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Charting the divide: a science-mapping perspective on the relationship between human and physical geography

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Introduction: on integration, similarity, and scientific relevance

- 1 Many words have been written on the relationship between human and physical geography, and the divide is explored in its epistemological, social, and cultural depths. This issue itself represents another attempt to clarify the problem: how should we, as geographers, look at our counterparts? In this paper, I am looking at the phenomenon on a documental level, i.e., I am interested in the material production of literature and the features it bears. The newest stances proposed by the emerging disciplinary strain of *Critical Physical Geography* (Lave, 2015) are renewing the interest over a long-troubled question, following the emergence of global socio-environmental problems. In their account, Lave *et al.* reject the idea that the fundamental unity of geography as a discipline can be explained in an inertial legacy of the past (Johnston, 2012) and propose a series of epistemological and pragmatological reasons for pursuing an integration between the two hitherto separate fields of geography. In their proposition, adopting a critical stance is entirely necessary to gain the explanatory power needed to shed light on environmental processes.
- 2 As the proposition gained momentum in 2015, it picked up the threads of a long, polarizing debate. Professionals from both sides of the divide chimed in the discussion,

delving into the potential benefits and shortcomings of integration between the disciplines. The result is a compelling discussion, inscribed in a cyclically recurring theme in the literary debate over geography, connecting – *inter alia*, and limiting our scope to the Anglo-American debate – the work of the likes of William Bunge (1962), Doreen Massey (1999), Nicholas Clifford (2002), Rob Ferguson (2003) and Andrew Goudie (2017). In such a landscape, Lave’s and associates’ work poses a turning point in the discussion, as they point effectively to many ongoing research pieces that *practice* a form of integration, instead of *advocating* for it, or moving within a merely theoretical framework. Supposing the claim is read under the lens of philosophy and sociology of science, the explicit invitation is to work on a strain of boundary research¹ (Gyern, 1983) – or even transboundary – that could overcome the Kuhnian problem of incommensurability between different scientific paradigms (Kuhn, 1962). In this perspective, Lave *et al.* point at several institutional, material, and political constraints that need to be reworked and reshaped to allow the melding of a new form of integrated knowledge.

- 3 Among them, the publishing practices assume a fundamental role.

“In our experience, it can be very hard to publish work that combines physical science and critical engagement with social theory and power relations. New journals are one possibility, but a better solution would be for editors and associate editors of existing journals to change the ways in which they select and recruit reviewers” (Lave *et al.*, 2014, p. 7).

- 4 Beyond the anecdotal, Lave *et al.* offer little evidence about the degree of fragmentation of the publishing fields, leaving a question mark around the existence of bridges connecting the two fields. How far are we? Or, rephrasing the opening question, are we even looking for the knowledge produced by our counterparts in our everyday academic life? Among the many voices contributing to the still ongoing discussion on the divide, a bibliometric approach is notably lacking. The only examples are given by Ferguson (2003), in his reply to the notorious Thrift’s paper “The future of Geography” (2002), and Bodman (1991). The former is a rare example of a documental account of the divide, in which the author inquires on the difference in publishing behaviours between human and physical geographers, as supposed by Thrift, with a close look at empirical data on publications. By contrast, the latter argues that citation data can be fruitfully employed to chart the structure and hierarchy of geography as an academic discipline. I am proposing a slightly different perspective on the matter within these pages, as I aim to chart the current degree of intellectual contact and engagement between the two disciplines. I am neither delving into citation frequencies as a tool to shed light on the social pyramid of academic geography nor confronting different publishing cultures; rather, my interest lies in the citational relationships that connect human and physical geographers, and specifically in when, where, and how much they cite each other. Bodman’s account suggests that citations are a measure of influence. I am advocating for a small semantic shift: citation is to be read, at least in the context of these pages, as a measure of *relevance*: in a multidisciplinary intellectual landscape, citing a piece of knowledge produced in a different scientific community tells us about what is intellectually relevant in our field of enquiry, and, indirectly, what is not. Hence, I am trying to reconstruct the network of citations of both Human (HG) and Physical Geography (PG) to understand (I) what pieces of scientific knowledge born on one side of the academic fence are relevant to the other side, and (II), how

scientific products are mobilised and employed as building blocks for further science-making endeavours in different fields.

