APPLYING MIXED METHODOLOGIES TO INFORM URBAN CONSERVATION: POLICY, KNOWLEDGE AND BEHAVIOUR AT THE INTERFACE OF NATURE AND SOCIETY

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Abstract

Globally biodiversity is in decline and the human population is urbanizing. The loss of species is so great, it has been dubbed the “sixth mass extinction.” Over half of the global population now live in cities. There is the loss of biodiversity coupled with the loss of experience of nature in our daily lives. Interacting with nature has been linked to improved health and well-being. Despite the co-benefits for both people and nature, there is an implementation gap between the science, policy and practice. My dissertation applied the concept of scale from spatial (landscape) ecology to an interdisciplinary context: peoples’ values of nature.

At a local scale, I explored peoples’ emotions towards urban greenspaces in a large Canadian city, during a time of abrupt change and societal shock – the COVID-19 pandemic. Parks acted as an emotional buffer, as places of escape and recovery. Parks as a support to well-being can be leveraged and translated into political capital for park maintenance and for park and greenspace expansion in large urban centers. At a national scale, my coauthors and I investigated Canadians’ values towards native bees and perceived barriers towards their conservation. Canadians value native bees for their contribution to people and want the federal and provincial governments to take the lead in their conservation. This grassroots support for conservation should be communicated to decision-makers. At the global scale, I analyzed publications from two environmental organizations to study how the conversation about sustainability has changed over the past 25 years. Funding shapes sustainability communication. Expectations and priorities of donors can hinder capitalization on known science. Making knowledge accessible and relevant to funders informs sustainability practice. Collectively, these results provide insights into biodiversity conservation in urban contexts and sustainability practice.

Keywords: Communication, Emotions, Public Perceptions, Survey, Urban Biodiversity, Urban Green Space

Dedication

I dedicate my dissertation to my departed mother, Pixie Laurine Wilson-Trip. She shaped the person I am today with her love and support.

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List of Abbreviations

ACF: Australian Conservation Fund

API: Application Programming Interface

CA: Correspondence Analysis

CATI: Computing Assisted Techniques Interviewing

CBD: Conventional on Biological Diversity

CND: Canadian Dollar(s)

COVID-19 (Synonym: SARS-CoV-2): Severe Acute Respiratory Syndrome Coronavirus 2

CSS: Colonel Samuel Smith Park

DOLA: Dogs Off-Leash Area

ESB: Safe and Just Earth System Boundaries

EDS: Ecosystem Disservices

EF: Ecological Footprint

EIC: Ecology in Cities

ENGO: Non-Governmental Organization

EOC-E: Ecology of Cities as Ecosystems

EOC-S: Ecology of Cities as Socioeconomic Structures

ES: Ecosystem Services

ESA: Ecological Sensitive Area

EU: European Union

GDP: Gross Domestic Product

GO: Governmental Organization

GTA: Greater Toronto Area

HBP: Humber Bay Park

HPL High Park

IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IUCN: International Union for the Conservation of Nature

LPR" Living Planet Report

MEA: Millennium Ecosystem Assessment

MNR: Ontario Ministry of Natural Resources

MSY: Maximum Sustainable Yield

MTRCA: Metropolitan Toronto and Region Conservation Authority

NCP: Nature's Contribution to People

NDP: New Democratic Party

NGO: Non-Governmental Organization

NRC: National Research Council

OCR: Optical Character Recognition

OP: Our Planet Magazine

PB: Planetary Boundaries

PCA: Principal Component Analysis

SEEA EA: United Nations System of Environmental Economic Accounting Ecosystem Accounts

SP: Sherwood Park

TBP: Trinity Bellwood Park

TEEB: The Economics of Ecosystems and Biodiversity

TRCA: Toronto and Region Conservation Authority

TTP” Tommy Thompson Park

UGS: Urban Greenspace(s)

UN: United Nations

UNEP: United Nations Environment Programme

WTP: Willingness to Pay

WWF: World Wildlife Fund

1 Introduction

Globally biodiversity is in decline. The loss of species is so great, it has been dubbed the “sixth mass extinction” (Ceballos et al., 2020). Despite our awareness of the global decline in biodiversity, the problem has not been properly addressed and we continue to behave in ways that are detrimental to the biosphere and ultimately ourselves (Nisbet et al., 2009; Mace, 2014). To address the “biodiversity crisis” it requires not only involvement in the wider scientific community- i.e. conservation science (see Soule, 1987), but larger societal commitment – for example in science communication, policies and governance (Mace and Baillie, 2007). There is no shortage of scientific knowledge about the biodiversity crisis (Gerber et al., 2023). Rather there is a lack of accessible, actionable scientific evidence for conservation practitioners (Buxton et al., 2021; Gerber et al., 2023). This lack of translation of scientific into actionable advice leads conservation scientists to call for more “solution-driven,” multi-scaled and interdisciplinary research (Knight et al., 2008; Musacchio, 2009; McAlpine et al., 2013) by primary researchers. More recent scholarship has recognized the limitations of both researchers and practitioners to achieve meaningful collaboration and knowledge exchange. Conservation researchers are trained to conduct primary research and publish in scientific journals (Bednarek et al., 2018; Kadykalo et al., 2021); they are writing for their peers. Conversely, conservation practitioners are a more highly diverse group such as individual landowners, government or industrial employees and rarely have the time or specific training to wade through the scientific literature to find the information that suits their needs (Buxton et al., 2021; Kadykalo et al., 2021).

There have been several proposed solutions to bridging the science-policy-practice divide. I will discuss three bridging models from the academic literature: 1) boundary spanning (Guston, 2001; Bednarek et al., 2018), 2) evidence bridges (Kadykalo et al., 2021) and 3) logic of inquiry and action synchronization (Gerber et al., 2023). To this I add my own theoretical contribution, not another bridging model but rather a supporting structure: values of nature across scales. Bednarek and colleagues (2018, p. 1176) define boundary spanning in sustainability practice as “…work to enable exchange between the production and use of knowledge to support evidence-informed decision-making in a specific context’ and boundary spanners‘ as individuals or organizations that specifically and actively facilitate this process.” Boundary spanning should not be conflated with advocacy work nor science communication. Such conflations could undermine the effectiveness of the boundary spanner (Shanley and López, 2009; Bednarek et al., 2018). Boundary spanners exist at the intersection of science and policy (Guston, 2001). Effective boundary spanners need to be politically savvy. They must be able to read social cues (“read the room”) and integrate diverse points of view

(Bednarek et al., 2018). A conservation evidence bridge… “synthesize evidence and collaborate with practitioners to identify their needs and translate science accordingly” (Kadykalo et al., 2021, p. 1730).

In contrast to boundary spanners that may be involved in mediation, knowledge coproduction and adaptive management, evidence bridges operate as an independent third party (Kadykalo et al., 2021). Evidence bridges communicate usable and timely information to practitioners (Kadykalo et al., 2021). To ensure quality of information synthesis, Kadykalo and colleagues (2021) proposed a college for “conservation decision making” comparable to the College of Physicians and Surgeons in the field of medicine. A very different model from boundary spanning or evidence bridges is proposed by Gerber and colleagues (2023), they argue for a logic synchronization framework. Gerber and colleagues (2023) posit that researchers are guided by the logic of inquiry whereas practitioners are guided by the logic of action. Under the logic of inquiry the goal is fundamental research (precision, reliability and validity) rather than practical applications (Gerber et al., 2023). Under the logic of action the goal is solutions to practical problems (feasibility, urgency) (Gerber et al., 2023). They encapsulate the difference in this phrase, “Research does not require an audience, and action does not require complete or accurate information” (Gerber et al., 2023). They critique boundary spanning because it leaves distinct logics of researchers and practitioners unchanged. Their logic synchronization framework seeks the “…reformation of the logics under which all stakeholders operate…” (Gerber et al., 2023). Their framework consists of three parts: a biodiversity systems piece which focuses on fundamental research, a biodiversity outcomes piece which focuses on actions needed and a transformation piece that would integrate knowledge from the other components (Gerber et al., 2023).

How do *values of nature across scales* help inform and support bridging the science-policy-practice gap? My dissertation explores how values of nature across scales shapes and informs sustainability science and practice. Moreover, my dissertation seeks to understand how and why nature matters to people in urban and suburban settings.

1.1 Values: Diverse Ways of Relating to Nature

The unifying principle throughout my dissertation is the values of nature. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) defines values of nature as “…representations of what people and society care about and what they consider important in relation to nature” (IPBES, 2022, p. 8). This very broad definition is further categorized into four components, referred to as “life frames”: 1) living *from* nature, 2) living *in* nature, 3) living *with* nature and 4) living *as*

nature (IPBES, 2022). These life frames are composed of different proportions of three values types: instrumental, intrinsic and relational. Each of these values types will be discussed in more detail throughout this chapter. Briefly, instrumental values are a utilitarian/anthropocentric worldview of nature, the use value of nature (Justus et al., 2009). Instrumental values are the simplest to quantify because economic valuation techniques may be readily applied. Intrinsic values are an ecocentric worldview of nature, non-humans have a right to be protected and exist independently of their use to humans (Chan et al., 2016; Himes and Muraca, 2018). Intrinsic values are much more difficult to capture and quantify than instrumental values (Justus et al., 2009). Intrinsic values measurement may require qualitative (i.e. in-depth interviews) and participatory (i.e. collaboration and consideration of diverse perspectives) methods (O'Connor and Kenter, 2019). Relational values are a pluricentric worldview, these values are relationships among people *through* nature and *with* nature (Chan et al., 2016; Himes and Muraca, 2018). These relationships among people are often mediated by local natural features (Chan et al., 2016; Himes and Muraca, 2018), a sense of place. Returning to the four categories (life frames) of relating to nature. Living from nature is primarily composed of instrumental values (IPBES, 2022). Living with nature is primarily composed of intrinsic values (IPBES, 2022). Living in nature is primarily composed of relational values (IPBES, 2022). Living as nature is mostly composed of intrinsic and relational values (IPBES, 2022). It is important to recognize that the three values types are not mutually exclusive and boundaries between them are fuzzy. Kim and colleagues (2023) use the analogy of the hyperdimensional space of a Principal Component Analysis (PCA). A PCA is a statistical technique that reduces the dimensions within a large dataset while retaining the most relevant information possible (Jolliffe and Cadima, 2016). Retaining the most "relevant" information means finding new variables from the original dataset that are uncorrelated to each other (Jolliffe and Cadima, 2016). Like the new variables of a PCA, nature value types simplify multifaceted and complex ways that people relate to nature (Kim et al., 2023). In the following sections I review the academic literature on nature value perceptions within the scientific discipline of landscape ecology, urban ecology and individuals in urban settings and how these fields have informed by research aims and questions. Following my research goals, questions and dissertation outline sections, I have a separate literature review on how values of nature have changed through time with a focus on this change within the conservation science literature.

1.2 The Ecological View of Nature

Historically conservation professionals have been exclusively trained in the biological/ ecological sciences (Jacobson and McDuff, 1998; Rose and Parsons, 2015). As discussed earlier, the domain of science instills a way of thinking about and

approaching problems; the goal is for precision, reliability and validity. Skills from outside the sciences (i.e. interpersonal skills) were rarely taught (Jacobson and McDuff, 1998). There is a recognition that skillsets, ways of thinking and knowing from the social sciences need to be integrated into conservation science and practice for it to succeed (Bennett et al., 2017). Here I explore how biodiversity has been understood in two fields of ecology: landscape and urban and how these ways of thinking relate back to the three nature values types: instrumental, intrinsic and relational.

1.3 Biodiversity: A Concept for Conservation

The concept of biodiversity is not just another name for nature. Biodiversity refers to the objective measurement of the components that make up the variety of life on Earth (Farnham, 2002, pp. 4–5). As a concept, biodiversity is often discussed in relation to environmental degradation. For example, biodiversity loss occurs in relation to pollination, over-exploitation and human population growth (Farnham, 2002, pp. 4–5). The most commonly used definition of biodiversity comes from the Conference of Parties to the Convention on Biological Diversity (CBD), “the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (“Convention on Biological Diversity,” 2019). This definition comprises three-tiers of variety. Within species (genes and populations), between species (ex. species richness) and within ecosystems (ex. Landscape level metrics). Absolute abundance of a species is not included in this definition. For conservation professionals the concept of biodiversity is closely associated with endangered species. For example, in 1986 the Society for Conservation Biology was founded as a “response...to the biological diversity crisis” (Soule, 1987, p. 4). The current mission statement states, “The Society for Conservation Biology advances the science and practice of conserving Earth's biological diversity” (“Society for Conservation Biology,” 2019).

1.4 Ecosystems in the Landscape

What is an ecosystem? I agree with Godron and Forman's (1983, p. 12) statement, “the ecosystem concept is used widely, but often ambiguously, in the world’s literature...”. The term “ecosystem” had different meanings depended upon one's field of expertise. In this dissertation, I limit my discussion of this to the ecological sense. The aim here is to briefly review how ecologist understand biodiversity. The term ecosystem was coined by Tansley (1935). He describes ecosystems as, “...are of the most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom” (Tansley, 1935, p. 229). It

is important to note that part of Tansley's motivation for creating the term ecosystem is because he rejected Clements (1916) concept of a super-organism termed a “complex organism”. Tansley (1935, p. 299) states, “...enthusiastic advocacy of holism is not wholly derived from an objective contemplation of the facts of nature, but is at least partly motived by an imagined future 'whole ' to be realised in an ideal human society whose reflected glamour falls on less exalted wholes, illuminating with a false light the image of the 'complex organism.'” For Tansley lumping animals and plants together as a “biotic community” was overreaching. He did find, however, Clements's term “biome” in which organisms inhabit a given region as “unobjectionable” (Tansley, 1935, p. 299). See also Clements (1936) for a discussion on biotic communities. Given Tansley’s objection of holism, it is striking how other authors have come to define it. Fosberg (1967) defined an ecosystem as, “the sum total of vegetation, animal, and physical environment, in whatever size or segment of the world” (as cited in Godron and Forman, 1983, p. 12). An alternative term and much earlier term is “biocenosis” (Mobius 1877 as cited in Godron and Forman, 1983, p. 12). A biocenosis exists “where the sum of a community of living species and individuals, being mutually limited and selected under the average external conditions of life, have, by means of transmission, continued in possession of a certain definite territory (Mobius 1877 as cited in Godron and Forman, 1983, p. 12). Godron and Forman (1983, p. 13) unify this somewhat ambiguous terminology by defining ecosystems as having specific spatial limits, being relatively homogeneous, and having similar dynamics (i.e. energy flows) and structure. A landscape then, consists a several ecosystems, thus by definition landscapes are heterogeneous.

1.5 Landscape Ecology: A Spectrum from Biophysical Science to Culture-Nature Interactions

The first branch of ecology I will review is landscape (spatial) ecology. Landscape ecology’s explicit consideration of space informed my study of nature values types at different scales. Landscape ecology is interested in how much of something there is and how it is arranged (Turner et al., 2001, p. 4). In more technical language landscape, composition and configuration. It also focuses on large geographic areas (i.e. tens of kilometers) setting it apart from the smaller scales studied by other branches of ecology (Turner et al., 2001, p. 4). However, this is not to say smaller spatial scales are not of interest. See Wiens (1989) for a discussion of the organism centric approach. Wiens (1999, p. 372) remarks, “landscape ecology continues to suffer from something of an identity crisis.” The “identity crisis” of landscape ecology partly stems for the historical development of the field. The other source of confusion is the myriad of ways a landscape can be defined. In previous eras landscapes were viewed as massive areas of land where such as activities as the growing of crops, herding of livestock, building of

grand monuments and fighting battlefields (Forman and Godron, 1986, p. 5). Moreover, a landscape may be defined in an aesthetic sense (McHarg, 1992), for example the European 18th century picturesque. Around the same period a more scientific view of the landscape was put forth by the German geographer and naturalist Alexander von Humboldt who described a landscape as "the total character of a region" (Farina, 2006, p. 1). These 18th and 19th century concepts of the landscape align with relational values.

The term "landscape ecology" (Landschaftsökologie) was coined by the German geographer and botanist Carl Troll (1939) combining the spatial perspective of the geographer and the functional perspective of the ecologist (Naveh and Lieberman, 1984, p. 4; Forman and Godron, 1986, p. 7; Turner et al., 2001, p. 2). Troll (1969) defined the study of landscape ecology as "the study of the main complex causal relationships between the life communities and their environment in a given section of a landscape. These relationships are expressed regionally in a definite distribution pattern (landscape mosaic, landscape pattern) and in a natural regionalization at various orders of magnitude" (Wu and Hobbs, 2007, p. 272). Troll (1971) took a holistic view of the landscape, which included relationships between the biosphere, the geosphere and human culture (the noosphere) (Naveh and Lieberman, 1984, p. 4). He regarded the landscape as a gestalt entity (Naveh and Lieberman, 1984, p. 4), this is it was more than the sum of its parts. Landscape ecology since its inception has been a transdisciplinary science encompassing the fields of geography, landscape architecture, regional planning, forestry, wildlife ecology (Forman and Godron, 1986, p. 11) (particularly the study of animal movement). More recent definitions tend to emphasize either the biological/geological (bio-physical) or the human-oriented landscape. Naveh and Lieberman (1984, p. 3) state that, "Landscape ecology is a young branch of modern ecology that deals with the interrelationship between man and his open and built-up landscapes." Forman and Godron (1986) emphasize the bio-physical aspects of structure, function and landscape change over time. Landscape structure refers to "the spatial relationships among the distinctive ecosystems;" landscape function refers to "the flows of energy, materials, and species among the component ecosystems;" and landscape change refers to "the alteration in the structure and function of the ecological mosaic over time" (Forman and Godron, 1986, p. 11). Advocates of the bio-physical approach Turner and colleagues (2001, p. 7) argue humans do not need to be an explicit component of the definition of landscape ecology because humans are but one of the factors creating and responding to landscape spatial heterogeneity.

The tensions within landscape ecology mirror that of the conservation science-practice implementation gap. To many Europeans, landscape ecology is an umbrella discipline integrating biophysical, social, and economic factors. Risser (Risser, 1999, p. 8) advocates for the integration of socioeconomic forces into landscape ecology. He

states, “There is a great danger that landscape ecology will focus on traditional science, retaining an avid interest in quite legitimate research questions. In doing so, however, it may become of only marginal importance, as landscape ecologists will not relate to the social forces that shape society. Thus, because decisions are made within a social and political setting, landscape ecology must become an integral part of that setting” (Risser, 1999, p. 8). To many North Americans, this approach lacks rigor and is unscientific. Wiens (1999, p. 377) argues a broadening will “...weaken landscape ecology, leading to a loss of rigor and credibility.” In Wiens's (1999) opinion the strength of landscape ecology is its focus on landscape patterns, ecological processes and a strong foundation in science. Landscape ecology practice does not need to adhere to strict experimentation to be “good” (Wiens, 1999, p. 375). Good practice should have “...clear logic, sound design, careful measurement, quantitatively rigorous and objective analysis and thoughtful interpretation” (Wiens, 1999, p. 375). There is no single “right” way of doing landscape ecology. The different perspectives are beneficial when applied to environmental problems, where human needs and activities must be considered. Landscape ecology in practice has much to offer conversation science which requires information from the humanistic (holistic) and the reductionist (biophysical) to be successful.

1.6 Landscapes, Values and Policy

Different landscapes may be managed for one specific value, multiple values or values that are spatially segregated, one value is managed for at the local level whereas another is managed for at the regional level. A real-world example of this are the protected area categories of the International Union for the Conservation of Nature (IUCN). The IUCN has six management categories: Ia Strict nature reserve, Ib Wilderness Area, II National Park, III National monument or feature, IV Habitat/species management area, V Protected landscape or seascape and VI Protected areas with sustainable use of natural resources (Stolton et al., 2013). For a full description of IUCN categories see (Stolton et al., 2013). Categories Ia and Ib align with intrinsic values of nature. Category II aligns with all three values. National parks are to protect large ecologically processes and characteristic species (intrinsic) and provide cultural, educational and recreational (relational and instrumental). Category III aligns with relational values. Category IV which value is given priority is dependent upon management goals. Category V relational and instrumental values and category VI aligns with instrumental values. Integrating diverse values can help set targets, identify and monitor interventions and track progress towards a desired biodiversity outcome.

1.7 Urban Ecology, Human Scale and Values

The second branch of ecology I will review in relation to values of nature is urban ecology. Urban ecology informed my study of peoples' values of nature in urban and suburban settings. Investigating diverse nature of values in urban settings is becoming of increasing importance as global urbanization continues. Currently globally 55% of the world's population lives in urban area and this number is projected to rise to 68% by 2050 (UN DESA, 2019). Canada is a highly urbanized country. As of July 1, 2022, over 80% of the Canadian population live in cities (Statistics Canada, 2023).

Ecologists have largely ignored cities during the twentieth century, viewing them as damaged or degraded (Grimm et al., 2008; Wu et al., 2013) areas and thus unworthy of study. Ecologists instead directed their research efforts toward so-called "human-free" ecosystems (Alberti et al., 2003). However, as early as the 1970s, there were calls from non-ecologists to include ecological perspectives in urban planning (Craik, 1972; Dorney, 1973). Ecologists themselves did not show much interest in urban environments until the 1990s (Daniels, 1988; McDonnell and Pickett, 1990; Kaiser, 1997). As a result, much of our understanding of cities comes from the fields of economics and sociology (Rees, 1997). In fact, the field of urban ecology has its roots in the social sciences (Wu et al., 2013).

Urban ecology is a term that takes on a different meaning depending upon one's academic background and training. Wu (2008) discusses three distinct concepts of urban ecology: 1) Ecology in Cities (EIC), 2) Ecology of Cities as socioeconomic structures (EOC-S) and 3) Ecology of Cities as ecosystems (EOC-E). The EIC concept takes a biological approach to the study of the city and ignores human social and economic structures; instead focusing on patterns and processes of non-human organisms (McDonnell and Hahs, 2008). For example, there are numerous studies in the "pure" ecological literature on the distribution and abundance of plants and animals in cities (for a review McKinney, 2008). The EOC-S concept takes a sociological/economic approach to cities, focusing on humans and the built environment (Wu et al., 2013). The EOC-S concept would be familiar to urban planners. EOC-E concept integrates both the EOC and EOC-S concepts of urban ecology. It considers both biological and socioeconomic components of a city which form an ecosystem (Wu, 2008). Cities as the primary habitat of humans and cities as a human ecological niche have been considered but the integration of human dimensions has been absent (Rees, 1997). Such integration benefits the fields of ecology and the social sciences and urban planning. Ecology benefits from the knowledge and insight into human society and structures; the social sciences and planning benefit for the knowledge and insight into ecological systems (Niemelä, 1999).

Landscape ecology studies ecological patterns and processes at multiple scales (Wiens, 1989). Because landscape ecology emphasizes spatially explicit thinking, it is by its nature a spatial ecology. Its practitioners consider it to be an interdisciplinary science since landscape ecologists study a wide range of topics: climate change, habitat fragmentation, land use and ecosystem services (Wu et al., 2013) are but a few. At the beginning of the 21st century "urban landscape ecology" began to emerge which couples the theories and concepts from landscape ecology and applies them in the urban setting (Wu et al., 2013). The highly complex and spatially heterogeneous city may be understood through hierarchical patch dynamics theory (Fu et al., 2013). This theory states that ecosystems are hierarchical, dynamic mosaics of sub-components (patches) whereby the different organizational levels are influenced by cumulative interactions of patches (Fu et al., 2013). A hierarchical ecological landscape, in a city, for example consists of individual species (a tree)-aggregations of species (a forest stand)-a wider ecological community (a park)- several different communities (parks spread across a city). A hierarchical social landscape in a city consists of individual households-blocks-a neighborhood – neighborhoods across a city.

Within the hierarchical patch dynamic theory is the consideration of ecological scale. In the urban context researchers may examine sites in the metropolitan area (the city core), suburbia, exurbia or combination of these areas. These different areas are commonly examined using the urban-rural gradient approach. McDonnell and Picket (1990) first proposed the urban- rural gradient approach for studying the ecology of cities 25 years ago. They took the well- known gradient paradigm from plant ecology (Whittaker, 1967) and applied it to the urban context. The gradient paradigm broadly states that ecological spatial patterns directly influence the underlying ecological structure and functions of a system (McDonnell and Pickett, 1990). The classic example given is vegetation along the elevation of a mountain. As elevation changes there are corresponding changes in plant community structure. McDonnell and Picket replaced the mountain with the city. Urbanization is an anthropogenic gradient caused by human habitation and consists of an urban core surrounded by asymmetric rings of development (McDonnell and Pickett, 1990; McDonnell et al., 2008). Cities can be seen as forming a "mountain range," the core is analogous to the mountain peak having the harshest conditions of the gradient (McDonnell and Hahs, 2008). The suburbs and exurbs can be considered analogous to the slopes and valley (McDonnell and Hahs, 2008).

Returning to the concepts of ecology *in* cities (EIC) versus ecology *of* cities (EOC); much of the work on urban-rural gradients is considered EIC approach since it is small-scale and biologically focused whereas the EOC [EOC-S] which incorporates socio-economic dimensions is understudied using the urban-rural gradient framework

(McDonnell and Hahs, 2008). The urban-rural gradient approach has been criticized for being too simplistic (Alberti, 2005; Ramalho and Hobbs, 2012) (Alberti 2008; Ramalho and Hobbs, 2012). Ramalho and Hobbs (2012) call for a dynamic urban framework that explicitly considers the temporal scale such as urbanization age and past land use legacies.

Now, returning to the topic of scale. By its very nature the EOC approach calls for a "human scale" level of analysis. The human scale is the scale at which humans interact with nature (Folke, 2006). Although ecological (both human and non-human) processes can operate at multiple scale choosing a scale perceivable and relevant to humans has the best chance of successful operationalization (Wu, 2008). Thus, using a common scale can bridge across disciplines such as the biological sciences, social sciences and urban planning. Concepts of human scale and hierarchical patch dynamics further informed my thinking on the appropriate scale to investigate values of nature in urban settings. I chose three intuitive human scales: 1) local (City of Toronto), 2) national (Canada) and 3) global.

1.8 Individuals' Connection to Nature in Urban Settings

Promoting pro-conservation behaviours must focus on changing people's behaviours (Schultz, 2011). A person's connection to nature may motivate pro-environment behaviour (Mayer and Frantz, 2004). Experiencing nature has been positively related to increased ecological literacy (Pilgrim et al., 2008) and ecological concern (Clayton and Myers, 2015). That said, environmental concern may not always translate into pro-environment behaviours (actions) (Clayton and Myers, 2015). This gap is partially explained by personal barriers a person experiences that prevent full engagement in pro-environmental behaviour engagement (Whitburn et al., 2020). This could be a personal cost (time or financial), structural (ex. No public transit) or knowledge (of the pro-environmental behaviour) (Whitburn et al., 2020). Disconnection with nature has been blamed for leading to apathy towards environmental conservation and protection (Pyle, 2003). The inability to experience nature in our daily lives has been termed the "extinction of experience" (Miller, 2005). This is a cycle in which people grow up in species poor environments, leading to apathy towards conservation, leading to further losses of species and isolation from nature (Miller, 2005). This direct experience with nature in our daily lives which fosters nature conservation has been termed the "Pigeon Paradox" by Dunn and colleagues (2006). Due to increasing urbanization, people will increasingly only have direct experience with species found in cities. Ives and colleagues (2018) argue that reconnecting people with nature can "leverage deep societal change for sustainability" (p.1390).

Because of these processes large urban parks and other urban greenspaces (UGS) have an important role in biodiversity conservation and human well-being. UGS such as forest remnants and parks support higher levels of biodiversity compared to the surrounding urban matrix (Alvey, 2006; Croci et al., 2008; Nielsen et al., 2014). UGS support human well-being (Cleary et al., 2019) by reducing stress (Chiesura, 2004), provide recreational opportunities which promote overall health (Bowler et al., 2010; Astell-Burt and Feng, 2019) and promote social cohesion (Peters et al., 2010). Public UGS may be relatively more important to lower income individuals whom may lack the resources to access a private green space (Kinzig et al., 2005), like private gardens or backyards. Societal and ecological demands can be difficult to reconcile. For example, the demands between the societal need for recreation values and the preservation of ecological values (ecological integrity) has been well documented particularly in large (>100 ha) protected areas (ref. Liddle, 1997; Monz et al., 2010) such as national forests. These interactions are complex and range from negative to neutral to positive (Miller et al., 2022). The twin societal and ecological demands can be difficult to reconcile. For example, the demands between the societal need for recreation values and the preservation of ecological values (ecological integrity) has been well documented particularly in large (>100 ha) protected areas (Liddle, 1997; Monz et al., 2010) such as national forests. These social and ecological demands have been understudied in urban and suburban parks and recreation areas compared to rural parks and protected areas (Sisneros-Kidd et al., 2021). Compared to rural parks, urban and suburban parks receive higher volumes of visitors all year round (Sisneros-Kidd et al., 2021). Overcrowding, litter, vandalism and off-leash dogs are common concerns for UGS visitors (Arnberger, 2012; Palliwoda and Priess, 2021). UGS must balance diverse human perceptions and needs (i.e. safety, aesthetics, amenities) with biodiversity conservation (Aronson et al., 2017). UGS have been shown to improve human well-being, particularly physical health and mental restoration (Reyes-Riveros et al., 2021). People are generally poor at identifying species richness in urban settings and high species plant richness has been shown to be negatively correlated to reported well-being (Dallimer et al., 2012). Understanding society at large and individuals' relationship with nature will be what ultimately protects it. Conservation come downs to human values and actions.

1.9 Research Goal

To analyze the diverse values of nature at different scales of society to support the bridging of the science-policy-practice implementation gap; thereby enhancing sustainability and biodiversity outcomes.

1.9.1 Research Questions

1) How is indigenous biodiversity understood and valued by the Canadian public(s) in urban and suburban settings? (Chapter 2)

2) How and why has the conversation about nature and sustainability evolved over the past 25 years within the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF)? What are the sustainability policy implications of this evolution? (Chapter 3)

3) How has the COVID-19 pandemic affected peoples' emotions towards their local park (urban green space) in a large Canadian city? (Chapter 4)

1.9.2 Research Objectives

My dissertation takes a multi-scale approach to explore instrumental, intrinsic and relational values of nature. See also graphical Abstract (Figure 1.1).

Objective for Research Question 1

At the **Meso** (national) Scale I apply ordinal and multinomial regression models to a national telephone questionnaire to assess Canadians' knowledge of and perceived barriers to native pollinator conservation.

Objective for Research Question 2

At the **Macro** (global) Scale I trace and analyze the evolution of ecological and economic framing of nature using content analysis of a global governmental organization (GO), the United Nations Environment Programme (UNEP) and compare them to the global environmental non-governmental organization (ENGO) World Wildlife Fund (WWF).

Objective for Research Question 3

At the **Micro** (local) Scale I identify Twitter users' sentiments towards their local park in Toronto, Canada; before, during and after the COVID-19 pandemic.

1.10 Dissertation Outline

This dissertation is organized around three empirical chapters (chapters 2, 3 and 4). Each empirical chapter examines values of nature at a different scale. Chapter 1 is a literature review that gives a broad overview of the science-policy-practice

implementation gap and an overview of historical and recent concepts of nature in the scientific discipline of ecology and conservation science in general. In Chapter 2, published in the journal *Conservation Science and Practice* (Trip et al. 2020), my coauthors and I examine the Canadian public's general level of bee knowledge and interest in native bee conversation via a nationwide telephone survey of 2,000 participants. Chapter 3 explores the discourse of two global environmental advocacy actors, the World Wildlife Fund (WWF) and the United Nations Environment Programme (UNEP) through an analyze of their publications over the past 25 years. Chapter 4 investigates changes in Toronto park visitors' sentiments before, during and after the COVID-19 pandemic via Social Media. Chapter 5 summarizes and synthesizes the main points of this dissertation and concludes with a discussion of the theoretical and practical implications of the results.

1.11 Research Contributions

My research applies a values of nature lens at multiple scales to advance conservation science and policy. Results from Chapter 2 show Canadians primarily value native bees for their instrumental value (Ecosystem Services provision). This aligns most with the Living from nature life frame. Canadians want the federal and provincial governments to take the lead in native bee conservation. This show there is grassroots support for pollinator conservation, which needs to be communicated to decision-makers. Furthermore, Chapter 2 makes an important methodological contribution by using a multinomial logistic regression modelling approach more common in the Health Policy (van Exel et al., 2008; Baji et al., 2013) and Sociology (Yamaguchi, 2000) but less widely used in conservation science and policy.

Results from chapter 3 demonstrate knowledge transfer from academic literature to global environmental organizations. The language of the UNEP aligns with the living from nature life frame, positive economic and prosperity framing features heavily in its publications. The language of WWF aligns with the living with nature life frame, existence values of nature and stewardship via environment governance feature prominently in its publications. For both UNEP and WWF funding shapes communication. Project must be communicated in way that makes them relevant to donors. For the UNEP this may hinder its ability to capitalize on known science. Chapter 3 draws on discourse analysis methodologies developed in the humanities and social sciences. I combine this with a quantitative technique – correspondence analysis and apply this combination in a novel way to the environmental communication and advocacy space.

Results of chapter 4 show that in times of unexpected stress and a societal shock – a global pandemic, Toronto's parks are emotional buffers. Overall, across all parks, people expressed more positive sentiment than negative sentiment regardless of pandemic conditions. More negative emotions, fear and sadness were expressed at the height of pandemic restrictions. These negative feelings largely returned to pre-pandemic levels following the easing of restrictions. Findings from this chapter align with the living in nature life frame, themes of aesthetic value, nature's contribution to people and sense of place are present. Chapter 4 uses sentiment analysis of text (words) and ideograms (emojis) to understand the impact of COVID-19 on peoples' emotions about local parks. To my knowledge this is amongst one of the first studies to incorporate emoji sentiments in the context of parks, well-being and urban biodiversity at a local scale. Findings from this chapter show the value of Toronto's parks in times of abrupt change, these findings may be interpreted as political capital for park maintenance and future park or urban green space expansion.

