



Principles for interdisciplinary research in social-ecological research: using analogical reasoning to build epistemological bridges

Juan Fernández-Manjarrés

► To cite this version:

Juan Fernández-Manjarrés. Principles for interdisciplinary research in social-ecological research: using analogical reasoning to build epistemological bridges. 2022. hal-03870526v2

HAL Id: hal-03870526

<https://hal.science/hal-03870526v2>

Preprint submitted on 20 Nov 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

Principles for interdisciplinary research in social-ecological research: using analogical reasoning to build epistemological bridges

Juan Fernández-Manjarrés^{1,*}

¹Ecologie, Systématique Evolution, CNRS, AgroParisTech, Université Paris-Saclay, 91405, Orsay, France

***Correspondence:** juan.fernandez@universite-paris-saclay.fr

Citation : Fernandez-Manjarrés, J.F. 2022. Principles for interdisciplinary research in social-ecological research: : using analogical reasoning to build epistemological bridges.

Unpublished manuscript, Working paper version: 1.1 November 2023

Abstract

There is ample consensus that interdisciplinarity between ecology and the social sciences is a prerequisite for solving complex biodiversity and environmental problems. However, differences in theories, concepts, methods, and data types hamper the efforts of many young students or experienced researchers in ecology that have not been exposed to the social sciences before. This paper argues that for certain types of questions where parallels can be drawn through analogical thinking between the ecological and social sciences, extending the set of principles of ecological theory from Scheiner and Willig (2008) can facilitate interdisciplinary research. The extended principles presented here build on notions of spatial patterns, interactions, contingency and temporal change (evolution) that are also studied by the social sciences. The proposed non-mutually exclusive principles belong to two main types depending on the study object: *i*) humans *per se* as ecological agents and *ii*) ecological knowledge in the broadest sense. Examples are given from the literature of ecological scientists borrowing methods from the social sciences and vice versa, and asking questions similar to the extended principles proposed here. The extended principles can be used as a starting point for students of ecology to tackle complex problems, encouraging further interdisciplinarity in a more systematic way. A tentative curriculum for a graduate seminar discussing the different principles is provided at the end of the text.

Keywords: ecological principles; interdisciplinarity; graduate education; social sciences

Introduction

What do the ecological models of prey-predators, ideal free distribution and ecosystem function have in common? That they all have helped develop ideas by analogical reasoning in the social sciences. The principles of predator-prey models of Lotka and Volterra, originally borrowed from chemical reaction dynamics, have been used widely including the behavior of stock markets (Marasco et al. 2016). Ideal free distribution studies originally developed for understanding how animals minimize competition, have been applied to understand the patterns of nomad pastoralism and patch resource (Moritz et al. 2014). Currently, ecosystem theory is informing enterprise management studies (Hou and Shi 2021, Tsujimoto et al. 2018).

Likewise, ideas from the social sciences have allowed several important breakthroughs in ecology and evolution. For instance, the familiar formulas of gene diversity were borrowed from early 20th century studies in economics (Stirling 2007). Perhaps the most famous example of analogue thinking between the social sciences and ecology and evolution were the insights Charles Darwin got from reading Humboldt's accounts of human population differences in the Canary Islands. As population size was uncorrelated to island size but rather to resource availability, Humboldt's readings of Malthus human population growth hinted him that resource availability was the limiting factor as the larger islands were not necessarily the most populated. A straight forward analogy for Darwin to explain resource competition and population growth was then finally available (Egerton 1970).

Analogical reasoning is a well-known step in interdisciplinary research (Newell et al. 2001, Szostak 2017). Ideas from one discipline often get adapted and transformed within another discipline without implying that the borrowing discipline presents a weaker theoretical foundation than the borrower. The analogical phase is not alone during an interdisciplinary process, and is part of a larger creative process that includes observing, imaging, abstracting, recognizing patterns, forming patterns, modeling, transforming, and synthesizing among others (for an in-depth analysis see Spooner et al. 2004). This kind of interdisciplinary that borrows concepts has been called 'informed disciplinarity' where disciplinary questions require outreach to one or more disciplines (Lattuca 2001, Musacchio et al. 2005). This is different from questions that seek to link disciplines to create new disciplines by synthesis, or whose objective is to transcend from the science circles to decision makers and stakeholders (transdisciplinarity).

69 If an iterative borrowing process happens for long time, maybe a new subdiscipline or
70 field may emerge, as molecular ecology or landscape ecology, to cite two familiar
71 interdisciplinary fields. This process of interdisciplinary borrowing work may take decades of
72 sorting success from dead-ends and may or may not, call for an overreaching theoretical
73 synthesis beyond the anecdotic analogy. The farther the distance between the disciplines
74 involved, the harder it appears to find any bridges that can initiate an interdisciplinary dialog,
75 a situation well known between ecology and the social sciences (Barthel and Seidl 2017).

76 The biodiversity and environmental crises that we are currently experiencing have
77 challenged and continue to challenge the disciplinary structure of faculties across the world.
78 This is not a new issue, but something that has been on the agenda of several higher education
79 institutions for at least 30 years now (Newell et al. 2001, Pickett et al. 1999). Graduate and
80 post-graduate education programs need to keep up pace with complex societal demands if
81 they are to survive in the long term. Collaboration between social scientists and applied
82 ecological practitioners has gained momentum in conservation science (Hintzen et al. 2020),
83 and its collaboration has been widely promoted for several years (Lowe et al. 2013, Lowe et
84 al. 2009). In this regard, conservation biology is currently viewed within the broader field of
85 conservation science using approaches that now include work at the scale of social-ecological
86 systems (Mace 2014) with concepts like environmental justice placed at the fore (Gould et al.
87 2018). Likewise, calls for joint work between the natural and social sciences have been
88 repeatedly made in sustainability studies (Clark and Harley 2020). Nevertheless, there is still a
89 lack of consensus about how to generate the kind of interdisciplinary required, mainly
90 because of the large number of disciplines and subdisciplines potentially involved in
91 interdisciplinary research. For instance, sustainability research has been described as an
92 “archipelago” of disciplines (Haberl et al. 2016) where interdisciplinarity is dictated by the
93 questions at hand, and collaborations are idiosyncratic.

