

Living Within the Earth's Carrying Capacity: Reflections from Memorial University



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Part of the Canada-wide Dialogue on
“Living Within the Earth’s Carrying Capacity”,
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Executive summary

This report is a result of an interdisciplinary discussion among graduate students from various disciplines at Memorial University that took place on April 24, 2020. The key messages and discussion points emerged from the workshop were:

- We should rethink “carrying capacity” to include multi-species collectives. That is, carrying capacity should move away from its anthropocentric focus to account for non-human beings, including technology. We question the utility of ecological metaphors such as “survival of the fittest” in describing the social world and suggest we redirect our attention towards a more mutualistic society.
- Translating this new way of thinking about carrying capacity as a multi-species collective into policy requires moving away from a focus on individual behaviors to redesigning the economic system and ensuring sound and effective governance. We identified capitalism and flawed governance systems as some of the main barriers for “living within the earth’s carrying capacity”, while recognizing that reimagining these is a complex, but important, challenge.
- Lastly, we recognize and appreciate the variety of ways in which different disciplines use and respond to issues of “carrying capacity”. The group identified cross-sectorial and interdisciplinary collaboration and knowledge sharing as a great opportunity to understand and mitigate human impacts on earth.

Land acknowledgement

We respectfully acknowledge the territory in which Memorial University campuses are located as the ancestral homelands of the Beothuk, and the island of Newfoundland as traditional territory of the Mi'kmaq. We would also like to recognize the Inuit of Nunatsiavut and NunatuKavut and the Innu of Nitassinan, and their ancestors, as the original people of Labrador. We strive for respectful relationships with all the peoples of this province as we search for collective healing and true reconciliation and honour this beautiful land together.

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1. Introduction

Carrying capacity is a concept that has been applied in many different contexts and across fields of study. The concept originates in the 19th century shipping industry, where carrying capacity was defined as a “mechanical or engineered attribute of a physical object or system” (Sayre, 2008:120). That is to say, the concept of carrying capacity was coined as a measurement to describe the maximum quantity (number or mass) of a particular object or thing within a finite physical space. Since then, the definition of carrying capacity shifted from a focus on inanimate objects (e.g., ships, production systems, resources) to encompass living beings, including humans. Throughout the twentieth century, the concept of carrying capacity was used in range and game management (ibid) before being applied within modern environmental policies and management. For example, carrying capacity is now used to define maximum allowable harm limits for anthropogenic activities, such as clear cutting or pollution release, that cause harm or disturbance to ecologies or particular species at risk (Williams et al., 2016).

Perhaps more commonly, and controversially, carrying capacity has been applied to the number of human beings a given ecosystem can support, with a given level of technology and regulation (Daly and Farley, 2010). For example, carrying capacity is a widespread concept in tourism management, where park managers apply it to gauge the number of tourists that can be allowed in a natural protected area, preventing unwanted consequences on the environment, communities, and tourism experiences (Needham, Haider, and Rollins, 2016; Mc Cool et al., 2001). The concept of carrying capacity as it is commonly used today is anthropocentric (i.e. about the number of people that can be sustained) and often paired with the idea of sustainable development. In a recent report (Policy Horizons Canada, 2018), Policy Horizons Canada, a federal government organization supporting the development of future-oriented (i.e., resilient to upcoming changes) policies and programs, wrote:

Humankind is putting an unsustainable strain on the Earth’s capacity to support life. We are at, or near, the tipping point for several ecosystem services. Fundamental changes in our economic and political systems and our way of life may be needed over the next two or three generations if humans are to live within the carrying capacity of the planet.

This quote served as a starting point for a Memorial University graduate student Dialogue on “Living Within the Earth’s Carrying Capacity.” This dialogue is a cross-disciplinary

conversation on the utility and pitfalls of engaging with the concept of carrying capacity, which took place on April 15, 2020. This report is a summary of this dialogue and intended to contribute to a series of similar, student-led dialogues across Canada, funded by Social Science and Research Council of Canada (SSHRC) and the Canadian Association of Graduation Students (CAGS).