1.12 Overview of Key Concepts of Nature in Conservation Discourse

In this section I will discuss key framing of nature conservation within the conservation literature. The emphasis will be on more current concepts; however, I will reference older concepts to demonstrate "new" ideas have historical roots. I am aware that the scholarly literature which I have reviewed here is predominantly Eurocentric. I am aware that there are diverse ways of knowing nature. In the last few decades, the importance of Indigenous knowledge has become fundamental to scholarly discourses surrounding biodiversity and ecosystem services. Organizations such as IPBES have been grappling with the very real challenge of how best to centre Indigenous voices in these discourses (IPBES, 2018). Indigenous perspectives are slowly being recognized in the academic literature and mainstream media (Jessen et al., 2022; Cecco, 2023).

1.12.1 Past Concepts of Nature: From a frightening place to a warehouse of resources

For much of human history, the line between nature and human civilization was blurred. Among nomadic hunters-gathers the natural world was their habitable space. With the advent of agriculture, animal husbandry and permanent human settlement; a dualism between nature and civilization was created. For good reasons, distinctions between controlled nature (domesticated livestock and crops), controlled spaces (walled cities) stood in stark contrast to uncontrolled nature (wild beasts, poisonous plants) and its uncontrolled spaces (dark forests, sheer mountains). The Ancient Greeks refer to this controlled nature, the space inhabited by people as the *oecumene* (Crist, 2014, p. 16). Outside the *oecumene* was uncontrolled nature with its uncontrolled spaces (Crist,

2014, p. 16). These non-civilized spaces were to be feared and tamed. The English word panic comes from Ancient Greek fears of encountering the Pan, god of the woods when traveling through a forest (Nash, 2014, p. 184). In Judaeo-Christian myths, God punishes people by casting them into “wilderness.” The term wilderness in English comes from the root Norse and Teutonic languages for “will” (Nash, 2014, p. 184). In Beowulf (8th century) the term *wildeor* which combines wild and doer (beast) was the space of forests and cliffs inhabited by mythical creatures (Nash, 2014, p. 184). The image of nature as threatening gave way during the late 18th to early 19th century with the Romantics (Nash, 2014, p. 185). It is important to note that the Romantics values of natural scenery and tranquility are anthropocentric. Nature is valued because people ascribe value to it.

1.12.2 Natural Resources (Resourcism)

The anthropocentric conceptualization of nature continued into the 20th century. Faced with dwelling game species for hunting and shrinking forests for timber production, North American conservation took the form of wildlife managers and foresters. Natural resources or resourcism become the dominant conservation paradigm. Resourcism is a utilitarian viewpoint that regards nature as a collection resources that exist for the sole purpose of human use (Farnham, 2002, p. 5). The natural resources paradigm has its conceptual roots in early 20th century conservation efforts to protect valuable “resources” as a game species and timber production. This paradigm is similar to the concept as “natural capital” in neoclassical economics (Chee, 2004). However neoclassical economists assume natural capital to be “free” and abundant (Chee, 2004) whereas the natural resources paradigm recognizes some resources are finite (i.e. crude oil) while others are renewable (i.e. a forest stand) but must be managed efficiently. This efficient management of resources is encapsulated in the concept of “maximum sustainable yield.” Maximum Sustainable Yield (MSY) postulates that each species produces an annual surplus of individuals which may be harvested (Larkin, 1977). If we harvest only the surplus and no more, one can continue exploiting the resource indefinitely (Larkin, 1977). MSY was widely applied to manage fish stocks in the second half of the 20th century. The collapse of the Canadian Atlantic cod fishery is an infamous example.

An early conservation typology came in the form of King's (1947) “wildlife” values. King states, “the total economic value of our wildlife resource is the sum of its several values plus the worth of the several services it performs” (1947:456 as cited in Farnham, 2002, p. 24). King's typology consists of six values: 1) commercial, 2) recreational, 3) biological, 4) social, 5) Aesthetic and 6) Scientific (Farnham, 2002, p. 24). It is important to note that all these values are instrumental.

Examples of King's biological value are to the value of animals as a means of biological control and as draft animals (Farnham, 2002, p. 24). King's scientific values is in the context of using wildlife to investigate natural phenomena “...that may affect man's interest either directly or indirectly” (King 1947: 456-7 as cited in Farnham p. 24). (King 1947: 456-7 as cited in Farnham, 2002, p. 24). King's typology has similarities to a more modern conservation typology- Ecosystem Services (ES). Both King's wildlife values and ES take a utilitarian view of nature and both assume nature is benevolent (Farnham, 2002, p. 25; McCauley, 2006). Equally important, neither typology explicitly considers the ethical dimension of conservation. These points will be further discussed in the coming sections.

1.12.3 Preservationism

The other conservation paradigm that dominated much of the 20th century was wilderness preservation (Callicott and Mumford, 1997; Mace, 2014). Early preservationists such as (Muir 2016) advocated the untamed value of nature (Campagna and Guevara, 2014, p. 59). In 1915 the Ecological Society of America promoted undisturbed areas in national parks as places for research and teaching for ecologists (Farnham, 2002, p. 204). The first president of the Ecological Society of America, Victor Shelford was critical of intrinsic valuation for nature, “there is much sentimental nonsense about nature”. (1913:8 Farnham, 2002, p. 204) Shelford and his colleagues advocated preservation of nature to retain the original biota for study (Farnham, 2002, p. 204). For this group ecologists the motivation for preserving the biotic community was to retain these areas as “control” sites. Mace (2014) characterizes the preservationist paradigm of conservation as “nature for itself.” The focus is on large protected areas, *without people* [emphasis mine] which underpins the sub-disciplines of wildlife management, theoretical ecology and natural history (Mace, 2014). Nature for itself implies intrinsic values, right to exist, non-human agency. Present in the preservationist paradigm are instrumental values, usefulness to people (nature for science, nature of beauty) and relational values, concepts of communal identity for professional ecologists.

1.12.4 Leopold's Land Ethic

A massive intellectual shift appeared in ecologist Aldo Leopold's seminal work; *A Sand County Almanac* originally published in 1949. In it he proposes an extension to current human ethics, shifting from an anthropocentric to an ecocentric framing of the relationship between humanity and nature.

Leopold remarks, “There is yet no ethic dealing with man's relation to land and to the animals and plants which grow upon it... [it] is still property. The land relation is still strictly economic, entailing privileges but not obligations” (Leopold, 1968, p. 203). “The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively the land; the land” (Leopold, 1968, p. 204). Leopold's land ethic aims to instill a sense of personal responsibility for conservation. “If the private land owner were ecologically minded, he would be proud to be the custodian of a reasonable proportion of such areas, which add diversity and beauty to his farm and to his community” (Leopold, 1968, p. 212). The IPBES (2022) living with nature life captures Leopold’s land ethic. The living with nature frame encompasses ideas of stewardship, personal responsibility, reciprocal relationships among people through nature and with nature and intrinsic existence values (IPBES, 2022, pp. 63, 71).

1.12.5 Sustainable Development & Ecological Sustainability

The term “sustainable” is broad. Immediately questions arise: sustainability of what and sustainability for whom? The concept of sustainability encompasses scholars from engineering, biotechnology, ecology, economics, social sciences and philosophy (Vucetich and Nelson, 2010).

Sustainability may be interpreted from an anthropocentric perspective, this is sustainable development or an ecocentric perspective, this is ecological sustainability. Vucetich and Nelson (2010) contrast the two approaches nicely. Sustainable development as “exploit as much as desired without infringing on future ability to exploit as much as desired.” Ecological sustainability as “exploit as little as necessary to maintain a meaningful life.” Sustainable development came into fashion in the latter half of the 20th century. The United Nations Commission on Environment and Development defines it as “…the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland and World Commission on Environment and Development, 1987, p. 43). As correctly stated by Purser and colleagues (1995) sustainability in this definition is that of future generations of humanity. It is anthropocentric. Sustainable development is related to the concept of Maximum Sustainable Yield (Callicott and Mumford, 1997); both have their roots in the resourcism. Like its forbearer, sustainable development is interested in reducing waste and increasing efficiency. Sustainable development sits within the living from nature frame.

The other definition of sustainability is ecological sustainability. Unlike sustainable development, ecological sustainability takes an ecocentric approach. Noss defines this as “A biocentric or holistic concept of sustainability focuses on sustaining natural

ecosystems and all their components for their own sake, with human uses included only when they are entirely compatible with conservation of the native biota and natural processes" (Noss, 1995, p. 26). Under the definition of ecological sustainability species and whole ecosystems have intrinsic value. An ethic dimension is implicit in ecological sustainability. Ecological sustainability sits within the living as nature frame. Relationships of care (for humans and non-humans), agency of non-humans and life support values (IPBES, 2022, pp. 63, 71) are present in ecological sustainability. How we define sustainability shapes our relationship with nature.

1.12.6 Economic Valuation of Biodiversity

The purpose of this section is to highlight four major policy documents that apply economic valuation to biodiversity and discuss these documents and main concepts therein through a values of nature lens.

The first policy document, the Millennium Ecosystem Assessment (MEA) was published in 2005 and popularized the concept of Ecosystem Services (ES). The most widely used definition of ES is the one used in the Millennium Ecosystem Assessment (MEA) report, which defines ES as "...the benefits people obtain for ecosystems" (M.E.A., 2005, p. v). The MEA defines four categories of ES, 1) regulating, 2) provisioning, 3) supporting and 4) cultural (M.E.A., 2005, p. v). Regulating services include flood control and water quality (M.E.A., 2005, p. v). Provisioning services include food and timber and supporting services include nutrient cycling and soil formation (M.E.A., 2005, p. v). Cultural services are the most broadly defined, they include aesthetic, recreational and spiritual (M.E.A., 2005, p. v). Within the MEA framework nature is viewed from an anthropocentric perspective. In 2010, the Economics of Ecosystems & Biodiversity (TEEB) was published. It builds upon the MEA and focuses on the economic valuation of nature. The TEEB motto is "Make Nature's Values Visible" (TEEB, 2023). This is a clear economic reference. Biodiversity exists outside traditional economic markets. Therefore, to traditional economists, nature is "invisible" (Chee, 2004). The objective of TEEB is to "...mainstream the values of biodiversity and ecosystem services into decision-making at all levels. It aims to achieve this goal by following a structured approach to valuation that helps decision-makers recognize the wide range of benefits provided by ecosystems and biodiversity, demonstrate their values in economic terms and, where appropriate, capture those values in decision-making" (TEEB, 2010). The TEEB framework defines ES in a similar way to MEA. TEEB defines ES as "the direct and indirect contribution of ecosystems to human well-being" (TEEB, 2010, p. Ch. 1 p.10). The TEEB makes an explicit case for economic valuation of nature, "Valuation plays an important role in creating markets for the conservation of biodiversity" (TEEB, 2010, p. Ch 5 Pg. 5). In 2021, the UN System of Environmental Economic Accounting (SEEA) Ecosystem Accounts (EA) and the Dasgupta Review of the Economics of

Biodiversity were published. The SEEA EA takes an accounting framework and links that to environmental data. The SEEA EA is defined as "…a spatially-based, integrated statistical framework for organizing biophysical information about ecosystems, measuring ecosystem services, tracking changes in ecosystem extent and condition, valuing ecosystem services and assets and linking this information to measures of economic and human activity" (United Nations et al., 2021, p. 24). The Dasgupta Review of Economics of Biodiversity, thereafter, referred to as the Dasgupta Review focuses on linking biodiversity to sustainable economic growth.

Here I will discuss key policy ideas for MEA, TEEB, SEEA EA and the Dasgupta Review. Much of this discussion will focus on Ecosystem Services (ES) because it has been the focus of intense scholarship within the sustainability science space.

Why must nature be integrated into the market economy? According to economic theory (market essentialism) markets are the most suited to the task of allocation of scarce resources (see Chee, 2004 and references therein). Supporters of the ES framework for conservation assert that protecting ES is enough to protect biodiversity. Mace and colleagues (2012) argue that some aspect of biodiversity is always involved in ES production. According to Mace and colleagues (2012) two common perspectives linking biodiversity and ES are: 1) either biodiversity and ecosystem services are the same thing – what she terms the ecosystem services perspective or 2) biodiversity is an ecosystem service – the conservation perspective. However, neither perspective fully captures this link because biodiversity plays multiple roles in ES- as good (cultural values), as regulator of ecosystem processes or as a final service (Mace et al., 2012). Mace and colleagues (2012) argue that viewing biodiversity this way will provide new opportunities for conservation and conservation professionals should not view these perspectives as a threat to conservation efforts. For Jax and Heink (2015) the relationship between ES and biodiversity is based on which values-based perspective is used. It is human values (both individual and societal) that will determine which parts of nature of relevant for ES (Jax and Heink, 2015). Recognizing that ES is defined by human values, Gunton and colleagues (2017) propose an expansion of the ES framework from 4 (originally laid out in the MEA) to 12 dimensions (summarized in table 2 in their article). In this expansion dimensions of ethics, cultural studies and sociology are explicit. An example of a valuation question under the ethics (altruistic value) dimension is "How does it [the site] enable us to love/care?" and under the religious and cultural studies (Certitudinal value) "How do we know ourselves here?" (Gunton et al., 2017). Other important articulated values are social - "How well can we socialize at the site?" and Symbolic value "How do we get information from it [the site]?" and "How meaningful is the site to us?" (Gunton et al., 2017). This effort to expand valuation

nature is extremely important. It leads to the important questions, what happens when there are conflicts among values? Do certain values trump other values?

Economic justification for biodiversity conservation is not new. At the turn of the 20th century, the field of economic ornithology emerged (reviewed by Whelan et al., 2015) to justify saving songbirds. Nowadays economic ornithology has been rebranded Avian Ecosystem services (ref. Whelan et al., 2015). Under the ES framework, in order to guarantee biodiversity conservation, said biodiversity must act for humanity's benefit. Basic ecology tells us an ecosystem is not benign, an ecosystem does not benefit a single species alone (McCauley, 2006). To address the fact that nature can be harmful to humanity's interests, the term Ecosystem Disservices (EDS) was created. EDS are functions or properties of ecosystems that are perceived by people as harmful, undesirable or unpleasant (Lyytimäki, 2015). Examples of EDS are damage/loss of crops due to pests or pathogens and allergic reactions to pollen. EDS may result from the functioning of relatively undisturbed or highly modified/disturbed ecosystems; the latter often increases EDS (Dunn, 2010; Lyytimäki, 2015). There is a vigorous debate with the literature about EDS. Supports of EDS as a concept tend to have a more anthropocentric orientation towards nature conservation. To minimize EDS, Dunn (2010) calls for a 'Gardened Planet". "As we move forward, we must garden nature. We need to manage not only for habitats with fewer disservices, but also in such a way that individual species provide fewer disservices" (Dunn, 2010, p. 556). Villa and colleagues (2014) are critical of EDS, claiming it is harmful to society and science and that it poses a direct threat to conservation. They prefer the term ecosystem flow dynamics as complex systems approach to human-nature interactions (Villa et al., 2014). Schaubroeck (2017) makes 5 arguments in support of EDS. I take issue with two of them, readers may see Schaubroeck (2017) for the complete list. They are as follows: 1) society has a right to know all the effects ecosystems have on well-being and 2) if nature is needed to ensure the survival of the future of humanity, more nature can exist outside urban environments, thus still meeting human needs and reducing disservices where most people live (Schaubroeck, 2017). The line between ES and EDS is blurred. Rasmussen and colleagues (2017) found a species can switch from a service to a disservice. In rural Laos wild animals (rats) and wild plants (weeds) were used as food and traditional medicine respectively, thus were an ecosystem service (Rasmussen et al., 2017). These services switched to disservices based on economic factors (increased wealth) and but also cultural values- peoples' changing aspirations and self-identity (Rasmussen et al., 2017). What is considered ES by one person maybe EDS to another. This may lead to social conflicts, particularly in the case of urban green space, where space is limited and there is strong divergence among user groups (von Döhren and Haase, 2015).

Schroter and colleagues (2014) give a broad defense of ES. Regarding biodiversity and ES, Schroter and colleagues (2014) recognize that both concepts are complex and not able to be captured by a single metric, however they argue there is overlap between the two concepts and maintain that writ large biodiversity underpins ES. This line of reasoning depends upon a strong and clear positive link between biodiversity and ES. In a review of the linkages using network analysis between biodiversity and ES, Harrison and colleagues (2014) demonstrated a highly complex and unclear relationship. That is, linkages could be positive, negative or unclear. A relationship between a given biodiversity attribute and an ES were classified as unclear if a threshold was found in which the direction of the relationship changed or there was conflicting evidence both within and between papers (Harrison et al., 2014). For example, Cammeraat and colleagues (2005) found the early successional vegetation increased erosion (an EDS) however 40 years later when a later successional community had been established this was reserved and it became an ES. In paper looking at pollination and species abundance and species richness; 14% and 10% respectively were classified as unclear due to indirect negative impacts of managed non-native honeybees competing with wild native species for floral resources (Harrison et al., 2014). Redford and Adams (2009) cautioned that ES need not be performed by native species and that maximization of a single ES may not lead to biodiversity conservation.

Schroter and colleagues (2014) and other supporters of ES maintain that ES is an important tool to facilitate decision making because it allows for trade-offs. This has been criticized by Silvertown (2015), who argues the win-win scenarios are rare, nature is more often than not, the loser. This assertion is supported by a meta-analysis of the ES literature conducted by Howe and colleagues (2014). This has troubling implications for the future of biodiversity conservation. In a review Hummel and colleagues (2019) found that the ES concept is becoming a central plank of protected area management. Graves and colleagues (2017) surveyed visitors to a state forest in USA to assess cultural ES values for different wildflower communities. They found the species richness had not influence aesthetic preference for images of wildflower communities (Graves et al., 2017). Importantly, they found there was no difference is preference based on participants' knowledge of local floral (Graves et al., 2017). This indicates that species richness and cultural ES are not linked, and local ecological knowledge does not increase valuation of biodiversity. In a recent study of China's nature reserves, Ma and colleagues (2019) found evidence of the conflict between economic development and biodiversity conservation. From 2007-2014 the total area of nature reserves in China shrank by 3% either from downsizing of the reserve or degazetting (Ma et al., 2019). Coastal areas along the Yellow Sea had the greatest loss, protected tidal decreased by 48.2% (Ma et al., 2019). The loss of reserve area was significantly related to local

economic development, the greater the increase in Gross Domestic Product (GDP), the greater the decrease in reserve area (Ma et al., 2019).

An equally important connection is the link between biodiversity, ES and human well-being. The relationship between biodiversity (including ecosystem function), ES and human well-being is poorly understood (Dallimer et al., 2012; Bennett et al., 2015). In a study in urban green spaces in England, self-reported well-being increased with increasing bird species richness, but no patterns were found with increasing butterfly richness (Dallimer et al., 2012). Increased plant species richness decreased self-reporting of well-being (Dallimer et al., 2012). Also, the public may underestimate the level of biodiversity compared to a trained specialist. For example, in an urban park in France Muratet and colleagues (2015) found that park visitors deviated negatively 61% from a trained botanist. If one takes a constructionist worldview of values- people interpret and make judgments based on experience, socialization and public discourse- values are not static (Balient et al., 2011, p. 33). To this point, little work has been done on temporal changes in demand for ES (Wolff et al., 2015). As discussed above, the relationship between biodiversity and human well-being may be mediated by concepts of self-identity and lived experiences.

As mentioned previously, the SEEA EA and the Dasgupta Review were published two years ago, the scholarship around these documents is still developing. SEEA EA makes two key contributions: 1) a standardized reference list of 25 ES plus one category, ecosystem and species appreciation and the 2) concept of exchange value (Edens et al., 2022). The concept of exchange value as the underlying valuation concept differs from the mainstream ES literature which uses economic welfare (Edens et al., 2022). In very simple terms, economic welfare relates well-being to economic prosperity. Gross Domestic Product (GDP), the market value of all the goods and services produced by a country within a given timeframe is typically used as a measure of economic welfare (Caparrós et al., 2021, p. 2). A typical example of economic welfare in the ES literature is Willingness to Pay (WTP). A popular method of estimating the monetary value of an ES is revealed preference (a type of WTP). Revealed preference is an indirect method that monetizes an ES based upon how much people pay to travel to or assess a site containing the service (Silvertown, 2015). The revealed preference method, specifically the travel cost method is a popular method to assess recreational services (Clawson & Knetsch, 2011). This method gives higher value to a person traveling to site by car rather than by bicycle or by foot (Silvertown, 2015). The travel cost method does not accurately assess the value of cultural “recreational services.” Recreation literature demonstrates that a primary barrier to frequent park visitation by an individual is poor proximity from home or work (Schipperijn et al., 2010; Akpinar, 2016; Boyd et al., 2018). Proximity to urban parks and other types of greenspace has been shown to be related

to income level. Wealthier neighborhoods show a “luxury effect”, they are greener, residents have greater access to greenspace compared to poorer neighborhoods (for a review ref. Misha et al., 2018). Therefore, wealthy individuals that can afford it and presumably willing to pay more (travel further distances by car) do not need to because they can easily access greenspace by foot. Conversely, poorer individuals whom may have a desire to pay (willingness to pay) for recreational services cannot do so because it is outside their budget.

Returning to SEE EA, the concept of exchange value links the economy, ES and economic decision-making (Caparrós et al., 2021, p. 4). By integrating the exchange value concept into the SEE EA, “This allows compilation of integrated monetary accounts that capture the flow of ecosystem services and stocks of ecosystem assets, including measures of income and wealth adjusted for ecosystem degradation” (Caparrós et al., 2021, p. 4). I think the key conceptual advance here is an attempt to directly link environmental degradation with economic decision-making. A discussion of environmental externalities is also present in the Dasgupta Review (Dasgupta, 2021, pp. 41–42). The core message of the Dasgupta Review is the economy is embedded in a living biosphere and there are real biophysical limits to economic growth (Groom and Turk, 2021). This message is not new but it is not yet part of mainstream economic thought and the main target audiences of this Dasgupta Review are mainstream economists and the financial sector (Groom and Turk, 2021). The Dasgupta Review expresses the components of nature biotic (biodiversity) and abiotic (i.e. soils) in terms of Natural Capital, Natural Capital via ES feeds into Produced Capital and Human Capital which in turn feed into the economy (Dasgupta, 2021, p. 17). In the Dasgupta Review, Produced Capital are goods, services and income and Human Capital are innovation are labour (Dasgupta, 2021, p. 23). The Dasgupta Review does directly acknowledge its purely anthropocentric stance. “The Review has developed the economics of biodiversity by viewing Nature in anthropocentric terms. That is an altogether narrow viewpoint, but it has a justification. … Nature should be protected and promoted even when valued solely for its uses to us, we would have even stronger reasons to protect and promote it if we were to acknowledge that it has intrinsic value (Dasgupta, 2021, p. 80). Spash and Hache (2022) give a scathing critique of the anthropocentric approach in the Dasgupta Review. Spash and Hache argue, “Dasgupta is proposing the optimal management of life on Earth in all its facets, an all encompassing approach, made possible by assuming the only thing that matters is maximizing social value measured as monetary wealth invested in a capital stock. The aim of life is to maximize rates of return on investments. Achieving social good requires that the wise ‘citizen investor’ choose the optimal portfolio of capital assets” (Spash and Hache, 2022, p. 657). This idea of the *wise citizen investor* has a parallel in the

conservation science discourse, that of the *wise gardener* or *planetary manager* (Johns, 2014).

Being a wise investor may prove difficult when you are picking wicked problems rather than stocks. Wicked problems are characterized by a high degree of scientific uncertainly (lack of information) and deep disagreement on values among stakeholders (Balient et al., 2011, p. 2). In the case of a wicked problem, a decision must be reached without knowing if all feasible options have been explored or tested (Balient et al., 2011, p. 2). Living organisms and whole ecosystems are characterized by uncertainty. Cushman (2010, p. 35) comments that given a complex, non-linear, non-stationary world, ecology is the “stitching together” of “particulate” (individual organisms' interaction with their particular environment) and contextual relationships across space and time. There can be uncertainty in their ecology or in their economic value or both and how management decisions will impact the former and the later.

As cautioned by Aldo Leopold in the 1940’s humanity in a role conqueror role is self-defeating because we cannot know all the uncertainties in managing nature (Leopold, 1968, p. 204). Mackey (2014, p. 129) makes an important distinction between our ability to disrupt and control, “The Anthropocene, while an empirical fact, does not mean that humans ‘run the show.’ Rather, it means only that we can be powerfully disruptive. This power to disrupt does not translate into a power to control the Earth system.” The idea that Planet Earth in the Anthropocene is a Garden Planet, humanity is the Gardner may be impossible at achieve. Nash (2014) sees wilderness as a moral resource for humanity. According to Nash (2014, p. 187) wilderness and other wild places are not owned, controlled or used by human, this “can open us to perceiving their intrinsic value.” As advocated by Deep Ecologists, this intrinsic valuation of nature allows us to pursue to move beyond human-centric social justice to pursuing ecological justice, justice at the whole ecosystem level (for a discussion of ecological justice see (Washington et al., 2018).

1.12.7 The Ethics of the Valuation of Nature

The field of ethics has a deep history, extending over two millennia and covers a wide range of topics (Aragbonfoh Abumere et al., 2019; Shafer-Landau, 2021), which space does not permit me to discuss here. Providing an ethical framework or the economic valuation of nature is, however, key to the research objectives of this dissertation. Meinard and colleagues (2016) have stated the importance of effective communication between conservation professionals and economists. Conservation biologists and practitioners need “make up their minds about the promises and limits of interaction with them” [economists] (Meinard et al., 2016, p. 67). Understanding the ethics behind the

economic valuation of nature is an important prerequisite for conservation professional wishing to develop interacting with economists (Meinard et al., 2016).

In this section I discuss two of the many sub-disciplines within the field of ethics: axiology (the discipline of valuation) and deontology (the discipline of duties and obligations). Traditional ethics has focused on the relations between humans; however, the field of environmental ethics has extended these relations to include non-human nature (ref. Callicott, 1984). Both axiology and deontology are crucial for environmental ethics. How and why humanity values nature impacts everything from scientific inquiry to public policy and law to interactions with nature in our daily lives. Mainstream ethical philosophy frames nature conservation in terms of humans' moral obligations to another humans (and future generations of humans) (Jax et al., 2013). Jax and colleagues (2013) use an example of a neighbor's garden. We have a direct moral obligation towards our neighbor but not their garden. The garden only has value because it is important to the neighbor. In axiological terms, beings that we have a direct moral obligation to are said to have inherent moral value (intrinsic value) whereas beings we have indirect moral obligation are said to have instrumental value (Jax et al., 2013).

1.12.8 Language and Values: Implications for Conservation

A key criticism of an intrinsic value relations between people and nature is that intrinsic value of nature as a concept is vague and therefore intrinsic values cannot be measured nor prioritized (Maguire and Justus, 2008; Justus et al., 2009) a process necessary in decision-making. I contend the vagueness in defining intrinsic values of nature is because we lack the language to define them (see also Campagna and Guevara, 2014, p. 60) (see also Campagna & Guevara, 2014, p. 60); see Callicott's (1984) Non-Anthropocentric Value Theory for an in depth discussion on the extension of mainstream ethics. Justus and colleagues (2009) argue that intrinsic values have no place in decision-making because they cannot be traded-off.

Supporters of an instrumental approach to nature conservation correctly argue there is often a conflation of monetary/economic methods (i.e. ES) and other instrumental values (aesthetic, cultural, educational) (Justus et al., 2009). Let me return to the point about language for intrinsic valuation. Campagna and Guevara state, "...when it comes to expressing it explicitly, the common terms and concepts available are inadequate, or at best proxies—or worse, the language of the 'enemy,' inasmuch as what is commonly available to us is a language and philosophy of value that has been honed for centuries in an effort to clarify the value of humanity" (2014, p. 60). The concept of Ecosystem Services has been promoted as a communication tool to engage the general public with biodiversity conservation. The Secretariat of the Convention on Biological Diversity

(CBD) “...telling stories that link biodiversity to the things that matter to people” (Secretariat of the Convention on Biological Diversity (CBD), 2014). Before proceeding with a discussion of ES as a communication tool, it is important to note that there has been little research into biodiversity messaging and why these messaging campaigns fail (Bekessy et al., 2018). The term biodiversity is a technical word and therefore the general public may have difficulty engaging with it. In a study of the residents of Zurich, Switzerland, 60% of participants has never heard the term biodiversity (Lindemann-Matthies and Bose, 2008). The less technical term of Nature maybe easier for people to engage with (Kusmanoff et al., 2017; Bekessy et al., 2018). The term “ecosystem services” is now widespread in the conservation discourse (Kusmanoff et al., 2017). See Kusmanoff and colleagues (2017) for a discussion of framing and discourse and Chapter 3. In a study of media coverage comparing climate change and biodiversity, Legagneux and colleagues (2018) examined English language press releases and scientific literature from the United States of America, Canada and the United Kingdom between 1991- 2016. They found that currently biodiversity coverage in the media is covered eight times less than climate change (Legagneux et al., 2018). Until 2002 climate change and biodiversity received similar coverage by the media, however after 2002 media coverage shifted towards climate change and away from biodiversity (Legagneux et al., 2018). Legagneux and colleagues (2018) argue that biodiversity conservation messaging is not reaching the general public and improved communication strategies are needed.

Biodiversity is not only disappearing from the mass media and scientific literature; it is also disappearing from government policy documents. Admiraal and colleagues (2016) conducted an analysis of word use in two European Union (EU) research programs. They examined the word use of biodiversity conservation and ecosystem services from 2007-2014, they found the total number of references to biodiversity decreased by a quarter and the use of ecosystem services increased 1.5 times (Admiraal et al., 2016). Moreover, during the same time frame word use of goals related to conservation and sustainability halved (Admiraal et al., 2016). By 2012 ecosystem services has been the dominate expression of the value of biodiversity in these prominent EU research programs (Admiraal et al., 2016). Kusmanoff and colleagues (2017) examined media releases from the Government of Australia and an Australian Non-Governmental Organization, Australian Conservation Foundation (ACF) from 2003-2014. Over this time period the use of biodiversity decreased whereas the use of economic language (ecosystem services) increased in both the Australian Government and Australian NGO documents (Kusmanoff et al., 2017). After 2006, economic language becomes dominant in Australian Government documents whereas in the NGO documents, economic language was always more prevalent (Kusmanoff et al., 2017). Shifts away from conservation framing to towards economic framing could have real negative

consequences for biodiversity conservation efforts. Economic incentives have been shown to undermine intrinsic motivations for nature conservation (Chervier et al., 2019). Chervier and colleagues (2019) found evidence of motivation crowding-out (undermining intrinsic valuation) when payments for biodiversity conservation stop. They conducted household surveys in the Cardamons Mountains region of Cambodia. They found that if individuals perceive forest conservation in monetary terms, after payments stop, there was an increase in the probability of creating new fields by 12% and the probability of illegal trade in forest products (illegal logging or wildlife poaching) increased by 16%. Chevier and colleagues (2019) have shown the way forest values are perceived can directly mediate conservation behaviors.

1.12.9 An Ecocentric Approach to Conservation Science and Practice

I agree with Piccolo and colleagues (2018) call to conservation scientists to reaffirm their commitment to the intrinsic value of nature. Ecocentric conservation encompasses both intrinsic and instrumental values (Piccolo, 2017). Nature is protected not only because of the benefits it provides us but also because it is the morally right thing to do. Kopnina and colleagues (2018, p. 144) argue that the concept of ecocentrism ensures plurality and democracy; "...if the plants, animals, other life-forms, ecosystems and geodiversity had a voice, theirs would be the voice of the majority." Ecocentrism can be applied to social justice to extend the principle that all community should have a voice; this is known as ecological justice or ecojustice (Kopnina et al., 2018; Washington et al., 2018). Ecojustice would extend legal recognition and protection to non-human community members (Washington et al., 2018). Of course, non-human Nature does not have a voice, so a human representative would be appointed to safeguard their interests (for a full discussion of ecojustice see Washington et al., 2018). The concept is not totally alien, humans that cannot represent themselves (ex. Infants or highly incapacitated persons) require an external advocate.

How can an ecocentric approach to conservation work in practice when conservation practitioners operate with limited budgets and resources? Vucetich and colleagues (2017) give an analogy with social justice. Both conservation and social justice are complex issues that are not universally supported and not full realized (Vucetich et al., 2017). They lay out a scenario in which there are two social justice agents; neither has enough resources to achieve complete social justice. One agent decides to support programs addressing starvation, the other decides to support programs that address human trafficking. They contend there is no rationale to discourage either agent because one cause is just as justified as the another (Vucetich et al., 2017). Why-because both causes have moral worth. If all of nature has moral worth, efforts to

protect non-charismatic species or ecosystems (biodiversity “cold spots” or low productive systems) would not be criticized nor considered as waste of resources.

1.13 Conclusion

Humanity’s relationship with nature is multifaceted and complex. Millenia ago nature was something to be feared and tamed. Ideas of wanting to control nature for the benefit of humanity are still very much present today, for example the idea of the wise gardener. Instrumental values exemplified by economic valuation of biodiversity are popular because concepts such as ES may be quantified. Quantifiable concepts may be more easily communicated. Equally important are intrinsic and relational values of nature. There is a lack of language to express intrinsic values making them more difficult to quantify. Relational values may be very localized and context-specific, making them difficult to generalize for policymakers. All three values should be considered by conservation science. The enhancement of environmental knowledge and awareness among diverse publics will benefit biodiversity conservation. Tapping into multiple pathways of human-nature relationships supports the bridging of the science-policy-practice gap and will ultimately benefit both society and nature.

