

Thinking complex interconnections: transition, nexus and Geography

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Abstract

More than ever is Geography surrounded by interdisciplinary movements claiming expertise with regard to the interconnections among nature, society and technology. These movements ask questions from Geography and geographers about if and how they can contribute to those movements and what form collaboration might take. This article analyses Human Geography's interactions with research on sustainability transitions since the early 2000s to think through future interactions between Geography and water-energy-food-nexus research. It shows that concepts, ideas, logics and methods have travelled from Human Geography into Transition Studies but that exchange between them has so far been partial and asymmetrical. Arguing that common ideas about how interdisciplinarity can be encouraged might be insufficient to change this situation, the paper develops ideas from Stengers, Whitehead, Foucault and others to explain the relations between Human Geography and Transition Studies in terms of modes of abstraction in an evolving ecology of power relations. It makes a case for slowing down modes of abstraction and proposes some ideas for slow collaborative research on sustainability transitions in contact zones. Implications for how Geography and geographers might engage with interdisciplinary nexus research are outlined.

Keywords: interdisciplinarity, sustainability transition, nexus, abstraction

1. Introduction

Recent decades have witnessed the emergence of various interdisciplinary movements concentrating on interconnections among nature, society and technology. The recent academic interest in the nexus of water, energy, food and climate is policy and business driven yet also the latest instalment of a series of movements focused on 'coupled human-environment systems', 'socio-ecological systems' and also 'sustainability transitions'. Originating in the interstices of conventional academic disciplines, research highlighting these concepts has expanded rapidly. Not only has it found domicile in a new field sometimes called sustainability science; it has also travelled into more established disciplines, including Geography. In fact, where previously cross-disciplinary intellectual and political developments such as positivism, phenomenology, Marxism, feminism, the crisis of representation and a (re)turn to materiality were key sources of change in (Human) Geography, the discipline now sees itself confronted by a proliferation of interdisciplinary movements that claim some of the intellectual terrain that has long been dominated by geographers.¹

As far as the interconnections among nature, society and technology are concerned, geographers have responded to this proliferation of interdisciplinary movements in multiple ways. Some have been enthusiastic, others more cautious or critical (see, for instance, Cote and Nightingale 2011; Lawhon and Murphy 2012; Castree *et al.* 2014; Castree 2016). In this paper I seek to add to debates about Geography's relations with interdisciplinary movements by reflecting on the questions if and how Geography can contribute to those movements and what forms collaboration might take. To make this broad aim manageable, I will use the recent interactions between (Human) Geography and sustainability transitions scholarship to think through future interactions between Geography and research on the water-energy-food nexus. My argument will be twofold. While (Human) Geography has much to offer in terms of concepts, ideas, logics and methods to the rapidly increasing interdisciplinary research about the interconnections among nature, society and technology, recent experience with research on transitions suggests that diffusion of geographical thought and praxis into nexus research is unlikely to come about naturally or easily. It thus seems that prevailing ideas about how interdisciplinarity can be advanced are not sufficient to encourage greater and more comprehensive uptake of concepts, ideas, logics and methods from Human Geography in transition or nexus research beyond our discipline. I will draw on the thought of Alfred North Whitehead and Isabelle Stengers to suggest that there is a need to slow down interdisciplinary reasoning and practices, and that this can be done by focusing on processes of abstraction.

I begin by discussing interdisciplinarity and outline an approach to understanding the relationships between disciplines and research fields that is informed by the philosophies of Stengers and Whitehead. I will then introduce sustainability transitions and nexus research in greater detail. Juxtaposing Transition Studies – a field in which I have been become involved in recent years through work on the everyday mobility of people – and nexus research may seem odd or even far-fetched but is, I suggest, insightful. As elaborated below, there are clear similarities in terms of emphasis on transdisciplinarity, interconnections and complexity but also important differences. Not only is research on sustainability transitions more mature, it is also closer to Human Geography because of its roots in *inter alia* science and technology studies and lacks most of the natural science traces that characterises nexus research. Thus, if the exchange of concepts, ideas, logics and methods between Transition Studies and Human Geography turn out to be constrained and uneven, it can be expected that stratifications and immobilisations will be larger if, as in nexus research, the difference between social and physical science needs to be negotiated over and beyond the boundary separating discipline from interdisciplinary movement.

2. Interdisciplinarity and disciplines

There are numerous definitions of interdisciplinarity and understandings of how this differs from multi- and transdisciplinarity. Here I follow Barry *et al.* (2008, page 28) for whom interdisciplinarity denotes a spectrum from multidisciplinarity – cooperation of disciplines whose framings remain largely intact – to transdisciplinarity. The latter term captures a type of reflexive and integrative knowledge production that is oriented at application and addressing societal and environmental problems and involves non-academic stakeholders as active participants (Osborne 2015; Klenk and Meehan 2015). It can be top-down and enabled by supranational organisations, or emerging through bottom-up modes of organisation that are rooted in particular localities. Much of it is akin to mode-2 knowledge production – context-driven, applied and focused on the solving of problems set by the funding agencies rather than initiated by the investigator(s) (Nowotny *et al.* 2003) – and post-normal in the sense of being focused on profound, systemic uncertainties and on social accountability to stakeholders beyond academia (Funtowicz and Ravetz 1993).

Interdisciplinarity can be pursued for different reasons (Barry *et al.* 2008) but with transdisciplinarity the most common remains integration. More than once this is underpinned by a presumption of superiority: knowledge production can be improved and made more effective and impactful in addressing societal problems if the inevitable partial and telescopic character of disciplinary perspectives and practices is overcome through some kind of fusion. This presumption is problematic insofar that the inevitably normative and situated criteria by which research is deemed to be improved are either left unspecified or reduced to a narrow utilitarian logic of contribution to societal problem solving. At any rate, there is widespread agreement that the desired integration is difficult to achieve. There now exists a large literature charting the barriers to integration and the processes and conditions that help transdisciplinary research to flourish; Table 1 summarises key insights that have emerged from this literature. It is evident that many conditions militate against integration but many authors draw specific attention to differences in language and discourse and the importance of overcoming these.

<Table 1 about here>

Despite their usefulness, attempts to reduce barriers to integration have been challenged by social scientists, geographers included, who point out the political nature of integration and the productivity of antagonism and friction. While some advocate epistemological pluralism (Castree *et al.* 2014; Stirling 2015; Adams 2016), others challenge the ontological dimensions of integration (Barry *et al.* 2008; Donaldson *et al.* 2010; Klenk and Meehan 2016). The argument in favour of what Barry and colleagues (2008) call agnostic-antagonistic modes of interdisciplinarity is that integration typically means that objects of interest, such as a socio-technical system or the nexus, are posited and taken for granted as *matters-of-fact* – “mere existence[s]” (Whitehead 1968[1938], page 6) that are “indisputable, obstinate, simply there” (Latour 2008, page 39) and abstracted from their relations and contexts, including the practices and techniques through which they have been enacted. This is both significant and political: once relations and contexts are brought into consideration, those objects become fragile, disputable and multiple – in other words, they become *matters-of-concern* (Latour 2008) – and alternative ways of being, becoming, thinking and imagining are opened up.

It is for this reason that Klenk and Meehan (2015) advocate a mode of transdisciplinary research on environmental issues that values difference and recognises that the construction of objects like a socio-technical system or the nexus is unequal and power-laden. This is why they advocate the co-production of knowledge across academic communities and with non-academic stakeholders using methods that foster the generative capacities of friction between *versions* (Despret 2004) of those

objects. The hope is that this will open up different futures and trajectories towards greater sustainability and wellbeing (on the understanding that both these terms are matters-of-concern themselves).

The thinking on how to overcome barriers to interdisciplinarity and the call to maximise difference within transdisciplinarity are important and helpful, but various issues can be identified. One is that much of the literature on interdisciplinarity is focused on the social/natural science dichotomy. Due consideration is not always given to further differentiations between and within disciplines and epistemic cultures – specific arrangements and “machineries” that make knowledge construction possible; have distinct technical, social and symbolic dimensions; and that exist and evolve within and across disciplinary boundaries (Knorr Cetina 2009). In addition, the disciplining and disciplinarising tendencies of interdisciplinary movements are not always recognised and explored. It is well-known that “[d]isciplines discipline disciples” (Barry *et al.* 2008, page 20) and channel research efforts into certain directions, but so do subdisciplines, epistemic cultures and interdisciplinary movements. Likewise, disciples self-regulate (Foucault 1985) as members of subdisciplines, epistemic cultures and research fields with specific concerns, methods, vocabularies and institutions. In other words, a complex landscape of power relations and forces within academia affects research into the interconnections among nature, society and technology.² This is all the more so because, over time, interdisciplinary movements often become institutionalised and turn into ‘interdisciplines’³ with their own journals, training and education programmes, learned societies, reward structures and career opportunities. Whilst still embedded in longer-standing disciplines and epistemic cultures, Transition Studies has gradually become an interdiscipline; nexus research may be on a similar trajectory.

