



The relevance of social imaginaries to understand and manage biological invasions in southern Patagonia

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Abstract Western environmental thought and practice historically separated humans and nature. This dichotomy led to an ecological bias in environmental research and management, but increasingly issues like biological invasions are being re-conceived as socio-ecological problems. Here, we studied how terrestrial and freshwater vertebrate species assemblages in Tierra del Fuego (TDF) have been co-constructed between humans and nature. The social imaginary concept was used to integrate shared discourses (e.g., species preferences, nature ideals, broader social values) and practices (e.g., species introductions,

environmental management) via institutions (e.g., informal norms, laws, governmental entities, organizations). To analyze how socio-historical processes interact with biological invasions, we used TDF as a case study linked to broader geographic scales in Patagonia, Argentina, Chile and beyond. We found three predominant social imaginaries characterizing human–nature relationships that led to 20 species being introduced and subsequent efforts to remove or control seven of these: Colonization (ca. 1850–1930), Development (ca. 1930–1980) and Conservation (ca. 1980–present). Each imaginary materialized via formal and informal institutions operating from local to international scales. Specifically, we uncovered 10 discourse categories that related to human interventions of TDF's species assemblage, ranging from

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racism and nationalism (Colonization and Development, respectively) to wilderness and uniqueness (Conservation). These ideas affected actions to introduce (eight and 10 species during Colonization and Development, respectively) or remove species (one and seven in Development and Conservation, respectively). An integrated socio-ecological understanding of biological invasions identified not only social preferences and values, but also underlying social processes that can help resolve the complex and underappreciated interactions between society and biological invasions.

Keywords Conservation social sciences · Coupled human–nature systems · Discourses · Invasive species · Non-native species · Tierra del Fuego

Introduction

Environmental problems have traditionally been studied from an ecological standpoint, highlighting the historical dichotomy in Western thought and modern sciences, including ecology, of understanding humans and nature separately (Pickett and Ostfeld 1995). Consequently, environmental research often has considered the role of humans as external to nature or merely as ecological disturbances (Vitousek et al. 1997; Crutzen 2002). This perspective is particularly evident in studies of biological invasions, which have mostly considered humans in this way (Vaz et al. 2017). Yet, humans have long played a key part in creating what Ellis and Ramankutty (2008) dubbed anthropogenic biomes, or ‘anthromes’ (i.e. ecoregions defined by human interactions with ecosystems). Indeed, even in many parts of what are today considered remote wilderness areas like the Amazon and the Yucatan Peninsula, vegetation species assemblages reflect millennial, co-constructed relationships with Native Americans and perhaps are best thought of as tropical ‘gardens,’ rather than pristine jungles (see Levis et al. 2018). Therefore, it has become conceptually and practically untenable to continue considering humans as separate from nature or only as negative drivers of ecosystem change; instead, environmental scholars increasingly conceive of these as socio-ecological systems, based on reciprocal physical and ecological interactions, as well as symbolic, political

and cultural relationships (Liu et al. 2007; Robbins 2010).

For the ecological sciences, and allied disciplines like conservation biology, the incorporation of human dimensions constituted a paradigm shift not only for environmental research, but also for new environmental management proposals (Pickett and Ostfeld 1995; Mace 2014). Today, institutions like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) seek not only to conserve nature, but also its contributions to people and a good quality of life (Díaz et al. 2015). Plus, IPBES explicitly recognizes that the very concept of ‘nature’ and its relationship to human well-being are social constructs that depend on plural evaluations occurring at the nexus of worldviews, epistemologies and power dynamics in association with biodiversity and ecosystems (Pascual et al. 2017; Díaz et al. 2018). In turn, environmental knowledge(s) and practices are embedded in worldviews, culture, human–nature relationships and concrete places. These socio-ecological interactions produce values and values systems that are influential not only in how we conceive of, but also live in and manage the natural world. Humans are drivers of biological invasions, but their broader engagement is necessary in both research and management to understand how specific stakeholders perceive and are affected by the invasive species and actions to manage them (e.g., the study and management of invasive pines in South Africa, van Wigen and Richardson 2012). In short, this paradigm shift has conceptual, ethical and practical implications (Mace 2014).

Consequently, the change in our understanding of the environment is transforming the study and management of biological invasions, which until recently have been addressed mostly as anthropogenic disturbances from a natural-science perspective at local (e.g., Patagonia et al. 2014), national (e.g., Chile, Quiroz et al. 2009), regional (e.g., Latin America and the Caribbean, Pauchard et al. 2011) and global scales (Jeschke et al. 2012; Estévez et al. 2015; Vaz et al. 2017). Between 2006 and 2012, the publication rate of invasion biology studies from a social-science perspective was more than sixfold greater than the previous 13 years (Estévez et al. 2015). Given the Anthropocene’s rapid and unprecedented changes that are occurring for social (e.g., human migration, global telecommunications) and ecological systems (e.g.,

climate change, sea level rise), the academic and management communities are calling for new ways to address the broader human dimensions of biological invasions to improve decisions and actions (Kueffer 2013; Kapitzka et al. 2019). Therefore, understanding today's socio-ecological systems and the drivers and consequences of their species assemblages requires an ecological viewpoint accompanied by an in-depth and contextualized look at the human–nature relationship itself.

Here, our goal is to investigate the socio-ecological dynamics involved in biological invasions, using Tierra del Fuego (TDF) and southern Patagonia as a study site to explore human–nature relationships that affect the terrestrial and freshwater vertebrate species assemblage by selective species introductions and environmental management to remove species deemed invasive. This process was analyzed based on social discourses and practices that have been instituted at different times in TDF. We applied a socio-historical approach to assess the ways that nature has been conceived in this region. First, we established a timeline of influential ideas and associated institutions that were relevant for creating TDF's species assemblages. Then, by determining when and why species were introduced or removed, we were able to link how these practices are part of broader socio-historical factors. Using these two lines of evidence (i.e. shared discourses and shared practices in TDF with regards to species introductions and removals), we classified predominant social imaginaries that serve as an analytical tool to explain the socio-ecological processes associated with the introduction of species and the management of their biological invasions. We seek to provide insights that can be used to make management more ethical, effective and efficient.

Methodology

Conceptual framework

To understand the context and history of biological invasions as a reciprocal socio-ecological system in TDF, we studied the social imaginaries (sensu Castoriadis 1993) that contributed to the co-construction of the species assemblages in southern Patagonia. Social imaginaries are defined as the collective and shared

systems of discourses and practices that embody and produce the values, beliefs and norms that organize societies' goals and decisions (Castoriadis 1993; Taylor 2004). Mediated by power differences, they can enable or hinder certain ideas and actions that dominate over others in a particular time and space. In this way, social imaginaries produce structures of thought upon which social groups represent and materialize themselves. As part of collective world-views, social imaginaries are constituted by institutions and should not be confused with individual, subjective representations of the world. Instead, social imaginaries: (1) are collective: they are representations that circulate beyond personal experiences to constitute and negotiate collective or group meanings of the world; (2) regulate practices through language, feelings, and myths: social imaginaries are more than a symbolic system between language and the world, they construct possible worlds; and (3) are dynamic: because imagination is creative, they also can be transformed, adapted and contribute to the production of new ideas, behaviors and institutions.

