar Convention Bureau (1990) considers three systems: marine and coastal, inland and man-made, which are divided into lower levels in order to describe the wetland system in terms of dominant aquatic plant or nature of the substrate.

Vegetation survey was carried out using the Aqua-Rap approach (Chernoff et al., 1996), an extension of Rapid Assessment Programme for Biodiversity for aquatic ecosystems

(Mittermeir & Forsyth, 1992). This approach provides, in the shortest time, basic information about the diversity and distribution of aquatic organisms. These studies help the establishment of conservation policies for biodiversity in tropical lands (Barbosa & Callisto, 2000).

In order to test the classification, a total of 146 palustrine wetlands was sampled distributed within the four geomorphologic units (36 in Coastal Plain, 19 in Central Depression, 15 in Cristaline Shield, 76 in Highlands) of the State of Rio Grande do Sul (Fig.1). The sampling sites were selected by the following characteristics: access, aquatic plant occurrence, wetland type, area, altitude and distribution along the geomorphologic provinces. Wetland localization was determined using a Global Position System (Personal Navigator, model GPS III Plus) and documental photographs were taken.

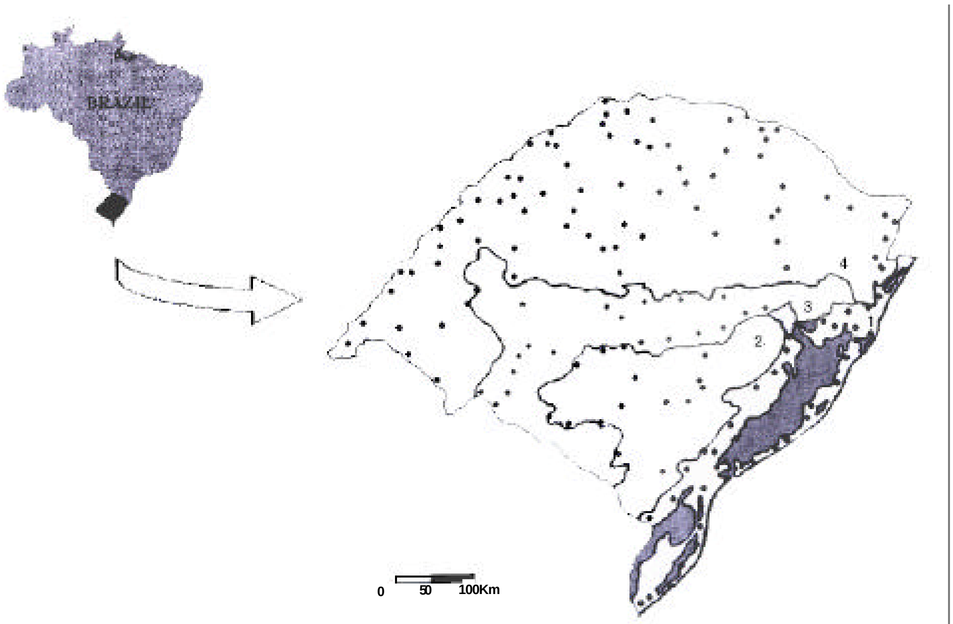


Figure 1: Sampled wetlands in the State of Rio Grande do Sul, Brazil (1- Coastal Plain; 2- Cristaline Shield; 3- Central Depression; 4- Highlands).

Wetland plants (aquatic plants, emergent plants, shrubs and trees) sampling was carried out from March 2002 to October 2002. The woody vegetation was identified in situ and no botanical material was collected. The time taken for sampling varied between 20 and 70 minutes depending on the wetland area. Sampling was distributed throughout the various habitats (water depth and distance from the margins). The plant samples were identified to species level according to taxonomic keys and specific bibliography for each family (Burkart, 1974; Cabrera, 1967, 1968, 1974; Kissmann, 1991, 1992; Kissmann & Groth, 1995; Lombardo, 1982, 1983, 1984; Irgang & Gastal, 1996). Plant specimens were deposited in HASU herbarium (Herbário Aloysio Sehnem – Unisinos).

