Selling Planet Earth: re-purposing geoscience communications

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(*Abbreviated title*: Re-purposing Geoscience Communications)

ABSTRACT

Earth scientists have a critical role to play in communicating to the public and policy makers what we know about looming societal threats including climate change, extreme natural events, resource conflicts and the energy transition. But whilst geoscientists are being encouraged - and, increasingly, trained - to 'go public' with our science, what is less clear is to what extent our current geo-communications are effectively addressing the long-term planetary concerns that confront society.

In this paper we argue that scientists are the interface between the research organisations that produce knowledge and the wider public who could use that knowledge, and, in that regard, are akin to marketers in the business world. Drawing from the dominant paradigms that shape business marketing, we re-consider the prevailing models of science communication and their consequent sense of purpose. We identify three dominant approaches of marketing-led science communication: 'make-and-sell'; 'sense-and-respond'; and 'guide-and-co-create'. We judge the first two to be incompatible with delivering long-term sustainability, in contrast to the emergent guide-and-co-create mode - purpose-driven, interdisciplinary, participatory, and reflexive - which we contend is best placed to tackle long-term geo-environmental concerns through having a clear wellbeing-focused objective whilst co-creating the path to achieving it.

We conclude with the contention that adopting a guide-and-co-create approach to science communications will require not only rethinking communication practice within universities but also radical institutional regime change towards universities becoming purpose-driven organisations.

Keywords: 'geology' 'science communication' 'marketing'

As society faces up to looming geo-environmental threats from climate change, extreme natural events, and resource conflicts whilst negotiating a troublesome energy transition, Earth scientists have a potentially critical role to play in communicating to people what we know about planetary wellbeing and stewardship (Rockstrom et al. 2009, Acocella 2015). For some, however, the geoscience community has been largely ineffective in conveying that broader message to the wider public.

'Geoscience was driven by a need to support discovery of raw materials and energy, and a need to understand Earth processes in order to support engineering and hazard reduction. As geoscience matured, it became sophisticated, specialized, and controversial. Unfortunately, geoscientists increasingly looked inward rather than outward and became increasingly isolated from society and regionalized. Since the 1990s, geoscience has been at a crossroads, struggling with diminishing funding reflecting the inability of society to recognize its value. This is unfortunate since geology is relevant to modern life in many ways. A wealth of geoscience knowledge is available, but the geoscience community has done a poor job of communicating its relevance to modern society; thus future vitality and relevance are dependent on developing systems and products that meet the needs of the 21st century.' (Broome 2005, p.51)

The perceived communication gap between geoscience and society is arguably most manifest by the apparent inadequate uptake of existing expert knowledge by the public and policy makers (e.g. Liverman 2008, Marker 2016, Beer et al. 2018). In climate-related decision making, for example, the urgency of projected climate change impacts demands a step-change in our knowledge communication and the requirement for usable climate information threatens to outstrip our ability to produce it using conventional approaches (Kirchhoff et al. 2013). Attempts to close

this gap have led most academic institutions – along with the funding agencies that support them - to encourage their research scientists to actively engage with the wider public. For many, it is a major shift in the academic outlook. According to the historian of science Naomi Oreskes (2015, p.257) '… scientists do not often consider communication to be part of science; science graduate programs only very rarely incorporate communication as part of students' training. The general view, among scientists, is that doing science is one thing, communicating it is another'.

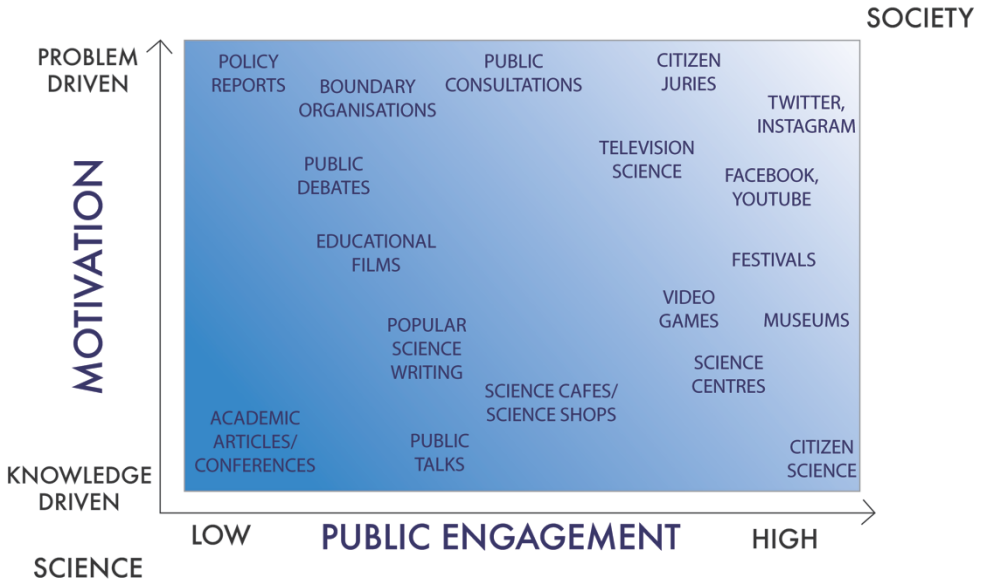

FIGURE 1: Conceptual depiction of the science communication 'landscape', represented in terms of the motivating impetus for scientific endeavour and the level of public participation.

Yet, this conventional view is changing as a rise in training opportunities allows early-career researchers in particular to hone their skills at presentations, media interviews and popular science writing (Warren 2007). Academics are reaching out in ever more imaginative ways and across a range of engagement formats, broadening and enriching the science communication landscape (Fig. 1). Academic and popular books, articles, reports, and blogs convey the principles and practices

of science communication (NAS 2017, Cormick 2019), some with a geological twist (Liverman 2008, Liverman et al. 2008, Stewart & Nield 2013, Stewart & Lewis 2016). The next generation of scientists are being schooled in accessible and entertaining ways to convey scientific knowledge, much of it inspired by contemporary popular mass media but guided by age-old, tried-and-tested communication techniques borrowed from print and broadcast journalism. Bending the attentions of science to the newsworthy needs of the mass media, however, has been questioned (e.g. Peters et al. 2008, Peters 2012), especially in relation to addressing complex societal challenges:

'…the emphasis on science communication as broadcasting and the drive for consistency and simplicity in messaging do not well serve the needs of either science-based governmental organizations, or the public at large, when dealing with messy, contested issues such as sustainability.' (Bielaik et al. 2008, p.202)

So, what precisely are we geoscientists expected to communicate? To what extent are our current communications addressing the real long-term concerns of society? And are the communication techniques in which we are being avidly schooled really those that are most appropriate for tackling the complex planetary crises that await humanity in coming decades? In raising these questions, we do *not* attempt to review how (geo)scientists *might* communicate, but rather we offer an inquiry about how (geo)scientists *should* communicate. Our paper explores the ethical underpinning of our current science communication praxis and considers how that reflects recent shifts in science's relationship with society.

In particular, we set out a fresh conceptual framework for re-thinking the *purpose* of science communication, that is, the reason for which it is done or created. We do so first by acknowledging two competing drivers that define how scientific

knowledge is produced and communicated (Kirchhoff et al. 2013). The first relates to *motivation*: the extent to which scientific endeavours are driven by curiosity, serendipity and blue-skies thinking (pure or basic research) or for practical application (applied research), which, in turn, reflects on whether problems are conceptualised as 'knowledge-driven' or 'solutions-led'. The second driver relates to *participation*: the extent to which external stakeholders or 'users' are involved in the scientific pursuit and the underlying knowledge that drives this. Figure 1 depicts those two axes of influence, showing the complexity of knowledge production increasing from 'low' where production is predominantly focused on expanding our fundamental knowledge, to 'high' where production aims to help solve societal problems, whereas the complexity of user participation rises from 'low' to 'high' as external stakeholders change from passive recipients of produced knowledge to active agents in knowledge creation. Academic research is traditionally dominated by a knowledge-driven agenda with minimal public input, though recent years have seen research funding directed more towards addressing societal problems and shifting the end-user emphasis from promoting a passive 'public understanding' of science to an active 'public engagement' in science (Nisbet & Schuefele 2009, NAS 2017).

