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Julia Astegiano, Jimena Andrieu, Matías Wajner, Victoria Marquez, Valentina Saur Palmieri, Julieta Karina Torrico Chalabe, François Massol, Ana Calviño, Fernando Zamudio

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Astegiano, Julia^{1,5}; Andrieu, Jimena²; Wajner, Matías¹; Marquez, Victoria¹; Saur Palmieri, Valentina³; Torrico Chalabe, Julieta Karina^{1,6}; Massol, François⁴; Calviño, Ana¹ & Zamudio, Fernando¹

¹ Grupo de Interacciones Ecológicas y Conservación, Instituto Multidisciplinario de Biología Vegetal, UNC, CONICET, FCEFyN

² Instituto Nacional de Tecnología Agropecuaria - Estación Experimental Agropecuaria San Juan (INTA EEA San Juan)-Dpto. Agronomía, Facultad de Ingeniería, Universidad Nacional de San Juan (UNSJ), San Juan, Argentina

³ Dpto. Div. Biológica y Ecología, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba-CONICET, Córdoba, Argentina

⁴ Univ. Lille, CNRS, Inserm, CHU Lille, Institut Pasteur de Lille, U1019 - UMR 9017 - CIIL - Center for Infection and Immunity of Lille, F-59000 Lille, France

⁵ Instituto Argentino de Investigaciones de las Zonas Áridas (IADIZA, CONICET-UNCuyo)

⁶ Cátedra de Ecología Agrícola, Facultad de Ciencias Agrarias, UNC

Abstract

The study of social-ecological networks (SENs) has mainly approached nature through a modern and functional to capitalism conception, i.e. a matrix over which human societies develop. Such a conception (1) neglects interdependencies among human and non-human entities and therefore

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between “culture” and “nature” *reproduction*, (2) assumes the existence of many cultures but only one nature, (3) understands nature as a pool of resources, goods or services that can be exploited, appropriated or enclosed, and (4) has been pointed out as one of the main causes of the current biodiversity crisis. Based on the work of sociologists and communitarian feminist scholars, here, we propose to conceive social-ecological systems (SES) as *the common*, i.e. systems that need to be produced through communal political practices that consider human-non-human interdependencies. In this vein, we introduce two frameworks related with the production of *the common*, relational ontologies and *other* economies, and present two examples applying them. One example helps rethinking the so-called “humans-wildlife conflicts”, by illustrating the emerging relational role of the “cabrero” (a livestock guardian dog) as a “mediator” of such conflicts, through the lens of ethnobiology.. The other example analyzes human and non-human co-production of SESs that produce (and are produced by) honey, honeybees and beekeepers’ *Social and Solidarity economies*. We think such perspectives may diversify ecologists’ understanding on human-human and human-non-human relationships and thus ecologists’ ideas about the representation of SENs and the *reproduction* of SESs as *the common*.

Keywords Ethnobiology; multiplex ERGMs; relational values; social, solidarity, popular and feminist economies; *the common*

1. Introduction

The way we conceive our relationships with nature clearly influences how we act as scholars, stakeholders and members of a community in the face of the current biodiversity crisis (Balvanera et al., 2022; Leff, 2002; Pascual et al., 2017). An increasing number of ecologists now emphasize the need to shift our perspective from ecosystems to social-ecological systems (SESs), which emerge as a result of human-nature relationships (Balvanera et al., 2022; Berkes et al., 2008; Díaz et al., 2018). This is in line with the impressive rise of studies on social-ecological

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Figure 2 (within Box 1)

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networks (SENs) in recent years (Kluger et al., 2020; Sayles et al., 2019). However, these studies mostly focused on the structure of either social or ecological interactions, and few ones have really challenged the full characterization of the social, ecological and social-ecological interactions that produce SESs (“fully articulated SENs” in Sayles et al., 2019; “type III networks” in Kluger et al., 2020; see also Barnes et al., 2017, and the third section of Labeyrie et al., 2021).

Even though SEN studies have advanced our understanding of human dependence on nature, they are still dominated by the modern conception of nature (e.g. Felipe-Lucía, 2022; Kluger et al., 2020; The QUINTESENCE Consortium, 2016; but see Sayles et al., 2019). Such a conception makes nature both external to society -i.e., nature is conceived as a matrix over which human societies develop- and universal -i.e., can be governed by universal laws established by modern sciences (Robertson, 2012; Smith, 2020). This implies that, even when the existence of several cultures is recognized, there is just one nature (Escobar, 2010), that in turn can be dominated and manipulated, and its *reproduction* (*sensu* Moore, 2020) can be separated from that of human societies (Moore, 2020; Smith, 2020). That is, a nature that neglects interdependencies between culture and nature. Thus, most current SEN studies may implicitly reproduce a narrative of human-nature relationships functional to capitalism, where nature(s) is(are) something that can be exploited, appropriated or enclosed by humans for value production, which ultimately is one of the main causes of the current biodiversity crisis (Escobar, 2016; Moore, 2020; Navarro-Trujillo and Linsalata, 2021; Navarro-Trujillo and Machado Aráoz, 2020). If the ultimate aim of SENs studies is to understand the *reproduction* of SESs in the face of such crisis, we urgently need to diversify our narratives about nature, i.e. to incorporate other conceptions of human-non-human interdependencies that may produce diverse and integrated *worlds* instead of obliterating them (Escobar, 2016; Haraway, 2016; Moore, 2020; Navarro-Trujillo and Linsalata, 2021).