One strategy for thinking through the complex landscape of (sub)disciplines, epistemic cultures and interdisciplinary movements within which academic research takes place is to turn to Stengers’s (2005a, 2010a-b, 2011a) idea of an ecology of practices. Her interest lies in understanding how different practices, particularly those of specific disciplines or research fields, relate to each other and in what this ecology enables them to become. She seeks to understand the “needs, behaviours, habits and crucial concerns” or *ethos* of a practice and how this influences and is influenced by its *oikos*, including other practices (Stengers 2011a, page 59). In her *Cosmopolitics* books she explores the ethos-oikos complex through a focus on the obligations and requirements of a practice (Stengers 2010a-b). Obligations in this context refer to the risks and challenges that a practice imposes on its participants (e.g., practitioners and stakeholders benefitting from its products), and requirements refer to the demands the practice makes on the environment on which depends. A unique constellation of obligations and requirements defines a practice. Thus, if disciplines impose constraints³ on research and disciples, then they can be articulated in terms of obligations and requirements. Yet, it is equally clear that disciplines are not the only entities imposing obligations and requirements; sub-disciplines, research fields and epistemic cultures do too.

The emphasis Stengers places on obligations and requirements is useful in the current context. It can help us understand how disciplines and interdisciplinary movements, such as Transition Studies and nexus research, discipline their environments and practitioners and how the latter self-regulate. It also draws attention to the power relations that connect and help to shape disciplines and research fields. Yet, she offers few concrete suggestions how obligations and requirements are to be examined in relation to academic practices; the analysis in the *Cosmopolitics* books remains at a very general level. I therefore propose to explore such obligations and requirements indirectly, by focusing – as Whitehead did throughout his career as philosopher – on modes of abstraction. Many such modes of course exist within disciplines and fields but there are often also important commonalities in abstraction within a given discipline or research field.

Whitehead believed that abstraction – selection, simplification, reworking and exclusion – was not necessarily the “malign process of generalisation and simplification through which the complexity of the world is reduced at the expense of the experience of those who live in the concrete reality of this world” (McCormack 2012, page 717). He was obviously aware of the danger of being led “away from the realities of the immediate world” (Whitehead 1967[1925], page 39) but understood abstraction as productive and creative. Elsewhere he suggested that abstraction is part of *any* instance of creation, not just by or involving human beings (Whitehead 1968[1938], 1977[1929]). Abstraction, on this view, is central to the effects the environment has on a particular entity. It is through processes of selection, simplification, reworking and excluded that a historically constituted and constantly changing environment becomes part of and helps to (re)constitute a particular entity (and vice versa).

For Whitehead (1968[1938]) the specifics of how abstraction unfolds – what is selected, simplified, reworked and excluded, and in what way and sequential order – depended on *importance*, which is the perspective that is imposed on the environment and that co-evolves with the interests of the entity being considered. The significance that Whitehead attributed to context means that there can be no general rules about when an abstraction is good or not, but he was critical of rigid modes of abstraction that did not adapt to the inevitable change and novelties that occur over time in philosophy, research and the world more generally. Extending Whitehead’s arguments, Stengers (2011b) argues that researchers should be vigilant about their abstractions to avoid that they are blindly led by them and that advances in a practice such as transition research or geography are no more than “progress in its own groove [that] prevents straying across country ... and the comprehension of human life” (Whitehead 1967[1925], page 197). Abstraction in research should thus be revisable, adaptable and responsive to the changing contexts of which it is part.

This line of reasoning allows us to appreciate how abstraction can play a generative role in how elements from certain academic practices, such as transition research or geography, become integrated into a practitioner’s thinking, writing and other actions. What at a specific moment gets selected, simplified, reworked, excluded and how, depends on her interests and the obligations and requirements of the practice she performs, and all of this can be expected to change over time. The creativity of abstraction is thus mediated by the continuously evolving constellations of obligations and requirements that define disciplines, epistemic cultures and interdisciplinary research fields. Nonetheless, absent from Whitehead’s texts is discussion of the political nature of abstraction and how selection, simplification and exclusion are shaped by the regimes of truth and governmentalities – respectively, the dynamics of what is seen as truthful and the shifting constellations of ideas, procedures, techniques and technologies through which practices and practitioners are governed – within wider *dispositifs* (Foucault 1980, 2010). Given that disciplines, epistemic cultures and interdisciplinary movements discipline self-regulating disciples, it is important to consider the politics of abstraction when Whitehead’s and Stengers’s concepts are used to understand Geography’s relationships with interdisciplinary research on the interconnections among nature, science and technology.

3. Transition and nexus

3.1. Multiplicity, creativity and interconnection

It is important to insist on the multiplicity of the thinking and research on sustainability transitions and the water-energy-food nexus because there are no simple origin stories, developmental narratives or future trajectories, and neither are their clear boundaries between in- and outside. For instance, many narratives of the evolution of Transition Studies highlight how it has emerged out of

integration of thinking and insights from science and technology studies, history of technology, evolutionary economics and innovation studies (Rip and Kemp 1998; Geels 2002) whilst others also draw attention to the incorporation of crucial inputs from biology and ecology, environmental studies and demography (Rotmans et al. 2001; Loorbach et al. 2017). It is nonetheless still possible to identify key moments and elements that have played a key role in the development of each interdisciplinary movement. Examples include the 2008 World Economic Forum in Davos (WEF 2011) for nexus research, and for sustainability research the incorporation of the concepts of transition and transition management in the fourth National Environmental Policy Plan of the Dutch government in 1990 (Loorbach et al. 2017) and the publication of Geels's (2002) Multi-Level Perspective (MLP) diagram (Figure 1).

<Figure 1 about here>

Geels's diagram is significant for at least three reasons. First, it has proven profoundly influential by suggesting that fundamental and durable change – a transition – demands the re-alignment of a socio-technical regime, landscape and one or more niches. Here the regime constitutes the set of rules that condition, and are reproduced by, the social practices from which a socio-technical system such as automobility or gas heating emerges; examples of such rules are cognitive routines, shared beliefs, social norms and conventions, regulations, industry standards, protocols, contracts and laws (Geels 2004). Regimes are dynamically stable; they favour and enable incremental innovations that tend to leave a socio-technical system's basic architecture intact. More radical forms of innovation, transition scholars hold, need the protection of socio-technical niches in which innovations are shielded from regime pressures, nurtured through experimentation and visioning, and empowered so that they become capable of reconfiguring the regime through competition or symbiosis (Smith and Raven 2012). The socio-technical landscape, finally, gathers all the wider contexts and developments over which regime actors have little influence, including demographic shifts, economic crises, and anthropogenic climate change. Geels's original diagram proposes one way in which regimes, niches and landscape interact to generate a transition and this has later been extended (Geels and Schot 2007; Geels *et al.* 2016). One of its strengths lies in how it foregrounds interconnections, not also among the three levels but also among markets and user preferences, industry, science, policy, culture and technology.

However, and secondly, the diagram needs to be seen as partial and selective, even if it has helped to initiate large numbers of non-innovation scholars into transition thinking. This is not least because it abstracts away geography and most of the insights from biology, ecology, environmental studies and demography that feature more prominently in other articulations of sustainability transitions (Rotmans *et al.* 2001; Loorbach et al. 2017). Partly because of this, and thirdly, the diagram by Geels – and subsequent reworkings – are not equivocally embraced within the interdisciplinary Transition Studies community. Reservations may be more easily articulated in one-to-one conversations than in peer-reviewed publications but they are not uncommon; the MLP is not as hegemonic within Transition Studies as it may appear at first sight.

3.2. Interconnection, instability and difficulty

Nexus thinking has its own diagram (Figure 2), originally included in Hoff's (2011) *Understanding the Nexus* and now rapidly replicated elsewhere. Whether it will become as influential as Geels's remains to be seen, but the nexus diagram highlights interconnectedness just as strongly – here primarily among water supply, energy security and food securities. To a degree the 'nexus' remains elusive, in part because it has only recently become popular. At the present time, the adjectives

‘unstable’, ‘difficult’, ‘technical’ and ‘governmental’ seem most appropriate to introduce nexus research.

<Figure 2 about here>

Instability is evident from the naming; a survey of the interdisciplinary literature reveals a range of sequences and differences in what is in/excluded. The term water-energy-food nexus clearly dominates but permutations and alternatives can also be encountered, including water-energy-land-food nexus, climate-energy-water nexus, water-soil-waste nexus, climate-energy-land-water nexus, and simply nexus. It is tempting to read this variability as a sign of immaturity and assume that ultimately one term will prevail. However, it is also possible to understand the heterogeneity as indicating that which really matters is interconnectivity; what is interconnected and how is perhaps slightly less important. Thus, Mohtar and Lawford (2016, page 194) claim that “the WEF nexus approach ideally begins with an interrelated system and then notes the two-way relationships between water, food, or energy and the other resources”, although many others argue that water is at the heart of it all (Allouche *et al.* 2015; Wichelns 2017). Yet instability also goes beyond naming. Understandings of the nexus are plural, variable and ambiguous and this “prevent[s] one from stating clearly what constitutes a nexus approach or nexus analysis” (Wichelns 2017, page 113; Cairns and Krzywoszynska 2016).