## Results

The wetland classification proposed for the state of Rio Grande do Sul is hierarchical and is divided into four levels based on hydrogeomorphologic and biologic factors (subsystems, types, classes and subclasses). The palustrine system is divided into four subsystems: palustrine, lacustrine, riverine and floodplains (Tab. I). The main difference between palustrine and lacustrine subsystems is related to the limnological analysis of the degree of interaction between the mass of water and the drainage area (Bernaldez & Montes, 1989). The influence of the terrestrial ecosystem is maximum in the palustrine wetlands and declines as the relationship between inundation area/water volume decreases. In practical terms, the surface water from the lacustrine subsystem is enclosed in the drainage area. The riverine subsystem comprises oxbows, which might be isolated or receive periodically influence of the river channel. The difference between the lacustrine systems and subsystems and the riverine system and subsystems is the size. The size of lacustrine subsystem must be no larger than 30 ha and the width of the main channel

Table I: Hierarchy of wetlands in the proposed classification for Rio Grande do Sul State.

| System | Subsystem | Type | Class | Subclass |
|---|---|---|---|---|
| Palustrine | Palustrine | Permanent | Lack of vegetation | |
| | | | Aquatic bed | Submerged/Floating-leaves |
| | | | Emergent | |
| | | | Woody | Shrub/Tree |
| | | | Multi-stratified | |
| | | Intermittent | Aquatic bed | Submerged/Floating-leaves |
| | | | Emergent | |
| | | | Woody | Shrub/Tree |
| | | | Multi-stratified | |
| | | Lack of surface water | Emergent | |
| | Lacustrine | Permanent | Lack of vegetation | |
| | | | Aquatic bed | Submerged/Floating-leaves |
| | | | Emergent | |
| | | | Multi-stratified | |
| | | Intermittent | Aquatic bed | Submerged/Floating-leaves |
| | | | Emergent | |
| | | | Multi-stratified | |
| | Riverine | | Lack of vegetation | |
| | | | Aquatic bed | Submerged/Floating-leaves |
| | | | Emergent | |
| | | | Woody | Shrub/Tree |
| | | | Multi-stratified | |
| | Floodplains | Lacustrine | Aquatic bed | Submerged/Floating-leaves |
| | | | Emergent | |
| | | | Woody | Shrub/Tree |
| | | | Multi-stratified | |
| | | Riverine | Aquatic bed | Submerged/Floating-leaves |
| | | | Emergent | |
| | | | Woody | Shrub/Tree |
| | | | Multi-stratified | |
| Lacustrine | | | | |
| Riverine | | | | |
| Estuarine | | | | |
| Marine | | | | |
| Man-made | Rice fields | | | |
| | Reservoirs | | | |

of the riverine subsystem must be under 6 meters. The floodplain subsystems are areas periodically inundated by the lateral overflow of rivers or lakes, and by direct precipitation and groundwater discharge in different combinations. The difference between palustrine and floodplain subsystem is the influence of the flowing water of rivers and lakes.

The wetlands of the palustrine subsystem are divided into three types: permanent (permanently flooded areas), intermittent (flooded areas at least 4 month of the year) and lack of surface water (presence of saturated soils). The lacustrine subsystem is divided in two types: permanent (permanently flooded areas) and intermittent (areas flooded only in some periods). The floodplains are subdivided according to water origin: lacustrine or riverine zones. The riverine subsystem does not present subdivisions (Tab. I).

The types are divided into classes with similar characteristics of aquatic plant cover. This hierarchical level is based on the presence (when the vegetative cover is higher than 30% of total wetland surface) and in the life form of the dominant species. By convention, "dominance" is the coverage of more than 30% of the surface area of a wetland by a plant type (Dennison & Berry, 1993). Five classes were identified: lack of vegetation, aquatic bed, emergent, woody, and multi-stratified (Tab. I).

The aquatic bed class is divided into two subclasses according to the dominant vegetation life form: submerged and floating-leaves (Tab. II). The emergent class comprises the erect herbaceous vegetation. The woody class is divided into two subclasses: shrubs and trees (Tab. II). These subclasses are differentiated by the height of species. Shrubs are woody plants shorter than four meters, usually with multiple stems; trees are woody plants taller than four meters with a single stem. The multi-stratified class is composed of at least two dominant classes.

The last hierarchical level refers to the dominant plant species or species composition in the wetlands (Tab. II). As the criterion of classification is specific for each wetland, the identification should be determined by the observer himself.

Table II: Dominant species of aquatic plants in wetlands of Rio Grande do Sul.

