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Public Policies and Territorial Management in the Canoas River Basin: Challenges between Production, Biodiversity, and Governance

Políticas Públicas e Gestão Territorial na Bacia do Rio Canoas: Desafios entre Produção, Biodiversidade e Governança

Políticas Públicas y Gestión Territorial en la Cuenca del Río Canoas: Desafíos entre Producción, Biodiversidad y Gobernanza

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Abstract: This article, developed as part of a master's dissertation, aimed to analyze the environmental, territorial, and socioeconomic effects of consolidated rural areas located within Permanent Preservation Areas in the Environmental Protection Area of the Canoas River Watershed, in the municipality of Franca, State of São Paulo, Brazil, considering the provisions of Federal Law No. 12,651/2012. The study also sought to address and disseminate complementary aspects that, although not directly examined within the main scope of the dissertation, are relevant to understanding the investigated issue and expanding scientific communication on environmental conservation and the regularization of rural properties. The research adopted a qualitative and quantitative, exploratory, and descriptive approach, based on bibliographic, documentary, and cartographic research. Data from the Rural Environmental Registry, the 2020 Forest Inventory, the hydrographic network, and vegetation cover were analyzed, with emphasis on rural properties of up to four fiscal modules. The results showed that, of the 431.94 hectares of water-related Permanent Preservation Areas assessed, only 66.59 hectares, equivalent to 15.42%, had vegetation cover, whereas 365.35 hectares, corresponding to 84.58%, were devoid of vegetation. The most critical proportional condition was identified in rural properties ranging from one to two fiscal modules, while properties ranging from two to four fiscal modules accounted for the largest absolute area potentially subject to environmental restoration. It was concluded that environmental regularization should be accompanied by territorial planning, ecological restoration, technical assistance, and economic incentives. In this context, the Environmental Regularization Program and Payment for Ecosystem Services represent relevant instruments for promoting riparian forest restoration, water resource protection, and the establishment of ecological corridors.

Keywords: Consolidated Rural Areas. Permanent Preservation. Environmental Regularization. Water Resources. Ecological Restoration.

Resumo: Este artigo, desenvolvido como parte de uma dissertação de mestrado, teve como objetivo analisar os efeitos ambientais, territoriais e socioeconômicos das áreas rurais consolidadas situadas em Áreas de Preservação Permanente na Área de Proteção Ambiental da Bacia Hidrográfica do Rio Canoas, no município de Franca, Estado de São Paulo, considerando as disposições da Lei Federal nº 12.651/2012. O estudo buscou, ainda, abordar e divulgar aspectos complementares que, embora não tenham sido tratados diretamente no escopo principal da dissertação, apresentam relevância para a compreensão da problemática investigada e para a ampliação da divulgação científica sobre a conservação ambiental e a regularização das propriedades rurais. A pesquisa adotou abordagem quali-quantitativa, de caráter exploratório e descritivo, desenvolvida por meio de pesquisa bibliográfica, documental

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e cartográfica. Foram analisados dados do Cadastro Ambiental Rural, do Inventário Florestal de 2020, da rede hidrográfica e da cobertura vegetal, com ênfase nos imóveis rurais de até quatro módulos fiscais. Os resultados demonstraram que, dos 431,94 hectares de Áreas de Preservação Permanente hídricas avaliados, apenas 66,59 hectares, equivalentes a 15,42%, apresentavam cobertura vegetal, enquanto 365,35 hectares, correspondentes a 84,58%, encontravam-se desprovidos de vegetação. A condição proporcionalmente mais crítica foi identificada nos imóveis rurais com área entre um e dois módulos fiscais, enquanto as propriedades entre dois e quatro módulos concentraram a maior área absoluta passível de recuperação ambiental. Concluiu-se que a regularização ambiental deve ser acompanhada por ações de planejamento territorial, restauração ecológica, assistência técnica e incentivos econômicos. Nesse contexto, o Programa de Regularização Ambiental e o Pagamento por Serviços Ambientais apresentam-se como instrumentos relevantes para promover a recuperação das matas ciliares, a proteção dos recursos hídricos e a formação de corredores ecológicos.

Palavras-chave: Áreas Rurais Consolidadas. Preservação Permanente. Regularização Ambiental. Recursos Hídricos. Restauração Ecológica.