In this vein, conceptualizing SESs, and therefore SENs, as *the common* that needs to be *produced* (Gutiérrez Aguilar and Rátiva Gaona, 2020; Gutiérrez Aguilar et al., 2016; Navarro-

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Supplementary Material

1. Icons credits for all figures used in the main text of the article

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Figure 1

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Trujillo and Linsalata, 2021; Roca-Servat, 2020) may be key to move forward. SENs studies have traditionally conceived commons as natural resources, goods or services, the maintenance of which depends on collective access and the use of which is regulated by collectively constructed norms (Barnes et al., 2019; Biggs et al., 2021; Felipe-Lucía et al., 2022; Ostrom, 2009; but see Mazé et al., 2021). In contrast, the framework based on producing *the common*, developed by sociologists and communitarian feminist scholars in the last two decades (Gutiérrez Aguilar and Rátiva Gaona, 2020; Gutiérrez Aguilar et al., 2016; Navarro-Trujillo and Linsalata, 2021), considers social-ecological goods and processes as parts of *the common* that needs a communal production. Such a framework builds on the idea of *the common* as being co-produced by humans and non-human entities, recognizing the dialectic nature of the web of life (Moore, 2020). This need of a communal production of *the common* is about establishing diverse, creative and situated spatiotemporal political practices of interdependence to produce human and non-human life (Navarro Trujillo and Linsalata, 2021). Thus, building SENs through the lens of frameworks that conceive SESs as *the common* may allow ecologists to diversify their ideas about interdependencies between human and non-human entities.

In this roadmap, we briefly present two frameworks (Figure 1), relational ontologies and *other* economies that, approached with the lens of ethnobiology and put into a dialogue with the production of *the common* framework may, from our own experience, diversify ecologists' ideas about interdependencies among human and non-human entities -i.e. about nature. We have built this proposal on a series of interdisciplinary seminars during which we have discussed the literature that exists across Ethnobiology, Political Ecology and Economy with a complex network approach. In this vein, we believe that by investigating how SESs components emerge in a relational way, i.e. they “are” because of co-constructed relationships between human and non-human entities, and how the cooperative and reciprocal human-human relationships that underpin *other* economies produce other human-non-human links, we may improve our understanding on the *reproduction* of diverse SESs.

