

Ramsar wetlands protected by conservation strategies and natural areas in Colombia

Humedales Ramsar protegidos por estrategias de conservación y áreas naturales en Colombia

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DOI: <https://doi.org/10.22517/23447214.25620>

Scientific and technological research paper

Abstract — The wetland ecosystem plays a vital role in preserving biodiversity, providing ecosystem services, and conserving cultural and natural heritage. Effectively identifying and protecting these ecosystems is important for sustainable development and the well-being of humans and the environment. No document addresses the issue of spatial distribution of Ramsar wetlands in Colombia under the jurisdiction of complementary conservation strategies. For this reason, a literature review and study of the information from the Single National Registry of Protected Areas and the Secretariat of the Ramsar Convention was carried out, to define and study the spatial distribution of Ramsar wetlands through Shapefile files analyzed in the ArcGIS Pro software. The results show that there is an overlap between wetlands with the Ramsar category and the National System of Protected Areas of 33,32%, which represents 350.667 ha, which indicates the need to continue declaring complementary strategies to maintain ecological values and sociocultural aspects of these vital ecosystems.

Index Terms — biodiversity, ecosystem, environmental protection, national areas, space distribution.

Resumen — El ecosistema de humedal tiene un papel vital en la preservación de la biodiversidad, la provisión de servicios ecosistémicos y la conservación del patrimonio cultural y natural. Identificar y proteger eficazmente estos ecosistemas es importante para el desarrollo sostenible y el bienestar de los seres humanos y del ambiente. No se encuentra ningún documento que aborde la temática de distribución espacial de humedales Ramsar en Colombia en jurisdicción de estrategias complementarias de conservación. Razón por la cual, se realizó una revisión de literatura y estudio de la información del Registro Único Nacional de Áreas Protegidas y la Secretaría de la Convención Ramsar, con el fin de definir y estudiar la distribución espacial de los humedales Ramsar por medio de archivos Shapelifile analizados en el software ArcGIS Pro. Los resultados muestran que existe una superposición entre los humedales con categoría Ramsar y el Sistema Nacional de Áreas Protegidas de 33,32% que representa 350.667 ha, lo cual indican la necesidad de seguir declarando estrategias complementarias para mantener los valores ecológicos y socioculturales de estos ecosistemas vitales.

Palabras claves — biodiversidad, áreas protegidas, protección ambiental, distribución espacial, ecosistema.

I. INTRODUCTION

TO protect and conserve wetland ecosystems, the Ramsar Convention was signed in 1971. This is an intergovernmental treaty that provides a framework for international and national cooperation for the preservation and rational use of these ecosystems and their resources as a contribution to sustainable development around the world [1]. The convention defines wetlands as diverse environments, including peatlands, swamps, floodplains, lakes, and rivers, as well as coastal areas of mangroves, salt marshes, coral reefs, and seagrasses with a maximum depth at low tide of six meters [2] [3].

Wetlands represent one of the most valuable ecosystems in the world by providing ecosystem services such as water and fish supply, support for agriculture, maintenance of water balance, nutrient retention, wood production, and opportunities for recreation and tourism [4], wetlands provide habitat for a wide variety of fauna, such as birds, insects, mammals, and fish [5]. These ecosystems present variations in their body of water, depending on the hydrological dynamics of the place where they are located, the time of year, and the weather [6] [7]. Of the ecosystem services they provide, natural buffering, climate regulation, flood risk reduction, and educational, aesthetic, spiritual, and cultural benefits stand out [8] [9] [10]. Furthermore, the variety of vegetation that inhabits the vicinity of wetland water bodies serves as an indicator of the ecological state of the environment [11].

Some problems in wetlands are the change in water dynamics, the appearance of invasive species, and desiccation [12] [13]. The extraction of groundwater and deforestation also generate negative effects on the quantity and biological quality of water [14]. Despite the interconnections between wetland ecosystem services and human well-being, their importance is often not adequately assessed [15]. The physicochemical health of wetlands has deteriorated due to anthropogenic interventions and the exploitation of their resources [16]. It is important to recognize and highlight the importance of wetlands due to their ecosystem services and contribution to the conservation and protection of different species.

This manuscript was submitted on May 10, 2024, accepted on August 13, 2024 and published on September 27, 2024. This work was supported by the Ministry of Science, Technology, and Innovation of Colombia and Fulbright Colombia.

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In Colombia, these ecosystems' most frequent activities of transformation are linked to livestock, agriculture, and deforestation [17] [18]. There is also a lack of coordination in planning and management, along with incoherent and disjointed sectoral development [19] [20].