Resumen: Este artículo, desarrollado como parte de una tesis de maestría, tuvo como objetivo analizar los efectos ambientales, territoriales y socioeconómicos de las áreas rurales consolidadas situadas en Áreas de Preservación Permanente dentro del Área de Protección Ambiental de la Cuenca Hidrográfica del Río Canoas, en el municipio de Franca, estado de São Paulo, considerando las disposiciones de la Ley Federal n.º 12.651/2012. El estudio también buscó abordar y divulgar aspectos complementarios que, aunque no fueron tratados directamente en el alcance principal de la tesis, son relevantes para comprender la problemática investigada y ampliar la divulgación científica sobre la conservación ambiental y la regularización de las propiedades rurales. La investigación adoptó un enfoque cualitativo-cuantitativo, exploratorio y descriptivo, desarrollado mediante investigación bibliográfica, documental y cartográfica. Se analizaron datos del Registro Ambiental Rural, del Inventario Forestal de 2020, de la red hidrográfica y de la cobertura vegetal, con énfasis en los inmuebles rurales de hasta cuatro módulos fiscales. Los resultados demostraron que, de las 431,94 hectáreas de Áreas de Preservación Permanente hídricas evaluadas, solo 66,59 hectáreas, equivalentes al 15,42 %, presentaban cobertura vegetal, mientras que 365,35 hectáreas, correspondientes al 84,58 %, carecían de vegetación. La condición proporcionalmente más crítica se identificó en los inmuebles rurales de entre uno y dos módulos fiscales, mientras que las propiedades de entre dos y cuatro módulos concentraron la mayor superficie absoluta susceptible de recuperación ambiental. Se concluyó que la regularización ambiental debe ir acompañada de acciones de planificación territorial, restauración ecológica, asistencia técnica e incentivos económicos. En este contexto, el Programa de Regularización Ambiental y el Pago por Servicios Ambientales se presentan como instrumentos relevantes para promover la recuperación de los bosques ribereños, la protección de los recursos hídricos y la formación de corredores ecológicos.

Palabras clave: Áreas Rurales Consolidadas. Preservación Permanente. Regularización Ambiental. Recursos Hídricos. Restauración Ecológica.

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1. Introduction

The protection of native vegetation on rural properties is one of the main challenges of Brazilian environmental management, especially in territories where productive activities have historically developed near rivers, streams, and springs. In these areas, applying environmental legislation requires reconciling the conservation of natural resources, the maintenance of economic activities, and the continued presence of rural populations in the countryside. This debate becomes even more relevant in Environmental Protection Areas, whose management must make human occupation compatible with the preservation of the ecological characteristics that justified their creation.

Federal Law No. 12,651/2012 established new guidelines for protecting native vegetation and introduced instruments aimed at the environmental regularization of rural properties, such as the Rural Environmental Registry (CAR) and the Environmental Regularization Program (PRA). The legislation also recognized so-called consolidated rural areas, characterized by human occupation prior to July 22, 2008, with buildings, improvements, or agricultural, forestry, livestock, ecotourism, and rural tourism activities. The possibility of continuing certain uses in Permanent Preservation Areas changed the criteria for restoring vegetation and intensified discussions about the boundaries between environmental protection, legal certainty, and the socioeconomic function of rural property (BRASIL, 2012a).

From an ecological perspective, Permanent Preservation Areas perform functions that are indispensable to landscape stability. Vegetation cover along watercourse banks, around springs, and in other environmentally fragile areas helps contain erosion, reduce sedimentation, maintain water quality, regulate the hydrological cycle, and protect biodiversity. These areas also promote connectivity among vegetation fragments, forming ecological corridors that enable wildlife movement, seed dispersal, and gene flow among previously isolated populations.

The reduction or fragmentation of vegetated strips may compromise the continuity of these ecological processes, particularly in watersheds dominated by small rural properties. This occurs because the restoration rules applicable to consolidated areas consider, among other factors, property size in fiscal modules. Consequently, landholding structure directly influences the width of restored areas and the ability of riparian forests to perform their functions as water-protection zones and biodiversity corridors.

On the other hand, the analysis of consolidated areas cannot disregard the economic and social reality of rural properties. A significant share of food production is carried out by family

farmers, many of whom occupy areas near water sources because of the historical formation of properties and the need for irrigation. In this context, environmental regularization can increase legal certainty, allow productive activities to continue, and help families remain in rural areas. These benefits, however, must be associated with the adoption of good agricultural practices, the restoration of legally required strips, and the use of incentive mechanisms that reduce the costs of environmental compliance.