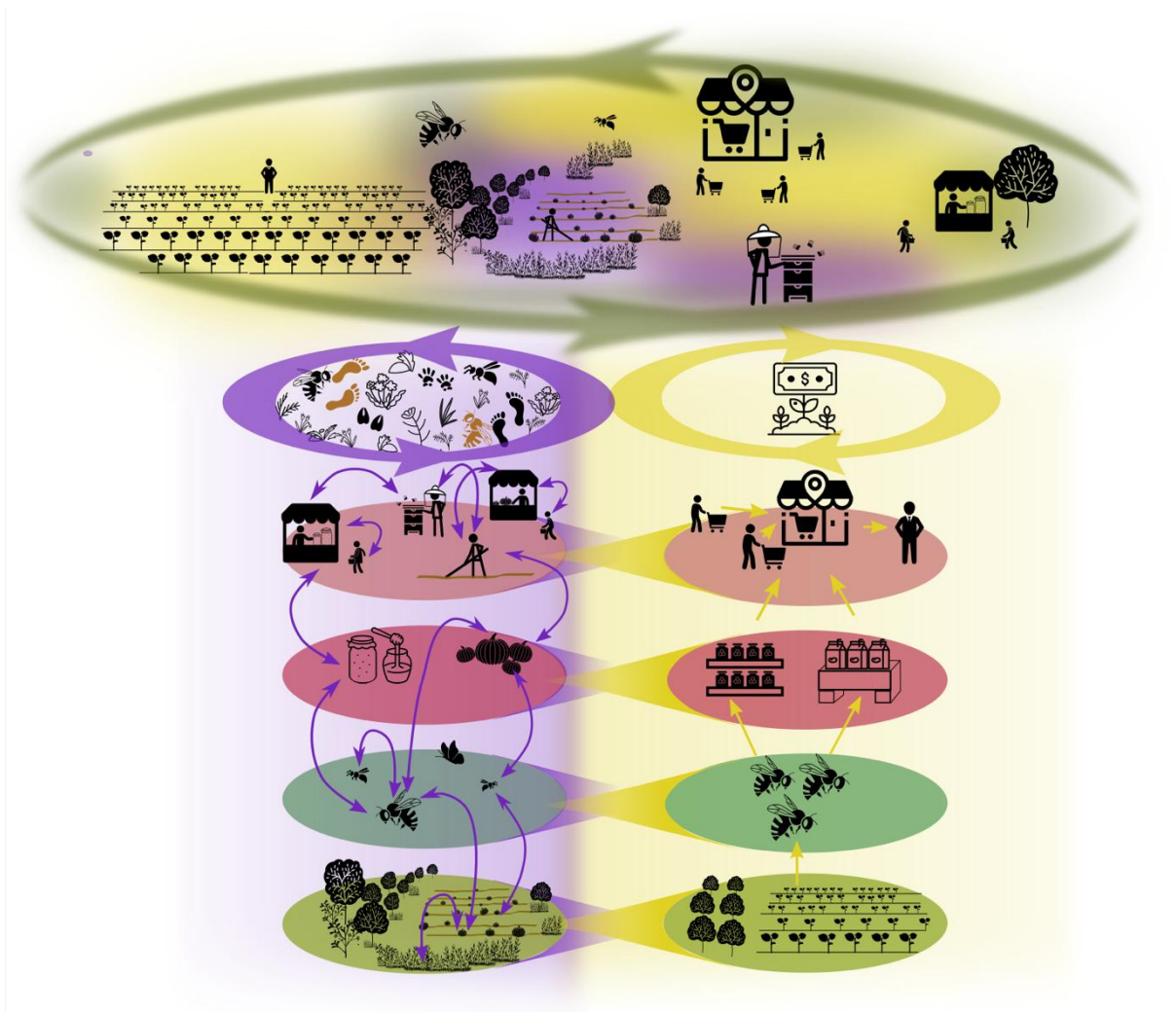


Figure 1. A simplified social-ecological system (SES) produced by two different social-ecological networks (SENs). A multilayered SEN based on relational ontologies and *other economies* that produce *the common* (the SES) is displayed on the left side of the figure. A multilayered SEN built under a modern conception of nature and a “total market” economy (see section 2.2. *Other economies*) is displayed on the right side. Asymmetric relationships showing how the hegemonic SEN exploits, appropriates and encloses what is *commonly* produced (*the common*) is illustrated by overlapped color composition in the middle of the two SENs. From bottom to top, the layers represent: land, wildlife, goods and humans. Ontologies underpinning such layers and their related links are shown at the top, depicted by violet and yellow circular arrows. The complex social-ecological system (SES) that emerges from the integration of the two SENs is at

the top. Icons are from the Noun Project (<https://thenounproject.com>). Details on icon credits are in Supplementary material_S1.

2. Diversifying ideas about human-non-human interdependencies: frameworks that built social-ecological systems as *the common*

2.1. Relational ontologies and values

2.1.1. Relational ontologies

In the last two decades, ecologists have produced diverse SENs to represent complex SESs and facilitate our understanding of relationships among humans and nature, in order to propose management strategies to preserve such systems (Kluger et al., 2020; Sayles et al., 2019). The adoption of a social-ecological perspective of networks, formerly characterized as “ecological”, made explicit the human impacts on nature by highlighting interactions among the “social” and the “biological” components of a given landscape (Biggs et al., 2021). That academic change certainly helped integrate such components and thus build the idea that SESs emerged from social-ecological interactions (Felipe-Lucía et al., 2022; Kluger et al., 2020). However, the naturalistic modern conception of the world based on the culture-nature dichotomy dominates the SEN literature and, therefore, our understanding of SESs, which fails to represent the complexity of biocultural landscapes (Toledo and Barrera-Bassols, 2008). This is an interpretative bias that prevents us from noticing the coexistence of multiple *worlds* and identifying the social-ecological relationships that may produce them, obliterating the conception of each SES as *the common* that we need to co-produce with non-human entities.

Relational ontologies encompass ways of being and living that are quite different from the individualistic narrative imposed by modernity (Escobar, 2016; Hernando, 2018). Relational ontologies assume that things and beings do not preexist the relations that constitute them, in other words, they are their relations (Escobar, 2016). With the lens of relational ontologies, new

worlds emerge beyond the one conceived under the modern culture-nature dichotomy, dissolving the limits that such dichotomy imposes on our understanding of SESs. *Worlds* are constituted by particular entities that acquire a sense of existence based on the rules and codes of each world (Blaser, 2009; Descola, 2012; Viveiros de Castro, 2013). Within the relational ontology approach, humans coexist and co-construct *worlds* with other entities, i.e., *worlds* are *enacted* by relations (Escobar, 2016; Varela, 1999). Thus, it can be easily recognized how the adoption of the relational ontology approach by ecologists developing SENs may encourage them to diversify ideas regarding the co-production of SESs (the common) by human and non-human entities.

In the SEN representation of SES, relationality is easy to conceptualize because networks focus on interactions between the system's parts. Each entity is related to the position it occupies in the network of interrelations with other entities. Following the relational ontology approach, entities are conceived in a particular and unique way in each *world*. In a SEN, nodes cannot be understood in isolation from the links they weave with other nodes, a conception that is key to understanding how relationships between entities *enact* each world (*sensu* Varela, 1999; see a recent use in Louafi et al., 2023). In this vein, ethnographic studies unraveling the conflicts underpinning wildlife conservation may provide insights on the relationship between the emergence of conflicts and the different ontological backgrounds of local and foreign actors of the territory, and on the importance of non-human entities in “mediating” conflicts by being part of a more-than-human sociability (e.g. Blaser, 2009; Furlan et al., 2020; Manzano García et al., 2017; Marquez et al., 2023; Martínez-Dueñas and Perafán Ledezma, 2017; Martínez-Medina et al., 2022; Tsing, 2013 ;Box 1).