2. Workshop format

This virtual workshop took place on April 15th, 2020 with 15 participating Memorial University graduate students from various disciplines at the St. John's and Grenfell campuses¹. The workshop was organized by Dr. Arn Keeling (Department of Geography) and Dr. Aimee Surprenant (Dean of Graduate Studies) and facilitated by three graduate student facilitators with three graduate student co-facilitators. The workshop started with welcoming words by Dr. Arn Keeling and Dr. Aimee Surprenant, followed by participant introductions. Participants were then divided into four dialogue groups and prompted to start a discussion from the following focus questions:

1. How does *your* research or discipline engage the concept of “carrying capacity”?
2. How does the concept of carrying capacity help us think through local and/or global environmental challenges?
3. What are the potential problems, risks, or pitfalls of framing environmental problems in terms of “carrying capacity”?

To conclude the workshop, all participants met in a plenary dialogue session to share the key messages from the groups. The following sections summarize the results of the four dialogue groups and of the plenary conversation.

3. Summary of Dialogue Groups Discussions

3.1 Dialogue Group One

Represented research interests: agriculture, food security, nature conservation, information management.

¹ The workshop was supposed to be held at Memorial University. Due to the COVID-19 pandemic, and to respect social distancing rules, we changed the format of the workshop from in-person to online. The workshop was hosted on the online meeting service BlueJeans (<https://www.bluejeans.com/>).

The participants in Group One discussed carrying capacity primarily in relation to food production, self-sufficiency, global markets, and agriculture. The participants discussed and reflected on how the concept has, or has not, been used across disciplines and how merging cross-disciplinary perspectives on carrying capacity can be conducive to addressing current anthropogenic environmental change. Reflections from Group One are presented in subsequent paragraphs.

3.1.1 Carrying Capacity from a Local & Global Perspective

Group One began their dialogue by raising the following question: Is carrying capacity always a global issue or should we consider it also at regional and local spatial scales? Drawing on examples of food security in the province of Newfoundland and Labrador, the group concluded that it is necessary to consider carrying capacity both globally and locally. For example, 90% of Newfoundland's food is imported into the province, raising questions around local food security, especially during recent events such as the so-called *Snowmageddon 2020* blizzard in St. John's or the current COVID-19 pandemic, both of which demonstrated the precariousness of our province's food system. However, increasing food production may raise other issues related to changes in land cover and use (e.g. encroachment), pollution, and use and import of non-renewable, limited resources such as phosphorus. The province is, at the same time, part of a global economy and food production system which also have associated environmental impacts (e.g. greenhouse gas emissions). The group also discussed the barriers for small scale local food producers when competing with international franchises. The group concluded that carrying capacity as it pertains to food production and security, must be considered both locally and globally.

3.1.2 Importance of Inter/Trans-disciplinary Collaboration & Knowledge Sharing

The concept of carrying capacity has many applications and uses across different fields. As a concept, it has been keenly adopted especially in the field of environmental management, where it has been used, among others, to refer to the number of visitors a protected area can sustain without unacceptable ecological impact (i.e. *social carrying capacity*). The group discussed how reaching a common understanding of carrying capacity is conducive for addressing environmental change and how drawing on different disciplines and knowledge sharing across disciplines, sectors, and countries can shed light on different components of carrying capacity that may otherwise have gone unnoticed. For example, a historical or social understanding of how the concept developed and has been utilized for particular end goals (e.g. sustainable development)

over time can helpfully demonstrate how environmental management practices informed by carrying capacity are necessarily 'natural' but informed by cultural and political ideas regarding 'good management' or 'healthy ecosystems'.

3.1.3 The Role of Humans

Humans both manipulate and adapt to the natural environment. The group discussed how a "future friendly" food system will require a change in demand and consumption patterns to include other sources of proteins (e.g. insects). The group recognized the role of technology - both in terms of environmental impact and technology as being part of the solution. The participants discussed how the concept of carrying capacity suggests *limitation in something* (e.g. limitation in the amount of anthropogenic pressure a certain system can sustain), but questioned whether this notion is accurate - while noting the issue of biodiversity loss - as anthropogenic activity on earth is characterized by manipulating systems, adapting the systems, and adapting to them. The group recognized the need for policy changes in meeting food demand at local level, and the role of culture in determining aspects of our life as consumers, including habits, motivations, and demand. Moreover, existing societal inequities (along the lines of race, class, gender, Indigenous status), likewise informed by culture, will need to be addressed to ensure technological developments adequately address, rather than exacerbate, issues of food insecurity.