To promote the conservation, sustainable use, and restoration of the country's wetlands at the local, regional, and national levels, in 2001 the Ministry of the Environment decreed the Policy for Colombia's Inland Wetlands, through the principles described in the Political Constitution and in the functions established in Law 99 of 1993 and Law 388 on Territorial Planning [21]. Law 357 of January 21, 1997, ratified the Ramsar Convention in Colombia, declared through the Ruling of the Constitutional Court C-582/97, and entered into force on October 18, 1998 [22] [23]. Wetlands cover 26% of the Colombian surface corresponding to 30.781.149 ha [24] [25] [26] (Fig. 1).

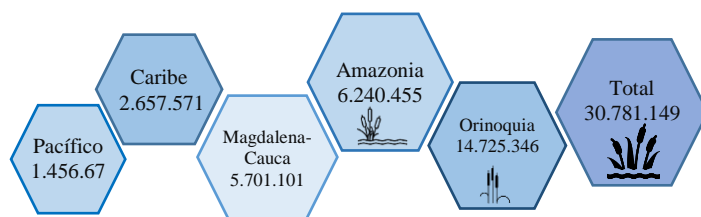


Fig 1. Extension of wetlands by hydrographic area (ha) in Colombia. Consultation source: Adapted from [25].

Proposing comprehensive planning and management initiatives for wetlands strengthens the management and dissemination processes of the actions undertaken for their protection and conservation [27]. As a relevant element for the management of wetland ecosystems, the consolidation of the National System of Protected Areas (SINAP) of Colombia has been an initiative that identifies areas of strategic interest, evaluating the feasibility of their incorporation into the SINAP. Colombia has enriched its management of protected areas through the integration of conservation initiatives at the international level, such as inclusion in Ramsar Wetlands, the Hemispheric Network of Reserves for Shorebirds, Important Areas for the Conservation of Birds, Key Areas for Biodiversity, sites of World Heritage and Biosphere Reserves [28] [29].

This article describes the different conservation categories and identifies the number of Ramsar category wetlands protected with initiatives of the National System of Protected Areas of Colombia, Important Areas for Bird Conservation, Biosphere Reserves, and Natural World Heritage sites, This is expected to understand the distribution and protection status of wetlands in Colombia, as well as their integration with protected areas, which help to preserve biodiversity and fulfill international commitments and sustainable development.

II. METHODOLOGY

A review was carried out of the information published by the Secretariat of the Ramsar Convention, the National System of Protected Areas of Colombia, BirdLife International, the United

Nations Educational, Scientific and Cultural Organization (UNESCO); as well as publications from the Ministry of Environment and Sustainable Development, the José Benito Vives de Andráis Marine and Coastal Research Institute (INVEMAR) and the Alexander von Humboldt Biological Resources Research Institute (IAvH), to define each of the categories of conservation strategies. The Shapefiles of the international strategies and Ramsar wetlands were obtained from the Colombian Environmental Information System (SIAC), and the Shapefiles of the protected areas of Colombia were identified in the Single National Registry of Protected Areas (RUNAP). Using data from geographical entities at a scale of 1:100.000, the number of Ramsar wetlands located within protected natural areas and international strategies were recognized; as well as the area of development of these initiatives in Colombian territory, this analysis was carried out through thematic tables in the ArcGIS Pro software.

III. WETLANDS

Wetlands constitute one of the most productive ecosystems on earth [30]. They contribute to mitigating floods and retaining sediments, toxic substances, and nutrients. Additionally, they are home to extensive biodiversity and play a crucial role in carbon storage and erosion [31]. This set of functions makes wetlands one of the most valuable ecosystems in terms of their economic and environmental contribution [32]. These ecosystems are found in areas where geomorphological and hydrological conditions make it possible to retain water for prolonged periods, which favors the formation of hydric soils and the development of vegetation adapted to aquatic environments [33] [34]. Therefore, research evaluating ecosystem services that considers in depth the relationships that occur in wetlands should be prioritized; as well as sociocultural and ecological evaluations [35].

The IAvH has carried out an inventory of 31.702 wetlands [36] and published the first map of wetlands in the country at a scale of 1:100.000 in 2015 [25]. Likewise, the Humboldt Institute has established the fundamental biological criteria to identify, characterize, and define the boundaries of wetlands [37]. On the other hand, INVEMAR found that approximately 74% of the coastal wetlands of the Colombian Caribbean are not articulated with the conservation initiatives registered in RUNAP [38].