2.1.2. Relational values

A relational ontology approach can also help ecologists think critically about the diversity of ways in which the values of social-ecological goods and processes are created, and to visualize the importance of considering such values within *the common* that needs to be co-produced.

Social-ecological goods and processes have been defined by classic ecology as either “ecosystem services” (Mulder et al., 2015) or, more recently, as “nature contributions to people” or “nature-based solutions” (Díaz et al., 2018; O’Hogain and McCarton, 2018; Pascual et al., 2017). In this vein, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has mainly considered values as intrinsic -value as an end-in-itself or not linked to human purposes- or instrumental -as a means to an end- (Balvanera et al., 2022), and only recently started to include the idea of relational values as another category for specific values (e.g. Unks et al., 2021). Relational values, by contrast, emerge, when importance shifts from values attached to “things” to values derived from “networks of relationships and responsibilities” (Chan et al., 2018). If entities do not preexist the relations that constitute them (Escobar, 2016), such a thing as intrinsic value does not exist. Only relational values remain. Entities do not just have instrumental value, they may have value through the relations they are part of (Tsing, 2015). This contrasts with the logic of capitalism where entities can be torn from their worlds to become objects of exchange. Although tightly related with understanding the value of nodes (entities) and links in SEN (e.g. Felipe-Lucia et al., 2022), such a different conception of specific values has been poorly explored in SES studies using the network approach.

BOX 1. Constructing ethnobiological social-ecological networks (ESEN) to integrate relational ontologies and values into SENs and conceive SESs as *the common*

Defining SES components (nodes) and relationships (links) and, thus, what “is” and what “is not” a SES, has so far been limited to scientists trying to do a big effort to address the incommensurability of socioecosystems (see Ludwing and El-Hani, 2020). This is, in part, why an integrated analysis of “social” and “ecological” elements remains challenging (Bodin et al., 2016; Cumming et al., 2010). Nodes and links may be differently conceptualized by ecologists, social scientists and local people, who use different systems of classification, epistemologies and have different scopes or *worlds* (Bodin et al., 2019; Felipe-Lucía et al., 2022; Kluger et al., 2020;

Sayles et al., 2019). In this regard, ethnobiology investigates relationships between societies and “nature(s)” from multiple perspectives; utilitarian, cognitive, and more recently relational (Hunn, 2007; McAlvay et al., 2021; Wolverton, 2013). It is a transdisciplinary science that integrates ecological and evolutionary theory and social sciences methodology (Casas et al., 2015; Albuquerque et al., 2014) and can be conceived as another form of “scientific knowledge” (Furlan et al., 2020). Therefore, ethnobiology may improve our ability to diversify SES representation by broadening the notions about nodes, links and the emergence of values as part of *the common* that needs to be co-produced by the SEN, since this discipline can deeply explore both academic and local knowledge systems. Considering the relational value framework (Chan et al., 2018), ethnobiology may also create space for systematizing expressions and practices about what matters to people on their own terms.

Until now social network analysis has focused on environmental management and local ecological knowledge and has used the interpretative power of SENs mainly to study information transmission, resource governance or seed circulation (Salpeteur et al., 2017). SENs have mainly analyzed relationships between different social actors around “resources” or “common goods” (reviewed in Salpeteur et al., 2017) or those between plant species and plant ecosystem services, represented by people’s knowledge about plants and their uses (e.g., Cámara-Leret et al., 2019). However, such studies have poorly explored how people or communities self-perceived the links between them and the “used”, “exploited” or “managed” nature. That is, how relations with non-humans were conceived, and therefore, how they were represented by ideas, knowledge, practices and cosmologies of local people. In this vein, relational states and relational events of dyadic (pairwise) links have been defined by questions formulated by scientists (*etic* SEN) and not by the local population (*emic* SEN; see Salpeteur et al., 2017). Changing “who” defines the nodes and the links and, therefore SENs, could certainly shed light on ways of diversifying our understanding of SES through the lens of relational ontologies and *other* economies (see section 2.2.). Such networks can be referred to as *ethnobiological social-ecological*

networks (ESENs). ESENs may differ from other already formulated SENs in at least two main points. First, as previously mentioned, the way and the type of information researchers use to construct nodes and links. For example, considering local taxonomies for node definition, as local and scientific classification does not always coincide (Martínez-Medina et al., 2022), and the type of relationship (and relational value assigned) obtained in narratives to define links. Second, the direction and intention of the question(s) through which the SENs are built. For instance, investigating the origin and destination of seeds will be different from inquiring about the entities that are linked to seeds. The first question will inevitably refer to a person (markets, gardens, etc.) while the second one is likely to lead us to a diversity of human and non-human entities and relationships, like non-animals included in myths, animals as birds and mammals included in the extended socio-ecological web in which seeds may be involved (e.g. Kujawska et al., 2020).