3.1.4 Carrying Capacity: A Useful Metaphor?

The group agreed that carrying capacity should be understood as a metaphor, rather than as a hard threshold. Throughout the dialogue the group kept returning to whether or not carrying capacity is a useful metaphor. The group agreed that the concept is useful in that it illustrates how a given system (e.g. ecosystem, social system, and other applications of the concept) is impacted by anthropogenic activity but questioned the utility of the concept in regard to human population growth.

3.2 Dialogue Group Two

Represented research interests: geography, information sciences, economy and renewable energy, governance and ethics, nature conservation.

Carrying capacity, defined as the maximum number of human beings that the earth can sustain, can be a dangerous concept. Group Two began their discussion by identifying how the concept of carrying capacity overlaps with each participant's respective discipline. It identifies a limit to population growth without specifying who will be limited

and where. Who will be “sacrificed” (i.e. equity implications) to maintain human populations below carrying capacity is a key issue that needs further discussion. Furthermore, the argument of reducing pollution has been used to point the finger towards developing countries when other countries and entities (e.g., corporations) are the cause of the current levels of pollution we experience today. As the earth’s carrying capacity emerges from a complex system, approaching the issue of anthropogenic impacts on the environment with a single number describing a population limit may be too simplistic.

Although participants had fairly different backgrounds, they all identified carrying capacity as a concept that engages with their disciplines in various ways. Carrying capacity is a concept that is currently engrained in environmental legislation. The US environmental assessment procedures, for example, require estimating environmental impacts in terms of “takes” of endangered species (i.e., how many animals can be hurt/killed/disturbed without causing impacts on endangered species/populations). In terms of governance, carrying capacity raises questions of equity and highlights the need for transparent communication and responsible leadership to avoid creating disparities on how we will keep the human population below the carrying capacity threshold. From an economic standpoint, carrying capacity relates to the consumption of finite resources such as oil, which will inevitably limit our ability to sustain a larger population if renewable resources are not made available in a timely manner.

Group Two then engaged in a discussion on the different pitfalls that may arise from the application of carrying capacity as a way to tackle current global issues (e.g., climate change, biodiversity loss, growing levels of pollution). The discussion verted around three main themes: a) Technology, governance, and leadership; b) Economic Systems; c) Post-COVID-19 scenarios. Group Two’s dialogue is summarized in Figure 1.

3.2.1 Technology, Governance, & Leadership

Part of the discussion focused on technology as a way to increase the planet’s carrying capacity and/or to reduce humans’ ecological footprint. Technology may provide aid for reaching this goal. For example, investing more in renewable energy and in the reduction of resource consumption would help reduce anthropogenic impact on the planet. However, governance was identified as the main limit to sustainable development. Untested technologies give uncertain outcomes, and participants identified the excessive/uncontrolled use of technology as one of the main factors that led to current levels of overexploitation of natural resources and to the degradation of ecosystems. , This aspect is, in most cases, paired with a form of governance that is oriented towards economic growth rather than towards the preservation of natural environments. The

discussion highlighted the shortcomings of a growth-oriented system, in which production is conceived as a never-stopping machine – a design flaw that is causing considerable problems to our economy during the Covid-19 crisis. Other governance and economic systems (different from capitalism), however, did not prove to be better in terms of limiting damage to the environment and in addressing societal issues such as poverty.

