UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

INSTITUTO DE BIOCIÊNCIAS

PROGRAMA DE PÓS-GRADUAÇÃO EM BOTÂNICA

Daniel Grasel

Conservação de áreas úmidas no âmbito da Lei de Proteção da Vegetação Nativa do Brasil

Porto Alegre

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Tese apresentada ao Programa de Pós-Graduação em Botânica da Universidade Federal do Rio Grande do Sul como parte dos requisitos para a obtenção do título de Doutor em Ciências: Botânica.

Orientador: Prof. Dr. João André Jarenkow

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Resumo

Em 2012, retrocessos na legislação ambiental mais importante sobre terras privadas brasileiras, renomeada como “Lei de Proteção da Vegetação Nativa” (LPVN), colocaram uma série de áreas úmidas sob risco de degradação e/ou conversão. Dentre as áreas úmidas mais afetadas estão as lagoas, que praticamente perderam sua proteção legal. As alterações legislativas na LPVN colocaram em risco não apenas a grande biodiversidade das áreas úmidas, mas também a provisão de importantes serviços ecossistêmicos por elas prestados. Aqui, contribuí com a identificação e divulgação de retrocessos e inadequações na LPVN e chamei a atenção para a necessidade da regulamentação sustentável dela nos estados. Além disso, conduzi investigações sobre a diversidade (alfa, beta e gama) e composição florística em áreas úmidas na bacia do alto Rio Uruguai, Sul do Brasil, que contemplaram três tipos de áreas úmidas amplamente predominantes na região: lagoas e áreas ripárias adjacente a córregos e rios. Esses estudos objetivaram a geração de subsídios para a gestão sustentável de áreas úmidas e a detecção de potenciais efeitos negativos decorrentes de medidas na LPVN. Os resultados mostraram que cada tipo de área úmida apresenta padrões de biodiversidade únicos e contribui de forma categórica para a conservação, evidenciando que a adequada proteção do contínuo de conectividade das áreas úmidas é essencial para a sua gestão sustentável. Além disso, mostrei que lagoas apresentam a maior singularidade florística, um número muito maior de espécies herbáceas exclusivas e níveis de diversidade vegetal até maiores do que os exibidos por áreas ripárias, que apresentam um *status* legal muito menos desfavorável, evidenciando que a remoção da proteção legal de lagoas é inadequada. Eu argumento que a legislação ambiental do Brasil precisa passar por mudanças drásticas se o objetivo for assegurar a conservação da biodiversidade nas áreas úmidas e a manutenção de importantes serviços provisionados por esses ecossistemas. A criação de uma política nacional focada na gestão de áreas úmidas e

baseada no conhecimento científico é provavelmente a melhor maneira de alcançar esse propósito.

Palavras-chave legislação ambiental; políticas públicas; lagoas; áreas ripárias; diversidade vegetal; composição florística.

Abstract

In 2012, setbacks in the most important environmental legislation on Brazilian private lands, renamed the "Native Vegetation Protection Law" (NVPL), have placed a number of wetlands at risk of degradation and/or conversion. Among the most affected wetlands are ponds, which have virtually lost their legal protection. The legislative changes in the NVPL put at risk not only the great biodiversity of wetlands, but also the provision of important ecosystem services they provide. Here, I contributed to the identification and divulgation of setbacks and inadequacies in the NVPL and drew attention to the need for its sustainable regulation in the states. In addition, I conducted investigations on diversity (alpha, beta and gamma) and floristic composition in wetlands in the upper Uruguay River basin, southern Brazil, which contemplated three wetland types widely prevalent in the region: ponds and riparian areas adjacent to streams and rivers. These studies aimed to generate subsidies for the sustainable management of wetlands and the detection of potential negative effects resulting from measures in the NVPL. The results showed that each wetland type has unique biodiversity patterns and contributes categorically to conservation, showing that the adequate protection of the wetland connectivity continuum is essential for its sustainable management. In addition, I showed that ponds have the greatest floristic uniqueness, a much greater number of exclusive herbaceous species and even greater levels of plant diversity than those displayed by riparian areas, which have a much less unfavorable legal status, showing that the removal of the protection of ponds is inadequate. I argue that Brazil's environmental legislation needs to undergo drastic changes if the objective is to ensure the conservation of biodiversity in wetlands and the maintenance of important services provided by these ecosystems. The creation of a national policy focused on wetland management and based on scientific knowledge is probably the best way to achieve this purpose.

Keywords environmental legislation; public policy; ponds; riparian areas; plant diversity; floristic composition.