This issue is particularly relevant in the Environmental Protection Area of the Canoas River Watershed, located in the municipality of Franca, State of São Paulo. The basin plays a strategic role in water supply, biodiversity conservation, and the maintenance of rural economic activities. At the same time, the presence of occupied areas, vegetation fragments, and degraded springs demonstrates the need to improve territorial planning, inspection, and ecological restoration actions. Surveys conducted in the region identified 158 springs, 99 of which had native vegetation cover and 59 of which required restoration measures, corresponding to approximately 37.34% of the springs assessed (BERTELLI et al., 2021). This scenario shows that property regularization must be accompanied by concrete measures to protect water resources.

In addition to the CAR and PRA, Payment for Ecosystem Services is an instrument capable of strengthening conservation policies in the basin. Remunerating or compensating landowners who protect springs, restore riparian forests, and conserve forest fragments may encourage participation in regularization actions, especially on smaller rural properties. Environmental protection thus ceases to be understood exclusively as a restriction on property use and comes to be recognized as an activity that generates benefits for society as a whole, including water availability, soil conservation, climate regulation, and biodiversity maintenance (BERTELLI et al., 2022).

Against this background, the general objective of this article is to analyze the ecological, territorial, and socioeconomic effects of consolidated-use areas located within Permanent Preservation Areas in the Canoas River Watershed Environmental Protection Area, considering Federal Law No. 12,651/2012 and the environmental regularization instruments applicable to rural properties. Specifically, it seeks to characterize the evolution of Brazilian forest legislation; identify the condition of water-related PPAs and consolidated areas in the basin; assess the implications of these occupations for spring protection and ecological corridor formation; examine the participation of rural properties of up to four fiscal modules in landscape configuration; estimate possible changes following PRA implementation; and discuss Payment

for Ecosystem Services as an incentive mechanism for restoration and native vegetation conservation.

Regarding methodological procedures, the research adopts a qualitative and quantitative, exploratory, and descriptive approach. According to Gil (2002), exploratory research provides greater familiarity with the problem under investigation, helping refine research questions and construct interpretations of phenomena that remain insufficiently systematized. Descriptive research, in turn, makes it possible to identify the characteristics of a given territory and analyze the relationships among its environmental, social, economic, and institutional components.

The qualitative dimension was developed through bibliographic and documentary research covering scientific publications, technical documents, and legal instruments concerning Permanent Preservation Areas, consolidated rural areas, family farming, ecological corridors, ecosystem services, and environmental regularization instruments. The principal instruments considered were Law No. 4,504/1964, which provides for the Land Statute; former Law No. 4,771/1965; Law No. 12,651/2012; and Law No. 14,119/2021, which established the National Policy on Payment for Ecosystem Services. The quantitative dimension comprised the analysis of territorial and cartographic data on rural properties, PPAs, areas without vegetation cover, and springs located in the Canoas River Watershed Environmental Protection Area.

The study is also applied in nature because it aims to produce information capable of supporting planning and decision-making in municipal and regional environmental management. Analyzing the situation before implementation of the Environmental Regularization Program, together with estimating possible scenarios after its execution, allows discussion not only of existing environmental liabilities but also of opportunities for landscape recovery. In this sense, the research seeks to contribute to public policies that integrate environmental regularization, ecological restoration, water-resource conservation, and socioeconomic development.

The study is based on the understanding that the effectiveness of Law No. 12,651/2012 does not depend solely on delimiting areas and registering rural properties. Its implementation requires the integration of environmental information, territorial planning, technical assistance, inspection, social participation, and economic incentives. In the Canoas River Watershed Environmental Protection Area, such integration is essential so that regularization of consolidated areas does not merely formalize previous occupations, but also restores the ecological functions of PPAs, landscape connectivity, and the springs that sustain multiple water uses in the municipality of Franca.

2. Materials and Methods

The research was conducted using a qualitative and quantitative, exploratory, and descriptive approach, combining the interpretation of normative and scientific documents with the measurement of territorial and environmental elements. The qualitative dimension focused on understanding the legal, ecological, and socioeconomic foundations related to consolidated rural areas located within Permanent Preservation Areas (PPAs). The quantitative dimension comprised estimating the areas occupied by PPAs, remnants of native vegetation, and Legal Reserves (LRs) within the analyzed territory.