It is also widely agreed that the nexus is difficult, not only in terms of policy development and implementation but also as an object of thought. Thinking interconnections across domains or systems is difficult, the argument goes, because of the specialisation and fragmentation of science. For instance, a recent Delphi-method study among experts at the U.S. Global Change Research Program demonstrated the difficulty of identifying research priorities that encompassed the full energy-water-land-climate nexus: “[m]ost people are expert in one or two topic areas and so are able to identify with relative ease topics that cover individual sectors or perhaps two sectors ... [w]e saw far fewer topics that hit three sectors and very few that touched all four elements” (Faeth and Hanson 2016, page 124). There is also a scalar dimension to the difficulty of researching the nexus. In research, the focus on the planetary scale that dominates much of the nexus discussion outside academia is often scaled down to the national or sub-national level (e.g., Foran 2015; Howarth and Monasterolo 2016; Yang *et al.* 2016) to make analysis more tractable. In addition, Leck and colleagues (2015) point out that data and modelling constraints mean that empirical analyses often consider two elements and two-way interactions only.

It is not surprising, then, that to date much research outside Geography has been technical in nature, focusing on the construction of new model systems and coupling of previously existing sector-focused models (e.g., Bazilian *et al.* 2013; Endo *et al.* 2015; Chang *et al.* 2016; Yang *et al.* 2016). Mathematical modelling and computer simulation do play a role in Transition Studies, but are much more common in nexus research and there often underpinned by methodological and epistemological frameworks originating in the natural sciences. Hence, while much nexus research aspires to be post-normal and transdisciplinary, there is also a lot of work that remains within a conventional model for stakeholder interactions that seeks to separate fact from value. Here, academics and scientists offer putatively neutral, a-political information that will allow others – politicians, policymakers, businesses – to make decisions that help to increase the efficiency of resource allocation. For, unlike Transition Studies’ emphasis on radical system transformation, it is in terms of increasing efficiency and optimisation and securitisation of existing systems that the nexus is often framed as a governance problem. For Allouche *et al.* (2015, page 621) this framing reflects a “scarcity crisis narrative” promoted by a conglomerate of business and political elites. This narrative holds that population growth, urbanisation, climate change, political instability and price volatility are culminating into unprecedented crises in water, energy and food availability and tradeoffs,

which are best overcome through a paradigm of control and ecological modernism's emphasis on technological innovation, better governance and greater market efficiency.

A critical social science literature has nonetheless emerged, challenging this framing of how the nexus should be governed. This work highlights such issues as siloed government departments and agencies, fragmented responsibilities, legislative and regulatory barriers, inattention to power structures and social distribution (who gains, who loses? Where? How?), and inability to deal with complexities and uncertainties in decision making (Pittock *et al.* 2013; Leck *et al.* 2015; Allouche *et al.* 2015; Cairns and Krywozynska 2016). Geographers are playing an important part in this, as they also did in the thinking on the governance of sustainability transitions (Sections 4.1).

3.3. Complexity

Transition and nexus research share more than this, or indeed an emphasis on interconnectivity and a commitment to transdisciplinarity. They are also linked through roots in complex systems theory. Rotmans *et al.* (2001) are clear on this as regards sustainability transitions, which they imagine as non-linear phase shifts from one dynamic equilibrium to another, even if they argue that transition is a sociological concept that stems from biology and demography. Kemp *et al.* (2007) draw on the concepts of punctuated equilibrium and, following Geels (2004), co-evolution as the scientific basis of the transition management approach; Loorbach and colleagues have advanced this grounding of transition management in thinking from physics, biology and ecology (Rotmans and Loorbach 2009; Loorbach *et al.* 2017). The nexus literature is equally suffused, animated and shaped by complex systems theory. This is evident, for instance, from a recent discussion of "key elements" (Howarth and Monasterolo 2016, page 54) defining the nexus, such as uncertainty, nonlinearity, feedbacks and emergence – all of which also feature prominently in research on transitions.

There are, however, subtle differences between the two interdisciplinary movements, and indeed within each. Discussions of complexity in the nexus literature have on balance a more natural science orientation than in transition scholarship in which much greater attention is directed towards complexity in institutions, governance and power relations (Loorbach *et al.* 2017). Still, it is not only nexus research and thinking that is often post-political (Mouffe 2005). The foreclosing of dissent and radically different imaginings of the future through a privileging of expert management, markets and consensus can also be found in some strands of transition scholarship, including part of the transition management literature. Other strands have nonetheless recognised the importance of fostering the political (Seyfang and Smith 2007; Loorbach *et al.* 2017) and this is another area where insights from Geography have influenced Transition Studies.

4. Transition and Human Geography

Having laid the groundwork for thinking through the relationships between Geography and interdisciplinary movements focused on the interconnections among nature, society and technology in the past two sections, I will now concentrate on the interface between transitions research and Human Geography before returning to nexus research in the next section.

4.1. From first encounters to asymmetries

Geography's first encounters with transitions research go back to around 2000. Since then transition concepts have moved into the discipline along different trajectories crafted out of the embodied

practices of specific individuals, including Bernard Truffer (Hoogma *et al.* 2002; Truffer 2008), Gordon Walker (Shove and Walker 2007; Walker and Cass 2007), James Murphy (Rock *et al.* 2008), Lars Coenen (Coenen *et al.* 2010), Mike Hodson and Simon Marvin (Hodson 2008; Hodson and Marvin 2009), and Harriet Bulkeley (Lovell *et al.* 2009; Bulkeley *et al.* 2010). These individuals were all engaged in interdisciplinary research over the 2000s, they were routinely publishing outside Geography's core journals, and more than half were employed at interdisciplinary institutes. All also have a long-standing interest in innovation, technology and/or climate change governance.

Yet, their discipline and the sub-disciplines they identify with have also imposed obligations on the research they were involved in, and at least two types can be identified. Firstly, their training and disciplining-*cum*-self-regulation meant they foregrounded emplacement and the demands for "the earthly materialities of place" that transitions make (Brown *et al.* 2012, page 1620). They started asking questions about how sustainable transition dynamics affected, and were mediated by, processes that were characteristic of specific regions (Hodson 2008; Truffer 2008), cities (Hodson and Marvin 2009, 2010; Bulkeley *et al.* 2010) and places (Murphy 2015) beyond the national level – historically the dominant focus in Transition Studies. This in turn directed attention to questions of scale (Hodson and Marvin 2009; Coenen *et al.* 2012) and translocal and transnational networks (Hodson and Marvin 2009; Bulkeley *et al.* 2010). Secondly, their training and disciplining-*cum*-self-regulation raised pertinent questions about politics and power (Shove and Walker 2007; Hodson and Marvin 2009). Similar concerns had emerged elsewhere previously (e.g., Meadowcroft 2005) but what geographers added were questions about spatial and scalar politics.

Obligations were accompanied by requirements. Concepts like transition, socio-technical system and regime had to be able to fulfil the demands made by Geography – and also Economic Geography, Urban Studies, etc. – and in some instances assembled empirical materials. Together, obligations and requirements ensured that for geographers transitions were and remained – arguably until this very day – matters-of-concern rather than matters-of-fact, triggering specific modes of abstraction. They began to compose different versions of the objects populating the transition literature. On the one hand, they offered alternatives to the until recently dominant practice in the latter to abstract away from dynamics at sub- and supranational scales and to pay only limited attention to innovations in which technology, market-based diffusion logics and/or private or public sector actors are only of secondary importance. On the other hand, the practices involving the aforementioned geographers inevitably selected, simplified, reworked and excluded in other ways. For instance, abstracting differently meant sacrificing the prospect of producing a rather neat typology of transition pathways (e.g., Geels and Schots 2007) that can be applied in many contexts and with the potential to exert significant impact beyond academia. Disciplinarisation implied ontological and epistemological differentiation.

Responses to the percolation of transition thinking into Geography have proliferated since 2010 and exhaustive discussion of all developments is beyond this article. They can, however, be represented heuristically by a triad with dismissal, addition and rethinking as its extremes (Figure 3). The resulting two-dimensional, inevitably abstract field can be used to position responses – i.e., specific studies and or research projects – as points, lines or fields themselves.⁴ *Dismissal* in pure form is rare, at least in the published literature (but see Temenos *et al.* 2017); it can sometimes be encountered at conferences but, in my situated experience, is usually articulated in informal conversations.