The group identified leadership as a major challenge in tackling environmental issues. For instance, no Western country can pressure other countries to implement the Paris Agreement and push actions on climate change without incurring in criticism. Moving from fossil fuel towards renewable energy, implies decisions relative to which country will need to reduce its pace of economic growth. As participants pointed out, this aspect can create new conflict as the self-interest bias precludes countries to take necessary steps. For instance, the global supply chain is heavily dependent on fast-developing countries (e.g., China), which are also considered responsible for their large environmental footprint. However, developed countries have contributed to the creation of a system that pushes environmental issues towards undeveloped and developing countries, creating disparity and preventing global environmental actions to take place. Because of lack of responsible leadership, countries cannot come to a consensus over sustainable goals for the protection of the environment. Ideally, developed countries should be leading our path towards a more sustainable future, however, this is often not the case (e.g., US dropping out from Paris Agreement and reducing environmental regulation to foster economic growth). More responsible leadership and governments could help shift our current path towards a more sustainable future. Good governance is key when framing environmental problems in terms of carrying capacity. Governance emerges from both responsible leadership and our values as citizens. For example, shifting from finite to renewable energy is a goal that, in order to be achieved, needs to be prompted by the public, requires support from governments and leaders who need to start perceiving the environment as a key aspect of the wellbeing of their citizens.

The group also identified de-growth as a possible future direction (e.g., reducing/changing production of unnecessary goods), however, the question of who should invert the trend in growth is difficult to answer. The group agreed that degrowth should happen in specific sectors (e.g., clothing, non-renewable energy) while other sectors (e.g., renewable energy) should receive more investments and be expanded.

3.2.2 Economic Systems

Capitalism creates push demand through advertisements, promoting the consumption of often unnecessary goods in order to sustain the economy. This approach promotes a

wasteful use of resources and this aspect is ingrained in our social system (e.g., waste of food and natural resources). Culture plays a crucial role in consumption decisions, and the group tried to imagine a world without marketing and advertising. If there was no advertisement, people would most likely limit consumption to necessary goods, and, as a result, pollution and waste of resources would be reduced. Capitalism pushes economic growth making it difficult to shift towards sustainable production. Although some countries have already begun shifting their economy from fossil fuels to renewable energy, large systemic issues remain unsolved. Rather than being framed as “capitalism”, the group pointed out that our society is organized as a system that supports socialism for the rich and capitalism for the poor (i.e., corporate socialism vs. individual capitalism). A large portion of state resources is given to corporations in times of crisis, while citizens in need find it difficult to receive aid. Overall, countries are often at odds when it comes to tackling environmental challenges in terms of carrying capacity. Major disagreement can be seen between developed and developing nations regarding climate change. Even developed countries are not united in this aspect. Solving global and complex issues requires honest collaboration between countries.

3.2.3 Post-COVID-19 Scenarios

Lastly, the group raised questions about the post-COVID-19 world and imagined two divergent scenarios. In the first scenario, we could experience a boom in consumption after social distancing restrictions are lifted. Oil has been accumulating in deposits and on tankers, and these resources will need to be consumed in order to avoid an economic crisis. On the other hand, this emergency put our concept of “normality” under scrutiny. Needs that were normal and engrained in our society such as using transportation to commute for work, consuming food in restaurants and other facilities, entertainment, etc. may become less of a priority in our daily life and for our well-being. Remote work, when possible, could help reduce resource consumption.