- 5 In such endeavour, I am borrowing some instruments from the domain of scientometrics (Leydesdorff, Milojević, 2015) and science-mapping. Science mapping is a young research topic at the crossroad of scientometrics, information visualization, network analysis, and sociology of science (Börner, Chen & Boyack, 2005; Börner, Theriault & Boyack, 2015). It aims to display the structure and dynamics of scientific knowledge by using 2- or 3-d visualizations, known as “science maps” (Chen, 2017). This methodology can reveal itself extraordinarily well-equipped to chart the bridges that still stand in connection between the two sides.

Charting science: a methodological remark on two studies

- 6 Techniques, methodologies, and technologies for mapping science are various and widely addressed in scientific literature (Petrovich, 2020). For the purpose of this paper, I built an archive of every Web of Science (WoS)-indexed publication and processed it with VOSviewer, a freely available science mapping tool developed by Ludo Waltman and Nees Jan van Eck at the Center for Science and Technology Studies (CWTS) in Leiden (van Eck, Waltman, 2007). VOSviewer allows the user to build science maps and arrange the results according to different sets of mapping rules.
- 7 I structured this paper around two complementary studies. One looks at the citational relationship detectable in a sample of HG and PG journals, while the other focus on the use made by a relevant interdisciplinary journal of the information produced from HG and different categories of scientific journals, via co-citations.
- 8 For the first case study, I selected 10 journals for each field of enquiry. Generally, data for the mapping is retrieved from a citation database, i.e., a database that collects the meta-data of scientific publications (authors, title, publication year, etc.) along with their references and citation links with subsequent works (citing articles). Clarivate’s WoS and Elsevier’s Scopus are the main resources for this kind of data². As a measure for preserving data’s structure, I restricted the field of potential analysis to WoS-indexed journals only.
- 9 Note that, in terms of journal indexing and academic publishing, the field is historically dominated by British scholars and institutions (Paasi, 2005), and the general publication landscape mirrors this imbalance. Taking Scimago Journal & Rank³ as a reference proves the claim, as the great majority of journals ranked in or above the second quartile (Q2) in SJR (Scimago Journal Rank indicator⁴) is either British or American in both disciplines. Research has already shown the distortive consequences of basing a bibliometric study solely on the head of the Lotka curve⁵ (Saam, Reiter, 1999) in terms of international representation (Paasi, 2005, p. 769). Hence, selecting a sample composed of top journals alone is risky, as it might suppress national variability among scientific communities and offer a very partial reconstruction of the relationship. The samples are therefore composed of a majority of Q1 British-American journals and a variable quota of lower quartiles journals of different nationalities. Despite the underpinning principle remain the same, the selection strategy must face two very different publication landscapes. The case of Human Geography (HG) presents

several specialistic journals that usually concentrate the bulk of the literature produced by human geographers (Ferguson, 2003). The selection process considered both tout-court Geography journals⁶ as well as specialisms in HG.

- 10 The selected journals are the following (nationality in brackets):
 1. Progress in Human Geography (UK)
 2. Geografiska Annaler Series B – Human Geography (SWE)
 3. Transactions of the Institute of British Geographers (UK)
 4. Annals of the American Association of Geographers (USA)
 5. Dialogues in Human Geography (UK)
 6. Geographical Journal (UK)
 7. Geography Compass (UK)
 8. Acme (CAN)
 9. Fennia (FIN)
 10. Geoforum (UK)
- 11 On the contrary, Physical Geography (PG) displays different publishing behaviour. Following Ferguson's account, the scientific community aims to publish its work in general, wide-scope scientific journals or multidisciplinary specialisms, and sub-disciplinary scientific periodical (*Id.*, 2003). The sample take consideration only of the last two categories. Hence, wide-scope, generalist scientific journals are not a feasible unit of analysis for the task, diluting the citational flow between the two disciplines into a vast multidirectional flow. The journals identified are either explicitly addressing PG or are part of Ferguson's original dataset.
- 12 Hence, the selected journals are the following:
 1. Progress in Physical Geography (UK)
 2. Geografiska Annaler Series A – Physical Geography (SWE)
 3. Physical Geography (UK)
 4. Geomorphology (NL)
 5. Earth Surface Processes and Landforms (UK)
 6. Hydrological Processes (UK)
 7. Catena (NL)
 8. Land (CH)
 9. Cryosphere (GER)
 10. Hydrology and Earth System Science (GER)
- 13 Articles' metadata have been retrieved for each journal, ranging from 1985 to 2020. These data alone are a valuable source of information about both disciplines' research dynamics: the name of authors, institutions, main topics of enquiry can all be traced with a science mapping approach. More importantly, the data allow the researcher to trace the citing relationship that marks the two distinctive disciplines. Our interest lies in the citational flow that connects the datasets with the broader scientific panorama. Starting from the initial dataset, I gathered all the citing articles, i.e., all the articles that cite one or multiple articles from the initial dataset, to map the number of citations and the disciplinary domains toward which the citations flow⁷. In other words, the methodology enables the researcher to trace which disciplines employ human and physical geography as a source of information for producing new knowledge.