Sumário

Introdução geral

Áreas úmidas podem ser genericamente definidas como sítios com substratos/solos hidromórficos submetidos temporária ou permanentemente ao encharcamento ou a inundações rasas, apresentando, portanto, uma biota adaptada aos seus regimes hídricos, especialmente a de hidrófitas – terras firmes internas, quando existentes, fazem parte do conceito (Junk et al., 2014; Mitsch e Gosselink, 2015). Tais ecossistemas são cruciais para a conservação da biodiversidade, uma vez que abrigam parcela substancial da biota, comunidades com composição muito particular e um sem-número de espécies exclusivas, raras e ameaçadas de extinção (Williams et al., 2004; MA, 2005; Davies et al., 2008a,b; Pitman et al., 2014; Draper et al., 2018). Além disso, áreas úmidas provisionam um portfólio de serviços ecossistêmicos essenciais ao bem-estar humano, incluindo o sequestro de carbono, a transformação de materiais, a melhoria da qualidade da água e a regulação hidrológica (MA, 2005; Marton et al., 2015; Rains et al., 2016; Craft et al., 2017; Hansen et al., 2018). O Brasil, por ser o país mais biodiverso do mundo, tanto em números gerais (Brandon et al., 2005) como em termos de espécies aquáticas (Padial et al. 2017), e por apresentar a maior área úmida e o maior volume de turfa nos trópicos e subtrópicos (Gumbricht et al., 2017), ocupa uma posição estratégica para a conservação de áreas úmidas no âmbito internacional.

Apesar do exposto, as áreas úmidas brasileiras em propriedades privadas passaram a estar sob grande risco depois da promulgação da Lei de Proteção da Vegetação Nativa (LPVN; Brasil, 2012), que substituiu o antigo “Código Florestal” (Brasil, 1965) – embora Maltchik et al. (2018) tenham concluído, inadvertidamente, que a LPVN assegura a proteção de todos esses habitats. Exemplos de retrocessos ambientais que colocaram tais ecossistemas sob risco de degradação e/ou conversão incluem:

- Remoção da proteção conferida – por meio de Áreas de Preservação Permanente (APPs) – às lagoas com < 1 ha e áreas úmidas associadas a nascentes e córregos efêmeros;
- Grande redução na largura de inúmeras APPs convertidas antes de 22 de julho de 2008, cujas larguras agora são determinadas com base no tamanho das propriedades rurais, independentemente do tamanho ou largura das áreas úmidas ou dos corpos d'água;
- Alteração da base para a delimitação das APPs adjacentes a córregos e rios, que passou do nível máximo do espelho d'água para o nível do leito regular dos cursos d'água;
- Autorização para a prática da aquicultura (incluindo a de espécies exóticas e invasoras) em APPs convertidas no entorno de lagoas e lagos e adjacentes a cursos d'água intermitentes ou permanentes em propriedades rurais com ≤ 15 módulos fiscais; e
- Permissão para a utilização de espécies lenhosas exóticas para a "restauração" de APPs no entorno de lagoas, lagos e nascentes e adjacentes a cursos d'água temporários ou permanentes e veredas em pequenas propriedades, mesmo que tais áreas estejam em ambientes campestres ou savânicos (Brasil, 1965, 2012; Brancalion et al., 2016; Garcia et al., 2016).

Essas e outras inadequações foram adicionadas a problemas já existentes no antigo "Código Florestal" e, em grande parte, retidos pela LPVN, como a provisão de mecanismos parcos para o monitoramento da conformidade ambiental das propriedades privadas (e.g., Taniwaki et al., 2018), e o emprego de termos e definições (quando existentes) pobres relacionadas com áreas úmidas, que geram grandes incertezas sobre o escopo da lei (Maltchik et al., 2018). As inadequações e retrocessos legislativos acima mencionados são especialmente preocupantes diante das já altas taxas de conversão de áreas úmidas na América do Sul (89% após 1900; Creed et al., 2017) e ao fato de a rede de unidades de conservação no Brasil ser enviesada para a gestão de terras firmes, fornecendo, portanto, eficiência apenas limitada para a conservação de áreas úmidas (Azevedo-Santos et al., 2019). Diante desse cenário, uma das opções mais

viáveis para a reversão dos retrocessos na LPVN, ao menos no curto prazo, é a sua regulamentação sustentável nos estados, uma vez que estes podem adotar medidas mais restritivas, porém nunca mais permissivas, do que as da lei federal. Nesse contexto, a academia cumpre papel fundamental no sentido de tentar reduzir a lacuna entre a ciência e a política (Brancalion et al., 2016).

Dentre a grande diversidade de áreas úmidas brasileiras (Junk et al., 2014), lagoas foram provavelmente as que sofreram o maior impacto em seu *status* legal após a promulgação da LPVN. Esses ecossistemas são amplamente definidos como áreas úmidas com ≤ 2 ha e completamente circundadas por terras firmes (Biggs et al., 2005; Hamerlík et al., 2014). A grande maioria e, em algumas regiões, a quase totalidade das lagoas apresenta < 1 ha – e.g., 76-99% (Martin et al., 2012; Williams et al., 2010). Um único retrocesso ambiental na LVPN, i.e., a remoção da proteção de lagoas com < 1 ha, tem, portanto, o potencial de permitir o colapso regional desses ecossistemas – vale lembrar que lagoas também foram afetadas por outras políticas e medidas insustentáveis com potenciais efeitos negativos adicionais (veja acima).