In terms of its objectives, the research is exploratory because it seeks to expand knowledge of the effects of applying forest legislation in consolidated areas of the Canoas River Watershed. It is also descriptive, as it seeks to identify, measure, and represent the environmental and territorial characteristics of the study area. According to Gil (2002), exploratory research provides greater familiarity with the investigated problem and helps refine ideas and research questions, while descriptive research presents the characteristics of a given population, territory, or phenomenon and establishes relationships among its variables.

The technical procedures included bibliographic, documentary, and cartographic research. The bibliographic research supported the discussion of PPAs, Legal Reserves, consolidated rural areas, forest fragmentation, ecological corridors, ecosystem services, and environmental public policies. The documentary research was based on environmental legislation, Rural Environmental Registry (CAR) records, the 2020 Forest Inventory, and territorial documents concerning the Canoas River Watershed Environmental Protection Area.

The study is also applied in nature, since its results are intended to support territorial planning, environmental regularization, ecological restoration, and public-policy formulation. Thus, the investigation is not limited to describing the basin's environmental condition; it seeks to produce information that may contribute to the recovery, protection, and conservation of native vegetation, water resources, soil, and biodiversity.

The study area corresponds to the portion of the Canoas River Watershed located in the State of São Paulo, within the municipality of Franca. The territory lies within the Canoas River Watershed Environmental Protection Area, established by Municipal Law No. 4,240/1992 to protect natural resources, particularly water sources important to the municipal public supply.

This area was selected because of its environmental, water-related, social, and economic importance to the municipality of Franca. The basin contains rural properties, areas used for

farming and livestock production, remnants of native vegetation, springs, watercourses, and areas under different conservation conditions. The coexistence of these elements makes the territory suitable for analyzing relationships among rural occupation, environmental regularization, and natural-resource protection.

The research did not involve direct participation by individuals or the use of questionnaires, interviews, or other data-collection instruments involving human beings. The target population, understood as the universe of analysis, therefore consisted of rural properties located in the Canoas River Watershed Environmental Protection Area, with special attention to properties of up to four fiscal modules, as well as water-related PPAs, Legal Reserves, springs, watercourses, and native vegetation fragments in the territory.

The consolidated rural areas recognized by Law No. 12,651/2012 were also considered, especially those related to occupations and activities established before July 22, 2008. Analyzing this universe made it possible to assess how landholding structure and different land uses affect the dimensions of restoration strips, vegetation continuity, and ecological corridor formation.

The first methodological stage consisted of surveying and analyzing legislation on the use and protection of native vegetation on rural properties. The main normative references were Law No. 4,504/1964, which established the Land Statute; Law No. 4,771/1965, the former Forest Code; and Law No. 12,651/2012, which established the current legal regime for protecting native vegetation. Municipal Law No. 4,240/1992, which created the Canoas River Watershed Environmental Protection Area, was also considered.

The documentary analysis sought to identify the changes introduced by Law No. 12,651/2012 regarding PPAs, Legal Reserves, and consolidated rural areas. It examined primarily the legal criteria for delimiting and restoring protected strips, the influence of the number of fiscal modules of rural properties, and the environmental regularization instruments linked to the Rural Environmental Registry and the Environmental Regularization Program.

In the second stage, territorial information was gathered from the Rural Environmental Registry, the 2020 Forest Inventory, and thematic maps of hydrography and native vegetation cover. These materials were used to identify the spatial distribution of rural properties, watercourses, springs, PPAs, Legal Reserves, and vegetation fragments in the study area.

The third stage involved cartographic analysis and measurement of environmentally relevant areas. The areas corresponding to PPAs, remnants of native vegetation, Legal Reserves, and land without vegetation cover were estimated. Comparing hydrographic information with vegetation distribution made it possible to diagnose the condition of water-

related PPAs and determine the degree of continuity or fragmentation of vegetation cover in the landscape.

Fragmentation was analyzed based on the distribution, proximity, and apparent connectivity among vegetation remnants. This assessment enabled discussion of the capacity of PPAs and other vegetation formations to function as ecological corridors, promoting wildlife movement, seed dispersal, gene flow, and the maintenance of ecological processes in the basin.