Within this evolving landscape of knowledge production, scientists and researchers lie at the intersect between the organisations in which scientific knowledge is conceived and produced (universities and research institutes) and the intended end users of that knowledge (key stakeholder groups, news media, students, general public). In that academic-public borderland it is scientists that, by and large, have the power to shape what knowledge is produced, how it is produced, how and where it is made available, and increasingly, how it is made public. In the wider business world that intersectional role is taken up by 'marketing' - '…the activity, set of institutions, and processes for creating, communicating, delivering, and

exchanging offerings that have value for customers, clients, partners, and society at large' (American Marketing Association 2013, p.1). This is traditionally understood within the 'marketing mix' – a tool box which includes what products or services are created (Product), their cost (Price), how they are made available (Place), and how they and the identity of the company or brands are communicated (Promotions) – within this Promotions bucket the 'promotional mix' includes communication tools such as PR, advertising, sponsorship and others. Hence marketing influences the material aspects of a value chain through which products are designed, distributed and disposed of, as well as creating a significant 'brain print' impact on identities, culture and societal behaviour (Hurth & Whittlesea 2017). Viewed through that commercial lens, we contend that scientists are increasingly the 'marketers' within the academic 'business', engaging with press teams and PR departments but essentially responsible for the original design of research products, for making them accessible, and for communicating their worth.

No doubt the notion of scientists as marketers – and of science itself being marketable - is one that is likely to be deeply uncomfortable with most professional geoscientists. After all, for many, public relations and marketing itself is the root cause of many of the planet's most acute problems, cynically driving a global consumerist / materialist culture of economic growth predicated on unsustainable resource use. Using the ways and wiles of marketing, therefore, to communicate the importance of geoscience knowledge and understanding for wise planetary stewardship would seem ironic at best, and deeply unethical at worst. Marketing and public relations are somewhat on the dark side of science communication, meriting only a few sentences in the recent state-of-the-art review, *Communicating Science Effectively* (NAS 2017). According to this influential report, they '…offer insights into several aspects of science communication—for example, understanding audiences—but the goals of marketing and public relations professionals may differ

from those of many science communicators' (NAS 2017, p.15). Those marketing-led goals centre on the science and art of 'persuasion' – encouraging people to change their attitudes or perceptions or to take particular courses of action. However, an economic system where a company's reason to exist was profit maximisation has led to this particular version of marketing being dominant. Decades of marketing research, and social/societal marketing practice in charities, social enterprises and other realms, has shown that the tools of marketing can be sharpened for sustainable wellbeing outcomes rather than profit maximisation (Kotler & Levy, 1969; Andreasen, 1994). As a result, marketing has been widely used to advance social change in the context of public health (Doner & Siegel 2004, Grier & Bryant 2005) and blueprints for how to reform the day-to-day practice of marketing to drive sustainability exist (Van Dam and Appeldorn, 1996; Beltz & Peattie, 2009; Peterson, 2012; Hurth et al. 2015; Hurth & Whittlesea 2017),

Given the growing recognition among geoscientists that meeting planetary challenges (UN Sustainable Development Goals, 2015 Paris Climate Agreement, Sendai Framework for Disaster Risk Reduction) will require radical new 'people-centred' approaches to science and technology, in order to promote large-scale behavioural change and adopt radical courses of collective action (FIGURE 2), might these radical considerations include bringing advanced, purpose-driven perspectives of marketing in as a potentially useful lens through which to view and shape the geoscience communication toolkit?

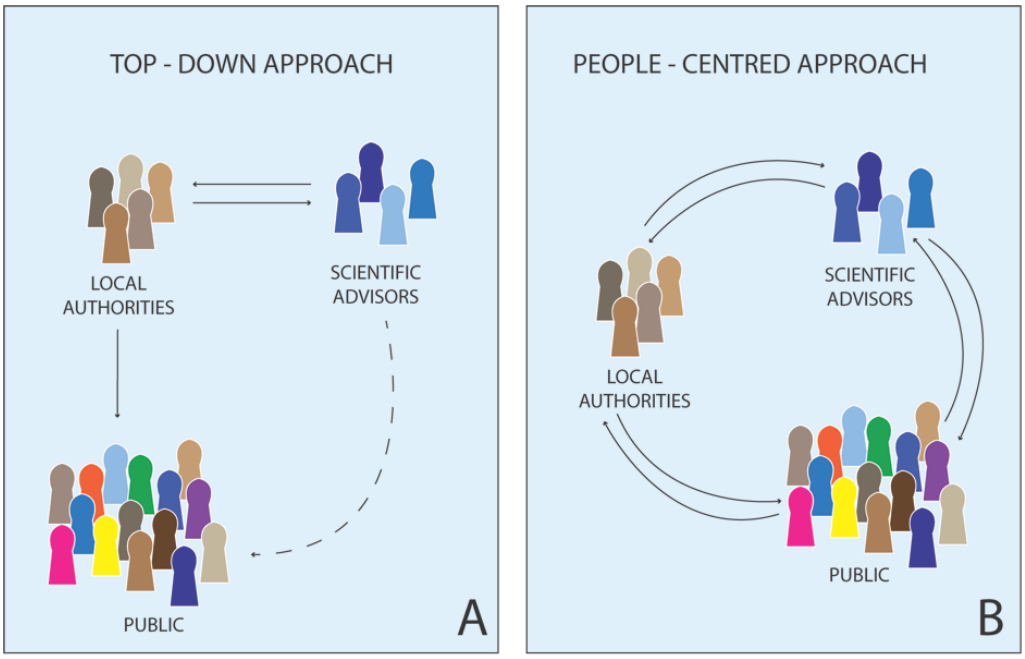

FIGURE 2. Two simplified models illustrating interactions between key stakeholders in (A) a conventional top-down, expert-led risk management approach, and (B) in a people-centred risk management approach, as encouraged by the Sendai Framework for Disaster Risk Reduction (redrawn from Scolobig et al 2015, figure 3). Although both 'ideal types' greatly oversimplify reality, the comparison highlights how responsibility redistribution, stakeholder relationships, and scientist-public interactions become more complicated with people-centred approaches.

With this provocation in mind, we examine the prevailing paradigms that guide marketing thinking and shape the relationships between businesses and the consumers they serve, two of which are deemed to be incompatible with delivering sustainability and one of which is. We use these paradigms as conceptual frames to compare with science communication paradigms, particularly in terms of their long-term purpose, to explore how different geoscience communication strategies might be advanced. Following the typology of Hurth & Whittlesea (2017), we define those conceptual marketing frames as 'make and sell', 'sense and respond' and 'guide and co-create'.

Make-and-Sell Communications

In marketing studies, the dominant theory of 'the firm', rooted in classical economic theory (Smith, 1776), emphasizes how a company's role is to efficiently design, make and then sell products (Haeckel, 1999, 2010). Many large corporations of the 20th century – automobile manufacturers, appliance manufacturers, even the computer makers of past decades – were in the main 'make and sell' organisations. They were product-focused, their core concern was growth through increased efficiency of production to decrease costs or increase in volumes sold, and hence company value rested in the reduction of price and increase in turnover (Hurth & Whittlesea 2017). This gives rise to an internal production-focused approach, aided by a company-customer relationship that starts internally with the company and resonates outwards. In this approach, marketing's main purpose is sales and promotion - an 'end of pipe' function that drives (usually near-term) profits and growth (Haeckel, 1999, 2010).