While Castoriadis (1993) previously stressed the need to study the imaginaries of nature that have promoted ecological devastation, we further highlight the necessity of exploring how social imaginaries actually produce different 'natures' (i.e. species assemblages, ecosystems, landscapes) across space and time in different social groups. In this sense, neither nature nor society determines each other, but rather are co-constructed through various mechanisms. Here, we specifically analyzed the predominant social imaginaries that contributed to the introduction or management of terrestrial and freshwater vertebrate species in TDF from 1850 to 2020. First, we identified a historical timeline of ideas, institutions and social groups, which in turn reflect and reproduce dominant values, practices and discourses, involved in the conceptualization and materialization of major social imaginaries. Second, building upon the work of Castoriadis (1993) and others, we analyzed the three different spheres that configure social imaginaries (Fig. 1). (1) Institutions: we identified both formal and informal institutions that played a role in configuring predominant environmental social imaginaries of TDF. Institutions are collective rules and norms, often embodied in organizations, such as networks, infrastructures, or agencies (Schyster and Calvert 2015). They involve formal devices, such as laws, and

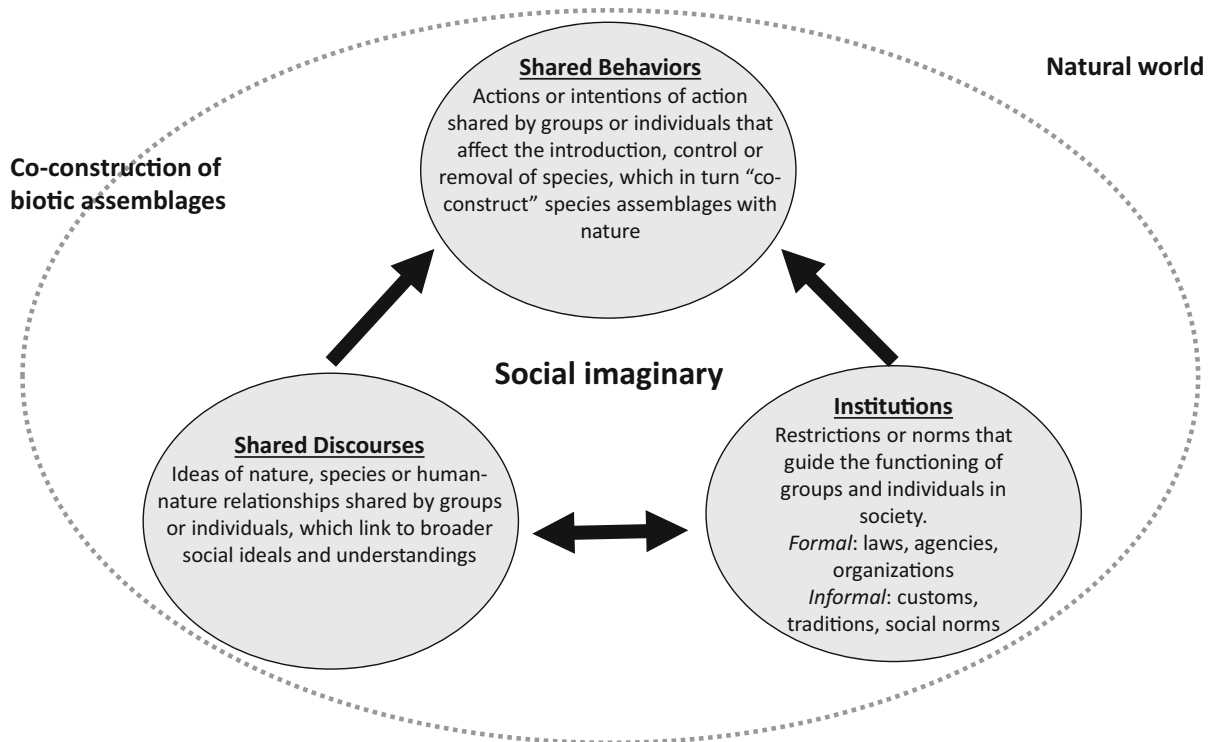


Fig. 1 Social imaginaries involve shared discourses among specific social groups that are institutionalized through formal structures and informal norms that affect the group’s collective

practices, including actions like the introduction or removal of species into local species assemblages and ecosystems

informal norms, such as codes of conduct (North 1991). Institutions produce regularities, reduce uncertainties and provide a basis for the functioning of societies. (2) Collective discourses: in this work, we identified predominant political and social discourses that oriented visions of TDF and its environment. In this way, we investigated shared discourses regarding nature, species and human–nature relationships that contributed to the co-construction of the species assemblage in TDF. (3) Collective practices: as used here, these are actions or intentions of actions that are shared between institutions, social groups or individuals that affect the introduction, control or removal of a species to TDF. In this work, we created a database of the species introductions and removals in the Chilean and Argentine portions of TDF. We identified the years, responsible person or organization, and reason for the introduction or removal.

Study site

This study focused on the TDF Archipelago (52–56°S), shared between Argentina and Chile and encompassing numerous large and small islands south of the Magellan Strait. TDF is located in the sub-Antarctic forest and Patagonian steppe ecoregions, which are classified as two of the world’s last wilderness areas, based on their large extensions, high percentage of intact native vegetation and low human population density (Mittermeier et al. 2003). Often referred to as the end of the world, TDF is known for its geographic remoteness and links to Antarctica, characteristics that reinforce its wilderness identity in the Western social imaginary (Moss 2008). While this study focused on TDF, it took into account relationships with socio-historical patterns and processes in southern Patagonia, Argentina, Chile, and the world (van Aert 2013).

Historical analysis: identification of relevant discourses and institutions

To investigate TDF's history of human–nature relationships, we delimited our analysis from the present back to 1850, when European settlement commenced. We reviewed primary source documents and peer-reviewed articles to identify defining events, key social figures and influential ideologies that shaped the introductions or removals of exotic species in TDF. In addition to key events, including the mentalities or discourses that such events represented, we took note of the institutions responsible for shaping these milestones. Literature searches were conducted in Academic Search Complete, EBSCO Host, Google Scholar, and SciELO databases. Key phrases searched in English (and their Spanish translations) were: “social–political history of Argentina,” “social–political history of Chile,” “social–political history of Tierra del Fuego,” “European immigration to Chile,” “European immigration to Argentina,” “European immigration to Tierra del Fuego,” “Chile nationalization,” “Argentina nationalization,” “conservation policies of Argentina,” “conservation policies of Chile,” and “conservation in Tierra del Fuego.” Well-known political figures and policies of the countries and the region were also searched in these sites. Predominant ideologies were highlighted as they related to species or more broadly nature.