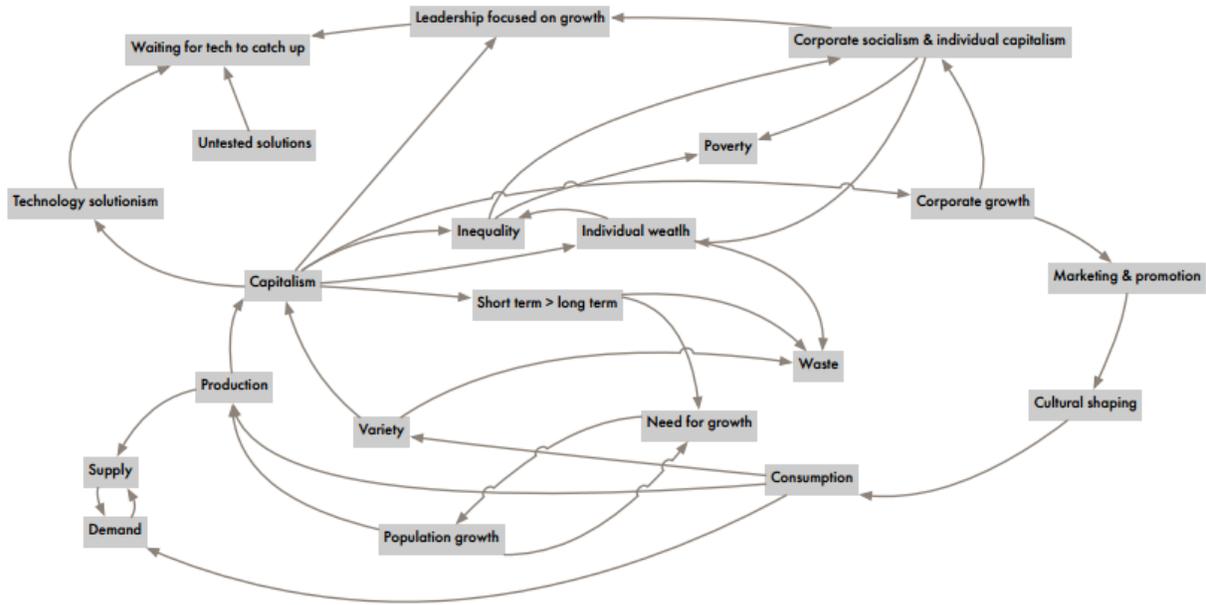


Figure 1 Dialogue Group Two: Why are we exceeding earth's carrying capacity?

3.3 Dialogue Group Three

Represented research interests: climate change, wildfire management, physical oceanography, environmental engineering, environmental impact assessment, social studies of science and technology.

3.3.1 Carrying Capacity is a Dynamic Process

The different backgrounds of the participants greatly influenced how they encountered and understood the idea of carrying capacity. Many participants had not directly encountered the term before, though its central tenet—namely, that species are limited by environmental factors—was one that participants had engaged with in their respective fields. A key theme for all participants is an understanding that ecological carrying capacity is not inherent to a particular environment but dynamic and subject to change over time. This can be caused by environmental changes (e.g. thinning of the ozone layer, pesticide use, or volcanic eruptions), which to varying degrees may also be associated with current technologies, political and economic systems. For example, in the arctic ocean, sea level rise caused by anthropogenic climate change may actually increase the carrying regional carrying capacity of certain species as ecological factors and physical ocean characteristics change. Changes to environments (often linked with human activity) also impact humans in uneven ways. Sea level rises caused by glacial melting and increased participation may result in decreased landmass for terrestrial and land dwelling

species including the vegetation, thus limiting the spaces available for physical crop production which in turn might impact local food sources and cultural practices. In these instances, environmental changes are not necessarily a good or bad thing, but calls to ask questions about which animals, plants, and people benefit or are harmed through human/environment interactions.

Understanding carrying capacity as a dynamic process that is always impacted by contexts including environmental factors calls into question the utility of 'carrying capacity' when framed as static. Rather than trying to understand the ecological carrying capacity of a region framed as constant, we might instead ask: what changes to infrastructure or political systems (e.g. international trade, food sharing and distribution) are necessary for humans and animals to thrive (Clarke and Haraway 2018)?

3.3.2 Teaching Carrying Capacity: Environment or Evolution?

A second idea that came up in group discussions was the way in which people from different fields were taught to engage with the concept of carrying capacity. For example, one participant discussed their background in conducting environmental impact assessment (EIAs). Here, 'carrying capacity' was seen as something pre-existing or inherent to a particular environment, which needed to be inventoried in order to be understood. EIAs involve assessing species abundance or biodiversity for a particular area, which would then help dictate whether and to which degree a development might be harmful. In this instance the 'carrying capacity' ideas had both harms and benefits. On the one hand, it rendered certain environments as able to be contaminated or damaged to a predetermined 'acceptable' amount. On the other hand, the concept created thresholds and remedial measures, that to some extent limit or at least direct the exploitation of resources. In this instance, the environmental framing of carrying capacity as 'natural' could be used as a justification for economic activities. Students and workers should therefore be taught that 'carrying capacity' is not natural but is constructed through a combination of environmental factors, including scientifically mediated ideas of what constitutes 'healthy' environments, and existing regional and national legislation.