It is tempting to see the bulk of science communication practiced in most universities as conforming to this production-oriented 'make-and-sell' paradigm. From this perspective, knowledge is the product and communications are the external-facing 'sales' arm of a knowledge production process that is internally-focused - academics design their research around what they already know and what funders want to buy (Maxwell 2007, 2014). The internal knowledge factory is oriented toward cutting-edge questions and new knowledge (Firestein 2012) 'made' via a production process largely driven by internal design (intellectual curiosity, opportunistic technological innovation, intellectual and path dependencies and the pragmatic considerations of funding and career advancement) and accrued in publications in the peer-reviewed scientific literature (Hering et al. 2014). Despite generating active debate within specialist scientific circles, little of this cutting-edge

research is intended to provide directly actionable information for policy and management (Hering et al. 2014) and it is hard to see how it could, as the disconnect between production and use means the deep understanding of what is relevant and useful is lacking. Viewed from the academic shop floor, the key objective of science communication therefore is to 'sell' this new knowledge back to the public, who ultimately paid for it. Thus, when scientists are surveyed on their decision to 'go public' their impetus often reflects top-line organisational motivations: a desire to 'educate the public', 'influence the public debate, foster 'a more positive attitude towards research', and 'increase the visibility of sponsors and funding bodies' (Royal Society 2006, Dudo & Besley 2016) as well as to increase University brand profile, increase student numbers and tick the boxes of 'impact', as increasingly expected. Simply put, at its most meaningful, the academic communication mission is to enhance 'public understanding of science' (Bodmer 1986, Durant et al. 1989, Ziman 1991), thought to be best achieved by making complex scientific information more digestible for popular consumption.

Viewed through a 'make and sell' lens, therefore, science communication is an 'end of pipe' approach designed to promote science and to persuade people of its societal value. The priorities of communication are often to defend science from misinformation (fake products) and bolster public support for original knowledge production, rather than encouraging the public to participate in, and critically evaluate, scientific endeavours. This could be likened to a 'CSR' approach to sustainability where the intent is to be seen to be doing the right thing and bolster corporate reputation (Hurth, 2020)

Because scientists are trained to emphasize knowledge acquisition and empirical evidence, their working assumption is that the public are similarly wired (Simis et al. 2016). Therefore, so the assumption goes, if scientific information can be

communicated 'better' then people would know more about science and cease to be in a state of knowledge deficit. Emerging from this 'healthier' relationship between science and the public, scientists would see an increased uptake of sound science in environmental decision-making and find greater acceptance in society (Mooney 2010). However, this 'deficit model' thinking, intricately connected to the 'rational man' view of human behaviour promulgated by dominant economic thinking, has largely faltered on real-world application (Sturgis & Allum 2004, Bubela et al. 2009) including in a social marketing domain (Wellings et al. 2006).

Aligned to this promotional objective, science communication is valued by institutions as a worthy endeavour and training courses are encouraged as a necessary means, albeit one that is not entirely embraced. According to Besley et al. (2015, p.200) '…one common theme that emerges from many initiatives that involve scientists in communication, outreach or informal science education is not only the need for basic communication training, but also a reluctance of scientists to receive such training.' Surveys of those taking training indicate that most participants prioritize communication designed to defend science from misinformation and educate the public about science; they least prioritize communication that seeks to build trust and establish resonance with the public (Besley et al. 2015, Dudo & Besley 2016). Often, such courses are grafted onto training on conventional peer-to-peer research communications (how to write an academic article, make a poster, give a technical talk, etc) but extended into the practices of popular print and broadcast journalism (e.g. prepare a press release, write a popular news article, or give a media interview) (Mulder et al. 2008). The rise of online media at the expense of traditional news outlets has changed the nature of science journalism and encouraged many researchers to communicate directly to public audiences via blogs, vlogs and social media posts (Brossard & Schufele 2013). Nevertheless, a cornerstone of many courses remains the 'media training' or

'communication training', often used interchangeably. The former tends to focus on speaking with journalists, dealing with unpleasant questions in live broadcast TV shows, etc., whereas the latter tends to be more about helping scientists to communicate with the public, focusing on abilities such as creating trust and appearing empathic (Baram-Tsabari & Lewenstein 2017).

Underpinning 'make and sell' communications, therefore, are long-standing tenets of print and broadcast journalism (NAS, 2017). Appropriate language is critical for accessibility and impact, with Sommerville & Hassol (2011*)* advising climate science communicators to '…craft messages that are not only simple but memorable, and repeat them often. Make more effective use of imagery, metaphor and narrative. In short, be a better storyteller, lead with what you know, and let your passion show.' Story-telling devices in particular offer important ways to improve the public impact of our communications (Martinez-Conde and Macknik 2017). Narrative formats offer increased comprehension, interest, and engagement, even for complex ideas; non-experts get most of their science information from a mass media that is constructed around storylines; and narrative formats are intrinsically persuasive, offering tactics for winning over otherwise resistant audiences (Dahlstrom 2014). Despite the rise of online media channels and platforms (Schäfer 2012, Brossard 2013), most scientists tend to draw on narrative communications rooted in this traditional media model:

'Despite obvious changes in science and in the media system, the orientations of scientists toward the media, as well as the patterns of interaction with journalists, have their roots in the early 1980s. Although there is more influence on public communication from the science organizations and more emphasis on strategic considerations today, the available data do not indicate abrupt changes in communication practices or in the relevant beliefs and attitudes of scientists in the past 30 yr. Changes in the science–media interface may be expected from the

ongoing structural transformation of the public communication system. However, as yet, there is little evidence of an erosion of the dominant orientation toward the public and public communication within the younger generation of scientists.' (Peters 2013, p.14102)

Sense-and-Respond Communications

The second major paradigm of marketing has parallels with the Public Engagement (Weigold 2001) approach to science communication. This 'sense-and-respond' approach (Haeckel, 1992, 1995, 1999), arrived in force in the 1950s with the dawn of the 'marketing concept' (LaLonde, 1963; Schutte & Wind, 1968, Haeckel, 1999) and the associated rise in the neo-classical economic view of company value creation (Hurth & Whittlesea, 2017). This paradigm - which continues to dominate business aspirations today - turned the value creation model on its head by primarily seeking to mould the company to satisfy customer demands, as the key route to growth. Hence, Sense-and-respond firms operate from the 'customer-back', not from the 'firm-forward' (Haeckel 1999), attempting to '…continuously discover what each customer needs, sometimes even anticipating unspecified needs, and then quickly fulfilling those needs with customized products and services delivered with heretofore unavailable capabilities and speed' (Bradley & Nolan 1998, p.4). Marketing became focused on techniques to accurately sense market desires, get into the shoes of customers and adapt the organisation and its offerings nimbly to this, thereby allowing companies to target customers more specifically. In this new 'customer is king' business mindset, the role of marketing, at least in theory, shifted from being an end-of-pipe tool connecting pre-existing products to markets via clever sales, to being the strategy setter - placing customers as a primary stakeholder, with the expectation that creating value for them would secure tactical

and strategic advantage and ensure maximised profitability. Consequently, in the second half of the 20th century, marketing principles and practices became central to determining a company's business model and success.

While in many ways an important advance in connecting a company with its stakeholders, it did not reflect a deeper shift in business purpose, which remained shareholder value (Table 1). Aligned with the neo-classical economic information deficit view, consumers were also still predominantly regarded as self-interested rational beings who, with the right information, could maximise their welfare through decisions they make from alternatives offered in the marketplace (McFadden, 2006; Sen, 1977). Importantly, the role of the firm was not to (overtly) influence what people demanded, which would distort the free market; public needs were private affairs. Instead, the aim was to first understand market requirements and then deliver them. This approach - people-focused but at arms-length and for private gain – provided the basis of the manipulation reputation of modern marketing.

The sense-and-respond business mindset has affinities with a people-centred model of science communication: Public Engagement (Weigold 2001) which emerged in the 1990s as the strict knowledge-deficit dogma faltered. Social scientists joined the fray, systematically studying the 'science of science communication', evaluating many of the factors that shape individual and societal decisions, and appraising the implications for effective communication (Burns et al. 2003, Sturgiss and Alun 2004, Bubela et al. 2009, NAS 2017). With due attention paid to public attitudes and interests, science communication evolved into '…the exchange of information and viewpoints about science to achieve a goal or objective such as fostering greater understanding of science and scientific methods or gaining greater insight into diverse public views and concerns about the science relate to a contentious issue' (NAS 2017, p.1-2). A more effective sensing of people's views and concerns, ideally

through empirical inquiry, allows scientists to respond with communication practices and products that are better targeted.