Ecological analysis: determination of actions to introduce or remove species from the assemblage

We assessed the actions involved in establishing the vertebrate species assemblage of TDF by determining species introductions and removals, compiled from primary source accounts and peer-reviewed scholarly articles (Valenzuela et al. 2014; Ballari et al. 2015, and sources cited therein). For introductions, we recorded the date, responsible party and reasons for introduction, sub-classified as (1) reason for being brought to the island and (2) reason for being released into the wild, either purposefully or accidentally. Environmental management actions were intentional efforts to eradicate or control a population of an invasive exotic species. Many of these programs lasted short periods of time and were mostly unsuccessful, but they still represent a concrete practice, based on an intention of

specific stakeholders to remove a species from the TDF species assemblage. For each introduction or management effort, we recorded: the target species, its common name, year the effort initiated, reason for being removed, and the responsible party. Where there was documentation, we included data for multiple introductions or attempted removals of the same species.

Integrative analysis: determination of predominant social imaginaries

We integrated the data collected above to delimit social imaginaries of TDF's species assemblages during the study period based on: (1) shared discourses (i.e. key events and mentalities throughout time), (2) shared practices (i.e. species introductions or removals), and (3) institutions (i.e. the formal and informal norms, rules and organizations that played a role in influencing both discourses and practices). After data collection, we assessed those discourses and practices to determine reoccurring themes and categories that were prominent for specific periods, based on Grounded Theory, which allowed for the inductive identification of social imaginaries based upon qualitative data (Strauss and Corbin 1990). Finally, we identified themes that characterized groups of shared discourses, practices and institutions, which were synthesized to determine predominant social imaginaries.

Results

The analysis of shared discourses resulted in 10 categories related to human–nature relationships in TDF (Fig. 2). These ideas were largely part of broader social processes beyond TDF and Patagonia, and they related to national and international concepts about humans, society and nature. As such, in this time period, TDF has been an overall recipient, rather than a source of discourses that have affected how nature and species assemblages are both conceived and managed. Plus, while these ideas have clearly different origins, they illustrate how local imaginaries are part of broader social networks.

Also, we identified a total of 20 terrestrial and freshwater vertebrate species that have been introduced to the archipelago, one of which—the reindeer

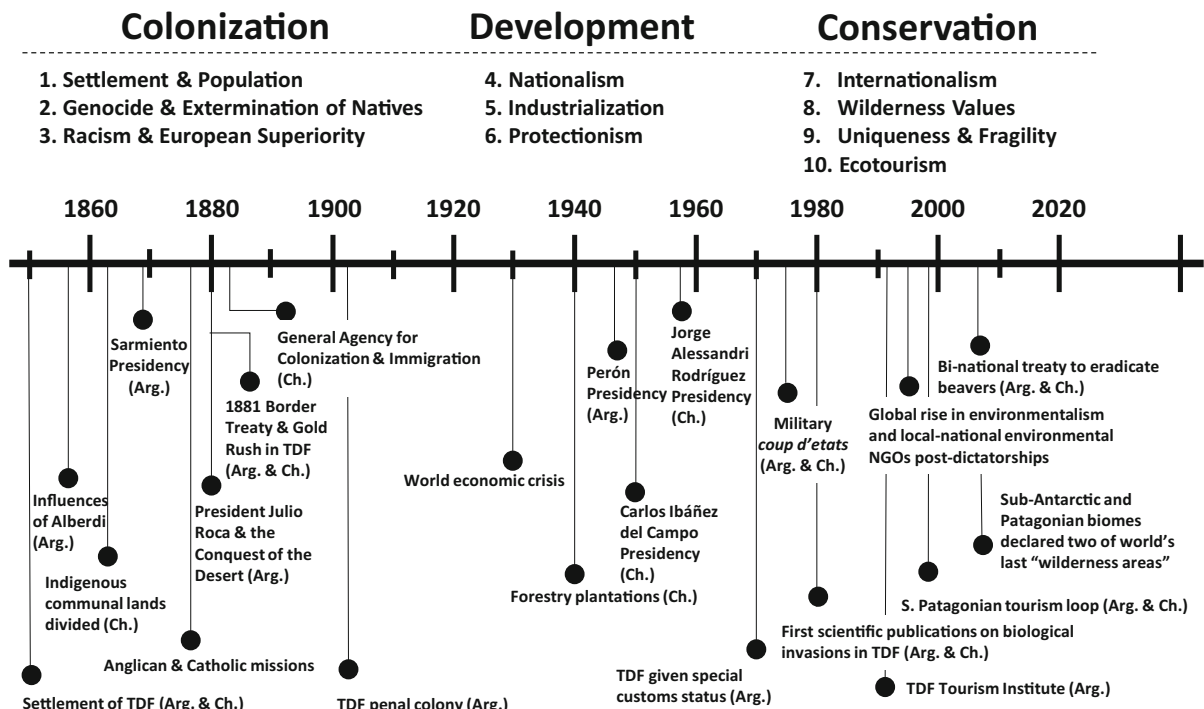


Fig. 2 Timeline of historical events and institutions affecting the discourses that contributed to the predominant social imaginaries of different time periods in Argentina and Chile. Key historical data are highlighted with regards to their

relationship to practices in Tierra del Fuego that affect species assemblages via (attempted) introductions or removals of invasive exotic vertebrates

(*Rangifer tarandus*)—did not become established (Table 1). Of these, only seven have been targeted for control programs. The European rabbit (*Oryctolagus cuniculus*) was managed as early as the 1950s. However, there were no other species control efforts until the mid-1980s and late-1990s (e.g., North American beaver, *Castor canadensis*), and the practice of invasive species management only became frequent in the 2000s (e.g., American mink, *Neovison vison*; muskrat, *Ondatra zibethicus*; Chinook salmon, *Oncorhynchus tshawytscha*; feral dog, *Canis lupis familiaris*; and feral horse, *Equus ferus caballus*). Six justifications were found for introductions, which mostly had to do with diverse values of these species for material contributions to people (e.g., food) and as economic resources linked with development models. Only two reasons were found to justify control programs of exotic species: damage to ecosystems and economic resources (Table 1).

Various emblematic institutions emerged during the analysis regarding factors involved in establishing

these ideas and behaviors. At the national level, the Chilean and Argentine governments and their policies, as well as key social thinkers, were influential, and at the local level, elite pioneer families and ranchers proved to be particularly important. Several institution types, such as environmental non-governmental organizations, ecotourism operators and scientific organizations, also were found to operate simultaneously from local to international scales, particularly since 1980. Similarly, local, national and international institutions conditioned behaviors involved in species introductions and removals. Combining these constituent elements, we delimited three distinct socio-historical periods based upon the predominant social imaginaries of Colonization (ca. 1850–1930), Development (ca. 1930–1980), and Conservation (ca. 1980–present) (Fig. 3), which we assess in greater detail below.

