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REVIEW

A systematic evidence map of conservation knowledge in Chilean Patagonia

María José Martínez-Harms[1,2,3] | **Juan J. Armesto**[2,3] | **Juan Carlos Castilla**[2,4] | **Anna Astorga**[5] | **José Aylwin**[6] | **Alejandro H. Buschmann**[7] | **Victoria Castro**[8] | **Giovanni Daneri**[5,9] | **Miriam Fernández**[2] | **Taryn Fuentes-Castillo**[10] | **Stefan Gelcich**[1,2,11] | **Humberto E. González**[12,13] | **Rodrigo Hucke-Gaete**[12] | **Pablo A. Marquet**[2,4] | **Flavia Morello**[14] | **Laura Nahuelhual**[1,13,15] | **Patricio Pliscoff**[2,3,10] | **Brian Reid**[5] | **Ricardo Rozzi**[16,17] | **Cesar Guala**[18] | **David Tecklin**[18]

[1]Instituto Milenio en Socio-Ecología Costera (SECOS), Pontificia Universidad Católica de Chile, Santiago, Chile

[2]Departamento de Ecología, Pontificia Universidad Católica de Chile, Santiago, Chile

[3]Instituto de Ecología y Biodiversidad (IEB), Santiago, Chile

[4]Centro Interdisciplinario de Cambio Global, Pontificia Universidad Católica de Chile, Santiago, Chile

[5]Centro de Investigación en Ecosistemas de la Patagonia (CIEP), Coyhaique, Chile

[6]Observatorio Ciudadano & Facultad de Ciencias Jurídicas y Sociales de la Universidad Austral de Chile, Valdivia, Chile

[7]Centro i-mar & CeBiB, Universidad de Los Lagos, Puerto Montt, Chile

[8]Departamento de Antropología, Facultad de Ciencias Sociales, Universidad de Chile & Universidad Alberto Hurtado, Santiago, Chile

[9]Centro COPAS Sur Austral, Universidad de Concepción, Concepción, Chile

[10]Instituto de Geografía, Facultad de Historia, Geografía y Ciencia Política, Pontificia Universidad Católica de Chile, Santiago, Chile

[11]Center of Applied Ecology and Sustainability, Pontificia Universidad Catolica de Chile, Santiago, Chile

[12]Instituto de Ciencias Marinas y Limnológicas, Universidad Austral de Chile, Valdivia, Chile

[13]Centro de Investigación Dinámica de Ecosistemas Marinos de Altas Latitudes (FONDAP-IDEAL), Punta Arenas, Chile

[14]Instituto de la Patagonia, Universidad de Magallanes, Punta Arenas, Chile

[15]Instituto de Economía, Universidad Austral de Chile, Valdivia, Chile

[16]Programa de Conservación Biocultural Subantártica, Universidad de Magallanes, Punta Arenas, Chile

[17]Universidad de North Texas, Denton, Texas, USA

[18]Programa Austral Patagonia, Universidad Austral de Chile, Valdivia, Chile

Correspondence
María José Martínez-Harms, Instituto Milenio en Socio-Ecología Costera (SECOS), Pontificia Universidad Católica de Chile, Santiago, Chile; Departamento de Ecología, Pontificia Universidad Católica de Chile, Santiago, Chile; Instituto de Ecología y Biodiversidad (IEB), Santiago, Chile.
Email: mariajosesmart@gmail.com

Abstract

Mechanisms that reliably and efficiently guide practitioners to find relevant evidence are urgent for conservation decision-making in Chilean Patagonia. The objective of this study was to systematically collect, characterize, and synthesize the extensive evidence about conservation knowledge in Chilean Patagonia focusing on the impacts of global change drivers on ecosystems and human–nature relationships, identifying knowledge gaps, and providing policy

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recommendations. The quality of the evidence was assessed through a predefined level-of-evidence hierarchy scale, applied to a sample of the studies reviewed. We compiled ~1000 studies documenting that evidence focusing on terrestrial and marine ecosystems has grown exponentially. For terrestrial ecosystems, most studies have addressed climate change, habitat change, and invasive species; while for marine ecosystems, studies have focused on pollution, invasive species, and habitat change. We identified that an important gap is the study of the social dimensions of conservation, and future efforts should focus on incorporating traditional and local knowledge as this can help point the way to ecosystem conservation. The appraisal of the quality of the evidence showed that ~80% of the sample represented reliable evidence with underlying data and an experimental design. Enhanced efforts to deliver this evidence to decision-makers in a user-friendly format for evidence uptake in conservation policy are urgent. In this review, we provide a tool that can help practitioners to find evidence reliably to improve decision-making for the conservation of ecosystems in Chilean Patagonia.

KEYWORDS
conservation decision making, global change drivers, human–nature relationships, interdisciplinary process, protected areas

1 | INTRODUCTION

Conservation decision-makers in Chile have little opportunity to identify, evaluate, and incorporate scientific evidence into their decisions and often these are made without access to the best quality evidence (OECD, 2016). Chilean Patagonia at the western margin of South America, south of 41°S, provides a globally outstanding opportunity for conservation of large intact landscapes and seascapes (Castilla et al., 2021) at a scale consistent with the most ambitious targets under discussion in the Convention on Biological Diversity (CBD, 2019). This can be achieved by consolidating the system of protected areas, particularly through the development and enforcement of management plans, particularly in the coastal–marine environment where effective protection has been historically absent. Robust scientific information is required to inform assessments of the viability of key biodiversity and ecosystem services under global change stressors, plan and execute effective and equitable management of protected areas, and to achieve ecologically representative and a well-connected conservation network (Watson et al., 2016).