<Figure 3 about here>

Addition is much more common in the published literature and comes in varieties and gradations. Some work remains very close to the work by leading innovation scholars but other research moves further away. A comprehensive overview of additive scholarship by geographers is offered by

Hansen and Coenen (2015) who single out bringing place specificity to the transdisciplinary literature on sustainability transitions as Geography's biggest contribution: its practitioners have, often in collaboration with scholars who would not self-identify as geographers, highlighted the role of a wide range of geographical factors and processes mediating transition processes. These include urban/regional visions and policies; often privatised, material infrastructures, localised institutions, norms and values; locally specific natural resource endowments; local technology and industry specialisations; and local market formation. Interestingly, Hansen and Coenen also question the usefulness of a focus on place specificity if there is no progression towards generalisable knowledge:

"There is a risk that such analyses simply observe geographical specificity and establish differences in transition dynamics as an empirical matter-of-fact without engaging with the undoubtedly daunting task of fully explaining such differences. This in turn may unduly limit the contribution of geographical analysis to sustainability transitions to that of topical contrivance: *of interest to geographers but with limited reach beyond*" (2015, page 105, emphasis added).

From my own inevitably partial and situated interactions with transition researchers I recognise the sentiment articulated here. I have, for instance, been asked the dreaded 'so what?' question when presenting my own research analysing spatial differentiation in transition trajectories in people's everyday mobility (Schwanen 2015, 2016). Not only is place specificity simply to be explained away by more universal processes and events for most scholars trained in disciplines imposing other constraints and requirements than Geography does; the sort of explanations that our discipline tends to offer also are at best half-convincing to many of them. My hunch is that additive geographical research published or undertaken since late 2014 – where Hansen and Coenen's overview stops – has not overcome these sentiments among practitioners from other disciplines either. I write this most emphatically not to call for more universalising theory by geographers but to highlight the uneven, power-laden ecology in which Geography and Transition Studies interact.

There is also a vibrant body of geographical scholarship that has actively sought to *rethink* the concept of sustainability transition. Prominent here is research that is to varying degrees inflected by political economy and political ecology thinking (e.g., Hodson and Marvin 2010; Lawhon and Murphy 2011; Bulkely and Castán Broto 2013; Newell and Mulvaney 2013; Bulkeley *et al.* 2014; Newell and Phillips 2016). Analysis of citations of selected publications in this vein offers insight into modes of abstraction – what has been selected, simplified, reworked and excluded, and how – as part of the uptake of geographical concepts, ideas, logics and methods by scholars who tend not to self-identify as geographers. Table 2 offers details for selected papers but several more general conclusions can be drawn. The good news is that geographers' work has influenced transdisciplinary research on sustainability transitions in different ways and with varying levels of intensity. This influence takes time to manifest itself, in part because of the ways in which academic publishing works and the very fact that, even in the digital age, information is not consumed everywhere instantly. It is therefore tempting to expect that more geographical concepts, ideas, logics and methods might be absorbed into transdisciplinary thought and practice in due course.

<Table 2 about here>

There are, however, significant asymmetries in the mobility of concepts, ideas and logics, and it is not obvious these will dissolve in future. On balance geographers rethinking research on transitions in line with their discipline's obligations and requirements are influenced more profoundly by transition scholars than that the latter are influenced by geographers' work. Moreover, inherited from geographers' published texts are often only what the geographical community would consider elementary ideas; the levels of simplification and reworking that facilitate mobility tend to be very

large. There is, then, no necessary relationship between what many in Geography would qualify as world-leading research and influence in the wider interdisciplinary literature. Fulfilling the obligation of working at the ‘cutting edge’ of geographical thought and praxis can go hand in hand with exclusion and gross simplification⁵ in the context of transdisciplinary research on transitions.

This tension can also be observed in other ways. Geographers have undertaken innovative work on pre-figurative community initiatives seeking to enact socially just transitions to a more sustainable, low-carbon and post-capitalist society, such as the Transition Towns movement, eco-developments and related experiments (Chatterton and Pickerill 2010; Aiken 2012, 2016; Mason and Whitehead 2012; Chatterton 2016; Barr and Pollard 2017). Yet, this literature has had limited influence on the now burgeoning scholarship within Transition Studies on grassroots innovations (Seyfang and Smith 2007). This is arguably why a recent systematic review on grassroots innovations (Hossain 2016) entirely disregards the wider geographical literature on Transition Towns and eco-developments, limiting itself to what I consider additive geographical research on community initiatives (Feola and Nunes 2014; Longhurst 2015). To an extent the disregard for the work by Chatterton, Aiken and colleagues reflects that most of it engages at best tangentially with the MLP and wider transition literature (but see Chatterton 2016; Barr and Pollard 2017). This wider geographical literature on community initiatives is nonetheless directly relevant to Transition Studies, not least because it refuses to buy into the already-hierarchical ontology that the very term grassroots innovation implies and offers alternative logics and vocabularies to the notion of up-scaling that pervades MLP-infected reasoning – for instance, by drawing on Deleuzian concepts of the rhizome and micropolitics (Chatterton 2016).

The tension can also be identified in relational geography critiques (Murphy 2015; Affolderbach and Schulz 2016) of transition thinking and especially the MLP. Now, the term ‘relational’ is used too often and too loosely in Geography but the conceptual purchase of highlighting the relational and contingent constitution of niches and regimes has been articulated succinctly by Affolderbach and Schulz (2016, page 1952):

“[a] relational perspective questions the hierarchies and logics of the multi-level perspective where innovations are clearly situated within contained niches ... [It] dissolves the clear boundaries of niches and regimes, changes the relationship between different levels and disconnects the alignment and hierarchy between distinct levels and spatial scales. Even further, if transition processes are understood as assembled or simultaneously co-produced by agents at multiple scales, we need to question the origin of innovations and inherently the role of ‘niches’ as test beds”.

And yet I have also experienced the difficulties of explaining a relational conception both of niches and regimes and of space more generally to sustainability transition scholars with whom I have interacted. Absolute and network understandings of space are now common in Transition Studies but more complex and nuanced conceptions of spatiality and spatial dynamics remain rare (but see Sengers and Raven 2015). The sort of thinking on space and spatiality advanced by authors as diverse as Lefebvre (1991), Thrift (2008), Massey (2005), or Harvey (2009) remains easy to exclude from transdisciplinary research on transitions, perhaps because those thinkers refuse to separate space from time and often foreground questions of contestation, politics and uneven development. The criticism that Transition Studies fails to consider power and politics has been addressed in various ways over the past decade (Avelino and Rotmans 2009; Geels 2014; Raven *et al.* 2016), but questions remain as to whether efforts have gone far enough. Little attention has been given to the idea that contestation, politics and uneven development can be effectively analysed by focusing on dynamics in geographical scale; territoriality; place; and the power-laden mobilities of initiatives, people, ideas, techniques and expertise (Bridge *et al.* 2013; Murphy 2015; Affolderbach and Schulz

2016; Schwanen 2016) – i.e., by fulfilling one of Geography's more important obligations. There have been several publications by transition scholars considering transnational linkages in niche innovation and globally distributed networks of sustainability experiments (e.g., Hansen and Nygaard 2013; Wieczorek *et al.* 2015), but these have ultimately different objectives. In line with their field's obligations, those scholars' interest lies in better understanding what encourages and facilitates innovation and transition dynamics rather than contestation, politics and uneven development.

The fact that selective diffusion of concepts and ideas from Geography into transdisciplinary research on transitions is replicated across different strands of research may reflect processes of disciplinarisation within Transition Studies. This young but rapidly expanding practice is undergoing academic institutionalisation and community formation and thus boundary formation, and the disciplining of self-regulating practitioners these processes entail has generated collectively sanctioned or at least preferred modes of abstraction and specific obligations for those practitioners. The key requirement that Transition Studies as interdiscipline is imposing on Geography and its practitioners is that their concepts, ideas and logics must not stray too far from common sense thinking about space, not contain too much 'jargon' (from the perspectives of Transition Studies), and be broadly compatible with the philosophical and methodological underpinnings of the MLP and other frameworks advocated by leading transition scholars.

4.2. An urban turn?

This conclusion can be extended to transition research focused on cities, but only up to a degree. There has been substantial exchange of concepts, ideas and logics between Urban Geography and Transition Studies since the latter embraced Urban Age discourse and the *leitmotiv* of the city as the quintessential space for innovation and experimentation with low-carbon practices, technologies and supporting institutional arrangements. Multiple narratives regarding the uptake of thinking from Urban Geography in Transition Studies can be put forward. Pessimistic storylines revolving around deficiency, shallowness and non-uptake can be placed on one end of a spectrum; optimistic versions highlighting increased engagement and cross-disciplinary learning due to transdisciplinary collaborative research projects and the formation of a contingent of early career researchers specialising in urban transitions occupy the other end.

