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PERSPECTIVE

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A leverage points perspective on sustainability

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Abstract

1. Drawing on seminal work by the late Donella Meadows, we propose a leverage points perspective as a hitherto under-recognized heuristic and practical tool for sustainability science. A leverage points perspective focuses on places to intervene in complex systems to bring about transformative change.
2. A leverage points perspective recognizes increasingly influential leverage points relating to changes in parameters, feedbacks, system design and the intent encapsulated by a given system. We discuss four key advantages of a leverage points perspective.
3. *First advantage*: A leverage points perspective can bridge causal and teleological explanations of system change – that is, change is seen to arise from variables influencing one another, but also from how human intent shapes the trajectory of a system.
4. *Second advantage*: A leverage points perspective explicitly recognizes influential, 'deep' leverage points – places at which interventions are difficult but likely to yield truly transformative change.
5. *Third advantage*: A leverage points perspective enables the examination of interactions between shallow and deep system changes – sometimes, relatively superficial interventions may pave the way for deeper changes, while at other times, deeper changes may be required for superficial interventions to work.
6. *Fourth advantage*: A leverage points perspective can function as a methodological boundary object – that is, providing a common entry point for academics from different disciplines and other societal stakeholders to work together.
7. Drawing on these strengths could initiate a new stream of sustainability studies, and may yield both practical and theoretical advances.

KEYWORDS
backcasting, scenario planning, social–ecological system, system change, transformation, transition

1 | INTRODUCTION

Despite intensifying efforts in both science and society, numerous indicators of social and biophysical unsustainability continue to exponentially increase (Ripple et al., 2017). Of course, there has been progress in some locations and for some indicators – gross domestic product per capita has increased substantially in many countries over the last decades (World Bank, 2018); renewable energy

sources, and especially solar energy, are rapidly expanding (IEA, 2017); and charismatic species such as the wolf (*Canis lupus*) have returned to locations from which they had been extirpated (Wagner, Holzapfel, Kluth, Reinhardt, & Ansorge, 2012). Notwithstanding the significance of such progress, the global picture is far from encouraging. To list just a few examples, anthropogenic climate change is ongoing (Pachauri et al. 2014), human population growth remains high in many of the world's poorest countries (United Nations, 2017), the global number of undernourished people is rising rather than declining (FAO, IFAD, UNICEF, WFP, & WHO, 2017), girls in many countries still have little opportunity to obtain a good education (Global Education Monitoring Report Team, 2018), consumption changes towards processed foods and diets rich in animal protein are driving massive rises in demand for commodities such as palm oil and soy (Khoury et al., 2014), and partly as a result of the above, global species extinction rates are up to 100 times higher than background rates (Barnosky et al., 2011; Millennium Ecosystem Assessment, 2005).

Humanity is living in overshoot, beyond the biophysical limits of the planet (Rockström, 2009; Steffen et al., 2015), and yet still below the provision of a basic socio-economic foundation for billions of people (Raworth, 2012). Despite global agreements on various iterations of well-intended goals (most recently, the Sustainable Development Goals), humanity has not managed to fundamentally change the trajectory of the global coupled human–environment system. Many indicators suggest an ever-growing rather than shrinking 'sustainability gap' – that is, a growing discrepancy between the actual state of the global human–environment system relative to what would be sustainable (Fischer et al., 2007).

Finding approaches that can effect transformative change, bringing about a biophysically sustainable and socially just world, thus becomes the holy grail of sustainability science. Without doubt, there is no panacea (Ostrom, Janssen, & Anderies, 2007). However, this humbling realization should not take away from cautious enthusiasm for those ideas that do have genuine potential to make a positive difference, and bend back down the 'hockey

TABLE 1 Four realms of leverage as proposed by Abson et al. (2017), their relationship to the 12 leverage points originally postulated by Meadows (1999) and examples. Increasingly influential (deep) leverage points are listed towards the bottom of the table