Chilean Patagonia is one of the few regions remaining in the world that has more than half of its natural habitat remaining and legally protected. It also shows a promising trend toward stakeholder coordination, and increasing mobilization of technical and financial resources in support of conservation (Castilla et al., 2021). Its terrestrial area covers approximately 380,000 km^2 and is one of the least transformed regions of our planet (Inostroza et al., 2016), which has been internationally recognized as one of the last large wildernesses on earth (Inostroza et al., 2016; Sanderson et al., 2002; Venter et al., 2016). Substantial progress has been made toward meeting the area targets of Aichi Target 11, concerned with establishing effective, equitable, and representative networks of protected areas (PAs). More than 54% of the terrestrial area of Chilean Patagonia is currently under protection. Marine protected areas now cover 6% of the Patagonian coastal zone (11,000 km^2). However, an additional 35% of the coastal zone (64,000 km^2) also has some level of legal protection as it lies within the boundaries of national parks and reserves spread across the region's fjords and archipelagos (Tecklin et al., 2021). Chilean Patagonia represents a natural heritage reservoir that can guide PA management, nonetheless, environmental stressors are also intensifying in the region (Castilla et al., 2021; Inostroza et al., 2016).

Despite progress to date, there are serious concerns, mainly because of the current gaps between legal and real protection, particularly in the marine realm that is most threatened by aquaculture expansion among other drivers (Buschmann et al., 2021). Salmon and mussel farming, overfishing, the impacts of climate change, the rapid spread of invasive species, the expansion of transportation infrastructure, traditional knowledge loss, and growing unregulated tourism in remote areas all represent major and growing threats to the region's biodiversity (Inostroza et al., 2016; Marquet et al., 2021). The recent update of the Chilean National Determined Contribution is explicit in recognizing the importance of protected areas as solutions to climate change, but addressing the threats facing Patagonia requires a substantial increase in the Chilean government's commitment to effectively manage and fund the region's conservation estate.

Chilean Patagonia is characterized by a vast extension of fjords, peninsulas, islands, and coastline, configuring an extensive land–sea interface (Iriarte et al., 2010; Rozzi et al., 2021), rooted at the latitudinal southern end of the continent and the triple convergence interphase of the Pacific, Atlantic, and Antarctic oceans. This biogeographic context promotes high levels of endemism and diversity of species supporting key ecosystem services (Rozzi et al., 2012), such as climate regulation, carbon storage, freshwater provision, and cultural diversity heritage. The region has one of the most continuous forest covers (120,000 km^2) and the largest area of peatlands and wetlands (42,000 km^2) representing the main carbon sink and carbon storage source in the southern hemisphere contributing to climate change mitigation (Astorga et al., 2018; Mansilla et al., 2021; Ministerio del Medio Ambiente, 2020; Rozzi et al., 2012). It is a global freshwater reserve because of the presence of the world's third-largest ice fields, and there is a rich diversity of cultures and languages represented in particular by distinctive rural cultures and indigenous populations (Aylwin et al., 2021). Recent research has documented a high level of public support for conservation in the region and local communities increasingly visualize future economic development related to nature-based tourism (Guala et al., 2021; Sepulveda, 2020).

While there is strong scientific, national, and international interest in protecting the region (Jones, 2012; Rozzi et al., 2012; Vila et al., 2016), there has yet to be an integrated compilation of the evidence of the status of its ecosystem's integrity, or of the needs and priorities for the effective protection of its ecosystems. For informed conservation decision making in Patagonia, it is essential to compile and synthesize knowledge on Patagonia's ecosystems and the major causes of their degradation—from climate change stressors to invasive species and habitat loss, to overfishing and salmon farming—as these all occur at the interface between humans and ecosystems. Addressing such complex problems requires an interdisciplinary framing involving different sources of information including terrestrial and marine ecology, social sciences, and traditional and local knowledge among other sources (Bennett et al., 2017; Rozzi et al., 2012; Tallis & Lubchenco, 2014).

In Chilean Patagonia, there is extensive scientific information and data available about conservation and management of ecosystems that is a valuable resource for delivering reliable and up-to-date information on biodiversity distribution, ecological processes, and knowledge of the human dimensions of pressing environmental issues (Rozzi et al., 2012). This information is currently fragmented and has never been collected, integrated, or analyzed at a comprehensive regional scale. Moreover, there is a large body of expertise in Chile that can be used as a valuable source of guidance for future protected area management. To address these gaps and further promote conservation in Chilean Patagonia this review article presents a systematic map performed by an interdisciplinary group of regional experts that comprehensively reviewed, characterized, and synthesized the state of knowledge about the conservation and management of ecosystems under global change drivers, identifying knowledge gaps and providing recommendations. Systematic maps are defined as reliable overviews of the quantity and quality of evidence about a broad question of policy relevance (Haddaway et al., 2018). In this study, the question framed was: What is the state of knowledge about conservation and management of Chilean Patagonian ecosystems? We also assessed the quality of the evidence collected, to determine whether the collected evidence was robust enough to support its potential use in decision-making processes that require ecosystem knowledge and the effects of global change impacts on ecosystems. The assessment was performed through the application of a predefined level-of-evidence hierarchy scale (Mupepele et al. 2016) that was applied to a sample of the studies reviewed.

2 | METHODS

Chilean Patagonia extends for approximately 1600 km along the southwestern margin of South America (41° 42′S 73° 02′W; 56° 29′S 68° 44′W). It is the largest system of estuaries and fjords in the southern hemisphere and one of the largest extensions of land-sea areas in the world. Its total area covers 452,204 km^2, including the inland sea and land landscape (Figure 1a).