Table 1 Actions intended to introduce or remove (shaded in grey) exotic vertebrate species in Tierra del Fuego were assessed by establishing the year and reason for each species' introduction or control

	Common name	Scientific name	Year	Reason	Institutions	Refs
Colonization	Feral dog	<i>Canis lupis familiaris</i>	<1850	Af, La	Pioneers	1, 2
	Feral goat	<i>Capra hircus</i>	1856	Fo	Pioneers	1, 3, 4
	Feral cat	<i>Felis silvestris catus</i>	1870	Af, La	Pioneers	1, 5, 6
	Feral sheep	<i>Ovis orientalis aries</i>	1871	Fo, Fi	Pioneers	1, 2, 7
	European rabbit	<i>Oryctolagus cuniculus</i>	1880	Fo	Pioneers	7
	Feral cow	<i>Bos taurus</i>	1884	Fo, Fi	Pioneers	1, 7
	Feral horse	<i>Equus ferus caballus</i>	1885	La	Arg navy	1, 7
	Feral pig	<i>Sus scrofa</i>	1887	Fo	Pioneers	1, 7
Development	Rainbow trout	<i>Oncorhynchus mykiss</i>	1931	Re, Fo	Industry, TDF	8, 9, 10
	Brown trout	<i>Salmo trutta</i>	1931	Re, Fo	Ranchers, TDF	8, 9, 10
	Brook trout	<i>Salvelinus fontinalis</i>	1931	Re, Fo	Ranchers, TDF	8, 9, 10
	European rabbit	<i>Oryctolagus cuniculus</i>	1936	Fi, Fo, Re	Ranchers	2, 11
	North American beaver	<i>Castor canadensis</i>	1946	Fi	Arg navy	12
	American mink	<i>Neovison vison</i>	1948	Fi	Industry, TDF	1, 11, 13
	Muskrat	<i>Ondatra zibethicus</i>	1948	Fi	Arg navy	1, 4, 14
	Reindeer*	<i>Rangifer tarandus</i>	1948	Re, Fo	Arg navy	15, 16
	Grey fox	<i>Pseudalopex griseus</i>	1951	Bio	Ranchers	1, 17
	European rabbit	<i>Oryctolagus cuniculus</i>	1951	Econ	Magallanes	4, 18, 19
	Reindeer*	<i>Rangifer tarandus</i>	1971	Re, Fo	Ch navy	20
	Red deer	<i>Cervus elaphus</i>	1973	Re, Fo	Arg navy	1, 4, 21
Rock pigeon	<i>Columba livia</i>	1980	Af	Urbanites	1, 6, 22	
Conservation	North American beaver	<i>Castor canadensis</i>	1981	Ecos, Econ	TDF	23
	Large hairy armadillo	<i>Chaetophractus villosus</i>	1982	Af, Fo	Ranchers, Truckers	1, 22, 24
	North American beaver	<i>Castor canadensis</i>	1984	Ecos, Econ	APN	25
	North American beaver	<i>Castor canadensis</i>	1993	Ecos, Econ	SAG	26
	North American beaver	<i>Castor canadensis</i>	1999	Ecos, Econ	TDF	26
	Chinook salmon	<i>Oncorhynchus tshawytscha</i>	2001	Fo	Industry, Ch	27, 28
	North American beaver	<i>Castor canadensis</i>	2001	Ecos	APN	25
	Muskrat	<i>Ondatra zibethicus</i>	2004	Ecos	SAG	29
	American mink	<i>Neovison vison</i>	2004	Ecos	SAG	29
	North American beaver	<i>Castor canadensis</i>	2004	Ecos, Econ	SAG	24, 29
	European rabbit	<i>Oryctolagus cuniculus</i>	2006	Ecos	SAG	29
	Feral dog	<i>Canis lupis familiaris</i>	2008	Ecos, Econ	SAG	2, 30
	North American beaver	<i>Castor canadensis</i>	2008	Ecos,	Ch, Arg, WCS	31
	American mink	<i>Neovison vison</i>	2010	Ecos	SAG	32
	Feral horse	<i>Equus ferus caballus</i>	2014	Ecos	Yendegaia	30, 33
	North American beaver	<i>Castor canadensis</i>	2014	Ecos, Econ	Arg	34
	Chinook salmon	<i>Oncorhynchus tshawytscha</i>	2015	Ecos	APN	35
	Feral dog	<i>Canis lupis familiaris</i>	2016	Ecos, Econ	TDF	36
North American beaver	<i>Castor canadensis</i>	2016	Ecos, Econ	Ch	37	
European rabbit	<i>Oryctolagus cuniculus</i>	2020	Ecos, Econ	CADIC	38	

Table 1 continued

No control efforts successfully eradicated a species; * indicates failed introduction attempts. Reasons for introduction included biological control (Bio), food (Fo), fiber (Fi), human affinity (Af), labor (La), recreation (Re). Reasons for control included ecosystem (Ecos) and economic (Econ) damage. Responsible organizations include: Argentine (Arg) and Chilean (Ch) national governments; Argentina's former Marine Ministry, which is equivalent to the navy (Arg navy), National Parks Administration (APN), Austral Center for Scientific Research-National Scientific and Technical Research Council (CADIC), and Tierra del Fuego provincial government (TDF); Chile's Magallanes regional government (Magallanes), Agricultural and Livestock Service (SAG), and navy (Ch navy); the Yendegaia Foundation (Yendegaia), a Chilean NGO; the Wildlife Conservation Society (WCS), an international NGO; pioneer settlers (Pioneers); local ranching families (Ranchers); commercial truckers (Truckers); urban residents (Urbanites); and industrial salmon and fur-farms (Industry)

1. Valenzuela et al. (2014), 2. Cabello (2014), 3. Martinic (1973), 4. Fabbro (1989), 5. Nogales et al. (2004), 6. Anderson et al. (2006), 7. Bridges (1949), 8. Moorman et al. (2009), 9. Fernández et al. (2010), 10. Casalnuovo (2013), 11. Jaksic et al. (2002), 12. Pietrek and Fasola (2014), 13. Valenzuela et al. (2016), 14. Castello (2013), 15. Daciuk (1978), 16. Navas (1987), 17. Pine et al. (1979), 18. Jaksic and Yañez (1983), 19. Jaksic and Castro (2014), 20. Bell and Dieterich (2010), 21. Massoia and Chebez (1993), 22. Cabello et al. (2017), 23. Schiavini et al. (2016) 24. Poljak et al. (2007), 25. Sanguinetti et al. (2014), 26. Anderson et al. (2011), 26. Sanguinetti et al. (2014), 27. Pascual et al. (2002), 28. Mundo Acuicola (2018), 29. Soto and Cabello (2007), 30. Ballari et al. (2015), 31. Menvielle et al. (2010), 32. Caicheo (2010), 33. Sur54 (2014), 34. FAO/GEF (2014), 35. APN (2015), 36. Provincia de Tierra del Fuego, Antártida e Islas del Atlántico Sur (2016), 37. FAO/GEF (2016), 38. CADIC-CONICET (2020). *See Online supplementary material for Full Citations