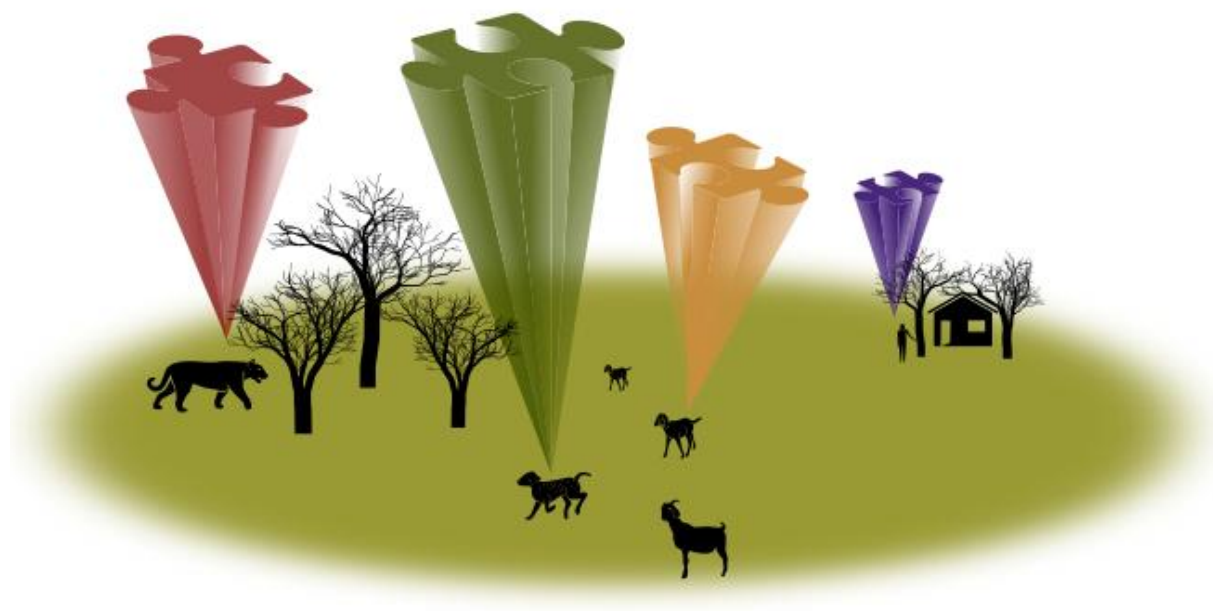


Figure 2. Relational ontologies in the arid Chaco, central Argentina (Marquez et al., 2023). To avoid livestock predation by the *Puma concolor*, peasants breed the “cabrero” (usually a dog) that takes care of goats when they are feeding in the “monte” far from the pen. The “cabrero” acts as a livestock guardian dog and becomes part of the more than human sociability of the arid Chaco. . This dog is important in peasant social life because of its role as

“mediator” of conflicts between humans and non-humans (e.g. goats, *Puma concolor*) and, ultimately, among humans (e.g. peasants, conservationists). . The “cabrero” has their own agency; hence, the “cabrero” along with humans co-produce the SES that they inhabit (and that produce them; Tsing, 2013). Icons are from the Noun Project (<https://thenounproject.com>). Details on icon credits are given in Supplementary material_S1).

We think that ESEs can contribute to broaden our notions of SESs by both allowing access to the diversity of ways of understanding (socio)ecological complexity and to the *emic* ways in which relationships (reciprocity, commensalism, or predation) between entities are conceived, and thus creating tangible and empirically accountable visual representations of local conceptualizations of SESs (*the common* that needs to be produced; see Atran et al., 2002; Levine et al., 2015). Following the proposal of Levine et al. (2015), the use of ESEs can particularly help analyze environmental conflicts derived from the clash between the multiple ideas that compose different *worlds*. For example, “conflicts” between rural producers and the puma (*Puma concolor*) in the arid Chaco of central Argentina are generally conceived by scientists as a typical human-wildlife fauna conflict arising from puma predation on goat herds (Marquez et al., 2023). However, such a conflict can be conceptualized as a conflict between rural producers and conservationists that want to produce a different SES, i.e. a human-human conflict (Blaser 2009) that affects the production of the common, or even as a condition in which the “cabrero” (i.e., the livestock guardian dog), by acting as an “intermediary” of the conflict between humans and non-human animals (Fig 2; Marquez et al., 2023), allows the production of a SES in which peasants can coexist with the puma. In this vein, following Goldman et al. (2013) and their study on lion hunting in Africa, we can propose that the conflict around the pumas (Figure 2) is about “*the overlap of motivations that are simultaneously social, emotional and political*” (Goldman et al., 2013: p.

490). That is, to a series of relational values that are supported by a particular relational ontology that produces a particular SES.

2.2. *Other economies*

Inquiring about the production of *the common* implies recognizing how social-ecological interactions become functional to capital, to the construction of *other economies* or both (Gutiérrez Aguilar and Rátiva Gaona, 2020). In the words of Gutiérrez Aguilar and Rátiva Gaona (2020: p. 44; personal translation by J. Astegiano), the production of *the common* “(...) far from showing an essentially harmonic or transhistorical view of communitarian relationships or of human relationships in nature, this framework enlightens a deep sense of interdependence that emerges from the concrete action of work -collective and individual- and from the imprints of non-human entities on human social life”.