In the fourth stage, cartographic and quantitative results were interpreted in light of environmental legislation and the theoretical framework consulted. The ecological functions of protected areas were compared with the socioeconomic effects resulting from the application of rules for consolidated rural areas. This interpretation considered both the possible impacts of reduced vegetation strips and the need to ensure legal certainty and conditions for rural producers to remain on the land, especially family farmers.

Finally, the results were related to opportunities for improving municipal and regional public policies. Strategies for environmental regularization, PPA restoration, spring protection, forest-remnant conservation, and ecological corridor formation were discussed. These measures were analyzed in line with the United Nations Sustainable Development Goals, especially those concerning clean water and sanitation, sustainable cities and communities, climate action, and life on land.

The integration of normative analysis, environmental data, cartographic information, and territorial measurements made it possible to construct a diagnosis of the Canoas River Watershed Environmental Protection Area. This methodological path enabled an assessment of the environmental and socioeconomic effects of consolidated areas and produced support for proposing policies aimed at the recovery, protection, and sustainable use of natural resources.

3. Results and Discussion

The analysis of legislation and specialized literature showed that Permanent Preservation Areas and Legal Reserves are complementary instruments for protecting native vegetation on rural properties. Although both contribute to natural-resource conservation, their functions and delimitation criteria differ. PPAs are associated with protecting environmentally sensitive spaces, such as watercourse banks, springs, and areas subject to erosion, whereas Legal Reserves correspond to a proportion of the rural property designated for the conservation and sustainable use of native vegetation.

In areas near watercourses and springs, vegetation directly influences the basin's hydrological dynamics. Vegetation cover reduces the impact of raindrops on the soil, limits compaction, and helps maintain porosity. Together with root systems, these processes increase water infiltration and contribute to aquifer and groundwater recharge. The absence of this protection tends to increase surface runoff, intensifying the transport of soil particles, nutrients, sediments, and residues from agricultural and livestock activities into water bodies (SKORUPA, 2003).

Riparian vegetation also stabilizes banks, reducing erosion and the transport of sediment into riverbeds. It therefore functions as a retention strip between productive areas and the aquatic environment. The loss or reduction of these formations compromises water quality, promotes sedimentation, and may alter the flow and stability of watercourses. At the watershed scale, such effects interfere with both water availability and the ability to regulate extreme events, including drought periods and episodes of concentrated surface runoff.

The results also indicate that PPA conservation should not be understood merely as a formal legal requirement. Its function is related to maintaining ecological processes that sustain productive activities themselves. Soil conservation, water availability, and bank stability are essential conditions for the continuity of agriculture and livestock production. The degradation of these areas may therefore cause losses that extend beyond property boundaries and affect other watershed users.

In addition to water protection, PPAs contribute to landscape connectivity. When conserved along watercourses, they form continuous or partially connected strips of vegetation, enabling wildlife movement, seed dispersal, and gene flow among populations. This function becomes particularly relevant in fragmented rural landscapes, where native vegetation remnants are separated by pastures, crops, roads, and other forms of occupation. Reducing riparian strips increases isolation among fragments and diminishes the landscape's ability to maintain viable populations of plant and animal species (METZGER, 2010).

In the Canoas River Watershed Environmental Protection Area, this discussion is particularly important because vegetation along the drainage network can establish connections among springs, forest fragments, and other environmentally protected areas. The conservation and restoration of water-related PPAs must therefore be planned in an integrated manner, considering not only compliance with the minimum widths required by law but also the spatial continuity of vegetation cover and its contribution to ecological corridor formation.

The application of Article 61-A of Law No. 12,651/2012, however, introduced differentiated criteria for restoring PPAs in consolidated rural areas. The width of the mandatory

restoration strip began to take into account, among other factors, rural property size in fiscal modules. This treatment sought to reduce the economic impacts of regularization on small producers, but it also produced relevant ecological implications. In basins dominated by smaller properties, successive application of reduced strips may result in narrow, discontinuous riparian corridors, limiting watercourse protection and connectivity among natural remnants.

This finding shows that formal compliance with the minimum strip does not always correspond to full recovery of the PPA's ecological functions. The width required to control sediment, protect habitats, or allow certain species to move may vary according to slope, soil type, intensity of agricultural use, and the biological characteristics of the landscape. General legal rules therefore need to be combined with watershed territorial planning and, whenever possible, additional conservation measures.