94 Lack of exposure to different epistemological frameworks (theories, concepts,
95 methods, and data) during undergraduate and graduate studies are commonly cited by
96 graduate students as recurrent obstacles for effective interdisciplinarity (Killion et al. 2018).
97 Indeed, words of caution have recently been expressed, as hasty interdisciplinarity by
98 ecologists may produce research without theoretical depth, and in some cases, it may even
99 provide wrong insights regarding human decision processes (Cooper and Larson 2020). The
100 question thus arises as to how to better train students who can potentially call on

interdisciplinarity to engage in a dialogue with colleagues in other disciplines if the question at hand so requires it without losing the perspective of their own fields.

What exactly is expected from ecologists?

As the ecological sciences are a collection of disciplines (Cooper 2007, McIntosh 1986), ecologists are as varied as they come. However, ecologists are appealed to as experts, not only because ecology is seen as the science of interactions (which follows from its more frequent definition), but also because there is an “ecological perspective” when looking at problems. Ecologists’ contribution can include, among others, theories, concepts, and methods to study the spatial and temporal distribution of organisms, contingent events that have shaped past and current biodiversity, and the study of constant biotic and abiotic change omnipresent in all environments affecting one organism in one way or another. An ecological perspective would therefore involve identifying very general concepts that can be understood by different disciplines. Some fundamental general concepts or principles in ecology have already been identified by Samuel M. Scheiner, Michael R. Willig, and others, as components of an ongoing construction of a general theory of ecology (Scheiner 2010, Scheiner and Willig 2008, Scheiner and Willig 2011, Vellend 2010, 2020). The challenge would therefore be to ask whether these ecological principles, if extended, could guide students from their foundations in ecology toward an interdisciplinary dialogue with the social sciences, without replacing the perspectives of the latter.

Here, as an educator rather than a philosopher of science, I would like to address some practical challenges faced by students trained in the natural sciences. To this end, I will first extend by analogy the eight principles of ecological theory proposed by Scheiner and Willig (2008) to outline potential interdisciplinary links between some ecological concepts and analogous ideas in the social sciences; second, I will provide some examples from the literature that address issues similar to the extended principles to demonstrate their usefulness; and finally, I will outline an introductory syllabus to help students and educators in ecology initiate a dialogue with the social sciences.

Using a suitable definition of ecology

Before elaborating their principles, Scheiner and Willig opted for a less common definition of the ecological sciences. In contrast to the more widespread definition of ecology as the science that studies the relations between organisms and their biotic and abiotic

environment, these authors used a slightly different description: “*The study of the spatial and temporal patterns of the distribution and abundance of organisms, including causes and consequences*” (Scheiner and Willig 2008). They explain that the word “causes” encapsulates the environmental limitations that determine why organisms occur where they do. In turn, the word “consequences,” encapsulates the process of competition, exclusion and of course the functional aspects of energy and matter flows resulting from their distribution, among others.

Principles of ecology: The starting point of an interdisciplinary dialogue

The word “principles” has been used in various ways in relation to scientific disciplines. For many authors, when we refer to principles it is frequent to state the obvious, and sometimes are called “truisms”. Here, we also retain the definition of principles given by Scheiner and Willig (2008) as “broad statements about empirical patterns and the processes that operate within a [research] domain.” In the context of ecology, the research domain or main subject of study defined by these authors is “*the spatial and temporal patterns of the distribution and abundance of organisms, including causes and consequences*” which follows the above definition.

The question that naturally follows is thus: what are some potential domain of interdisciplinary studies that ecologists may conduct in collaboration with social scientists? For many current scholars, this domain already exist and it would be the social-ecological system (Levin et al. 2013). Here, I prefer to present a domain description that is not based on the theory of complex adaptive systems on which social-ecological system research relies. Instead, I approach the issue of defining the domain at an even more general level as the “*spatial and temporal patterns of the distribution and abundance of humans within ecosystems, including causes and consequences*” (my own definition). This definition of the domain will fit many disciplines like geography, history, ecological anthropology, and environmental sociology, which allows us to focus on similarities between disciplines instead of their differences. Many readers would argue, with reason, that this domain is not new and that it has been the *raison d’être* of the branch of sociology known as human ecology (Christensen 2014, Visvader 2017, Young 1974), which is perfectly coherent with the reasoning I am trying to develop here.

In addition to studying the causes and consequences of the distribution of humans as stated above, interdisciplinarity would further be facilitated in some cases if a second related

domain were proposed, namely that of “*studying the causes and consequences of the distribution of ecological knowledge*” (my own definition, Figure 1).

Before continuing, the expression “ecological knowledge” needs some clarification. In contrast to a dichotomy between local ecological knowledge and expert knowledge (Davis and Ruddle 2010, Lam et al. 2020), I propose using a more general definition. First of all knowledge, we may adopt the definition of (Renn 2014) “*as the capacity of an individual or a group to solve problems and to mentally anticipate the corresponding actions.*” It thus follows that “ecological knowledge” can be conceived as “*as the capacity of an individual or a group to solve ecological problems and to mentally anticipate the corresponding actions*” (my own definition). Here, ecological problems would be anything from understanding agriculture, forestry, fisheries, husbandry, watershed management, and so forth.