1.14 References

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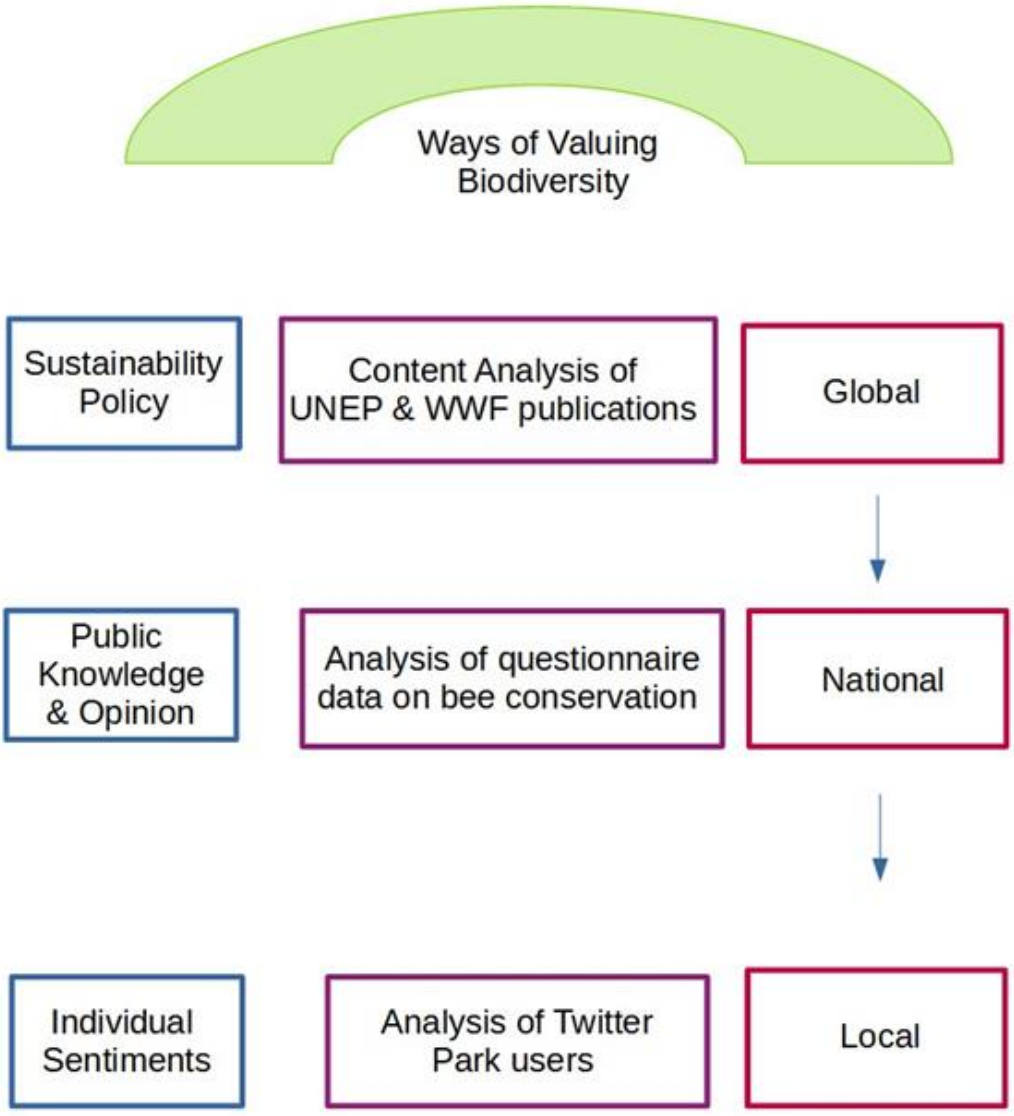

Figure 1.1:Graphical abstract of dissertation proposal. The overall uniting concept is understanding ways for valuing biodiversity (symbolized by a green arc). Peoples' ways of valuing biodiversity will be analyzed at three scales (symbolized by the red boxes): sustainability policy (global), public knowledge and opinions (national) and individual sentiments (local) [blue boxes]. Research that corresponds to each scale is indicated in purple boxes.

2 Chapter 2: Examining the public's awareness of bee (Hymenoptera: Apoidae: Anthrophila) conservation in Canada

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2.1 Abstract

Understanding the general public's knowledge and perceptions of an issue can help drive action on the part of decision-makers. Such understanding is critical when decision-makers are faced with multiple stakeholders, which is the case with biodiversity conservation issues. We surveyed the Canadian general public using a telephone questionnaire to assess the level of knowledge and perceptions of native wild bee (Hymenoptera: Apoidea: Anthophila) health and conservation. We found that the general level of bee knowledge among participants was low. Half of participants named the non-native managed European honeybee (*Apis mellifera* Linnaeus 1758) as a wild bee, native to Canada. Over two-thirds of participants stated the provisioning of ecosystem services (ES) is the most important reason to conserve bees. Half of participants thought the Canadian federal and provincial government should be principally responsible for bee conservation. One-third of participants perceived no personal barriers to bee conservation and nearly one-quarter stated they did not know how to help bee conservation efforts. Our results highlight that scientific researchers can play an important role in outreach and education and environmental non-governmental organizations (ENGOs) can take an active lobbying role at the provincial and federal levels with respect to bee conservation.

Keywords: Bee, Canadian Public, Conservation, Conservation Policy, Perceptions, Pollinators, Multinomial Logistic Regression; Questionnaire

2.2 Introduction

Pollinators, such as bees, flies, beetles, butterflies, and other animals are well known for their role in the reproduction of over 80% of all flowering plants (Ollerton et al. 2011) and 5-8% of global agricultural crops would be lost without pollination (Potts et al. 2016). In recent years, pollinator decline has become a subject of intense public support and policy development (Neumann & Carreck 2010; Ontario Ministry of Agriculture Food

and Rural Affairs 2016; Colla & MacIvor 2017; Underwood et al. 2017; Hall & Steiner 2019). Research has supported that many wild pollinator species and the pollination services they provide are in decline globally due to threats including pesticides, habitat loss or fragmentation, pathogens, competition with non-native and/or managed species and climate change (Biesmeijer et al. 2006; Potts et al. 2010; Cameron et al. 2011; Burkle et al. 2013; Kerr et al. 2015; Koh et al. 2016; Powney et al. 2019; Cameron & Sadd 2020).

However, this is not the case of all pollinator species. In fact, many of the studies that show pollinator declines also show that some species remain common and are even increasing in relative abundance (e.g. for bumble bees Colla & Packer 2008; Grixti et al. 2009; Colla et al. 2012; Mathiasson & Rehan 2019; Richardson et al. 2019; Cameron & Sadd 2020). In addition, often bee decline messaging in North America refers to the managed non-native honeybee (*Apis mellifera* Linnaeus 1758), though this species is not assessed to be in decline or at-risk of extinction (Aizen & Harder 2009; Ollerton et al. 2011; Garibaldi et al. 2013; Colla & MacIvor 2017; Geldmann & González-Varo 2018). Given the public interest and subsequent resource availability to conserve pollinators, it is important to understand to what extent the public understands the situation. Misinformation on the topic has and could continue to lead to policies and management plans which do not conserve declining species (Kleijn et al. 2015; Senapathi et al. 2015; Colla & MacIvor 2017; Cardoso & Gonçalves 2018; Geldmann & González-Varo 2018; Alaux et al. 2019). When programs are not effective, there can also be an erosion of trust between the public and scientists, policy makers and environmental non-governmental organizations (ENGOs) (Horton et al. 2016; Loss & Marra 2018).

There are at least 855 species of bees known to be in Canada, with potentially another 110-135 currently undescribed species (Sheffield et al. 2017; Bennett et al. 2019). They occur in six families including the Andrenidae (mining bees), Apidae (honeybees, bumble bees), Colletidae (plasterer bees), Halictidae (sweat bees), Megachilidae (leaf cutter bees), and Melittidae (melittid bees) (Sheffield et al. 2017; Bennett et al. 2019). Bees can be found in all of Canada's terrestrial ecozones, except for the northern parts of the Arctic (Bennett et al. 2019). Species distribution varies across the country with over 400 species in both British Columbia and Ontario and more than 300 in Alberta, while the three territories (Nunavut, Northwest Territories and Yukon Territory) and Newfoundland and Labrador all have less than 100 known species each (Sheffield et al. 2017). The conservation status of many species are unknown, but eight species or subspecies (one species has two at-risk sub-species) are considered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be at-risk of extinction: three are considered Endangered, two are Threatened, and three are Special Concern (Committee on the Status of Endangered Wildlife in Canada 2020). The International

Union for the Conservation of Nature and Natural Resources (IUCN) Red List ranks approximately 20% of native bumblebees as at-risk of extinction (International Union for the Conservation of Nature and Natural Resources 2020).

Relative to its land mass (10 million km^2), Canada has a small population of 37.6 million people (Statistics Canada 2019). Canada's population is highly urbanized: over 70% of Canadians live in urban areas (Statistics Canada 2019). The majority of the population live within 100 km of the southern border with the United States of America and within four provinces: Ontario (38.8%), Quebec (22.6%), British Columbia (13.5%) and Alberta (11.6%) (Statistics Canada 2019).

Canada has a multiparty democracy consisting of five mainstream political parties: 1) the Progressive Conservative Party (PC), 2) the Liberal Party (LP), 3) the New Democratic Party (NDP), 4) the Bloc Québécois (PQ) and 5) the Green Party (GP). The Conservative party is considered politically to be right-of-centre, while the Liberal party is politically left-of-centre and the New Democrats are on the left (Walks 2004; Cochrane 2010). The ultimate goal of the Bloc Québécois is independence for the province of Quebec (Walks 2004): it can be considered centrist. Camcastle (2007) describes the Canadian Green party as a centrist party compared to Green parties in Europe and Australia that are on the political left. Canadian Greens do share the same ideology of environmentalism and ecologism (non-human beings have intrinsic value) as their Australian and European counterparts (Camcastle 2007). Compared to other democracies, Canadian politics are largely centrist, but within the Canadian political spectrum there exists distinct right/left ideologies (Cochrane 2010).

Insect conservation does not happen in a vacuum: not only do researchers need to know information about species biology and abundance to make any conclusions, the general public, policymakers, and stakeholders need to be aware of their intrinsic and extrinsic value (e.g. relating to ecological services) and the threats they face (Cardoso & Gonçalves 2018; Hall & Martins 2020). The aims of this study were to assess Canadians' 1) understanding of general bee knowledge, 2) level of concern for bee health, 3) perceptions of threats to bees, 4) attribution of responsibility for bee protection/conservation and 5) perceptions of personal barriers to bee conservation.

2.3 Materials and Methods

We analyzed telephone survey data of Canadian residents, aged 18 years or older, that was conducted by the market research company Oraclepoll Research Ltd. This survey was commissioned by the environmental non-governmental organization, Friends of the Earth (Canada). It was designed by Beatrice Olivastri and Dr. Paul Seccaspina of Oraclepoll with substantial input from VM, SC and others. The survey was designed to investigate the public's perceptions of bees, threats to bee health and overall knowledge

of bees. Survey questions analyzed are given in Table 2.1. Anonymized and aggregated information were provided to the authors by Oraclepoll.

2.3.1 Survey Logistics & Study Sample

All surveys were administered using live operators. The survey was conducted using computer-assisted techniques interviewing (CATI) and random phone number selection. The database used was developed by Oraclepoll, included land-line and mobile phone numbers, and was inclusive of new numbers and private numbers. Interviews were conducted from May 14-24, 2017. Initial calls were made between the hours of 17:00 and 21:00 within each national time zone. Subsequent call backs of no-answers and busy numbers were made on a staggered, daily, rotating basis up to 5 times, during the hours of 10:00 to 21:00, until contact was made. In addition, telephone interview appointments were attempted with those respondents unable to complete the survey at the time of contact.

A total of n=2,000 surveys were conducted. For question 2 a total of n=31 observations were missing, representing 1.6% of the data; these respondents were completely removed from analyses related to this question. The total sample used for statistical modelling of question 2 was n=1969. The population surveyed was similar to that of Canadian population for each of the predictor variables (Table A.1).

2.3.2 Statistical Analysis

We conducted all statistical analyses using R v. 3.6.3 software (R Core Team 2020). The Cumulative (Ordinal) Logit Models (CLMs) were built using the “ordinal” package (Christensen 2019). The multinomial logistic regression models were built using the “nnet” package (Venables & Ripley 2002, 2016) and the “stargazer” package (Hlavac 2018). Plots were made using the “ggplot2” and the “likert” packages (Bryer & Speerschneider 2016; Wickham 2016).

Question 1 was an open-ended question and therefore not suitable to further modelling. Descriptive statistics are presented (Table A.2) using the complete (n=2000) sample.

All six demographic variables (Area, Age, Gender, Income, Vote and Rural/Urban) were tested for intercorrelation using Pearson's r test. Pearson’s correlation coefficient (r) is a common diagnostic for collinearity; a threshold of r>0.7 indicates high collinearity (Dormann et al, 2013). All demographic variables were weakly correlated. The strongest correlation was between area (the province where the respondents' lived) and federal voting intent (r=0.10).

For question 2 we tested for a significant difference in level of concern of bee health among the six demographic variables. We used CLMs with level of concern as the response and demographic variables as the predictors (Table A.3). Significance of the predictors were tested using marginal fitting of terms based on a X^2 test. We did not include interactions because there was no *a priori* expectation of interactions among the demographic variables.

Item lists were consolidated for questions 3, 5 and 6 to allow for statistical analysis (Tables A.4-A.6). For questions 3, 5-11, responses were tested for significant differences using multinomial models that included all six demographic variables (Tables A.7-A.14).

For question 3 responses were coded by Oraclepoll into six categories: “Pollination”, “Honey”, “Endangered”, “Nature”, “Don't Care”, and “Don't Know.” We further consolidated this by grouping “Pollination” and “Honey” into Ecosystem Services (“ES”), while “Endangered” and “Nature” were grouped into pro-nature (“Eco”). “Don't Care” was renamed as “Indifferent” while “Don't Know” remained the same (Table A.4).

For question 4 we tested for a significant difference in perceived threats to bees among all demographic variables using binary logistic regression models (Table A.15).

In Question 5 respondents could only choose one answer from a nine-item list (Table S5). We consolidated this list into five categories: Agriculture, Government, Own (responsibility), Pesticide Manufacturers and Don't Know (Table A.5).

Question 6 was an open-ended follow-up to Question 5. Oraclepoll consolidated the responses down to nine items, and we further consolidated this to five categories: No Barriers, Don't Know How to Help, Dislike/Fear Bees, Not a Priority and Lack of Resources (Table A.6).

2.4 Results

The general level of bee awareness among participants was poor, for example 11.8% of respondents could not name a single wild native bee species and 51.4% named the non-native European honeybee (*Apis mellifera* L.) as a native wild bee (Table A.2). While 29.4% named bumble bees, which is correct, 3% listed yellow jackets and 0.4% wasps, which are not. Moreover a few respondents gave non-species as answers, 1.9% and 2% of respondents named “drone bee” and “queen bee” respectively as wild native bee species (Table A.2). Neither of these are a species of any kind (rather a descriptor related to caste), indicating some lack of understanding of the concept of a species. Only 1 respondent (out of 2000) named a solitary bee, “mason bee” as a native wild

species (Table A.2). Solitary bees comprise the majority of bee species in Canada (Bees Of Canada, 2020).

Two-thirds of respondents did not know if the honeybee can replace wild bees as crop pollinators (Figure 2.1). Nearly a quarter of participants agreed with the statement that all bees can sting (Figure 2.1) even though this is incorrect (Packer 2010). Forty-two percent of participants thought all bee species were endangered (Figure 2.1). The top two ranked perceived threats to bees, as determined by 89% and 79% of participants respectively, were pesticide use and loss of floral resources (Figure 2.2). However, predictors for these items were non-significant (Table A.15). Green Party and New Democratic Party voters were more likely to perceive factors such as climate change, disease, modern intensive agriculture and habitat loss as threats to bees than Conservative voters (Table A.15). Urbanites were more likely to perceive modern intensive agriculture as a threat to bees compared to rural dwellers (Table A.15).

Federal voting intent, age and area (province) were found to significantly influence the level of bee health concern (Table A.3). Respondents who identified themselves as Green Party voters were 3.78 times more likely to express the highest level of concern of bee health ("Very Concerned") compared with voters who identified themselves as Progressive Conservative voters ($p<0.001$) (Table A.3). Residents of British Columbia and Quebec were 1.63 times and 1.47 times more likely to express the highest level of bee concern respectively compared to residents of Alberta ($p<0.01$) (Table A.3).

Over two-thirds (68.3%) of participants stated the provision of ecosystem services was the most important reason to protect bees while under a quarter (24.2%) stated it was because of a pro-nature orientation (Ecological) (Figure 2.3). Half (50.1%) of participants thought that the Federal and Provincial Government should take the most responsibility for wild bee protection (Figure A.1). Different demographics held different entities responsible for the protection of bees. Voters for the New Democratic Party (NDP) were 1.6 times ($p<0.05$) more likely than Progressive Conservative (PC) voters to attribute responsibility for bee protection to the Government (Figure 2.4 & Table A.8) category. Participants from the Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island) and British Columbia were 1.8 times and 1.7 times ($p<0.05$), respectively, more likely to attribute responsibility for bee protection to the Government compared to respondents from Alberta. Respondents from Manitoba and Saskatchewan were 2.6 times ($p<0.05$) more likely to attribute responsibility for bee protection to the agriculture sector and 2.4 times ($p<0.05$) more likely to attribute responsibility for bee protection to the 'Own' category (Figure 2.4 & Table A.8) compared to voters from Alberta. Elderly people (71 years old and older) were 2.3 times ($p<0.05$) more likely to

not know whom to assign responsibility for the protection of bees compared to young people (18-35 years old).

One-third of participants perceived no personal barriers to bee conservation (Figure A.2). Nearly one-quarter (23.9%) did not know how they could personally help bee conservation and 19.4% stated bee conservation was not a personal priority (Figure A.2). Urbanites were 2.76 times ($p<0.001$) more likely to state lack of resources (Figure 2.5 & Table A.9) as a barrier to bee conservation compared to rural dwellers. Urbanites were also 1.66 times ($p<0.05$) more likely to state fear or dislike of bees as a barrier compared to rural dwellers. Left-wing voters were less likely to state “Not a Priority” as a perceived personal barrier to bee conservation compared to conservative voters (Table A.9). People living in Quebec, Ontario, Manitoba, Saskatchewan and British Columbia were less likely to state “Not a Priority” as a barrier to bee conservation compared to people living in Alberta (Table A.9). Therefore, conservative voters and residents of Alberta were more likely to perceive bee conservation as not being a personal priority.

2.5 Discussion

We found that Canadians had a poor overall knowledge of native wild bees, although the majority thought bees should be protected, particularly for their ecosystem services (ES) provision. Our results are similar to Wilson et al. (2017) who found that although actual knowledge was low, there was widespread general interest in bee conservation among the public in the United States of America. They also found that survey participants greatly underestimated species richness and misidentified non-bees as bees in test photos (Wilson et al. 2017). In a survey of Louisiana, USA beekeepers and the general public, Penn and colleagues (2019) found that beekeepers were more likely to know European honeybees were non-native to North America than the general public. Interestingly, both beekeepers and the public tended to agree with the statement that European honeybee were more similar to wildlife than to livestock (Penn et al. 2019). While not related to pollinators specifically, a recent poll of Canadians (McCune et al. 2017) found that 89% of respondents also believed general species conservation was important, although that support dropped slightly depending on the potential economic impacts and limiting of individual property rights that would be involved. This clearly shows there is strong public support for further conservation work for all at-risk species, including pollinators.

In Canada over half of all land is publicly owned (Huque & Watton 2010). In relation to environmental policy, Canada has one of the most decentralized frameworks for implementation in the world (Huque & Watton 2010). Under Section 92A(1) of the Canadian Constitution, provincial legislatures have exclusive powers to create laws in

relation to "(*a*) exploration for non-renewable natural resources in the province; (*b*) development, conservation and management of non-renewable natural resources and forestry resources in the province, including laws in relation to the rate of primary production therefrom" (Constitution Acts, 1867 to 1982, 1982). However, the Canadian Constitution does not assign specific responsibility for the environment and judication is shared between the federal and provincial governments (Office of the Auditor General of Ontario 2019 p. 14). In addition, municipalities come under provincial legislative authority and have no separate constitutional powers, the provinces may delegate powers to them some environmental stewardship may be addressed at a local level (Office of the Auditor General of Ontario 2019 p. 14). On environmental policy, the federal government takes a supportive role, such as with the coordination of standards and establishing broad guidelines (Huque & Watton 2010). There is currently little legislation in Canada to support pollinators (Tang et al. 2007); this is but one area that could be addressed. The majority of our respondents thought the federal and provincial governments should take the lead in protecting native wild bee populations in Canada. This was also seen by McCune et al. (2017) who found that 70% of Canadian respondents believed federal or provincial governments were primarily responsible for species conservation.

The Canadian provinces are slow to implement environmental policies because they do not wish to alienate extractive industries (Huque & Watton 2010) from which they receive royalties. In Alberta the oil industry dominates the landscape and provincial governments stay in power for long periods of time (Timoney & Lee 2001). The Progressive Conservatives were the governing party in Alberta for 44 years (1971-2015) consecutively (Legislative Assembly of Alberta 2020). Timoney and Lee (2001) are critical of Alberta's "stable" governance that prioritizes the interests of multinational corporations over biodiversity conservation. Other provinces also lag when it comes to implementing biodiversity measures despite calls from multiple organizations to do so, such as with the Ontario government not having a robust plan, and with its multiple ministries being unaware of their responsibilities or having confusion over who is responsible for acting (Environmental Commissioner of Ontario 2012).

Environmental organizations should bring the shown desire for governments to take action to the attention of relevant politicians and government employees as part of a push for increased action for bee conservation, including policy and funding. They also need to continue educating these decision makers, as well as other influential groups including the media, about the issues and steps that need to be taken to ensure success (Bickford et al. 2012).

We found that two-thirds of participants value bees for what they provide for people. It is hard to quantify the services bees provide, and limited information exists for Canadian systems, but values are likely in the $4-5.5 billion/year range for Canadian crops for European honeybees alone (Mukezangano & Page 2017). Indeed, for the Credit River watershed in Ontario, Canada, the valuation of pollination services was found to be $5/household/year or $4 million/year (Kennedy & Wilson 2009), while the Greenbelt area of Ontario had the value of wild pollination services (excluding European honeybees) estimated to be $48 million/year. Globally, the value has been estimated at €153 billion/year for crop pollination by insects (Vaissière et al. 2008). These values are high and give the added economic incentive for conservation to occur even without the consideration of the values to natural systems.

At-risk insects tend to receive less funding than other at-risk species: Cardoso and Gonçalves (2018) found European arthropods received 1000 times less funding than mammals. Current funding for all types of endangered species in Canada is about $2/person, although there is a willingness to pay a median of $5/person (McCune et al. 2017). In the UK, the mean willingness to pay for bee protection policy was found to be approximately £43 per household per year (Mwebaze et al. 2018). The valuation of wild bees, both perception by the public and calculated ecosystem service values, should be investigated further.

Pesticides and loss of floral resources were ranked highly as threats to bees by most participants, with all demographic predictors being non-significant: this suggests that these threats are perceived equally by all respondents. In the case of pesticides in particular, this may be because it has been a highly publicized threat, receiving media coverage through efforts by environmental organizations and governments to limit the use of specific types of agrochemicals like neonicotinoid pesticides (e.g. Ontario Ministry of Agriculture Food and Rural Affairs 2016; Health Canada 2016). However, published scientific literature on the decline of wild, native Canadian bees includes pathogen spillover from managed bees and climate change as the top threats (Colla et al. 2012; Szabo et al. 2012; Kerr et al. 2015; Colla 2016). Indeed, public awareness and government policies have increased thanks to these types of discussions (Colla 2016; Colla & MacIvor 2017; Underwood et al. 2017; Hall & Steiner 2019).

Nearly one-fifth of participants stated bee conservation was not a personal priority, which is likely because they want their governments to assume a leading role in native wild bee conservation; indeed, the participants that stated responsibility for bee conservation should be at the individual level were more likely to state bee conservation was a personal priority. Residents of Manitoba and Saskatchewan were more likely to attribute personal responsibly for bee protection and that bee conservation was a

personal priority; these provinces could be specifically targeted with resources providing ways individuals can help. In an online survey of residents of Connecticut, USA, the major barriers to purchasing pollinator-friendly plants were lack of labelling (cited by 34% of participants) and high cost of plants (cited by 28% of participants) (Campbell et al. 2017). Retailers can facilitate the purchase of pollinator-friendly plants by providing their customers with trusted information sources in their marketing/messaging (Campbell et al. 2017).

For most participants in our survey, the European honeybee is *the bee* species, which helps to confirm that misinformation about native pollinators is widespread in Canada. It is not surprising that the honeybee is foremost is people's mind given its prominence in Western mass media. In a one year study of media coverage of pollinators in the United Kingdom, Ollerton et al. (2012) found the European honeybee comprised 40% of articles compared to bumblebees that had only 10% of coverage. In a study of Australian pollinator media coverage (2006-2015) the European honeybee comprised 50% of all coverage, whereas native bees received 15% of all coverage (Smith & Saunders 2016). Indeed, the extensive publicity around Colony Collapse Disorder of managed honeybee hives (Neumann & Carreck 2010) served to fuel intense scientific research and to promote increased public awareness of threats to bee health.When misinformation is spread that implies that honeybees are a native pollinator that need saving, federal and provincial policies are adopted that focus on helping this species, which can be to the detriment (directly or indirectly) to native bees (Colla & MacIvor 2017, Geldmann & González-Varo 2018). Additionally, private companies and even non-governmental organizations are routinely using honeybees to drive their campaigns and to increase their profits under the guise of "#savethebees" (Colla and MacIvor 2017, Geldmann & González-Varo 2018) (see also https://www.bee-washing.com/, run by University of Toronto PhD Candidate Charlotte De Kezyer).

While one-third of participants perceived no personal barriers to assisting in bee conservation efforts, nearly a quarter of participants stated they did not know how to personally help. This group represents an opportunity for education and outreach: indeed, communicating (marketing) the plight of pollinators and providing the public with relevant information can help conservation efforts (Bickford et al. 2012; Cardoso & Gonçalves 2018). Avenues include traditional media, but also other platforms such as social media, websites, blogs, documentaries, movies, science magazines, photography exhibitions, music and arts broadly, faith groups, and more (Bubela et al. 2009; Nisbet & Scheufele 2009; Bickford et al. 2012; Cardoso & Gonçalves 2018).

Although urbanites were more likely to state a fear or dislike of bees as a barrier to bee conservation as compared to rural dwellers, this did not rank among the top 3 perceived

personal barriers (Fig 2.5). This may be surprising as typically the general public views invertebrates, particularly arthropods, with fear and disgust (Kellert 1993). However, Sieg and colleagues (2018) found that although general knowledge of bumblebees amongst German secondary students was relatively low, their attitudes were generally positive. O'Hara (2012) found that both the majority of residents of a neighbourhood in Guelph, Ontario and participants in gardening and pollinator-themed organizations in that same city felt that there were no (63% and 61%) or only slight (37% for both) threats from bees, and that bees were extremely (83% and 77%) or very important (10% and 17%) to humans, respectively.

The fear of bees may be mitigated using their perceived value as pollinators (Cho & Lee 2018). O'Hara (2012) notes that the word "bee" causes fear in some people and could be alleviated by using the word pollinator. Although the value of pollination services is a common message in pollinator protection, it is unemotional: a greater impact may be made by establishing an emotional connection with the public, such as by referring to pollinators as "creative connecters, emblematic of the interconnected and interdependent nature of ecosystems", and building on pre-existing social and cultural values (Christmas et al. 2018).

In general, the demographic variable with the strongest predictive power was stated federal voting intent. Voters align with political parties on a collection of issues and importantly the symbolic values those issues represent. We found that the Green and NDP party supporters had the most support by those passionate about pollinators, but neither 2019 federal election platforms addressed pollinator conservation in any detail (Thompson 2019). Interestingly, there was no difference among Green party voters between valuing bee protection for ecosystem services (extrinsic motivation) and ecological (intrinsic motivation) categories (Table A.7). Given Green party supporters hold values of ecologism (Camcastle 2007), one would expect Greens to state ecological values as the reason for bee conservation.

National NDP and Green parties could incorporate pollinator protection policy into their platforms that can serve as guidance for their provincial counterparts. We strongly encourage elected officials, policy makers, and public servants to work to better reflect public interest in this area, which developing evidence-based policy to protect these small insects.

2.6 Limitations of the Study

Our sample of respondents does not completely match the demographics of the Canadian population according to the 2016 Census (Table A.1). The variables of Age and Income have slightly different classes in our survey compared to the 2016 Census,

making direct comparison difficult. Younger people had higher representation is our survey compared to their proportion of the general population (Table S1). Lower income earners (households making under $50,000 CND per year) were underrepresented whereas middle income earners (households making $50,000-$74,999 CND per year) were overrepresented in our survey (Table A.1). Moreover, Statistics Canada does not collect information on federal voting intent. We choose to use 2019 federal election results as a proxy for comparison. At the 2019 federal election, voting turnout was 65.95% (CBC News 2019) indicating nearly one-third of eligible voters in Canada did not vote. For example, it appears Conservative party voters are underrepresented in our sample (Table A.1). However, the proportion of Conservation party voters in the 2019 federal elections results may be because more Conservative voters turned out to cast their ballots. The survey was also only conducted in English; although this is the most common language spoken in Canada, French is a second official language.

2.7 Conclusion

Conservation of wild native bees in Canada has broad public support. Although engaged with this issue, we found Canadians have limited general knowledge. An understanding of types of wild bees, what constituted wild native species vs. domestic non-native species, general ecology (fact awareness) and general classification knowledge (what a species is) was lacking. Green party voters expressed the highest level of concern for bee health yet were not more likely to express ecological (intrinsic) reasoning for bee conservation. A follow-up study could explore more explicitly the connection between political affiliation and salient motivations for bee conservation. We found broad consensus that pesticides and loss of floral resources were perceived as threats to bees. Scientists could play a role in science communication related to wild native bee fauna and the threats they face, such as climate change and pathogen spillover for non-native bees.

The majority of respondents want a top-down (government lead) approach to bee conservation. In Canada, the majority of the land is publicly owned and authority for environmental policy is delegated to the provinces. Policymakers at the provincial level could craft policies to suit their subnational context and the federal government could play an active supporting role providing standardized guidance at the national level. Respondents from Manitoba and Saskatchewan were more likely to attribute bee protection to the individual than the provinces. Provincial policymakers could design programs to enable individual stakeholder participation in bee protection and conservation. Nearly one-quarter of respondents identified not knowing how to help as a perceived personal barrier to bee conservation. This indicates a need for science

communication and targeted programs emphasizing actions individual can take to promote bee conservation, i.e. planting pollinator friendly garden plants.

Researchers and environmental non-governmental organizations can play a role in communication and education among the public and policymaker's understandings of the evidence and solutions around pollinator decline and conservation. We found Canadians want governments to take the lead in bee conservation: members of the public and those working in the conservation field can bring this to the attention of policy makers as a call to action.

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Table 2.1: Questions posed to Canadian telephone respondents in May 2017, and the reason for the question.

Question	Testing
Q1. Thinking of the many species of wild bees that are native to Canada, how many can you name?	An open-ended question to assess bee species recall ability. Multiple responses were accepted.
Q2. How concerned are you about the health of honeybees and the conservation of wild, native bees in Canada? Please use a scale from one not at all concerned to five very concerned.	Assesses the level of respondents' concern for bee health using a five-point scale
Q3. Why (if at all) is it important that bees are protected?	An open-ended follow-up to Q2. One response was allowed. Assesses why it was important to conserve bees.
One sentence descriptive preamble to question 4. Wild, native bees reflect the overall health of an ecosystem and, if they are in distress, so is the entire system. Q4. Which of the following do you think are the most important threats to wild, native bees in Canada?	Assesses respondents' perceptions of threats to bees. A list of six possible threats to bees was read and respondents were asked if each item posed a threat to bees. Item List: Habitat Loss, Loss of Floral Resources, Modern Intensive Agriculture, Pesticides, Climate Change and Disease.
Q5. Which of the following do you feel should MOST take responsibility for the protection of wild native bees and their populations in Canada?	Respondents were read a list of nine items and only one response was accepted. Assesses which entity has perceived most responsibility for bee protection. Item List: Agricultural Industry, Beekeepers, Commercial Operators, Federal/Provincial Government, Local Government, Homeowners, Landowners, Pesticide Manufactures and Don't Know.