Whereas make-and-sell marketing has parallels with the 'public understanding of science' approach to communication, sense-and-respond marketing is akin to the 'scientific understanding of the public'. Whilst sharing the make-and-sell assumption that people are, at heart, rational decision makers, sense-and-respond communications focus on understanding how individuals process scientific information, and the influencing role of values, attitudes, beliefs, norms, and personality traits (Dietz 2013). Psycho-social research revealed cognitive biases and short-cuts in decision-making, showing how experts and non-experts alike misconstrue scientific information (Slovic 1987). This, in turn, underlines the critical nuances of 'framing', recognizing that the way a given piece of information is presented in the media—either visually or textually—can significantly impact how audiences receive the information (Nisbet & Mooney 2009). Borrowing directly from commercial marketing (known as STP – segmentation, targeting and positioning), audience segmentation was used to distinguish multiple publics, allowing science communicators to design and develop messages tailored to different subsets of the population, or crafted to resonate with all groups, thereby increasing the probability of influencing individuals' attitudes, beliefs, and behaviors (Kahan et al. 2009, Cormick 2014). Increasingly, the utilisation of 'consumer behaviour' inquiry into social influences has widened to encompass how online social networks, memberships, and loyalties shape public responses to scientific messaging (Brossard, 2013; Brossard & Schuefele 2013). Drawing from behavioural economics and the work by psychologist Kahneman and colleagues (e.g. Kahneman et al. 1982), the prolific use of heuristics in decision-making showed how communicators could adjust their social messaging to 'nudge' people in the right direction and highlighted how science messages ought to be socially and culturally targeted to

connect to the audience's experience of the world rather than the scientists'. The headline messages emerging from this substantive body of social science inquiry are summarized in Figure 3 (Cormick 2014).

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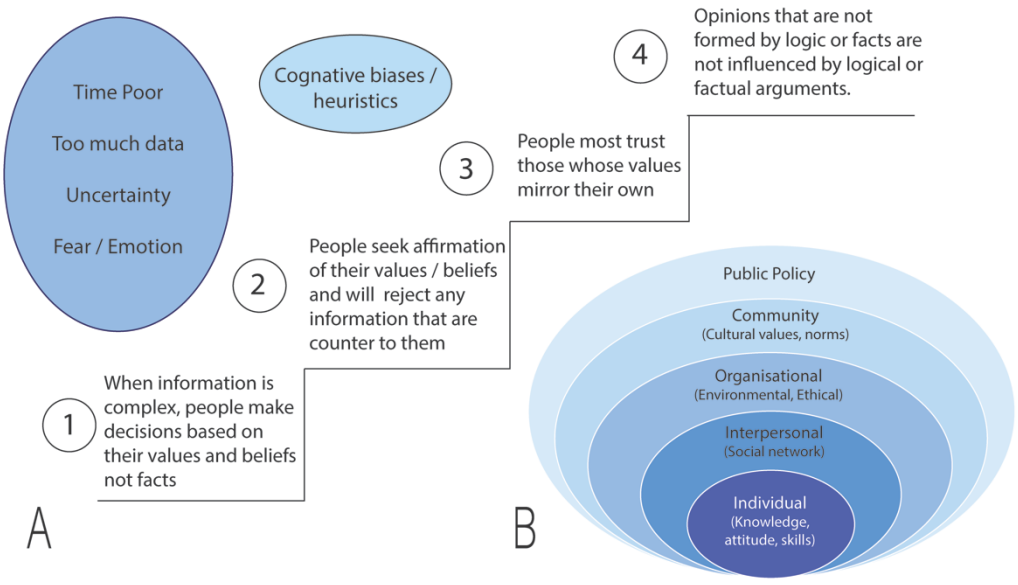

FIGURE 3: (A) Summary of the cognitive heuristics that individuals rely on to process information in situations that are time-poor, data-rich, uncertain and emotional (from Cormick 2014). (B) A socio-ecological framework for decision making highlighting how individual reasoning is nested within a broader set of social, cultural, economic and political influences.

People make decisions, people shape policies, and people face the consequences of environmental change (Keeler et al 2017). Putting people front and centre in science communication, however, requires technical specialists to establish partnerships with practitioners in the human sciences (arguably with marketing, and its focus on utilising these insights for targeted behavioural change, the most relevant), not least because these disciplines have the methodological know-how to engage diverse and hard-to-reach publics in authentic dialogues. There have long been calls for human and behavioural science thinking to be explicitly merged into

Earth science communications (Lubchenco 1998, Moser & Dilling 2011, Pidgeon & Fischhoff 2011, Palsson et al. 2013, Rapley & Meyer 2014), with some such as Naomi Oreskes (2015) arguing that, in its real-world applications, the Earth sciences are already operating as a social science:

'Many major questions in earth science research today are not matters of the behavior of physical systems alone, but of the interaction of physical and social systems. Information and assumptions about human behavior, human institutions and infrastructures, and human reactions and responses, as well as consideration of social and monetary costs, play a role in climate prediction, hydrological research, and earthquake risk assessment. The incorporation of social factors into "physical" models by scientists with little or no training in the humanities or social sciences creates ground for concern as to how well such factors are represented, and thus how reliable the resulting knowledge claims might be.' (Oreskes (2015, p.246)

In the emergent sense-and-respond landscape of science communication, not only social science but also the humanities and creative arts offer up alternative ways to engage the broader public (Nisbet et al. 2010) (FIGURE 4). Borrowing oral, written and visual practices from the creative arts and media professions, along with data gathering and analytic tools from computer science (Brossard & Schuefele 2013), dramatically expands the communication toolkit, allowing connections to be made with new audiences and fresh ways to visualize and imagine scientific information (Sheppard 2012). This exciting new transdiscplinary culture of society-science interaction is eloquently imagined by Nisbet et al. (2010, p.330) through the lens of climate change:

'Allies in communicating about climate change will be found among society's storytellers, including novelists, poets, and other creative writers; journalists;

musicians, documentary filmmakers; film and television producers; visual artists; and practitioners of the burgeoning variety of online social media. With the aid of environmental and social scientists, and inspired by moral and religious philosophers, these creative artists and associated professionals can accurately communicate about science in imaginative, compelling and novel ways. Perhaps more importantly, they can provide the context for values-based discussions about how we ought to act in the face of the challenges presented by climate change, and increasingly through digital media and innovative deliberative forums, the resources and opportunities for direct participation by the public'.

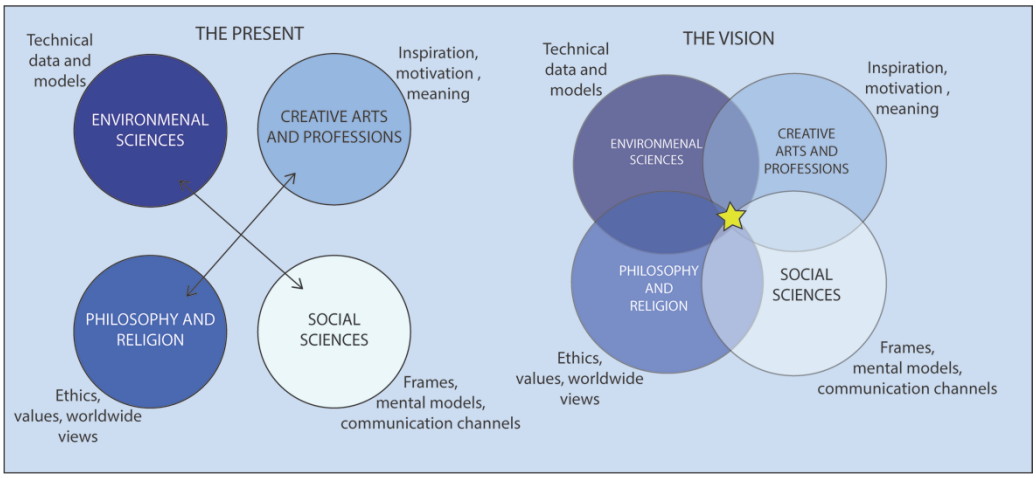

FIGURE 4: Transforming the four cultures. (Left) The Present: the four cultures address environmental concerns semi-independently, which has not yet fostered sufficient action. (Right) The vision: the four cultures engage fully and equally with each other, whose novel synergies foster rapid and effective societal responses to environmental challenges. From Nisbet et al. (2010, fig 1).