A more optimistic position is supported by the observation that the transition literature has come a long way in a short time-span, from Geels's (2010) argument – itself more a response to work by geographers and urban scholars than reflecting an intrinsic interest in the urban – that there are no inherent reasons for a focus on cities, via the emergence of a sustainable urban transformation (SUT) literature (McCormick *et al.* 2013), to the current interest in urban experimentation and cities as sites that are uniquely suited to transition management and grassroots innovation (Loorbach *et al.* 2016; Wolfram 2016). Moreover, geographers such as Harriet Bulkeley, Lars Coenen and James Evans have recently collaborated with transition scholars in dedicated projects that have extended the thinking on urban experimentation in ways that are world leading in both Geography and Transition Studies (Bulkeley *et al.* 2016; Evans *et al.* 2016).

There are nonetheless two reasons for caution. Firstly, concepts, ideas and logics from Urban Geography are still engaged selectively in the wider transition literature. Empirically oriented research on urban climate change governance (Bulkeley 2010) and social innovation in cities (Moulaert *et al.* 2010) has been taken up in rather superficial ways, and theoretical thinking that has proven deeply influential in Urban Geography (Lefebvre 1991; Roy 2009) is acknowledged rather than fully engaged. Beyond Geography, work on policy mobilities (e.g., McCann and Ward 2013) has

so far only been considered by transition scholars who have since actively collaborated with geographers (Sengers and Raven 2015).

Still other thinking remains disregarded altogether, as is the case with both the work on planetary urbanism (e.g., Brenner 2013) and post-colonial attempts to 'world' or 'provincialise' urban research (e.g., Roy and Ong 2011; Sheppard *et al.* 2013). The thinking by Brenner and colleagues seems particularly germane to Transition Studies. This is because their Lefebvre-inspired approach not only allows resistance and politics to be examined and theorised much more fully and deeply, but also insists on conceptually separating the empirical category of the city from the theoretical notion of the urban. It thereby enables modes of abstraction inclined towards theoretical generalisation whose ethos is at least commensurate with that of the MLP and wider transition theory. Committing to the city/urban distinction means that the argument that cities matter because they are the empirical sites where complex systems meet, mingle and interfere is no longer adequate; it requires theorising how the urban as transformative potential is constitutive of transitions under capitalism. Accepting this premise will fundamentally reconfigure the conditions for the diffusion of concepts, ideas and logics from Geography into Transition Studies and demand new modes of abstraction from transition scholars.

The thinking on worlding and provincialisation holds equal but different potential given that Transition Studies has begun considering transition dynamics beyond the global North (e.g., Romijn *et al.* 2010; Wieczorek *et al.* 2015). This work has engaged with insights from development studies but neither with post-colonial thinking on the ordinary city (Robinson 2006) nor with critiques of the neo-colonial relationships between theory and the field according to which sites scattered across the South effectively produce data for theories formulated in northern academic institutions (McCann *et al.* 2013). Embracing the worlding thesis would mean moving beyond adapting analytical frameworks such as the MLP or transition management to theorising innovation and transition dynamics in Africa, Asia and Latin America in their own right using new, or at least radically reconfigured, concepts that potentially draw on local knowledge traditions and/or emerge from collaborations with local co-producers. Geography is by no means the only discipline to have worked with local knowledges and experimented with co-productionist methods, but many of its practitioners are well versed in provincialising their own assumptions, concepts, techniques and practices and thus abstracting differently. Cross-fertilisation of their experience with research on transitions would again reset the conditions for the exchange of concepts, logics, methods and practices between Geography and Transition Studies and open up new trajectories for cross-boundary collaboration.

Secondly, there are significant path dependencies in the abstractions by transition scholars that constrain the uptake of concepts, ideas and logics from Urban Geography. Geels (2010) identified three potential roles for cities in transition processes: as important actors engaging in visioning processes and offering specific types of protection to innovations, as early seedbeds where innovations can be demonstrated and tested by different actors, and as being of limited significance. This distinction has become influential within the SUT literature. For instance, recent research on transition management has used the first two of Geels's roles – the city as actor and as seedbed – as both justification for its city orientation (Loorbach *et al.* 2016) and starting points for the elaboration of new tools, such as the Urban Transition Lab (Nevens *et al.* 2013). The roles defined by Geels are important but they also risk turning cities into both passive receptacles and internally homogenous agents with shared interests.

More generally, the SUT literature tends to enact the city in specific ways. Differences notwithstanding, there are several path dependencies in abstraction that are at odds with current practice in most of (Anglophone) Geography. Two of these undergird the matter-of-fact versions of

the city as a container in which actions and processes unfold and as a concentration of people, resources, materials, etc. characterised by physical proximity. The third path dependency is evident from the idea of the city as an adaptive complex system which reflects both wider scientific discourses about cities and Transition Studies' indebtedness to complex system theory, physics, biology and ecology. As Figure 4 suggests, differences and tensions between the versions of cities enacted by these three fundamental abstractions of the city are negotiated and resolved by turning cities simultaneously into intersections of complex systems – systems of systems – owing to spatial proximity and concentration, locations in which problems and opportunities as well as barriers and inertia are concentrated, and into physically bounded spaces. As far as urban networks are considered, relations between cities are imagined as interaction between pre-existing, discrete elements instead of as the processes through which cities are configured and change.

<Figure 4 about here>

My concern is not so much whether the abstractions and versions of cities circulating through the transdisciplinary transitions literature are correct but over the effects they generate. Not only are these versions directing attention away from the tensions, contradictions, inequalities, exclusions and contestations that for many urban geographers characterise cities and the urban; they also seem to impose the requirement on Urban Geography and its practitioners to develop concepts, ideas and logics that are broadly compatible with complex systems thinking if geographers want their research be taken up in interdisciplinary research on urban transitions. This highlights how collaborations across (porous) boundaries occur in ecologies conditioned by complex power relations.

4.3. Where next?

The rapid evolution of Transition Studies as well as its practitioners' willingness to experiment and respond to critics should be appreciated. There will be further incorporation of concepts, ideas and logics from Geography, just as Geography will adapt to accommodate research on transitions. This is no guarantee, however, that the previously observed asymmetrical exchange and the very selective incorporation of what for many geographers are basic concepts, ideas and logics will be overcome.

To me, the observed asymmetries and selective incorporation are problematic, not because Geography is superior but because diversity brings benefits: geographers don't know better, but they do know differently and can therefore help to imagine, think and enact different futures. Nonetheless, I also believe that more is needed to reconfigure current modes of abstraction than the epistemological and procedural strategies summarised in Table 1. Those strategies are very important but many are insufficiently attuned to the ecology of power relations in which disciplines and research fields develop. They also often operate on longer time-scales than those over which developments in transition and nexus research unfold. Moreover, those strategies may not pre-empt the risk that matters-of-concern – for instance, what is a sociotechnical system? What is a city? – are treated as matters-of-fact. At the same time, harnessing agnostic-antagonistic modes of interdisciplinarity (Barry *et al.* 2008) and engaging in methodological experiments (Stirling 2015; Klenk and Meehan 2016) risk what Bernstein (1988) called fragmenting pluralism (see also Barnes and Sheppard 2010). This is a situation in which researchers communicate within narrow, homogenising epistemic communities and become more or less isolated from others working on similar issues. My own experience suggests this risk is particularly pertinent in areas, such as transport and energy, where many researchers have a strong desire to generate policy-relevant knowledge. I consider fragmenting pluralism undesirable as it might solidify boundaries between

Transition Studies and Geography to such an extent that only shallow and simple concepts, ideas, logics and methods travel between them.

A promising way forwards, certainly in the short term, is collaborative research that brings together diverse practices and practitioners from Geography and Transition Studies (especially if there is also a mix of epistemic cultures, career stages, genders and other social differences). As Peter Galison (1997) has argued, meaningful exchange between divergent academic practices is best coordinated locally rather than globally, and the previously mentioned collaborations around questions of urban experimentation (e.g., Evans *et al.* 2016) exemplify the benefits from local coordination of research practices in a *trading zone*. Galison (1997, 2010) developed this metaphor to characterise the practical ways by which communication in science occurs across Kuhnian paradigms through the development of inter-languages. Others have since developed these ideas by considering the role of materiality, skills and tacit knowledge, and power differences (see the chapters in Gorman [2010] for elaboration). Galison's metaphor has appeal because it understands trading zones as always-in-the-making, contingent and emergent and means that no standard recipes for their creation are on offer. Whilst effectively deployed in pleas for improved communication within Geography (Barnes and Sheppard 2010), the metaphor is less suited to the problem I want to address. This is because Galison (2010, page 32) understands trade as the incomplete coordination of research practices that strips away meaning and memory. This incompleteness offers welcome flexibility but also places the trading zone metaphor at risk of co-optation by the neo-liberalised university and research funding landscape with its fast-paced, volatile conditions for transdisciplinarity. Treading in Galison's footsteps may marginalise Whitehead's vigilance over modes of abstraction, sidestep the importance of obligations and requirements of disciplines and epistemic cultures, and perpetuate asymmetrical exchanges among disciplines and research fields.