IV. NATIONAL SYSTEM OF PROTECTED AREAS IN COLOMBIA

It is the integration of social actors, protected areas, instruments, and management strategies that work together to meet the country's conservation objectives. Colombia has 1.652 protected areas [39]. These declarations show significant progress in the preservation of national biodiversity and the safeguarding of collective rights linked to the conservation of areas of great ecological importance [40] [41]. In Colombia, 12 Ramsar wetlands have been proposed with a total area of 1.052.300 ha, information obtained from the map catalog of the Colombian Environmental Information System, 10 have

jurisdiction in the SINAP with a protection area of 350.667 ha, which represents 33,32 %. The area category with the greatest representation was the Regional Integrated Management District with 173.727 ha (Table I).

TABLE I
RAMSAR SITES IN COLOMBIA PROTECTED BY SINAP

Wetland	Geographic area (ha)	Location	Protected Natural Area	Area (ha) protection
Sistema delta estuarino del río Magdalena, ciénaga grande de Santa Marta	520.846	Magdalena	1. Vía parque Isla de Salamanca 2. Santuario de Fauna y Flora Ciénaga Grande de Santa Marta	55.609
Laguna de la Cocha	39.918	Nariño	1. Santuario de Flora isla de la Corota 2. RFPN laguna la Cocha cerro Patascoy 3. RFPN río Bobo y Buesaquillo 4. PNR Páramo de las Ovejas-Tauso 5. RNSC Miraflores 6. RNSC San Gabriel	39.182
Delta Río Baudó	52.345	Chocó	1. Parque Nacional Natural Uramba Bahía Málaga 2. DRMI Encanto de los Manglares del Bajo Baudó	8.956
Complejo de humedales laguna del Otún	115.883	Risaralda	1. Distrito de Conservación de Suelos Campoalegre 2. Parque Nacional Natural los Nevados 3. RFPN el Humedal y la Santísima Trinidad 4. RFPR Cerrobravo 5. RFPR el Diamante 6. RFPR el Palmar y la Secreta 7. RFPR el Toro 8. RFPR los Bosques de la Chec 9. RFPR Torre Cuatro 10. RFPR La Pradera 11. RFPR Esmeralda 12. RFPR Vallelargo 13. RFPN río Blanco y quebrada Olivares 14. RNSC La Sonrisa 15. PNR Ucumarí 16. DRMI Cuenca Alta del Río Quindío de Salento	67.163
Sistema Lacustre Chingaza	4.072	Cundinamarca	Parque Nacional Natural Chingaza RFPN Ríos Blanco y Negro	4.072
Complejo de humedales de la estrella fluvial del Inírida	250.159	Guainía	None	0

TABLE I
RAMSAR SITES IN COLOMBIA PROTECTED BY SINAP

Wetland	Geographic area (ha)	Location	Protected Natural Area	Area (ha) protection
Complejo de humedales del Alto Río Cauca Asociado a la Laguna del Sonso	5.532	Valle del Cauca	DRMI laguna de Sonso o del Chircaal	2.033
Lagos de Tarapoto	45.464	Amazonas	Parque Nacional Natural Amacayacu	1.181
Ciénaga de Ayapel	54.377	Córdoba	DRMI Complejo de humedales de Ayapel	52.123
Complejo Cenagoso de la Zapatosa	121.725	Cesar, Magdalena	DRMI Complejo Cenagoso de Zapatosa	110.300
Complejo de humedales de la Cuenca del río Bitá	824.535	Vichada	1. RNSC El León 2. RNSC Anelim 3. RNSC Casa Roja 4. RNSC Playa Alta 5. RNSC La Reina 6. RNSC La Pedregosa 7. RNSC El Ocarro 8. RNSC Puerto Chigüiro 9. RNSC Indomable 10. RNSC Doñana 11. RNSC Matapalito 12. RNSC San Luis	10.048
Complejo de humedales urbanos de Bogotá	667,4	Bogotá Distrito Capital	None	0
	1.052.300			350.667

Source: Adapted from the list of Wetlands of International Importance [3]. Acronyms: Regional Natural Park (PNR), National Protective Forest Reserve (RFPN), Civil Society Natural Reserve (RNSC), Regional Protective Forest Reserve (RFPR), Regional Integrated Management District (DRMI).

The IBA is a worldwide project by BirdLife International, focused on identifying, documenting, and managing a global network of sites vital for the conservation of birds and biodiversity [42]. In Colombia, the IBA program began in 2002, and 128 IBA have been identified, which represents 9.333.351 ha, 8% of the country's total area [43]. Of the 128 IBA, 18 are in the jurisdiction of 10 Ramsar wetlands, representing 590.695 ha, 6,32% of the protected area (Table II).