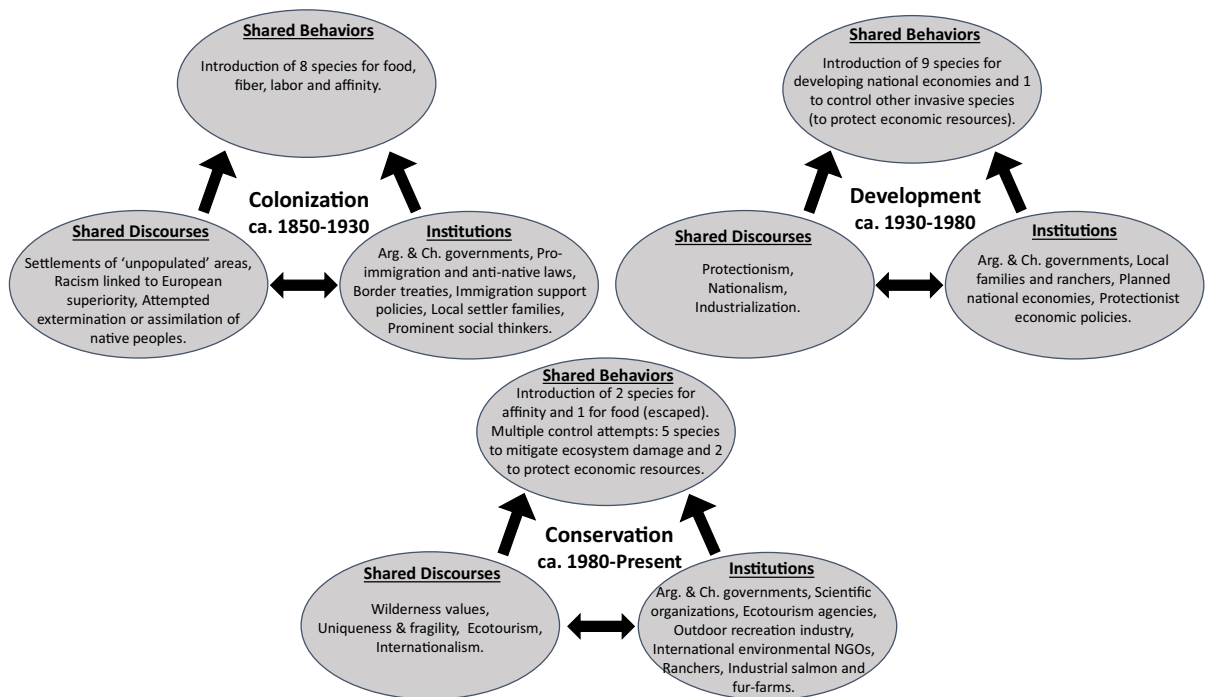


Fig. 3 Three social imaginaries were delimited for Tierra del Fuego since 1850: Colonization, Development and Conservation. Each of these imaginaries responds to specific shared discourses that were promoted by particular institutions and

ultimately lead to the shared actions involved in the introduction or removal of species. In this way, social processes influence Tierra del Fuego's biotic assemblage and ultimately are a key driver of biological invasions

Social imaginary of Colonization (ca. 1850–1930)

Discourses and institutions: nation-building through European colonization

Both Argentina and Chile built their nascent national politics upon desires to ‘whiten’ and ‘civilize’ the creole and *mestizo* populations through European immigration and the extermination of Indigenous peoples (Gott 2007), a discourse that helped make Argentina one of the South American countries with the largest number of European immigrants (Solberg 1969). With new immigrants and their practices, such as raising livestock or expanding national and international trade, previous cultures and human–nature relationships were more-or-less violently displaced or exterminated (Giucci 2014; Harambour 2017; Dicenta 2020). This colonization mentality was supported by key political figures in both countries. Between the 1850s and 1870s in Argentina, the intellectual Juan Bautista Alberdi and President Domingo F. Sarmiento promoted racialized population politics, which can be synthesized in Alberdi’s dictum ‘*gobernar es poblar*’ (to govern is to populate) (Moya 1998). Planned immigration policies selected peoples according to their state of ‘civilization,’ privileging those from particularly northern Europe in contrast to supporting native born migration to new areas (see also Sarmiento’s seminal work of fiction, published in 1845 under the title *Facundo: Civilization and Barbarism*, that sets out similar thinking regarding how Latin America should be settled and developed). During these years, the Chilean elite shared ideas regarding population politics that in turn shaped human–nature relationships (Bohoslavsky 2009). For example, German immigrants that came to the Valdivian rainforests of south-central Chile were considered exemplar settlers, and there were laments that the rest of Chile had not been occupied by such immigrants (Solberg 1969; Bohoslavsky 2009; Harambour 2017).

These colonial discourses were institutionalized by governmental policies and agencies at the national level. For example, the 1870s Argentine military campaign known as the ‘Conquest of the Desert’ sought to eliminate native populations in Santa Fe Province and mainland Patagonia (Nugent 1992). In the first Argentine Constitution, European immigration was explicitly promoted (Article 25, National Constitution of 1853), and in the Special Immigration

Law of 1876 European racial and cultural superiority was affirmed (Fernández 2017). In Chile, legislation from 1874 made European immigrants eligible to receive 150 hectares of flat land, while native-born Chileans were eligible for nothing (Solberg 1969). As elsewhere, European settlement in TDF also brought new diseases that proved deadly to native peoples (Magee 2003).

However, by the early 1900s, nationalism began to rise and produced a contradictory view of European immigration, which came to be seen not only as a civilizing mechanism, but also as a potential threat for national security and incipient national identities. Social thinkers began to associate immigration with an erosion of cultural heritage, and regulations like the Residence Law of 1902 in Argentina permitted the expulsion of foreigners that threatened national security or the public order. In this period, we begin to see a shift in public perceptions of immigration and immigrants (Solberg 1970). In turn, there is a rise in nationalistic ideas, including the superiority of the *raza chilena* (Chilean race), and the need for the government to support native Chileans arose (Solberg 1969). At the end of this period, the discourses regarding the inherent superiority of European culture and peoples began to be challenged in favor of nationalist (but still white-Eurocentric) ideals.