| Class/ Subclass | Dominant species |
|---|---|
| **Aquatic bed** | |
| **Submerged** | Nitella spp.; Chara spp.; Potamogenton spp.; Sphagnum spp.; Mayaca spp.; Utricularia spp.; Cabomba caroliniana A. Gray; Ceratophyllum demersum L. |
| **Floating-leaves** | Riccia spp.; Ricciocarpus natans (L.) Corda; Luziola peruviana Gmelin; Enhydra anagallis Gardn.; Ludwigia peploides (Kunth) Raven; Hydrocotyle ranunculoides L. f.; H. verticillata Thumb.; Nymphoides indica (L.) Kuntze; Myriophyllum aquaticum (Vell.) Verdc.; Eichhornia crassipes (Mart.) Solms; Salvinia herzogii de la Sota; S. minima Bak.; Azolla filiculoides Lam.; Azolla caroliniana Willd.; Pistia stratiotes L.; Lemna spp.; Wolffiella spp. |
| **Emergent** | Eryngium spp.; Pontenderia cordata L.; Typha spp.; Cyperus spp.; Scirpus spp.; Ludwigia spp.; Panicum spp.; Juncus spp.; Sagittaria montevidensis Cham. & Schl.; Echinodorus longiscapus Arech; E. grandiflorus (Cham. & Schl.) Michx; Zizaniopsis bonariensis (Bal. & Poit.) Spreg.; Cladium jamaicense Crantz; Rhynchospora aurea Vahl. |
| **Woody** | |
| **Shrub** | Sesbania puniceae (Cav.) Benth.; Sesbania virgata (Cav.) Pers.; Aeschynomene spp., Mimosa bimucronata (DC.) Kuntze; Cephallantus glabratus (Spr.) K. Schum.; Phyllantus sellowianus M. Arg. |
| **Tree** | Eryhtrina crista-galli L.; Salix humboldtiana Willd.; Inga spp.; Sebastiania commersoniana (Baill.) Smith & Downs; Sebastiania schottiana (M. Arg.) M. Arg.; Guarea macrophylla Vahl.; |

The 146 analyzed wetlands in Rio Grande do Sul were distributed in two systems: "palustrine" (95.9%) and "man-made" (4.1%) (Tab. III). All wetlands of the "man-made" system corresponded to the "rice field" subsystem. The palustrine system was divided in three subsystems: "palustrine" (62.8%), "lacustrine" (28.6%) and "floodplain" (8.6%). A total of 17 wetland classes were identified in the State, which palustrine palustrine permanent emergent (18.5%) and palustrine palustrine permanent aquatic bed (11.6%) were the most frequent (Tab. III).

Table III: Locality, geographic localization and classification of wetland type in Rio Grande do Sul, Brazil ( Coastal Plain, C.P.; Cristaline Shield, C.S.; Central Depression, C.D.; Highlands, H.; Palustrine, P.; Man-Made, M.-M.; Rice Field, R.F.; Floodplain, F.; Lacustrine, L.).

| Locality | Geographic localization | | Geomorphologic formation | System | Subsystem | Type | Class | Subclass |
|---|---|---|---|---|---|---|---|---|
| 1. Cerro Grande | 30° 06' 40.2"S | 50° 47' 11.8"W | C.P. | P. | P. | Permanent | aquatic bed | floating-leaves |
| 2. Palmares do Sul I | 30° 14' 53.8"S | 50° 29' 42.8"W | C.P | M.-M. | R.F. | - | - | - |
| 3. Palmares do Sul II | 30° 22' 45.8"S | 50° 29' 47.0"W | C.P | P. | P. | Permanent | emergent | - |
| 4. Mostardas I | 30° 37' 23.8"S | 50° 30' 32.2"W | C.P | P. | P. | Permanent | multi-stratified | - |
| 5. Mostardas II | 30° 49' 17.7"S | 50° 40' 35.0"W | C.P | P. | P. | Permanent | emergent | - |
| 6. Mostardas III | 31° 08' 41.6"S | 50° 56' 01.8"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 7. Tapera | 31° 13' 48.7"S | 51° 02' 10.2"W | C.P | P. | P. | Intermittent | multi-stratified | - |
| 8. Bojuru | 31° 31' 17.9"S | 51° 17' 14.1"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 9. Lagoa do Peixe | 31° 32' 09.7"S | 51° 15' 56.7"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 10. São José do Norte I | 31° 38' 08.0"S | 51° 25' 39.5"W | C.P | P. | P. | Permanent | multi-stratified | - |
| 11. São José do Norte II | 31° 48' 37.8"S | 51° 42' 18.1"W | C.P | P. | P. | Permanent | multi-stratified | - |
| 12. São Caetano | 31° 52' 36.7"S | 51° 51' 06.7"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 13. Guaíba I | 30° 13' 24.8"S | 51° 24' 13.6"W | C.P | P. | F. | Lacustrine | emergent | - |
| 14. Guaíba II | 30° 24' 42.8"S | 51° 27' 28.6"W | C.P | M.-M. | R.F. | - | - | - |
| 15. Tapes | 30° 42' 20.6"S | 51° 34' 55.4"W | C.P | M.-M | R.F | - | - | - |
| 16. Camaquã | 30° 57' 27.9"S | 51° 58' 22.0"W | C.P | M.-M | R.F | - | - | - |
| 17. São Lourenço | 31° 23' 16.1"S | 52° 08' 15.6"W | C.P | P. | P. | Permanent | multi-stratified | - |
| 18. Pelotas | 31° 45' 52.5"S | 52° 23' 19.1"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 19. Rio Grande I | 31° 57' 47.5"S | 52° 18' 23.1"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 20. Rio Grande II | 32° 17' 36.9"S | 52° 31' 53.6"W | C.P | M.-M. | R.F. | - | - | - |
| 21. Rio Grande III | 32° 30' 01.5"S | 52° 34' 23.7"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 22. Santa Vitória do Palmar I | 32° 47' 40.4"S | 52° 40' 19.8"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 23. Santa Vitória do Palmar II | 33° 06' 18.7"S | 52° 55' 08.8"W | C.P | P. | P. | Permanent | emergent | - |
| 24. Santa Vitória do Palmar III | 33° 30' 39.8"S | 53° 18' 46.7"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 25. Santa Vitória do Palmar IV | 33° 20' 14.2"S | 53° 08' 56.7"W | C.P | P. | P. | Permanent | aquatic bed | floating-leaves |
| 26. Pelotas II | 31° 46' 44.7"S | 52° 27' 54.8"W | C.P | P. | P. | Permanent | emergent | - |
| 27. Pelotas III | 31° 53' 37.4"S | 52° 39' 28.4"W | C.P | P. | P. | Permanent | multi-stratified | - |
| 28. Jaguarão I | 32° 11' 44.9"S | 53° 00' 47.2"W | C.P | P. | P. | Permanent | emergent | - |
| 29. Jaguarão II | 32° 31' 09.4"S | 53° 20' 28.1"W | C.P | P. | P. | Permanent | emergent | - |
| 30. Pedro Osório | 31° 51' 31.4"S | 52° 48' 48.5"W | C.P | P. | F. | Riverine | multi-stratified | - |