As inadequações e retrocessos ambientais relacionados às lagoas estão em profunda dissonância com importantes contribuições acadêmicas, embora muito escassas, que apontaram para a crucial relevância desses ecossistemas para a conservação da biodiversidade de ambientes aquáticos numa perspectiva de paisagem. Por exemplo, em comparação com outros ecossistemas como lagos, córregos, rios e valas, lagoas foram mostradas para exibir grande singularidade florística, a maior diversidade vegetal beta e gama, bem como um número muito maior de espécies exclusivas e raras (Williams et al., 2004; Davies et al., 2008a,b). Contudo, a contribuição de lagoas para a biodiversidade vegetal de redes de áreas úmidas é ainda amplamente desconhecida. Logo, estudos comparativos que abordem a diversidade e composição de plantas em lagoas e nas demais áreas úmidas em escala regional são

fundamentais para reduzir essa lacuna de conhecimento e subsidiar a gestão sustentável desses ecossistemas como um todo.

Apesar da extrema carência de estudos voltados à avaliação da diversidade e composição de plantas em redes de áreas úmidas, cada um de seus tipos tem potencial para apresentar padrões de biodiversidade únicos, já que os mesmos tendem a exibir características particulares relacionadas, por exemplo, com a hidrologia, a geomorfologia, as propriedades físico-químicas da água e do substrato/solo, a organização espacial e a luminosidade (Keddy, 2010; Junk et al., 2014; Mitsch e Gosselink, 2015). Logo, tanto lagoas como as demais áreas úmidas das paisagens tendem a contribuir de forma singular para a manutenção das funções e serviços ecossistêmicos, necessitando, portanto, de proteção legislativa adequada.

Os principais propósitos dessa Tese foram: (1) identificar e divulgar medidas insustentáveis na LPVN relacionadas à gestão de áreas úmidas e propor ajustes; (2) chamar a atenção para a necessidade da regulamentação sustentável da LPVN nos estados; (3) corrigir interpretações infundadas sobre a proteção que a LPVN confere às áreas úmidas; (4) realizar estudos sobre a diversidade (alfa, beta e gama) e composição florística de diferentes tipos de áreas úmidas, a saber, lagoas e áreas ripárias adjacentes a córregos e rios, numa paisagem na bacia do alto Rio Uruguai, Sul do Brasil, para subsidiar a gestão sustentável desses ecossistemas e possibilitar a identificação de potenciais efeitos negativos das inconsistências na LPVN. Dados os excepcionais riscos enfrentados por lagoas nas propriedades privadas brasileiras e a sua grande relevância para a conservação, esta Tese foca principalmente nesses ecossistemas. Com relação ao item (4), as hipóteses levantadas foram: (1) cada tipo de área úmida apresenta padrões de diversidade e composição únicos e, portanto, contribuições singulares para a conservação; e (2) lagoas fazem contribuições essenciais para a diversidade beta e gama de redes de áreas úmidas.

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Manuscrito I

Brazil's Native Vegetation Protection Law threatens to collapse pond functions[I]

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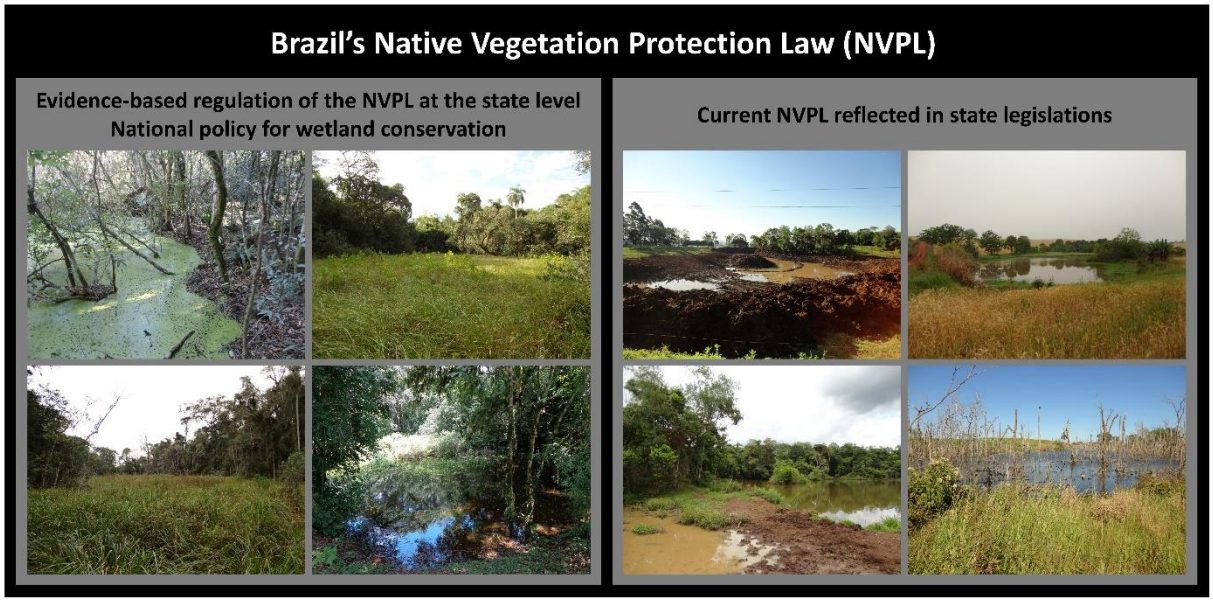
Highlights

- Pond systems provide essential and unique landscape functions.
- Unsustainable policies threaten to collapse pond functions in Brazil.
- Emergency measures are necessary to prevent pond extirpation.
- Brazil needs a national policy for wetland conservation.