The concept of carrying capacity also brought up tensions regarding the role of evolution and the concept of 'survival of the fittest'. One participant had a background in biology and explained that he was introduced through the concept through his university biology education. Specifically, the concept was introduced through a videogame, wherein a certain number of snails were placed on a particular plot of land. The user of the game could increase the number of snails in a given region and over time they would reproduce. If the number of snails exceeded carrying capacity they would begin to die off. To avoid

this, the user could increase or decrease this number by changing environmental factors, such as food and water sources, number of predators, and mutation rates over time (thus introducing diversity into the species). While the carrying capacity of ‘snails’ for a given space was framed as ‘natural’, this idea of ‘natural’ was understood as the by-product of species abundance, food sources, predation, and evolutionary rates — environmental factors (that may or may not be altered) — as opposed to simply the inherent qualities of the snail itself. For this participant, the game usefully pointed towards the role of environmental factors in understanding carrying capacity, and, in turn, the harm that may be caused when deaths attributed to ‘carrying capacity’ are associated with individual adaptability or ‘species fitness’ alone. This is particularly the case regarding humans when inequities built in to economic systems that unevenly target particular groups of people (women, queer and BIPOC folks, those living in the ‘Global South’), are in turn blamed for not being ‘fit’.

The different views of carrying capacity as biologically inherent or physically inherent versus the outcome of factors that are both environmentally and socially constructed has different political ramifications, particularly when discussing humans. Is evidence of global food insecurity or poverty the result of ‘humanity’ reaching Earth’s carrying capacity? Or is it the outcome of ‘environmental’ factors, including global economic systems and food distribution? These questions attribute responsibility differently, and may lead to different policy-oriented solutions. For example, assuming that a singular humanity has reached its carrying capacity may pave the way for policies aimed at population control and in turn the status quo of economic systems may go unchallenged. By contrast, focusing on environmental factors, including local and global economic policies (e.g. basic income supports, neoliberal economic policies) might instead become the focus of change. Accordingly, it’s important to underscore the role of ‘environmental’ factors when teaching carrying capacity, and push back against its deployment as a natural metaphor.

3.4 Dialogue Group Four

Represented research interests: human dimensions of wildlife, nature conservation, extractive industries, environmental policy, climate change.

3.4.1 *Physical vs. Cultural Carrying Capacity*

In sharing their knowledge and encounters with the concept, the group discussed the distinction between physical carrying capacity (understood as material ecological “limits” to a system) versus cultural carrying capacity, understood as how much of some condition or input a social/cultural system can withstand. This latter perspective prompts

thinking about the connections between ecological and cultural values, rather than an environmentally determinist perspective. It also highlights the social capacity of human systems to adjust, absorb, and manage a given challenge. This is not to say there are not physical limits, but these, too, relate to questions not only of “how much” but also of “when” and “for how long” there are pressures placed on the system. Physical “tipping points” may be relatively easy to measure and define (for instance, through reconstructions of paleoclimate data); can we say the same for cultural tipping points?

3.4.2 Carrying Capacity and Environmental Justice

These relational, distributional issues associated with both physical and cultural carrying capacity raise fundamental questions of distribution of resources, therefore environmental justice. However, it’s not clear that carrying capacity as traditionally defined deals with distributional issues very well. “Too much” is defined differently by different groups and individuals, and may also be related to the sense of a loss of control or stability. Thus, cultural carrying capacity is not an absolute but relative measure—even if it can be somehow “calculated.” Who defines (and/or imposes) limits and their indicators is of great significance, even if we agree that certain kinds of indicators are useful. Because of the complex and changing nature of carrying capacity, there is a need for caution in developing and applying such measures.

4. Plenary Dialogue

The plenary dialogue can be summarized in four different themes: a) (Re)-Defining Carrying Capacity to Account for the Collective; b) Redefining Dominant Values; c) Using Metaphors from Biology; and d) Carrying Capacity is Interdisciplinary. Alongside these four points of conversation, the group also posed a number of questions moving forward. The group also expressed interest in expanding this conversation to include other disciplines that were not represented in this dialogue. These included, but were not limited to, business, education, health, psychology, political science, civil engineering, and the arts.