Table III cont.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 31. Gravataí | 29° 57' 24.6"S | 50° 52' 32.5"W | C.P | P. | L. | Permanent | aquatic bed | floating -leaves |
| 32. Chico Lomã | 29° 54' 41.7"S | 50° 30' 41.8"W | C.P. | P. | P. | Intermittent | emergent | - |
| 33. Osório | 29° 52' 06.1"S | 50° 14' 41.6"W | C.P. | P. | F. | L. | emergent | - |
| 34. Maquiné | 29° 41' 05.8"S | 50° 08' 57.6"W | C.P. | P. | F. | L. | emergent | - |
| 35. Torres | 29° 23' 03.7"S | 49° 49' 48.7"W | C.P. | P. | F. | L. | emergent | - |
| 36. Porto Alegre | 29° 59' 33.6"S | 51° 16' 37.1"W | C.P. | P. | F. | Riverine | multi -stratified | - |
| 37. Alto Alegre | 31° 40' 24.6"S | 53° 04' 59.8"W | C. S | P. | P. | Permanent | emergent | - |
| 38. Candiota | 31° 27' 02.1"S | 53° 40' 48.4"W | C.S. | P. | P. | intermittent | emergent | - |
| 39. Bagé I | 31° 17' 44.2"S | 54° 03' 19.7"W | C.S. | P. | P. | permanent | aquatic bed | floating -leaves |
| 40. Bagé II | 31° 08' 15.6"S | 54° 22' 37.1"W | C.S. | P. | F. | ri verine | woody | trees |
| 41. Bagé III | 31° 00' 45.4"S | 54° 36' 18.4"W | C.S. | P. | F. | riverine | woody | shrub |
| 42. Palmas I | 31° 07' 22.2"S | 53° 46' 46.7"W | C.S. | P. | L. | permanent | lack of vegetation | - |
| 43. Palmas II | 30° 47' 34.2"S | 53° 34' 44.6"W | C.S. | P. | P. | permanent | aquatic b ed | floating -leaves |
| 44. Caçapava | 30° 22' 28.2"S | 53° 33' 43.1"W | C.S. | P. | L. | permanent | aquatic bed | floating -leaves |
| 45. Vila Nova do Sul | 30° 21' 51.6"S | 53° 48' 51.5"W | C.S. | P. | L. | permanent | aquatic bed | submerged |
| 46. São Gabriel | 30° 22' 00.3"S | 54° 14' 17.5"W | C. S. | P. | L. | permanent | aquatic bed | floating -leaves |
| 47. Encruzilhada do Sul I | 30° 30' 49.2"S | 52° 29' 18.2"W | C.S. | P. | P. | intermittent | emergent | - |
| 48. Encruzilhada do Sul II | 30° 48' 19.0"S | 52° 34' 11.3"W | C.S. | P. | L. | permanent | aquatic bed | floating -leaves |
| 49. Encru zilhada do Sul III | 30° 53' 08.4"S | 52° 31' 48.2"W | C.S. | P. | P. | permanent | woody | shrub |
| 50. Canguçu | 31° 02' 41.1"S | 52° 43' 26.5"W | C.S. | P. | L. | permanent | lack of vegetation | - |
| 51. Santana da Boa Vista | 31° 02' 40.4"S | 53° 01' 10.8"W | C.S. | P. | L. | permanent | aquatic bed | floating -leaves |
| 52. Arroio dos Ratos | 30° 02' 50.9"S | 51° 31' 07.4"W | C.D | P. | P. | intermittent | emergent | - |
| 53. São Jerônimo | 30° 06' 47.7"S | 51° 50' 78.8"W | C.D. | P. | P. | permanent | woody | shrub |
| 54. Butiá | 30° 09' 45.9"S | 52° 09' 07.4"W | C.D. | P. | P. | permanent | multi -strat ified | - |
| 55. Pantano Grande | 30° 12' 55.9"S | 52° 33' 56.7"W | C.D. | P. | P. | intermittent | emergent | - |
| 56. Cachoeira do Sul I | 30° 16' 08.2"S | 52° 57' 42.1"W | C.D. | P. | L. | permanent | aquatic bed | floating -leaves |
| 57. Cachoeira do Sul II | 30° 22' 15.4"S | 53° 22' 49.2"W | C.D. | P. | L. | permanent | aquatic bed | floating -leaves |
| 58. Unhatium | 30° 15' 41.1"S | 54° 31' 10.6"W | C.D. | P. | F. | riverine | multi -stratified | - |
| 59. Rosário do Sul | 30° 17' 34.5"S | 54° 59' 13.8"W | C.D. | P. | L. | permanent | lack of vegetation | - |
| 60. Guará | 30° 28' 43.6"S | 55°03' 41. 2"W | C.D. | P. | P. | intermittent | emergent | - |