Graphical abstract



Abstract

Pond systems perform a myriad of ecosystem services and make unique contributions to aquatic biodiversity conservation at the landscape scale. Despite their high conservation value, in Brazil, natural ponds have been lost and degraded at alarming rates. The remaining have become exceptionally vulnerable after the enactment of the recent Native Vegetation Protection Law (NVPL), whose unsustainable policies threatens to collapse these ecosystems. Although

in force since 2012, the regulation of the NVPL is still in course at the state level, offering a unique opportunity to reduce the gap between science and policy. Here, we show why the NVPL threatens ponds and how its inadequacies can be overcome. Finally, we emphasize the need to create a national policy specifically focusing on wetland conservation.

Keywords Biodiversity; Ecosystem services; Upland-embedded wetlands; Conservation; Environmental legislation; Unsustainable policies.

Introduction

Ponds – temporary or permanent upland-embedded wetlands (UEWs; sensu Calhoun et al., 2017a) with ≤ 2 ha (Biggs et al., 2005; Hamerlík et al., 2014) – are important landscape features, performing a portfolio of hydrological, biogeochemical, and biological functions crucial to maintaining the ecological integrity of watersheds and the provision of ecosystem services (Cohen et al., 2016; Evenson et al., 2018). Benefits provided by pond systems include carbon sequestration (Craft et al., 2017), material transformation (Marton et al., 2015), water quality improvement (Hansen et al., 2018), hydrologic regulation (Rains et al., 2016), and biodiversity support (Schofield et al., 2018). Particularly noteworthy are the contributions of ponds to the protection and management of the aquatic biota at the regional scale. Compared with lakes, rivers, streams, and ditches, ponds present the highest gamma diversity and support a disproportionately larger number of unique and rare species, in addition to having the smallest average catchment size, what makes them to be amongst the most valuable, easiest, and cheapest waterbody types to conserve (Davies et al., 2008a,b).

Despite their high conservation value, ponds have been historically neglected in Brazil, leading to the alteration or destruction of their majority in anthropized landscapes, caused

mainly by agricultural expansion, urban development, combating mosquito-borne diseases, and road constructions (e.g., Macedo-Soares et al., 2010; Moraes et al., 2014; Setubal et al., 2016, personal observations). Although there are no estimates of the former and current distribution, number, and size of UEWs for any region of the Brazilian territory, a recent paper reported that 89% of wetland area in South America was lost after 1900 (Creed et al., 2017), which may mean that Brazil is inserted in the region with the highest conversion rate of ponds in the world.

Regardless of their conservation status, all the remaining ponds outside conservation units become exceptionally vulnerable after the enactment of the recent Native Vegetation Protection Law (NVPL; Law nº 12,651 from May 25, 2012; http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm), which replaced the 1965 "Forest Code". The NVPL is the primary environmental legislation on private land, regulating, in the case of UEWs, the conservation and restoration of "buffer zones" (legally considered Permanent Preservation Areas – PPAs) in their surroundings. In practical terms, however, the NVPL does not present clear elements that ensure the protection of ponds, besides establishing a series of unsustainable policies that put their ecosystem functions and structure at risk.

Although in force since 2012, the regulation of the NVPL at the state level is still in course, offering a unique opportunity to reduce the gap between science and policy. In this context, we have expanded the debate around the NVPL (e.g., Brancalion et al., 2016) and pointed out potential solutions to overcome the inadequacies that threaten to extirpate the natural ponds in the most biodiverse country of the planet (Brandon et al., 2005).

Inadequacies of the NVPL

One of the main inadequacies of the NVPL, which turns all ponds vulnerable, is the dissociation of the indissociable, i.e., the untying of the concept of "wetlands" from the term "ponds" (not conceptualized in the law). As the NVPL does not directly protect wetlands (the term is not used in any public policy) through PPAs, but supposedly contemplates ponds (which are wetlands), what should be considered a pond is unclear, making conservation strategies impractical.

Equally comprehensive and potentially catastrophic threats stem from the fact that the NVPL does not provide protection for ponds with < 1 ha and does not mention UEWs that hold surface water or near-surface groundwater temporarily. This means that virtually all ponds are at risk, once the large majority generally have less than one hectare (e.g., ca. 76% and 99%; Martin et al., 2012 and Williams et al., 2010, respectively) and, depending on the climatic characteristics in certain regions (e.g., in the semi-arid Northeast Brazil), the totality can be temporary (Junk et al., 2014; Lane and D'Amico, 2016). The imminent massive conversion of small and temporary ponds, in addition to causing direct losses of biodiversity and of a myriad of essential and unique ecosystem services (Calhoun et al., 2017b; Cohen et al., 2016), will also dramatically reduce the connectivity between the few large (≥ 1 ha) and permanent ponds that may remain and, consequently, compromise the viability of metapopulations (Gibbs, 2000) and metacommunities (Dias et al., 2016). In the short to medium term, the inadequacies herein mentioned can mean the extirpation of almost the totality of natural ponds outside conservation units in Brazil, given that just a tiny fraction of the original number of these ecosystems currently remains. In the long term, however, all ponds can be lost, once the successional process tends to transform permanent ponds in temporary ones (Biggs et al., 1994), without legal protection.