Figure 1. Design of the first study.

Left: Starting datasets (light grey) and citing references (dark grey). Right: Isolating HG citations from the overall citational flow generated by the PG dataset. The same process has been applied on the HG dataset.

- 14 The sample has been analysed via WoS built-in tools to break down the citing articles' main categories and obtain a complete analysis of the citation flows that cross the disciplines. It is then possible to isolate the share of citations moving from one geography to the other and retrieve the raw data needed to map the citation flow. Citational maps are constructed for every journal regarding the citations received from the "other geography". The citation datasets are then aggregated and analysed. For the sake of this study, the functional relationships among the nodes are traced via *bibliographic coupling*⁸. As a result, the articles or journals mapped are the ones who cite articles published by one of the journals of the other dataset, while their relative position and the strength (graphically presented as the width of the line) of their connections are determined by the share of references they have in common. The analysis aims at:
 1. tracing the actual dimension of the citation flows between the two geographies;
 2. mapping the journals serving as harbours for citation flows;
 3. mapping the main topics that incorporate scientific information coming from the other side of the divide.
- 15 The second study is structured around a complementary perspective. Once obtained a picture of the journals' direct citational scopes, the interest turns to an external perspective. I focused on a middle ground publication – a journal which field of interest crosses but does not entirely belong to the discipline – to evaluate how and how much HG journals are combined with different disciplinary and multidisciplinary journals in the construction of new, potentially integrative knowledge⁹. Co-citation analysis (Small, 1973) provides a valuable conceptual tool to engage in such evaluations. In co-citation analysis, the similarity of publications is measured based on the number of times they are cited together in the references of a set of other publications¹⁰. If publications are frequently cited together, they are likely to be more related than if they are seldom or never cited together.
- 16 To achieve the task, I isolated all the articles published in Global Environmental Change – Human and Policy Dimensions from its birth to today. The journal aims to publish articles dissecting the social drivers or consequences of environmental change or social and policy processes that seek to address environmental change problems. The journal provides a clear benchmark, as its task requires the employment of geo- and bio-scientific information to generate new humanistic, social, and political analyses.

Therefore, the study aims to evaluate the frequency of co-citation of papers from HG journals and different categories of scientific journals (fig. 2).

Figure 2. Design of the second study.

Tracing the citational flows between HG and PG in the samples

- 17 The first exploratory step in the study consists in a quantification of the citational flows moving from one geography to the other. WoS indexed articles are retrieved for every journal in the datasets and employed in the quantification of the share of citations directed to the other geography (table 1, figure 2). Note that table 1 reports on the number of articles that are citing the initial dataset (*citing articles*) and the share of such articles that are indexed as PG or HG in WoS database.

Table 1. The study's dataset.

	<i>Journal</i>	<i>Category</i>	<i>Country</i>	<i>Published articles</i>	<i>Citing articles</i>	<i>citing by PG</i>	<i>%</i>
1	Progress in Human Geography	HG	UK	4272	45741	681	1.49
2	Geografiska Annaler Series B	HG	SWE	778	8768	127	1.45
3	Transactions of the Institute of British Geographers	HG	UK	2678	39006	1721	4.41
4	Annals of the American Association of Geographers	HG	USA	597	3074	188	6.12
5	Dialogues in Human Geography	HG	UK	428	1000	10	1.00
6	Geographical Journal	HG	UK	9719	20650	1647	7.98