Q6. What if anything is preventing you from doing more to help save bees?	An open-ended follow-up to Q5. Assesses respondents' perceived personal barriers to bee conservation.
Q7. Honeybees can replace wild, native bees in pollinating crops and wild flowers.	An agreement statement on bee fact awareness
Q8. I think of wasps and bees as being the same.	An agreement statement on bee fact awareness
Q9. All bees nest in hives and make honey.	An agreement statement on bee fact awareness
Q10. All bees are endangered.	An agreement statement on bee fact awareness
Q11. All bees can sting.	An agreement statement on bee fact awareness

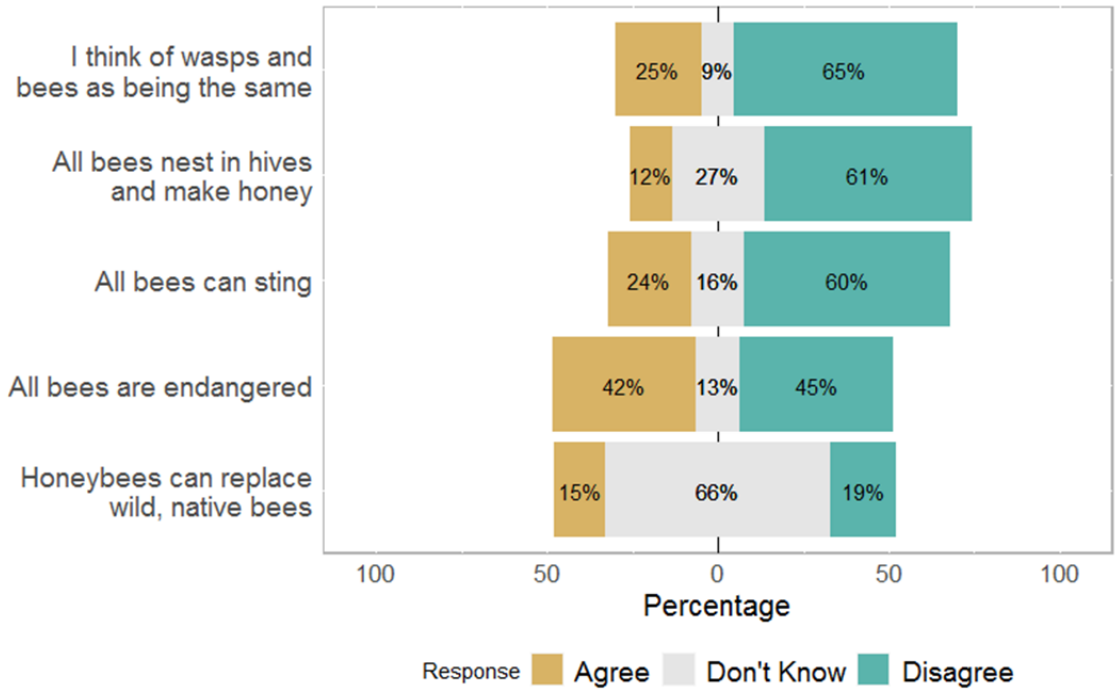

Figure 2.1: Summary of survey results. (a) Summary of responses to general bee fact awareness questions (questions 7-11). Disagreement indicates greater awareness (n=1969).

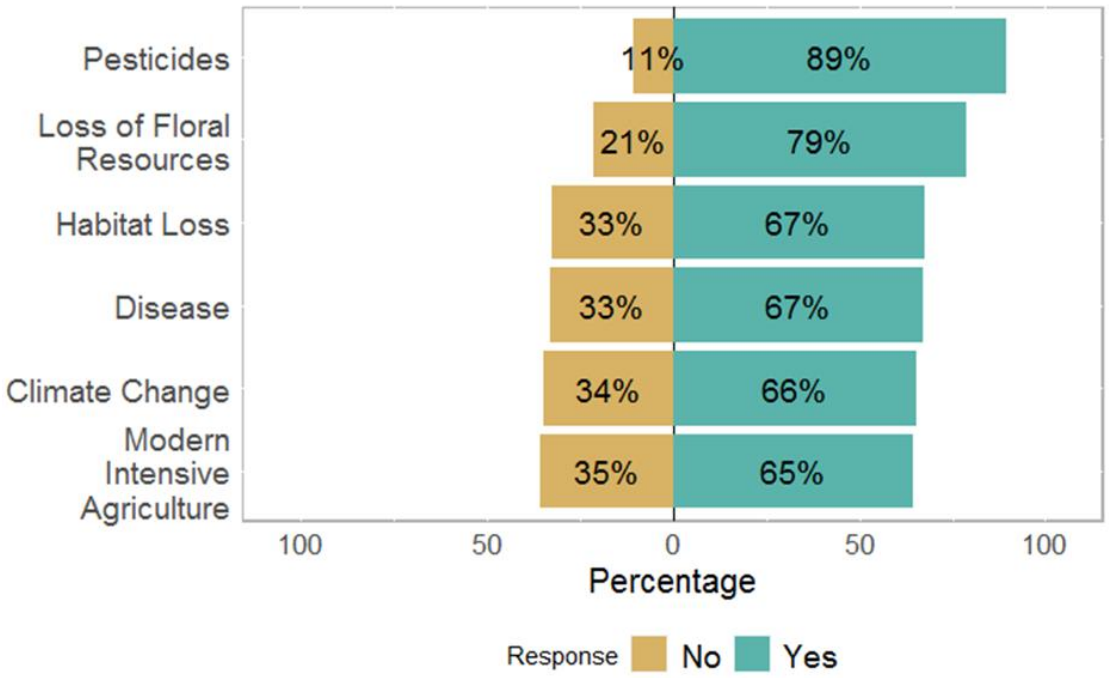

Figure 2.2: Summary of responses to perceived threats to bee health (question 4). Agreement (Yes) indicates participants perceived the activity/process as a threat to bee health (n=1969).

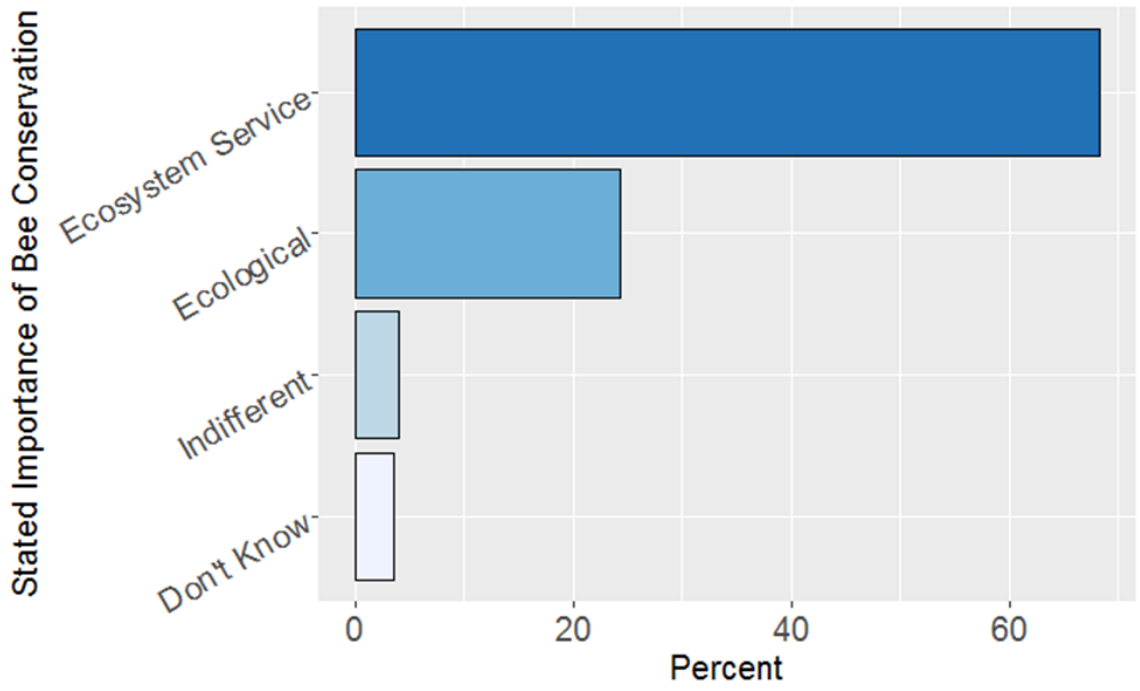

Figure 2.3: Summary of perceptions of bee conservation. Percentages of responses by category of stated importance of bee conservation (n=1969).

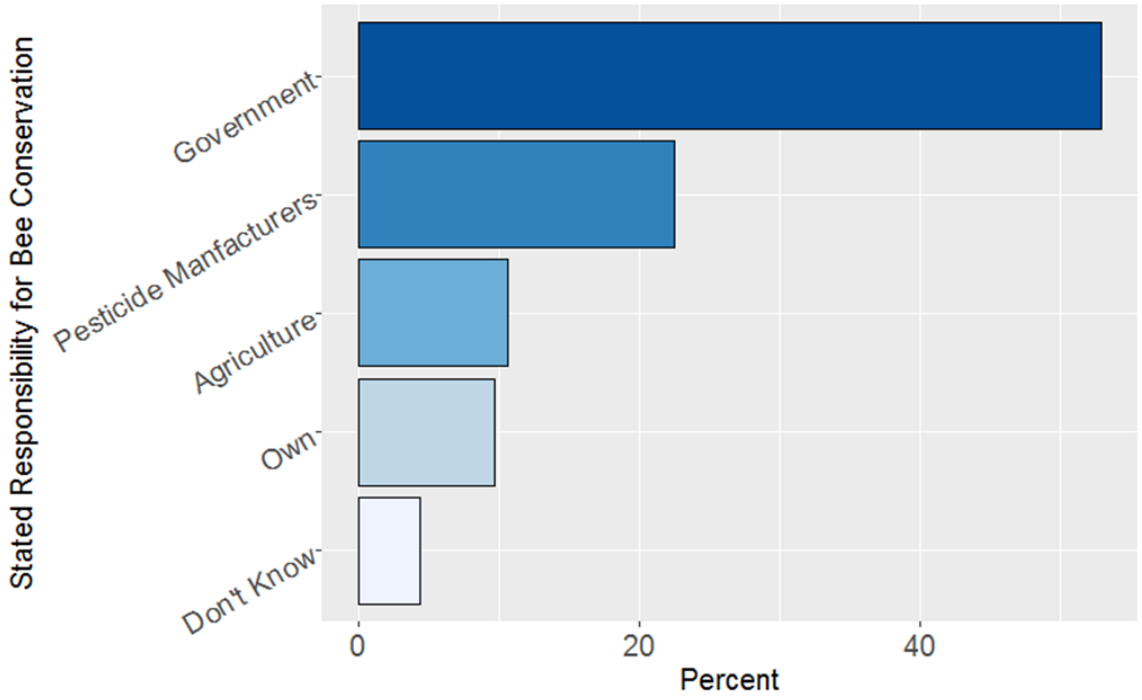

Figure 2.4: Summary of perceptions of bee conservation to stated responsibility for bee conservation. Percentage of responses by pooled categories (n=1969).

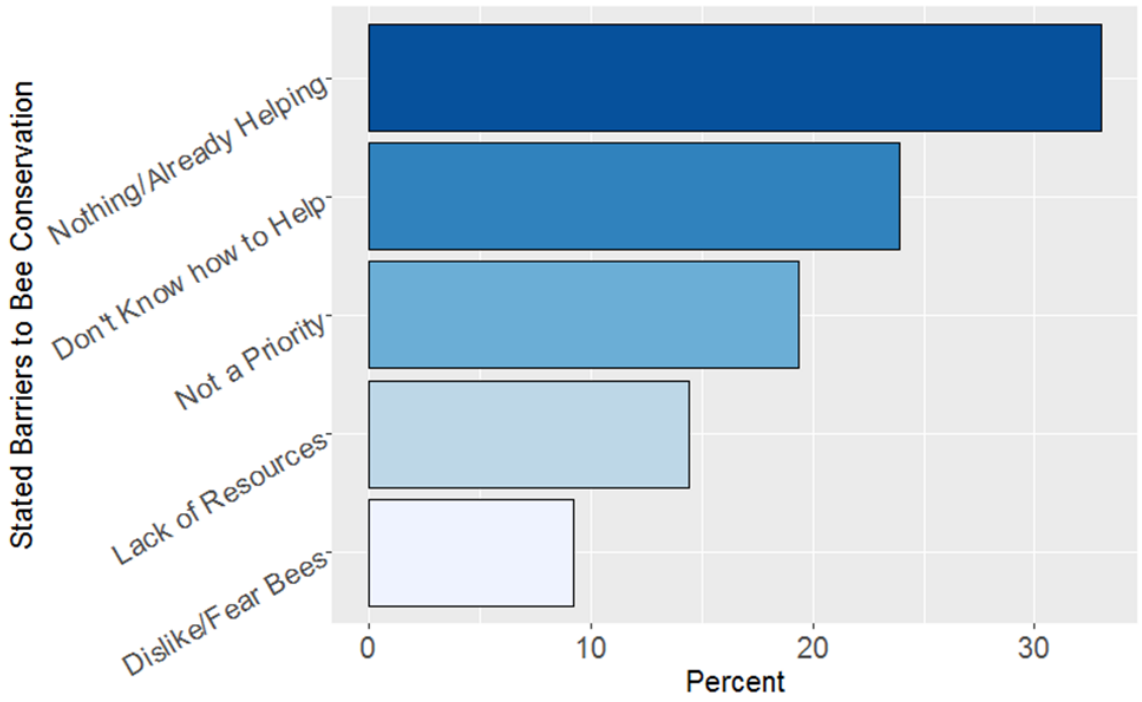

Figure 2.5: Summary of perceptions of bee conservation to stated responsibility for bee conservation. Percentage of responses by pooled categories (n=1969).

3 Chapter 3: Signaling Green: a content analysis of the environmental advocacy of the UNEP and WWF

3.1 Abstract

Effective environmental communication seeks to influence attitudes and behaviors. By identifying the variation between different discursive foci used by environmental advocates, one may gain an understanding of the different objectives, target audiences and strategies of the organization. Using publications from the UENP and WWF over the past 25 years I conducted a quantitative content analysis to study the organizational communication of two global environmental advocates. To contextualize the analysis, I traced the evolution of key concepts: ecosystem services, ecological footprint and planetary boundaries using foundational papers. These terms were used in expanding spaces from higher education, to global environmental advocacy organizations to mainstream media. UNEP uses the language of green growth, economics and sustainability to advance its message, whereas WWF uses the language of environmental governance and ecological conservation. UNEP is messaging to donors and other agencies within the UN system. WWF is messaging as a bridge between local, national and supranational actors.

Keywords: content analysis, correspondence analysis, environmental advocacy, environmental communication, sustainability discourse, text mining

3.2 Introduction

Despite clear science, the ongoing decline of biodiversity, dubbed the “sixth mass extinction” and the catastrophic impacts of climate change seem to suffer from a lack of action. Massive loses in biodiversity may be the most serious threat to human civilization because it is irreversible (Ceballos et al., 2020). With climate change there is still the possibility of reducing carbon dioxide emissions however over the past 30 years levels have continued to rise (Stoddard et al., 2021). The reasons for this inaction are complex and multifaceted. Ideas, beliefs, attitudes and behaviors shape how we approach and solve or ignore problems. Our beliefs, attitudes and behaviors on environmental issues are mediated by communication (Cox, 2006, p. 20). Environmental issues may be represented by different discursive frames. Frames both select information and make to salient to the audience (Entman, 1993). Frames select by highlighting pieces of information to make salient (Entman, 1993). Salient refers to “…making a piece of information more noticeable, meaningful, or memorable to audiences” (Entman, 1993, p. 53). Framing is a communication tool to make complex topics more salient to lay audiences (Cox, 2006, pp. 164–165; Scheufele & Tewksbury,

2007). Framing influences not what audiences think about, but how they think about it. Environmental discourses influence how society understands and addresses environmental issues (Coffey, 2016; Kusmanoff et al., 2020). Agenda-setting is an attempt to direct public attention to a set of issues or problems (McCombs & Shaw, 1972; Scheufele & Tewksbury, 2007). Different actors (mass media, governments, non-governmental organizations) may use different frames in agenda-setting to direct public attention on an issue. In environmental advocacy how agendas are set, and issues framed influences support or lack thereof for environmental issues.

Environmental advocacy like other forms of advocacy aims to influence individual behavior and/or policies or practices of governments or corporations. By identifying the variation between different discourses used by environmental advocates, one may gain an understanding of the different objectives, target audiences and strategies of the organization. In other words, how do advocates "cut through the noise" to gain support or promote action? To answer this, I chose to compare two global environmental advocacy organizations: The United Nations Environment Programme (UNEP), a government organization (GO) and the World Wildlife Fund (WWF), an environmental non-governmental organization (ENGO).

The UNEP was created in 1972 as a programme of the UN rather than a specialized agency (Ivanova, 2010). At that time, it was thought a flexible programme could respond more effectively to environmental challenges and by not being a specialized agency, it would not compete with other existing agencies for funding and authority within the UN (Ivanova, 2010). THE UNEP role is to "…serve as a focal point for environmental action and co-ordination within the United Nations system…" (Ivanova, 2010 Table 1). There is debate if the UNEP in its current form has the capacity and ability to achieve its mandate and researchers have called for the UNEP to be upgraded to a specialized agency-a World Environment Organization with compliance powers (Bina, 2013; Ivanova, 2021). Based on country submissions to Rio+20 compilation document, 35% of countries were in favor of establishing the UNEP as a specialized agency, 30% were in favor in strengthening the mandate of the existing UNEP, of these 30 countries, 77% were developing countries and 34% of countries made no mention of reform (Ivanova, 2012 Table 1). The current mission statement of the UNEP is as follows, "UNEP's mission is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations. UNEP works on delivering transformational change for people and nature by drilling down on the root causes of the three planetary crises of climate change, nature and biodiversity loss, and pollution and waste" (UNEP, 2023).

The World Wildlife Fund for Nature (known as the World Wildlife Fund within Canada and the United States of America) was established in 1961 and operates in over 100 countries and has 5 million supporters worldwide (Zheng, 2022). The original WWF entity is based in Switzerland and is commonly known as WWF International. National offices of WWF are separate legal entities from WWF International but operate as a coordinated network within WWF International's guidelines (Clive Hamilton & Andrew MacIntosh, 2004). The current mission statement for the WWF is as follows, "The mission of World Wildlife Fund is to conserve nature and reduce the most pressing threats to the diversity of life on Earth. Our vision is to build a future in which people live in harmony with nature. We seek to save a planet, a world of life. Reconciling the needs of human beings and the needs of others that share the Earth... From the smallest community to the largest multinational organization, we seek to inspire others who can advance the cause of conservation. We seek to be the voice for those creatures who have no voice. We speak for their future" (WWF, 2023b).

In this study I build upon previous discourse analytical work in the environmental policy and advocacy space. I trace and evaluate the movement of terms from two global environmental advocacy actors: World Wildlife Fund (WWF), an environmental non-governmental organization (ENGO) and the United Nations Environment Program (UNEP), a global governmental organization. To further contextualize the analysis, I use foundational papers (Costanza et al., 1997; Rockström et al., 2009; Wackernagel & Rees, 1997) to trace the key concepts of ecosystem services, ecological footprint and planetary boundaries from academic literature to environmental advocacy organizations to mainstream media. I expand upon the environmental discourse dictionary of Luxon (2019), I identify two new discourses: human security and governance. I map these discourses using a novel technique to the environmental policy and advocacy space-correspondence analysis (CA).

3.3 Theoretical Framework

Content analysis is defined as "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (Krippendorff, 2004, p. 18). It has its origin in the 1950s in communication studies, since then it has been applied in anthropology, political science, psychology and sociology (White & Marsh, 2006). In quantitative content analysis (also referred to as basic content analysis) data are assumed to manifest content, which is meaningful content is completely captured within the texts being studied (Drisko & Maschi, 2015, p. 4). The entire dataset is referred to as a corpus. Quantitative analysis is often descriptive or exploratory and is based on a positivist epistemology (see Drisko & Maschi, 2015). Content analysis may be used to understand communications of organizations. When

applied to study organizational communication, communications within an organization (i.e. emails, internal audits) or external communications with outside publics or other entities (i.e. annual reports) can elucidate motives and ideology (Neuendorf, 2017).

Within content analysis, discourse analysis is a popular method for analyzing communication (Neuendorf, 2017). Discourse is ‘‘a shared way of apprehending the world. Embedded in language, it enables those who subscribe to it to interpret bits of information and put them together into coherent stories or accounts. Discourses construct meanings and relationships, helping define common sense and legitimate knowledge. Each discourse rests on assumptions, judgements, and contentions that provide the basic terms for analysis, debates, agreements, and disagreements’’ (Dryzek, 2013, pp. 9–10). Discourse analysis has been applied to the analysis for environmental policy (Gelcich et al., 2005; Kusmanoff et al., 2017; for an extensive review see Leipold et al., 2019). Applying discourse analysis to environmental issues frames these issues, it creates understanding, validates actions and empowers local communities (Gelcich et al., 2005); however, a critical discourse analysis perspective recognizes that environmental discourses are often contested (Luxon, 2019). Content analysis is a flexible analytical tool that may be applied to the study the discourses of environmental organizations and thereby gain insight into organizational objectives, targets audiences and strategies.

3.4 Materials and Methods

3.4.1 The Data: The Corpus

I conducted a quantitative content analysis using documents from WWF Living Planet Report (LPR) and UNEP Our Planet (OP) magazine. The UNEP OP is a flagship magazine that brings together government leaders, policy experts and subject matter experts to analyze and make recommendations on environmental issues (United Nations Environment Programme, 2017). WWF LPR is a flagship publication that gives a comprehensive study in global trends of biodiversity and planetary health (W.W.F. International, 2023). LPR began publication in 1998 and is biannual; for this study full coverage was available, 1998-2020. For OP full coverage from the start of publication (in 1989) was not available. OP document corpus covered 2003-2017 (Table B.1). UNEP OP is available at https://wedocs.unep.org/ and the WWF LPR is available at https://livingplanet.panda.org/.

3.4.2 Building a Dictionary

The text analytic (dictionary) approach whereby lists of search words or phrases are created a priori has been used to examine environmental discourse (Admiraal et al.,

2016; Coffey, 2016; Kusmanoff et al., 2017). Luxon (2019) expanded on this work by creating a more expansive dictionary (lists of words and phrases) to explore environmental economic discourses.

I build upon Luxon's (2019) dictionary. I added new terms to Luxon's identified discourses and identify two new discourses: environmental governance and human security. To construct this new dictionary, I only used bigrams (two words) (Table B.2). Prior to dictionary construction, I read through the documents to gain a sense of the topics covered. The range of topics covered by UNEP OP was greater than WWF LPR, therefore the threshold for inclusion in the UNEP dictionary was lower than the WWF dictionary. To be included in the dictionary a bigram had be to be repeated five times in UNEP OP and ten times in WWF LPR. All analysis was done in R v. 4.1.2 (R Core Team, 2022). All documents were downloaded in PDF format and prepared for analysis using the optical character recognition (OCR) function in the "readtext" package (Benoit et al., 2021). Documents were tokenized using the "tidytext" package (Silge & Robinson, 2016) and English stop words were removed using the "SnowballC" package (Bouchet-Valat, 2020). I created my own list of stop words for both WWF LPR and UNEP OP and removed those words prior to analysis (Table B.3). Each set of documents had a unique set of custom stop words (Table B.3). Additional data processing was done using "tidyverse" (Wickham et al., 2019) and "stringr" packages (Wickham, 2019).

Analysis was performed for UNEP OP and WWF LPR separately. A contingency table (year x discourse) was created for each set of documents. These tables were used for the CA analysis. When CA is applied to textual analysis, typically n-grams (single words or phrases) are the unit of analysis (Hosoi et al., 2014; Petrović et al., 2009). I extended this by using *a priori* defined dictionary (lists of word pairs coded into categories – discourses).

The CA biplots were scaled using a contribution of points display (Greenacre, 2013) to control for outliers. CA was done using the "FactoMineR" package (Lê et al., 2008) and the biplots were made using the "factoextra" package (Kassambara & Mundt, 2020).

3.4.3 Mass Media Coverage of Selected Terms

To contextualize the evolution of terms from within higher education to international environmental organizations (UNEP and WWF) to mass media, I selected three terms: ecosystem services (ES), ecological footprint (EF) and planetary boundaries (PB). To assess media coverage of key terms (ES, EF and PB), queries were restricted to English-language only. The keywords, ["ecological footprint*," "ecosystem service*," and planetary boundar*" were queried using Factiva (https://www.dowjones.com/professional/factiva/). All dates were included in the search.

The results from year 2023 were not included in further analysis. These three terms relate to the dictionary developed Luxon (2019) as follows. Luxon's dictionary includes the terms "Market Economic Discourse" and "Socio-Ecological Discourse". Ecosystem Services falls within the Market Economic Discourse and Ecological Footprint and Planetaries Boundaries fall within Socio-Ecological Discourse (see Table B.2).

3.5 Results

3.5.1 Correspondence Analysis of Discourse

UNEP

The first three dimensions accounted for 90.2% of the total inertia (variance) in the UNEP dataset (Figure 3.1a and 3.1b). The Green discourse dominated the first dimension, accounting for 79% of the principal component of the first dimension (Table B.4). The Green discourse had no strong associations with any other discourse (Figure 3.1a, B.1a). Human security, public economic and market economic discourses comprised 37.79%, 23.10% and 19.88% respectively of the principal component of the second dimension (Table B.4). Human security was negatively associated with Market Economic and Public Economic discourse (Figure 3.1a, Table 3.1). The third dimension was composed of Socio-Ecological (58.96%) and Conservation Ecological (30.61%) and they are negatively associated (Figure 3.1b, Table 3.1). Several different publication years contributed to the definition of the dimensions (Figure S1b, Table B.5); indicating a variety of topics being discussed through time rather than a focus on one topic at a point in time.

WWF

In the WWF dataset the first three dimensions accounted for 92% for the total inertia (Figure 3.2a and 3.2b). Public Economic discourse composed 89.23% of the first dimension (Table B.6). Public Economic discourse had no strong association with other discourse (Figure B.1c, Table 3.1). The second dimension was composed of Environmental Governance (36.15%), Socio-Ecological (33.73%) and Conservation Ecological (19.17%) (Table S6). Socio-Ecological discourse was negatively associated with Environmental Governance and Conservation Ecological discourses (Figure 3.2a, Table 3.1). Human security (54.32%) and Conservation Ecological (38.38%) contributed to the third dimension and are negatively associated, although the third dimension only contributed an additional 9.1% inertia (Figure 3.2b, Table B.6). In contrast to the UNEP dataset, the WWF dataset had strongly discriminating publication years (Figure S1d). The first publication year of the LP in 1998 was highly distinct from other years, contributing 93% to the first dimension (Table B.7). Publication years 2018 and 2020

were highly contributing to the second dimension, 25% and 37.37% respectively (Table B.7). Both years are closely associated with Conservation Ecological Discourse and Environmental Governance (Figure 3.2a). Publication years 2014 (27.7%), 1999 (25.1%), 2000 (14.78%) and 2016 (10.78%) were the highest contributing rows to the definition of the third dimension (Table B.7) and highly distinct (Figure 3.2b).

3.5.2 Key Terms in Mass Media

ES had the earlier usage in popular media, first appearing in 1986 (Figure 3.3a). ES received the greatest amount of coverage in popular print media (n=60,802), appearing approximately four times more compared to EF (n=22,909) and six times compared to PB (n=9,122) (Figure 3.3a). PB was found as early as 1988 (Figure 3.3a), however this usage referred to “planetary boundary layer” in the atmospheric sense of the term. My results show that prior to 2008, PB was used strictly as an atmospheric term (Figure 3.3d). The first mention of the term in the popular media was in 2008 in an article by the South China Morning Post, entitled “Earth’s the Limit.” Unsurprisingly, coverage lagged in the popular media compared to the UNEP and WWF publications (Figures 3.3b-d). ES showed the greatest lag, over a decade from foundational paper to uptake in popular media (Figure 3.3b). PB showed the least lag time, under five years from foundational paper to uptake in popular media (Figure 3.3d).

3.6 Discussion

I describe two new discourses within the UNEP and WWF: environmental governance and human security. Environmental governance features prominently in WWF LPR but not in the UNEP OP (Figure 3.1, 3.2). Interestingly human security is negatively associated with conservation ecological discourse in WWF LPR whereas human security is an isolated discourse in the UNEP OP (Figure 3.1, 3.2, Table 3.1). Green discourse (green business, green growth) is highly prominent in UNEP whereas public economic discourse (common goods, inclusive wealth) is highly prominent in WWF (Figure 3.1a, 3.2a). PB shifted in meaning, prior to 2008 it was strictly an atmospheric term, post 2008 it was used as a limits term (Figure 3.3d).

Previous environmental content analysis studies have used single or word pairs as the unit of analysis (Admiraal et al., 2016; Kusmanoff et al., 2017; Legagneux et al., 2018; Luxon, 2019). This work builds upon the discourse categories of Luxon (2019) and makes a methodological contribution by introducing the ordination technique – correspondence analysis to the study of environmental policy and advocacy discourse. Leipold and colleagues (2019) call for a “theoretical cross-fertilization across different

analytical frameworks” in the field of discourse analysis. They suggest the use of quantitative text analysis to draw out new discursive patterns (Leipold et al., 2019).

Because a key aim of my study was to apply a novel technique (correspondence analysis) to an environmental content analysis, direct comparison with previous studies is not possible. What follows is a discussion of discursive patterns.

3.6.1 Green Discourse

My coding of green discourse aligns with the policy literature concepts of “green growth” or the “green economy” (Barbier, 2012; Bina, 2013). The policy aim is to achieve resource-efficient, low-carbon growth (Bina, 2013). The “greening” growth discourse combines economic, environmental and sustainability discourses (Bina, 2013). Green growth was a main theme of the 2012 UN Rio+20 conference however no new international commitments were made. Barbier (2012) argues that “green economy” was seen as a “buzz concept” and ignored by the G20 as a sidelined “environmental” issue. This perception of the “environment” as a special interest has been called out as a fatal flaw of environmentalism (Shellenberger & Nordhaus, 2009). Shellenberger and Norhaus (2009) [original self-published in 2005] criticize environmentalists for their narrow focus on the “environmental” that is a thing that needs be to protected and defended without placing it into the broader political context thereby rendering it a single issue and achieving no political traction. Within the environmental movement a “political myopia” has set in, the focus is on short term policy “pay-off” rather than long term political transformation (Shellenberger & Nordhaus, 2009). Such political transformation is echoed by Barbier (2012) who calls for the UNEP to be transformed into a specialized agency (similar to WHO) with a strengthened mandate and predictable funding (see also Ivanova & Lele, 2022).

UNEP is primarily engaging with their audience through positive economic framing to achieve conservation outcomes. These different discursive foci may be interpreted within the wider context of each organization’s structure and function. UNEP funding consists of three components: 1) the regular UN budget, 2) the Environment Fund and 3) Earmarked Contributions (UNEP, 2023). In 2022, approximately 5% of UNEP’s funding came from the regular UN budget, 15% from the environment fund and 80% from earmarked contributions (UNEP, 2023). There is no minimum contribution system. The Environment Fund are unrestricted funds donated by Member States whereas Earmarked Contributions are earmarked by the donor to be spent on specific projects or specific countries (UNEP, 2023). From 1979 to 2019 UNEP’s financing from the Environment Fund has decreased by 37% (Ivanova, 2021). In 2019, the Environment Fund received no contributions and was reliant on Earmarked Contributions for its

programme of work (Figure B.2 and Figure B.3). Whereas donors to the Environment Fund are entirely composed of UN Member States (Table B.8), donors to Earmarked Contributions are composed of financing mechanisms (the Global Environment Facility), Foundations, NGOs, other UN Agencies and Member States (Table B.9).

I believe UNEP is using Green discourse (green, jobs, blue economy) to speak to its donors and other (better funded) UN agencies. The UNEP has been called the “UN Everything Programme” (Ivanova, 2021). Green discourse allows UNEP to message to a broad audience. Framing environmental issues with clear economic benefit speaks to donor countries- sustainability and prosperity for your citizens is not only possible, it is the way ahead. It also speaks to the world of finance. From 2019 onwards, UNEP is actively engaging the global financial sector via the UNEP Finance Initiative (UNEP, 2023). Green discourse is used to engage and motivate other UN agencies in their domains. For example, “green inclusion” which links economic, environment and social justice. By seeking to enable other UN agencies to perform environmental duties, it is a way for UNEP to reduce competition for authority and resources between itself and other agencies within the UN.

3.6.2 Being Green and Sustainable

The concepts of green growth and sustainable development are closely linked. Dryzek (2013) considers sustainable development to be a discourse. Bina (2013) refers to the linking by the UN of sustainable development with green growth as the “economization” of the sustainable development discourse. Results of my analysis show no association between Green discourse and Socio-Ecological (includes the term sustainable development) discourse. Sustainable development has no real limits to growth (Dryzek, 2013) and green growth seeks continuous growth by efficient utilization of resources. Recently, the UNEP has become more reliant on global financial mechanisms (i.e. Global Environment Facility, the Green Climate Fund) as an income stream (UNEP, 2023) and see Supplemental Information (Table B.8-9, Figures B.2-3). UNEP’s funding sources are discussed below in the context of discursive focus and organization structure. WWF is using public economic discourse (includes terms such as inclusive wealth, public goods) however this too is not associated with other discourses. In the WWF LPR Socio-Ecological discourse was negatively associated with Conservation Ecological and Environment Governance. WWF is using governance to pair with conservation rather than sustainable development.

3.6.3 Governance, Human Security and Conservation

Governance is not government. Government is thought of as a hierarchical, centralized authority whereas governance is thought of as a decentralized network (Dryzek, 2013). Governance extends the process of governing to non-state actors- to corporations, to civil society to charities and NGOs (Evans, 2011; Dryzek, 2013). In the late 20th century the role of government has shifted from "one of rowing to one of steering" (Rhodes 1997 as cited in Evans, 2011, p. 4). Economic globalization lead to a crisis in legitimacy of the traditional welfare state (Evans, 2011). Evans (2011) states, "The hollowing out of the state in terms of decision-making was accompanied by a withering of its capacity for action…"(Evans, 2011, p. 32). A shift from government to governance became a necessity to achieve delivery of services (Evans, 2011). It is not surprising that Governance discourse featured prominently in WWF- a global ENGO, what is surprising is the relative absence of Governance discourse from UNEP- a global governmental organization. Why is this? UNEP is a programme not an agency of the UN. As a programme it relies on donations rather than a consistent allocated budget. As such, UNEP is focused on what issues its donors want to focus on.