The NVPL also undermines pond conservation through the requirement of extremely narrow PPAs. In urban and rural areas, the width of the PPAs that must be maintained is 30 m and 50 m, respectively. However, landowners that suppressed PPAs before July 22, 2008, must restore them up to the width of only 5 m, 8 m, 15 m and 30 m on properties with up to 1, >1-2, >2-4 and >4 fiscal modules, respectively (for details about fiscal modules, see Brancalion et al., 2016). Considering that the area of ponds and of their catchments are positively correlated, and that the PPAs width is not proportionally adjustable to pond size, it is expected that most of the uplands in depressional watersheds will remain economically exploited or humanly inhabited (especially those around large ponds on small properties in irregular situation), which has been shown to deteriorate pond environmental properties (Novikmec et al., 2016) and reduce their conservation value (Stuber et al., 2016; Thornhill et al., 2017). Additionally, insufficient buffer zones can accelerate pond clogging, increasing the likelihood of invasions by exotic species (Tsai et al., 2012), causing the loss of ecosystem services (e.g., water storage capacity) and, ultimately, the disappearance of these wetlands from the landscapes (Bowen and Johnson, 2017). It is also important to mention that probably all the PPAs proposed in the NVPL cannot be considered buffer zones per se, but only part of the full range of terrestrial habitats essential for various semiaquatic species to complete their life cycles (Semlitsch and Bodie, 2003).

How PPAs can be restored in family farms is also a cause of great concern. Among the strategies foreseen in the NVPL, landowners can use exotic woody species in the restoration of 50% of the PPAs, even in grassy biomes, where afforestation can devastate ecosystem functions (Veldman et al., 2015). Exotic woody species within depressional watersheds can alter a range of pond environmental features, reducing species richness and abundance, and modifying community composition (Stenert et al., 2012). The consequences of this inadequacy, however, can be much more severe. In the Argentine Pampas, e.g., an *Eucalyptus camaldulensis* stand reduced groundwater to levels (>50 cm) (Engel et al., 2005) higher than the mean depth of

temporary ponds (e.g., 26 cm) and close to the mean depth of permanent ones (e.g., 65 cm) (Hill et al., 2017). Changes of this magnitude in the groundwater table can dry temporary ponds and transform permanent ponds in temporary ones (unprotected by NVPL), determining the loss or collapse of biodiversity and ecosystem services, once hydrology is the core control of aquatic ecosystem functions (McLaughlin and Cohen, 2013). PPAs with exotic woody species, therefore, assume a contradictory role to their finality of safeguarding biodiversity and ecosystems' services and structure.

Another inadequacy in environmental terms is the authorization of aquaculture in converted PPAs on rural properties with ≤ 15 fiscal modules. However, although the NVPL refers only to PPAs, it does not provide explicit impediments to aquaculture (and any other practice) within ponds that are not legally protected, substantially expanding the possible multiplicity of environmental (reviewed by Martinez-Porchas and Martinez-Cordova, 2012) and biological (reviewed by De Silva, 2012) impacts resulting from such activities. The use of natural ponds for aquaculture, like conventional and organic rice cultivation (which includes the application of pesticides and fertilizers and/or intensive mechanization and water management), was shown to reduce species abundance and biomass and alter the communities functional and taxonomic diversity and composition (Dalzochio et al., 2016a,b; Linke et al., 2014). Moreover, aquaculture can compromise the provision of several pond services, like the water quality improvement (Hansen et al., 2018), through the discharge of polluted effluents (Rosa et al., 2013), and the hydrologic regulation (Rains et al., 2016), through water management (Dalzochio et al., 2016a). Aquaculture within PPAs, in turn, in addition to intensifying land use within depressional watersheds and maintaining portions of PPAs without native vegetation, whose negative impacts were mentioned previously, may have similar impacts on pond functions, mainly because of the temporary or permanent release of effluents

into the ponds, either by surface (e.g., by the frequent practice of draining cultivated wetlands; Linke et al., 2014) or ground-water flows.

Lastly, the NVPL also threatens pond functions for not protecting swales and ephemeral streams that temporarily or permanently connect ponds to downgradient waterbodies/wetlands through surface water flows (see Fig. 2a and b in Lane et al., 2018). Since ecosystem functions emerge from multiple connections, the predictable degradation or loss of swales and ephemeral streams are expected to severely impair biodiversity and ecosystem services supported by ponds (Lane et al., 2018; Schofield et al., 2018).

Solutions to the inadequacies of the NVPL

We identified the following potential solutions to the inadequacies of the NVPL: (1) to adopt a clear and comprehensive definition of ponds; (2) to provide protection to the entire continuum of wetland connectivity (Cohen et al., 2016); (3) to require PPAs with at least 50 m width around ponds to maximize the retention of contaminants and sediments (Haukos et al., 2016) until more studies introduce biological criteria for the design of buffer zones (e.g., Semlitsch and Bodie, 2003); (4) to consider only the use of native species for the active restoration of PPAs; and (5) to explicitly prohibit the use of ponds and PPAs for the practice of aquaculture.