To promote evidence-based conservation in Chilean Patagonia an interdisciplinary group compiled, characterized, and synthesized the evidence (Figure 2) applying a systematic mapping approach (James et al., 2016). Following a decision tree protocol, this review synthesized ecosystems knowledge (terrestrial, marine, freshwater, and social) and the knowledge on the impacts of global change drivers (climate change, habitat change, invasive species, overexploitation, and pollution) on these ecosystems and the PAs of the region. We delivered the complete database of studies reviewed in an open access

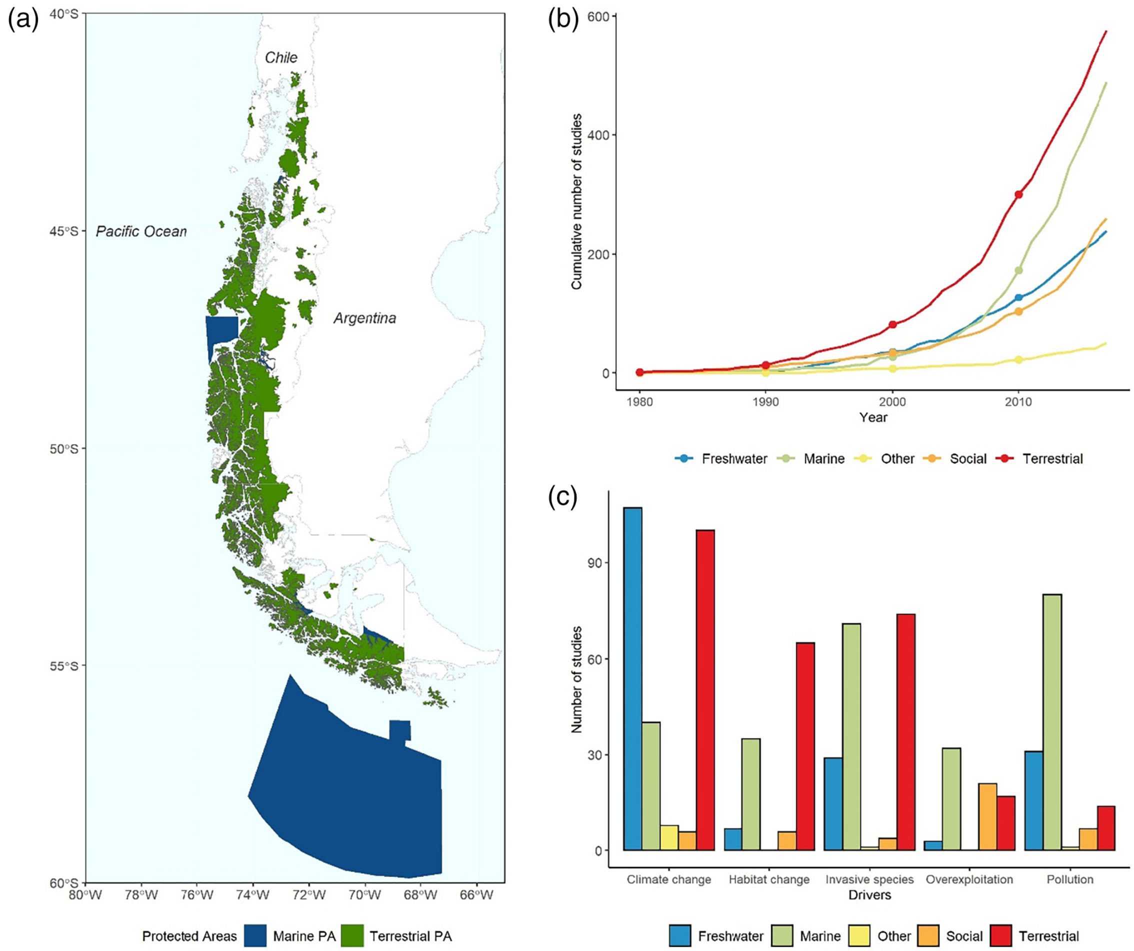

FIGURE 1 (a) Map of the conservation network in Chilean Patagonia, including marine and terrestrial Parks. (b) The cumulative number of publications (published between 1980 and 2017) per system in the region. There is a clear deficit of studies about freshwater ecosystems (except for climate change) and social systems. (c) Distribution of the number of published studies coded by the direct driver of change and by the system in western Patagonia. The *X*-axis represents the driver of change per system and the *Y*-axis represents the number of publications. See Martínez-Harms (2021), appendix B (https://doi.org/10.17632/4sff2xhzmh.1) for the complete list of papers included in this analysis

repository (Martínez-Harms, 2021) intending to provide information that supports and guides conservation practitioners to locate evidence reliably.

Our work followed the stages defined for systematic mapping in conservation science and environmental management, including (1) formation of a work team, definition, and scope of questions and development of search protocols, (2) search for evidence (see Figure 3 for the flow chart of the search for evidence of systematic mapping), (3) critical review of the evidence, establishing criteria for the inclusion of studies, (4) coding and elaboration of a database, and (5) evaluation of temporal and spatial trends. The work team in this study was led by two senior experts or "co-chairs," which were supported by a technical secretariat, who had the role of collecting, compiling, and cataloging the evidence, using the systematic mapping method. The "co-chairs" together with the technical secretariat convened a scientific panel, made up of an interdisciplinary group of eight national experts that combined thematic and geographic experience of the region, to peer-review the synthesis (see Figure 2).

In addition, 17 chapters (see Martínez-Harms, 2021, appendix C) were commissioned to cover the following key topics in detail: marine, terrestrial, and freshwater biodiversity; the acceleration of pressures of global and local changes in ecosystems; the impacts of aquaculture; the land-sea interface; the conservation of glaciers, peatlands, and pristine forest; Indigenous peoples and conservation; as well as the management of protected areas and socio-economic trends in the region, among other themes (see Figure 2). The chapters collected the available information, critically reviewed the literature on these conservation themes, and made specific recommendations for better management (Castilla et al., 2021). The

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FIGURE 2 Scheme showing how the interdisciplinary team collected and synthesized the evidence was organized. The synthesis was led by two senior "co-chairs," who are marine and terrestrial senior ecologists, who are at the core of the synthesis. The "co-chairs" were supported by a technical secretariat, who had the role of the synthesis classifying the evidence according to systems and drivers of change. A scientific panel (made up of an interdisciplinary group of 8 national experts) overseen the whole process providing their revision and feedback to the whole process. The technical secretariat coordinated the preparation of the synthesis and the preparation of 17 thematic chapters by national authors and co-authors addressing key conservation issues (10 of the 17 thematic chapters are highlighted outside the circle, see Martínez-Harms (2021), appendix C for the complete list of chapters)

leading authors and co-authors of the chapters were researchers or teams of researchers with experience in the specific topics in Chilean Patagonia (Castilla et al., 2021).