WWF is primarily engaging with their audience through positive environmental governance framing to achieve conservation outcomes. In the context of global environmental governance Zheng (2022) argues that ENGOs acts a bridge connecting individuals, states and international organizations. WWF prefers to partner with private actors, raises awareness on environmental issues in local communities and advocates for them (Zheng, 2022). This policymaking and negotiating role can be seen as a public service that governments either do not wish or are unable to perform (Gondor & Morimoto, 2011). For example, WWF Japan has worked promote and increase the visibility of eco-labelling (MSC certification) of seafood (Gondor & Morimoto, 2011). Major supermarkets in Japan have embraced MSC certified products (Gondor & Morimoto, 2011). In the policy process NGOs are most effective at the agenda setting phase, the consultation phase – writing White Papers (Green Papers) and in the final phase as watchdogs – monitoring and enforcement (Long & Lörinczi, 2009, pp. 176–177). An example of this is WWF's lobbying role in the European Union (EU). WWF has played an active lobbying role in the EU since the late 1980s when it opened an office in Brussels (Long & Lörinczi, 2009, p. 171). WWF EU lobbied the European Commission to implement the Natura 2000 protected areas network through the use of media campaigns- "Making Natura an Opportunity", "EU Shadow List" and "Member State Evaluation" (McCauley, 2007), the latter two campaigns fulfilled the compliance role. National WWF offices compiled information on missing sites (EU Shadow List) and evaluated national performance (Member State Evaluation) (McCauley, 2007). Working closely with governments does carry the risk of lack of political independence. For

example, WWF Australia engages in public advocacy and policy work but also in program delivery for the Federal Government (Clive Hamilton & Andrew MacIntosh, 2004). Hamilton and MacIntosh (2004) critique WWF Australia's high level of public support and muted criticism of the Howard Government's environment policies. During the Howard Government (1996-2007) WWF Australia received the majority of its funding from the Federal Government (Clive Hamilton & Andrew MacIntosh, 2004). In apparent greenwashing, the Howard Government used the WWF brand to advance its own environmental credentials and discredit other ENGOs critical of government policy (Clive Hamilton & Andrew MacIntosh, 2004). WWF uses environmental governance discourse to signal its policymaking and negotiating role. WWF bridges local communities, national governments and supranational organizations.

In UNEP human security is negatively associated with market economic (includes ES), nor public economic (includes public goods, inclusive wealth) discourse (Table 3.1) In WWF human security is negatively associated with conservation ecological discourse (Table 3.1). Given the transdisciplinary nature of the concept, a negative association in both UNEP and WWF was unexpected. Human security may be thought of as a transboundary concept connecting the fields of security, development and environmental policy (Karen O'Brien & Jon Barnett, 2013). Human security centers people, by recognizing their agency as both cause and solution to environmental challenges (Karen O'Brien & Jon Barnett, 2013).

Human security as a concept can be traced back to the 17th century and comes from the notion that a state is responsible for protecting (physical safety) its citizen within its own borders (MacFarlane, 2006). Modern definitions of human security vary but can broadly be conceptualized as "freedoms." The UN Commission on Human Security states, "Human security naturally connects several kinds of freedom-such as freedom from want and freedom from fear, as well as freedom to take action on one's own behalf" (Commission on Human Security, 2003, p. 10).

The key terms I used to define human security (i.e. water scarcity, food security) align with the assessment report on the Intergovernmental Panel on Climate Change (Adger et al., 2015). An alternative way of interpreting human security is from the dimension of scarcity. Scarcity ties into sustainability – resources are finite. In economics scarcity can be a positive force, driving innovation (Bina, 2013). In green growth discourse scarcity is a problem to be overcome through efficient use of resources (Bina, 2013). In the UNEP OP this scarcity dimension may be a possible explanation for human security's negative association with the concept of ES (included in market economic discourse). UNEP may not wish to mix human security with economic discourses as to present a clear message to its donors. Major funding sources for WWF are individuals and private

foundations. In 2021, donations from Foundations accounted for the majority of WWF's revenue stream (29%) followed by individuals (28%) and in 2022 individual accounted 31% of revenue, followed by contributed nonfinancial (in-kind) assets and other revenues at 21% (WWF, 2023a). Similarly, to UNEP, WWF may wish to keep human security separate with conservation ecological discourse to clearly message to their donors. Their donors have come to expect conservation messaging from WWF, the concept of human security may be too broad and vague a term to engage potential donors.

3.6.4 Limits, Boundaries and Valuing Nature

In the UNEP OP social ecological discourse (concepts of EF, PB) are negatively associated with conservation ecological discourse and in the WWF LPR it was negatively associated with both conservation ecological and environmental governance (Table 3.1). EF is a concept of limits- that is the amount of land/sea needed to support a given population (Wackernagel & Rees, 1997). PB is a concept of boundaries- none of the boundaries are extractive resources but crossing a boundary puts humanity in danger (Rockström et al., 2009). The UNEP works with governments to draft outcome documents. In the 2012 Rio+20 conference Outcome document PB was excluded and the focus of the document was on the green economy (Ivanova, 2012). Luxon (2019) identified WWF as an "Economic Pluralist", as an organization it uses market-economic, public economic and conservation discourses. My results show that public economic is not associated with other discourses. The discourse of limits, boundaries and sustainability is not being discussed with economics. It is negatively associated with governance and conservation. Shibaike (2022) refers to large-scale, highly visible (name recognition) ENGOs like WWF as issue generalists. These large ENGOs must appeal to diverse publics, government and the private sector and therefore must focus on issues salient to their existing supports as to not risk alienating them (Shibaike, 2022). Shibaike (2022) argues small NGOs have more agenda setting power because they are low-profile, they can take more risks and focus on more niche specialist issues. The language of limits and boundaries may not be appealing to donors that wish to focus on business-oriented solutions and governance mechanisms to achieve conservation outcomes.

3.7 Limitations of Study

This study is limited by not having a more complete coverage for UNEP OP, particularly the period of the late 1990s. That said there was chronological overlap between the UNEP and WWF documents.

More generally, the field of discourse analysis has a lack of meta-studies and has multiple theoretical frameworks (Leipold et al., 2019) and there are multiple typologies of environmental discourses (for examples see Bina, 2013; Dryzek, 2013) hindering comparison among studies.

3.8 Future Work

Future analysis could explore the emerging concept of Nature's Contribution to People (NCP). Diaz and colleagues (2018, p. 270) define NCP as "the contributions, both positive and negative, of living nature (diversity of organisms, ecosystems and their associated ecological and evolutionary processes) to people's quality of life." NCP was introduced as a supra-concept to ES (Díaz et al., 2018). NCP re-frames "services" to "contributions" and "well-being" to "quality of life" (Díaz et al., 2018). ES has focused on biophysical and economic values and its supporters maintain that ES is an important tool to facilitate decision making because it allows for trade-offs (Schröter et al., 2014). Diaz and colleagues (2018, p. 271) state that NCP goes beyond "stock and flow framing of nature relationships." Kadykalo and colleagues (2019) suggest that NCP may strengthen the science-policy interface because it captures a plurality of relationships between people and nature. They suggest that NCP is theoretically expanding ES and is a complimentary term to ES (Kadykalo et al., 2019). Future work could explore ES and NCP in the environmental discursive space and their relationship to nature conservation, social and economic discourses. Future work could also track environmental governance and human security discourse, particularly within the UNEP. In 2022, the fifth largest donor to Earmarked Contributions to the UNEP was the Multilateral Fund (Table B.9). The Fund was established to assist developing countries who are parties to the Montreal Protocol implement it (Multilateral Fund, 2022). The Montreal Protocol seeks to control the emission of ozone layer depleting substances into the atmosphere (Multilateral Fund, 2022). Governance discourse may increase as UNEP messages to their donors. Human security that places people at the center, will that be taken up as a transboundary discourse by UNEP or WWF or will it continue to remain more isolated?

3.9 Conclusion

This study used quantitative content analysis to identify new discursive patterns in the environmental advocacy space and represent those patterns spatially. UNEP uses the language of green growth, economics and sustainability to advance its message, whereas WWF uses the language of environmental governance and ecological conservation. Both organizations are trying to tell stories that matter to people. UNEP is messaging to donors and other agencies within the UN system. WWF is messaging as

a bridge between local, national and supranational actors. These approaches are complementary, since effective communication is highly context specific. A “one-size fits all” model will not mobilize supporters, raise awareness and win-over critics.

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Table 3.1:Matrix of Association of Discourses with UNEP and WWF Publications

	UNEP			WWF		
	Dim 1	Dim 2	Dim 3	Dim 1	Dim 2	Dim 3
Con_Eco			—		+	—
Enviro_Gov					+	
Green	○					
Market_Eco		+				
Public_Eco		+		○		
Security		—				—
Socio_Eco			—		—	

Abbreviations for discourses are as follows: Con_Eco = Conservation Ecological, Envrio_Gov = Environmental Governance, Green = unabbreviated, Market_Econ= Market Economic, Pub_Econ= Public Economic, Security= Human Security and Socio_Eco= Socio-Ecological. Dim= Dimension. Open circle ○ indicates no associations with other discourses. Plus sign + indicates positive association and minus — sign indicates association with other discourses. Diagonal line indicates discourse was not highly contributing to the definition of the dimension.

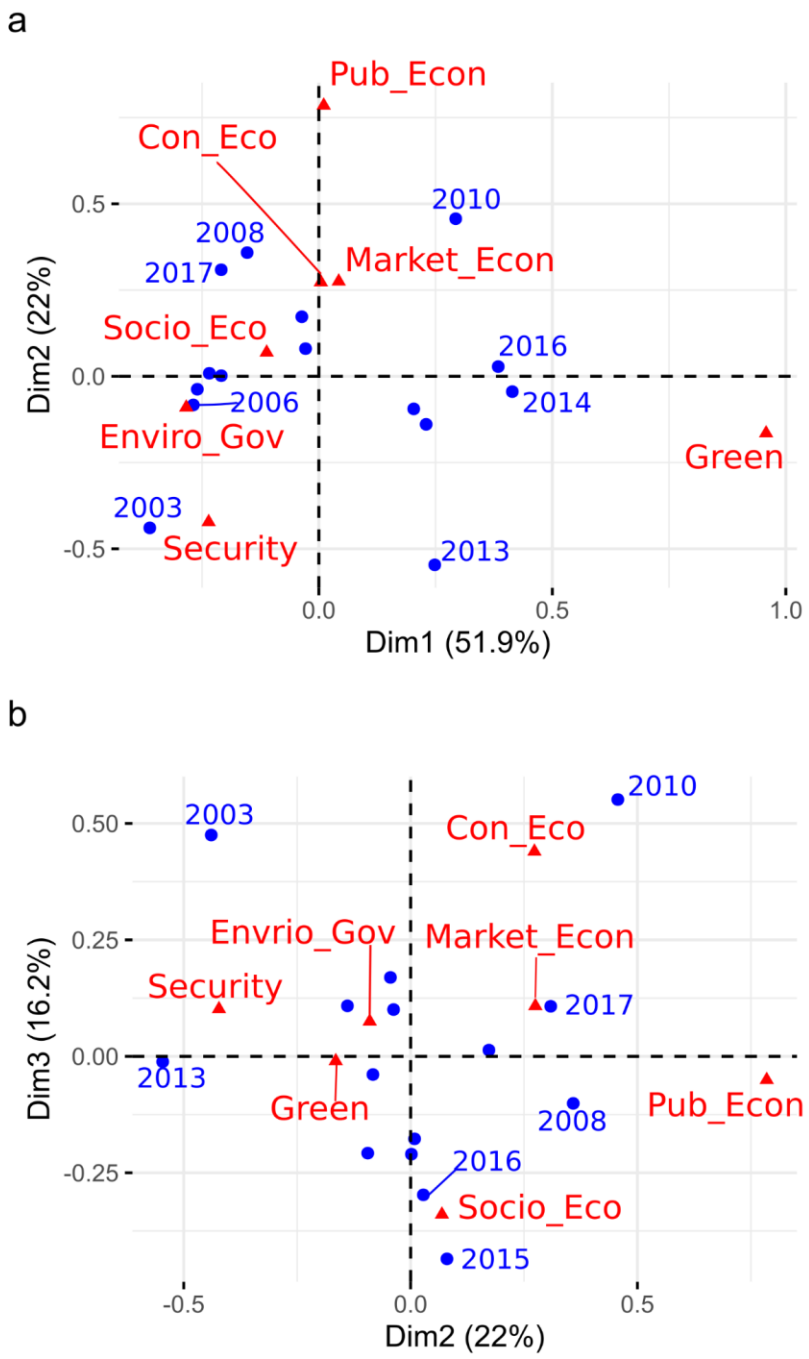

Figure 3.1: Contribution Biplots of correspondence analysis of UNEP Our Planet Magazine. (a) Dimension 1 (horizontal black dashed line) and Dimension 2 (vertical black dashed line) are displayed, (b) dimensions 2 (horizontal black dashed line) and dimension 3 (vertical black dashed line) are displayed. Discourses are symbolized by red triangles; document publication years are symbolized by blue circles. Discourses are displayed in principal coordinates following (Greenacre, 2013) showing visually the most contributing points. Only high contributing years are labeled. The plot origin is the intersection of the two black dashed lines. Less distinct points are closer to the origin. More discriminating points are further from the origin.

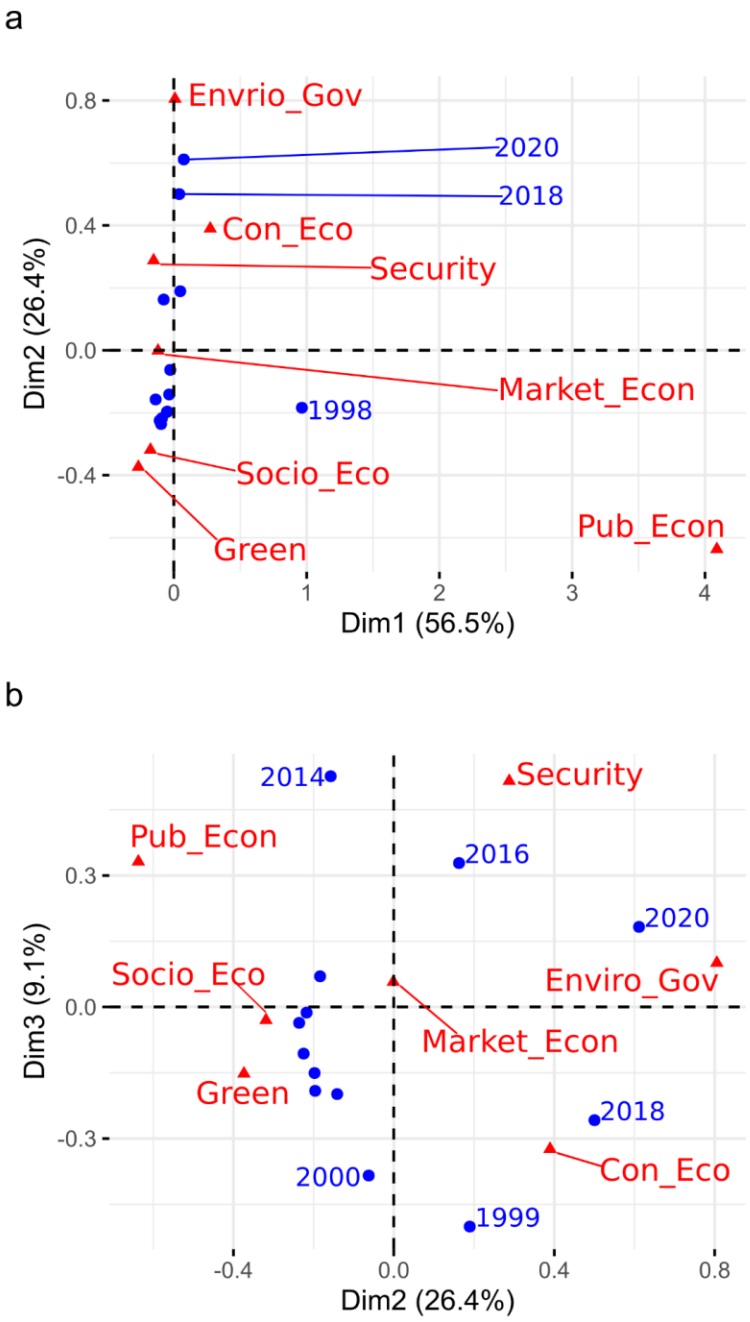

Figure 3.2: Contribution Biplots of correspondence analysis of WWF Living Planet Report. (a) Dimension 1 (horizontal black dashed line) and Dimension 2 (vertical black dashed line) are displayed, (b) dimensions 2 (horizontal black dashed line) and dimension 3 (vertical black dashed line) are displayed. Discourses are symbolized by red triangles; document publication years are symbolized by blue circles. Discourses are displayed in principal coordinates following (Greenacre, 2013) showing visually the most contributing points. Only high contributing years are labeled. The plot origin is the intersection of the two black dashed lines. Less distinct points are closer to the origin. More discriminating points are further from the origin.

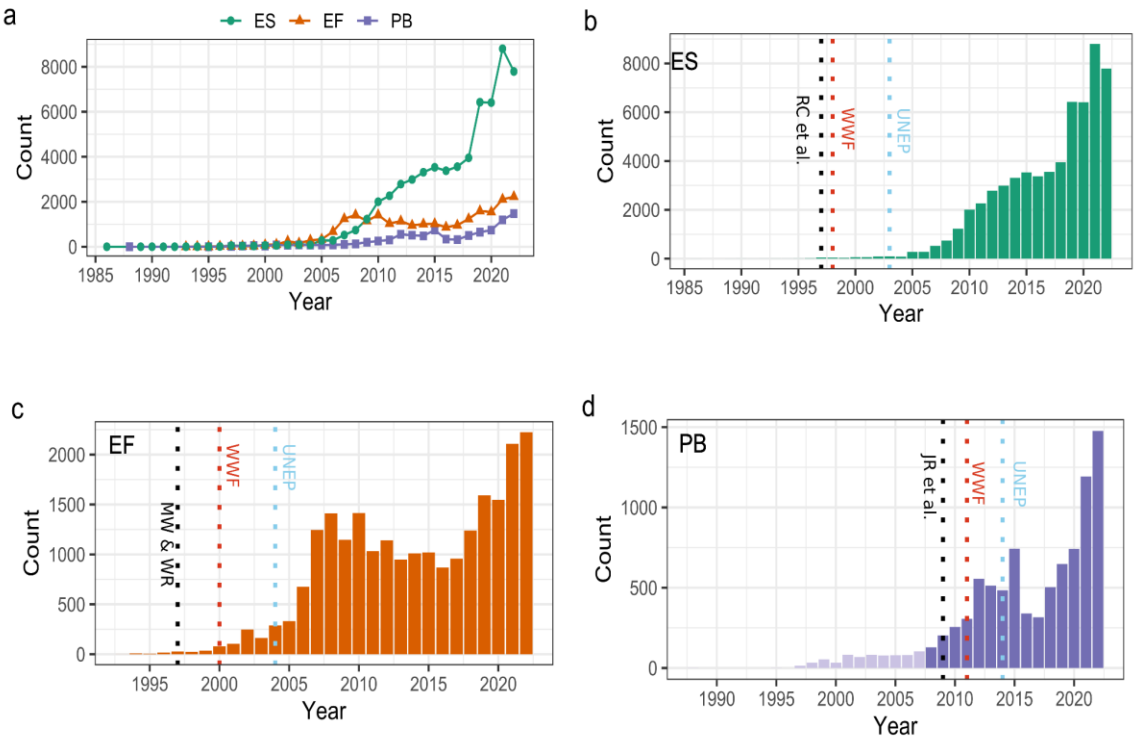

Figure 3.3: (a) Ecosystem Services (ES), Ecosystem Footprint (EF) and Planetary Boundaries (PB) usage in popular print media (Count) through time (Year). (b-d) are individual terms used in popular print media (Count) through time (Year). Black reference lines are the appearance of the term in the foundational paper. Vermillion reference lines are the appearance of the term in WWF and light blue reference lines are the appearance of the term in UNEP. (d) Light purple bars indicate use of PB as an atmospheric term, dark purple bars indicate use as a “limits” term. RC et al. = Costanza et al., 1997. MW & WR = Wackernagel & Rees, 1997 and JR et al. = Rockström et al., 2009.

4 Chapter 4: Urban Parks and the COVID-19 Pandemic: peoples' emotions towards their local park enable more resilient cities

4.1 Abstract

Public urban green spaces (UGS) provide important social and ecological functions in large urban centers. This study explores the changes in peoples' emotions in six urban parks in Toronto, Canada. The three timeframes are: Pre-COVID (January 1, 2019 - February 28, 2020), COVID (March 1, 2020-August 31, 2021) and Recovery (September 1, 2021- October 31, 2022) using Twitter data. Two modes of communication are analyzed, 1) words (text) and 2) emoji (ideogram) using sentiment analysis. Overall, across all parks, people expressed more positive sentiment than negative sentiment regardless of pandemic conditions. More positive emoji were used Pre-COVID compared to COVID, except in the case of an urban wilderness park, more positive emoji were used during COVID compared to the Recovery phrase. In a highly utilized park in the downtown core, both fear and sadness were least in the Pre-COVID and Recovery phrases and highest in the COVID phrase. This may indicate a restorative effect. Understanding peoples' emotions towards their local urban park may assist in the maintenance and creation of resilient communities for people and nature.

Keywords: COVID-19; Emoji, Sentiment Analysis, Social Media, Urban Green Spaces (UGS), Urban Parks

4.2 Introduction

In conjunction with global biodiversity loss, the global human population is becoming more urbanized. In Canada currently over 80% of the population is urban (Statistics Canada, 2021); by 2050 two-thirds (68%) the world's population is projected to live in cities (United Nations, 2019, p. 11). Despite this urbanization, ideas of wilderness and wild spaces are deeply embedded in the minds of Canadians (Cheesbrough et al., 2019). Because of these processes large urban parks and other urban green spaces (UGS) have an important role in biodiversity conservation and human well-being. UGS such as forest remnants and parks support higher levels of biodiversity compared to the surrounding urban matrix (Alvey, 2006; Croci et al., 2008; Nielsen et al., 2014). UGS support human well-being (Cleary et al., 2019) by reducing stress (Chiesura, 2004), provide recreational opportunities which promote overall health (Bowler et al., 2010; Astell-Burt and Feng, 2019) and promote social cohesion (Ayala-Azcárraga et al., 2019). Public UGS may be relatively more important to lower income citizens whom

may lack the resources to access a private green space (Kinzig et al., 2005), i.e. private gardens/ backyards. The twin societal and ecological demands can be difficult to reconcile. For example, the demands between the societal need for recreation values and the preservation of ecological values (ecological integrity) has been well documented particularly in large (>100 ha) protected areas (Liddle, 1997; Monz et al., 2010) such as national forests. These social and ecological demands have been understudied in urban and suburban parks and recreation areas compared to rural parks and protected areas (Sisneros-Kidd et al., 2021). Compared to rural parks, urban and suburban parks receive higher volumes of visitors all year round (Sisneros-Kidd et al., 2021). Overcrowding, litter, vandalism and off-leash dogs are common concerns for UGS visitors (Arnberger, 2012; Palliwoda and Priess, 2021). UGS must balance diverse human perceptions and needs (i.e. safety, aesthetics, amenities) with biodiversity conservation (Aronson et al., 2017). UGS have been shown to improve human well-being, particularly physical health and mental restoration (Reyes-Riveros et al., 2021). That said, high levels of biodiversity do not directly translate into high human well-being. People are generally poor at identifying species richness in urban settings and high species plant richness has been shown to be negatively correlated to reported well-being (Dallimer et al., 2012). Understanding peoples' attitudes towards UGS may help urban planners and managers create and maintain spaces that satisfy the values of people while still achieving urban biodiversity conservation.

With increasing urbanization, there is an accompanying decrease in contact with nature in peoples' daily lives, termed "the extinction of experience" (Miller, 2005; Soga et al., 2016). People that live further away from natural areas visit them less frequently (Colléony et al., 2017). Giving people opportunities to experience nature in their daily lives close to home is important for not only urban nature conservation but also non-urban nature (Miller and Hobbs, 2002). A sense of connection to nature promotes attention to and concern for the natural world. People tend to see themselves as separate from nature (Schultz, 2011). People cannot appreciate what they do not value. A key idea to the investigation of emotion in urban areas in the peoples' emotional responses vary depending upon how they perceive the environment around them.

Despite our awareness of the global decline in biodiversity, the problem has not been properly addressed and we continue to behave in ways that are detrimental to the biosphere and ultimately ourselves (Nisbet et al., 2009; Mace, 2014). To address the "biodiversity crisis" it requires not only involvement in the wider scientific community i.e. Conservation Science (Soule, 1987) but larger societal commitment – for example in conservation communication, policies and governance (Mace and Baillie, 2007). Promoting pro-conservation behaviors must focus on changing people's behaviors (Schultz, 2011). A person's connection to nature may motivate pro-environment

behavior (Mayer and Frantz, 2004). Experiencing nature has been positively related to increased ecological literacy (Pilgrim et al., 2008) and ecological concern (Clayton and Myers, 2015). That said, environmental concern may not always translate into pro-environment behaviors (actions) (Clayton and Myers, 2015). This gap is partially explained by personal barriers, any barrier a person experiences that prevents full engagement in pro-environmental behavior (Whitburn et al., 2020). This could be a personal cost (time or financial), structural (ex. No public transit) or knowledge (of the pro-environmental behavior) (Whitburn et al., 2020). Disconnection with nature has been blamed for leading to apathy towards environmental conservation and protection (Pyle, 2003). The inability to experience nature in our daily lives has been termed the "extinction of experience" (Miller, 2005). This is a cycle in which people grow up in species poor environments, leading to apathy towards conservation, leading to further losses of species and isolation from nature (Miller, 2005). This direct experience with nature in our daily lives which fosters nature conservation has been termed the "Pigeon Paradox" by Dunn and colleagues (2006). Due to increasing urbanization, people will increasingly only have direct experience with species found in cites. Ives and colleagues (2018) argue that reconnecting people with nature can "leverage deep societal change for sustainability" (p. 1390).

Instagram, Weibo and Twitter are the three prominent platforms used in UGS research (Zabelskyte et al., 2022). Instagram users typically upload photos about their day-to-day experiences (Tenkanen et al., 2017). Since 2016, Instagram has restricted access to its Application Programming Interface (API) thereby limiting the access to data for research purposes (Zabelskyte et al., 2022). Research has focused on other platforms that allow for easier access to data. Twitter is a free microblogging platform (established in 2006), it is used for short-text discussion. Twitter is popular among its users for sharing their thoughts and opinions on topics (Tenkanen et al., 2017). Twitter provides a platform for the dissemination of information, opinions and emotions. As of July 2022, Twitter has 237 million daily active users (Dixon, 2022).

The COVID-19 (SARS-CoV-2) pandemic caused massive disruption to peoples' daily lives. Residents of densely populated areas (i.e. cities) experienced restrictions (including quarantine) on going out for school, work and socializing. Studies on human health and UGS have shown mitigation of quarantine by providing a sense of escape/respite (Dzhambov et al., 2021). UGS provided amenities/resources for exercise and socializing while maintaining social distancing. Other studies have shown people appreciated UGS more during the pandemic (Cheng et al., 2021); fostering a connection to urban nature.

The city of Toronto, Canada has an extensive system of green spaces. UGS comprise 12% of the total urban space (Kabigting, 2018). Two entities are responsible for the management of Toronto's UGS: the city of Toronto and the Toronto and Region Conservation Authority (TRCA). The City of Toronto has jurisdiction to manage municipal parks and the TRCA has jurisdiction to manage ravines, stream corridors and valleys (*Conservation Authorities Act*, 1990; City of Toronto, 2017). In 1954 Hurricane Hazel caused the death of 81 people and caused widespread property damage in the city of Toronto and surrounding area (Rai, 2020). This natural disaster strengthened the existing provincial legislation, *Conservation Authorities Act* leading to the creation of the Toronto and Regional Conservation Authority (TRCA) that had the authority to acquire land for both conservation and flood management purposes (*Conservation Authorities Act*, 1990). Toronto's ravines account for 17% of the city's total area however only 60% are publicly owned (Richard, 2018). Although the TRCA is mandated by the government of Ontario to protect and manage the ravine system; the City of Toronto is responsible for the development of legislation and policy for the ravine system and Toronto's urban forests and parks (Richard, 2018).

4.3 Research Questions

How have Toronto park visitors' sentiments changed before, during and after the COVID-19 pandemic?

Hypothesis 1: There will be a change in the amount of negative sentiment expressed in tweets by Toronto park visitors from January 2019- October 2022.

Hypothesis 2: There will be a change in the types of emojis used in tweets by Toronto park visits from January 2019- October 2022.

Prediction 1: More words expressing negative sentiments (fear, disgust, anger and sadness) will be contained in tweets during the COVID-19 pandemic compared to before the pandemic.

Prediction 2: More negative emojis will appear in tweets during the COVID-19 pandemic compared to before the pandemic.

4.4 Methods

4.4.1 Study Area

Six urban parks located within the City of Toronto, Ontario, Canada were chosen as the study sites (Figure 4.1). Toronto (43.7^{o}N, 79.4^{o}W) is the most populous city in Canada and the provincial capital of Ontario with a population of 2.7 million, including the

adjacent municipalities the Greater Toronto Area (GTA) has a population of 6.2 million (Statistics Canada, 2021). Toronto sits within the Lake Erie Lowland Ecoregion. This ecoregion has a temperate climate- summers are warm and humid (mean temperature 18º) and winters are mild (mean temperature -2.5ºC) (Nature Conservancy of Canada, 2019). This ecoregion is heavily urbanized, it is home to nearly a quarter (23.1%) of Canada's population (Statistics Canada, 2016).

4.4.2 Focal Parks

Colonel Samuel Smith Park (CSS)

CSS is 78.8 ha in size, located on the shore of Lake Ontario, much of the area consists of anthropogenic lakefill deposited in the 1970s and 1980s, the remainder of the site is the former Lakeshore Psychiatric Hospital and the RL Clark Filtration Plant, that were manicured lawns. It is a popular location for fishing and birdwatching. The park has an unfenced Dogs Off-Leash Area (DOLA) and allows commercial dog walkers (City of Toronto, 2017). Dominant tree species are planted, these include red pine *(Pinus resinosa),* Norway Spruce *(Picea abies),* Scots Pine *(Pinus sylvestris),* white spruce *(Picea glauca)* and white birch *(Betula papyrifera)* (Terrestrial Inventory, Pg. 8).

High Park (HP)

High Park is a 161 ha multi-use park established in the late 19th century using a leisure centric design characteristic of urban parks of that era (Toronto and Region Conservation Authority (TRCA), 2019). High Park offers a diverse array of attractions such as a zoo, a café, ornamental gardens, ex. Japanese cherry trees (*Prunus serrulate*) and walking trails ("High Park Toronto," 2022). Approximately 60 ha of the park is considered natural, containing the now rare Black Oak (*Quercus velutina*) savannah ecosystem that once dominated Southern Ontario's sandy loam soils (Toronto and Region Conservation Authority (TRCA), 2019). The park is easily accessible by public transit and the surrounding neighborhood is an affluent one. It has a very high number of users from all socioeconomic backgrounds.

Humber Bay Park (HBP) East & West

HBP consists of two peninsulas that jut into Lake Ontario, each half is referred to as east and west. The original soil was sandy and clay loam, but this has been replaced by anthropogenic lakefill deposited from the 1950s until 2007 (Toronto and Region Conservation Authority (TRCA), 2014). The total land area is 43 ha (City of Toronto and Toronto and Region Conservation Authority (TRCA), 2018). HBP is popular among dog-walkers and hikers (Toronto and Region Conservation Authority (TRCA), 2014).

Humber Bay Park East

HBP East features the Humber Bay Butterfly Habitat, an ecological restoration project that planted tall-grass prairie species from 1998-2000 (Terrestrial Biological Inventory 2014). These meadows (2.3 ha) provide habitat for indigenous butterfly species and other wildlife (Toronto and Region Conservation Authority (TRCA), 2014).

Humber Bay Park West

HBP West is noted for watching waterfowl. It has a fenced in Dog Off-Leash Area (DOLA) and allows commercial dog walkers. It has several paved paths making the park more accessible to persons with more limited mobility.

Sherwood Park (SP)

SP was established in the early 20th century, named after the famous Sherwood Park in England. Until the mid-19th century the site of SP was agricultural land (Toronto and Region Conservation Authority (TRCA), 2022). SP features a baseball diamond, playground, wading pool and a fenced DOLA (City of Toronto, 2017). SP has an Ecological Significant Area (ESA) of 8.5 ha at the centre of the park (Toronto and Region Conservation Authority (TRCA), 2022). Most of the ESA is forest (85%), this includes mature canopy trees (120-150 years old) (Toronto and Region Conservation Authority (TRCA), 2022). Mature tree species include red oak (*Quercus rubra*), white pine (*Pinus strobus*), and white ash (*Fraxinus americana*) (Toronto and Region Conservation Authority (TRCA), 2022).

Trinity Bellwoods Park (TBP)

TBP is the former grounds of Trinity College established in the mid-19th century (Trinity Tree Team, University of Toronto, 2010). The college sold its land and buildings to the city of Toronto in 1925 (Trinity Tree Team, University of Toronto, 2010). Today TBP is a 14.6 ha park and features several recreational facilities: outdoor tennis courts, volleyball courts, skating ring, playgrounds, baseball diamond, a DOLA and several bike trails (City of Toronto, 2017). TBP is an important UGS for the local community neighborhood as there is little parkland per capita in the TBP area (Trinity Tree Team, University of Toronto, 2010). The most abundant tree species in TBP is the non-indigenous Norway Maple (*Acer platanoides*) (Trinity Tree Team, University of Toronto, 2010).