The result has been a creative rush of popular science outreach activities, aiming to engage the wider public about scientific topics and counter the perceived rising mistrust in science and scientists by reaching out to people on their terms and in their social spaces - from museums and festivals to cafes and bars (e.g. Tan & Perucho 2018) . But whether it is Cafes Scientifique, Nerd Nites or Science Fairs ,

the extent to which the resources invested in public engagement by scientists and universities is broadening end-user participation in science is uncertain, with indications that outreach activities disproportionately reach affluent and educated audiences already invested in science (Kennedy et al. 2018). Arguably, much public engagement activity still aligns with promoting and celebrating existing institutional models for science - simply a sophisticated 'user-oriented' extension of 'make-and-sell'. This apparent reluctance to move beyond an internal-focused sales orientation is also reflected in the business sector (Haeckel 1999, 2012; Kumar, 2105) where, despite decades of desire to become truly customer-led, in reality 'make-and-sell' appears a more comfortable mode that sits more easily in a system of self-interest (Hurth & Whittlesea, 2017).

Both sense-and-respond and make-and-sell paradigms are based on an assumption that the purpose of an organisation is to optimise its own success, judged over short time frames and within narrow terms. In make-and-sell communications, it is the public consumption of academic endeavours that provides the institution with its reward, whereas in sense-and-respond communications it is bending scientific resources to the public's concerns that brings organizational benefits. Hence, although it is people-oriented, sense-and-respond marketing also operates at arm's length, and focuses on immediate concerns, driven by current demands of customers or possible anticipation of what they might want next (TABLE 1) in order to apply the resources the institution can command to underpin its own success and growth. Given the underlying purpose of marketing in both approaches is for those internal ends and assumes an instrumental view of people, Hurth & Whittlesea judge that both of these organisational/marketing paradigms are incompatible with delivering against an agenda of wellbeing for all in the long-term - which they argue is the essence of the focus of both sustainability and an economy (Hurth & Whittlesea, 2017).

On that basis, we question whether our current make-and-sell and sense-and-respond communications are 'fit for purpose' in tackling Earth science's priority challenges. Many of the most high-profile issues in geoscience are about securing societal acceptance for untried and untested technologies (geo-engineering, 'fracking', Carbon Capture and Storage (CCS), radioactive waste isolation) whose novel technical risks go beyond the professional protocols and expert judgements of geoscientists and extend into the values of organisations and of the public at large (FIGURE 5). These controversial geoscientific interventions are dependent on public choices and hence it would be easy for us to rely on the art of persuasion. However, these societal concerns involve moral and aesthetic choices that reflect a deeper set of questions about equity and ethics (Oreskes 2004), as well as regarding central questions of what solutions, technical or otherwise, are being pursued by academia, for what ends and with what assumptions about what is a valuable set of outcomes for society. In other words, they are based on a cultural system of assumptions and valuing that requires reflection and discursive deliberation by different stakeholders balancing up potential benefits and risks of the associated technologies, rather than abstracted manipulation of the 'customer preferences' these produce. In that context, we contend that geoscience communication ought to have a deeper starting place and a different set of assumptions, beyond just that of human behaviour, that centre instead on the fundamental purpose of that communication in the first place.

In summary, our proposition is that conventional paradigms of communication, aligned and driven by a self-oriented purpose of an organisation, are incompatible with delivering a sustainable future appears to need serious consideration by those concerned with science communication. With the most acute environmental crises that threaten society being long-term, difficult to define, and sprawling in their

complexity, a new paradigm for science communications in the 21st century would seem to be needed.

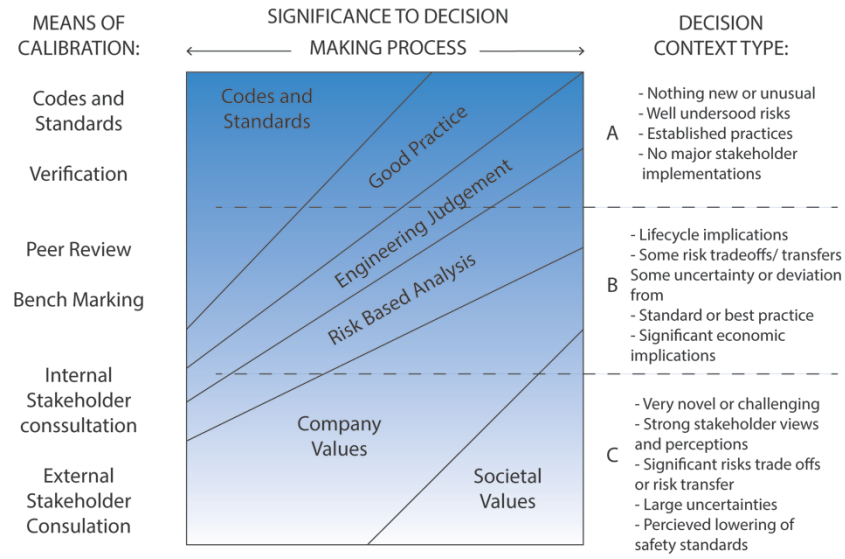

FIGURE 5: Risk-related decision support framework (Health and Safety Executive, 2004).

Guide-and-Co-create Communications

The answer may be emerging in the less noticed but parallel paradigm of marketing which has been emerging over the decades, where the role of marketing has been conceived in relation to genuinely socially oriented ends, rather than as means of capturing financial value for the firm and its shareholders. Examples include concepts such as 'societal marketing' (Kotler & Levy 1969; Kotler et al. 2010), where marketing offerings are designed to meet the long-term wellbeing of end users, and 'social marketing' by which social objectives (e.g. safe driving, healthy eating, family planning, sexual health protection for HIV/AIDs etc.) are advanced through the application of marketing principles (Andreasen, 1994; Peattie & Peattie, 2009).

Social marketing approaches have been extended to geoscience concerns, notably climate change interventions (Maibach & Parrot 1995, Maibach et al. 2008). Corner & Randall (2011), however, whilst acknowledging the effectiveness of social marketing in achieving specific behavioural goals, argue that it is insufficient to build support for ambitious policy changes. In part, this relates to the tendency to co-opt techniques and tools from make-and-sell and sense-and-respond marketing e.g. utilising arms-length market research, defining targets, identifying desired behavioural outcomes, promoting benefits that reinforce self-interest and decreasing the barriers that inhibit behaviour (Siegel & Doner 2007). However, the extent to which such tools and techniques are appropriate and effective, or new marketing tools are needed, is dictated by the ultimate objective of the firm that marketing to create, and the fundamental view of human behaviour it is based on. These are foundational aspects are beginning to change and with it the role of marketing and marketing communications.

Conventional economics limits the role of an organisation (and associated marketing practice), to maximising the capture of financial value (which indirectly is assumed to deliver optimised wellbeing through a free market of rational consumers). However, this role is beginning to be overturned in favour of a 'purpose-driven' approach to business, whereby profits are the result of a company that exists to solve problems of people and planet (British Academy 2020) as a way to serve the long-term wellbeing of society (Hurth et al. 2018). Recently, the bastion of conventional company thinking, the US Business Roundtable, declared the purpose of business was no longer to maximise profits for shareholders but to serve all stakeholders (Gartenberg & Serafim, 2019).

With the rejection of the traditional economic paradigm, a second, related, core shift is in the dominant view of human motivation and behaviour can be seen

occurring from the traditional economic view of humans as bounded-rational, self-interest decision-makers served by exchange mechanisms, to an emergent relational and purpose-oriented view of humans, enacted through co-construction of identity, values and behaviour that is situated in more holistic and systemic understanding of society, (e.g. Arnould and Thompson, 2005; Grönroos and Voima, 2013) which purpose also rests on. As a result of these twin shifts in how value and value-creation is conceived in business, a new aligned paradigm of marketing is beginning to be conceived and put into practice.