The decisions applied to search the evidence were documented in the decision tree protocol (Table 1). The search included a technical secretary search and a specialist search. The technical secretary searched the *ISI Web of Knowledge* core collection database (http://apps.webofknowledge.com) from 1975 to June 8, 2018 using search keywords suggested by the work team (see the full list of keywords in appendix A, Martínez-Harms, 2021). The studies identified were filtered applying the questions of the decision tree protocol (Table 1) looking at the title, abstract, and keywords selecting the studies to be included in the review database. The bibliographic information collected by the chapters was also entered in the systematic review, becoming part of the database of scientific publications and most gray literature that was included in this review, such as management plans of protected areas, traditional and local communities' knowledge, and other technical reports.

The compiled evidence was coded with semantic analysis using the R *Bibliometrix package* and classified into one of the five systems: terrestrial, marine, freshwater, social, and the other category (Mazor et al., 2018). The articles were classified according to the presence of frequent words in their respective titles, keywords, and abstract. The set of specific words of the system was determined by extracting the 250 most frequent keywords

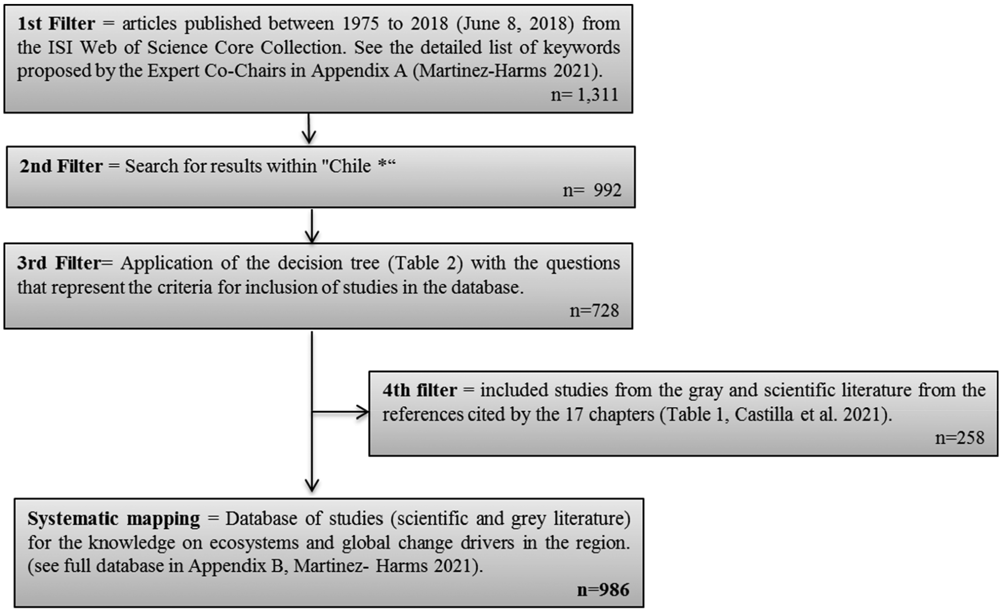

FIGURE 3 Flow chart of the stages of systematic mapping for the search of the scientific and gray literature of Patagonia

TABLE 1 Decision tree with questions representing the criteria for inclusion of studies in the database. See Martínez-Harms (2021), appendix A for the full description of the methodological approach (https://doi.org/10.17632/4sff2xhzmh.1)

Question	Answer	Action
(1) Does the paper cover the Patagonia region or any area in the Chile's Patagonia region? (e.g., global studies: No, studies comparing Patagonia systems with other systems? Yes)	No Yes Unclear	Exclude Go to 2 Go to 2
(2) Does the paper consider research in any of the systems of Patagonia (freshwater, marine, terrestrial, social, or other)?	No Yes Unclear	Exclude Go to 3 Exclude
(3a) Does the paper consider drivers affecting ecosystems or conservation and management issues in the Chilean Patagonian region?	No Yes Unclear	Go to 3b Include Cannot exclude
(3b) Does the paper consider human–nature relationships, identity issues (indigenous traditional knowledge) or human occupation patterns in Patagonia?	No Yes Unclear	Exclude Include Cannot exclude

from all the articles considered and assigning each word to the main topics: terrestrial, marine, freshwater, social, or others. Articles with multiple systems or those that could not be classified were included in “others.”

We considered the five direct drivers of change responsible for biodiversity and ecosystem services loss according to the classification of the Millennium Ecosystem Assessment (MEA, 2005) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019). These drivers of change were: climate change, habitat change, invasive species, overexploitation, and pollution (Mazor et al., 2018) and studies could fall into multiple drivers. The set of direct drivers of change search words was determined based on the top 100 keywords of articles that contain the explicit stressor in the title, abstract, or keywords. We manually inspected the classification of the articles in each system (100% or 986 studies were classified in systems) and driver classification (56% or 556 studies were classified in drivers) to validate its classification. We registered the location (Latitude and Longitude) of the study sites represented in the collected studies to spatialize the synthesis and to finally overlap the map of the study sites to the protected areas map.

The database of scientific publications and other gray documents considered keywords of the publication, authors, title, abstract, year of publication, type of publication (article, technical report, or website), system that characterizes the study (terrestrial, marine, freshwater, social, or others), driver of change (climate change, invasive species, land-use change, pollution, and overexploitation of resources), and the relationship between society and nature among other criteria (see Table 1). We calculated the number and distribution of articles among systems within drivers of change and the temporal trends of the reviewed evidence on drivers of change per system.