7	Geography Compass	HG	UK	257	1900	35	1.84
8	Acme	HG	CAN	200	928	5	0.54
9	Fennia	HG	FIN	107	223	9	4.04
10	Geoforum	HG	UK	3437	47793	646	1.35
	TOTAL			22473	169083	5069	3.0
	<i>Journal</i>	<i>Category</i>	<i>Country</i>	<i>Articles</i>	<i>citing</i>	<i>citing by HG</i>	<i>%</i>
11	Progress in Physical Geography	PG	UK	749	17483	842	4.82
12	Geografiska Annaler Series A	PG	SWE	1172	14956	528	3.53
13	Physical Geography	PG	UK	998	8307	383	4.61
14	Geomorphology	PG	NED	6853	86288	1869	2.17
15	Earth Surface Processes and Landforms	PG	UK	4715	62680	1416	2.26
16	Hydrological Processes	PG	UK	7559	107447	977	0.91
17	Catena	PG	ND	5039	61725	965	1.56
18	Land	PG	SWI	776	2318	154	6.64
19	Cryosphere	PG	GER	1695	15394	122	0.79
20	Hydrology and Earth System Sciences	PG	GER	4408	66935	610	0.91
	TOTAL			33964	443533	7866	1.77

- 18 The HG dataset consists of 22,473 articles, while 33,964 articles compose PG's set. The articles in the HG dataset were cited by 169,083 articles, while those from the PG dataset appeared in the references of 443,533 articles.
- 19 Citation flows between the two geographies, as expected, are a residual amount of the totality of citations traced in the fields (fig. 3). On average 3% of the citations of articles from HG dataset were made in PG articles. Tout-court geographical journal as the *Transactions*, *Annals*, *Geographical Journal* and *Fennia* show higher values, which probably reflect the fact that they publish a minority of PG papers. When excluded, the citation share drops to 1.42%. On the opposite side, 1.77% of the total citations of papers published in the PG dataset are found in HG journals, with lower values for sub-disciplinary journals: *Hydrology and Earth System Sciences*, *Cryosphere*, *Hydrological*

Processes and Landforms. On the contrary, wide scope journals, as *Progress in PG*, or *Land* display higher values.

- 20 The analysis can be extended by adding a time dimension. The citation data were then disaggregated on an annual basis and expressed as a simple percentage of the citations obtained by individual journals from the “other geography” over the total volume of citations they received. Figure 3 shows percentage rates over a 6-year time window for all ten HG journals and a 30-plus year reconstruction of recorded trends for journals with longer time series¹¹.

Figure 3. % values of HG journals over a 6-year window (2015-2020) and over a 31-year window (1990 to 2020).

- 21 The short time window shows converging trends for all journals considered, apart from Fennia between 2016-2018, and the Annals, which show consistently higher than average values. In the case of journals with a longer time window, the Geographical Journal stands out, reaching values of 20% several times, before dropping drastically since the early 2000s. A comparative analysis of the two timeframes demonstrates that the most recent data show lower average values than those from the 1990s.
- 22 Figure 4 repeats the same experiment with PG journals.

Figure 4. % values of PG journals over a 6-year window (2015-2020) and over a 31-year window (1990 to 2020).

- 23 In this case, the short time window displays the peculiarity of *Land*¹², which is cited in HG journals more consistently and frequently than the overall six-year average, in line with its mission¹³.
- 24 A look at the long term, on the other hand, shows a downward trend, which can be clearly seen, for example, in the decrease of the journals *Physical Geography* and *Progress in Physical Geography*.

- 25 The samples confirm the existence of an intellectually broad space separating two largely different disciplines, and the time-series are testifying a deepening of an already notable divide. However, a point of contact exists and should be explored in its constitutive elements.

Mapping the bridges: where, and why, PG cites HG

- 26 The citing articles can be employed effectively to map how and why PG cites HG or vice versa. A first interesting question to ask is where the two disciplines intertwine. Which are the journals in the field of HG and PG that host the highest share of citation towards the “other” geography?
- 27 Figure 5 maps PG journals citing articles from the original HG sample. The map identifies the 78 PG journals that cite papers from the original HG dataset¹⁴ and organizes the spatial configuration via bibliographic coupling. As a result, the connections between the journals express the similarity of their bibliographic references. Additionally, a cluster analysis based on the modularity function¹⁵ (Brandes *et al.*, 2008) superimposes a classification over the structure, helping the identification of different families of journals.

Figure 5. Network map of PG journals citing HG articles.

The size of the bubbles is proportional to the number of times the journal cites HG articles, while the lines connect journals with a higher share of bibliographic references, as a measure of similarity between two journals.