Realm of leverage	Leverage points	Example
Parameters	Constants, parameters, numbers	Average fuel consumption of a car
	Size of buffer stocks, relative to flows	Amount of total standing timber in a production forest
	Structure of material stocks and flows	Run-off dynamics of nutrients from agricultural fields into adjacent water bodies
Feedbacks	Length of delays, relative to rate of system change	Time it takes for the ozone hole to close after harmful emissions seize
	Strength of negative feedback loops	The extent to which a lake can absorb nutrients and thus remain clear
	Gain around positive feedback loops	The extent to which poverty leads to population growth, which may further exacerbate poverty
Design	Structure of information flows	Consumer knowledge about where certain products come from
	Rules of the system (incentives, constraints)	Policies governing natural resources, including among others taxes and regulations
	Power to change system structure or self-organize	Ability of farmers to organize the sustainable use of a communal pasture
Intent	Goals of the system	Organization of global institutions to support free trade versus global equity
	Paradigm underpinning the system	A 'green revolution' paradigm underpinning agricultural policies
	Power to transcend paradigms	The conscious shift from a growth-based economy growth to a steady-state economy

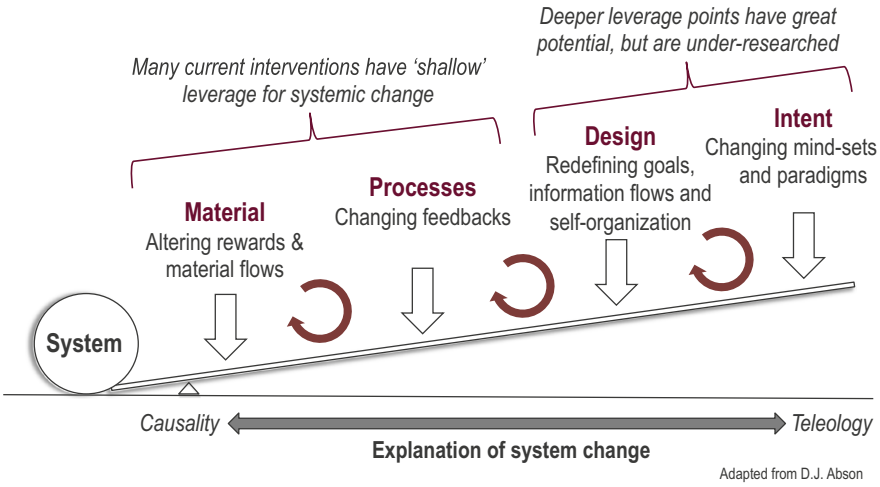

FIGURE 1 Schematic illustration of four realms of leverage (Abson et al., 2017) showing a gradient from shallow leverage points to deep leverage points (see Table 1 for details and examples); and the position of those realms of leverage regarding their explanation of system change in terms of causality or teleology. Round arrows indicate stylized interaction that may occur between any combination of leverage points. (Figure is adapted with permission from an earlier version by D.J. Abson.)

stick' patterns of out-of-control exponential growth, which characterize The Great Acceleration (Steffen, Crutzen, & McNeill, 1989, 2007; e.g. climate change Pachauri et al., 2014; biodiversity loss Millennium Ecosystem Assessment, 2005). In this paper, we argue that a leverage points perspective on human–environment systems deserves greater attention, because it holds substantial promise to inspire new directions in sustainability science and practice. We briefly summarize what we mean by a leverage points perspective, and then highlight four key advantages of such a perspective that suggest it might be well placed to stimulate much needed progress.

2 | ORIGIN AND RECENT REVIVAL

Leverage points are places in a system where relatively minor interventions can lead to relatively major changes in certain outcomes (Meadows, 1999). The concept is not new to systems thinking, nor is its application to human–environment systems. Based on years of experience, in 1999, Donella Meadows –one of the world's pioneers in research on coupled human–environment systems (Meadows, Meadows, Randers, & Behrens, 1972) – postulated a hierarchy of 'places to intervene' in complex systems (Meadows, 1999). She distinguished between leverage points at which interventions are easy but limited in their potential to bring about transformative change (here, termed 'shallow') and leverage points where interventions are difficult but have great potential to bring about transformative change (here, termed 'deep'). Recently, Abson et al. (2017) simplified the 12 leverage points postulated by Meadows into four 'realms of leverage'. Increasingly deep (i.e. powerful) realms of leverage, according to Abson et al. (2017), related to changes in parameters, changes in feedbacks, changes in system design and changes in the intent encapsulated by the system (Table 1, Figure 1). Abson et al. (2017) provided a detailed discussion of the nature of different realms of leverage, and especially focused on examples of deep leverage points. Unlike Abson et al. (2017), here we specifically focus on four general advantages of taking a leverage points perspective.