VI. BIOSPHERE RESERVES

TABLE II
RAMSAR SITES PROTECTED WITH IBA

Wetland	IBA	Area (ha)
Complejo de Humedales Urbanos del Distrito Capital de Bogotá	Humedales de la Sabana de Bogotá	268
Complejo de Humedales Alto Río Cauca asociado a la Laguna de Sonso	Reserva Natural Laguna de Sonso	820
Complejo de Humedales Lagos de Tarapoto	Parque Nacional Natural Amacayacu	1.198
Sistema Lacustre de Chingaza	Parque Nacional Natural Chingaza y alrededores	4.065
Laguna de La Cocha	Laguna de la Cocha	4.061

Biosphere Reserves represent natural and cultural landscapes

TABLE II
RAMSAR SITES PROTECTED WITH IBA

Wetland	IBA	Area (ha)
Otún Lagoon	Alto Quindío	25.609
	Cañón del Río Combeima	
	Lagunas Bombona y Vancouver	
	Reserva Hidrográfica, Forestal y Parque Ecológico de Río Blanco	
	Reserva Natural Ibanasca	
Delta del Río Baudó y Delta del Río San Juan	Cuenca del Río Toche	41.789
	Finca Paraguay	
Complejo Cenagoso de Ayapel	Bosques del Oriente de Risaralda	52.134
Sistema Delta Estuarino del Río Magdalena, Ciénaga Grande de Santa Marta	Delta del Río San Juan	41.789
	Ciénaga de Ayapel	52.134
Estrella Fluvial del Inírida	Valle del Río Frío	217.699
	Reserva de Biosfera RAMSAR Ciénaga Grande, Isla de Salamanca y Sabana Grande	
Estrella Fluvial del Inírida	Estrella Fluvial Inírida	247.113
	Total	590.695

Source: own elaboration

that have the recognition of the UNESCO “Man and the Biosphere” (MaB) program and offer examples of how the safeguarding of cultural diversity, the preservation of nature, and promoting economic development at the local level [44]. Likewise, they reflect the diversity of strategic ecosystems in different geographical regions, the variety of climates, and the biodiversity present in them [45]. Colombia has 6 declared biosphere reserves (Seaflower, the Sierra Nevada de Santa Marta, the Andean Belt, El Tuparro, the Ciénaga de Santa Marta, and Tribugá-Cupica-Baudó) [46].

The Ramsar wetlands Bitá River Basin and Magdalena River Estuarine Delta have protection with three Biosphere Reserves in a total area of 403.144 ha, which represents 1.61% of the total Biosphere Reserve area of 24.886.121 ha (Table III). These reserves aim to promote and preserve a harmonious relationship between human beings and the biosphere, through the conservation of biodiversity and ecosystems, sustainable development models to combat climate change, and participation in local management [47] [48].

TABLE III
RAMSAR SITES PROTECTED BY BIOSPHERE RESERVES

Biosphere Reserves	Area (ha)	Location	Ramsar Wetland	Area (ha)
El Tuparro	1.097.085	Vichada	Complejo de humedales de la Cuenca del río Bitá	5.200
Sierra Nevada De Santa Marta	2.369.562	Guajira, Magdalena y Cesar	Sistema Delta Estuarino del Río Magdalena, Ciénaga Grande de Santa Marta	10.016
Cinturón Andino	2.374.363	Huila, Cauca, Valle del Cauca, Tolima	None	0
Seaflower	17.987.337	Archipiélago de San Andrés	None	0
Ciénaga Grande De Santa Marta	511.169	Magdalena	Sistema Delta Estuarino del Río Magdalena, Ciénaga Grande de Santa Marta	387.928
Reserva de Biósfera Tribugá	546.605	Chocó	None	0
Cupica Baudó				
Total	24.886.121			403.144

Source: own elaboration

defined by physical, geological, physiographic, or biological characteristics, or by a combination of these, that have exceptional aesthetic value and that serve as habitat for endangered animal and plant species, with universal value from the scientific or aesthetic point of view [49] [50]. Places included on the World Heritage List play a vital role as global landmarks and symbols to raise awareness [51]. Colombia has 3 protected natural areas of natural heritage, the Los Katíos National Natural Park (PNN), the Malpelo Fauna and Flora Sanctuary (SFF), and the Serranía de Chiribiquete PNN [52] [53]. None of these areas have recognized any Ramsar wetland category (Fig. 2).