- 28 Three significant clusters compose the backbone of the map, with a fourth marginal cluster on the periphery. The first cluster (red) isolates landscape planning, landscape ecology, biogeography, and GIS science. The second (blue) and third clusters (green), which are strongly connected, concentrate the bulk of the broad geomorphology and physical geography journals on the one hand and quaternary research on the other. Finally, the fourth cluster deals with narrow regional fields of enquiry. The map testifies at least two different fronts of contact between the disciplines in PG: journals of landscape analysis and planning, together with sources of spatial sciences, and

classic journals of geosciences. Table 2 shows the top 20 journals for number of articles published with at least one reference to HG articles, alongside their clusters and the average publication year of the articles citing HG articles.

Table 2. Top 20 PG journals citing HG articles.

label	Documents	Avg. pub. year	cluster
geomorphology	511	2010	3
earth surface processes and landforms	389	2004	3
landscape and urban planning	326	2013	1
progress in physical geography-earth and environment	258	2002	3
international journal of geographical information science	228	2012	1
isprs international journal of geo-information	185	2018	1
quaternary science reviews	163	2006	2
journal of coastal research	157	2008	3
quaternary international	127	2011	2
erdkunde	98	2013	1
zeitschrift fur geomorphologie	97	1999	3
palaeogeography palaeoclimatology palaeoecology	95	1999	2
mountain research and development	90	2006	1
landscape ecology	78	2013	1
erde	75	2014	1
journal of quaternary science	69	2006	2
holocene	68	2007	2
journal of maps	68	2015	1
revista de geografia norte grande	67	2014	1
geografiska annaler series a-physical geography	65	1996	2

- 29 Furthermore, mapping the keywords indexed in every article allows the researcher to visualize the main topics of enquiry of a given field, together with the functional relationship among them (fig. 6)

Figure 6. Keyword map of the articles (at least 15 occurrences per word) of the dataset showing the main topic of research in PG articles citing HG.

The size of the bubble is proportional to the number of times the keyword is found in the articles' metadata. The width of the lines is proportional to the number of times two keywords co-occur in the same article.

- 30 In the case of PG, HG citations are distributed along an ample spectrum of topics and themes. Most of the keywords are part of the traditional disciplinary focus of PG, while cutting-edge keywords make their way into the map. Climate change research occupies a central place, as the most evident example of this capillary trend, acting as the scientific, and epistemic trading zone where diverse sub-disciplines intertwine. However, among the heterogeneous fold of keywords, some of the distinctive lexicon of social-sciences and HG spilled-over into the dataset: specialistic terms as “ecosystem services”, “environmental justice”, “political ecology”, “urban forest”, and “green infrastructure” make comparison as highly cited keywords, alongside with more general, but still strangers to the traditional realm of geosciences, as “social media”, and “urbanization”. Hence, the red cluster display the traits of a research branch deviating from the historical disciplinary norms, revolving around GIS and landscape studies.

Mapping the bridges: where, and why, HG cites PG

- 31 The replication of the experiment with the PG dataset shows the distinctive features of this common ground: the source of information retrieved in the geosciences' domain currently employed in the process of knowledge-making in the field of HG is displayed in figure 7.

Figure 7. Network map of HG journals citing PG.

The size of the bubbles is proportional to the number of times the journal cites PG articles, while the lines connect journals with a higher share of bibliographic references, as a measure of similarity between two journals.

- 32 The map structure comprises 124 journals and is centred over the presence of five major clusters and a marginal sixth. Cluster 1 (red) concentrates journals of cartography and GIS science application alongside some tout-court geographical journals. These sources are a peculiar case (e.g. the *Journal of Maps*, also present in the PG dataset) publishing only research pieces employing maps as a tool of analysis and/or representation of data; Cluster 2 (green) aggregates most tout court geography journals (the *Annals*, *Transactions*) and historically relevant specialism (*Progress in Human Geography*, *Geography Compass*). Clusters 3 (purple) and 4 (blue) build on the presence of regionalisms (the *Journal of Alpine Geography*, *Australian Geographer*, the *Scottish Geographical magazine*). Cluster 5 (yellow) defines a family of journals, focused on the applied dimension of the geographical sciences, whether social, economic, or digital. Journals as *Transactions in GIS*, *Professional Geographer*, *Journal of Geographical Systems* are all part of the cluster. Notably, *Landscape and Urban Planning* is also part of the HG dataset, as the journal is indexed as both a HG and PG source. Table 3 shows the first 20 sources in descending citation order, alongside their clusters and the average publication year of the articles citing HG sources.