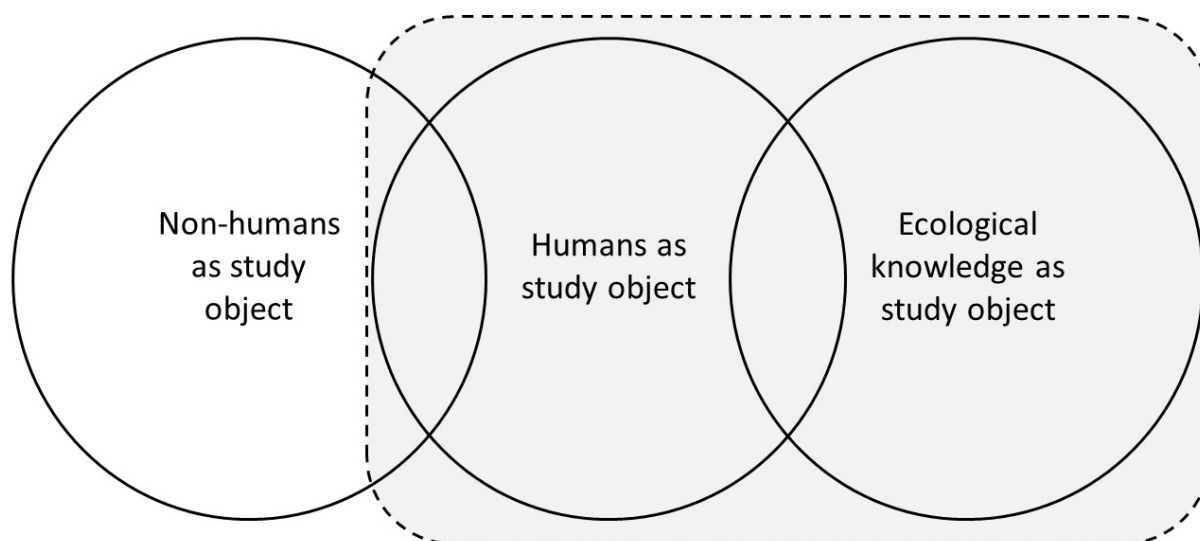


Figure 1. Studies about our own species are within a gradient of disciplines that span two extremes: on the one hand, the study of organisms themselves, and on the other, the study of ecological knowledge (*sensu lato*) that cannot be dissociated of the presence of humans themselves. In our case, the type of human knowledge of interest to us is the ecological knowledge that we use to survive and fulfill our essential needs. The central circle largely represents the subject of anthropology, human ecology and related fields. Interdisciplinarity would arise in some cases at the intersection of each object or domain.

In line with Figure 1, the subject of certain interdisciplinary studies such as human ecology or anthropology could be seen as part of a tripartite typology: some studies address humans within ecological systems, others focus on people’s knowledge about their supporting

ecosystems and how that knowledge is maintained and shared, and finally, some explore both aspects. The domain space depicted in Figure 1 cannot account for all possible types of interdisciplinarity that exist or can exist between the ecological sciences and the human sciences, but just a subset of them.

Scheiner and Willig's eight principles of ecology

Scheiner and Willig (2008, 2011) published their principles aimed at contributing to a general theory of ecology, while cautioning readers that their postulates may be incomplete and that other researchers could come up with a different set of principles. We transcribe these principles in Table 1, mostly using the 2011 version of the principles that differ slightly from the 2008 version. Bear in mind that the order in which the principles are presented do not imply a hierarchy. Some principles are exclusive to the ecological sciences, while some are shared with other scientific branches (see the original publication). In this context, “heterogeneous” can be replaced by “non-random”.

Table 1. Transcribed ecological principles based on the works of Scheiner and Willig (2008, 2011). The labels E1-E8 were added to facilitate the identification of each principle.

<i>Label</i>	<i>Transcribed ecological principle</i>
E1	Organisms are distributed in space and time in a heterogeneous manner
E2	Organisms interact with their abiotic and biotic environments
E3	Variation in the characteristics of organisms result in heterogeneous ecological patterns and process
E4	Distributions of organisms and their interactions depend on contingencies
E5	Environmental conditions are heterogeneous in space and time
E6	Resources are finite and heterogeneous in space and time
E7	Birth and death rates are the consequence of interactions with the abiotic and biotic environments (originally, this principle was defined as “all organisms are mortal.”)
E8	Species ecological properties result from evolution

Extending the principles beyond the ecological sciences

Through analogical reasoning, I propose here that the original eight principles of Scheiner and Willig can first be elaborated for humans as the study object, and second, for ecological knowledge as the study object (hopefully without upsetting our colleagues in the social sciences too much!). The extended principles, like the original ones, are built on what we can call an ecological perspective consisting of the following: *i*) spatial patterns, *ii*) interactions, *iii*) contingency, and *iv*) notions of change (evolution). These notions are not exclusive to the ecological thinking as they are used in the social sciences too. Hence, they can be used as starting points to help students from an ecological background ask whether there is a need for an ecological perspective when addressing a question mostly about humans, mostly about ecological knowledge, or both (Figure 2).