The quality of the evidence was assessed through a predefined level-of-evidence hierarchy tool developed by Mupepele et al. (2016) and applied to a ∼30% sample of the studies reviewed. This hierarchy ranks the studies hierarchically based on the experimental design and a predefined level-of-evidence scale (Mupepele et al., 2016). Systematic and conventional reviews (LoE1) are at the top of the evidence hierarchy providing the most reliable information because these are conducted under strict guidelines with an a priori protocol on design and procedure (e.g., *Collaboration for Environmental Evidence*, 2013). Following reviews, studies with a reference/control (LoE2), case–control or before-after control-impact studies (LoE2a) and the comparison of different treatments, comparing results of different approaches (LoE2b) are the most reliable. Observational studies (LoE3) including studies employing inferential and correlative statistics, for example, testing for the influence of environmental variables on biodiversity proxies (LoE3a) and descriptive studies implying data collection and representation without statistical testing (LoE3b) follow in this hierarchy. The lowest level of evidence is statements without underlying data (LoE4) that usually include individual expert opinions or gray literature. To assess the strength and reliability of the collected evidence, we performed this critical appraisal of the quality of the research and coded a random sample of the collected evidence (∼30% of the studies) according to this hierarchy.

3 | RESULTS

We compiled a database of nearly 1000 studies of Chilean Patagonia documenting the increase in the number of publications during the past 10 years (see appendix B for the database, Martínez-Harms, 2021). Most publications addressed terrestrial and marine systems with an increasing number of studies integrating social variables (Figure 1b). The systematic map showed an exponential increase of the evidence during the last 10 years. To date, most publications have corresponded to marine (325 studies, 33%) and terrestrial systems (282 studies, 29%), followed by social (205 studies, 21%), freshwater (148 studies, 15%), and other (26 studies, 3%). There has been a slow increase in the number of studies that involve social variables and human dimensions of the conservation and management of ecosystems in Patagonia. The drivers of change classification (Figure 1c) showed that most studies have addressed climate change (191 records, 19%), followed by the study of invasive species (131 records, 13% mainly addressing the issue of the introduction of salmon and beaver), pollution impacts (102 records, 10%), habitat change (79 records, 8%), and overexploitation of marine and terrestrial natural resources (53 records, 5%).

Studies in terrestrial systems mostly dealt with climate change (56 studies, 6%), invasive species (49 studies, 5%), and habitat change (34 studies, 3.4%). The temporal trend showed a significant steady increase on the study of climate change and invasive species especially since 2000 and 2010 while for habitat change a significant increase started the year 2010 (see Figure 3). Studies in marine systems mostly dealt with the threat of pollution (70 studies, 7%), invasive species (60 studies, 6%), habitat (35 studies, 3.5%), and climate change (33 studies, 3.3%). The temporal trend for the marine system showed an exponential increase in pollution and invasive species with a significant increase in the year 2010. Studies in the freshwater system have mostly dealt with climate change (91 studies, 9%), distantly followed by invasive species (18 studies, 1.8%), and pollution (15 studies, 1.5%). Climate change gathers 61% of the publications on freshwater systems, with a significant increase starting in the year 2005 (see Figure 4). Most of these publications refer to the issue of glacier mass loss under the effects of global warming. The social system studies mostly dealt with overexploitation of resources (18 studies, 1.8%), and pollution (7 studies, 1%). The increase in the number of social system studies started very recently in the year 2014. Most studies classified under the social system category addressed human-

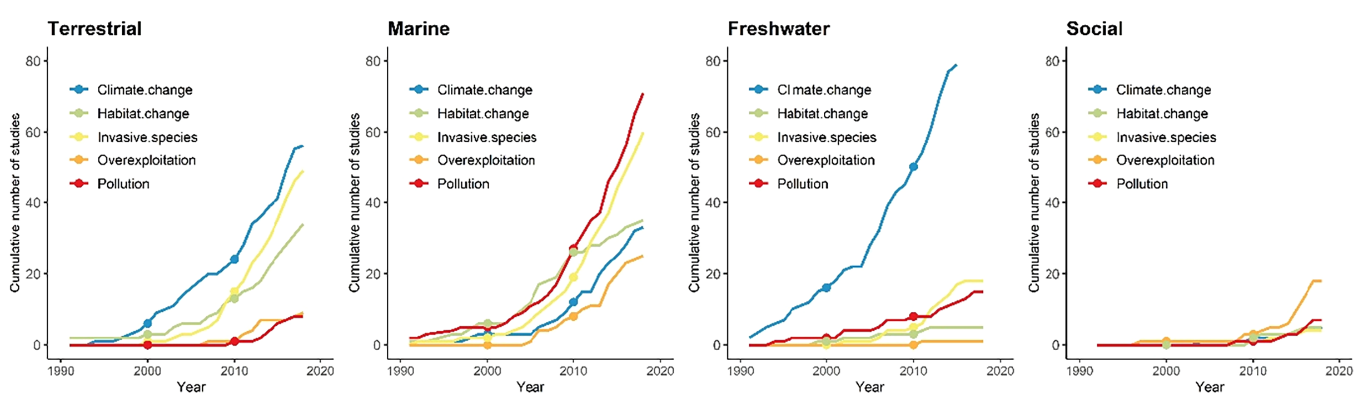

FIGURE 4 Temporal trends of the reviewed evidence on drivers of change per system (excluding the category "other" because a marginal 3% of the evidence was classified under this category)

nature relationships, Indigenous peoples, or human occupation patterns in Patagonia (see Table 1, question 3b) and did not consider drivers of change.

After spatializing the study sites from the records of the database (2159 sampling sites for almost 1000 records), we overlapped the map of the protected areas with the map of evidence for the Chilean Patagonia region. We found that less than 31.5% of the evidence (311 studies) was collected within the protected areas network (Figure 5). Most of the studies concentrated in just three of the largest national parks (Bernardo O'Higgins, Laguna San Rafael, and Torres del Paine, Figure 5), revealing that a vast fraction of this wild region remains understudied, and additional work will be needed to improve knowledge for conservation throughout the region.