Tommy Thompson Park (TTP)

Tommy Thompson Park (TTP) is located on artificial substrate created from landfill and dredgeate disposal (the Leslie Street Spit, also known as “the Spit”) (MTRCA, 1992). The Spit is approximately 500 ha, from the late 1950s until the 1970s the Toronto Port Authority (TPA) operated this site as an industrial brownfield. In 1976 TTP (247 ha) was created and is operated by the Toronto and Region Conservation Authority (TRCA) (MTRCA, 1992). The remaining portion of the Spit (224 ha) is leased by the TPA from the Ontario Ministry of Natural Resources (MNR) (MTRCA, 1992). In 1982 the Spit was designated as an Ecological Sensitive Area (ESA) (MTRCA, 1982) based on its importance as a stopover for migratory birds and regionally rare habitat containing nationally and provincially rare plant species (MTRCA, 1982). The Spit receives more than 250,000 visitors per year (Taylor et al., 2011). TTP is currently managed as a public “urban wilderness” (Ontario, 1994). A key feature in the definition of urban wilderness is in defining human presence as low intensity (i.e. recreation activities such as walking, hiking and bird watching).

4.4.3 Study Area Map Data

Data for the study area map (Figure 4.1) were downloaded from the City of Toronto’s Open Data portal (City of Toronto, 2022). The data files were mapped using QGIS v3.28 (QGIS Development Team, 2022).

4.4.4 Twitter Data Collection and Processing

The data collection, processing and overall methodological framework is illustrated in Figure 2. All tweet data processing and analysis was done is R v4.2.2 statistical software (R Core Team, 2022) Tweets were collected using Twitter’s Academic Research Product Track v2 Application Programming Interface (API) endpoint. Twitter has a specific API for academic researchers (Twitter 2022). Following the approval of an academic research application to Twitter, API access is granted. The “academictwitteR” R package was used to connect to the API. The package is designed specifically for working with the Twitter academic API (Barrie et al., 2022). Connecting to the Twitter API using this procedure makes use of the OAuth 2.0 authentication protocol, which allows researchers to access public twitter accounts without gaining access to passwords or other private information (Barrie et al., 2022). This protocol uses access tokens which act as credentials to access user data (Barrie et al., 2022).

A search query was used to restrict the downloading of tweets by geographic location and timeframe. Only tweets posted within the City of Toronto and from January 1,2019-October 31, 2022 were downloaded. Within the same query, keywords were included to

ensure tweets contained references to green spaces (Figure 4.2, Table C.1). The collection process was iterative, general keywords were used to determine which UGS were being tweeted about the most. This initial API call returned 72,489 original tweets. The text of these tweets was scanned using R code to list every two words in front of each search keyword. This gave the names of the UGS. I inspected the UGS name and the associated hashtag for relevance. I created a revised list of search keywords and hashtags (Table C.1). Using the revised search list, I called the API, this returned 11,691 original tweets (Figure 4.2). I filtered for the most UGS (> 300 tweets per individual UGS) and used this to determine the focal parks. The total tweets for the focal parks were 10,821 (Table C.2). The total number of tweets used for further analysis was 8,077 (74.6% of the original total). Nearly a quarter of the tweets collected were public service announcements or advertainments and were excluded from the analysis.

4.4.5 Sentiment Analysis

Text-Based Analysis

Sentiment analysis is a natural language processing method that allows for the analysis of opinions, personal beliefs and feelings expressed in online text. Several different approaches are available to conduct a sentiment analysis using social media data, ranging from supervisor lexicon-based classification to unsupervised machine learning (Dhaoui et al., 2017). A pre-defined lexicon-based approach using the Natural Research Council (NRC) of Canada Word-Emotion lexicon (Mohammad and Turney, 2013) has been successfully applied in recreation studies (Hausmann et al., 2020). The NRC Word-Emotion lexicon contains a list of English unigrams (single words) that have been manually annotated and validated through the use of a crowdsourcing platform (see Mohammad and Turney, 2013). Crowdsourced dictionaries may be less prone to bias or omissions compared to manually created dictionaries (Schwartz and Ungar, 2015). Words are assigned either a positive or negative sentiment and an emotion class based on Plutchik's eight based emotions (Mohammad and Turney, 2013). The eight emotion classes are: anger, anticipation, disgust, fear, joy, sadness, surprise and trust (Mohammad and Turney, 2013). I accessed the NRC lexicon through the "tidytext" package in R (Queiroz et al., 2022).

Emoji-Based Analysis

Prior to the widespread use of emoji, emoticons were popular shorthand for facial expressions. Emoticons were introduced in the late 19-century and use punctuation marks to represent facial expressions. Emoji have extended the non-verbal communication of emoticons. The term emoji is a transliteration of the Japanese words for picture ("e"), write ("mo") and character ("ji"). Emoji are ideograms, visual symbols

that represent ideas or concepts. Emoji originated in Japan, the first set was released in 1999, however they did not become popular globally until Apple supported them for iphone use in 2010. Novak and colleagues (2015) created a emoji sentiment score for 751 emoji from over 1.6 million tweets in 13 European languages. Ranking ranges from -1 (extremely negative) to +1 (extremely positive), a score of 0 is neutral (Novak et al., 2015). Emoji were parsed from the tweet text using the “tidyemoji” R package (Yu, 2022). The parsed emoji were mapped onto the sentiment ranking of Novak and colleagues (2015) using their unique Unicode identifier to assign a sentiment score for each emoji. This sentiment score was used to create an emoji sentiment variable, see below.

4.4.6 Variable Definitions

Two different sentiment response (dependent) variables were created. The first response variable was based on the tweet text, the second based on the emoji within the tweet. Each tweet contained a timestamp, this was used to create the predictor (independent) variable - Pandemic. Timestamps were processed using the “lubridate” R Package (Spinu et al., 2022). The pandemic variable consisted of three discrete time blocks: Pre-COVID (January 1, 2019 -February 28, 2020) COVID (March 1, 2020-August 31, 2021) and Recovery (September 1, 2021- October 31, 2022). The pandemic variable was the predictor for all statistical models.

4.4.7 Descriptive and Statistical Analysis

Descriptive statistics, mean, median and maximum and minimum values were calculated for emoji sentiment scores by park. All other statistical plots were made using the “ggplot2” R package (Wickham et al., 2022). To visualize topic patterns for each park, word clouds of hashtags were created using the “wordcloud” R package (Fellows, 2018). Two types of statistical models were built: 1) a text-based (individual word) sentiment model and 2) an emoji-based (ideogram) sentiment model. Both types of models were analyzed using the non-parametric Kruskal-Wallis test and pairwise comparisons of mean values were tested using Dunn’s Method with Bonferroni Correction (Zar, 2010).

4.5 Results

4.5.1 Description of the Dataset

There were 10,821 original tweets about the six parks from January 1, 2019 - October 31, 2022 (Table C.2). The total number of tweets used for further analysis was 8,077 (74.6% of the original total). Nearly a quarter of the tweets collected were public service

announcements or advertainments and were excluded from the analysis. HP was the most tweeted about park, whereas CSS was the least tweeted about park (Table C.2). Overall, across all parks, people expressed more positive sentiment than negative sentiment regardless of pandemic conditions (Figure C.1, Table C.3). Of the total number of tweets analyzed, 19.7% of tweets contained emoji (Table C.4). In emoji containing tweets, over 80% contained a single emoji per tweet (Figure C.2). HBP contained the most tweets with emoji (32.4%) whereas CSS contained the least number of tweets with emoji (7.5%) (Table C.4). The sentiment ranking captured 62.3% of emoji in the entire dataset (Table C.4). The top 10 emoji of the entire dataset are very similar to the top 10 emoji captured by the sentiment ranking. A difference of note, the Canadian flag and camera flash emoji are not captured by the sentiment ranking (Table C.5). The average emoji sentiment score was positive (0.453) across all parks (Table C.6). HBP has the highest average (0.471) and median (0.521) emoji sentiment (Table C.6). TTP had the lowest average (0.379) and median (0.417) emoji sentiment (Table C.6).

4.5.2 Popular Hashtags

Prominent hashtags for CSS and HBP are related to bird watching, photography, scenic views and dog walking (Figure 4.3). Prominent hashtags for HP and TBP are related to cherry blossoms, politics (i.e. topoli) and COVID-19 (Figure 4.3). Prominent hashtags for SP are nature photography (particularly of mushrooms), seasons and walking (Figure 4.3). Prominent hashtags for TTP are related to birds, bird watching, nature and cycling (Figure 4.3).

4.5.3 Emoji Use and Sentiment

Unsurprisingly the most popular emoji categories were smileys and emotion and animals and nature. The most popular emoji across of all parks, HP and TBP was the cherry blossom (Table C.7). The eyes emoji was the most popular for TTP, a smiley emoji was popular for SP, the heavy black heart was the most popular for HBP and sparkles emoji were the most popular CSS (Table C.7). Different types of emoji were used during COVID compared to the Pre-COVID and Recovery phrases (Table C.8). For example, for TTP the blue heart was only used during COVID (Table C.8). IN TBP the face with medical mask and person with folded hands (prayer hands) emoji were only used during COVID (Table C.8).

More positive emoji were used prior to the pandemic in SP (Kruskal-Wallis $\chi^2(2)=7.60$, $p<0.05$; Figure 4.4a). Pre-COVID was significantly larger than COVID (Dunn's test z-score = -2.13, $p<0.05$; Table C.9). Pre-COVID was significantly larger than Recovery

(Dunn's test z-score 2.69, $p<0.05$; Table C.9). In SP positive emoji use had not returned to pre-pandemic levels. More positive emoji were used during the pandemic compared to the recovery period in TTP (Kruskal-Wallis $\chi^2(2)=8.17$, $p<0.05$; Dunn's test z-score=2.52, $p<0.05$; Figure 4.4b; Table C.9). More positive emoji were used prior to the pandemic and in the recovery phrase in TBP compared to during the pandemic Kruskal-Wallis $\chi(2)^2=21.85$, $p<0.001$; Figure 4.4c). There was significant difference between pre-COVID and COVID, (Dunn's test z-score=-4.24, $p<0.0001$; Table C.9) and between COVID and the recovery phrase (Dunn's test z-score=-3.37, $p<0.01$; Table C.9). Across all parks more positive emoji were used prior to the pandemic compared to during the pandemic (Kruskal-Wallis $\chi(2)^2=10.95$, $p<0.01$; Figure 4.4d). Pre-COVID was significantly higher than COVID (Dunn's test z-score =-3.27, $p<0.01$; Table C.9).

4.5.4 Word-Based Sentiment

Visitors of TBP showed the greatest difference in emotional valence among the three time periods. There were significantly more sadness expressed during COVID and Pre-COVID compared to the Recovery phrase, Kruskal-Wallis $\chi^2(2)=6.60$, $p<0.05$ (Table C.10 and Figure 4.5a). The Recovery phrase had the least amount of sadness expressed. COVID had more sadness expressed than the Recovery phrase, Dunn's test z-score=2.42, $p<0.05$. Pre-COVID had more sadness expressed than the Recovery phrase, Dunn's test z-score =2.16, $p<0.05$. Significantly more fear was expressed by TBP visitors during COVID compared to Pre-COVID or the Recovery phrases (Kruskal-Wallis $\chi^2(2)=11.60$, $p<0.01$; Table C.11, Figure 4.5b). COVID had more fear expressed compared to pre-COVID, Dunn's test z-score 2.71, $p<0.01$ (Table C.11). COVID had more fear expressed than Recovery, z-score=2.50, $p<0.05$ (Table C.11). Visitors to HP expressed higher anticipation Pre-COVID compared to COVID; Kruskal-Wallis $\chi^2(2)=6.09$, $p<0.05$, Dunn's test z-score=-2.46, $p=0.02$ (Table C.12, Figure 4.5c). Visitors to TTP expressed greater surprise during COVID compared to the Recovery phrase; Kruskal-Wallis $\chi^2(2)=7.78$, $p<0.05$; Dunn's test z-score=2.58, $p<0.05$ (Table C.13; Figure 4.5d). There are no significant differences in the amount of joy, anger and disgust expressed across the three time periods (Table C.14-16).

4.6 Discussion

More positive emoji were used in SP, TBP and across all parks prior to the start of pandemic restrictions compared to during pandemic restrictions (Figure 4.4). TBP and across all parks a rebound of positive emoji use had occurred, with no differences in emoji sentiment during the pandemic restrictions compared to the recovery phrase. SP has not experienced this rebound in positive sentiment (Figure 4.4). Interestingly TTP had more positive emoji during the pandemic restrictions compared to the recovery

period (Figure 4.4). Visitors to TTP expressed more surprise during the pandemic compared to the recovery phrase (Figure 4.5). TTP is considered an urban wilderness. In a survey of 25,000 French urban residents, perceived well-being had the higher association with “undomesticated” nature – fields, forests and scrublands compared to other UGS – city parks and gardens (Allard-Poesi et al., 2022). Similarly, Yap and colleagues (2022) compared Google search results UGS in Singapore pre-pandemic (Pre-Circuit Breaker) and after a relaxation in mobility restrictions (Post-Circuit Breaker). Pre-Circuit Breaker, the top searched UGS were all manicured, whereas Post-Circuit Breaker the top searched UGS were less manicured and more naturalistic (Yap et al., 2022). In the City of Edmonton, AB, Canada, visitors to Natural Area Parks valued them for the parks being dominated by natural features close to where they lived, study reported that it gave them “a feeling of being away” (Cheesbrough et al., 2019). Expression of surprise during the pandemic, may indicate visitors to TTP were experiencing the parks as an escape and discovering urban nature. Visitors to HP expressed more anticipation prior to the pandemic compared to during the pandemic (Figure 4.4). This may be explained by visitors looking forward to activities at the park. Large parks promote social cohesion, due to their size, it allows several different types of activities to occur at the same time (Ayala-Azcárraga et al., 2019).

The emotions of joy, anger and disgust did not differ among the three time periods. Unsurprisingly visitors to TBP expressed the most fear during the pandemic. There is no difference in the amount of fear expressed pre-pandemic and post-pandemic periods, which may indicate a restorative effect. In an online survey of 323 university students in the city of Plovdiv, Bulgaria, access to outdoor greenery (i.e. a garden) was found to have a restorative effect on mental health during the COVID-19 quarantine period (Dzhambov et al., 2021). TBP visitors expressed the least amount of sadness during the Recovery phrase (Figure 4). Previous research of twitter data has shown that people are generally happy within UGS (Roberts, 2017; Lim et al., 2018). In a study of 21.2 million tweets of users in Melbourne, Australia; Lim and colleagues (2018) found more positive emotions and less negative emotions expressed within UGS. Also, people expressed more positive emotions within UGS compared to non-UGS (Lim et al., 2018). In a sentiment analysis of 10,000 tweets, covering 60 UGS in Birmingham, UK, positive emotional responses were more common than negative responses and happiness was the highest frequency emotion expressed (Roberts, 2017). Anger responses occurred because of events happening within the UGS rather than the space itself (Roberts, 2017). Fear responses were associated with the UGS space, not feeling safe at that location, particularly at night (Roberts, 2017). In a study of facial expressions of photographs posted to social media from 34 UGS across 3 cities in Northern China; expressions of happiness were expressed most frequently and strongly (Zhu et al., 2021). Visitors to UGS in the Chinese megacity of Nanjing expressed greater

appreciation and more awareness of high quality UGS in their daily lives during pandemic restrictions compared to prior to the pandemic (Cheng et al., 2021).

TBP had the greatest emotional swings and non-nature related hashtags (Figures 3-5). Although HP did have political hashtags (i.e. onpoli) the prominent hashtags were related to nature (Figure 4.3). TBP is much smaller than HP and the surrounding neighborhood has little UGS per capita. These factors may contribute to TBP being a more contested space compared to the other parks examined. Key UGS features that promote well-being are distance to home, tree abundance, quality of facilities, cleanliness and a sense of safety (Ayala-Azcárraga et al., 2019). In study of urban green and blue space (parks, waterways and lakes) in Georgetown, Guyana, it was found that the sense of safety had the strongest sense of well-being compared to other features (Fisher et al., 2021). A key factor in creating a sense of safety among UGS visitors are relationships of trust (Ayala-Azcárraga et al., 2019). Sharing a space with trustworthy neighbors, well-known people and trustworthy visitors are promotors of trust in UGS (Ayala-Azcárraga et al., 2019). Junot and colleagues (2018) examined the influence of two aspects of place attachment on general well-being and pro-environmental behavior. The two aspects were 1) place identity, defined as the beliefs, feelings, values and patterns of behavior that connect personal identity to a physical environment and 2) place dependence, defied as a functional connection to a specific place which support specific goals and desired activities (Junot et al., 2018; for a review see of place attachment Raymond et al., 2010; Halpenny, 2010). They found that place identity was not related to perceived well-being and negatively related to pro-environmental behaviors; whereas place dependence was positively related to subjective well-being and pro-environmental behavior (Junot et al., 2018). Dasgupta and colleagues (2022) considered two additional aspects of patch attachment, nature bonding (connectedness to nature) and social bonding among residents of the Greater Tokyo region specifically in relation to UGS. They found that nature bonding variables were highly correlated to place dependence; indicating a more utilitarian function of UGS among respondents (Dasgupta et al., 2022).

To my knowledge this is one of the first studies to incorporate emoji sentiments in the context UGS, well-being and urban biodiversity at a city scale. Emoji research is rapidly expanding. Current research is dominated by the fields of computer science, marketing, communications, linguistics and psychology (Bai et al., 2019). Typically studies of emoji are conducted at a global scale (Ljubešić and Fišer, 2016; Li et al., 2019). This makes direct comparison of results difficult. Das (2021) collected tweets from over 220 countries at two time periods – July 2019 (pre-pandemic) and March 2020 (pandemic). Using Novak and colleagues (2015) emoji sentiment ranking; the top 5 emoji scores stayed largely unchanged pre-pandemic and at the beginning of the pandemic (Das,

2021). Das (2021) found no significant difference in the popular emoji (top 10) used between the two timeframes. This was interpreted as a lack emoji to express the sentiments associated with the pandemic (Das, 2021). Although my study is local rather than global, significant differences in emoji sentiment score were detected (Figure 4.4). For example, in TBP, the face with medical mask and person with folder hands (prayer hands) only appeared during the COVID timeframe (Table S8).

The COVID-19 pandemic has highlighted the value of urban nature to diverse publics. Marconi and colleagues (2022) observed a shift in the perception of the role of UGS among residents of Buenos Aires City, Argentina. Pre-pandemic the main role of UGS was described as “a place to be with nature”; whereas during the height of the restrictions the main role of UGS was described as “an important place in the city” (Marconi et al., 2022). In the United Kingdom, in an online qualitative survey conducted in August 2021; 90% of participants reported that green spaces had improved their quality of life during the pandemic and 85% think that green spaces will continue to have a positive impact on their lives once the pandemic has ended (Crossley and Russo, 2022). There is uncertainty if this is a short term or more permanent shift in thinking (Crossley and Russo, 2022). Dushkova and colleagues (2022) conducted surveys of experts (public officials, academics, NGO and citizen groups) and local residents of Moscow, Russia on the importance of UGS. All groups agreed UGS were important for coping with the challenges posed by COVID-19 and the need for all residents to have equal access to UGS (Dushkova et al., 2022). Greater awareness and appropriation of UGS has implications of future expansion of UGS networks and the maintained of existing networks. Policymakers wishing to expand and enhance existing UGS could cease upon this moment of social capital.

Humans are irrational and emotional (Cosmides and Tooby, 2000). Although evolutionary psychologists argue the behavioral patterns caused by our “irrational” emotions were adaptive under ancestral conditions (Cosmides and Tooby, 2000). Emotions are the driving force of decision making and motivate actions; as demonstrated through marketing research. Nature helps people manage their emotions and often elicits positive emotions. Pro-nature behaviors require personal commitment (Richardson et al., 2020). A pathway to these behaviors is to increase connectedness to nature via emotions and meaning (Richardson et al., 2020). By fostering emotional bonds between people and nature, society at large may be engaged (Richardson et al., 2020). Engaging peoples’ hearts will benefit urban nature conservation.

4.7 Study Limitations

The emoji sentiment score of Novak and colleagues (2015) is not current which is a limitation of the emoji analysis performed in this study. Because new emoji are being created every year, the emoji sentiment score is dated. Released in September 2022, the Standard Unicode Emoji 15.0 had 3,664 emoji listed (The Unicode Consortium, 2023). Currently, there are nearly 5 times as many emoji in existence compared to Novak and colleagues (2015) ranking of 751 emoji. Unsurprisingly, one-third of the emoji in the dataset did not have an associated sentiment score (Table C.4). Nevertheless, the procedure of applying emoji analysis in the urban ecology space may be easily replicated with an updated sentiment ranking, when one becomes publicly available.

Data collection via Twitter for UGS research has several advantages, it is unobtrusive, cost-effective and less time intensive compared to observation or intervention-based methods (Roberts, 2017). The use of Twitter data is research has several limitations. Sociodemographic variables such as age, gender and education level are absent. There are significant differences in how individuals relate to nature and these individual traits mediate responses to visiting UGS (Schwartz et al., 2019). Population bias is present (ref. Olteanu et al., 2019). Twitter users tend to be younger (under 50 years old), wealthier and urban (Zabelskyte et al., 2022). In 2021, 25-34 years old comprised 38.5% of Twitter's user base and 56.4% were men (Dixon, 2022). Users are most likely to tweet about an exceptional experience rather than common experiences (Kovacs-Györi et al., 2018). Fake accounts may exist designed to influence public opinion, posting negative or positive tweets (Roberts, 2017). This study was relatively small, in larger datasets (millions of tweets) fake influencer accounts may be more difficult to detect. Currently, Twitter's policy heavily restricts access to geotagged tweets (Twitter Inc., 2023). Cao and colleagues (2022) explored the effect of three Twitter app policy changes in 2015, 2017 and 2019. Of interest here are the policy changes in 2015 and 2017. In April 2015, the default option (opt-in) to share the exact coordinates of each tweet was removed and in November 2017 the permitted number of characters increased from 140 to 240 characters per tweet (for details see Cao et al., 2022). Prior to the April 2015 policy change the number of tweets containing exact was coordinates was 97.3%; after the policy change this dropped to 17.5% (Cao et al., 2022). If researchers are granted permission to access coordinates associated with individual tweets, number of geotagged tweets is greatly reduced. Post November 2017, tweet length and place name mentions within tweet text increased (Cao et al., 2022). The increase in tweet length made sentiment analysis easier (Cao et al., 2022). Although not as accurate as geotagged tweets, the increase in place name mentions does allow for general location identification. The six focal parks studied are in a range of urban

neighborhoods. While a brief description is given in section 4.4.2, a deep dive into the socioeconomics of the surrounding neighborhoods was not provided due to time constraints. There are two ways to provide in-depth context for these parks: 1) in-person surveys of park users and 2) acquiring publicly available data on social-economic characteristics of surrounding neighborhoods from Statistics Canada and the City of Toronto.

4.8 Future Work

Previous studies have assessed the value of social media data on UGS for urban planning (Kovacs-Györi et al., 2018; Heikinheimo et al., 2020). However, data methodologies and analyses need to be improved to support urban planning (Zabelskyte et al., 2022). A triangulation of text, emoji and photographs from social media may support urban planning. For example, Oteros-Rozas and colleagues (2018) analyzed landscape features in photographs posted to social media. They identified specific cultural ecosystem services (recreation, social, spiritual or cultural) with specific landscape features (Oteros-Rozas et al., 2018). A similar approach could extract landscape features from photographs and compare them with both text and emoji within that post. A sentiment analysis based on these three components could be conducted. Knowing which landscape feature elicit positive or negative emotions can inform future UGS design and improve existing UGS.

4.9 Conclusion

This study contributes to the growing literature on the role of UGS during an unexpected and rapid global challenge, the COVID-19 pandemic. Using Twitter data, I investigated the emotions of park visitors to six urban parks in Canada's largest city, Toronto. Two modes of communication were analyzed: words (text) and emoji (ideogram). These two modes yielded slightly differing results, indicating the value of multi-modal investigation. Understanding peoples' emotions towards their local park in times of abrupt change may be useful for planning and maintaining resilient urban environments.

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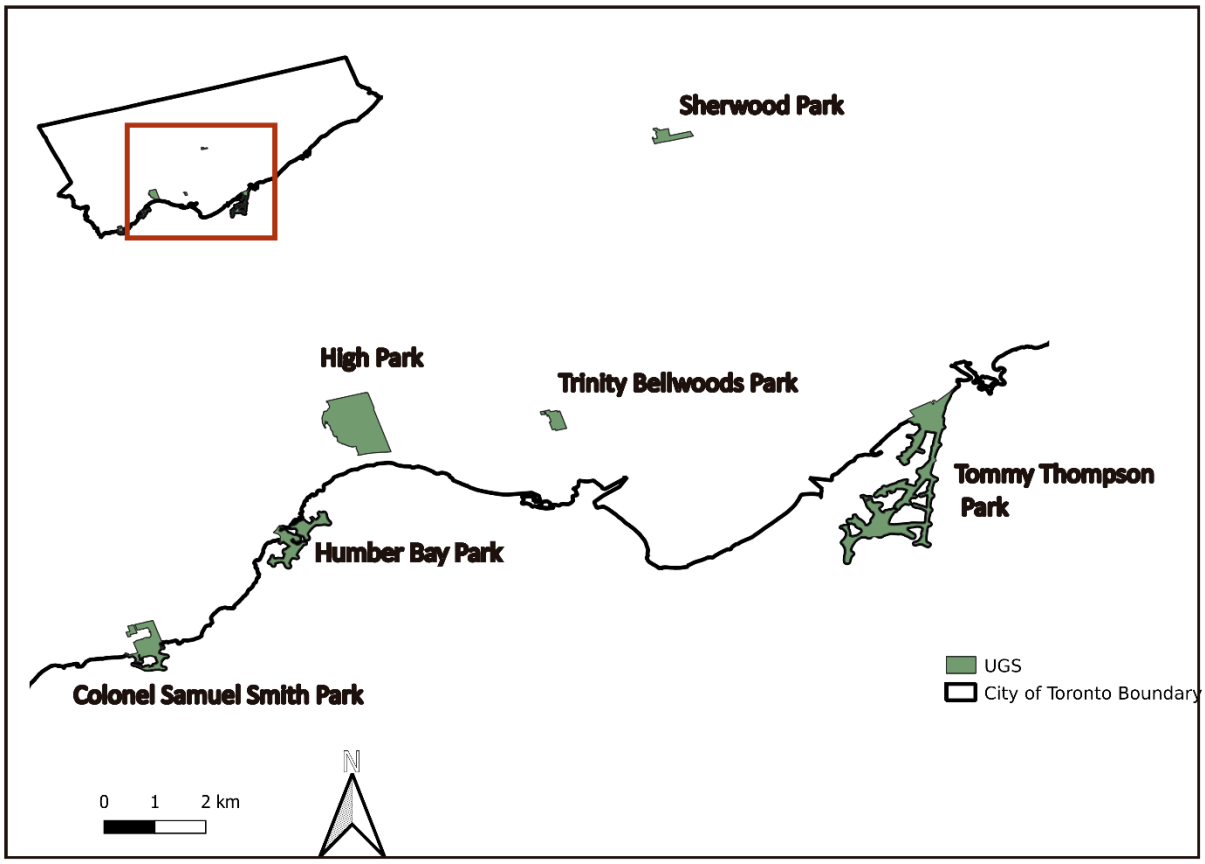

Figure 4.1: Local of focal parks analyzed in the City of Toronto. Top Left Corner: Solid black line indicates the municipal boundary of the City of Toronto. Main panel: Urban Green Space (UGS) park boundaries are indicated in dark green.

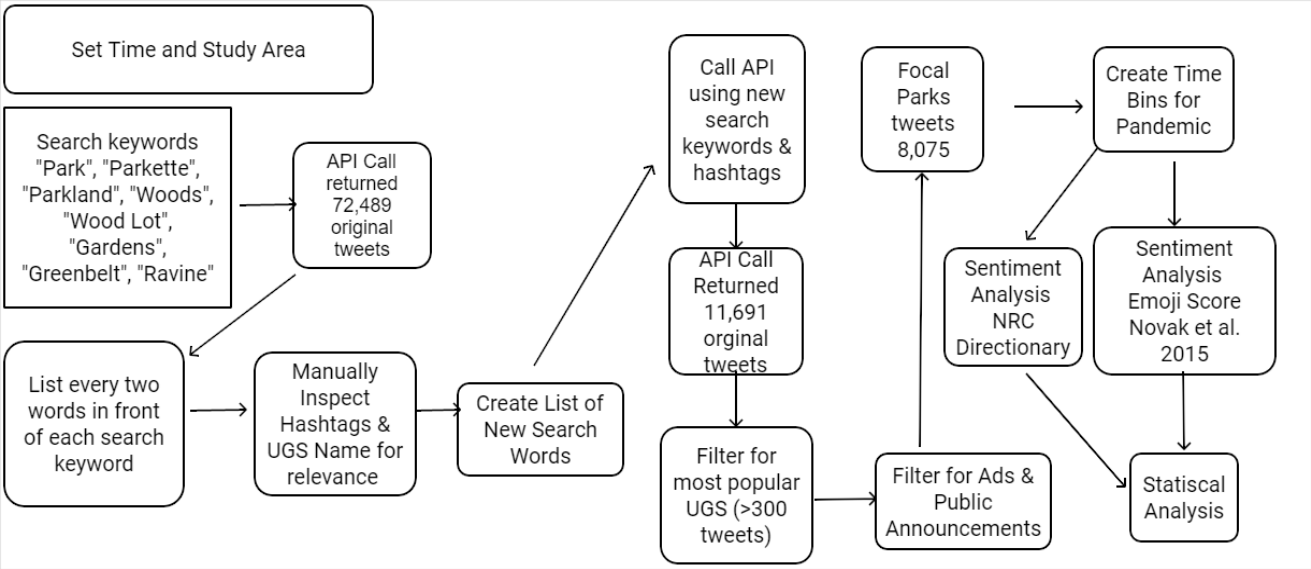

Figure 4.2: Flowchart of Twitter data collection and processing.

Figure 4.3: Wordclouds of the focal parks analyzed in this study, Colonel Samuel Smith Park (CSS), Humber Bay Park (HBP), High Park (HP), Sherwood Park (SP), Trinity Bellwoods Park (TBP) and Tommy Thompson Park (TTP).

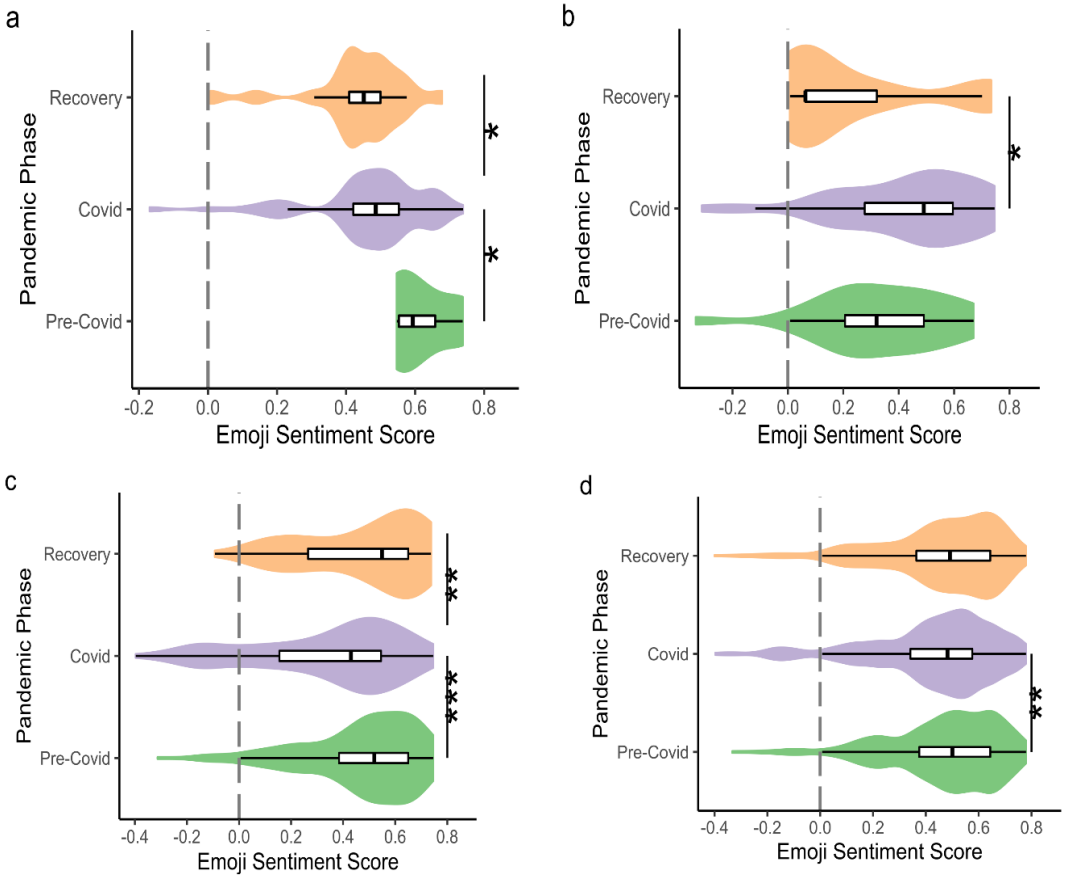

Figure 4.4: Violin and box plots of emoji sentiment scores by park. (a) Sherwood Park (SP), (b) Tommy Thompson Park (TTP), (c) Trinity Bellwoods Park (TBP) and (d) All six focal parks. A reference line (dashed black line) is place at zero. A sentiment score of zero is neutral. Asterisk (*) denote significance level based on pair-wise comparisons using Dunn's test. One asterisk (*) denotes $p<0.05$, two asterisks (**) denotes $p<0.01$, three asterisks (***) denotes $p<0.0001$.