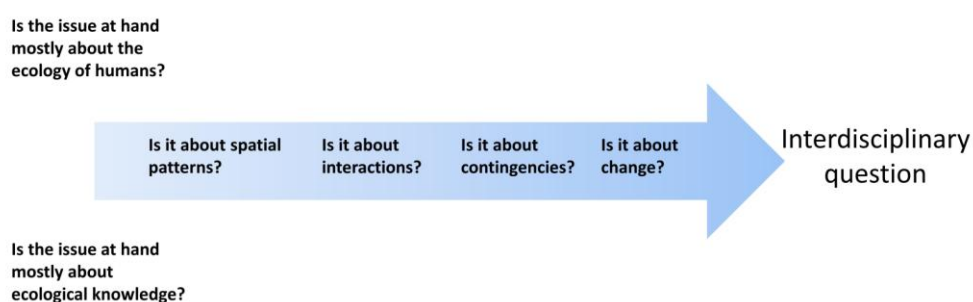


Figure 2. Series of check questions to identify whether the ecological sciences can bring additional insights into studies of humans or ecological knowledge. If the answer is ‘no’ to all the questions, this means that the issue at hand is better handled by the social sciences.

Before analyzing each possible extended principle, we depict them to show their relation to the original principles (Figure 3), shown as a continuous gradient of the three domains depicted in Figure 1. As with the original principles, these extended principles are complementary to each other, not mutually exclusive, and without a hierarchy. Two of the principles were not elaborated for humans because they can be considered to apply to all living organisms: principle **E5** (Environmental conditions are heterogeneous in space and time) and **E6** (Resources are finite and heterogeneous in space and time) are thus depicted the same as in Figure 2.

Some analogies are also not possible between humans and ecological knowledge as study objects, resulting in fewer principles for ecological knowledge than for the other categories.

How close or far removed are these extended principles from existing interdisciplinary research? Examples from the scientific literature of the different fields can shed light on their utility. Tables 2 and 3 enumerate the extended principles while providing examples from the literature in which this kind of thinking has been used. The first three principles proposed for humans (**H1**, **H2**, and **H3**) are familiar in studies exploring the ecological properties of the human species. In particular, principle **H3** is the most interdisciplinary (Humans interact with their abiotic, biotic, and social (other humans) environments), because it can be addressed from the perspective of the ecological sciences, the social sciences, or both. In a way, if there is one principle that would hold across many research questions, it would be this one.

Likewise, principle **H4** is highly interdisciplinary, because human demographic parameters are a function of both the biotic environment and human interactions, as wars and conflicts can have demographic consequences that are just as catastrophic as diseases or pandemics, and often they are related.

Historical processes (i.e., time related) lie at the core of principles **H5** and **H6**: the former focuses on the order of events and the path dependencies that are set in motion, while the latter directly mentions human ecological capacities as the result of biological and social evolution. In this context, “contingencies” mean not only the uniqueness of a situation, but also the random processes that create structure like genetic founding effects. For instance, the order of events during the colonization of empty niches has important consequences on the structuring of natural communities (Fukami 2015), an idea that can be transposed by analogy to situations that involve humans, with all the similarities and differences that exist.

Principles relating to knowledge are less straightforward to extend by analogy, because it is widely believed knowledge, but especially culture, is a human exception. While it is known that many vertebrates can teach their young how to find feeding spots and that primates are capable of social learning (see for example Whiten et al. 2005), scholars still do not agree whether these behaviors and information transmission are equivalent to human culture (Tennie et al. 2009).