Final remarks

The regulation of the NVPL at the state level, currently underway, offers probably the best opportunity to supplant its inadequacies, since states can adopt more rigorous, but never more permissive, conservation measures than the federal law. Our suggestions, however, should

be interpreted only as emergency strategies in an attempt to avoid the imminent collapse of pond functions in Brazil. Effective conservation initiatives, which will need to address the projected impacts of climate change (Junk et al., 2013) and the alarming rate of pond loss and degradation, will trigger a demand for actions that will make the Brazilian environmental legislation mostly obsolete. Therefore, we emphatically reinforce the need to create a national policy specifically focusing on wetland conservation (Junk et al., 2014), which should include the protection, restoration, management, mapping, monitoring and, especially, the creation (e.g., https://freshwaterhabitats.org.uk/projects/million-ponds/) of ponds. Dialogue between scientists and policymakers will be essential in this process (Azevedo-Santos et al., 2017; Karam-Gemael et al., 2017).

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Manuscrito II

Brazilian wetlands on the brink[II]

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To the Editor,

Wetlands harbor a huge biodiversity, provide essential services, and are key regulators of climate change (notably peatlands) (MA 2005). Brazil not only hosts the world's richest freshwater aquatic biota (Padial et al. 2017) but also leads in wetland area and peatland volume in the tropics and subtropics (Gumbricht et al. 2017). In 2012, controversial revisions to Brazil's "Forest Code", now renamed the "Native Vegetation Protection Law" (hereafter NVPL; Federal Law no. 12,651/2012; http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm), imposed catastrophic risks to wetlands. The reform was catalyzed mainly by the agribusiness sector, which argued that the Forest Code was too restrictive in the face of an alleged need for agricultural expansion (Metzger et al. 2010). However, this argument has been strongly contested by multiple studies (e.g., Soares-Filho et al. 2014; Strassburg et al. 2014; Brancalion et al. 2016). The question now is how to minimize the setbacks.

Riparian wetlands can now be cleared because the NVPL changed the basis for delimiting "buffer zones" (legally considered "Permanent Preservation Areas"; hereafter PPAs) from the maximum water level to the regular bed of watercourses, thus removing protection from many riparian areas, especially from the vast floodplains with flood pulses of high amplitude in Amazonia (Souza et al. 2011). Ponds <1 ha and wetlands adjacent to

intermittent springs and ephemeral streams lost their legal protection. These habitats are also on the verge of destruction (Brancalion et al. 2016; Grasel et al. 2018). The same goes for large tracts of salt marshes and hypersaline areas, which can now be used for shrimp farming and salt exploitation, also threatening associated mangroves (Rovai et al. 2012; SBPC and ABC 2012). Other setbacks include the dramatic reduction in requirements for restoration of PPAs cleared before 22 July 2008 (Brancalion et al. 2016), allowing 50% of any required restoration of PPAs to be done with exotic woody species, and authorization of aquaculture in most cleared PPAs.

Among other consequences, setbacks associated with the NVPL may substantially increase greenhouse gas emissions (Moomaw et al. 2018), cause a massive loss of native species (Metzger et al. 2010; Volcan and Lanés 2018), introduce alien taxa (Pelicice et al. 2017), and jeopardize vital ecosystem services (MA 2005). However, Brazil now has a valuable opportunity to rescue its wetlands and so sustain its international treaties and its leadership in conservation. Although in force since 2012, the NVPL's 'regulation' (setting of rules to implement a law) is still in progress at the state level, where its setbacks can be attenuated through adoption of more rigorous policies. We urge policymakers and scientists to engage in open dialogue on this critical 'regulation'.

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Manuscrito III

Brazil's Native Vegetation Protection Law jeopardizes wetland conservation: a comment on Maltchik et al.[III]

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Abstract

The future of Brazil's vast and highly biodiverse wetlands depends on interpretation of the country's new Native Vegetation Protection Law (NVPL). Maltchik *et al.* recently reviewed wetland-related terminologies and concepts in Brazilian legislation and concluded that all the country's wetlands are legally protected under the NVPL. Here we show that this is not the case. Finally, we point to a unique opportunity for scientists to help minimize damage to wetlands by contributing to the state-level 'regulation' of the NVPL, now underway, and we argue that the country needs a national policy focused specifically on the conservation of these ecosystems.

Keywords wetland policy; terms; definitions; unsustainable legislation; biodiversity; ecosystem services

Brazil's vast and highly biodiverse wetlands are under relentlessly increasing threat, and input from the scientific community is crucial to help minimize the impact of recent legislative setbacks. Terminologies and concepts in laws affecting wetlands are part of this, and Maltchik et al. (2018) have contributed a comprehensive review of such elements. However, their treatment needs reinterpretation.