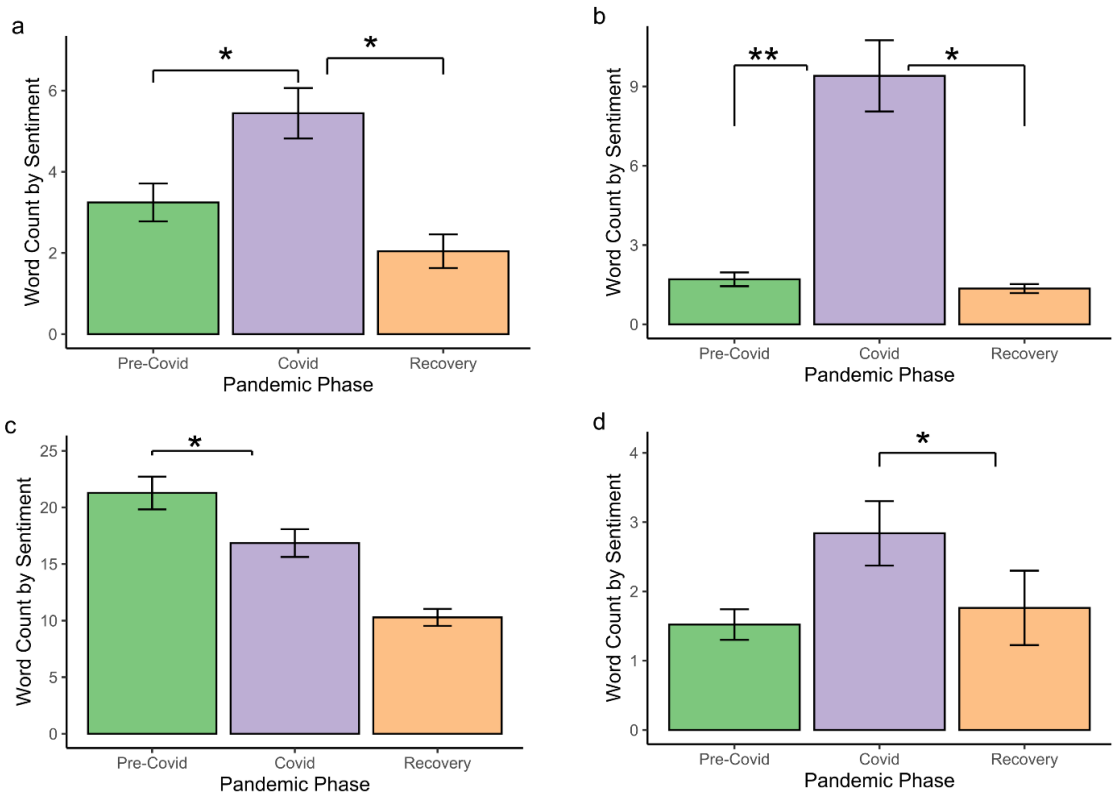

Figure 4.5: Bar plots with error bars based on 95% confidence intervals of word-based sentiment analysis by park. (a) Sadness emotion of Trinity Bellwoods Park (TBP), (b) Fear emotion of Trinity Bellwoods Parks (TBP), (c) Anticipation emotion of High Park (HP) and (d) Surprise emotion of Tommy Thompson Park (TTP). Asterisk (*) denote significance level based on pair-wise comparisons using Dunn's test. One asterisk (*) denotes $p<0.05$, two asterisks (**) denotes $p<0.01$.

5 Chapter 5: Discussion and Conclusions

My dissertation analyzed different values of nature at the local, national and global scale with the aim of supporting the bridging of the science-policy-practice gap. In the following sections, I highlight major findings from each chapter, discuss implications, limitations and identify directions for future research.

5.1 Bridging the science-policy-practice gap: A Perspective of a Scientist

In Chapter 1, I established that there is no shortage of scientific knowledge about the biodiversity crisis, rather there is a lack of actionable, relevant and accessible scientific information for conservation practitioners. There is a mismatch of ways of thinking and goals among researchers and practitioners. Researchers seek to publish in the academic literature and operate on precision, reliability and validity (Gerber et al., 2023). Practitioners seek practical solutions and operate on urgency and flexibility (Gerber et al., 2023). To support bridging this gap, my dissertation examined diverse values of nature across scales. The fields of landscape and urban ecology informed my thinking on appropriate scales and my conceptualization of values types was informed by a review of the conservation and sustainability academic literature.

5.2 The Local Scale: Parks, Emotions and Relational Values

Chapter 4 asks the question, *how has the COVID-19 pandemic affected peoples' emotions towards their local park (urban green space) in a large city?* I answered this question by identifying Twitter users' sentiments towards their local park in Toronto, Canada; before, during and after the COVID-19 pandemic restrictions using a text-based and an emoji-based sentiment analysis. To my knowledge this is amongst one of the first studies to incorporate emoji sentiments in the context of parks, well-being and urban biodiversity at a local scale. Typically studies of emoji are conducted at a global scale (Ljubešić and Fišer, 2016; Li et al., 2019). I found that regardless of pandemic condition, people expressed more positive sentiment compared to negative emotions when tweeting about their local park. During and post pandemic restrictions Toronto's parks were places of anticipation, surprise and recovery. Findings from this chapter align with the living in nature life frame. In the living *in* nature life frame, relational values are prominent (IPBES, 2022, p. 71). Themes of aesthetic value, nature's contribution to people and sense of place are present.

5.3 The National Scale: Engagement, Bee Conservation and Instrumental Values

Chapter 2 asks the question, *how is indigenous biodiversity understood and valued by the Canadian public(s) in urban and suburban settings?* I answered this question by applying ordinal and multinomial regression models to a national telephone survey to assess Canadians' knowledge of and perceived barriers to native pollinator conservation. Canadians surveyed were highly engaged with the topic of bee conservation despite overall low general knowledge about bees. Respondents primarily valued native bees for their ecosystem services provision and thought the federal/provincial government should take the lead in native bee conservation efforts. This study makes an important methodological contribution by using a multinomial logistical regression modelling approach more common to Health Policy (van Exel et al., 2008; Baji et al., 2013) and Sociology (Yamaguchi, 2000) but less widely used in conservation science and policy. Finding from this chapter align with the Living *from* nature life frame. In the living from nature frame, instrumental values such as ecosystem services and nature's contribution to people are prominent (IPBES, 2022, p. 71). Canadians valued bees for their pollination of crops and making honey.

5.4 The Global Scale: Money, Messaging and Instrumental and Intrinsic Values

Chapter 3 asks the question*, how and why has the conversation about nature and sustainability evolved over the past 25 years within the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF)?* What are the sustainability policy implications of this evolution? I answered this question by tracing and analyzing the evolution of ecological and economic framing of nature using content analysis of a global governmental organization (GO), the United Nations Environment Programme (UNEP) and compare it to a global environmental non-governmental organization (ENGO), the World Wildlife Fund (WWF). The way an issue is presented or described is referred to as framing (Kusmanoff et al., 2020). Different frames may be used strategically to target different audiences; particularly in the case of biodiversity conservation multiple frames are often needed (Kusmanoff et al., 2020). I used a novel technique to the environmental policy and advocacy space – Correspondence Analysis (CA) to trace the shifts in framing. By analyzing over 50 documents I found UNEP primarily use positive economic framing whereas WWF uses positive environmental governance framing to communicate to its audience. Donors to the UNEP and WWF influence what language is used and thereby shape the conversation about sustainability policy. In contrast to chapters 2 and 4, findings from chapter 3 align with two life frames: living *from* nature and living *with* nature. Communication from the UNEP

aligns with the living from nature life frame whereas communication from the WWF aligns with the living with nature life frame. In the living with nature frame, intrinsic values such as existence rights and existence value (independent of human use) are prominent (IPBES, 2022, p. 71).

5.5 Recommendations from Values of Nature across Scales

The Local Scale

Toronto's parks act as emotional buffers in times of unexpected stress and societal shock. Relational values are the primary pathway Toronto's social media users are connecting with and valuing nature in their local parks. These findings may be interpreted as political capital for the maintenance of existing parks and future park or urban green space expansion.

The National Scale

Canadians care about native bee conservation and want a top-down, government led approach to their conservation. Instrumental values are the primary pathway Canadian's surveyed are connecting with and valuing native biodiversity. These findings demonstrate grassroot support for government lead conservation efforts. Clear communication of public support for bee conservation needs to be conveyed to decision-makers at provincial and federal levels of government.

The Global Scale

Environmental organizations use different communication strategies to speak to their target audiences. The UNEP primarily uses the instrumental values of nature pathway to connect with its donors and diverse publics. The WWF primarily uses the intrinsic values of nature pathway to connect with its donors and diverse publics. Continued and consistent funding is critical for both organizations. Value pathways are expected to be tightly aligned with perceived value types of donors.

5.6 Limitations and Future Research

The synthesis of social and ecological work presents practical and theoretical challenges such as the over/under representation of certain demographic groups and difficulties in reconciling typologies across fields. In Chapter 2 the main limitation was an over/under representation of certain demographic groups of the Canadian population. The demographic variable with the strongest predictive power was stated federal voting intent. There was possible underrepresentation of Conservative Party voters (Table A.1)

compared to voter turnout of the 2019 federal election. Although the proportion of Conservative Party voters in the 2019 federal may be because more Conservative voters participated in the election. For a detailed discussion see Section 2.6. Interestingly, there was no difference among Green party voters between valuing bee protection for ecosystem services (extrinsic motivation) and ecological (intrinsic motivation) categories (Table A.7). Given Green party supporters hold values of ecologism (Camcastle, 2007), one would expect Greens to state ecological values as the reason for bee conservation. A follow-up survey could focus on elucidating nature values types using the IPBES life frames. The life frames are more nuanced and may tease apart more salient meanings.

The general limitations of Chapter 3 is that the field of discourse analysis has a lack of meta-studies and has multiple theoretical frameworks (Leipold et al., 2019) and there are multiple typologies of environmental discourses (for examples see Bina, 2013; Dryzek, 2013) hindering comparison among studies. Recently, Rockström and colleagues (2023) extended the concept of planetary boundaries (PB) to include a justice dimension, termed safe and just earth system boundaries (ESBs). Safe and just ESBs incorporate concepts of interspecies justice, inter and intragenerational justice (Rockström et al., 2023). Safe and just ESBs integrate the biophysical limits of PB with a social justice dimension. If ESBs can successfully transition from the academic literature to the policy domain, it has the potential to be a bridge the fields of social justice, ecological justice and physical sciences. Future studies could analyze stated values of donors to the UNEP and WWF. Is there alignment between stated values of donors and UNEP and WWF messaging? How closely does the UNEP and WWF track any changes in stated values of donors over time?

The key limitation for Chapter 4 was the lack of a current emoji sentiment ranking list. Currently, there are nearly 5 times as many emoji in existence compared to Novak and colleagues (2015) ranking of 751 emoji. Unsurprisingly, one-third of the emoji in the dataset did not have an associated sentiment score (Table C.4). An updated and publicly available emoji sentiment ranking list should be created. As new emoji are created, an international ideogram vocabulary is expanding. As this mode of communication becomes increasingly complex, people may be able to express more ideas related to their diverse values of nature. Future studies could explore peoples' emotions and values towards nature using a triangulation of text, emoji and images.

5.7 Concluding Remarks

In this dissertation, I analyzed the diverse values of nature at different scales of society to support the bridging of the science-policy-practice gap and thereby enhance

biodiversity and sustainability outcomes. I found that at the local scale, relational values are the pathway in which people connect with nature. Local parks supported emotional well-being before, during and after pandemic restrictions. This knowledge may be used by municipal governments as political capital for UGS expansion. More parks and UGS support urban biodiversity. At the national scale, I found that instrumental values are the pathway in which people connect with nature. Canadians care about the topic of bee conservation, value bees for their ecosystem service provision and think the federal and provincial governments should be leading conservation efforts. This grassroots support needs to be communicated to political leaders and integrated into policy platforms. At the global scale, instrumental and intrinsic values of nature were being used to connect people with nature. The UNEP and WWF know their respective audiences and are tailoring their messaging to them. A steady stream of funding allows both organizations to continue their environmental advocacy work. A more complete and nuanced understanding of diverse human values of nature can yield win-win solutions for both people and biodiversity.

5.8 References

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A Appendix A: Supplementary Information for Chapter 2

Table A.1: Demographic factors, frequency and proportion of respondents in each group, compared with data from the 2016 Canadian Census

Factor	Group	Frequency in Survey Sample (n=1969)	Proportion in Survey Sample (%)	Proportion in the Canadian Population (%)
Federal Vote Intent	Liberal Party	641	32.6	33.1[a]
	New Democratic Party	350	17.8	15.9[a]
	Conservative Party	509	25.9	34.4[a]
	Green Party of Canada	74	3.8	6.5[a]
	Bloc Quebecois (Quebec Only)	83	4.2	7.7[a]
	Undecided	312	15.8	NA
Province	Alberta	193	9.8	11.8[b]
	British Columbia	256	13	13.2[b]
	Manitoba & Saskatchewan	137	7	6.8[b]
	The Maritimes	139	7.1	5.2[b]
	Ontario	769	39.1	38.3[b]
	Quebec	475	24.1	23.2[b]
Age*	18-35	656	33.3	20.2[c] (20-34)
	36-51	512	26	20.3[c] (35-49)
	52-62	279	14.2	22.3[c] (50-64)

	63-70	230	11.7	23.3[c] (65-69)
	71+	292	14.8	14[c] (70+)
Combined Household Income	Under $50,000	310	15.7	34.8[d]
	$50,000-$74,999	598	30.4	18.3[d]
	$75,000-$99,999	295	15	14.2[d†]
	$100,000 & above	451	22.9	32.4[d†]
	Declined to Answer	315	16	NA
Rural/ Urban	Urban	1446	73.4	71.5[e]
	Rural	523	26.6	28.5[e]
Gender	Male	986	50.1	47.6[f]
	Female	983	49.9	53.4[f]

*Age is calculated as a proportion of people aged 18 and over, because we did not survey people under the age of 18 years of age.

[a] Federal Vote Proportion based on the popular vote (total numbers of votes a party received) in the 2019 Canadian federal election. Source: Elections Canada. 2020. October 21, 2019 Federal Election, Election Results. Retrieved from Elections Canada Website: https://enr.elections.ca/National.aspx?lang=e.

[b] Source: Statistics Canada. 2017. Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29 2017. http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

[c] Age classes from the Canadian 2016 Census categories do not completely match the age classes we used in our survey. Census age classes are in brackets below the proportion. Source: Statistics Canada. 2017. Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29 2017. http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

[d] Income proportions are based on total 2015 private household income for people 15 and over. †The Statistics Canada 2016 Census did not match our categories explicitly, as one of the income brackets in the census goes from $70,000 to 79,999 while our category ended at $75,000. We assumed that households would be evenly distributed throughout this category, and thus we split the total for the Statistics Canada $70,000-$79,900 category in half and put half in each of our $50,000-$74,999 and $75,000-$99,999 income brackets. Source: Statistics Canada - 2016 Census. Catalogue Number 98-400-X2016097.

[e] Statistics Canada. Table 17-10-0135-01 Population estimates, July 1, by census metropolitan area and census agglomeration, 2016 boundaries DOI: https://doi.org/10.25318/1710013501-eng

[f] Gender proportions for the Canadian population are based on people 20 and over. Source: Statistics Canada. 2017. Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29 2017. http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

Table A.2: Descriptive Statistics for Question 1: “Thinking of the many species of wild bees that are native to Canada, how many can you name?” (n=2000; open-ended question)

	Bumble bees	Drone bees**	Honey bees*	Mason Bee	NA	Queen Bees**	Wasps*	Yellow* jackets
Count	588	38	1028	1	237	41	8	59
%	29.4%	1.9%	51.4%	<1%	11.8%	2%	0.4%	3%

NA- participants did not know or could not name a species.

* denotes a response that is not a wild native bee

** denotes a response that is not an appropriate name and may or may not refer to a wild native bee

Table A.3: Results from a Cumulative (Ordinal) Logistic Regression Model for Question 2: "How concerned are you about the health of honeybees and the conservation of wild, native bees in Canada? Please use a scale from one not at all concerned to five very concerned"

Income	Rural/Urban	Vote	Age	Area (Province)	Gender
p=0.8466	p=0.1345	**p=<0.001** (Green party voters and Bloc voters, 3.78 and 1.91 compared to PC voters)	**p<0.05** (Aged 71 and over 0.67 compared to people 18-35)[a]	**p<0.01** (BC and Quebec, 1.63 and 1.47 compared to Alberta)[a]	p=0.8805

Note: p-values are based on X^2 tests, with significant tests in bold ($p<0.05$). Odds ratios are given in brackets for significant predictors. a: To obtain odds ratios factors were modelled as a non-nominal variable, but these factors are best fitted as a nominal variable.

Table A.4: Original Item List and Consolidated Categories for Question 3: "Why (if at all) is it important that bees are protected?"

Original List	(n)	New Categories	(n)
Pollination	706	ES	1344
Honey	638		
Nature	52	Eco	478
Endangered	426		
Don't Know	69	Don't Know	69
Don't Care	78	Indifferent	78

Table A.5: Original Item List and Consolidated Categories for Question 5: “Which of the following do you feel should MOST take responsibility for the protection of wild native bees and their populations in Canada?”

Original List	(n)	New Categories	(n)
Agricultural Industry	9	Agriculture	208
Beekeepers	158		
Commercial Operators	41		
Fed/Prov Government	1002	Government	1042
Local Gov.	40		
Homeowners	42	Own	191
Landowners	149		
Pesticide Manufacturers	443	Unchanged	443
Don't Know	85	Unchanged	85

Table A.6: Original Item List and Consolidated Categories for Question 6: “What if anything is preventing you from doing more to help save bees?”

Original List	(n)	New Categories	(n)
Can't Find Plants	35	Lack of Resources	284
Lack of gardening space	38		
Lack of time and money	167		
Live in a Condo	19		
No Space	25		
Not a priority	382	Unchanged	382
No Barriers- already helping	650	Unchanged	650
Dislike/Fear Bees	182	Unchanged	182
Don't Know how to help	471	Unchanged	471

Table A.7: Results of a multinomial logit model for Question 3: “Why (if at all) is it important that bees are protected?” Ecosystem services is the reference level for the response variable.

	Don't Know	Ecological (Pro-Nature)	Indifferent
Constant	0.034 **p<0.001**	0.348 **p<0.001**	0.117 **p<0.001**
Rural/Urban(Urban)	p=0.064	p=0.864	p=0.077
Gender(Male)	p=0.516	p=0.289	p=0.924
Income(NA)	p=0.867	p=0.062	p=0.822
Income(75-100K)	p=0.864	p=0.098	p=0.814
Income(50-74K)	p=0.267	p=0.650	p=0.347
Income(>100k)	p=0.960	p=0.428	p=0.246
Vote(NDP)	p=0.085	p=0.945	0.264 **p<0.001**
Vote(NA)	0.392 **p<0.05**	p=0.945	0.264 **p<0.001**
Vote(LP)	0.460 **p<0.05**	p=0.413	0.144 **p<0.001**
Vote(Greens)	p=0.331	p=0.523	p=0.955
Vote(Bloc)	p=0.670	p=0.245	0.0005 **p<0.001**
Area(QC)	p=0.706	p=0.697	p=0.880
Area(ON)	p=0.324	p=0.487	p=0.342
Area(MT)	p=0.278	p=0.414	p=0.441
Area(MB.SK)	p=0.207	p=0.528	p=0.596
Area(BC)	p=0.476	p=0.562	p=0.249
Age(36-51)	p=0.470	p=0.544	p=0.484
Age(52-62)	p=0.940	p=0.477	p=0.127
Age(63-70)	p=0.130	p=0.462	p=0.785
Age(71+)	3.08 **p<0.01**	1.38 **p<0.05**	p=0.939

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.8: Results of multinomial logit model for Question 5: “Which of the following do you feel should MOST take responsibility for the protection of wild native bees and their populations in Canada?” Pesticide Manufacturers is the reference level for the response variable.

	Agriculture	Don't Know	Government	Own
Constant	0.448 p=0.048	0.187 **p<0.01**	1.710 p=0.049	0.386 **p<0.05**
Rural/Urban(Urban)	p=0.470	0.459 **p<0.01**	p=0.742	p=0.054
Gender(Male)	p=0.827	p=0.965	p=0.734	p=0.139
Income(NA)	p=0.540	p=0.952	p=0.885	p=0.764
Income(75-100K)	p=0.074	p=0.843	p=0.755	p=0.388
Income(50-74K)	p=0.046	p=0.749	p=0.263	p=0.086
Income(>100k)	p=0.414	p=0.341	p=0.433	p=0.863
Vote(NDP)	p=0.254	p=0.766	1.578 **p<0.05**	p=0.623
Vote(NA)	p=0.999	p=0.470	p=0.178	p=0.536
Vote(LP)	p=0.300	p=0.422	p=0.623	p=0.211
Vote(Greens)	p=0.087	p=0.759	p=0.075	p=0.281
Vote(Bloc)	p=0.633	p=0.157	p=0.042	p=0.687
Area(QC)	p=0.429	p=0.410	*p=0.059*	p=0.582
Area(ON)	p=0.168	p=0.491	p=0.642	p=0.787
Area(MT)	p=0.810	p=0.894	1.804 **p<0.05**	p=0.791
Area(MB.SK)	2.604 **p<0.05**	p=0.402	p=0.054	2.420 **p<0.05**
Area(BC)	p=0.179	p=0.988	1.734 **p<0.05**	p=0.234
Age(36-51)	p=0.492	p=0.533	p=0.620	p=0.769
Age(52-62)	p=0.787	p=0.434	p=0.136	p=0.441
Age(63-70)	p=0.508	p=0.894	p=0.100	p=0.763
Age(71+)	p=0.096	2.373 **p<0.05**	p=0.225	p=0.632

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.9: Results of multinomial logit model for Question 6: “What if anything is preventing you from doing more to help save bees?” No Barriers is the reference level for the response variable.

	Lack of Resources	Dislike/Fear Bees	Don't Know	Not a Priority
Constant	0.157 **p<0.001**	0.203 **p<0.001**	p=0.162	p=0.209
Rural/Urban(Urban)	2.76 **p<0.001**	1.663 **p=0.013**	p=0.550	p=0.655
Gender(Male)	p=0.517	p=0.469	p=0.852	p=0.821
Income(NA)	p=0.382	p=0.388	p=0.458	p=0.267
Income(75-100K)	p=0.353	p=0.749	p=0.645	p=0.204
Income(50-74K)	p=0.668	p=0.762	p=0.941	p=0.091
Income(>100k)	p=0.378	p=0.368	p=0.287	p=0.108
Vote(NDP)	p=0.940	p=0.768	p=0.786	0.648 **p<0.05**
Vote(NA)	p=0.645	p=0.727	p=0.984	p=0.723
Vote(LP)	p=0.231	p=0.589	p=0.312	p=0.220
Vote(Greens)	*p=0.060*	p=0.957	p=0.110	0.043 **p<0.01**
Vote(Bloc)	p=0.229	p=0.433	p=0.703	0.223 **p<0.01**
Area(QC)	p=0.637	p=0.404	p=0.637	0.546 **p<0.05**
Area(ON)	p=0.489	p=0.685	p=0.590	0.646 **p<0.05**
Area(MT)	p=0.132	p=0.754	p=0.234	p=0.741
Area(MB.SK)	p=0.895	p=0.695	p=0.405	0.540 p=0.047
Area(BC)	p=0.340	p=0.810	p=0.180	0.303 **p<0.001**
Age(36-51)	p=0.777	p=0.093	p=0.900	p=0.768
Age(52-62)	p=0.763	p=0.579	p=0.850	p=0.243
Age(63-70)	p=0..488	p=0.830	p=0.087	p=0.909
Age(71+)	p=0.354	p=0.984	p=0.688	p=0.279

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.10: Results of multinomial logit model for Question 7: “Honeybees can replace wild, native bees in pollinating crops and wild flowers.” Disagree is the reference level for the response variable.

	Agree	Don't Know
Constant	p=0.625	4.769
		p<0.001
Rural/Urban(Urban)	p=0.631	p=0.085
Gender(Male)	p=0.242	p=0.286
Income(NA)	p=0.726	p=0.642
Income(75-100K)	p=0.657	p=0.859
Income(50-74K)	p=0.898	p=0.714
Income(>100k)	p=0.586	p=0.857
Vote(NDP)	p= 0.189	p=0.056
Vote(NA)	p= 0.877	p=0.226
Vote(LP)	p=0.170	0.619
		p<0.01
Vote(Greens)	0.253	0.379
	p< 0.01	**p<0.001**
Vote(Bloc)	p= 0.264	p= 0.179
Area(QC)	p=0.586	p=0.349
Area(ON)	p= 0.846	p= 0.648
Area(MT)	p= 0.396	p= 0.550
Area(MB.SK)	p=0.904	p= 0.841
Area(BC)	p=0.693	p=0.697
Age(36-51)	p=0.714	p=0.122
Age(52-62)	p=0.812	p=0.269
Age(63-70)	p=0.345	p=0.341
Age(71+)	p=0.321	p=0.076

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.11: Results of multinomial logit model for Question 8 “I think of wasps and bees as being the same.” Disagree is the reference level for the response variable.

	Agree	Don't Know
Constant	0.291 **p<0.001**	0.132 **p<0.001**
Rural/Urban(Urban)	1.623 **p<0.001**	p=0.239
Gender(Male)	p=0.536	p=0.423
Income(NA)	p<0.006	p=0.317
Income(75-100K)	p=0.448	p=0.987
Income(50-74K)	p=0.190	p=0.190
Income(>100k)	p=0.170	p=0.454
Vote(NDP)	0.706 **p<0.05**	p=0.565
Vote(NA)	p= 0.941	p=0.232
Vote(LP)	0.750 **p<0.05**	p=0.534
Vote(Greens)	p= 0.330	p=0.606
Vote(Bloc)	p= 0.823	p= 0.210
Area(QC)	p=0.130	p=0.750
Area(ON)	p= 0.755	p= 0.573
Area(MT)	p= 0.951	p= 0.393
Area(MB.SK)	p=0.479	p= 0.541
Area(BC)	p=0.151	p=0.577
Age(36-51)	p=0.221	p=0.238
Age(52-62)	p=0.394	p=0.382
Age(63-70)	p=0.883	p=0.104
Age(71+)	p=0.778	p=0.111

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.12: Results of multinomial logit model for Question 9: “All bees nest in hives and make honey.” Disagree is the reference level for the response variable.

	Agree	Don't Know
Constant	0.202 **p<0.001**	0.310 **p<0.001**
Rural/Urban(Urban)	1.725 **p<0.01**	p=0.102
Gender(Male)	p=0.892	p=0.233
Income(NA)	p=0.528	p=0.364
Income(75-100K)	p=0.250	p=0.758
Income(50-74K)	p=0.435	p=0.295
Income(>100k)	p=0.344	p=0.758
Vote(NDP)	p=0.580	p=0.387
Vote(NA)	p=0.319	p=0.603
Vote(LP)	p=0.952	p=0.707
Vote(Greens)	0.326 **p<0.05**	0.268 **p<0.001**
Vote(Bloc)	p=0.212	p=0.303
Area(QC)	p=0.170	p=0.523
Area(ON)	p=0.587	p=0.525
Area(MT)	p=0.563	p=0.955
Area(MB.SK)	p=0.951	p=0.236
Area(BC)	p=0.241	p=0.198
Age(36-51)	p=0.709	p=0.644
Age(52-62)	p=0.980	p=0.059
Age(63-70)	p=0.188	p=0.141
Age(71+)	p=0.837	p=0.843

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.13: Results of multinomial logit model for Question 10: “All bees are endangered.” Disagree is the reference level for the response variable.

	Agree	Don't Know
Constant	p=0.179	0.351 **p<0.01**
Rural/Urban(Urban)	0.789 **p<0.05**	p=0.359
Gender(Male)	1.324 **p<0.01**	p=0.352
Income(NA)	0.586 **p<0.01**	p=0.110
Income(75-100K)	p=0.076	p=0.826
Income(50-74K)	0.705 **P<0.05**	p=0.188
Income(>100k)	0.691 **p<0.05**	p=0.943
Vote(NDP)	p=0.478	p=0.089
Vote(NA)	p=0.978	p=0.060
Vote(LP)	p=0.249	p=0.341
Vote(Greens)	p=0.069	p=0.924
Vote(Bloc)	p=0.230	p=0.906
Area(QC)	p=0.188	p=0.161
Area(ON)	p=0.300	p=0.742
Area(MT)	p=0.719	p=0.392
Area(MB.SK)	p=0.786	p=0.355
Area(BC)	p=0.237	p=0.564
Age(36-51)	0.729 **p<0.05**	p=0.769
Age(52-62)	0.498 **p<0.001**	p=0.458
Age(63-70)	0.604 **p<0.05**	p=0.185
Age(71+)	0.627 **p<0.01**	p=0.412

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.14: Results of multinomial logit model for Question 11: “All bees can sting.” Disagree is the reference level for the response variable.

	Agree	Don't Know
Constant	0.554 **p<0.05**	0.169 **p<0.001**
Rural/Urban(Urban)	p=0.170	p=0.690
Gender(Male)	p=0.751	p=0.465
Income(NA)	p=0.796	p=0.465
Income(75-100K)	p=0.538	p=0.730
Income(50-74K)	p=0.862	p=0.386
Income(>100k)	p=0.761	p=0.709
Vote(NDP)	p=0.605	p=0.848
Vote(NA)	p=0.343	p=0.333
Vote(LP)	p=0.063	p=0.479
Vote(Greens)	p=0.579	p=0.498
Vote(Bloc)	p=0.246	p=0.254
Area(QC)	p=0.471	p=0.079
Area(ON)	p=0.582	p=0.071
Area(MT)	p=0.858	p=0.321
Area(MB.SK)	p=0.807	p=0.956
Area(BC)	p=0.264	p=0.879
Age(36-51)	p=0.685	1.543 **p<0.05**
Age(52-62)	p=0.724	p=0.081
Age(63-70)	p=0.943	p=0.712
Age(71+)	p=0.678	1.501 **p<0.05**

Significant results are in bold (p<0.05). Odd ratios (above p-value) are only given for significant results.

Table A.15: Results of binary logistic regression models for Question 4a-f “Which of the following do you think are the most important threats to wild, native bees in Canada?”. The response “No” was the reference level for the binary response variable.

	Income	Rural/Urban	Vote	Age
Question 4a Habitat Loss	p=0.4074	p=0.07613	**p<0.001** (Green Party and NDP voters, 4.3 and 1.5 compared to PC voters)	p=0.9702
Questions 4b Loss of Floral Resources	p=0.4508	p=0.1942	p=0.3391	p=0.4678
Question 4c Modern Intensive Agriculture	p=0.3558	**p<0.01** (Urban 1.3 compared to Rural)	**p<0.001** (Green Party voters 3.5 compared to PC voters)	p=0.08188
Question 4d Pesticides	p=0.3922	p=0.5894	p=*0.08456*	*p*=0.0485
Question 4e Climate Change	p=0.6964	p=0.9936	**p<0.001** (Green Party and Liberal Party, 9.8 and 1.6 compared to PC voters)	p=0.9936
Question 4f Disease	p=0.5609	p=0.8878	**p<0.05** (Bloc 0.51 compared to PC voters)	p=0.7531

Note: p-values are based on χ^2 tests, with significant tests in bold (p>0.05). Odds ratios are given in brackets for significant predicators.

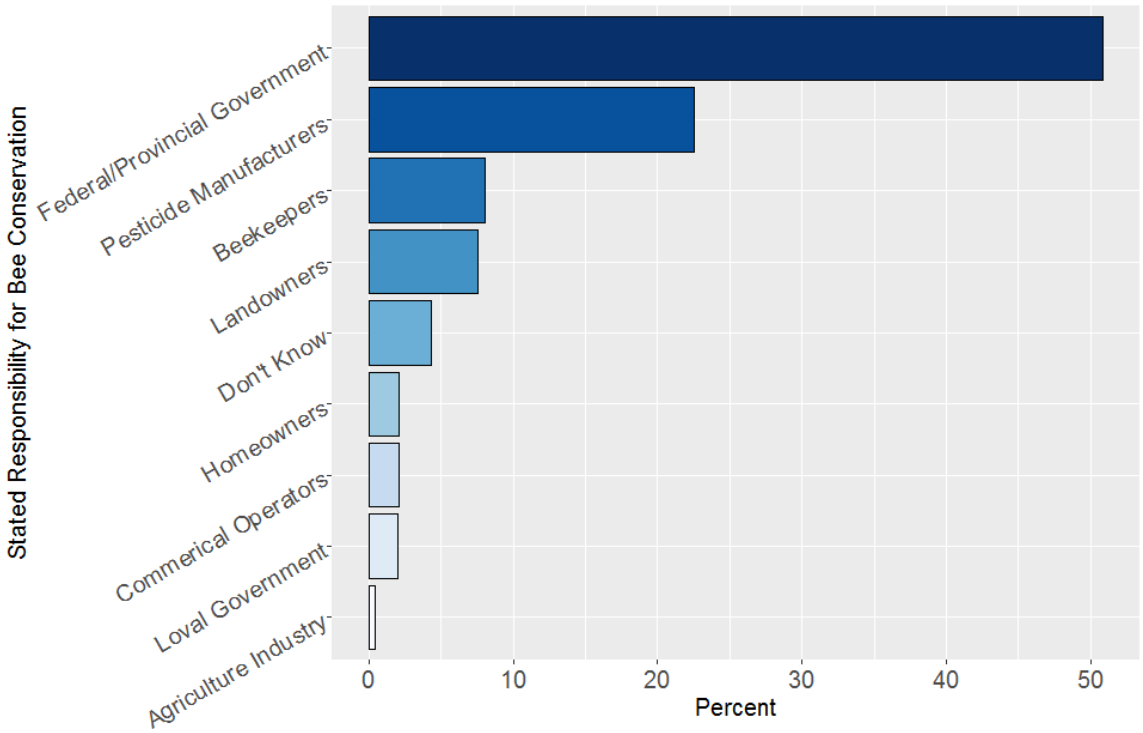


Figure A.1: Summary of perceptions of bee conservation to stated responsibility for bee conservation. Percentage of responses by unpooled categories (n=1969).