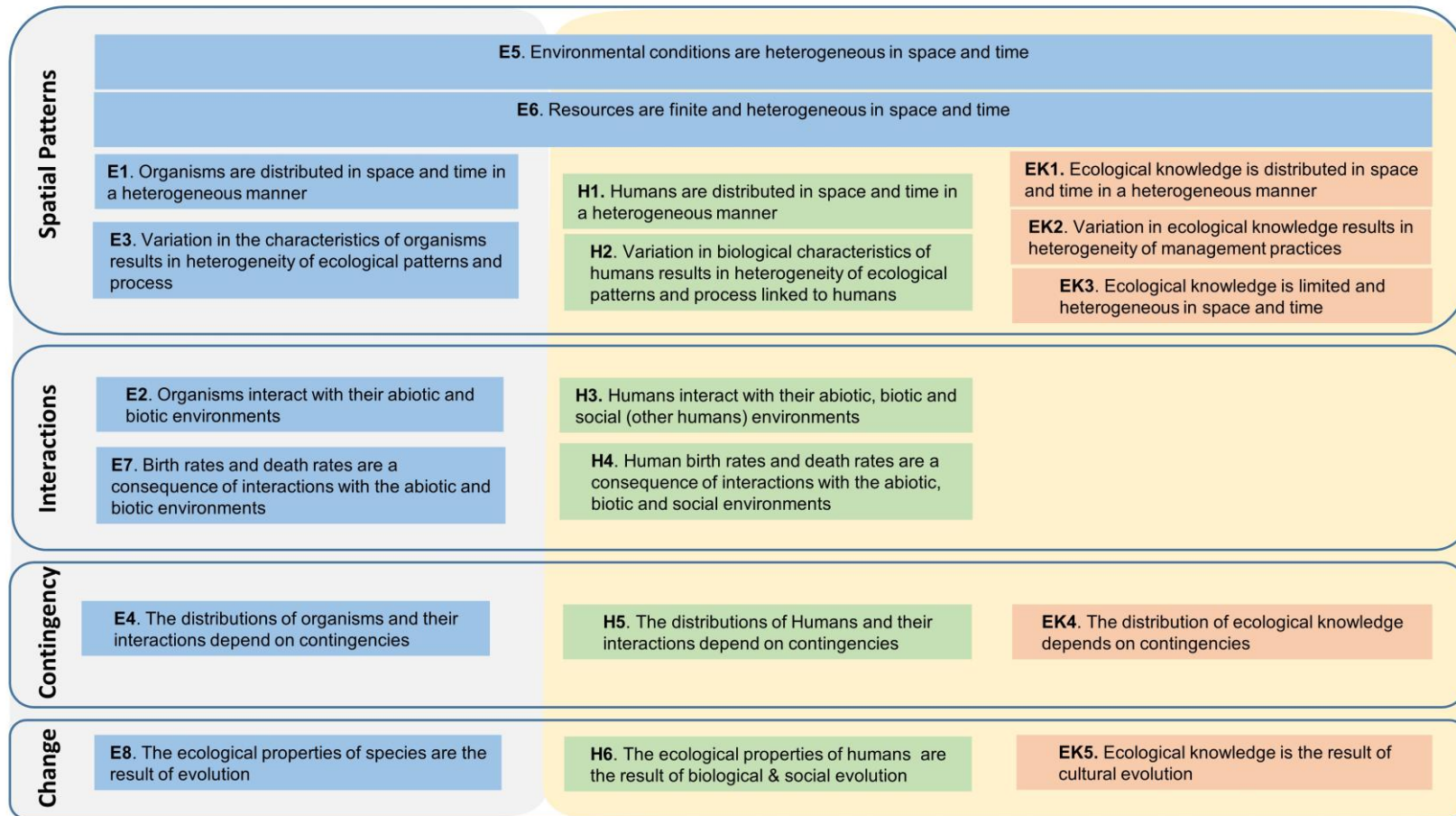


Figure 3. Extended principles drawing from Sheiller and Willig (2008, 2011), elaborated for humans (H1-H6) and ecological knowledge (EK1-EK5) as the objects of study (see Figure 1). Two of the original principles (E5 & E6) apply to all living organisms and do not need to be elaborated. The order of the original ecological principles was changed to bring together those relating to spatial patterns, interactions, contingency and change.

268 **Table 2.** Selected, non-exhaustive list of examples in the literature asking questions akin to the extended ecological principles when humans are considered as the study object.

	<i>Extended principle</i>	<i>Examples in the literature</i>
Spatial Patterns	H1. Humans are distributed in space and time in a heterogeneous manner	(Hodder and Hassall 1971) analyzed the non-random distribution of Roman towns in England using the “central place theory,” a concept still widely used in urban studies (Hsu 2012), along with fractal (power law) analyses of urban phenomena (Mori et al. 2020)
	H2. Variations in human biological characteristics result in heterogeneous ecological patterns and processes linked to humans	The emergence of lactose tolerance allowed husbandry and thus modified landscapes in Africa and Europe (Cramp et al. 2014, Ingram et al. 2012)
Interactions	H3. Humans interact with their abiotic, biotic, and social (other humans) environments	A review of archaeological and paleoenvironmental datasets (300–12 thousand years ago) by (Roberts and Stewart 2018) suggests that compared to the genus <i>Homo</i> , our species developed a new ecological niche (i.e., “generalist specialist”) by occupying a diversity of environments, but also specialized in some environmental extremes
	H4. Human birth and death rates are a consequence of interactions with the abiotic, biotic, and social environments	Analysis of radiocarbon databases in the Amazon and Orinoco regions allowed the authors to test the hypothesis of a logistic growth of pre-Columbian populations, suggesting that carrying capacity was reached and maintained durably in the region (Arroyo-Kalin and Riris 2021)
Contingency	H5. Distributions of humans and their interactions depend on contingencies	Any study addressing indigenous displacements because of colonialist or post-colonialist practices; the current rural exodus in European countries because of economic crises (Merino and Prats 2020); any study exploring the causes of the current migration patterns
Change	H6. Human ecological properties result from biological evolution	(James et al. 2019) review evidence of how the available nutrients from the food selected in different areas of the during the expansion of <i>Homo sapiens</i> for lactose tolerance, increased amylase for digesting starchy foods, ability to digest long-chain polyunsaturated fatty acids, and ability to synthesize vitamin D from sunlight exposure

In general, knowledge is a subject of many fields, traditionally philosophy, but it is also central to anthropology (Crick 1982) and sociology (Shapin 1995). For this reason, we can expect that any principle related to knowledge developed by analogy may be ill fitted if not wrong in many cases. Nevertheless, for the sake of the argument, let us accept that under certain circumstances, a broad research domain of “ecological knowledge” is a useful study object to which ecologically oriented questions (spatial patterns, interactions, contingency, and evolution notions) may be relevant, especially if they help shed light on the distribution of the human species and their interactions with other humans or other species.

Probably one of the most useful principle is **EK2** (Variations in ecological knowledge result in heterogeneous management practices), as this may sum up the core of many studies in conservation biology, conservation sciences, and sustainability. This principle can easily be used to frame hypotheses and help comparative studies to establish cause-effect processes when various landscapes and regions are examined. Clearly, **EK2** it is a principle to be used in complement or in parallel to an anthropological and sociological analysis of the causes of these variations in ecological knowledge. Almost invariably, a historical approach will address the questions of the contingency and change of ecological knowledge (principles **EK4** and **EK5**) using geographical, anthropological, or cultural evolution approaches. Principle **EK3** is needed, because there will always be “unknown unknowns” limiting the level of agency that any people or culture may exert over an ecosystem. As for **EK1** (Ecological knowledge is distributed in space and time in a heterogeneous manner), it joins the other first principles, **E1** and **H1**, which together are the most intuitive and general principles of all.

Principles in practice

A common surprise or frustration for students trained in ecology when participating in an interdisciplinary research project is that the ecological sciences are usually used as a mere diagnostic tool. However, questions can be asked from another perspective. For instance, to assess the impact of a development project, the questions can arise in a gradient similar to what is shown in Figures 1 and 2: What is the distribution of not only the endangered species but all the species present (principle **E1**)? How does the distribution of these species correlate with the distribution of humans in the area (principle **H1**)? What kind of knowledge (or lack thereof) do these humans have with respect to the management of these species (**EK2** and **EK3**)? And which historical events can explain these patterns of knowledge (**EK4** and **EK5**)?