Thus, (re)producing *the common* is about “*the multiform productive activity that generates and re-actualizes ties and shared meanings beyond, against and beyond the separations imposed by capital accumulation*” (Gutiérrez Aguilar and Rátiva Gaona, 2020: p. 50; personal translation by J. Astegiano).

Understanding each SESs as *the common* through the lens of complex networks will imply that SENs are constructed based on those economic perspectives that incorporate the life-capital conflict into their formulation. We are interested in introducing the *other economies*' framework as the value systems of such economies may allow ecologists to focus on the *reproduction* of the web of life (and not profit). By characterizing SENs using such value systems we want, first, to establish a distance from those frameworks that link economic relationships with the idea of a “total market”, defined by Coraggio (2009: p. 2): “*the dominant paradigm (...) proposes a universal answer to the question of which is the best system to optimize the use of the scarce resources (...) That solution is the market, which, when considered as an exclusive rational institution, results in the “total market”*”. Second, we want to highlight the need to *make visible the invisible*, which means to explicitly recognize interdependencies between humans and non-human entities and its dialectic relationship (*produce*

/ *be produced*; Moore, 2020; Navarro Trujillo and Linsalata, 2021). Third, we want to go beyond the split imposed by the “*total market*” on labor and use and exchange values (Gutiérrez Aguilar and Salazar Lohman, 2019). Last, to recognize that such *other* economies can be functional to the *reproduction* of capital but, we insist, at the same time can show ways that *disconnect* them from the logics of capital and create new logics *beyond* those of capital, enabling the emergence of other human-human and human-non-human relationships that may produce *the common*.

2.2.1 Social, solidarity, popular and feminist economies

The economic perspectives embraced under the term *other* economies are those that problematize the neo-classical economic logic (i.e., an individualistic and universal logic centered in the *homo aeconomicus*) and discuss the role of capital and the “*total market*” (Coraggio, 2009).

Social Economy denotes the idea that every economic practice needs to be interpreted linked to its social aspect and the other multiple dimensions which make up the context of that practice (Coraggio, 2009). *Social Economy* can also be defined by the actions of entities that assume different legal forms to organize economic activities (e.g. cooperatives, mutual aid organizations or associations; Chaves-Ávila and Monzón-Campos, 2019). *Solidarity Economy* brings shared values (e.g., cooperation, reciprocity, communalism,) as central to conceive economic rationality, decentering such rationality from both individuals and monetary profit (Miller, 2010; Razeto, 1999). A different value system is also proposed as a project in which the boundaries between each perspective (*Solidarity* and *Social Economies*) are not drawn rigidly (Razeto, 2010, 1999).

Popular Economy, in turn, broadens the definition of work beyond the crisis of formal employment in the context of social exclusion systematically imposed by the logic of capital accumulation (Weeks, 2014). The emergence of this economic perspective is usually attached to the context of social emergency and increased labor informality that characterize the recurrent “social-economical” crises in Latin America (Chena, 2018; Fernández-Álvarez, 2018; Roitman, 2021). However, we are interested in highlighting the possibility of experimentation with both theory

and praxis to “*empower and expand the scope of (...) people’s lives*” that such practice brings (Gago, 2018: p. 1).

In the context of our proposal, it is also important to consider a central discussion developed by feminist economies (Rodríguez-Enríquez, 2012): which work is recognized as productive (and which not), and which is paid (and unpaid). In this line of thought, highlighting the inter-relationship between care work (invisible) and productive work (visible) will be key to go beyond the discussion of gender economic inequalities expressed *just as* a lower participation of women in productive work and a higher participation in care work (Rodríguez-Enríquez, 2015). We consider that these discussions that take place in the theoretical and practical framework that defines feminist economies will help ecologists make *visible* the *invisible* that builds SENs and, therefore, *reproduces* SESs in two important ways. First, by transforming unpaid care work into paid work as a mechanism to make it *visible*, the discussion about the role of salary as a way to recognize interdependencies between productive and reproductive work (i.e., care work) will be introduced (Denning, 2010; Federici, 2018; Rodríguez-Enriquez, 2016; Weeks, 2014). Second, by solving the unrecognition of care work in a different way from that proposed by the “*total market*” (i.e., individually and paying for care services), feminist economies will introduce a discussion on the centrality of communal care to produce *the common* and, therefore, to reproduce human and non-human life (Navarro-Trujillo and Linsalata, 2021; Perez-Orozco, 2021; Rodríguez-Enríquez, 2012).

Sociologists and communitarian feminists scholars provide key elements for recognizing other forms of organization within, against and beyond capitalism by placing communitarian work on the roots of producing *the common* (Gutiérrez Aguilar and Rátiva Gaona, 2020). There is “*(...) a necessary work for the reproduction of the common as a social relation with power to create material wellness and political strength*” (Gutiérrez Aguilar and Rátiva Gaona, 2020: p. 56; personal translation by J. Andrieu). Such community-based work can assume multiple forms and can present its own spatio-temporal specificities (Gutiérrez Aguilar and Salazar Lohman, 2019). These forms of

relationship potentially go beyond the logic of the “total market” and the conflict capital-life, although sometimes they are not exempt from contradictions (Andrieu and Eliosoff Ferrero, 2019). Thus, the crossovers with *other* economies are opportune; even if the coincidences we find are involuntary and can show contradictions (Villalba-Eguiluz et al., 2020).