3 | KEY ADVANTAGES OF A LEVERAGE POINTS PERSPECTIVE

3.1 | Combining causality and teleology

Traditional science is strongly rooted in finding principles of causality. Finding cause-and-effect relationships (including feedbacks) is in fact a critical part of systems thinking. A focus on causality has, for example, led to strong predictive models. Such models, in turn, relate to the dominant scientific mode of forecasting – where known causalities are extended into the future. Scientific forecasts, either for anthropogenic climate change, demographic change or biodiversity loss, are extremely useful tools in a decision-making context.

However, as aptly summarized by Dreborg (1996), there is a second, far less widely used mode of engaging with the future – namely that of backcasting. In backcasting, a desired ('normative') endpoint is defined, and then the means to reach such an endpoint are determined in response. Probably the most famous example of backcasting in practice was United States President Kennedy's decision to put a man on the moon 'before the decade is out' (Kennedy, 1962; Manning, Lindenmayer, & Fischer, 2006). The actual means by which this became reality were only systematically worked out after this bold (and at the time 'unrealistic') decision had been made. Causal relationships of course still exist when operating in backcasting mode, but causality is drawn on within firmly defined bounds of teleology – that is, 'the explanation of phenomena in terms of the purpose they serve rather than of the cause by which they arise' (Oxford Dictionaries, 2018). Backcasting thus allows for the creative pursuit of truly bold goals that will routinely fall outside the bounds of what forecasts based on current systems understanding predict.

How does this relate to leverage points? The hierarchy of leverage points proposed by Meadows (1999) and Abson et al. (2017) is unique in that it spans the full range of considerations from deeply causal to deeply teleological. Parameters, buffers and feedbacks among parameters thus fall firmly within the scope of causality;

whereas the goals pursued through a system, and especially the power to transcend the paradigm underpinning a system acknowledge that human agency, its normative direction and thus teleology fundamentally shape outcomes (Table 1, Figure 1). This, in turn, means that two frequently conflicting perspectives (causality and teleology) are integrated within one meta-perspective (leverage points) – providing a place where quite fundamentally different modes of thinking can meet.

Routinely integrating causal and teleological explanations of system change could lead to major breakthroughs in sustainability. Countless well-intentioned targets have been articulated in political documents – on climate change, biodiversity loss or sustainable development more broadly – but these often do not translate into sufficient action. Focusing solely on teleological means of bringing about change thus appears to be insufficient – concrete steps, based on an understanding of system causalities, need to be taken for an intended system trajectory to actually manifest. Put bluntly, rhetoric and targeted action (teleology and causality) need to be linked. A leverage points perspective provides a coherent framework that recognizes the joint importance of both teleology and causality as mechanisms of change.

3.2 | Digging deep

A second major benefit of a leverage points perspective is its explicit distinction of shallow versus deep types of interventions. Abson et al. (2017) emphasized the importance of deep leverage points, arguing that interventions at shallow leverage points had been used much more frequently for the pursuit of sustainability, but in many cases had evidently been insufficient by themselves. Three deep leverage points were specifically highlighted by Abson et al. (2017): (a) to restructure institutions so as to create conditions that favour sustainable behaviours by relevant societal actors (e.g. Ostrom, 2009); (b) to reconnect humans with the natural environment (e.g. Folke et al., 2011); and (c) to rethink how different types of knowledge interact and need to be drawn on to foster sustainability (e.g. Cash et al., 2003). While these three deep leverage points provide valuable starting points in many social–ecological systems undergoing change, there are countless other truly deep leverage points that are worthy of investigation. Examples include the notions of different worldviews (de Vries, 2013) or value orientations (Schwartz, 1992) and their influence on sustainability, the role of spirituality (Tolle, 2005) and religion (Pope Francis, 2015), or of compassion (His Holiness the Dalai Lama, 1999) and love (Fromm, 1956) as guiding principles for a sustainable future. Indeed, it is questions around worldviews and values that have recently stirred new discourses in the ecosystem services arena (Masood, 2018). Where these discourses lead remains to be seen, but a key point is that open discussions about worldviews and values are needed, since these shape and constrain interventions deemed plausible at more shallow levels of leverage (Fischer et al., 2012). Increased recognition of the importance of deep leverage points could help to facilitate such discussions in constructive ways.