301

302 **Table 3.** Selected, non-exhaustive list of examples in the literature asking questions akin to the extended ecological principles when ecological knowledge is considered as the
 303 study object (see text for the definition of ecological knowledge). No interaction principles were developed for ecological knowledge to avoid over-interpretation of analogies
 304 with ecology.

	<i>Extended principle</i>	<i>Examples in the literature</i>
Spatial Patterns	EK1. Ecological knowledge is distributed in space and time in a heterogeneous manner	(Ghimire et al. 2004) analyze how knowledge about medicinal plants in the Himalayas is non-random due to “differences in level of specialization in relation to medicinal plants, to socio-cultural and institutional contexts, and to extra-local factors that govern people’s activities”
	EK2. Variations in ecological knowledge result in heterogeneous management practices	Virtually any comparative landscape analysis considering the cultural and physical aspects of agriculture, forestry, and so forth (van Zanten et al. 2016)
	EK3. Ecological knowledge is limited and heterogeneous in space and time	Any study addressing how a lack of ecological knowledge causes biodiversity loss
Contingency	EK4. Distributions of ecological knowledge depend on contingencies	(Prado and Murrieta 2018) analyze how the loss of swidden cultivation entails the loss of ecological knowledge about animal species in indigenous communities in south-eastern Brazil; lessons from colonialism imposing alien land use (Paterson 2018)
Change	EK5. Ecological knowledge results from cultural evolution	Any study addressing how knowledge is transmitted across generations, and how variations in practices are a consequence of knowledge change over time. See, for instance, the review of (Santoro et al. 2018) on the fields of cultural evolution and evolutionary ethnobiology. In this context, evolution is considered in the broadest sense as change

A second application of the principles would occur in the context of common pool resources. The use of common pool resources depends on the rules and norms that regulate access, which result from the complex histories and institutional development of the actors involved (Ostrom 2009b) within the context of a social-ecological system (Ostrom 2009a). At the core of this kind of analysis, there is principle **H3**: humans interact with their abiotic, biotic, and social (other humans) environments. Human interactions are addressed by sociology and institutional economics, not to mention public policy studies. If a historical perspective is needed, principle **H5** (contingency of human distributions) would be explicit in the analysis, as human populations develop around key resources, a recurrent theme in geography and history.

Using the extended principles for teaching interdisciplinarity

If there is any practical use of the extended principles outlined above, it would be to help teaching some possible interdisciplinary connections that exist between the ecological and the social sciences. For instance, an interdisciplinary seminar¹ could be envisaged for middle to advanced graduate students (Table 4), ideally inviting researchers from other fields to lead the discussions. Reviews of the main ideas in sociology, anthropology, political science, history and physical and human geographies could be potentially discussed around the principles before students prepare their dissertation projects. A hybrid lecturing/ seminar approach in which each person dwells in depth on a subject allowing for critical thinking and discussion, could allow the discovery of other fields not only by students but by faculty themselves. Whether more principles, or simply other principles are needed to foster interdisciplinarity, will probably emerge through these discussion prompting curiosity about the other fields of research in both directions.

Concluding remarks

I do not claim or imply that it is enough to simply use some analog concepts to create a new interdisciplinary stable field, whether it is the ecological sciences that borrow from social sciences or *vice versa*. Only, that these extended principles may be useful in certain cases to answer specific questions.

¹ In North American graduate programs, seminars are graduate level courses in which each student presents her/his take on a given subject which is then discussed by all the peer students

335 **Table 4.** Example of a seminar curriculum for graduate students built around the extended principles. Contents would vary depending on the availability of different
 336 faculty, as well as the subjects chosen to discuss. Rows marked with an asterisk (*) correspond to subjects generally taught in biology departments and faculties.

<i>Main Subject</i>	<i>Week</i>	<i>Subject of seminar</i>	<i>Main Principles Discussed</i>	<i>Disciplines</i>	<i>Potential Subjects (non-exhaustive list)</i>
Spatial patterns	1	Heterogeneous and limited distribution of resources	E5; E6	Earth sciences*; Demography*	Planetary boundaries; Understanding human population growth
	2	Heterogeneous Human distribution	H1; H2	Archaeology; history; human geography	History of human colonization of the biosphere; Glaciations & human dispersal;
	3	Heterogeneous knowledge distribution	EK1-Ek3	anthropology; philosophy	Cosmologies of western and non-western cultures; the notion of nature in different cultures
Interactions	4	Human/non-human interactions	H5	Ecology*; conservation biology*	Humans as super-predators
	5	Human/human interactions	H2	Law; Institutional economics; political studies; sociology	The law as a social regulator of human interactions; managing common pool resources; gender inequalities and environmental justice
Contingency	6	Contingencies creating human distributions and ecological knowledge	H5/EK4	Archaeology; history; human geography	ecological and social consequences of different colonization/wars events in history
Change	7	Human ecological properties through time	H6; EK5	Archaeology; history; human geography	Origins of agriculture; origins of urbanization; industrial revolution

337

338

Our main goal here was to highlight *similarities* of underlying processes studied by both the ecological and social sciences, as often it is the case that it is the *differences* among them that are emphasized (Moon and Blackman 2014). Many scholars will argue that similarities are just superficial and that questions cannot be answered isolated from a disciplinary context, a position I agree with. The ecologist will still give her/his perspective and the social scientist theirs to the problem at hand based on their own set of values issued from each discipline. The use of very extended principles developed here do not call for any need of one discipline superseding another one but for an epistemic pluralism (Persson et al. 2018), in which each discipline stands by its own right.