Practices and institutions: European species introductions

Under the Colonization social imaginary, eight species were brought with early pioneers as they began to establish permanent settlements in the archipelago (Table 1). Early settlers to the region (e.g., the Bridges family that founded the city of Ushuaia and some of the first ranches on the island, Bridges 1949) released Eurasian species important for food sources (e.g., cow, pig, goat, rabbit, and sheep), labor (e.g., dog, cat and horse), fiber (e.g., cow and sheep), and companionship (e.g., dog and cat) to increase the habitability of the landscape for Europeans. Some of these species were introduced purposefully to the ‘wild’ to populate the landscape, but much of the established populations from this period resulted from feral domestic animals or the practice of keeping livestock in a semi-wild state (Valenzuela et al. 2014). Overall, these species reflect a prioritization of species valued in the European culture and economies of the time.

Synthesis

At the turn of the nineteenth century, European settlement of the land resulted from national policies to support foreign immigration and establish dominance over remote territories, stimulated by Indigenous resistance and geopolitical struggles between Argentina and Chile (van Aert 2013). The Colonization social imaginary physically manifested in TDF starting with the first pioneers and was characterized by ideas of racial superiority and attempts to either assimilate (e.g., evangelization by both Catholic and Anglican missionaries) or exterminate (e.g., armed conflicts) native peoples. It was institutionalized via policies and advanced by elite national intellectuals and government figures that supported European immigration to Argentine and Chilean Patagonia, including appropriating the lands inhabited by Indigenous communities. While this phenomenon dates as far back as the early nineteenth century in both countries, it only began to arise in TDF during the second half of the century, when sheep ranching and gold mining catalyzed permanent European settlements in the archipelago (Klepeis and Laris 2008; van Aert 2013; Harambour 2017). These settlers and their ranches were local institutions in their own right, yet simultaneously reflected the values of national institutions that asserted European superiority and the value of foreign immigration. Consequently, eight species important in European society for food, fiber, labor, and companionship were brought to this region to foster a new culture and develop economies based on imported development models (e.g., livestock, wool).

Social imaginary of Development (ca. 1930–1980)

Discourses and institutions: national economic development

Changing perspectives of foreign relations solidified in the 1930s in both countries, catalyzed in part by the Great Depression and World War II. Chilean and Argentine export economies were drastically affected by both events, which sparked the need to develop internal markets through import substitution, tariffs, industrialization and national investment (Solberg 1970; Garretón 2007; Ratliff and Calviño 2007). While ecosystems had been used for productive

purposes since the Spanish colonial period, beginning in the 1930s new economic and development ideas sought to industrialize nature (e.g., exotic plantation forestry in Chile, Klepeis and Laris 2006) and develop substitutes for imports. However, instead of promoting the introduction of foreign resources (i.e. humans, capital), as occurred in the previous period, we begin to find political initiatives and policies oriented towards the removal of foreign influence from Patagonia (Bohoslavsky 2009). Foreign immigrants represented rivals for native-born citizens in tough economic times, and they were characterized as disloyal citizens that were robbing the country of its resources only to return to their homelands (Solberg 1970). Immigration-support programs ended, and land was made more readily available to native-born citizens (Solberg 1969).

The pro-industrialization ideologies and values of these years were exemplified by the presidencies of Juan D. Perón (1946–1955) in Argentina and Carlos Ibáñez del Campo (1927–31 and 1952–58) and Jorge Alessandri Rodríguez (1958–64) in Chile. The Perón presidency signified an attempt to change the human-nature identity of Argentina from one of exporting natural and agricultural resources to supply the rest of the world to a modern, industrial nation (Mateo and Carreras Doalla 2013) by promoting national markets for both agricultural and manufactured goods, while simultaneously turning away from the liberal trade policies of the Colonization period (Ratliff and Calviño 2007). At the same time, Chilean presidents between 1938 and 1958 created national companies and agencies to regulate energy, transportation and agriculture (Muñoz Gomá 2017).

The shift from promoting European settlement, including not only people, but their cultural practices and animals, to protectionist and nationalist development policies directly affected TDF's species assemblage via the introduction of specific species that were part of this development mentality. Starting in the 1940s, a stronger emphasis was observed on the national integration of the local population, government and economy. New industries were developed, with a heavy emphasis in TDF on textile manufacturing and petroleum exploitation (Blanco and Mendes 2006). In the 1970s, both countries promoted favorable tax status for people and industries located in TDF to stimulate local economies, which transformed the Argentine portion of TDF into an industrial hub (van

Aert 2013). Simultaneously, the nationalistic industrial model that governed the planned development of TDF and Patagonia during these decades obscured the local association with nature and environmental impacts (Blanco and Mendes 2006).

Until the latter half of the twentieth century, national governments played a central role in guiding development policies in southern Patagonia (Garretón 2007). During both countries' civilian-military dictatorships of the 1970s and 80s, the governments' shift from protecting national economies towards implementing neoliberal reforms re-opened domestic markets and reduced the state's role in the economy (Carruthers 2001; Klepeis and Laris 2006). During this time, the exploitation of natural resources also increased (Klepeis and Laris 2006; van Aert 2013).

Practices and institutions: introductions and control of economically important species

As part of efforts to 'enrich' TDF's fauna (Anonymous 1946) for development, we find both individual efforts and state-supported programs to introduce species. In the 1930s, three trout species were introduced by a local pioneer family for both food and recreational economic opportunities. Subsequently, the local government also began to promote trout, establishing a hatchery in Ushuaia in the 1970s. During the 1940s, the Argentine government also attempted to start a fur industry in TDF, leading to the introduction into the wild of several pelt-bearing species, such as the North American beaver and muskrat, and an association with the private sector to develop fur-farming of mink. Together, these public-private efforts exemplify the national trends of industrialization to develop local economies. Plus, both the Argentine and Chilean naval authorities, with jurisdictions over these territories at the time, sought to introduce reindeer to TDF's main island (1948) and Navarino Island (1971), respectively (Table 1). In both cases, this species would have been used as a source of meat and also hunting, but the attempts to establish it in TDF failed. However, in 1972, the Argentine navy did successfully introduce red deer (*Cervus elaphus*) to Staten Island for the same purposes (Valenzuela et al. 2014). While the first rabbits were introduced in southern TDF in the Colonization period, a second introduction in the Chilean portion of the island's northwest coast, which is part of the steppe biome used heavily for sheep

ranching, occurred in 1936. Soon thereafter in 1951, the grey fox (*Pseudalopex griseus*) was introduced to the island from mainland Patagonia by ranchers to act as a biological control on invasive European rabbits, which were damaging pastures and therefore affecting the ranchers' economic interests (Jaksic and Castro 2014).