The question thus becomes how durable and inclusive zones of interaction between Geography and Transition Studies can be created that can persist beyond the lifetime of short-term research projects and enable the symmetrical exchange of concepts, ideas, logics and methods. The answer, I believe, lies in slowing down of collaborative research. Other geographers have used this term recently but to different ends (Whatmore 2013; Mountz *et al.* 2015; Lane, 2017). Like Whatmore and Lane, I follow Stengers (2011b) for whom slowing down is less about reducing the speed of research and academic life than about reworking scientific creativity by revising modes of abstraction. Stengers's (2011b) approach is a form of resistance against the "knowledge economy," the contemporary neoliberal configuration in which much academic research takes place, often in partnership with industry, and with a narrow focus on questions that are relevant from commercial or policy perspectives. She urges scientists to understand the world not as messy realm of competing value systems from which research should abstract to arrive at transcendental and disinterested truths but as an inevitable condition they have to appreciate and learn from. They should develop research practices that maximise friction by allowing competent colleagues and non-academics to object and induce other modes of thinking. Adopting Stengers's propositions will help researchers not only to "stray across country" (Whitehead 1967[1925], page 197) by addressing other – typically value-laden and context-specific – problems, but also to move beyond their own groove and develop more revisable, adaptive and responsive abstractions.

Stengers's arguments are oriented towards natural scientists; questions can be asked about their novelty in social science contexts. Her aims are also different from mine, but two key insights in light of my objectives can be derived from her writings on slowing down research and reasoning (Stengers 2005b, 2011b). One is that subjecting modes of abstraction to scrutiny can help geographers and transition scholars to reason differently and turn matters-of-fact into matters-of-concern. This is because concentrating on abstractions can induce a form of reflexivity that Foucault called problematisation by thought (Rabinow 1994). Thought is here a reflective action that "allows one to

step back from this way of acting or reacting, to present it to oneself as an object of thought and to question it as to its meaning, its conditions, and its goals” (Rabinow 1994, page 117). Foucault (2010) was optimistic about thought’s generative capacities: even if interlocutors are entangled in uneven power relations, the uncertainties induced by thought unhinge the habitual entanglements of cognition and action in research praxis, thereby opening up a space for the emergence of new modes of abstraction.

The second insight is that slowing down reasoning complicates the notion of a straightforward solution to the issue of asymmetric exchange of concepts, ideas, logics and methods between Geography and Transition Studies. Stengers (2005b) cautions that practitioners addressing an issue should not assume they understand a situation or event in the same manner as others. She urges them to try to accommodate the *idiotic* – that which makes no sense in the context of the consensual interpretation of a situation or issue and which subverts prevailing meanings through, for instance, irony, distraction, refusal or disruption (Michael 2012).⁶ The challenge, then, is to allow oneself to be affected by the idiotic and to replace standard recipes with open-ended suggestions.

Based on earlier experiences,⁷ I propose an open-ended and necessarily general three-pronged strategy for collaborative research involving geographers and transition scholars rather than a ready-made solution. The particulars of how to slow down reasoning need to be worked out locally but might involve collaborative analysis of enacted abstractions, historicising and collage over a series of intensive dialogues. A useful point of departure might be making an inventory of different versions of a concept or methodological practice and analysing what is included, simplified, reworked and excluded in those versions. Interlocutors’ interests and shared notions of importance may guide the selection of concepts or practices. The discussion in previous section suggests that socio-technical system, city and experimentation as well as the examination of power relations or interactions between spatial scales are likely candidates for collaborative analysis.

The analysis of the abstractions characterising different versions can be enriched by the adoption of an explicitly historicising orientation to trace the inherited elements within those versions of the concept(s) or practice(s) through space and time. The result would be a time-geographical genealogy: Where do those versions come from? How have their elements been reworked? How have trajectories of inheritance been shaped by the obligations and requirements of disciplines and epistemic cultures, as well as by wider regimes of truth and governmentalities? Doing this would improve understanding and appreciation of why, for instance, the urban is understood so differently by urban geographers and researchers from other disciplinary backgrounds working on urban transitions.

Further moving beyond established grooves would result from creating a collage by juxtaposing and overlaying relevant versions of a concept or methodological practice. This step will not only multiply the uncertainties generated by the first two stages and so further stimulate experimentation with new modes of abstraction. It will also encourage participants to work with elements from earlier versions of a concept or methodological practice, which will have changed by their inclusion in the collage. This working with partially pre-existing, partially new elements is useful given that multiple academic disciplines now recognise that innovation entails putting such elements together in new configurations (Arthur 2009; Urry 2012; Schwanen 2015). Collage may induce or intensify problematisation by thought and open up a space for a collective assessment of the contribution that alternative, so far marginalised concepts, ideas or methods from a particular (sub)discipline or field can make to the understanding of transition processes by others. In this way ideas from, say, the planetary urbanism literature could be introduced and absorbed into the thinking of non-geographers working on urban transitions.

Yet, it will be crucial to remain attentive to the idiotic in the form of irony, distraction, refusal and disruption by researchers from other disciplines or fields. Particular concepts, ideas, logics and methods should not be plugged as ready-mades; they will have to be adapted and hybridised to greater or lesser degree, and may even have to be dropped altogether. What works and what doesn't will need to be worked out along the way.

These necessarily broad suggestions are not intended to create identical abstractions across disciplines, epistemic cultures or research fields; all have specific obligations and requirements. They rather seek to produce more adaptable, revisable and responsive modes of abstraction in each through the creation of contact zones rather than trading zones. I use the contact zone metaphor here in a similar way as Haraway (2008) and others have done in the wake of Mary Louise Pratt's influential writings. She understands contact zones as "social spaces where cultures meet, clash, and grapple with each other, often in contexts of highly asymmetrical relations of power" (Pratt 1991, page 34).

My suggestions to slow down abstractions may seem utopian and in tension with the fast-paced funding and reward structures of what Stengers (2011b) calls the knowledge economy, but they can work under certain conditions. From participants they demand commitment, patience, openness to being challenged and the willingness to experiment and accept the risk of failure. Meeting these demands will be easier when there is extensive time for dialogue and participants trust each other. Projects in which participants from different disciplinary and research backgrounds meet each other for one or a few days at specified intervals won't suffice; considerably longer periods of intense joint activity will need to be written into research designs. Having a long-term strategy of collaboration beyond a single project will also help. As far as finance is concerned, there are many opportunities to obtain funding for capacity building from national and EU agencies and charities that can be used to develop contact zones for the slowing down of abstractions. Depending on restrictions on that capability building funding, follow-up grants can be secured to consolidate contact zones.

5. Nexus and Geography

Commonalities and differences between Transition Studies and nexus research have been identified in previous sections. Collectively they imply that human geographers interested in the nexus find themselves in an *oikos* where obligations, requirements and abstractions are even more diverse and replete with contrasts, tensions and opportunities to make a difference than for disciples working on sustainability transitions. It is yet unclear what this means for the diffusion of concepts, logics, methods and practices from Human Geography into nexus research. Time will tell what will be abstracted from the political ecology conceptualisation of nexus-related processes by Williams *et al.* (2014) or from Cairns and Kryzwozynska's (2016) discourse analysis of nexus as a buzzword in resource debates in the UK – to name but two examples of significant contributions to geographical scholarship on the nexus. Nonetheless, partial inheritance and problematic simplifications in (future) research outside Geography as well as asymmetrical exchange of insights between disciplines and epistemic communities are distinct possibilities.

To my mind, these possibilities should be borne in mind in the development of a nexus research agenda for Human Geography. Understanding the place-specific and multi-scalar nature of the interconnections of water, energy, food, land and climate should certainly be a major research priority. The same holds for research that critically analyses the discourse and genealogy of nexus thinking, develops epistemologically diverse understandings of the nexus using a plurality of methods, and seeks to harness the potential of ontological frictions in nexus processes. Yet, if asymmetrical exchange of concepts, ideas and methods across disciplines, epistemic communities

and research fields and fragmenting pluralism are seen as undesirable, then a slowing down of reasoning will be needed.⁸

The creation of durable contact zones to scrutinise modes of abstraction to turn matters-of-fact into matter-of-concern may be useful for nexus research too, but the approach suggested for research on transitions will need to be adapted. For one, it will be important to involve the thinking and colleagues from Physical Geography where the nexus has yet to be embraced as a key research focus. The challenges of collaborating across the human/physical divide within the discipline are well-known but certainly not insurmountable (see, for instance, Lane *et al.* 2011). The value of collaboration lies not only in the concepts, ideas, logics and methods physical geographers have to offer but also in the mediating role they can fulfil between human geographers and natural scientists beyond Geography in the creation of contact zones for experimentation with alternative modes of abstraction.