Table 3. Top 20 HG journals citing PG articles.

label	Documents	Avg. pub. year	Cluster
journal of maps	443	2015	1
applied geography	411	2012	5
landscape and urban planning	286	2012	5

annals of the association of american geographers	256	2001	2
international journal of geographical information science	231	2011	1
global environmental change-human and policy dimensions	159	2014	3
arctic and alpine research	153	1989	4
professional geographer	134	2004	5
area	109	2006	4
transactions of the institute of british geographers	84	1998	2
geographical journal	82	2001	2
canadian geographer-géographe canadien	81	2004	4
scottish geographical journal	73	2010	4
geoforum	71	2010	2
singapore journal of tropical geography	70	2006	1
boletin de la asociacion de geografos espanoles	70	2014	1
geographical research	64	2011	4
australian geographer	58	2002	4
transactions in gis	58	2015	1
erdkunde	52	2013	1

Figure 8. Keyword map (at least 20 occurrences per word) of the dataset showing the main topic of research in HG articles citing PG.

The size of the bubble is proportional to the number of times the keyword is found in the articles' metadata. The width of the lines is proportional to the number of times two keywords co-occur in the same article.

- 33 A close view at the keywords composing the sample (fig. 8) reveals signs of consistency with the first map: once again the entire structure revolves around climate change, geomorphology, GIS, and remote sensing as most common topics of research.

Second study: co-citation in Global Environmental Change references

- 34 Adopting a different perspective, a co-citational analysis of a citational trading zone can reveal new evidence. Every article published in Global Environmental Change – Human and Policy Dimension has been extracted, and their bibliographies are processed to obtain a complete co-citation chart. Co-citation networks involve a variety of different sources, hence a degree of reduction is needed to make sense of the data. I grouped all journals detected into nine categories, according to their disciplinary scopes (table 4).

Table 4. Categories of co-citations.

Category	Description
0 Human geography	HG exclusive disciplinary scope
1 Wide scope science	Top cited general science journals
2 Geosciences multidisciplinary	Journals addressing geosciences in different disciplinary domains

3 Biosciences multidisciplinary	Journals addressing biosciences in different disciplinary domains
4 General interdisciplinary natural sciences	Wide scope natural sciences journals
5 Interdisciplinary sciences and social sciences	Wide scope interdisciplinary journals addressing both social and natural sciences
6 Physical geography	PG exclusive disciplinary scope
7 Science-policy interface	Journals addressing research on the policy dimension of environmental phenomena
8 Extra-disciplinary specialisms	Disciplinary specialisms outside the scope of geography

- 35 A filter is superimposed to the analysis to limit the statistical noise, hence the study considers only papers that are co-cited at least ten times in the sample, corresponding to the third quartile in the distribution. These publications concentrate 80% of the total co-citation volume. The study evaluates then the co-citation frequency of such categories with a set of HG journals cited in GEC-HPD. The set includes HG journals that published at least one article that is co-cited ten times or more. Figure 9 summarizes the results.

Figure 9. Co-citation frequencies of HG journals and different categories of scientific journals. Total articles 39249.

- 36 HG is frequently co-cited with several extra-disciplinary specialisms (24%), interdisciplinary science and social science journals (20%), policy journals on environmental issues (18%), and broad scope tout court scientific journal (e.g. *Nature*, *Science*; 18%). Pure HG co-citation happens at a relatively low frequency (9%), while co-citations with geosciences, biosciences and general natural sciences journals equal the same frequency (9%). Finally, the fraction of co-citations between HG journals and pure PG journals is negligible, but the result should also weight in the fact that pure PG journals are an uncommon source in the publication landscape (Ferguson, 2003).

The documental features of boundary research and the mobilisation of scientific results