Table III cont.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 61. Armada | 30° 43' 34.7"S | 55° 08' 40.4"W | C.D. | P. | P. | intermittent | emergent | - |
| 62. Santana do Livramento I | 30° 50' 16.9"S | 55° 23' 22.7"W | C.D. | P. | P. | intermittent | emergent | - |
| 63. Santana do Livramento II | 30° 46' 05.4"S | 55° 43' 12.5"W | C.D. | P. | L. | permanent | aquatic bed | floating -leaves |
| 64. São Sepé | 30° 07' 07.2"S | 53° 37' 07.0"W | C.D. | P. | F. | riverine | multi -stratified | - |
| 65. Santa Maria | 29° 44' 58.6"S | 53° 47' 31.1"W | C.D. | P. | P. | permanent | multi -stratified | - |
| 66. Cerro Chato | 29° 42' 02.4"S | 53° 16' 58.4"W | C.D. | P. | F. | riverine | woody | trees |
| 67. Candelária | 29° 40' 53.1"S | 52° 48' 02.1"W | C.D. | P. | P. | intermittent | emergent | - |
| 68. Venâncio Aires | 29° 39' 19.1"S | 52° 13' 22.9"W | C.D. | P. | L. | permanent | aquatic bed | floating -leaves |
| 69. Rosário do Sul II | 30° 10' 41.7"S | 54° 51' 24.5"W | C.D. | P. | P. | intermittent | emergent | - |
| 70. São Francisco | 29° 41' 38.8"S | 54° 55' 22.7"W | C.D. | P. | P. | intermittent | emergent | - |
| 71. Serra I | 29° 21' 16.6"S | 50° 10' 20.9"W | H. | P. | P. | intermittent | emergent | - |
| 72. Serra II | 29° 20' 04.3"S | 51° 11' 11.4"W | H. | P. | L. | permanent | emergent | - |
| 73. Cambará I | 29° 13' 25.3"S | 50° 15' 01.2"W | H. | P. | P. | permanent | aquatic bed | floating -leaves |
| 74. Cambará II | 29° 00' 40.6"S | 50° 06' 33.6"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 75. São José dos Ausentes I | 28° 49' 20.9"S | 49° 59' 52.6"W | H. | P. | P. | intermittent | aquatic bed | floating -leaves |
| 76. São José dos Ausentes II | 28° 44' 09.9"S | 50° 07' 00.8"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 77. Bom Jesus | 28° 38' 28.6"S | 50° 34' 25.7"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 78. Vacaria | 28° 30' 50.7"S | 50° 53' 19.9"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 79. Carlos Barbosa | 29° 19' 19.2"S | 51° 26' 36.5"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 80. Cotiporã | 29° 01' 01.9"S | 51° 32' 52.9"W | H. | P. | P. | intermittent | emergent | - |
| 81. Nova Prata | 28° 43' 56.4"S | 51° 37' 40.7"W | H. | P. | P. | lack of surface water | emergent | - |
| 82. André da Rocha | 28° 39' 02.7"S | 51° 32' 41.9"W | H. | P. | P. | permanent | emergent | - |
| 83. Lagoa Vermelha | 28° 22' 44.0"S | 51° 28' 40.8"W | H. | P. | P. | permanent | emergent | - |
| 84. Ibiaça | 28° 01' 32.1"S | 51° 46' 23.7"W | H. | P. | P. | intermittent | emergent | - |
| 85. Cacique Doble | 27° 49' 48.6"S | 51° 41' 24.2"W | H. | P. | P. | permanent | emergent | - |
| 86. Barracão | 27° 43' 24.4"S | 51° 32' 31.4"W | H. | P. | P. | intermittent | emergent | - |
| 87. Paim Filho | 27° 42' 47.0"S | 51° 44' 49.0"W | H. | P. | P. | intermittent | emergent | - |
| 88. Pinhalzinho | 27° 34' 04.4"S | 51° 55' 52.6"W | H. | P. | P. | permanent | emergent | - |
| 89. Erechim | 27° 35' 39.1"S | 52° 10' 23.7"W | H. | P. | P. | permanent | emergent | - |