Synthesis

As the support for foreign immigrants and markets began to wane in the early 1900s, a new predominant imaginary linked to national development and its relationship to Patagonia arose and lasted until around 1980. This social imaginary became influential following the world economic crisis of the 1930s that led Argentina and Chile, and by extension TDF, to adopt protectionist economic policies and industrialization as a development pathway. At the same time, the surge in nationalism moved immigration policies towards fomenting and protecting native-born citizens. During the Development period, a total of 10 species were introduced by elite local settler families and the Argentine government with the main reasons being for their economic values vis-à-vis food, fur/fiber industries and recreational activities. Here, we also find the first recognition of introduced species as a threat to other values. The case of European rabbit control, however, does not constitute a new understanding of biological invasions, but rather the idea of a 'plague' that must be dealt with precisely because one of the attempts to address the problem was the introduction of another species—the grey fox. Overall, the Development period was characterized by the valuation of species for their economic contributions both in terms of introduction and removal efforts.

Social imaginary of Conservation (ca. 1980–present)

Discourses and institutions: global environmental conservation

As Chile and Argentina implemented neoliberal policies in the late 1970s and 80s, social and economic ideas were reconstructed in TDF. While the emphasis on local development was maintained, there were also influences from international institutions regarding the primacy of conservation values. These came along

with the increase of locally produced scientific publications about exotic and invasive species, beginning in early 1980s (e.g., Blanco and B rquez 1980; Siefeld and Venegas 1980). Information from the emerging sub-discipline of invasion biology demonstrated a significant change in the scientific paradigm of species introductions, and science institutions began to play an increasingly influential role in the perceptions of the natural world in TDF. For example, in an analysis of local media sources, it was shown that the major source of information regarding biological invasions came from local scientists, such as the Austral Center for Scientific Research (*CADIC-CONICET*) in Ushuaia, which is frequently quoted in the local news that relate to biological invasions (Car et al. 2018).

In addition to scientific organizations, the nature-based tourism sector increased its presence since the 1980s, when major infrastructure investments to receive large numbers of tourists, such as the port and airport in Ushuaia (Snyder and Stonehouse 2007). Plus, tourism became institutionalized in the Argentine TDF government structure in 1992 with the creation of the Fuegian Tourism Institute (*INFUTUR*), which brands TDF as ‘the end of the world’ and promotes nature-based tourism practices that reinforce conservationist ideas of TDF as a wilderness area that is not only singular, but also fragile and in need of conservation (see also Rozzi et al. 2012). Furthermore, while many of southern Patagonia’s protected areas were established earlier than the 1980s, and often for geopolitical reasons, today protected areas in TDF and throughout the region are largely valued for their intrinsic and relational values, such as the existence value of nature or its use for observation and recreation (Mrotek et al. 2019). In TDF and southern Patagonia, the extensive protected natural areas are managed mostly by state agencies, but there are also NGOs and private families who have further contributed to the conservation of this region’s iconic landscapes, previously open to more extractive uses.

Although conservation values do not dominate across the whole of Argentina and Chile, there are many national and international initiatives that contribute to this social imaginary. Global conferences and agreements, such as the Brundtland Report of 1987 or the second conference of the United Nations of Environment and Development in Rio de Janeiro in 1992, represent broad global environmentalism movements that have also pushed conservation ideals that

affect TDF (Carruthers 2001). Chile now has over 300 protected areas, most of which have been designated since 1991, following the end of its last civilian-military dictatorship (Ogden and Holmes 2016). In the late 1990s, the Argentine government held several workshops on non-native species and began its own research for their prevention (see <http://www.inbiar.uns.edu.ar/>), and in TDF the beaver became the focus of binational coordination efforts with a series of meetings and events (Anderson et al. 2011).

Practices and institutions: introductions and removals of harmful species

Since 1980, only three species have been introduced to TDF. Two of these were brought by the initiative of individuals due to the human affinity with the rock pigeon (residents of Puerto Williams, Chile) and the large hairy armadillo (ranchers and truckers in TDF), and the third introduced species in this period came from escapes of Chinook salmon brought to the Chilean portion of the region (e.g., Capit n Aracena Island) for salmon farming in the 1990s (Table 1).

Multiple control attempts of invasive species have occurred since the 1990s, focused on seven species: North American beaver, American mink, muskrat, European rabbit, Chinook salmon, and feral dogs and horses. All of these were implemented for conservation purposes related to the ecosystem and economic damage these species were causing. The Argentine government authorized beaver-hunting in 1981, and in 1993, the beaver was declared a ‘harmful’ species in Chile, thus permitting its hunting year-round. However, the local governments in both countries did not begin more systematic efforts to manage this species until the late 1990s (Table 1). In particular, the Magallanes Region office of the Chilean Agricultural and Livestock Service (*SAG*) has promoted various efforts for all of these species, while most organizations, such as Argentina’s National Parks Administration (*APN*), have focused more attention on the beaver. In 2008, Chile and Argentina signed an unprecedented binational treaty to work together to restore degraded ecosystems via the eradication of the beaver as an invasive species, demonstrating a growing commitment to the conservationist perspective by agreeing to restore the ecosystem degraded by this biological invasion (Menvielle et al. 2010). Paradoxically, however, there are small-scale initiatives by tourism

operators to promote the observation of beavers as a nature-based recreational activity, and this introduced ecosystem engineer is even used in the name of the region's most important ski resort (i.e. *Cerro Castor* or 'Beaver Mountain'). In large part, the binational efforts to eradicate the beaver were catalyzed by the influence of the Wildlife Conservation Society (WCS), an international environmental NGO based in the U.S., but with Chilean and Argentine affiliate organizations that supported much of conservationist perspective that led to prioritizing eradication in the binational agreement. Around this time, the provincial government of the Argentine portion of TDF also promulgated a law to support and finance the control of feral dog populations in TDF, with the backing not only of *CADIC-CONICET* scientists, but also in conjunction with local ranchers (Ballari et al. 2015). Likewise, feral dogs are seen as both a threat to local economic resources and livestock by ranchers, but also to wildlife populations by scientists and environmental managers, and thus this invasive species is also being controlled for both their ecosystem and economic damage. Similarly, European rabbits are associated with economic and ecological damage, which led to two control attempts during this period by *SAG* (2006) and *CADIC-CONICET* (2020) (Table 1). The Yendegaia Foundation, a Chilean environmental NGO associated with the U.S. conservation philanthropists Douglas and Kristine Thompkins, is responsible for an attempt to control feral horses on their property before it was designated a Chilean national park, and their reasons for doing so were to restore the ecosystems to a 'natural' state (Ballari et al. 2015). Finally, in 2015 *APN* attempted to restrict the spread of Chinook salmon in Tierra del Fuego National Park through barriers and traps placed in the Ovando River (APN 2015).

Synthesis

Overall, the 1970s and 80 s represented times of socio-political turmoil and major policy changes in Argentina and Chile, due to civilian-military dictatorships, but at the same time the region came to be perceived as a priority for global conservation, a shift that was largely driven by international NGOs, the tourism industry and scientific organizations. This ongoing social imaginary highlights and characterizes TDF as a wild and pristine landscape for the world, rather than

as only a national province or local resource. The least number of vertebrate species were introduced in the Conservation period ($n = 3$), while conversely, we find the most attempted controls of invasive species during this time period ($n = 7$) for purposes of protecting ecosystems and agricultural resources. In summary, TDF's Conservation period has been driven primarily by desires to protect biodiversity and the environment, which has brought a negative light to the introduction of species and has in turn decreased introduction numbers and increased removal campaigns.