In the purpose-driven paradigm, the notion of 'wellbeing' becomes the central value outcome focus of the organisation - addressing real long-term human needs rather than short-term wants (Table 1). The very reason for an organisation to exist is defined in terms of its specific contribution to solving recognised problems for long-term wellbeing, as understood by society at the time. This radical change in the core value objective has been found to direct an organisation's activities to: '…a transcendent, meaningful and enduring reason to exist that aligns with financial performance, provides a clear context for daily decision making, and unifies and motivates relevant stakeholders' (Hurth et al. 2018, p.5.).

Marketing is the engine room of value creation for an organisation, so a purpose-driven organisation still relies on marketing to create the value it is seeking, but the change in the super-ordinal value objectives of an organisation cannot help but require a different kind of marketing from make-and-sell or sense-and respond. A purpose-driven organisation is intent, primarily, on leading society towards a better future, and as such imbues marketing primarily with a societal leadership (as opposed to response) imperative. Marketing success in a mature purpose-driven organisation can only be viewed against how well the value it creates aligns with the organisational goals for wellbeing outcomes. That includes not only what products

and services marketing designs and delivers but the social, cultural and psychological effects it has on society during that process. Whilst having a vision of what wellbeing outcomes look like and focusing efforts towards that is critical, the more realistic perspective of human behaviour precludes merely coming up with the answer and selling it to customers, which could be likened to make-and-sell for wellbeing. Instead, if human behaviour is understood as being based on a co-constructed reality, where the symbolic meaning (that marketing has central responsibility for creating), shapes the identities and cultures, that in term dictates how people consume and act (Wilkie & Moore, 1999; Firat, Dholakia & Venkatesh, 1995), then a company cannot 'design' the desired behaviour and persuade people to adopt it. Instead marketing becomes viewed more as negotiating and ushering in co-designed outcomes through close partnership those who are taking the journey. Hence purpose-driven marketing has been conceptualised as about both leading to socially beneficial outcomes, but via co-creating the path to this outcome with beneficiaries (hence 'guide-and-co-create') (Hurth & Whittlesea 2017).

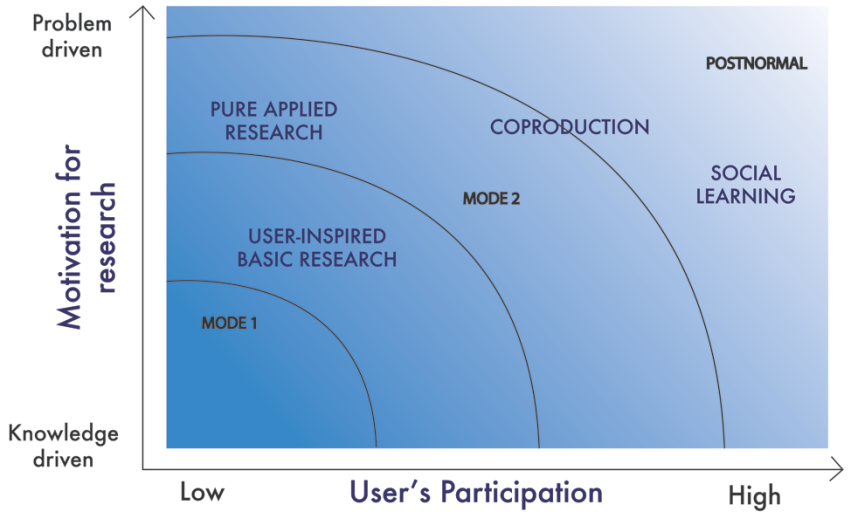

FIGURE 6: Evolution in the complexity of knowledge production and user participation. On the vertical axis, the complexity of knowledge production increases from low (where production is predominately focused on increasing our fundamental knowledge) to high (where production aims to help solve societal problems). On the horizontal axis, the complexity of user participation changes from

low to high as users become increasingly active agents in the knowledge creation process. Redrawn from Kirchhoff et al. (2013, figure 1).

The emerging guide-and-co-create marketing paradigm has similarities with 'mode-2' or 'post-normal' models of science-society engagement that have emerged from the field of sustainability science (Gibbons 1999, Kates et al. 2001, Nowotny et al. 2001, Miller et al. 2012, Schneidewind and Augenstein 2012, Schneidewind et al. 2016a, Konig 2017 Nowotny et al. 2001) (FIGURE 6). Mode-2 science is that which is primarily aimed at responding to questions from society, rather than following the precepts of 'blue-skies research' (Gibbons et al, 1994). Confronting situations 'when facts are uncertain, stakes high, values in dispute and decisions urgent', post-normal science tackles systemic uncertainty by integrating different and often conflicting interests in an 'extended peer community' (Funtowicz & Ravetz 1993, p.752). Such communities, or 'thought collectives' (Schneidewind et al. 2016b), involve all those who have a stake in that system - from the experts of various scientific disciplines, to stakeholders, whistle-blowers, investigative journalists, and the community at large – and do so by working collectively to develop new knowledge through social learning. Under post-normal conditions, the knowledge base is pluralized and diversified to include the widest possible range of high-quality, potentially usable, knowledges and sources of relevant wisdom, and thereby avoid the demand for science to speak with one voice. Scientists from different disciplines and non-academic stakeholders from business, government and civil society need to cooperate in socially deliberative research processes that are challenge-led and solution-oriented (Lang et al. 2012, Dietz 2013, Schneidewind et al. 2016b). This twinned approach of 'co-design' and 'co-production' is finding its way into mainstream research funding strategies, notably within the European Commission's Science in Society programme and in the context of the Horizon 2020 Strategy through the notion of Responsible Research and Innovation (RRI) (Owen et al. 2012).

In the frame of RRI, scientists, citizens, politicians and businesses are encouraged to collaborate on the research process, a partnership that allows science to fulfil its tasks responsibly and legitimised by society (Glerup & Horst 2014, Guston et al. 2014).

Co-design and co-production are the centerpiece of 'transformative science' – 'a specific type of science that does not only observe and describe societal transformation processes, but rather initiates and catalyses them' (Schneidewind et al. 2016b). Transformative research '…is driven by ideas that stand a reasonable chance of radically changing our understanding of an important existing scientific concept or leading to the creation of a new paradigm or field of science' (NSF, 2007, p.10). Ultimately, it goes beyond RRI, not simply exploring but actively initiating and steering radical societal change. This, in turn, requires a *re-purposing* of knowledge production, recognising that '…the silo-based approach to science and expertise, government and practice, with strict separation of research in the natural sciences and social sciences and the humanities that has co-evolved with industrialization, is no longer adequate for our civilization to cope with twenty-first century challenges.' (Konig 2017, p.13).

In this realignment of academic purpose, science communication fulfills a far broader set of assumptions and core motivations. We envisage that the limits of guide-and-co-create communications, situated within a broader guide-and-cocreate toolkit, will however be quickly reached unless they are part of a university system that is itself authentically focused on delivering the wellbeing value as its ultimate purpose - as explicitly achieved through an aligned strategy and operational system. A university that was genuinely focused on leading towards explicit wellbeing outcomes would require a much broader repertoire of research approaches, developed in partnership with the beneficiaries. Extending the skillsets of make-

and-sell and sense-and-respond communications, public scientists would be expected to develop and amplify 'interpersonal competence' (Wiek et al. 2011), developing '…communication, collaboration and related skills necessary for constructive involvement with other professionals, a range of stakeholders and the public in general.' (Crofton 2000, p.400). A key part of working out research possibilities and actions would be resolving tensions between stakeholders, so facilitative and conciliative skills will be critical (Kearins & Springett 2003).