Table III cont.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 90. Getúlio Vargas | 27° 57' 18.2"S | 52° 13' 14.7"W | H. | P. | L. | permanent | lack of vegetation | - |
| 91. Passo Fundo | 28° 14' 04.9"S | 52° 24' 41.3"W | H. | P. | P. | permanent | emergent | - |
| 92. Soledade I | 28° 54' 51.3"S | 52° 23' 19.5"W | H. | P. | P. | lack of surface water | emergent | - |
| 93. Soledade II | 28° 36' 59.5"S | 52° 37' 08.3"W | H. | P. | P. | lack of surface water | emergent | - |
| 94. Carazinho I | 28° 08' 29.7"S | 52° 50' 53.8"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 95. Sarandi | 27° 52' 19.5"S | 53° 00' 24.4"W | H. | P. | P. | intermittent | emergent | - |
| 96. Palmeira das Missões I | 27° 53' 45.6"S | 53° 14' 38.9"W | H. | P. | P. | permanent | emergent | - |
| 97. Palmeira das Missões II | 27° 49' 36.3"S | 53° 24' 59.8"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 98. Campo Novo | 27° 42' 39.2"S | 53° 46' 57.2"W | H. | P. | P. | lack o f surface water | emergent | - |
| 99. Bom Progresso | 27° 29' 39.3"S | 53° 52' 37.5"W | H. | P. | P. | permanent | emergent | - |
| 100. Tenente Portela | 27° 23' 18.4"S | 53° 50' 06.0"W | H. | P. | P. | permanent | emergent | - |
| 101. Turvo | 27° 14' 16.7"S | 53° 50' 52.3"W | H. | P. | P. | intermittent | emer gent | - |
| 102. Palmitinho | 27° 21' 33.9"S | 53° 32' 59.7"W | H. | P. | P. | permanent | multi -stratified | - |
| 103. Cristal do Sul | 27° 27' 57.0"S | 53° 12' 16.0"W | H. | P. | P. | permanent | emergent | - |
| 104. Carazinho II | 28° 19' 05.3"S | 52° 45' 39.4"W | H. | P. | P. | permanent | emergent | - |
| 105 . Campina | 28° 25' 09.5"S | 53° 07' 21.6"W | H. | P. | P. | permanent | emergent | - |
| 106. Panambi | 28° 19' 17.9"S | 53° 48' 06.9"W | H. | P. | P. | intermittent | emergent | - |
| 107. Santo Ângelo | 28° 22' 34.0"S | 54° 11' 03.2"W | H. | P. | P. | lack of surface water | emergent | - |
| 108. Giruá | 28° 04 ' 50.4"S | 54° 20' 54.7"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 109. Santa Rosa | 27° 51' 22.0"S | 54° 29' 39.1"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 110. Cinqüentenário | 27° 40' 09.8"S | 54° 34' 38.4"W | H. | P. | P. | intermittent | emergent | - |
| 111. S anto Cristo | 27° 50' 05.8"S | 54° 36' 50.3"W | H. | P. | P. | lack of surface water | emergent | - |
| 112. Santa Catarina | 27° 47' 58.1"S | 54° 51' 21.6"W | H. | P. | L. | permanent | aquatic bed | submerged |
| 113. Porto Xavier | 27° 57' 37.0"S | 55° 07' 51.0"W | H. | P. | P. | permanent | emergent | - |
| 114. Roque Gonzales | 28° 13' 55.6"S | 54° 58' 37.3"W | H. | P. | P. | intermitente | emergent | - |
| 115. São Luiz Gonzaga | 28° 25' 37.7"S | 55° 04' 53.4"W | H. | P. | P. | intermitente | emergent | - |