The possibility of counting PPAs toward the Legal Reserve percentage, provided for in Article 15 of Law No. 12,651/2012, is another relevant change. The mechanism may facilitate property regularization provided that it does not involve new vegetation conversion, that the areas are conserved or under recovery, and that the property is registered in the Rural Environmental Registry. The law establishes that this calculation may be applied to different means of complying with the Legal Reserve requirement, including regeneration, restoration, and compensation (BRASIL, 2012a).

Although this instrument reduces overlapping territorial requirements imposed on landowners, it must be applied cautiously. PPAs and Legal Reserves do not perform entirely equivalent functions. A PPA is delimited because of the fragility or environmental importance of a given landscape feature, whereas a Legal Reserve seeks to ensure a minimum proportion of vegetation within the property and may allow forms of sustainable management. Counting one area toward the other may therefore meet the legally required percentage without necessarily increasing the actual amount of native vegetation on the property.

Sparovek et al. (2011) had already warned that some flexibilities introduced during the revision of the Forest Code could increase the complexity of environmental control. Counting PPAs in the Legal Reserve calculation, for example, changes the composition of the protected percentage on each property and requires efficient systems for recording, analyzing, and validating declared information. Without the proper functioning of these mechanisms, control may be limited to quantitative analysis of areas without considering their location, conservation status, or importance to landscape connectivity.

Legal Reserve compensation options also offer benefits and limitations. Compensation on another property within the same biome may favor the maintenance of extensive areas of

native vegetation and create economic mechanisms for conservation. However, when implemented far from the property with the deficit, it may not compensate for the loss of ecosystem services at the local scale. Protecting an area in another region does not fully replace functions related to soil conservation, water regulation, wildlife shelter, and connections among fragments in the sub-basin where clearing occurred.

The Legal Reserve should therefore be analyzed as a component of rural landscape planning. Bitencourt and Mendonça (2004) emphasize that its location can contribute to ecological corridor formation, the expansion of buffer zones, and connections among protected areas. This perspective shows that the environmental value of a Legal Reserve depends not only on its size but also on its position in relation to PPAs, vegetation remnants, and Protected Areas.

The Legal Reserve can also generate indirect economic benefits for landowners because maintaining vegetation contributes to conserving soil, water, pollinators, and other components needed for rural production. Moreover, the law allows sustainable management under certain conditions, enabling the use of forest products and by-products provided that technical criteria, licensing requirements, and the limits necessary to conserve ecological processes are respected.

Law No. 12,651/2012 also established differentiated treatment for rural properties of up to four fiscal modules. Under Article 67, properties that, on July 22, 2008, had a percentage of native vegetation below the required level may establish their Legal Reserve using the vegetation existing on that date, without being required to reach the full general percentage through new restoration. The measure recognizes the economic constraints faced by small producers and seeks to prevent environmental regularization from making their activities unviable.

From a social perspective, this treatment contributes to legal certainty and helps families remain in rural areas. From an ecological perspective, however, it may consolidate landscapes with reduced vegetation percentages, particularly when combined with smaller PPA restoration strips. The environmental effect of the rule therefore depends on the landholding structure prevailing in the basin and the spatial distribution of existing remnants.

Replacing the registration of the Legal Reserve in the property registry with its registration in the Rural Environmental Registry represented another important change. Under Article 18, paragraph 4, of Law No. 12,651/2012, registering the Legal Reserve in the CAR dispenses with its annotation at the Real Estate Registry Office. Decree No. 7,830/2012, in turn, regulated the operation of the CAR and Environmental Regularization Programs (BRASIL, 2012b). This model makes it possible to integrate information on the property, its PPAs, Legal Reserves, vegetation remnants, and consolidated areas in a single electronic database.

The electronic system has the potential to expand monitoring and enable territorial analyses at both property and watershed scales. Its effectiveness, however, depends on validation of declared information, compatibility among cartographic databases, and the technical capacity of environmental agencies. Because the CAR is initially declaratory in nature, registration alone does not automatically prove that a property is environmentally compliant.

Historical problems related to Legal Reserve compliance reinforce this need. Bacha (2005) identified low adherence by rural properties to legal requirements and limitations in the available data, which were often based on information supplied by landowners themselves. Although the CAR represents progress compared with previously fragmented records, improved control depends on effective analysis of registrations, inspection, and implementation of Environmental Regularization Programs.