By engaging in active dialogues with societal stakeholders, researchers would accept the challenges that come with this by explicitly questioning and reflecting their own implicit assumptions (Konig 2017). This would include the recognition of, and adaptation to, different cultural traditions, contrasting aesthetics and alternative cognitive approaches, fusing knowledge and experience into a common pragmatic approach. It would also involve identifying new social spaces in which to embed research, possibly through the creation of 'real world labs' – testing grounds for new knowledge and solutions that are delineated by a research question and can serve as natural laboratories for mutual learning (Schneidewind et al. 2016b). Finally, and perhaps most significantly, it would create new social contracts between scientists and 'the public'.

'At the social level, the success of scientists' communication depends on their awareness of the role that their work plays in the public discourse. Although scientists may know more than anyone about the facts and uncertainties, applications of that science can raise complex ethical, legal, and social questions, regarding which reasonable people may disagree. As a result, if scientists want to be effective in their communication, they must understand and address the perspectives of interest groups, policy makers, businesses, and other players in

debates over decisions that require scientific expertise.' (Fischhoff & Scheufele 2013, p.14031)

Conventional (normal) science sees scientists as operating between two end-member modes (Scholz 2017): (1) the 'knowledge workers' who indulge in self-enhancing and value-capturing behaviour (e.g. writing articles and present conference papers for consumption by other scientists); and (2) the 'luggage carriers' who act as a lobbyist tool by serving society directly (e.g. through contract-based research and development) (Figure 5). Transformative (post-normal) science, however, imagines the scientific process as an active driver for social change and envisages scientists as being reflexive in that endeavour, as facilitators, catalysts or activists (Wittmayer et al. 2014) - in other words working to guide-and-co create. Whereas 'facilitators' act as knowledge brokers, fostering mutual learning from multiple stakeholders to develop socially robust sustainable solutions, 'catalysts' take an active role in instigating change processes to increase a stakeholder's capacity for reflexivity and promote collective social learning. 'Activists', by comparison, are the most socially-committed scientists, taking direct action to mobilise stakeholders and purposefully drive sustainable transitional change. (FIGURE 7).

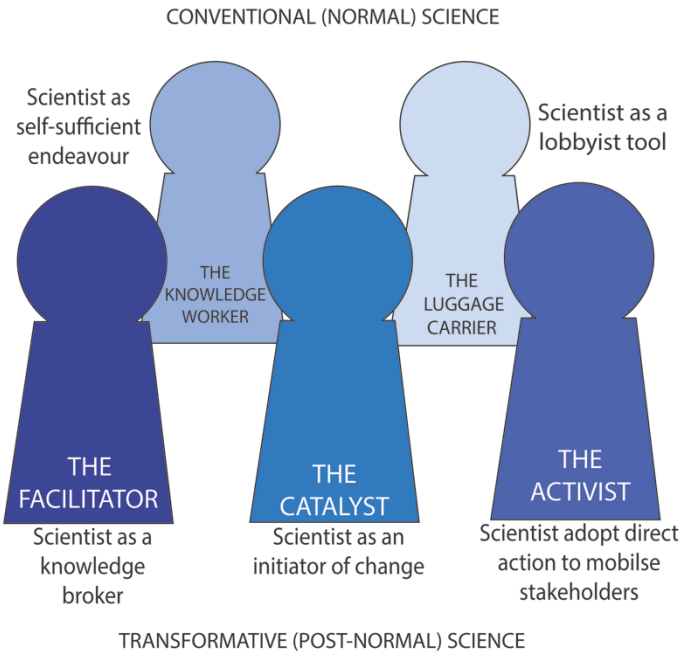

Figure 7: Different roles of scientists in their relationship with society (based on Scholz 2017)

In transformative research, confronting long-term issues of sustainability and environmental wellbeing will require scientists to assume very different, even deeply conflicting, societal roles. In his book, *The Honest Broker*, the geoscientist Roger Pielke Jr., draws attention to several of these contrasting roles: the *Pure Scientist* seeks to focus only on facts and has no interaction with the decision maker; the *Science Arbiter* answers specific factual questions posed by the decision maker; the *Issue Advocate* seeks to reduce the scope of choice available to the decision maker; and the *Honest Broker* seeks to expand, or at least clarify, the scope of choice available to the decision maker (Pielke 2007). These distinctions are deeply ethical and personal to the individual researcher, so the starting point for any science communicator – and arguably every science communication course - ought to be a discussion about what kind of public scientist they want to be, and from that what the requisite skillsets are to support that decision.

Yet, although these are personal choices, a scientist working within a university or research institute cannot separate these questions from what kind of ultimate outcome their organisation wants to produce (its purpose) and what assumptions, behaviours and outcomes that organisation therefore drives. Despite the need for a new breed of science intermediaries steeped in the ethical dimensions of both the science and the communications, critical reflection around the *purpose* of public engagement is currently missing from our culture of science communication training. Equally missing is the more foundational conversation about the *purpose* of academic institutions. We would argue that these are missing because our public interventions are rooted and routinized in a wider academic culture that remains largely tied to traditional knowledge-deficit thinking (Besley & Tanner 2011, Simis et al. 2016). Any academic shift to a 'guide-and-co-create' mindset and skills (FIGURE 8), therefore, will first require universities and research institutes to embrace their potential as purpose-driven organisations.

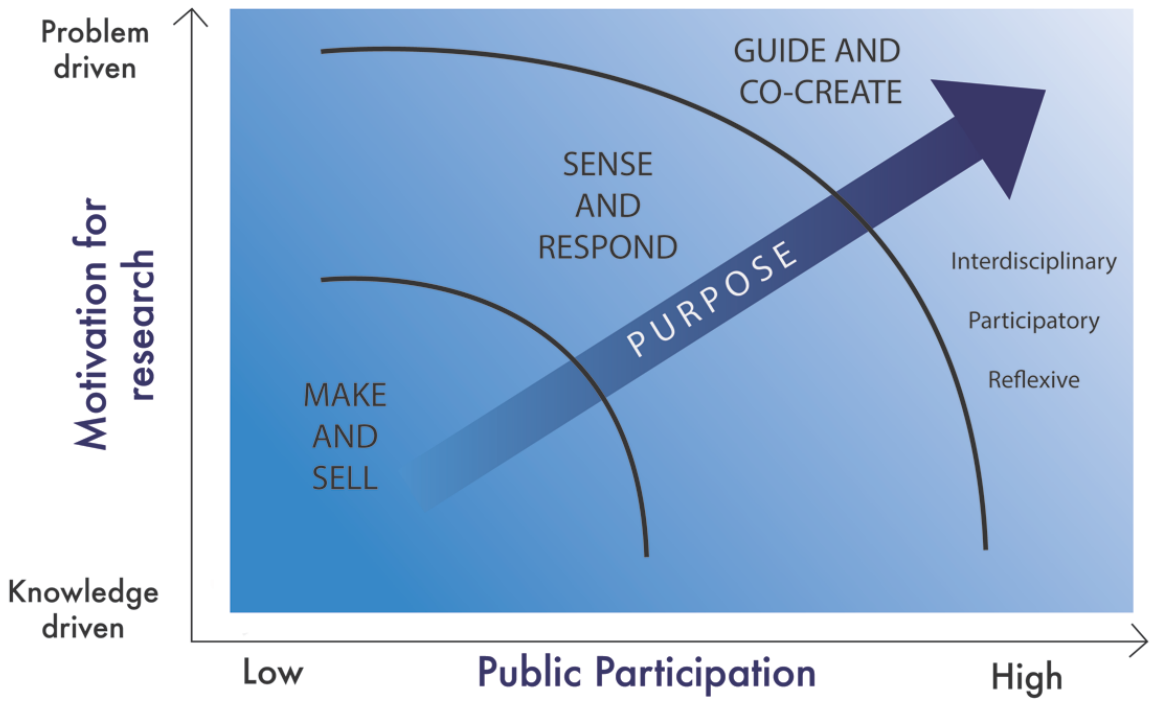

FIGURE 8: The science-public communication landscape in the context of 'make-and-sell', 'sense-and-respond', and 'guide and co-create' marketing paradigms.