The same exercise could have been done in the other direction, by starting with the social sciences and then asking the question about what they can contribute in an interdisciplinary context to the ecological sciences. The use of terms such as population, community, and association in plant ecology is not fortuitous, as they entered into ecological thinking in the late 19th century at a time when both ecology and the social sciences were burgeoning (Egerton 2015). Today, the wealth of research in both the ecological and social sciences shows that the ideas of spatial variation, contingency, change in time, and so forth are not the exclusive prerogative of the ecology, far from that. However, being aware of these notions and principles may help both educators and students to better understand how scientific knowledge is developed by the different disciplines when the question at hand calls for more than one scientific field.

References

- Arroyo-Kalin M, Riris P. 2021. Did pre-Columbian populations of the Amazonian biome reach carrying capacity during the Late Holocene? *Philosophical Transactions of the Royal Society B* 376:20190715.
- Barthel R, Seidl R. 2017. Interdisciplinary Collaboration between Natural and Social Sciences – Status and Trends Exemplified in Groundwater Research. *PLOS ONE* 12:e0170754.
- Christensen CB. 2014. Human Ecology as Philosophy. *Human Ecology Review* 20:31-49.
- Clark WC, Harley AG. 2020. Sustainability Science: Toward a Synthesis. *Annual Review of Environment and Resources* 45:331-386.

- 370 Cooper CB, Larson IR. 2020. Advice for collaborations among natural and social scientists.
371 *BioScience* 70:373-373.
- 372 Cooper GJ. 2007. *The science of the struggle for existence: on the foundations of ecology*. Cambridge
373 University Press.
- 374 Cramp LJ, Evershed RP, Lavento M, Halinen P, Mannermaa K, Oinonen M, Kettunen J, Perola M,
375 Onkamo P, Heyd V. 2014. Neolithic dairy farming at the extreme of agriculture in northern Europe.
376 *Proceedings of the Royal Society B: Biological Sciences* 281:20140819.
- 377 Crick MR. 1982. Anthropology of Knowledge. *Annual Review of Anthropology* 11:287-313.
- 378 Davis A, Ruddle K. 2010. Constructing confidence: rational skepticism and systematic enquiry in
379 local ecological knowledge research. *Ecological Applications* 20:880-894.
- 380 Egerton FN. 1970. Humboldt, Darwin, and population. *Journal of the History of Biology* 3:325-360.
- 381 Egerton FN. 2015. History of ecological sciences, part 54: succession, community, and continuum.
382 *The Bulletin of the Ecological Society of America* 96:426-474.
- 383 Fukami T. 2015. Historical contingency in community assembly: integrating niches, species pools, and
384 priority effects. *Annual Review of Ecology, Evolution, and Systematics* 46:1-23.
- 385 Ghimire SK, McKey D, Aumeeruddy-Thomas Y. 2004. Heterogeneity in ethnoecological knowledge
386 and management of medicinal plants in the Himalayas of Nepal: Implications for conservation.
387 *Ecology and Society* 9.
- 388 Gould RK, Phukan I, Mendoza ME, Ardoin NM, Panikkar B. 2018. Seizing opportunities to diversify
389 conservation. *Conservation Letters* 11:e12431.
- 390 Haberl H, Fischer-Kowalski M, Krausmann F, Winiwarter V. 2016. *Social ecology: Society-nature*
391 *relations across time and space*. springer.
- 392 Hintzen RE, Papadopoulou M, Mounce R, Banks-Leite C, Holt RD, Mills M, T. Knight A, Leroi AM,
393 Rosindell J. 2020. Relationship between conservation biology and ecology shown through machine
394 reading of 32,000 articles. *Conservation Biology* 34:721-732.
- 395 Hodder I, Hassall M. 1971. The non-random spacing of Romano-British walled towns. *Man* 6:391-407.
- 396 Hou H, Shi Y. 2021. Ecosystem-as-structure and ecosystem-as-coevolution: A constructive
397 examination. *Technovation* 100:102193.

- 398 Hsu WT. 2012. Central place theory and city size distribution. *The Economic Journal* 122:903-932.
- 399 Ingram CJ, Liebert A, Swallow DM. 2012. Population genetics of lactase persistence and lactose
400 intolerance. *eLS*.
- 401 James W, Johnson R, Speakman J, Wallace D, Frühbeck G, Iversen P, Stover P. 2019. Nutrition and
402 its role in human evolution. *Journal of internal medicine* 285:533-549.
- 403 Killion AK, et al. 2018. Preparing the next generation of sustainability scientists. *Ecology and Society*
404 23 (art. 39).
- 405 Lam DP, Hinz E, Lang D, Tengö M, Wehrden H, Martín-López B. 2020. Indigenous and local
406 knowledge in sustainability transformations research: a literature review. *Ecology and Society* 25.
- 407 Lattuca LR. 2001. *Creating interdisciplinarity: Interdisciplinary research and teaching among college
408 and university faculty*. Vanderbilt university press.
- 409 Levin S, Xepapadeas T, Crépin A-S, Norberg J, De Zeeuw A, Folke C, Hughes T, Arrow K, Barrett S,
410 Daily G. 2013. Social-ecological systems as complex adaptive systems: modeling and policy
411 implications. *Environment and Development Economics* 18:111-132.
- 412 Lowe P, Phillipson J, Wilkinson K. 2013. Why social scientists should engage with natural scientists.
413 *Contemporary Social Science* 8:207-222.
- 414 Lowe P, Whitman G, Phillipson J. 2009. Ecology and the social sciences. *Journal of Applied Ecology*
415 46:297-305.
- 416 Mace GM. 2014. Whose conservation? *Science* 345:1558-1560.
- 417 Marasco A, Picucci A, Romano A. 2016. Market share dynamics using Lotka–Volterra models.
418 *Technological forecasting and social change* 105:49-62.
- 419 McIntosh RP. 1986. *The background of ecology: concept and theory*. Cambridge University Press.
- 420 Merino F, Prats MA. 2020. Why do some areas depopulate? The role of economic factors and local
421 governments. *Cities* 97:102506.
- 422 Moon K, Blackman D. 2014. A Guide to Understanding Social Science Research for Natural
423 Scientists. *Conservation Biology* 28:1167-1177.
- 424 Mori T, Smith TE, Hsu W-T. 2020. Common power laws for cities and spatial fractal structures.
425 *Proceedings of the National Academy of Sciences* 117:6469-6475.