The results therefore indicate that conserving PPAs and Legal Reserves in the Canoas River Watershed Environmental Protection Area requires an approach that goes beyond isolated compliance with legal percentages. The effectiveness of these instruments depends on the location of protected areas, the width and continuity of vegetation strips, integration among neighboring properties, and connections with other natural remnants.

Environmental regularization should be accompanied by technical assistance, monitoring, inspection, and economic incentives for landowners who conserve or restore strategic areas. Instruments such as Payment for Ecosystem Services may help reduce the costs borne by producers and encourage the restoration of PPAs and Legal Reserves in priority locations for water protection and ecological connectivity.

The analysis therefore shows that reconciling rural production and environmental conservation cannot be limited to relaxing legal obligations. It requires planning at the watershed scale, coordination among rural properties, and the definition of priority areas for restoration. In the Canoas River Watershed Environmental Protection Area, integrating PPAs, Legal Reserves, and native vegetation remnants is essential for forming ecological corridors, protecting springs, and maintaining the ecosystem services required for sustainable development.

Final Considerations

The analysis showed that applying Federal Law No. 12,651/2012 to consolidated rural areas involves a complex relationship among environmental protection, agricultural and

livestock production, and the continued presence of families in the countryside. The differentiated treatment granted to smaller rural properties may contribute to environmental regularization and the economic viability of small producers. Its effects, however, should not be assessed only from social and economic perspectives, because reducing mandatory restoration strips may limit recovery of the ecological functions originally performed by Permanent Preservation Areas.

In the Canoas River Watershed Environmental Protection Area, cartographic results revealed a troubling situation in water-related PPAs located on rural properties of up to four fiscal modules. Of the 431.94 hectares assessed, only 66.59 hectares, corresponding to 15.42% of the area, had vegetation cover. The remaining 365.35 hectares, equivalent to 84.58%, were classified as non-vegetated. These figures demonstrate that formal property regularization alone is insufficient to ensure the protection of watercourses, springs, and the basin's other environmental components.

The most critical proportional condition was identified on properties between one and two fiscal modules. Conversely, properties between two and four modules concentrated the largest absolute extent of PPA and, consequently, the greatest territorial potential for restoration actions. This distinction confirms the need for public policies tailored to the landholding and environmental characteristics of each property group, avoiding uniform strategies for different realities.

The map produced by the research was an important instrument for spatial synthesis and interpretation. Integrating property boundaries, classification by fiscal modules, the hydrographic network, and vegetation cover made it possible to identify priority restoration areas and show the territorial distribution of environmental liabilities. In addition to supporting the Environmental Protection Area diagnosis, this product may guide later surveys aimed at more accurately delimiting vegetated, non-vegetated, and consolidated parcels.

The results also reinforce that PPAs and Legal Reserves should be planned in an integrated manner. Protecting isolated fragments has limited reach when connectivity among vegetation formations is insufficient. Riparian forest restoration should therefore favor the formation and expansion of ecological corridors, contributing to wildlife movement, gene flow, species dispersal, and the maintenance of regional biodiversity. At the same time, restoring these areas promotes bank stability, reduces sedimentation, conserves soil, and improves the quality and availability of water resources.

The social function of rural property is not limited to economic productivity; it also encompasses the appropriate use of natural resources, family well-being, and compliance with

environmental obligations. Reconciling conservation and production should therefore not be understood as opposition between environmental and socioeconomic interests. The continuation of productive activities must be conditioned on the adoption of conservation practices, impact control, and restoration of areas strategic to watershed stability.

In this process, the Rural Environmental Registry and Environmental Regularization Program are indispensable instruments for identifying liabilities, establishing commitments, and monitoring the environmental recovery of properties. Participation in the PRA, associated with preparing and implementing Projects for the Restoration of Degraded or Altered Areas, can transform cartographic diagnoses into concrete restoration actions. This requires registry validation, technical assistance, inspection, periodic monitoring, and targets compatible with the environmental and economic conditions of the properties.

The draft law on Payment for Ecosystem Services is an applied contribution of this research. Its implementation may prioritize properties of up to four fiscal modules and encourage rural landowners and occupants to protect springs, conserve vegetation remnants, and restore degraded PPAs. The financial incentive recognizes that the benefits generated by conservation extend beyond property boundaries and reach society as a whole, especially through the protection of water, soil, biodiversity, and the regulation of ecological processes.