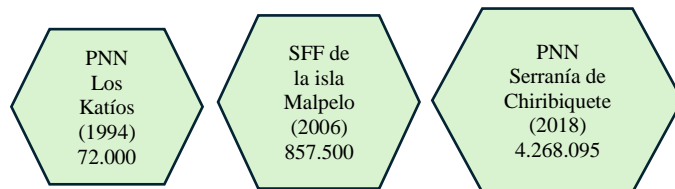


Fig 2. Natural Heritage Areas in Colombia (ha) [54].

Wetlands offer a conducive environment to observe current environmental changes and their impacts on ecosystem services. Therefore, it is crucial to establish criteria for systematic monitoring of change indicators, as well as ensure the installation and maintenance of monitoring instruments and networks [55]. The success and durability of efforts to conserve wetlands will be strongly linked to the proposed ecological strategies and the commitment of the entities responsible for

their administration [56]. There is an urgent need to develop international wetland policies that promote the sustainable preservation of these ecosystems [57], which face increasingly serious threats in the 21st century [58].

The loss of wetlands not only affects ecological processes of global relevance, but also has serious repercussions on local livelihoods and human well-being, this is reflected in an increase in poverty and unemployment, and the reduction of opportunities for fair and equitable development [59]. Wetlands are socio-ecological systems, and the design of a monitoring structure must consider aspects associated with climate change and anthropogenic, legal, or illegal activities related to land use. To find favorable scenarios for the research, protection, and sustainable management of wetlands. It is suggested to characterize different wetland complexes to estimate regional dynamics, and orders of magnitude of spatiotemporal scales, and determine patterns and trends [60] [61].

Colombia's wetlands play a crucial role in conserving the country's biodiversity. These ecosystems present a wide variety of animals and plants, including endemic species that are in danger of extinction. Additionally, wetlands are important for the migration of birds and other animals and are critical habitats for many at-risk species. Therefore, it is essential to protect these ecosystems to ensure the survival of these species and maintain the country's biodiversity. Wetlands play a fundamental role in the water cycle and climate regulation. They act as natural regulators of water flow, helping to prevent flooding and maintain water levels in rivers and lakes. In addition, they function as carbon sinks, which helps mitigate the effects of climate change. It is crucial to protect these ecosystems to ensure their ability to regulate water and climate.

VIII. CONCLUSIONS

The figures obtained show a significant panorama of Colombia's commitment to the conservation of its wetlands and protected natural areas. With 12 Ramsar sites covering more than one million hectares, and 10 of them under the jurisdiction of SINAP, a considerable effort is evident to preserve these vital ecosystems, which represent 33,32% of the protected area. The Regional Integrated Management District stands out as the category with the greatest representation, with 173.727 hectares. In addition, 18 of the 128 IBAs are in the jurisdiction of 10 Ramsar wetlands, covering 590.695 hectares. Although Colombia's natural heritage includes protected areas such as Los Katíos, Malpelo, and Serranía de Chiribiquete, none of them have been recognized as Ramsar wetlands.

The information described indicates the importance of wetlands in Colombia, highlighting the commitment to the protection of these ecosystems through the designation of Ramsar wetlands. Despite progress in identifying and protecting areas of conservation importance, there is still work to be done. The lack of recognition of the Ramsar wetland category in key protected natural areas highlights the need for greater integration and coordination between the different government agencies and actors involved in environmental management. It is essential to continue promoting the conservation and sustainable management of wetlands, recognizing their value nationally and globally, and ensuring their long-term protection for present and future generations.

Wetlands are important for the local economy and for promoting the sustainable development of the region. These ecosystems provide ecosystem services such as fishing and agriculture, which are vital for the communities that depend on them. In addition, wetlands attract tourists and are important for the sustainable development of the region. It is essential to protect these ecosystems to ensure a sustainable future for local communities. The conservation of Colombian wetlands in protected natural areas is vital to preserving biodiversity, regulating the water cycle and climate, guaranteeing a sustainable future for local communities, and protecting these fragile ecosystems. Action needs to be taken to protect these valuable ecosystems and ensure a sustainable future for generations to come.

The integration of Ramsar wetlands into territorial planning under Law 388 is essential for maintaining Colombia's rich biodiversity and cultural heritage. By recognizing and addressing the environmental determinants of these vital ecosystems, Colombia can achieve sustainable development that benefits both nature and society. Future research should explore the socio-economic dimensions of wetland conservation to further inform policy and planning.

ACKNOWLEDGMENT

This work was carried out within the framework of the scholarship for doctoral studies in the United States funded by the Ministry of Science, Technology, and Innovation of Colombia and Fulbright Colombia.

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