Maltchik et al. (2018) evaluated wetland-related terms and definitions in Brazil's federal and state legislations to contribute to the assessment of the efficacy of wetland conservation policies. Most of the terminologies they found had only regional application and poor or nonexistent conceptualization. The generic term 'wetlands' ('*áreas úmidas*' in Portuguese), which is the most basic and important term in any wetland policy, was only used in one law: the Native Vegetation Protection Law (hereafter NVPL; Federal Law no. 12,651/2012; Brazil 2012). Based on this term being better defined than other designations, and given the precedence of the NVPL over state laws, Maltchik et al. (2018) concluded that: (1) the term 'wetlands' represents all wetland types; (2) the clear descriptors of the term's definition allow the identification of the totality of wetland ecosystems; and (3), due to (1) and (2), the NVPL ensures the protection of all wetlands.

Maltchik et al. (2018) have provided important input for a better understanding of the adequacy of Brazil's legislation on wetlands; however, the generalizations that these authors make regarding the NVPL's protection of all wetlands is unfounded. The term 'wetlands' appears only twice in the NVPL and is not used in any conservation policy. Its first appearance is before its definition (Chapter I, Article III, Subsection XXV), and the second (Chapter II, Section I, Article VI, Subsection IX) is in a clause that specifies that wetlands (especially those of international relevance) may become protected only if declared to be of 'social interest' by an act of the President of the Republic. The term 'wetlands' and its definition therefore do not guarantee the protection of any wetland in Brazil.

Regardless of the effective use of terminologies, the elements reviewed by Maltchik et al. (2018) lead to conclusions different from those that they drew. The term ‘wetlands’, although generic when considered in isolation, does not represent all wetland types in the context of the NVPL; because its definition is highly exclusionary, using this term cannot ensure the effectiveness of wetland-related conservation policies. Examples of wetlands that clearly do not fit the NVPL’s definition are those that are subject to unpredictable (i.e., non-periodic) flood pulses (e.g., riparian wetlands adjacent to streams and low-order rivers), all areas that are permanently flooded (e.g., permanent ponds, lakes and lagoons) and all or any parts of these areas that are not subject to flooding but are temporarily or permanently saturated (Junk et al. 2014, Mitsch & Gosselink 2015).

An inclusive definition of ‘wetlands’ would also not guarantee the efficacy of wetland conservation strategies. As shown by Maltchik et al. (2018), Brazilian legislation is remarkably insufficient with regards to the representation and detection of singular wetland types (which is especially worrying in view of the extreme diversity and complexity of the country’s wetlands; see Junk et al. 2014). These shortcomings cannot be masked or overcome only by adoption of the generic term ‘wetlands’ (and hence its definition), since each wetland type has unique characteristics and therefore specific conservation needs (e.g., buffer zone width) that can only be met through their being recognized as particular landscape features. A single conservation measure cannot serve for ecosystems ranging from the vast Amazonian floodplains to small temporary ponds in the semi-arid zone. One of the main functions of the term ‘wetlands’ (if not the main one) is not to replace terms for specific wetland types, but to constitute elements representing and/or describing them (e.g., ‘upland-embedded wetlands’ as a description of ponds and lakes; Calhoun et al. 2017a) in order to ensure that they cover the full range of wetland subtypes (e.g., from temporarily saturated to permanently flooded areas). However, this crucial auxiliary function is not fulfilled in any Brazilian law (Maltchik et al. 2018).

Potentially negative consequences of the lack of this kind of application of the term 'wetlands' is exemplified by the NVPL's term 'ponds' ('*lagoas*' in Portuguese), which lacks conceptualization. As comprehensively defined, ponds are upland-embedded wetlands of ≤2 ha (Hamerlík et al. 2014). However, some researchers alternatively use the term 'pools' ('*poças*' in Portuguese) in place of 'temporary ponds' (e.g., De Meester et al. 2005). It is therefore unclear whether temporary ponds are protected by the NVPL, which may lead to exclusionary conservation policies and, consequently, to the collapse of unique ecosystem services (Calhoun et al. 2017b) and communities (Hill et al. 2017, Volcan & Lanés 2018) – in fact, the NVPL does not ensure the protection of any pond (Grasel et al. 2018b). Given the paramount importance of appropriate terms and definitions of wetland types in environmental policies, it should be recognized that Brazil's legislation seriously jeopardizes wetland conservation.

Deficiencies related to the elements used to represent and identify wetland systems, however, are not the only problems that compromise the conservation of these ecosystems in Brazil. While a detailed analysis of the country's wetland-related policies is beyond the scope of this comment article, it is also important to highlight that the NVPL's enactment in 2012 (when it replaced the old 1965 'Forest Code') imposed catastrophic risks to Brazil's wetland heritage (Grasel et al. 2018a). Setbacks or inadequacies in the NVPL that diverge from Maltchik et al.'s conclusions include:

- Removal of the protection conferred to ponds of <1 ha and wetlands associated with intermittent springs and ephemeral streams.
- Dramatic reductions in the requirements for restoration of 'buffer zones' (legally considered 'Permanent Preservation Areas'; hereafter PPAs) cleared before 22 July 2008, especially for those around ponds and lakes (for which protection with PPAs is now only 5–30 m) and adjacent to streams and rivers (where protection is only 5–100 m). This

protected vegetation is now delimited according to the size of the property, regardless of the size or width of the wetlands or waterbodies.