It is therefore concluded that the effectiveness of Law No. 12,651/2012 in the Canoas River Watershed Environmental Protection Area depends on coordination among environmental regularization, territorial planning, native vegetation recovery, and support for rural producers. The high percentage of PPAs without vegetation cover demonstrates the need for priority, continuous measures guided by technical criteria and the ecological relevance of each area. The mapping produced, together with the PRA and Payment for Ecosystem Services, provides a basis for more balanced, inclusive environmental management committed to conserving natural resources.

Finally, future research should advance the validation of CAR information, the quantification of consolidated rural areas, the assessment of connectivity among fragments, and the monitoring of areas under restoration. Recovery costs, landowner participation in environmental programs, and the effects of adopted measures on water quality, spring protection, and biodiversity should also be investigated. These studies may increase diagnostic accuracy and support public policies applicable not only to the Canoas River Watershed but also to other watersheds with similar landholding and environmental characteristics.

References

BACHA, C. J. C. Eficácia da política de reserva legal no Brasil. *Teoria e Evidência Econômica*, Passo Fundo, v. 13, n. 25, p. 9-27, 2005.

BERTELLI, C. et al. *Estratégias de restauração ecológica, proteção e conservação das nascentes da Bacia Hidrográfica do Rio Canoas, Franca-SP*. [S. l.: s. n.], 2021.

BERTELLI, C. et al. *Pagamento por Serviços Ambientais no atendimento dos Objetivos do Desenvolvimento Sustentável da ONU 2015*. [S. l.: s. n.], 2022.

BITENCOURT, M. D.; MENDONÇA, R. R. *Viabilidade de conservação dos remanescentes de cerrado no Estado de São Paulo.* São Paulo: Annablume, 2004.

BRASIL. *Lei nº 4.504, de 30 de novembro de 1964.* Dispõe sobre o Estatuto da Terra e dá outras providências. Brasília, DF: Presidência da República, 1964. Disponível em: https://www.planalto.gov.br/ccivil_03/leis/l4504.htm. Acesso em: 16 jul. 2026.

BRASIL. *Lei nº 4.771, de 15 de setembro de 1965*. Institui o novo Código Florestal. Brasília, DF: Presidência da República, 1965. Revogada pela Lei nº 12.651, de 25 de maio de 2012. Disponível em: https://www.planalto.gov.br/ccivil_03/leis/l4771.htm. Acesso em: 16 jul. 2026.

BRASIL. *Lei nº 12.651, de 25 de maio de 2012*. Dispõe sobre a proteção da vegetação nativa e dá outras providências. Brasília, DF: Presidência da República, 2012a. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm. Acesso em: 16 jul. 2026.

BRASIL. *Decreto nº 7.830, de 17 de outubro de 2012.* Dispõe sobre o Sistema de Cadastro Ambiental Rural, o Cadastro Ambiental Rural e os Programas de Regularização Ambiental. Brasília, DF: Presidência da República, 2012b. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/decreto/d7830.htm. Acesso em: 16 jul. 2026.

BRASIL. *Lei nº 14.119, de 13 de janeiro de 2021*. Institui a Política Nacional de Pagamento por Serviços Ambientais. Brasília, DF: Presidência da República, 2021. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/l14119.htm. Acesso em: 16 jul. 2026.

FRANCA (Município). *Lei Municipal nº 4.240, de 1992.* Institui a Área de Proteção Ambiental da Bacia Hidrográfica do Rio Canoas. Franca: Prefeitura Municipal, 1992.

GIL, A. C. *Como elaborar projetos de pesquisa.* 4. ed. São Paulo: Atlas, 2002.

METZGER, J. P. O Código Florestal tem base científica? *Natureza & Conservação*, v. 8, n. 1, p. 92-99, 2010. DOI: https://doi.org/10.4322/natcon.00801017.

NAÇÕES UNIDAS. *Transformando nosso mundo: a Agenda 2030 para o desenvolvimento sustentável.* Nova York: ONU, 2015.

SKORUPA, L. A. *Áreas de preservação permanente e desenvolvimento sustentável.* Jaguariúna: Embrapa Meio Ambiente, 2003.

SPAROVEK, G.; BARRETTO, A. G. O. P.; KLUG, I. L. F.; PAPP, L.; LINO, J. A revisão do Código Florestal brasileiro. *Novos Estudos CEBRAP*, São Paulo, n. 89, p. 111-135, 2011. DOI: https://doi.org/10.1590/S0101-33002011000100007.