The number of studies by protected area category (see Figure 6) showed that national parks concentrate the evidence (216 studies), followed by national reserves (50 studies), marine protected areas (40 studies), and natural monuments (5 studies). From the total of all studies covering the protected area network (311 studies), most studies covered the marine system (134 studies), followed by freshwater (97 studies), terrestrial (77 studies), and social studies (3 studies). From the total studies covering the protected area network, just half of the studies (152) addressed the impacts of global change drivers, mainly represented by climate change (72 studies), pollution (44 studies), and invasive species (35 studies).

For the assessment of the quality of the evidence, we randomly selected 259 studies (26% of the studies) and applied the hierarchy evidence tool. The critical appraisal of the evidence showed that most studies collected are observational studies (LoE3) mainly including descriptive studies without statistical testing (LoE3b, 39 studies), followed by studies employing inferential and correlative statistics (LoE3a, 34 studies). More reliable studies, including experimental design with before-after control-impact studies followed (LoE2a, 20 studies). The sample also represented grey studies without underlying data (LoE4, 17 studies), systematic and conventional reviews (LoE1, 7 studies), and just a couple of studies comparing results of different approaches (LoE2b, 3 studies). The overall trend of the quality of evidence assessment showed that ~80% of the sample represented reliable evidence with underlying data and an experimental design (Figure 7).

4 | DISCUSSION

4.1 | Evidence based conservation in Chilean Patagonia

Evidence has grown exponentially in Chilean Patagonia during recent decades, but most of the evidence has been biased to a few terrestrial protected areas and this has also been reflected in terms of management of protected areas in the region (Araos et al., 2020; Tecklin et al., 2021). As conservation progress has been made in the region, with more than half of its terrestrial area protected, and increasing advances in coverage of marine protected areas, there are serious concerns, as to whether the conservation situation can be advanced from "on paper" to "in operation," to effectively manage and protect biodiversity in the region (Fernández et al., 2021). There are major gaps between legal and real protection, particularly in the marine realm that is most threatened by agro-industrial use, evidenced by the 416 concessions granted for salmon farming in protected areas in Chilean Patagonia (Mongabay, 2021). In Chilean Patagonia, there is an urgent need to secure the existing protected area system against increasing stressors, so knowledge on the abatement of anthropic threats to improve the resilience of the conservation network while benefiting local communities is a research priority.

For terrestrial ecosystems, most studies have addressed climate change, habitat change, and invasive species while in marine ecosystems studies have concentrated in pollution, invasive species, and habitat change drivers. An important gap is the study of the social dimensions of conservation and management of ecosystems. The relationships between people and nature, Indigenous-led conservation, and human occupation patterns in Patagonia are scarcely represented in the scientific literature and need to be urgently addressed. This synthesis mainly relied on published scientific data whereas there is a handful of useful evidence that is stored in the grey literature or in the form of indigenous and traditional knowledge. This is a limitation of this evidence-based approach that needs to be acknowledged, as future efforts should incorporate traditional and local knowledge as communities hold a centuries-old ecological understanding of Patagonian ecosystems and can help point the way to ecosystem management (Uprety et al., 2012).

4.2 | Ways forward to effectively implement conservation in Chilean Patagonia

The Chilean government is making increasing efforts to strengthen marine and terrestrial protected areas in the region, with the development of management plans and pilot surveillance programs targeting protected coastal–marine ecosystems, to avoid activities that affect the integrity of its ecosystems (CONAF, 2017; Foro para la Conservación del Mar Patagónico y Áreas de Influencia, 2019).