3.3 | Recognizing interactions across leverage points

A leverage points perspective postulates that transformative change is unlikely if only shallow leverage points are acted upon; but it also recognizes that acting on deep leverage points (e.g. altering worldviews) is difficult in practice, even if the benefits could be substantial. Based on this, it may be particularly interesting to learn how shallow and deep interventions interact in different situations (Figure 1). For example, a recent study in Ethiopia showed that changes to rules related to the rights of women (a relatively deep leverage point) had led to changes in parameters (a relatively shallow leverage point) describing women's increased presence in public life, thus paving the way for men to gradually adjust their attitudes about women (a deep leverage point) (Manlosa, Dorresteijn, Schultner, & Fischer, 2018).

Interactions between leverage points such as in the example above suggest that there are 'chains of leverage' that can be studied; describing how one type of change in a system precipitates another, across different depths of leverage. A working hypothesis is that if such chains do extend to deep leverage points, then a given chain of leverage has the potential to bring about transformative change. In contrast, a chain that only involves shallow leverage points is unlikely to effect transformation. This framing provides a new lens for how to study change in systems, and provides new impetus to connect different bodies of empirical and theoretical work – linking, among others, changes in institutions, practices and values in new, largely unexplored ways.

3.4 | Providing a methodological boundary object

There are three primary modes in which sustainability science might generate insights – through conceptual work, qualitative empirical work or quantitative empirical work. The integration of these modes benefits from boundary objects – that is, perspectives or concepts that facilitate inter- and transdisciplinary communication and collaboration by offering a shared vocabulary and narrative (Star & Griesemer, 1989). Prominent examples of boundary objects in sustainability science include resilience (Folke, 2006) and ecosystem services (Costanza et al., 1997; Daily, 1997), which have been successful partly because they have functioned at multiple levels, for multiple users (Strunz, 2012). Both ecosystem services (Ehrlich & Ehrlich, 1981) and resilience (Holling, 1973) started out as concepts or even metaphors, but quickly opened up to increasingly sophisticated qualitative and quantitative applications (e.g. Bateman et al., 2013; Carpenter, Walker, Anderies, & Abel, 2001).

A leverage points perspective also can be engaged from multiple methodological angles. This, in turn, generates the potential to attract numerous different scholars, and importantly, creates the potential for different types of scholars to collaborate by using a leverage points perspective as a boundary object. For example, conceptual work might examine how different potential changes in a system may translate to interventions at shallow or deep leverage

points (e.g. Ives et al., 2018), thus using leverage points largely as a metaphor. Qualitative methods may be used to elicit narratives of system change, tracing for example, how chains of leverage may unfold in a given system. Various quantitative methods could also be used, including in a process modelling context (e.g. Meadows et al., 1972) but also in the context of statistical analyses of relationships among different variables denoting a given system's state with respect to different realms of leverage.

Finally, our personal experience in a transdisciplinary context has shown that a leverage points perspective has considerable appeal to non-academic audiences. This is critical because decision-making power usually does not reside with scientists – narratives that also speak to other stakeholders are therefore critical to generate sustainability 'ripple effects', where different actors learn from and inspire one another (Everard et al., 2016). Especially at a metaphorical level, the notion that we need to look more deeply for what needs to change speaks to the growing sense of dissatisfaction felt by many people in increasingly modernized societies (Eckersley, 2016). Developing and using methods and communication tools, in turn, that different audiences can relate to is a critically important priority for sustainability science (Fazey et al., 2018). Like other successful boundary objects such as resilience and ecosystem services, a leverage points perspective could be valuable because it has both heuristic and practical appeal.

4 | CONCLUSIONS

We argued that a leverage points perspective holds considerable potential as a boundary object for sustainability science. We reiterate that no single silver bullet, conceptual or otherwise, will be able to turn around the self-destructive trends that have led to the proclamation of the Anthropocene. But still, history has proven that major changes in human behaviour do occur – the end of slavery or racial segregation, and increasing equality of women and men being examples of major changes that at some point would have seemed utterly unthinkable to contemporary analysts. Paradigm shifts and societal transformation are possible, arguably when the desire for change coincides with practical means to enact concrete measures. Through spanning the broad range of considerations from simple parameters to shifts between paradigms, a leverage points perspective might hold considerable promise for sustainability science.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

J.F. and M.R. conceived the ideas and wrote the manuscript. Both authors contributed critically to the drafts and gave final approval for publication.

DATA ACCESSIBILITY

This paper does not include any data.

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