Final remarks: towards an institutional re-purposing of science communication

Over 30 years ago, the environmental scientist Jane Lubchenco used her Presidential Address at the American Association for the Advancement of Science to advocate a 'New Social Contract for Science', calling on all scientists to '…devote their energies and talents to the most pressing problems of the day in proportion to their importance' (Lubchenco 1998, p.491). Three decades on, and, impelled by the 2015 global road maps of the Paris Climate Agreement, the UN Sustainable Development Goals, and the UN Sendai Framework for Disaster Risk Reduction, it is difficult to argue that the geoscientific community has not been given clear new rules of societal engagement at an international governmental level.

We question whether, as presently configured, the Earth sciences is up to this challenge. Like other physical science disciplines, the bulk of our public engagement remains at arm-length to societal concerns and tied to a redundant deficit-model that advances the contributions of geoscientists and their organisations but maintains a largely ineffectual one-way transfer of knowledge to a dissonant public. Communications that move people to action are those that align with particular social, economic, political and cultural frames, yet this 'science of persuasion' tends to be viewed suspiciously by physical scientists as ethically inappropriate. If a self-serving objective is suspected, it is easy to see what this is the case. As a consequence, the much-vaunted cross-disciplinary merging of the 'four cultures' (Nisbet et al. 2010) (Fig. 4) has so far been largely resisted by academic institutions that remain partitioned in conventional (normal) disciplinary silos that curate entrenched modes of knowledge production. To more directly confront societal challenges, therefore, '…scientists and their institutions must set

up an integrated system of research *and action* that will anticipate future problems and determine how to handle them' (Mooney 2010, p.14).

The idea that universities need to re-purpose their role in society at the deepest level is not a new idea. In 1970, the scientist, engineer and futurist Erich Jantsch introduced the notion of society as a user (or client) of science, and suggested that '…the university will have to adopt a new purpose which may be recognized as a means of society for continuous renewal' (Jantsch 1970, p.7). Along similar lines, Nicholas Maxwell's decades-long philosophical enquiry into the mission of science argues the methodological assumptions that academia has adopted has led to an irrational pursuit of knowledge without a meaningful human aim, and that universities need to be reoriented to confront 'the problems of the living' (Maxwell 2007, 2014).

Universities clearly have enormous potential to address the problems of the living. Realising this potential, however, is hindered by institutional structures, review and reward systems, and funding mechanisms (Whitmer et al. 2010). Although the sector is diversifying, the success of most universities and research institutes remains measured, implicitly or explicitly, on higher production levels (league tables of research quality and volume) and reduced production costs (financial sustainability). Research that has brought in the most surplus funds is usually viewed as the most valuable. Bounded by that narrow organisational mission there is a heavy reliance on 'selling' to persuade people that they should want the knowledge that has been most convenient or rewarding to produce. Although attentive to public needs, universities that are 'research-led' do not operate from the 'customer-back' but rather from the 'firm-forward' – archetypally make-and-sell. We would argue that in shifting towards a sense-and-response model they are not so much directly satisfying public needs but rather better gauging public attitudes to science in order

to ensure a market for their products, thereby maintaining the conventional organizational model of knowledge production. In short, whether make-and-sell or sense-and-respond, current science communication would seem to serve institutional purpose more than social purpose:

'In the not too distant past, researchers toiled in ivory towers, presenting findings at meetings of learned societies and publishing in obscure journals, often entombing information. As the need for stakeholder and public accountability grew, public relations and 'big C' communications departments flourished. They trumpeted the scientific discoveries of their institutions to demonstrate the excellence or relevance of their research and, of course, to generate more funding. In government settings, in particular, their role evolved from broadcasting or 'pushing' the scientific advances of their parent organizations to creating and ensuring consistent, overarching messaging about those institutions—both internally and to the public at large. This resulted in 'closing down' the science communications process, effectively burying uncertainty and staving off debate.' (Bielak et al. 2008, p.202).

Opening up science communications to more directly tackle acute societal problems will require the institutions in which geoscientists work to overturn their operationalised assumptions about human behaviour and the purpose of research. Based on the comparative experience of organisations in the business sector, our analysis of marketing paradigms emphasises that this will need universities to re-appraise their reason to exist, to continually question if this is the best articulation of this common good, and devise the best approaches to tackling the most challenging threats to this, including via education and research. Purpose-driven universities would not just be expected to deliver meaningful and measurable long-term wellbeing for society but also for other stakeholders, particularly researchers. They would have at their heart a clear organisational direction that sets out their

unique contribution to the global wellbeing agendas. Collaboration across departments and institutions would ease as narrow disciplinary interests are transcended. Trust would be heightened as research projects would be co-created through deep relationships formed with those they serve and those they rely on to help them serve. Within that re-purposed guide-and-co-create academic culture, research practices of geoscientists would become overtly interdisciplinary, participatory, reflexive, innovative and ethical. Arguably the first step in this institutional transformation will be geoscientists recognising that, at heart, we are marketers for humanity in peril.

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Marketing paradigm:	Make and Sell	Sense and Respond	Guide and Co-create
THEORY OF THE FIRM	**Purpose**: Profit maxmisation for shareholders **Value**: via cost of production **Focus:** internal	**Purpose**: Profit maxmisation for shareholders **Value**: via consumer preference **Focus:** external	**Purpose**: Societal wellbeing maxmisation for long term **Value**: via transition-focused relationships with stakeholders **Focus:** systemic

THEORY OF THE CONSUMER	'Humans can be selfish but this is held in check by an inherent desire for self-respect from others. Behaviour must be understood in a social context.' **Dominant relationship focus:** Internal (sales)	'Humans are self-interested rational beings, or bounded-rational decision-makers who, with the right information, can maximize their welfare through decisions they make from alternatives offered in the marketplace.' **Dominant relationship focus:** External (response)	'Relationships between all system levels shape human's identities, values and practices. Systems of symbolic meaning create and reinforce connections between wellbeing and consumption.' **Dominant relationship focus:** Systemic (co-creation)
TEMPORAL OUTLOOK	Narrow (firm and market system), fragmented, linear, short-term		Broad (planetary and future), integrated, systemic, long-term

TABLE 1: Comparison of the make-and-sell, sense-and-respond, and guide-and-co-create paradigms of marketing (modified from Hurth & Whittlesea 2017).

FIGURES

Fig. 1: Conceptual depiction of the science communication 'landscape', represented in terms of the motivating impetus for scientific endeavour and the level of public participation.

Fig. 2. Two simplified models illustrating interactions between key stakeholders in (A) a conventional top-down, expert-led risk management approach, and (B) in a people-centred risk management approach, as encouraged by the Sendai Framework for Disaster Risk Reduction (redrawn from Scolobig et al 2015, figure 3). Although both 'ideal types' greatly oversimplify reality, the comparison highlights how responsibility redistribution, stakeholder relationships, and scientist-public interactions become more complicated with people-centred approaches.

Fig. 3: (A) Summary of the cognitive heuristics that individuals rely on to process information in situations that are time-poor, data-rich, uncertain and emotional (from Cormick 2014). (B) A socio-ecological framework for decision making highlighting how individual reasoning is nested within a broader set of social, cultural, economic and political influences.

Fig. 4: Transforming the four cultures. (Left) The Present: the four cultures address environmental concerns semi-independently, which has not yet fostered sufficient action. (Right) The vision: the four cultures engage fully and equally with each other, whose novel synergies foster rapid and effective societal responses to environmental challenges. From Nisbet et al. (2010, fig 1).

Fig. 5: Risk-related decision support framework (Health and Safety Executive, 2004).

Fig. 6: Evolution in the complexity of knowledge production and user participation. On the vertical axis, the complexity of knowledge production increases from low

(where production is predominately focused on increasing our fundamental knowledge) to high (where production aims to help solve societal problems). On the horizontal axis, the complexity of user participation changes from low to high as users become increasingly active agents in the knowledge creation process. Redrawn from Kirchhoff et al. (2013, figure 1).

Fig. 7: Different roles of scientists in their relationship with society (based on Scholz 2017).

Fig. 8: The science-public communication landscape in the context of 'make-and-sell', 'sense-and-respond', and 'guide and co-create' marketing paradigms.