Discussion

Understanding the socio-historical context of environmental problems, such as biological invasions, helps overcome the traditional separation of humans and nature that has allowed ecological approaches to dominate the research and practice of such conservation-related domains (Vaz et al. 2017; Kapitzka et al. 2019). Even though many invasion biologists themselves recognize the importance of social, political and applied research topics (e.g., Anderson and Valenzuela 2014), there is still a relative dearth of social-science studies on invasive exotic species. Here, however, we used a socio-ecological approach to show that the TDF's species assemblages during the past 150 years have been partially driven by three predominant social imaginaries (Colonization, Development and Conservation). Using this analytical tool, it was possible to disentangle complex socio-historical factors that couple human and natural systems by evaluating the constituent components (i.e. shared discourses, shared practices and institutions). Consequently, this methodological approach to the study of biological invasions as a socio-ecological process demonstrated how research on social imaginaries can highlight the social and political aspects of invasions via the related key ideas, stakeholders, policies and institutions. In turn, these socio-political dimensions are precisely what can be affected by management decisions to promote more inclusive and effective solutions or to minimize management conflicts.

Therefore, the study of social imaginaries helped confer human agency to what is mostly understood as a 'biological' process (Jescke et al. 2012). For example, we can assess how specific ideas,

stakeholders or institutions are involved in creating meanings and significances of nature in general and of species in particular, which in turn affects which species are valued and allowed to be present on the landscape. By identifying the shared ideas and actions of specific groups, as well as recognizing the institutions that shape them, environmental managers can better frame environmental policies to coincide with the social imaginary and way of thinking for a particular time period or stakeholder. Furthermore, environmental researchers and managers can have a limited range of nature values that is not always reflective of the entire community (Zagarola et al. 2014). Therefore, better understandings of broader, diverse and sometimes divergent social beliefs and values of nature and species (including exotic ones) provides the opportunity to develop more realistic and relevant solutions in a more ethical manner, including stakeholders that are often outside of the environmental sphere. For example, in Australia, Aboriginal cultural practices now incorporate and value some exotic species (Trigger 2008), but conversely it has been shown that promoting relationships with native species can develop a ‘sense of place’ and even affect tourism visitation to a region, due to its distinctiveness (Forristal et al. 2014). Therefore, understanding these nuances can help create real-world decision-making processes that reflect, democratize and orient social imaginaries, allowing engagement regarding those values and ideals we want to strengthen (e.g., sustainable ranching, ecotourism) so that they affect the natures, institutions and species assemblages in which we want to live (Estévez et al. 2015). In short, the study of social imaginaries regarding biological invasions challenges invasion biologists to understand invasive species from multiple perspectives, but simultaneously provides new discourses that can be employed around a management plan to harness public support by framing them in line with the values and actions of society as informed by the social imaginary.

At the same time, it is important to note that social imaginaries coexist throughout space and time, and multiple imaginaries of nature have arguably been present simultaneously and contested throughout all the delimited time periods in this study. For example, while the contemporary conservation imaginary has manifested itself in invasive species control programs, the Argentine TDF provincial government

(2014–2019) also promoted the introduction of exotic salmon farming. While this effort was discontinued, due to a broad-scale public backlash, such farming complexes are found in the Chilean portion of the archipelago. Additionally, though much of the nature-based tourism and conservation imaginary has been developed in more recent years, as far back as the 1930s, the Chilean and Argentine governments began establishing protected areas in the region and emphasizing tourism as a form of viable economic development, as demonstrated by the APN’s efforts to reimagine the Patagonia region as an alpine wilderness (Mendoza et al. 2017). Plus, both historical and contemporary efforts to conserve Patagonia and TDF coexist with activities related to extractive development (e.g., oil and gas exploitation), which is favored by particular social groups (Schweitzer 2013). Therefore, it is important to acknowledge that social imaginaries are not fixed, but rather vary among groups, constantly form and transform, and therefore should not be considered static or monolithic.

Finally, using the social imaginary as a socio-ecological approach to biological invasions can help to offer practical solutions and to conduct more relevant and targeted science, ultimately reducing society-management conflicts. For example, not only does invasion biology need more research on the process’s human dimensions, but there is also a need to enhance research on the introduction stage [e.g., Pauchard et al. (Pauchard et al. 2011) in Latin American and the Caribbean], and social imaginaries help to clarify the broader socio-historical drivers of species introductions, something that managers have been asking for to make better decisions and plans (Anderson et al. 2017). Though it focuses on the social imaginaries regarding the co-construction of species assemblages through introductions or control programs, this work also provides insights into the imaginaries regarding other environmental conflicts in the region and can be used as a stepping stone to facilitate understanding of issues like dams, mining and infrastructure projects, as well. A continuous analysis of contemporary and historic imaginaries can elucidate times or points of action that will foster participation and action. As such, social imaginaries open possibilities for action. The fact that neither nature nor society determine each other, but rather are co-produced through reciprocal relationships and mechanisms, including the practices analyzed by social imaginaries, enables scientists,

policymakers and the civil society to intervene for generating other natures and societies. If different natures have been produced through the entangled history of the social and the natural processes, it means we can promote imaginaries for other more sustainable natures and ecosystems.

Anthropogenic modifications to the environment now dominate planetary biogeophysical forces (Crutzen 2002). Yet, not only are current rates of ecological change unprecedented, but social transformations (e.g., migration, communication, etc.) are equally novel. In this context, it is imperative that we develop new understandings of global environmental change in terms of their integrated, socio-ecological dimensions. The socio-historical perspective of biological invasions obtained from this study illustrates that predominant social imaginaries can change over time, but importantly that they can also differ between social groups at the same time. Indeed, stakeholders can alternatively have elements of Colonization, Development or Conservation imaginaries at the same time, affecting how they conceive, value and manage the environment. Our findings regarding terrestrial and freshwater vertebrates represent only a portion of the species that are part of the socio-ecological systems we now know as Tierra del Fuego. There are also a great deal of introduced plants and invertebrates in the region. In particular, we would expect plants to be a large part of ‘nature-making’ *vis-à-vis* their use for symbolic, productive and ornamental purposes, while invertebrates are likely less linked to human–nature relationships and merely ‘passengers’ (and often undesirable consequences) of human movement. By providing this type of nuanced insights into the way humans have conceived and co-constructed nature in southern Patagonia for the last 160 years, we better bridge the gaps in the science of studying invasive species as a socio-ecological system, rather than merely a ‘biological’ invasion.

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