BOX 2. Human and non-human co-production of SESs: *commoning* honeybees, honey and beekeepers’ economies

Argentina is one of the main honey producers worldwide (Andrieu et al., 2021a). 63% of beehives are concentrated in the central pampas, where most produced honeys are “monofloral” and light yellow, and an exportation-oriented economy based on the supply-dependent paradigm of “the green revolution” dominates honey production (Andrieu, 2020). Overall, honey in Argentina is mostly conceived and produced as a commodity (Folguera, 2021; Nimmo, 2015). Moreover, honeybees are mostly treated as conventionally managed cattle, i.e. beehives are supplied with different synthetic substances that either feed (“sugar syrup” and “protein cakes”) or treat them against different diseases (Nimmo, 2015; Salizzi, 2014; Shanahan, 2022). Honey is also produced in other SESs, such as those found in the Cuyo region in western Argentina. These SESs, and the honeys they produce, are conceived as *marginal* because of their small contribution to the exportation market, which mostly commercializes undifferentiated honey (Andrieu et al., 2021a). Interestingly, such marginalized SESs produce a high diversity of honeys in terms of colors -brown or dark yellow-, flavors, consistency (Andrieu et al., 2021b), and pollen and nectar-supplying species that feed honeybees (and other bees) and make honeys “multifloral” (Andrieu, 2023). Beekeepers’ management practices are also diverse, ranging from agroecological practices (i.e. with almost no supply of provision to beehives and a strong focus on the analyses of honeybee food and water sources to decide beehives location) to those highly dependent on supplies (Andrieu, 2023). Such a diversity in the way honey production is conceived *is necessarily produced by and will produce* different relationships among beekeepers, and

between beekeepers and other people producing “food” for honeybees (e.g. agroecological farmers) as well as beekeepers and honeybees (Cely-Santos, 2020; Gutiérrez Aguilar and Rátiva Gaona 2020; Navarro Trujillo and Linsalata, 2021; Nimo, 2015; Shanahan, 2022). Therefore, in these SESs, honey is more than a commodity; it is also about nourishment, commensality, encounters between humans and non-human entities, and the production of flavors and colors that co-produce the web of life.

The work of beekeepers is also organized in a diversity of collective forms in the Cuyo region, including traditional forms of the *Social Economy* such as cooperatives, but also others more related to the *Popular Economy* (Andrieu et al., 2022). Thus, collaborative practices and forms of reciprocity that are rarely considered as “labor” by the “total market” economy may be key for honey production (Denning, 2010). Moreover, as most beekeepers need to negotiate the land to their beehives (Andrieu, 2020), collaborative practices among beekeepers may influence the way they relate with landowners. Land negotiations, in turn, may imply paying a rent but usually may be associated with other relationships like gifting some produced honey, offering honeybees to pollinate crops, buying farmers’ production or just starting a friendship. Thus, beekeeping in the Cuyo region can be understood in terms of a collective (economic or social-ecological) practice that (re)produces *the common* (the SES that produces honey, honeybees and beekeeping itself), by diversifying both human-human and human-non-human relationships that reproduce life (Andrieu, 2020).

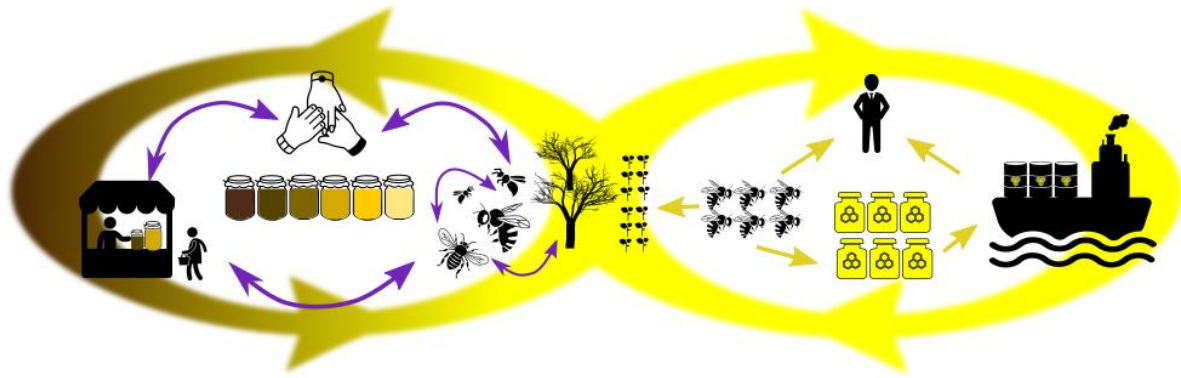


Figure 3. Economies and the production of SESs: : beekeeping practices that co-produce (or not) the common. Simplified SENs depicting relationships (i.e., links) among human and non-human entities promoted by other economies (e.g., cooperation, reciprocity, production of *the common*) and “total market” economy (e.g., exploitation, appropriation, and enclosure of *the common*) are shown, respectively, on the left and right sides of the figure. Circular arrows represent the emergent honeys as exemplified with the argentinean study case. Icons are from the Noun Project (<https://thenounproject.com>). Details on icon credits in Supplementary material_S1.