- Alteration of the basis for delimiting PPAs adjacent to streams and rivers from the maximum water level to the 'regular bed' of watercourses, thus reducing or removing protection from many riparian areas, especially from the vast Amazonian floodplains, which can reach widths of tens of kilometres and be 'protected' by PPAs as narrow as 5 m (Souza Jr et al. 2011, Brancalion et al. 2016).
- Authorization of aquaculture (including raising alien species) in converted PPAs around ponds and lakes and adjacent to either intermittent or permanent watercourses on rural properties with ≤15 fiscal modules (for details about fiscal modules, see Brancalion et al. 2016).
- Non-protection of mangroves, salt marshes and hypersaline areas (sensu Junk et al. 2014) through non-wetland PPAs (mangroves are themselves considered PPAs, but salt marshes and hypersaline areas are not).
- Permission to use salt marshes and hypersaline areas for shrimp farming (including exotic species) and salt production (10% of the area of these ecosystems can be used in the Amazon biome and 35% in other Brazilian biomes) (see also Rovai et al. 2012, Oliveira-Filho et al. 2016).
- Allowing 50% of any required restoration of PPAs around ponds, lakes and perennial springs and adjacent to intermittent/permanent watercourses and *veredas* (wetlands in the *Cerrado* biome) to be done using exotic woody species (even in grassy biomes).
- Establishment of the Rural Environmental Registry (known as the 'CAR') with poor provision for monitoring compliance with the rules for protection of waterbodies and wetlands, especially in the case of narrow or small aquatic ecosystems (e.g., Taniwaki et al. 2018).

Recognizing the limitations and problems of the NVPL is a pressing need in the current Brazilian political scenario. Although in force since 2012, the NVPL's 'regulation' (setting of rules to implement a law) at the state level is still underway, offering a unique opportunity to supplant its inadequacies. Therefore, scientists and policy-makers must engage in dialogue to regulate environmental legislation with evidence-based criteria (Azevedo Santos et al. 2017).

However, the legal mechanisms provided by the NVPL, even if improved at the state level, are clearly insufficient to promote wetland conservation in Brazil. Overcoming environmental challenges imposed, for example, by climate change (Junk et al. 2013), high rates of wetland loss (Creed et al. 2017) and the spread of exotic species (e.g., Stenert et al. 2016) will require the adoption of effective integrated strategies for the protection, restoration, management, creation, mapping and monitoring of wetlands (e.g., Grasel et al. 2018b). We emphatically recommend the creation of a national policy specifically focusing on wetland conservation.

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Considerações finais

Com esta Tese, contribuí com a identificação e divulgação de políticas e medidas insustentáveis relacionadas à gestão de áreas úmidas no âmbito da LPVN, reforcei a necessidade da sua regulamentação sustentável nos estados, corrigi interpretações equivocadas sobre a suposta proteção que ela confere a todas as áreas úmidas, e realizei pesquisas sobre a biodiversidade vegetal em diferentes tipos de áreas úmidas na bacia do alto Rio Uruguai, a saber, lagoas e áreas ripárias adjacentes a córregos e rios, a fim de criar aporte teórico para a gestão sustentável desses ecossistemas. A maioria das contribuições foram focadas em lagoas, o que se justifica pela excepcional ameaça de degradação e conversão que elas enfrentam, bem como pela sua grande relevância para a conservação da biodiversidade.

As contribuições relacionadas com as pesquisas de campo são provavelmente as primeiras que abordaram coletivamente a biodiversidade vegetal de lagoas e áreas ripárias adjacentes a córregos e rios em escala de paisagem, que contemplaram tanto espécies herbáceas como lenhosas, e que foram realizadas através de protocolos de amostragem padronizados, gerando, portanto, dados inéditos. De modo geral, mostrei que cada tipo de área úmida estudado apresenta padrões únicos de diversidade e composição, contribuindo, assim, de forma singular para a conservação da biodiversidade vegetal, o que implica que a gestão sustentável de áreas úmidas passa necessariamente pela adequada conservação do contínuo de conectividade desses ecossistemas. Além disso, mostrei que lagoas apresentaram a maior singularidade florística, o maior número de espécies herbáceas exclusivas e níveis de diversidade até maiores do que áreas ripárias, evidenciando que a remoção de sua proteção legal é inadequada.

A LPVN representa um grande retrocesso na gestão do patrimônio de áreas úmidas no Brasil. Mesmo que o processo de regulamentação da lei nos estados possibilite que suas inadequações sejam parcialmente suplantadas, é improvável que esse processo por si só resulte

em medidas que atendam de forma satisfatória as necessidades de conservação. O Brasil precisa urgentemente de uma política nacional focada na gestão de áreas úmidas e que seja fundamentada no conhecimento científico.

Por fim, vale ressaltar que os dados de campo coletados ainda resultarão em contribuições adicionais, incluindo artigos sobre a diferenciação florística e sobre os determinantes dos padrões de biodiversidade vegetal nas áreas úmidas estudadas.