- 426 Moritz M, Hamilton IM, Scholte P, Chen Y-J. 2014. Ideal Free Distributions of Mobile Pastoralists in
427 Multiple Seasonal Grazing Areas. *Rangeland Ecology & Management* 67:641-649.
- 428 Musacchio L, Ozdenerol E, Bryant M, Evans T. 2005. Changing landscapes, changing disciplines:
429 seeking to understand interdisciplinarity in landscape ecological change research. *Landscape and*
430 *Urban Planning* 73:326-338.
- 431 Newell WH, Wentworth J, Sebberson D. 2001. A theory of interdisciplinary studies. *Issues in*
432 *Interdisciplinary Studies*.
- 433 Ostrom E. 2009a. A general framework for analyzing sustainability of social-ecological systems.
434 *Science* 325:419-422.
- 435 ---. 2009b. *Understanding institutional diversity*. Princeton university press.
- 436 Paterson A. 2018. Once were foragers: The archaeology of agrarian Australia and the fate of
437 Aboriginal land management. *Quaternary International* 489:4-16.
- 438 Persson J, Hornborg A, Olsson L, Thorén H. 2018. Toward an alternative dialogue between the social
439 and natural sciences. *Ecology and Society* 23 (art. 14).
- 440 Pickett STA, Burch WR, Grove JM. 1999. Interdisciplinary research: Maintaining the constructive
441 impulse in a culture of criticism. *Ecosystems* 2:302-307.
- 442 Prado HM, Murrieta RSS. 2018. The Role of Swidden cultivation in shaping ethnozoological
443 knowledge: integrating historical events and intergenerational analyses among Quilombolas from
444 Southeast Brazil. *Journal of Ethnobiology* 38:297-313.
- 445 Renn J. 2014. The globalization of knowledge in history and its normative challenges.
446 *Rechtsgeschichte–Legal History* 22:52-60.
- 447 Roberts P, Stewart BA. 2018. Defining the ‘generalist specialist’ niche for Pleistocene *Homo sapiens*.
448 *Nature Human Behaviour* 2:542-550.
- 449 Santoro FR, Nascimento ALB, Soldati GT, Júnior WSF, Albuquerque UP. 2018. Evolutionary
450 ethnobiology and cultural evolution: opportunities for research and dialog. *Journal of ethnobiology*
451 *and ethnomedicine* 14:1.
- 452 Scheiner SM. 2010. Toward a conceptual framework for biology. *The Quarterly Review of Biology*
453 85:293-318.
- 454 Scheiner SM, Willig MR. 2008. A general theory of ecology. *Theoretical Ecology* 1:21-28.

- 455 Scheiner SM, Willig MR. 2011. The theory of ecology. University of Chicago Press.
- 456 Shapin S. 1995. Here and everywhere: Sociology of scientific knowledge. *Annual review of sociology*
457 21:289-321.
- 458 Spooner M, Navakas F, Fiscella J. 2004. Generating integration and complex understanding:
459 Exploring the use of creative thinking tools within interdisciplinary studies. *Issues in Interdisciplinary*
460 *Studies*.
- 461 Stirling A. 2007. A general framework for analysing diversity in science, technology and society.
462 *Journal of the Royal Society Interface* 4:707-719.
- 463 Szostak R. 2017. Interdisciplinary research as a creative design process. Pages 17-33. *Creativity,*
464 *design thinking and interdisciplinarity*, Springer.
- 465 Tennie C, Call J, Tomasello M. 2009. Ratcheting up the ratchet: on the evolution of cumulative culture.
466 *Philosophical Transactions of the Royal Society B: Biological Sciences* 364:2405-2415.
- 467 Tsujimoto M, Kajikawa Y, Tomita J, Matsumoto Y. 2018. A review of the ecosystem concept —
468 Towards coherent ecosystem design. *Technological forecasting and social change* 136:49-58.
- 469 van Zanten BT, Zasada I, Koetse MJ, Ungaro F, Häfner K, Verburg PH. 2016. A comparative
470 approach to assess the contribution of landscape features to aesthetic and recreational values in
471 agricultural landscapes. *Ecosystem Services* 17:87-98.
- 472 Vellend M. 2010. Conceptual synthesis in community ecology. *The Quarterly Review of Biology*
473 85:183-206.
- 474 ---. 2020. The theory of ecological communities (MPB-57). Princeton University Press.
- 475 Visvader J. 2017. Philosophy and Human Ecology. *Human Ecology Review* 23:125-134.
- 476 Wallace RL, Clark SG. 2017. Barriers to Interdisciplinarity in Environmental Studies: A Case of
477 Alarming Trends in Faculty and Programmatic Wellbeing. *Issues in Interdisciplinary Studies* 35:221-
478 247.
- 479 Whiten A, Horner V, De Waal FB. 2005. Conformity to cultural norms of tool use in chimpanzees.
480 *Nature* 437:737-740.
- 481 Young GL. 1974. Human ecology as an interdisciplinary concept: a critical inquiry. Pages 1-105.
482 *Advances in ecological research*, vol. 8 Elsevier.