Compared to the transition case, geographers may have to devote greater effort to drawing attention to elements that are often excluded in nexus research. As Wichelns (2017, page 120) has observed “[w]ith regard to agriculture, the water-energy-food nexus is largely silent on issues pertaining to other critical inputs, such as land, labour, capital, seeds, plant nutrients, and farm chemicals. The nexus also does not address issues involving land tenure, financial credit, and extension services.” Ideas from various approaches, from Hägerstrand’s (1976) time-geography to recent materialisms in Cultural Geography, can be introduced to non-geographers as potentially useful to their thinking. At the same time, geographers may have to be more explicit and reflexive about their own reasoning, given that many nexus researchers will lack the familiarity with social theory that is fairly common across Transition Studies. Thus, the for most geographers uncontentious ideas that the ‘metabolism’ of energy, water or food is conditioned by capitalism or that spatiotemporally contingent power relations (re)configure forms of rule, governance, hegemony and consensus (*cf.* Ekers and Loftus 2008; Williams *et al.* 2015) will need to be worked through carefully in contact zones. The same may hold for the idea from the wider social sciences that scientific representations emerge from all sorts of power/knowledge dynamics that are refracted and mediated by equally heterogeneous material techniques and instruments.

Human geographers should also dedicate extra effort to slowing down the abstractions enacted by mathematical and computer modelling. This is not only because such modelling plays a very dominant role in interdisciplinary nexus research, but also because over the past 15-20 years Geography has seen the rise of new and alternative modes of abstraction using computer modelling and quantitative data. Examples are work on critical and qualitative GIS (Schuurman 2000; Cope and Elwood 2009), on critical quantitative geography (Kwan and Schwanen 2009), on critical studies of big data (Kitchin 2014; Shelton *et al.* 2016) and on participatory modelling as knowledge co-production (Lane *et al.* 2011). Such work can aid in bringing more reflexivity to nexus modelling research and reorient it towards questions, experiences and interplays of values that are easily abstracted away (*cf.* Stengers 2011b; Lane 2017). Building on earlier work (Schwanen and Kwan 2009), I see several ways in which this can be achieved. Recognised lacunae in much interdisciplinary nexus research (Allouche *et al.* 2015; Leck *et al.* 2015) can be addressed by co-developing models of nexus processes to raise questions about justice – who gains? Who loses? How? – and by incorporating different types of knowledge and understandings. Text, video and other materials could be incorporated into nexus modelling so that the differentiated and complex everyday experiences of local populations can be addressed as problems in nexus research and thinking. Geographers can also help to bring out the situatedness and spatiotemporal contingent nature of modelling research and thus co-construct different modes of interpreting and generalising model results. Finally, they can aid in the experimental deployment of models so that they function as technologies for thinking differently, opening up alternative understandings and engineering

surprising ideas and hypotheses that could not have been anticipated beforehand. Slowing down modelling won't be easy and Stengers's prescription that the idiotic be accommodated in the crafting of contact zones needs to be heeded but the use of models to diffuse insights from Geography into interdisciplinary nexus research may resonate beyond the discipline as an analytically rigorous, efficient, and relatively easy-to-understand way of communication.

6. Conclusion

More than ever is Geography surrounded by interdisciplinary movements claiming expertise with regard to the interconnections among nature, society and technology. Its practitioners are also increasingly expected to collaborate across disciplinary boundaries. These developments bring many benefits to Geography and provide opportunities for its concepts, ideas, logics and methods to be taken up beyond its boundaries. However, there is a genuine risk that what many geographers consider cutting-edge thinking gets excluded or overly simplified when encountered by researchers who neither are trained nor self-identify as geographers. Whilst differences in language between disciplines, epistemic communities and research fields go some way to explaining this risk, rigidity in the modes of abstraction – and, related to these, obligations and requirements – that prevail in specific disciplines, epistemic cultures and research fields are equally if not more important. This means that many of the widely promoted ideas about how modes of interdisciplinary research oriented at integration across disciplines, epistemic cultures or research may be insufficient to generate research on the interconnections among nature, society and technology that is 'transgeographical' – at once transdisciplinary and widely seen as world-leading within Geography as a discipline. Other strategies and approaches that are flexible, emergent, open-ended and attentive to what Stengers and others call the idiotic may be needed. The slowing down of abstraction as elaborated in this article may play a useful role in harnessing Geography's contributions to thinking, imagining and reinventing the inevitably place-specific interconnections among nature, science and technology in an increasingly transdisciplinary world.

Notes

1. I am grateful to one of the reviewers of an earlier version of this manuscript for bringing out this point much more clearly than I did.
2. The ways such research is shaped by funding mechanisms, stakeholder interactions, the changed role and governance of universities in late capitalism and so forth are deliberately not considered here.
3. These constraints should be understood as non-deterministic; they steer and shape action but do not produce inevitable, certain effects.
4. A point would only be appropriate if there is no uncertainty or controversy about a particular response, a situation that is likely rare.
5. This mode of abstraction may not be productive and creative to many geographers but it can be generative from the perspective of researchers from other disciplines and research fields may find it (very) generative and inspiring. The generative capacities of abstraction are not only relational but also relative; claims about those capacities need to be accompanied by discussion of the question for whom/what and in what ways.
6. Stengers (2005b) derives the figure of the idiot from Deleuze and Guattari (1994) as someone who challenges the consensual interpretation of events because their (in)action is incommensurable with those events.
7. My proposal is informed by two sets of experiences. One relates to my ongoing interest in habit change, the other to research project on the interdependence of transport and social exclusion. In that project we combined the ideas and concerns of researchers from different disciplinary and research backgrounds through an emergent and open-ended process.

8. Another reason for slowing down nexus research is that much of it adheres to what Stengers (2011b) calls the knowledge economy and can be considered to “progress in its own groove” (Whitehead 1967[1925], page 197) with limited interrogation of its modes of abstraction, the kinds of problem it addresses or how it seeks to solve those.

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Table 1: Interdisciplinary research: barriers and facilitators

Barriers	Facilitators
<i>Wider organisational field & institutions</i>	
Research agendas	Involvement of academics from different disciplines & non-academic stakeholders in identification of research priorities (substantive topics, methodological developments) and in framing of issues
Inadequate funding	Collaboration among funding agencies; Longer-term, transdisciplinary funding programmes; Evaluation panels with experts from different disciplines and end users
Reward structures	Broad performance indicators (beyond publication portfolios) in funding allocation and research evaluation; Champion impacts beyond academia
Researcher capacity	Training of interdisciplinary students & early-career researchers; Organisation of summer schools, seminars, workshops and other platforms for cross-disciplinary dialogue
Career trajectories	Change to promotion structures & pathways; Mentorship
Expectations beyond academia	Engagement of non-academic stakeholders & end users in agenda setting, funding decisions, research evaluation; Effective communication with non-academic stakeholders & end users
Data availability, access and management	Appropriate infrastructures; Promotion and use of publicly available data; Reliance on open source software; Clarification of intellectual rights
<i>Research programs, projects & teams</i>	
Differences in expectations & purpose	Frequent & effective communication; Establishment of common goals; Identification of object of study; Participation of non-academic stakeholders in all phases
Lack of common understandings, concepts & language	Frequent & effective communication; Reflexive & recursive research designs; Clear definition of concepts and terms; Identification of relevant temporal and spatial scales
Lack of trust across disciplinary boundaries	Frequent & effective communication; Spatial proximity of researchers; Diversity of team members w.r.t. career stage, gender, ethnicity, discipline & function; democratic leadership; Conflict resolution
Hierarchies in types of expertise; social science & humanities as 'add-on'	Reflexive & recursive research designs; 'Frontloading' social science & humanities

Based on: Bracken and Oughton (2006); Marzano *et al.* (2006); Jahn *et al.* (2012); Lang *et al.* (2012); Brown *et al.* (2015); Adams (2016); Wassen and Hekkert (2015); Klenk and Meehan (2016)

Table 2: Abstraction from selected geographical publications on sustainability transitions beyond the discipline

Authors and year of publication	Journal	Citation count ¹	Inheritance
Hodson and Marvin (2010)	<i>Research Policy</i>	336	Wide uptake and significant influence ² across various constituencies, including transition scholars in innovation studies, but especially among scholars interested in urban transformations and urban studies
Lawhon and Murphy (2012)	<i>Progress in Human Geography</i>	171	Reasonably wide uptake and significant influence ² across various constituencies, including transition scholars in innovation studies, possibly because of its generic nature (not focused on cities) and limited use of discipline-specific vocabulary
Bulkeley and Castán Broto (2013)	<i>Transactions of the Institute of British Geographers</i>	257	Wide uptake and significant influence ² across various constituencies but mostly among geographers, sustainability scientists and those interested in urban transformations, less so among transitions scholars in innovation studies
Newell and Mulvaney (2013)	<i>The Geographical Journal</i>	55	Some uptake and influence across various constituencies, including geographers and among several leading transition scholars, but mostly in the peripheries of the transitions literature
Bulkeley <i>et al.</i> (2014)	<i>Urban Studies</i>	65	Mostly taken up in geographical research and interdisciplinary research on the role of cities in sustainability transition, less so among transition scholars in innovation studies