Table III cont.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 116. Santo Antônio | 28° 29' 23.6"S | 55° 15' 55.4"W | H. | P. | P. | intermittent | aquatic bed | floating -leaves |
| 117. Rincão do Meio | 28° 27' 41.4"S | 55° 33' 15.6"W | H. | P. | P. | intermitente | emergent | - |
| 118. São Nicolau | 28° 12' 36.5"S | 55° 09' 12.7"W | H. | P. | L. | permanent | lack o f vegetation | - |
| 119. São Miguel das Missões | 28° 24' 19.2"S | 54° 41' 15.7"W | H. | P. | P. | permanent | emergent | - |
| 120. Quaraí I | 30° 32' 40.1"S | 56° 07' 39.8"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 121. Quaraí II | 30° 14' 26.8"S | 56° 30' 20.6"W | H. | P. | L. | perma nent | multi -stratified | - |
| 122. Uruguaiana I | 29° 56' 08.0"S | 56° 37' 32.9"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 123. Uruguaiana II | 30° 52' 26.3"S | 57° 06' 45.2"W | H. | P. | P. | permanent | emergent | - |
| 124. Beleza | 30° 06' 01.2"S | 57° 19' 20.4"W | H. | P. | L. | perm anent | aquatic bed | floating -leaves |
| 125. Manoel Viana I | 29° 29' 07.2"S | 55° 15' 23.1"W | H. | P. | L. | permanent | emergent | - |
| 126. Manoel Viana II | 29° 30' 30.1"S | 55° 29' 02.4"W | H. | P. | P. | intermittent | emergent | - |
| 127. Alegrete I | 29° 39' 56.8"S | 55° 43' 14.4"W | H. | P. | P. | permanent | aquatic bed | floating -leaves |
| 128. Alegrete II | 29° 54' 55.2"S | 56° 02' 48.2"W | H. | P. | P. | permanent | aquatic bed | floating -leaves |
| 129. Touro | 29° 30' 34.1"S | 56° 43' 11.8"W | H. | P. | P. | permanent | aquatic bed | floating -leaves |
| 130. Itaqui I | 29° 17' 09.7"S | 56° 35' 26.9"W | H. | P. | L. | permanent | lack of vegetation | - |
| 131. Itaqui II | 29° 17' 37.6"S | 56° 26' 45.3"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 132. Maçambará | 29° 11' 30.5"S | 56° 05' 12.1"W | H. | M. -M. | R.F. | - | - | - |
| 133. São Donato | 28° 59' 36.8"S | 56° 03' 46.9"W | H. | P. | P. | permanent | emergent | - |
| 134. São Borja | 28° 47' 06.7"S | 56° 03' 12.6"W | H. | P. | P. | permanent | emergent | - |
| 135. Nhuporã | 28° 42' 07.4"S | 55° 47' 12.5"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 136. Arabutã | 28° 56' 33.2"S | 55° 33' 48.4"W | H. | P. | F. | river ine | emergent | - |
| 137. Unistalda | 29° 02' 18.0"S | 55° 04' 27.7"W | H. | P. | L. | permanent | lack of vegetation | - |
| 138. Bossoroca | 28° 35' 57.1"S | 54° 56' 22.3"W | H. | P. | P. | permanent | emergent | - |
| 139. Carajazinho | 28° 36' 54.7"S | 54° 16' 52.9"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 140. Coimbra | 28° 47' 17.2"S | 54° 22' 26.5"W | H. | P. | P. | permanent | emergent | - |
| 141. Santa Tecla | 28° 54' 24.8"S | 54° 04' 43.3"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 142. Tupaciretã I | 29° 04' 18.8"S | 53° 53' 00.1"W | H. | P. | P. | permanent | mul ti -stratified | - |
| 143. Tupaciretã II | 29° 03' 04.3"S | 53° 43' 20.9"W | H. | P. | L. | permanent | emergent | - |
| 144. Júlio de Castilhos | 29° 20' 18.1"S | 53° 40' 25.6"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |
| 145. Cruz Alta | 28° 46' 47.2"S | 53° 35' 50.9"W | H. | P. | P. | per manent | emergent | - |
| 146. Salto do Jacuí | 28° 55' 29.6"S | 53° 21' 30.1"W | H. | P. | L. | permanent | aquatic bed | floating -leaves |

In the Highlands, the majority of the wetlands belonged to the palustrine (61.8%) and lacustrine (35.5%) subsystems. While the palustrine subsystem was represented mainly by permanent wetlands with predominance of emergent plants (42.6%), the lacustrine subsystem was represented mainly by the class of aquatic beds with predominance of floating-leaves (66.7%). In the Coastal Plain the man-made and palustrine systems corresponded to 13.9% and 86.1% from the total analyzed wetlands, respectively. In the palustrine system of Coastal Plain, the most frequent wetlands were the palustrine permanent with predominance of aquatic bed (floating-leaves) (35.5%). In the Central Depression there was a predominance of palustrine intermittent wetlands with emergent vegetation (42.1%). In the Cristaline Shield, the lacustrine and palustrine subsystems represented, respectively, 46.7% and 40% of the observed wetlands. The aquatic bed class corresponded to 71.4% of the lacustrine subsystem and 33.3% of the palustrine subsystem.