- 37 This paper explored the feasibility of scientometrics as a potential tool to enquire into the divide on a documental level, i.e., focusing on formal relationships of citation between papers and journals. The exercises delivered some new evidence that can enrich our knowledge on the divide with a new perspective. However, before delving into any interpretation of the data, it is to be remarked that the results should be read as an entry point for further research, as many other questions remain open. My findings could be checked against different volumes of literature. For instance, despite the selection of an international sample, the results display a striking majority of Anglo-American journals, which call for an in-depth comparative review of non-Anglo-American literature, even considering publication in different languages. At the same time, a strict consideration of journal articles prevents an exploration of the citational flows between books and chapters, leading the researcher to contemplate different publishing venues.
- 38 Despite their exploratory nature, the analyses provided useful evidence to structure a reflection on the scientific relevance of geographical knowledge, both from inside the discipline (as a whole) and outside. I am offering some thoughts on three elements that arise from the analysis and might guide future research on the topic of integration between the two geographies, namely corridors, trading zones, and mobilisation of knowledge.
- 39 The first study testifies the abysmal distance that separates HG and PG on a citational level. In other words, knowledge produced on the other side of the disciplinary fences of our domain is, for the most part, hardly relevant to the conduct of our everyday scientific work. The emergence of CPG as a topic of discussion and theoretical speculation inside the community sparked some interest in our counterparts. However, any effect as a unifying paradigm at the level of publication practices is still to be witnessed. Despite the stark divide, traces of direct intellectual contact between PG and HG are recorded in the sample, as the analysis detects three groups of bidirectional citation flow between PG and HG journals. I call them *corridors*, as they serve as the material conduits of intellectual contact that cut their way sharply through the divide. Corridors testify the existence of spaces for codified interactions between the disciplines. The first type of corridor is provided by recognized disciplinary research journals on both sides. Coherently with the description drawn by Lave and associates, CPG might find little, yet fertile ground in this family of journals. Additionally, GIS, cartography, and mapping journals display their own and recognizable epistemological stance on the geographical sciences that look beyond divisions, focusing on the

common interest for the spatial dimension of physical and social phenomena and the tools that come with it. Third, urban and landscape planning journals contribute to gathering and mobilising relevant knowledge from PG and HG even if they partly transcend the domain of geography.

40 If corridors describe the material conduits of interactions, they hardly allow the researcher to determine the nature of the information flowing through them. By contrast, keyword analysis allows locating the main topics of boundary research, detecting similarities between two otherwise distant vocabularies, providing us a glimpse of the topics that are generating an active discussion between the disciplines. Assuming keywords as an *explanandum* of different research strains (the *explanans*), Climate Change, GIS and remote sensing, and geomorphology play the role of the shared border for boundary research, or, in other words, the role of a conceptual and epistemic *trading zone*.

41 GIS and mapping constitute a notable case of inter-language trading zone (Galison, 1997), where in the case of climate change and geomorphology, the shared interest is completely organic to the normal disciplinary interest of both disciplines, as they maintain enough conceptual plasticity to be interpreted differently across scientific communities, and thus resemble boundary objects (Star, Griesemer, 1989). Even if potentially fruitful, such trading zones are unruly and spontaneous, opening the question of how to exploit the potential for co-operation in a systematic and structured fashion. As Tadaki *et al.* recently laid it down:

We feel that there is emancipatory potential in considering prospects for a more explicit critical turn in physical geography, and in imagining how our practices connect to others (Tadaki, Brierley, Dickson, Le Heron & Salmond, 2015).

42 Taking this citation into consideration and broadening our view to the larger context of knowledge making in a multidisciplinary domain, the second study calls for some reflection on geography's place in such a process. I am not looking here at the different processes of science-making that characterize the two disciplines, and potential ways to integrate them, as an emic standpoint is certainly better suited to undertake such an endeavour. Hence, the study isolates and assess a possible integration field in terms of mobilisation of disciplinary research products in the process of knowledge creation outside of the boundaries of geography. The co-citation relationship between HG and different geo-sciences, bio-sciences, and natural sciences at large journals (categories 2, 3, and 4 in the scheme) is far from negligible if measured in the context of an environmental science-policy journal such as GEC-HPD. There is proof of a certain degree of interoperability between the forms of knowledge considered. Interoperable forms of knowledge are easier to mobilize and travel effectively across disciplinary boundaries. Such interoperability, however, implies no obvious direct interaction between the practitioners, as the expertise of a scientific group, as well as its scientific culture, might remain black-boxed to the other groups, and therefore the encounter intrinsically non-transformational (Collins, Evans & Gorman, 2007). Interoperability, in this case, is restricted to scientific language and products rather than practices. Hence, one should look at co-citation data as pieces of evidence of the degree in which, once mobilised by works in other research fields, HG knowledge, geo-scientific knowledge (comprising of PG) and other fields of scientific literature are already being held in close contact. In this light, our data provide support to Lave's claims about the epistemic potential of CPG, as "*we cannot rely on explanations grounded in physical or critical human geography alone*" (Lave *et al.*, 2015, p.3) if we are to correctly analyse and

interpret the complexities of landscapes and environmental processes; the use of HG and PG knowledge highlighted by the case-study testifies how this concept is operationalized in the realm of environmental policy studies.