4.1 (Re)-Defining Carrying Capacity to Account for the Collective

Despite variations across disciplines, carrying capacity is commonly understood as an ecosystem’s ability to sustain a certain number of people *within given levels of consumption, extraction, technology and wealth distribution*. Carrying capacity is a metaphor that is at the same time both useful and problematic. Its utility lies in raising awareness on issues such as climate change, biodiversity loss, waste of natural

resources, systemic poverty and social inequalities, and more generally on the environmental consequences of anthropogenic activities. However, a carrying capacity understood as ‘natural’ alone, risks legitimizing or naturalizing existing social and economic issues.

Carrying capacity is not just an environmental issue, but it is also a cultural, political, and social issue, which operates across spatial, temporal, and moral scales. Issues of carrying capacity are not just local. Places cannot be thought of as “space containers”, as issues at a local level are connected to regional and global developments and economies. We suggest expanding the definition to account for multispecies collectives. By this we mean that carrying capacity should also encompass non-human beings and technology. Framing carrying capacity around the “collective” also accounts for spill-over effects.

4.2 Redefining the Dominating Values

We identified capitalism as a dominating value dictating the set of practices that define the current economic system and approaches to environmental change. Capitalism is, however, not the only human value—nor is it one likely shared by the ‘other’ (non-human) participants in the collective. To overcome unsustainable environmental change, we need to reframe our own position in nature away from consumption. Technology, which is also part of the collective, can aid in this goal, but must be directed towards this end. We encourage reflection on which values and priorities we want to see reflected in policy and governance, and we identify the current global pandemic as a critical opportunity.

We believe that the definition of soil health could be a metaphor that would be beneficial for re-thinking carrying capacity:

“Soil health is the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health” (Doran and Zeiss, 2000, p. 3).

4.3 Using Metaphors from Biology - Mutualism instead of Survival of the Fittest.

“Survival of the fittest” is often associated with Darwin’s evolutionary theory. In the 19th century English philosopher Herbert Spencer adopted the idea to describe the social world in what has since been referred to as *Social Darwinism*. The plenary group discussed the utility of “survival of the fittest” in relation to carrying capacity and

highlighted the limitations of the concept both to describe the natural world and the social world. Not all relationships between organisms originate from competitive selection, and mutualism (i.e., interactions between organisms of different species, in which each organism gains a benefit) is widespread in the natural world. Explaining evolution using the “survival of the fittest” metaphor implies that new traits are acquired only when they confer an advantage to a species over other species or the environment. For its application in the social world, it was clear to the participants that the concept is embedded in colonial, racist thought, as it does not consider issues pertaining to equity and social justice. The group discussed how ‘fitness-thinking’ tends to dominate the social science metaphors borrowed from biology, and suggested instead that we think of carrying capacity in relation to concepts such as mutualism (Kropotkin, 2006 [1914]). This concept provides a potentially more productive starting point for discussions around co-operative governance of resources, rather than visions of conflict and scarcity.

4.4 Carrying Capacity is Interdisciplinary — Addressing it is, too.

Ecosystems’ ability to sustain human and non-human populations is impacted by technology, global trade and production, and their physical capacities for recovery and regeneration. To address issues of carrying capacity thus requires knowledge sharing and collaboration across disciplines, sectors, regions, and countries. Interdisciplinary dialogue can aid in (re)defining management and governance regimes and finding common ground for collective action. Transcending disciplinary boundaries also allows us to understand how the carrying capacity metaphor is used across disciplines.

4.5 Questions that Remain Unanswered

At the end of the session, the group still questioned *what carrying capacity is*, how a meaningful and operative definition of carrying capacity could be put in place, and how the concept can account for local, regional, and global environmental change while also redefine dominating values based in capitalism. The group also questioned how carrying capacity can help us tackle current challenges, be they environmental such as climate change and biodiversity loss, or related to the COVID-19 pandemic.