¹ Google Scholar, 29 January 2017

² Here understood as having a direct, albeit it subjectively identified, effect on the thinking or research practice of the papers in which the publication is referenced

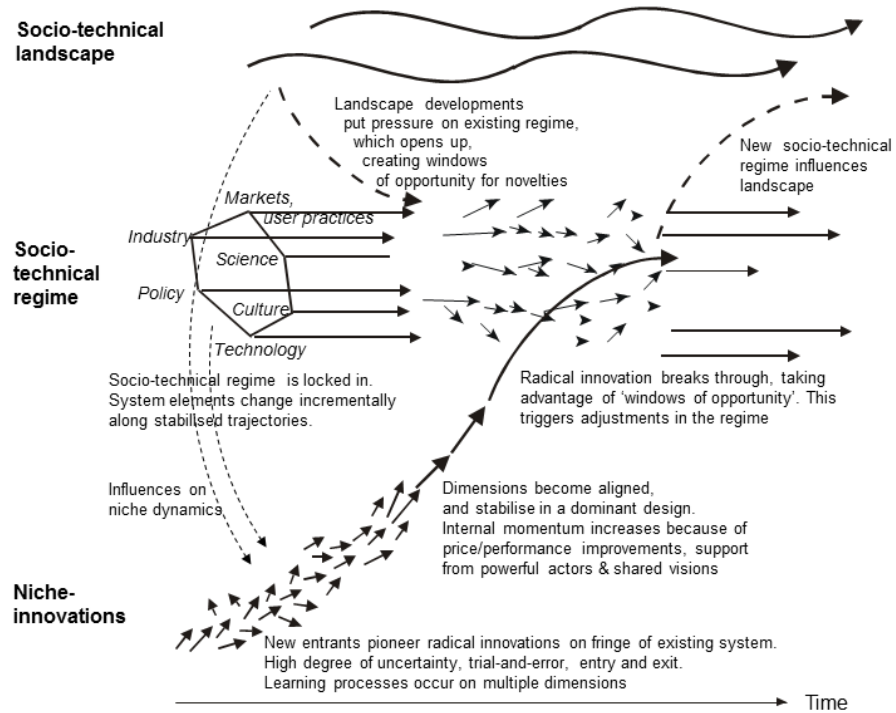


Figure 1: Multi-level perspective diagram (adapted from: Geels 2002)

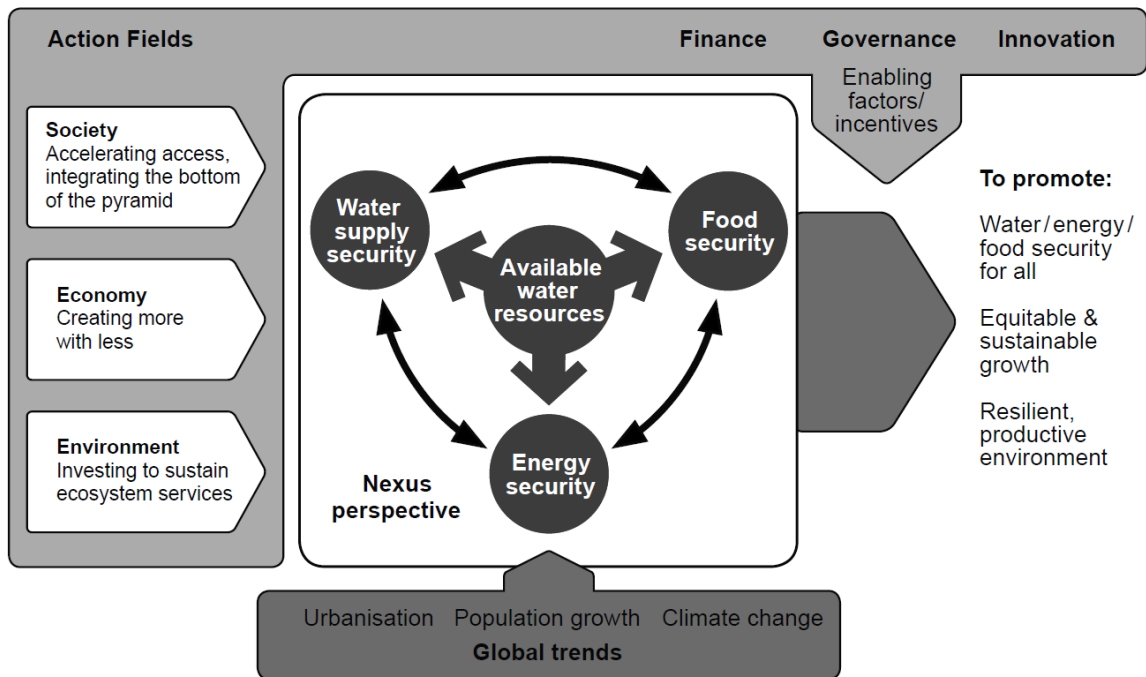


Figure 2: Water-energy-food nexus diagram (adapted from: Hoff 2011)

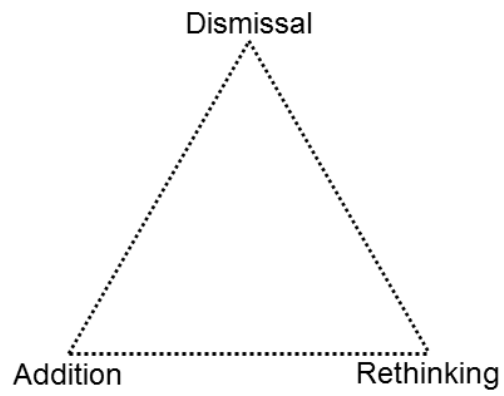


Figure 3: Responses to the mobility of transition thinking into Geography

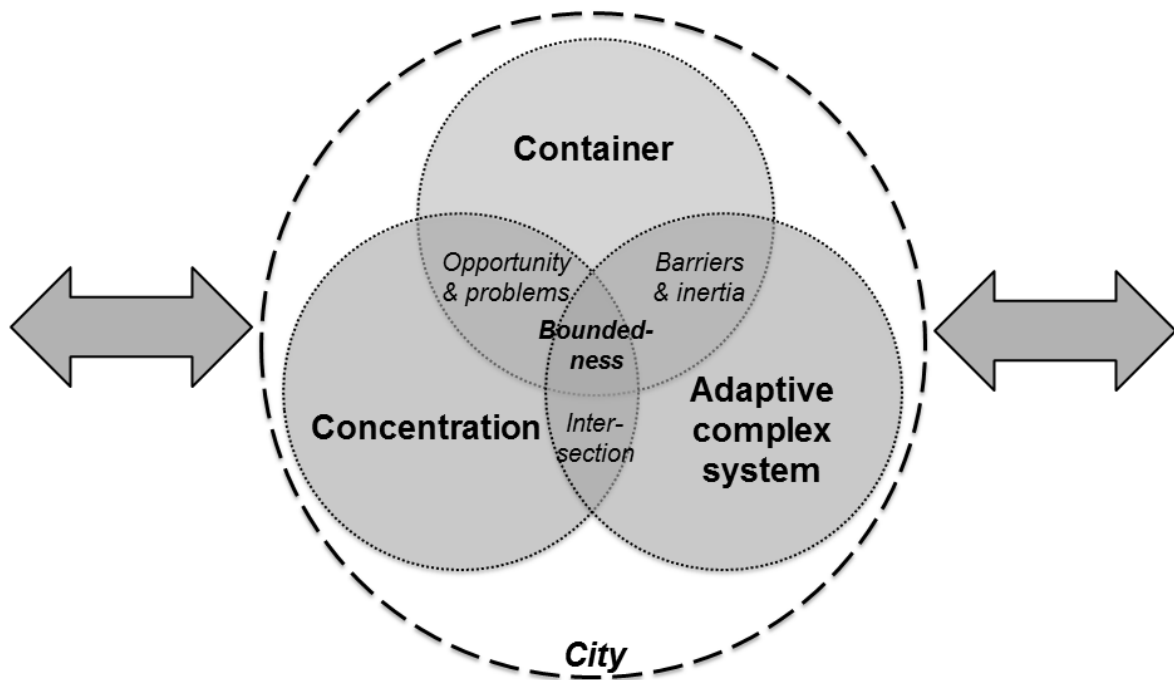


Figure 4: Versions of the city in the urban transitions literature