2.3. Characterizing SESs as *the common*: How the network approach can help us

The study of networks resulting from SES studies and the building blocks that produce and are produced by *the common* (the SES itself) can make use of a variety of existing tools, from a variety of disciplines including social sciences and statistical ecology. Social network analysis has made heavy use of models to explain the occurrence of links (e.g. reciprocity relationships among people) in networks based on the rest of the other links and external variables (e.g. people belonging to different social groups), culminating with exponential random graph models (ERGMs; Handcock et al., 2008; Jasny et al., 2018; Robins et al., 2007; Snijders et al., 2006) as one of their most theoretically advanced statistical methods (Jasny et al., 2019; Labeyrie et al., 2016). Although initially conceived to deal with networks with only one type of links (e.g. social

networks or bipartite ecological networks), recent developments have led to the use of multiplex ERGMs (Barnes et al., 2019; Ferrare et al., 2021; Guerrero et al., 2015; Wang et al., 2013), i.e. models which could explain the occurrence of a social link (e.g. cooperation between a beekeeper and a farmer) based on other social links (e.g. cooperative relationships among beekeepers) and associated social-ecological links (e.g. beekeepers locating a beehive in a farm that produces a crop that feeds honeybees and whose reproduction is facilitated by them). Thus, which cooperative or reciprocal links among humans and non-humans co-produce *the common* (e.g. the SES that produces and is produced by honey production), can be evaluated with multiplex ERGMs.

Another important tool for such studies is the family of stochastic block models (SBM; Govaert and Nadif, 2010, 2008), which aim at defining groups of nodes (blocks) that interact in a similar fashion, i.e. such that the patterns of interactions within and among blocks can be the most efficiently modeled with as few parameters as possible. In this vein, using ethnobiological and social methods (e.g. structured, semi-structured and in-depth interviews or participant observation research; Albuquerque et al., 2014) to define which set of social practices are produced as and can be characterized as communal forms of politics oriented to produce *the common* will be crucial (e.g. Box 1 and 2). As SBM approaches have drawn the interest of ecologists for some time (Baskerville et al., 2011; Leger et al., 2015; Miele and Matias, 2017), they have been progressively adapted to the study of SENs. SBMs have been extended to multipartite (i.e. networks in which nodes belong to different levels and never interact with a single level) and multilevel/multiplex networks, which make them a tool of choice for the analysis of multiplex networks such as SEN (Bar-Hen et al., 2020; Chabert-Liddell et al., 2021).

While networks provide an important tool for the study of SES as *the common*, it is worth keeping in mind that networks only represent pairwise interactions between entities (nodes), and thus fail to accurately represent non-pairwise interactions, i.e. interactions that involve three or more entities (Felipe-Lucia et al., 2022). Non-pairwise interactions can most often be

“rearranged” into multipartite networks – e.g. communal actions such as communal flailing of harvested millet (Gariné, 2001) could possibly be represented using a bipartite network with farmers on one level and flailing groups on the other – but this is not necessarily the best representation to evidence social-ecological relationships, especially when the nodes involved in non-pairwise interactions are of different types (e.g. when interactions are management discussions involving individuals, institutions, and several wildlife species). Another choice of representation is the hypergraph, which works on all types of interactions (pairwise or otherwise), and has begun to garner some interest from ecologists (Golubski et al., 2016). However, the above-mentioned methods (ERGM and SBM) are not yet fully functional for the study of large hypergraphs (but see Brusa and Matias, 2022 for small hypergraph SBMs).

3. Final remarks

We wrote this roadmap because we believe that it is time for ecologists to question the hegemony of the culture-nature dichotomy imposed by modernity on the construction of SESs as SENs. We urgently need to find frameworks that help us generate *other* understandings around collaborative interdependencies between humans and non-humans that *reproduce* the web of life (SESs, *the common*). Many scholars have previously highlighted such a need and proposed other *starting points* (Despret, 2022; Federici, 2020; Haraway, 2016; Thomsen et al. 2022). In this vein, disturbance-based ecologies, in which many species sometimes live together without either harmony or conquest, has been recently proposed by Tsing (2015). As she states “*We are contaminated by our encounters; they change who we are as we make way for others*” (Tsing, 2015: p. 26). Because of these transformative encounters, the idea of conceiving a SES as *the common*, which produces and needs to be produced by communal political practices promoting both human and non-human lives, is promising. We advocate for the potential of relational ontologies and *other economies* to build more diverse ideas of social relationships co-producing (and being produced by)

the common. These frameworks in dialogue with current ethnobiological approaches may certainly help ecologists think about “a world where many worlds fit” (*Zapatista dictum* in Escobar, 2016).

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To all communities that allowed us to know and to enact *other worlds*.

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