5. Conclusion

Adopting carrying capacity as a metaphor to develop federal policies and to communicate with the public warrants a clear definition of the concept. What exactly is meant by “the earth carrying capacity”? How is carrying capacity measured and how can this metaphor help us avoid ecological collapse? As highlighted in the Policy Horizon document, “living

within the Earth's carrying capacity" means that "virtually every aspect of our current lifestyles, beliefs, business practices, homes, cities, and economies would likely need to change." Individual behaviors only account for a small fraction of human-induced environmental change and biodiversity loss, and, as the group discussed, the political and economic systems play a much larger and more important role. The Policy Horizon document identifies 16 interlinked great challenges, and provides a diagram showing the connections between each challenge (Policy Horizons Canada, 2018, p. II). It does not, however, directly link "envisioning governance systems that work" to living within earth's carrying capacity. In the plenary discussion, participants agreed that the most important directions for the future are to rethink the current economic system and developing effective governance systems. Both in the group discussions and in the plenary dialogue, the participants identified the shortcomings of governance systems as one of the main barriers to solving local and global environmental issues. This reflects, to some extent, "paper targets" (Policy Horizons Canada, 2018, p. 53) (i.e. the Paris agreement targets) as laid out in the Policy Horizon document. However, while the document identifies "paper targets" as an issue, it does not make any direct/explicit connections between governance and humanity living within the earth carrying capacity.

Echoing the Policy Horizon document, the group called for profound changes in individual, societal, and economic behaviors. The COVID-19 pandemic provides us with an opportunity to rethink how we position ourselves, as humanity, within the natural world. All the shortcomings of a consumption-oriented humanity are emerging across the globe. We can already see how, prioritizing consumption and rebooting the economy while dismissing basic medical and ecological knowledge resulted in the US becoming the country with the highest death toll from COVID-19. Large sectors of the economy built under the assumption of continuous growth (e.g., energy, transportation, tourism) are among the mostly affected by the pandemic, with the remarkable example of oil prices reaching negative values in the US market. The past five months give an indication of how large-scale changes can help tackle the current environmental crisis. As our everyday life came to a halt – international travels dropped, many commercial and productive activities shut down either temporarily or permanently, and large portions of the population forced to work remotely – global emissions of greenhouse gases dropped 17% (Harvey, 2020, May 19; Le Quéré et al., 2020). However, 83% of emissions remained unchanged, highlighting that without the introduction of systemic and structural changes to governance and the economy there is little to no hope for humanity to reach net-zero emissions by 2050 (Harvey, 2020, May 19; Le Quéré et al., 2020).

Governance will also play a central role in how changes are distributed across different demographics. Currently, our economic and political systems are generating inequality

and are designed to provide more support to the wealthy portion of the population. Does “sharing the earth remaining carrying capacity” imply sharing it equally, independently from socio-economic disparities between people and countries? Or will equity be adequately addressed when deciding which sacrifices need to be made in order to avoid ecological collapse? What changes are needed in governance and productive systems to tackle environmental challenges at a global and regional scale? What are the respective roles of citizens, industries, and governments in maintaining humanity below the earth carrying capacity? Rather than “learning to share the remaining carrying capacity” (Policy Horizons Canada, 2018, p. V), one of the greatest challenges of humanity may be learning how to coexist with the natural world, and, even more so, to develop technological, economic, and cultural systems that provide benefits to both the human and the non-human. We suggest that such a trajectory would account for the multi-species collective. Achieving mutualism requires a deep and diffused understanding of the natural world, calling for higher levels of eco-literacy and ecological education. In the light of the current situation, we are now learning how important it is to understand the dynamics that regulate natural systems, as the perturbations we cause can backfire and have tremendous consequences for the health, well-being, and security of the human population. A population that is educated towards ecological thinking may be better prepared to prevent irreversible environmental damage and to adapt to rapidly changing conditions (Monbiot, 2020, May 12). This includes changing how metaphors from ecology are used to communicate global environmental issues. The “survival of the fittest” is one of a multitude of ways species interact with each other and the environment and other metaphors such as mutualism and symbiosis should also be part of the narrative.

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