- 43 Given these final remarks, one should consider the course of action that would better fit the necessary reforms in the disciplinary publication practices. Lave *et al.* point at both the institution of new journals and a substantial change in the way editors select reviewers for the existing ones. Both solutions proposed are feasible but need extensive work, given the distance measured between the fields. However, the bargaining of enforced (*sensu* Collins *et al.*, 2007), institutional and explicitly codified trading zones between HG and PG – following the suggestion of Lave *et al.*, a dedicated journal – could nurture an enhanced level of scientific novelty and relevance for geography and provide an interesting testing ground for further reforms.

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NOTES

1. Boundary research exists on the fringes of all fields and sometimes ends up pushing these fields forward in spite of great resistance or general indifference (Wanskin, Van Ittersum, 2016). Such research often operates on blurred interdisciplinary lines that are direct result of a continuous bargaining between disciplines. Following this line, a form of integration between

Human and Physical Geography must rely on the mutual interest needed to work at the edge of the respective scientific cultures and mainstream interests.

2. Note that WoS and Scopus require subscriptions that are usually provided by the researcher's home institutions and thus are not free.

3. <https://www.scimagojr.com/>

4. It expresses the average number of weighted citations received in the selected year by the documents published in the journal in the three previous years.

5. The Lotka curve describes the Lotka's Inverse Square Law of scientific productivity, generally recognized as a power law distribution. Power-law distributions have the general shape of negative exponential J-curves with a long tail to the right.

6. Even if tout-court Geography journals are open to submission for articles in PG, the number of actual PG articles published is limited due to a different publishing behaviour of PG researchers, as already noted by Ferguson (2003).

7. Note that the analysis is limited to journal articles and do not consider citations of books and chapters.

8. In bibliographic coupling, publications sharing many references, namely, publications whose bibliographies largely overlap, are considered as more similar than publications sharing few or no references at all (Petrovich and Tolusso, 2019)

9. The exercise is not repeated for PG journals as, once again, a substantially different publication behaviour (Ferguson, 2003) prevent its replication.

10. Note that the analysis is limited to journal articles and do not consider citations of books and chapters.

11. Note that the length of the time series is conditioned by the institutional subscription to the database, and not necessarily by the historical publishing life of the journal itself.

12. Despite the journal being founded back in 1912, the time series starts in 2016 due to limitations in the host university subscription to the database.

13. The case of Land is of particular interest given the wide scope of the journal, cutting through the physical and social sciences with a focus on land use, land use change and landscape, and the marked scientific diversity in the editorial board.

14. The visualization includes only sources with at least 5 documents indexed in the database.

15. Modularity is a measure of the structure of networks or graphs which measures the strength of division of a network into modules (also named clusters or communities). Networks with high modularity have dense connections between the nodes within modules but sparse connections between nodes in different modules. Modularity is a key method for detecting community structure.

ABSTRACTS

With the aim of developing a reflection on the documental level of geography, and to understand how physical and human geography are materially related, this paper analyzes an ample spectrum of indexed literature from a distant reading perspective based on scientometric tools. Moving under a sociology of science lens, the study address (I) the citational relationship between the two fields, and (II) how scientific articles in geography are mobilised and combined with different categories of research journals in a cognate scientific field. The study relies on

science mapping techniques to chart, describe, and visualize the citational relationships among journals and fields.

Dans le but de développer une réflexion sur la production de publications de la géographie et de comprendre comment la géographie physique et la géographie humaine sont matériellement liées, cet article analyse un large éventail de littérature indexée dans une perspective basée sur des outils scientométriques. Se déplaçant sous le prisme de la sociologie des sciences, l'étude aborde (I) la relation des citations entre les deux domaines et (II) la manière dont les articles scientifiques en géographie sont mobilisés et combinés avec différentes catégories de revues de recherche dans des domaines de recherche apparentés. L'étude s'appuie sur des techniques de cartographie de la science (« science mapping ») pour tracer, décrire et visualiser les relations de référence entre les revues et les domaines.

INDEX

Mots-clés: science mapping, scientométrie, géographie physique critique, analyse de réseau

Keywords: science mapping, scientometrics, critical physical geography, network analysis

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