The palustrine, lacustrine and floodplain subsystems were present in all the geomorphologic provinces of Rio Grande do Sul. In the palustrine subsystem, 62.5% of the wetlands were permanent, 30.7% intermittent and 6.8% did not have surface water. The lacustrine subsystem with lack of surface water was restricted to the Highlands. The lacustrine subsystem was represented mainly by the class aquatic bed (72.5%). In the floodplain subsystem, the riverine and lacustrine types corresponded to 66.7% and 33.3% of the analyzed wetlands, respectively. The lacustrine floodplains were restricted to the Coastal Plain.

## Discussion

We proposed here a simple hierarchical classification based on the Ramsar and U.S. Fish and Wildlife classifications. We hope that this classification will generate some discussion among limnologists, wetland ecologists, and hydrologists and that it will gradually establish an acceptable classification system for wetlands in the State of Rio Grande do Sul. There is no doubt that a nationwide classification system for the wetlands in Brazil will allow to identify and to recognize the diversity and abundance of wetlands, establishing tools for conservation purposes. To get an idea of how much we lack of research related to the classification of wetlands in Brazil, Pressey & Adam (1995) compiled more than 600 published studies about inventory and classification of wetlands between 1970 and 1995 in Australia, while in Brazil these surveys are scarce (Diegues, 1990; Maltchik et al, 1999; 2003a, 2003b).

The starting point for a wetland inventory, biodiversity surveys, wetland_management and protection should be the development of a wetland classification. In Brazil there are many regional wetland terms ("pântanos", "brejos", "alagados", "banhados", etc) that do not relate to each other in terms of possible similarities or dissimilarities. These terms are used in the technical literature due to the lack of a formal and explicit system of classification, leading to confusion in scientific communication and compromising the advance of comparative studies.

The state of Rio Grande do Sul has a large amount and diversity of wetlands (Maltchik et al, 2003a), all of them protected by environmental laws. However, the majority of these laws are based on regional terms, which do not necessarily include all classes of wetlands. So, many classes of wetlands are vulnerable to man's action due to the lack of legal instruments for their protection. In this way, the proposed classification should be used in the state of Rio Grande do Sul and in Brazil, as it is able to identify wetlands of different classes, sizes and environmental impact, working as an excellent tool for conservation.

An important hydrologic characteristic of South America is the occurrence of great extensions of wetlands (Neiff, 2001). In large wetlands, a detailed classification of the different habitats might be extremely confusing and may also be irrelevant (Finlayson & van der Valk, 1995). In this way, large wetlands in the state of Rio Grande do Sul ("Taim" and "Lagoa do Peixe") and Brazil ("Pantanal") should be classified only up to the level of palustrine systems, without divisions in lower hierarchical levels (sub-systems, types, classes and sub-classes) since the probability of several subsystems to occur is extremely high.

Several criteria are used for wetland classification. The vegetation, hydrology, morphology, types of soil and size are some of the parameters used (Tiner, 1999). The vegetation has been the focal point in most wetland classifications (Tiner, 1999). The classification proposed for the state of Rio Grande do Sul is mainly based on vegetation. Some scientists regarded that the use of vegetation as main criteria for wetland classification is not appropriate, since vegetation is the product of hydrologic and geomorphologic factors. Nonetheless, the ecological importance of plant communities is undisputable and vegetation differences among wetlands are readily observed (Tiner, 1999).

The criteria used to group palustrine wetlands into levels of class and subclass permit to understand wetlands in other regions around the planet, since vegetation classification in life forms (submerged, floating-leaves, emergent, shrubs and trees) is worldwide recognized. However, the classification in the last hierarchical level (dominant species) restricts a little its understanding due to the fact that some species are dominant in a few geographic areas only. Irgang (1999) suggests a series of terminologies for the dominant species in wetlands of Rio Grande do Sul, for example, "camalotal" (Eichhornia spp.); "gravatal" (Eryngium spp.); "juncal" (Juncus spp.), "taboal" (Typha spp.); "maricazal" (Mimosa bimucronata); "sarandizal" (Cephalanthus glabratus). This classification is based on the presence of a dominant species or an association of dominant species in the community and it again generates regional terminologies. The use of such classifications may increase the local understanding, however they are still limited to provide an international understanding.

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