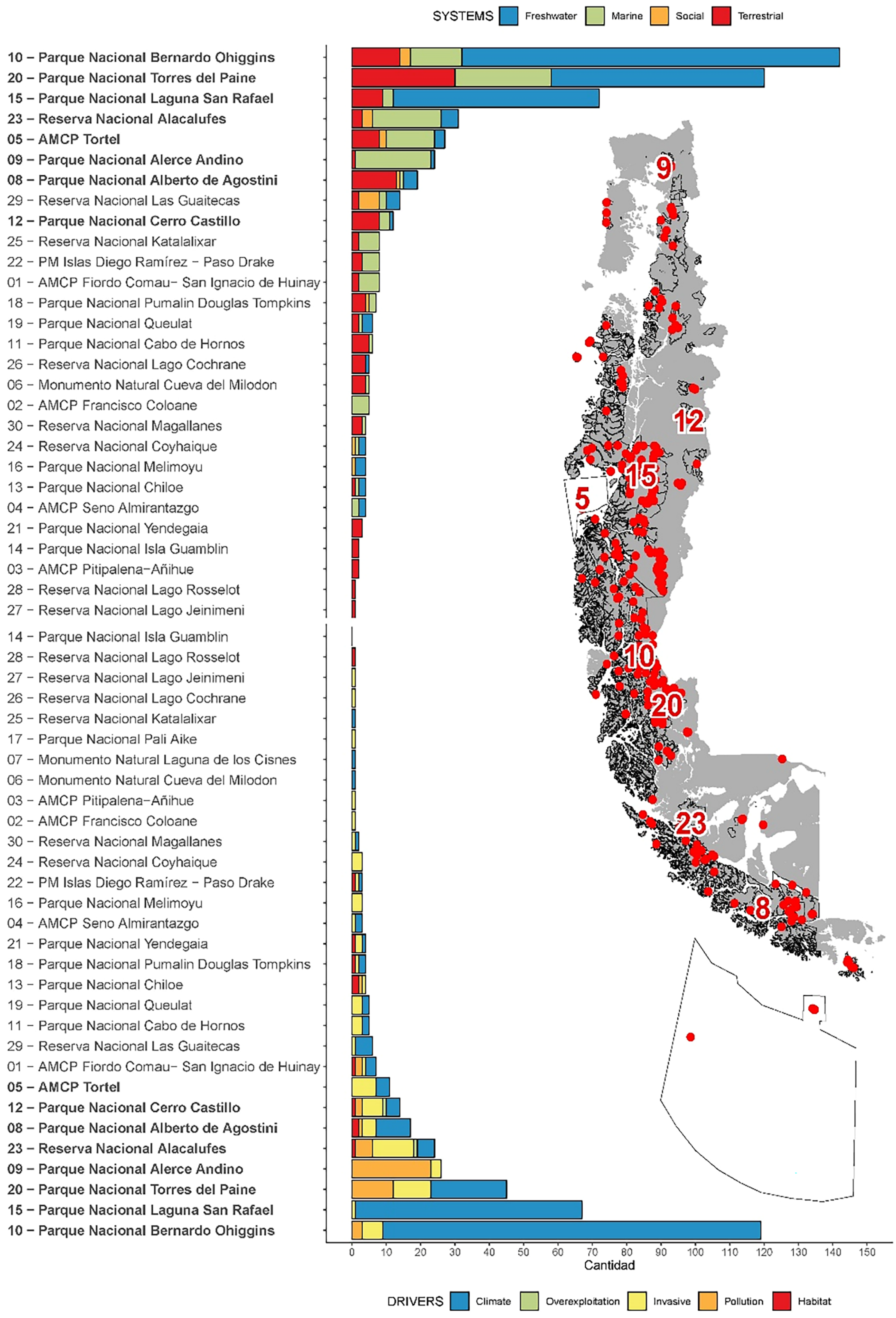

FIGURE 5 Distribution of the number of studies conducted in the protected areas of Patagonia, coded by the system and by the driver of change. The central map shows the study sites found within protected areas, highlighting the protected areas that have more than 10 studies (numbers on the map)

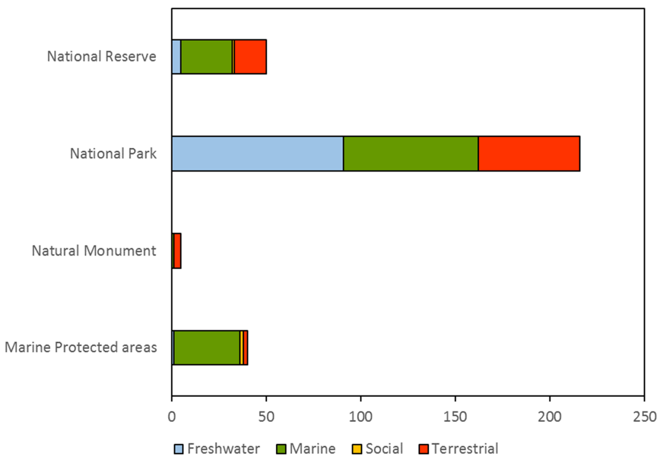

FIGURE 6 The number of studies (311 studies in total) conducted in Patagonia's protected areas, coded by the system. National parks concentrate the number of studies (216 studies), followed by national reserves (50 studies), marine protected areas (40 studies), and natural monuments (5 studies)

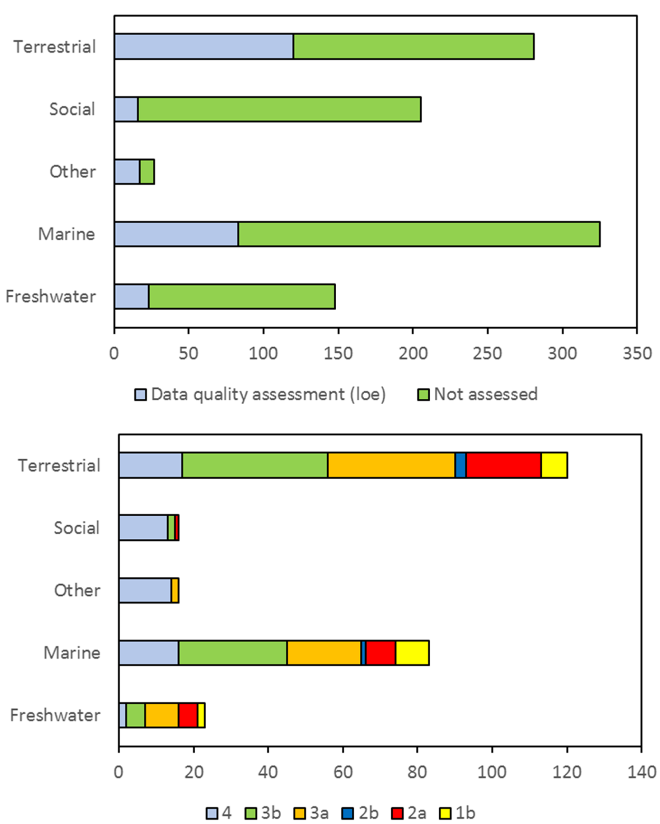

FIGURE 7 The upper graph shows the distribution of the random sample that was selected for the data quality assessment coded by the system. The lower graph shows the classification of the random sample according to the hierarchy evidence tool

The development of protected areas management plans is following open standards methods for conservation practices, as this approach aims to standardize the design, management, and monitoring of conservation projects, facilitating best practices for conservation (Schwartz et al., 2012). To inform this decision-making process, further knowledge and understanding of the status of conservation targets such as key ecosystems or biodiversity proxies, and knowledge on the abatement of stressors are urgently needed. The synthesis and open-access database of studies compiled in this review (Martínez-Harms, 2021) can be used to inform different stages in the conservation planning process, such as to inform the feasibility analysis of the conservation targets selected in management plans. This study aimed to enhance efforts to deliver existing conservation knowledge so it can be used in decision-making processes as this is a priority for policy-relevant research in the region and the world (Rose et al., 2019).

4.3 | Emerging opportunities for conservation in Chilean Patagonia

In Chilean Patagonia, efforts should also be targeted to effectively resourcing the system of public protected areas and complementing it with other forms of conservation such as private and community-led conservation areas (Tacon et al., 2021; Tecklin et al., 2021). The application of innovative non-conventional conservation strategies underway in the region that include integrated land-sea park management, multiple-use marine conservation areas, and biocultural conservation through the allocation of access and management rights over marine areas to Indigenous communities, provide important opportunities for conservation (Araos et al., 2020; Armesto et al., 2021). Public institutions and private entities that manage protected areas need to consider the potential of existing policies such as private conservation policy, Indigenous co-management of marine ecosystems, and a national legal framework for conservation. Private conservation tools have been recently established in Chile (law 20930) enabling private landowners to protect the conservation attributes of their land. Through voluntary agreements, landowners can take long-term action to protect their land and establish restrictions to the real estate incentivizing a market of economic transactions for private conservation (MMA, 2016). Another relevant policy (law 20249) has created Coastal Marine Spaces of Indigenous Peoples in Chile to incentivize marine conservation mechanism and recognize the customary rights of indigenous people over marine ecosystems (Hiriart-Bertrand et al., 2020; Tecklin et al., 2021). Moreover, the completion of a long-awaited national legal framework for the protected area system is urgent to unify conservation plans, improve management enforcement, and better link protected areas and local livelihoods.

Planning for the other half of the land that currently is not protected is also crucial. This is especially important for freshwater systems and land–sea connections, which are the most noteworthy aspect of Patagonia's conservation network. Half of Chilean Patagonia's intact forested watersheds, which are key areas for primary forest, carbon storage, biodiversity refugia, and water conservation, lack any form of protection (Astorga et al., 2021). It remains to be defined how existing or potential freshwater and marine reserve design may complement terrestrial conservation in an integrated way. Low elevation river valleys that concentrate productive lands and human settlement are generally excluded from parks and reserves in Chilean Patagonia, highlighting the need to apply existing legal mechanisms to ensure free-flowing rivers such as national water reserves, as well as to develop legislation to enhance the permanence and scope of such measures. An integrated protected areas strategy in Patagonia needs to consider not only this distinctive terrestrial–freshwater–marine connectivity (Alvarez-Romero et al., 2011), but also to explore novel ways of capturing conservation features that may change over time as a result of global change drivers like climate change (Duarte et al., 2020; Elsen et al., 2020; Maxwell et al., 2020). Moreover, the limited coverage of managed marine reserves within the interior seas of the Patagonian archipelago highlights the need to develop management plans and appropriate management formulas to abate threats to marine biodiversity over vast and remote areas. To be effective such work also requires increasing commitment to cooperation between stakeholders, local communities, and national to local governments.

Enhancing the use of evidence in conservation decision-making has been a long-standing focus of the conservation community (Rose et al., 2019). This synthesis provided an updated baseline that classified and spatialized the evidence, helping to identify current knowledge gaps and establish priorities to strengthen conservation efforts. The assessment of the evidence quality showed that the collected evidence is robust enough to support its potential use in decision-making processes that require ecosystem knowledge for conservation. However, it is important to acknowledge that evidence uptake in decision-making is much more than just sharing the information with a decision-maker; rather, it must be delivered in a user-friendly format and a politically salient way (Rose et al., 2020). We acknowledge that conservation decision-making takes into account multiple other variables such as stakeholder interests, values, perceptions, and other types of local knowledge, however, enhancing access and use of evidence is likely to contribute to improved decision-making for the conservation of ecosystems.

5 | CONCLUSION

The synthesis documented that evidence has grown exponentially focusing on terrestrial and marine ecosystems. Nonetheless, we identified that an important gap is the study of the social dimensions of conservation and management of ecosystems, such as Indigenous and community-led conservation. Future efforts should be taken to incorporate traditional and local knowledge as communities hold a centuries-old ecological understanding of Patagonian ecosystems and can help point the way to ecosystem conservation. This synthesis can facilitate the use of scientific evidence in conservation decision-making and can help practitioners to reliably find evidence in order to contribute to improved decision-making for the conservation of ecosystems in Chilean Patagonia.

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

AUTHOR CONTRIBUTIONS

María José Martínez Harms conceived the idea of the manuscript. María José Martínez Harms designed the systematic map, collected, and analyzed the data and María José Martínez Harms led the writing and Taryn Fuentes-Castillo help prepared Figures 1 and 4. María José Martínez Harms, Juan Armesto, Juan Carlos Castilla, Anna Astorga, José Aylwin, Alejandro H. Buschmann, Victoria Castro, Giovanni Daneri, Miriam Fernández, Taryn Fuentes-Castillo, Stefan Gelcich, Humberto E. González, Rodrigo Hucke, Pablo A. Marquet, Flavia Morello, Laura Nahuelhual, Patricio Pliscoff, Brian Reid, Ricardo Rozzi, David Tecklin, Cesar

Guala, provided important feedback, contributed in the writing of the manuscript, and reviewed the final manuscript.

DATA AVAILABILITY STATEMENT

Martínez-Harms, María José (2021), "Database for: An interdisciplinary approach to evidence-based land-sea conservation in Chilean Patagonia," Mendeley Data, v1. https://doi.org/10.17632/4sff2xhzmh.1. Appendix A. Supplementary text with the systematic mapping approach (including the five stages to reproduce the synthesis). Appendix B. Database of the coded 986 studies reviewed in this synthesis. Appendix C. List of the 17 chapters that were part of the conservation assessment.

ETHICS STATEMENT

There are no human or animal subjects in this article.

ORCID

María José Martínez-Harms https://orcid.org/0000-0003-2655-3116
Alejandro H. Buschmann https://orcid.org/0000-0003-3246-681X
Stefan Gelcich https://orcid.org/0000-0002-5976-9311

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