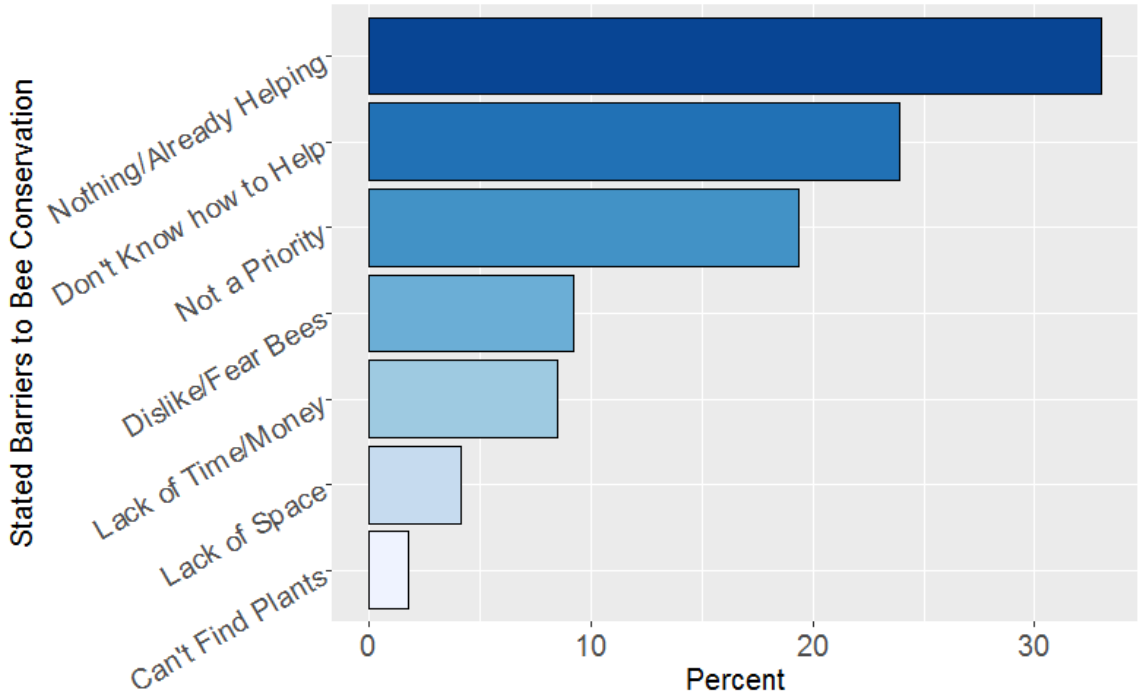


Figure A.2: Summary of perceptions of bee conservation to stated personal barriers to bee conservation. Percentage of responses to unpooled categories (n=1969).

B Appendix B: Supplementary Information for Chapter 3

Table B.1: Metadata for UNEP and WWF Documents

Document Type	Year Coverage	Notes
WWF LP (n=13)	1998, 1999, biannual 2000-2020	Complete coverage to date
UNEP OP (n=51)	2003-2017, quarterly	Incomplete coverage
		Document Coverage 2003- 2 issues 2004- 3 issues 2005 – 3 issues 2006- 4 issues 2007- 4 issues 2008- 4 issues 2009- 3 issues 2010- 4 issues 2011- 3 issues 2012- 3 issues 2013- 4 issues 2015 – 2 issues 2016- 3 issues 2017- 4 issues

Table B.2: List of term by discourse category used to construct the dictionary

Conservation Ecological	**Environmental Governance**	**Green**	**Market Economic**	**Public Economic**	**Human Security**	**Social Ecological**
arctic biodiversity	cartagena convention	blue carbon	amenity value	adaptation fund	adequate sanitation	butterfly effect
biodiversity conservation	civil society	blue solutions	backstop resource	appropriate distribution	clean water	carbon footprint
biodiversity hotspot	climate policy	green bond	backstop technology	circular economies	drinking water	climate injustice
biodiversity hotspots	conservation union	green bonds	benefit transfer	circular economy	drinking water	climate injustices
biodiversity level	decision makers	green business	biodiversity banking	club good	environmental consequences	climate justice
biodiversity levels	development agenda	green cities	biodiversity bond	club goods	evergreen agriculture	collective responsibilities
biodiversity loss	diversity cbd	green collar	biodiversity bonds	collective good	extreme weather	collective responsibility
biological diversity	environment day	green economies	biodiversity investment	collective goods	flood control	collective rights
biological diversity	environmental governance	green economy	biodiversity investments	collective property	flood disasters	common good
biological inertia	environmental law	green entrepreneurial	biodiversity offset	common good	food production	common responsibilities

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
biological legacies	environmental protection	green growth	biodiversity offsets	common goods	food security	common responsibility
biological legacy	framework convention	green infrastructure	biodiversity offsetting	common pool	food system	communal rights
biotic resistance	heritage convention	green investments	biodiversity valuation	common property	food waste	community energy
conservation management	heritage sites	green market	biological resource	commons centered	global water	community rights
ecological diversity	human rights	green state	biological resources	commons centred	grey water	cropland footprint
ecological heritage	intergovernmental panel	green tax	carbon budget	consumption pressure	poor people	culturing sustainabilities
ecological threshold	intergovernmental science	green taxes	carbon budgeting	crown land	population growth	deep ecologist
ecological thresholds	international community	green youth	carbon dividend	crown lands	safe water	deep ecology
ecological trap	international law	inclusive green	carbon dividends	ecological commons	slum dwellers	deliberative democracies
ecological traps	kyoto protocol	blue economy	carbon market	environmental equity	urban poor	deliberative democracy

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
ecosystem conservation	local governments	green accounting	carbon markets	financing action	water crisis	development goals
ecosystem function	minamata convention	green bond	carbon offset	global commons	water issues	differentiated responsibilities
ecosystem functions	montreal protocol	green bonds	carbon offsets	global commons	water resources	differentiated responsibility
ecosystem health	national park	green businesses	carbon offsetting	global consumption	water risk	earth democracies
ecosystems functioning	national park	green city	commercial value	human capital	water scarcity	earth democracy
ecosystems functions	paris agreement	green development	conservation portfolio	inclusive wealth	water supplies	earth jurisprudence
energy conservation	parks congress	green economy	conservation portfolios	intergenerational equity	water supply	ecocentric democracies
environmental conservation	parks congress	green entrepreneurial	consumptive value	intrinsic value	water supply	ecocentric democracy
environmental noise	policy makers	green gdp	contingent ranking	just compensation	World water	ecological citizenship
extinction risk	policy platform	green growth	contingent valuation	natural commons		ecological community

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
food chain	red list	green investment	contributory value	nonconsumptive benefits		ecological consciousness
food chains	science policy	green jobs	deficit forest	nonconsumptive use		ecological democracy
food web	world heritage	green markets	double benefits	nonconsumptive value		ecological footprint
food webs	world leaders	green states	double dividend	nonmarket valuation		ecological injustice
forest cover	world parks	green taxation	ecological asset	polluter pays		ecological injustices
forest degradation	world parks	green wall	ecological assets	public good		ecological integrity
land degradation		greening business	ecological benefits	public goods		ecological justice
freshwater ecosystems		planet greening	ecological budget	public land		ecological solidarity
marine ecosystems			ecological budgeting	public lands		economic injustice
natural systems			ecological capital	public ownership		economic injustices

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
natural world			ecological capitals	teeb study		economic justice
nature conservation			ecological resource			ecosystem approach
net biodiversity			ecological resources			ecosystem assessment
plant diversity			ecological service			ecosystem index
soil biodiversity			ecological services			ecosystems index
species population			economic valuation			energy footprint
species populations			ecosystem benefits			energy injustice
species richness			ecosystem goods			energy justice
trophic cascade			ecosystem market			energy sovereignty
trophic cascades			ecosystem markets			environmental injustice
wildlife conservation			ecosystem service			environmental injustices

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
wildlife diversity			ecosystem services			environmental justice
			ecosystem valuation			environmental stewardship
			ecosystems service			environmental sustainability
			ecosystems services			environmentally sustainable
			ecotechnological productivity			food injustice
			emission banking			food justice
			emission credit			food sovereignty
			emission credits			footprint network
			emission permit			forest footprint
			emission permits			gaia hypothesis
			emission trading			gha person
			emissions banking			global justice

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
			emissions credit			global village
			emissions credits			ground footprint
			emissions permit			human development
			emissions permits			indigenous rights
			emissions trading			just sustainabilities
			energy budget			land footprint
			environmental amenities			livelihood practices
			environmental amenity			millennium development
			environmental asset			mother earth
			environmental assets			national footprint
			environmental benefits			native rights

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
			environmental bond			person footprint
			environmental bonds			planet solutions
			environmental capital			planetary boundaries
			environmental capitals			planetary boundary
			environmental evaluation			shallow ecologist
			environmental service			shallow ecology
			environmental services			social injustice
			environmental value			social injustices
			existence value			social justice
			extrinsic value			spaceship earth
			financial sector			sustainability transformation

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
			financial system			sustainability transformations
			financial valuation			sustainability transition
			forest products			sustainability transitions
			free good			sustainable development
			genetic resource			sustainable forestry
			genetic resources			sustainable futures
			habitat banking			sustainable management
			habitat offset			sustainable transformation
			habitat offsets			sustainable transformations
			habitat offsetting			sustainable transition

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
			habitats offset			sustainable transitions
			habitats offsets			timber footprint
			habitats offsetting			transition town
			hedonic pricing			transition towns
			human demand			water footprint
			instrumental value			water injustice
			market approach			water justice
			market based			water sovereignty
			market based			
			market making			
			market making			
			market oriented			
			market oriented			
			monetary valuation			

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
			monetary valuations			
			natural asset			
			natural assets			
			natural capital			
			natural capitals			
			natural resources			
			natural subsidy			
			natural wealth			
			nature services			
			open access			
			private good			
			private goods			
			private rights			
			private sector			
			productive space			

Conservation Ecological	Environmental Governance	Green	Market Economic	Public Economic	Human Security	Social Ecological
			renewable resources			
			species offset			
			species offsets			
			surplus forest			
			tragedy commons			
			use value			
			value capture			
			water resources			
			wetland banking			
			wetland banks			
			wetland credits			

Note: Not all the terms appear in all the documents.

Table B.3: List of UNEP and WWF Custom Stop Words

UNEP	**WWF**
µg	al
achim	box
al	data
arthus	doi
asia.org	fao
bertrand	fig
cc	figur
cn	Figure
data	ha
dc	http
de	i.d
dios	i.d.
director	kg
doi	km
edwards	live
ellen	living
executive	map
fig	n.a
figur	na
Figure	page
gallo	pg
getty	po

UNEP	WWF
harding	rep
http	report
httpwww.unep.org	table
i.d	unit
i.d.	wwf
iii	www.fao.org
images	yr
kg	
km	
lbs	
library	
live	
living	
m3	
maccarthur	
magazine	
map	
mario	
mark	
molina	
n.a	
na	
nations	

UNEP WWF
nc
noharm
page
pg
photo
programme
publication
publications
rep
report
rio
robert
sa
shutterstock
steiner
table
topham
unit
united
vcy
wwf
www
yr

UNEP	**WWF**
zck	
zh	

Table B.4: Percentage Contributions of Discourses to the Definition of Dimensions for UNEP Documents

	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
Conservation Ecological	0.00	8.65	30.61	2.15	6.11
Environmental Governance	13.80	3.27	3.09	4.74	32.03
Green	79.00	5.52	0.03	1.13	1.46
Market Economic	0.20	19.88	4.20	19.59	18.22
Public Economic	0.00	23.10	0.13	67.63	6.71
Security	5.01	37.79	2.98	1.11	34.97
Socio-Ecological	1.99	1.79	58.96	3.65	0.50

Percentages were rounded to 2 decimal places.

Table B.5: Percentage Contributions of Publication Year to the Definition of Dimensions for UNEP Documents

	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
2003	13.11	19.31	22.58	2.95	2.80
2004	4.37	0.00	4.41	6.00	7.88
2005	5.50	0.01	3.14	11.91	1.78
2006	7.23	0.69	0.15	1.47	7.18
2007	6.78	0.14	1.01	2.73	4.49
2008	2.36	12.85	1.02	6.04	4.12
2009	5.28	1.94	1.17	0.67	5.78
2010	8.59	20.87	30.39	15.98	6.73
2011	0.13	2.98	0.02	27.83	0.49
2012	4.13	0.89	4.32	1.60	2.31
2013	6.16	29.86	0.01	1.14	29.09
2014	17.16	0.20	2.87	0.19	22.54
2015	0.08	0.64	18.91	2.60	0.15
2016	14.75	0.08	8.84	6.48	4.23
2017	4.37	9.54	1.15	12.41	0.44

Percentages were rounded to 2 decimal places.

Table B.6: Percentage Contribution of Discourses to the Definition of the Dimensions for WWF Documents

	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
Conservation Ecological	4.43	19.17	38.38	0.38	19.31
Environmental Governance	0.00	36.15	1.63	3.79	47.12
Green	0.11	0.46	0.22	83.29	4.45
Market Economic	0.65	0.00	0.93	6.73	1.78
Public Economic	89.23	4.64	3.64	0.00	0.86
Security	0.77	5.85	54.32	0.67	25.25
Socio-Ecological	4.81	33.73	0.87	5.15	1.23

Percentages were rounded to 2 decimal places.

Table B.7: Percentage Contribution of Publication Year to the Definition of the Dimensions for WWF Documents

	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
1998	92.99	3.38	0.49	0.02	0.04
1999	0.23	3.58	25.09	0.02	30.59
2000	0.08	0.39	14.78	0.51	3.73
2002	0.24	3.85	3.66	6.40	4.22
2004	0.12	2.00	3.95	4.11	12.17
2006	0.27	3.91	2.27	2.22	0.31
2008	0.93	5.57	0.13	2.97	0.27
2010	1.14	5.06	1.13	76.57	2.86
2012	0.81	4.74	0.02	0.25	4.16
2014	1.89	2.48	27.70	4.26	2.57
2016	0.58	2.64	10.78	0.13	1.28
2018	0.17	25.04	6.67	1.62	30.60
2020	0.56	37.37	3.34	0.92	7.20

Percentages were rounded to 2 decimal places.

Table B.8: Top 10 Donors to the Environment Fund for 2022

Donor	Contribution (USD)
Netherlands	8,379,200
Germany	7,910,730.8
United States of America	7,600,000
France	7,550,550
Norway	7,025,764.9
Denmark	6,517,545.23
Sweden	5,053,036.28
United Kingdom of Great Britain and Northern Ireland	4,461,960
Belgium	4,199,600
Switzerland	4,027,880

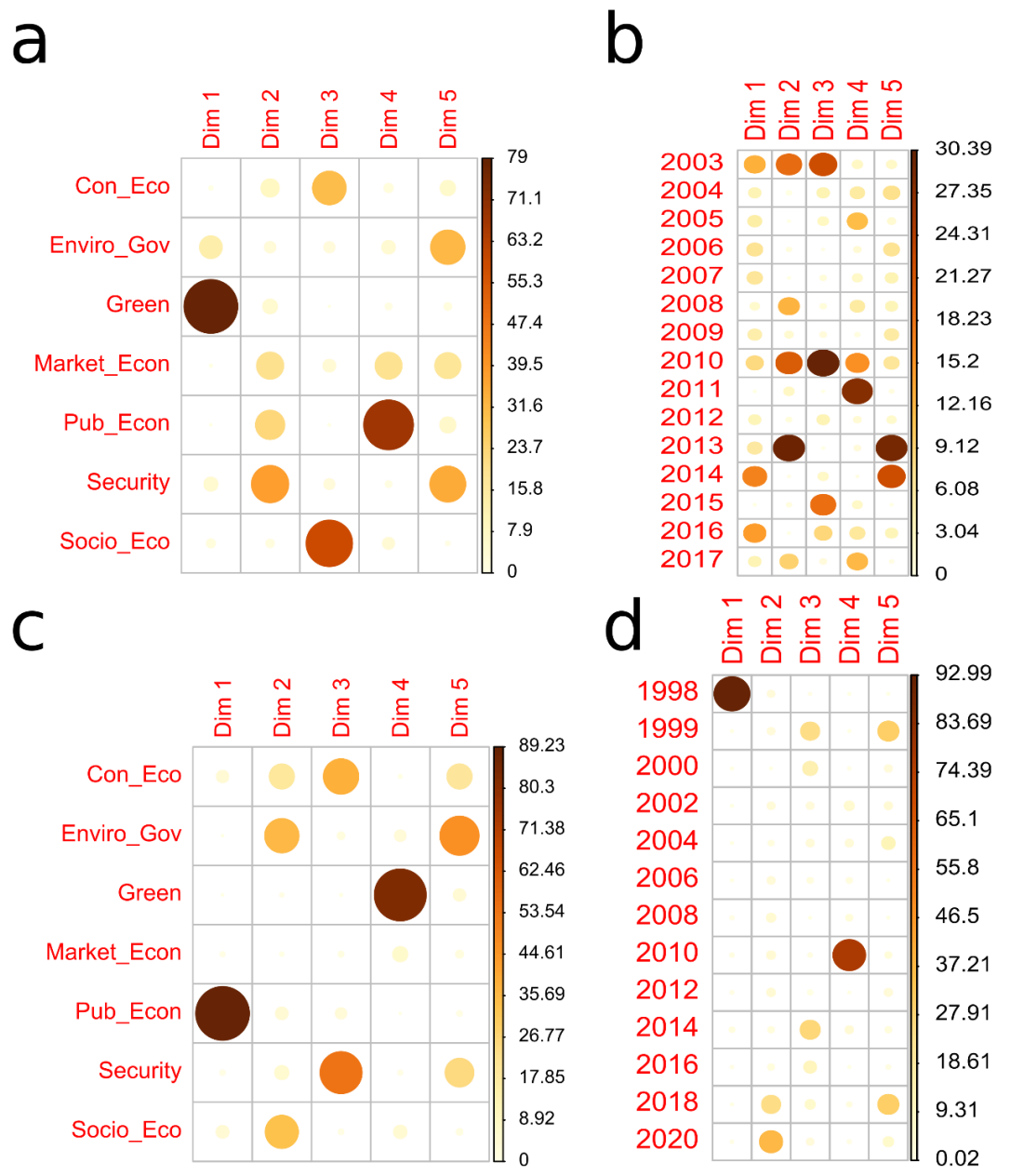
Source: UNEP (unep.org)

Table B.9: Top 10 Donors to Earmarked Contribution for 2022

Donor	Contribution (USD)
Global Environment Facility	321,537,732
Germany	52,009,114.64
UN Agencies	34,599,901.3
Sweden	30,286,777.82
Multilateral Fund Secretariat (These are funds from the Multilateral Fund Secretariat to implement IML activities)	22,550,135
United States of America	22,507,076.71
European Commission	21,165,176.53
Norway	21,069,209.22
UNEP Finance Initiative*	18,500,251.93
Foundations/NGOs	15,012,950.42

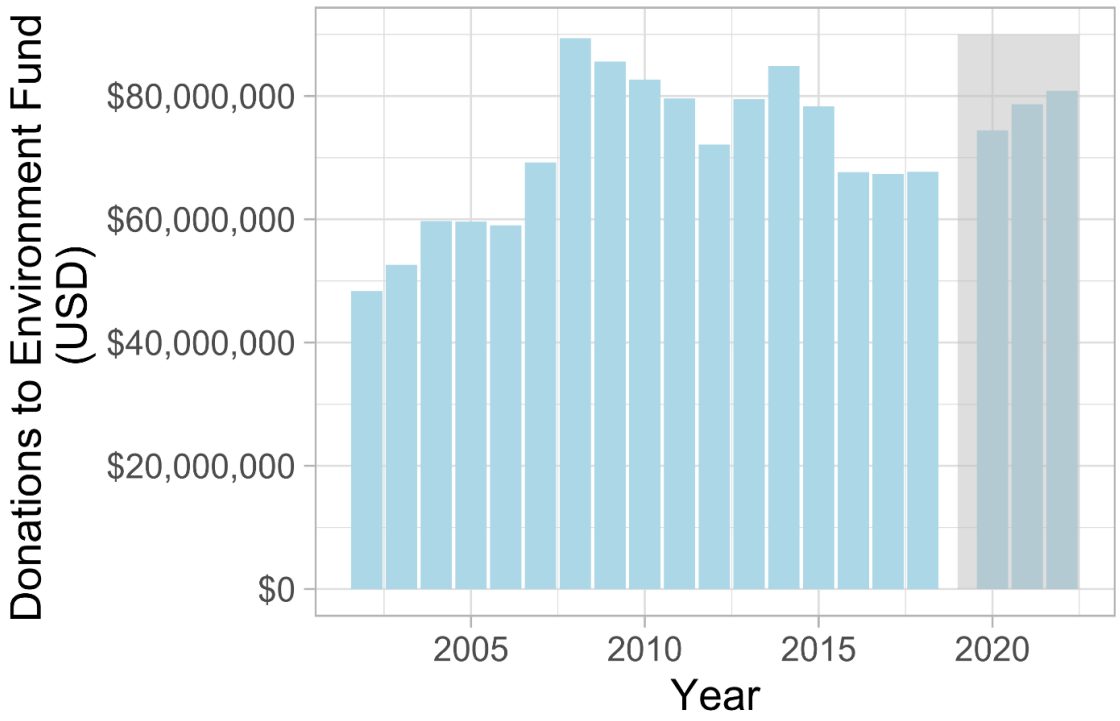
*UNEP Finance Initiative is a partnership between UNEP and the global financial sector to mobilize private sector finance. Source: UNEP (UNEP.org)

Figure B.1: Visual Representation of the Most Contributing Discourses and Publications Years for UNEP (a-b) and WWF (c-d) to the Definitions of Dimensions.



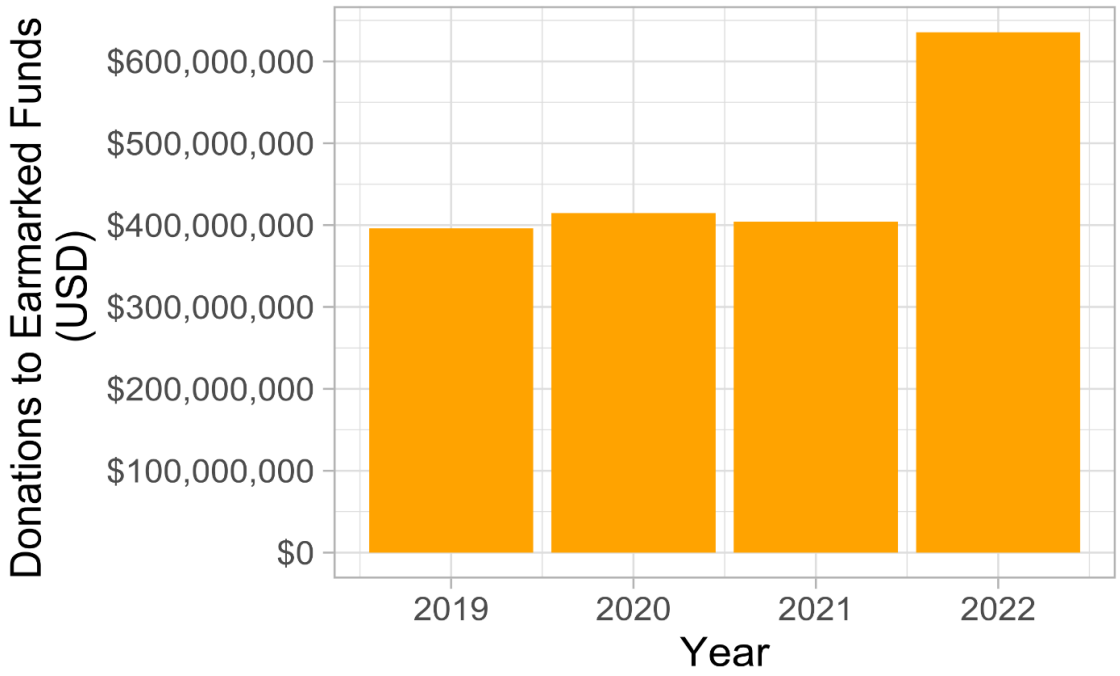
Labels on the gradient bar (right axis) are a percentage contribution to dimension definition. Abbreviations for discourses are as follows: Con_Eco = Conservation Ecological, Envrio_Gov = Environmental Governance, Green = unabbreviated, Market_Econ= Market Economic, Pub_Econ= Public Economic, Security= Human Security and Socio_Eco= Socio-Ecological.

Figure B.2: Donations to the Environment Fund from 2022-2022. Shaded area (grey) indicates overlap with Earmarked Contributions (2019-2022). Note: The Environment Fund received no contributions in 2019.



Data Source: UNEP (unep.org)

Figure B.3: Donations to Earmarked Contributions from 2019-2022.



Data Source: UNEP (unep.org)

C Appendix C: Supplementary Information for Chapter 4

Table C.1: List of Search Keywords and Hashtags used in the API Query

Keywords used in initial query	Gardens, Greenbelt, Park, Parkette, Ravine, Parkland, Woods, Wood Lot
Keywords and hashtags used in revised query	#colonelsamuelsmithpark, #highpark #HighPark, #highparkto, #highparktoronto , #Humber Bay Park #Humber Park, #humberbaypark #ParkHP, #sherwoodpark #tommythompsonpark, #trinitybellwoods #trinitybellwoodspark, #TTP colonel samuel smith park ,Colonel Samuel Smith Park, high park, High Park humber bay park, Humber Bay Park samuel smith #park, samuel smith park Samuel Smith Park, Sherwood #Park sherwood park, Sherwood Park sherwoodpark, tommy thompson Tommy Thompson, Tommy Thompson #Park tommy thompson park, Tommy Thompson Park, trinity bellwoods, Trinity Bellwoods, Trinity Bellwoods #Park, Trinity Bellwoods Park, trinitybellwoods, TTP

Table C.2: Descriptive Statistics for Tweets by Park

Park	Total Tweets (n)	Total Tweets included in analysis (n)*
Colonel Samuel Smith Park	434	347
High Park	6261	4357
Humber Bay Park	1090	491
Sherwood Park	518	518
Tommy Thompson Park	803	686
Trinity Bellwoods Park	1715	1676
All Parks	10821	8077

*Public Service Announcements (i.e. Toronto Fire Services) and Advertisements were excluded from the analysis.

Table C.3: Stemmed Word Counts for NRC Sentiments by Pandemic Category

Park	Sentiment	Pandemic Category (n)			Total (n)
		Pre-COVID	COVID	Recovery	
Colonel Samuel Smith	anger	5	14	2	21
	anticipation	29	21	17	67
	disgust	3	9	1	13
	fear	11	11	6	28
	joy	29	27	21	77
	sadness	10	14	6	30
	surprise	18	10	9	37
	trust	25	26	15	66
	positive	87	56	44	187
	negative	17	28	7	52
High Park	anger	139	113	114	366
	anticipation	209	186	162	557
	disgust	90	65	60	215
	fear	165	155	123	443
	joy	220	172	163	555
	sadness	125	113	101	339
	surprise	112	93	95	300
	trust	259	216	206	681
	positive	2401	1611	1258	5270
	negative	652	525	422	1599
Humber Bay Park West	anger	19	12	3	34
	anticipation	44	41	16	101
	disgust	9	13	0	22
	fear	25	17	3	45
	joy	44	47	20	111
	sadness	24	15	2	41
	surprise	18	15	7	40
	trust	26	36	15	77
	positive	149	141	60	284
	negative	54	46	20	120
Sherwood Park	anger	2	17	8	27
	anticipation	12	45	20	77
	disgust	1	16	8	25
	fear	7	25	9	41
	joy	12	54	25	91
	sadness	7	20	15	42
	surprise	3	23	12	38
	trust	12	46	20	78
	positive	20	167	54	241
	negative	14	58	32	104
Tommy Thompson Park	anger	15	25	16	56
	anticipation	35	52	30	117
	disgust	15	20	17	52

Park	Sentiment	Pandemic Category (n)			Total (n)
		Pre-COVID	COVID	Recovery	
	fear	24	31	30	85
	joy	33	59	33	125
	sadness	20	32	19	71
	surprise	18	35	16	69
	trust	32	56	26	114
	Positive	93	213	99	405
	negative	38	67	46	151
Trinity Bellwoods Park	anger	38	146	29	213
	anticipation	71	143	47	261
	disgust	25	108	19	152
	fear	43	174	28	245
	joy	80	128	50	258
	sadness	32	129	33	194
	surprise	42	73	20	135
	trust	71	164	46	281
	Positive	400	848	193	1441
	negative	119	556	68	743
All Parks	anger	159	219	137	515
	anticipation	250	264	191	705
	disgust	106	159	85	350
	fear	202	266	157	625
	joy	246	237	185	668
	sadness	156	204	131	491
	surprise	126	136	110	372
	trust	298	312	226	836
	positive	3150	3036	1708	7894
	negative	894	1280	595	2769

Table C.4: Descriptive Statistics for Emojis by Park

Park	Total Tweets included in analysis (n)	Total Tweets containing emoji	Emoji Total (n)	Emoji Total used in Sentiment Analysis
Colonel Samuel Smith Park	347	26 (7.5%)	46	26 (56.2%)
High Park	4357	905 (20.8%)	1904	1219 (64.0%)
Humber Bay Park	491	159 (32.4%)	338	197 (58.3%)
Sherwood Park	518	86 (16.6%)	139	89 (64.0%)
Tommy Thompson Park	686	83 (12.1%)	174	89 (51.1%)
Trinity Bellwoods Park	1676	330 (19.7%)	594	370 (62.3%)
All Parks	8075	1589 (19.7%)	3195	1990 (62.3%)

Table C.5: Comparison top 10 emoji of the full dataset and top 10 emoji of sentiment ranked

Full Dataset			Sentiment Ranked Emoji Only		
Emoji	Text Description	Count	Emoji	Text Description	Count
🌸	cherry blossom	146	🌸	cherry blossom	146
CA	flag: Canada	99	🍁	maple leaf	71
📷	camera with flash	72	❤	heavy black heart	57
🍁	maple leaf	71	😍	smiling face with heart-shaped eyes	48
❤	heavy black heart	57	😀	grinning face	42
😍	smiling face with heart-eyes	48	✨	sparkles	40
😀	grinning face	42	🙏	person with folded hands	36
✨	sparkles	40	🌳	deciduous tree	35
🙏	folded hands	36	😂	face with tears of joy	34
🌳	deciduous tree	35	🍂	fallen leaf	33

Table C.6: Descriptive Statistics for Emoji Sentiment Scores by Park

Park	Mean	Median	Max/Min
Colonel Samuel Smith Park	0.458	0.496	0.709/0.111
High Park	0.464	0.491	0.779/-0.400
Humber Bay Park	0.471	0.521	0.759/-0.327
Sherwood Park	0.466	0.486	0.739/-0.169
Tommy Thompson Park	0.379	0.417	0.746/-0.397
Trinity Bellwoods Park	0.420	0.486	0.746/-0.333
All Parks	0.453	0.491	0.779/-0.400

Table C.7: Top 5 emoji by Park based on Sentiment Ranked Emoji

Park	Emoji	Text Description	Count
CSS	✨	sparkles	2
CSS	🌇	sunset over buildings	2
CSS	😍	smiling face with heart-shaped eyes	2
CSS	🌙	crescent moon	1
CSS	🌞	sun with face	1
HBP	❤	heavy black heart	19
HBP	😀	grinning face	15
HBP	✨	sparkles	9
HBP	😂	face with tears of joy	7
HBP	🌞	sun with face	6
HP	🌸	cherry blossom	107
HP	🍁	maple leaf	49
HP	❤	heavy black heart	32
HP	🍂	fallen leaf	25
HP	😍	smiling face with heart-shaped eyes	25
SP	😄	smiling face with open mouth and smiling eyes	6
SP	🙏	person with folded hands	6
SP	🍁	maple leaf	5
SP	🌳	deciduous tree	4
SP	🎵	musical note	4
TBP	🌸	cherry blossom	32
TBP	🍁	maple leaf	12
TBP	😍	smiling face with heart-shaped eyes	11
TBP	🙏	person with folded hands	11
TBP	🍻	clinking beer mugs	9
TTP	👀	eyes	5
TTP	🔥	fire	5
TTP	🍁	maple leaf	4
TTP	💙	blue heart	4
TTP	🚲	bicyclist	4

Park Abbreviations: CSS (Colonel Samuel Smith Park, HBP (Humber Bay Park), High Park (HP), SP Sherwood Park), TBP (Trinity Bellwoods Park) and TTP (Tommy Thompson Park)

Table C.8: Common emoji for Parks by Pandemic Category

Park	Emoji	Text Description	Pre-Covid	Covid	Recovery
SP					
1		fallen leaf	1	NA	1
2		party popper	1	NA	NA
3		two hearts	1	NA	NA
4		flexed biceps	1	NA	NA
5		smiling face with open mouth and smiling eyes	NA	4	2
6		winking face	NA	4	NA
7		person with folded hands	NA	4	2
8		deciduous tree	NA	3	1
9		musical note	NA	3	1
10		multiple musical notes	NA	3	1
11		thumbs up sign	NA	3	NA
12		growing heart	NA	3	NA
13		green heart	NA	3	NA
14		camera	NA	3	NA
15		maple leaf	NA	NA	3
16		smiling face with open mouth and tightly-closed eyes	NA	NA	3
17		dog face	NA	NA	2
18		leaf fluttering in wind	NA	NA	1
TBP					
1		cherry blossom	18	9	5
2		maple leaf	7	NA	4
3		smiling face with heart-shaped eyes	7	NA	2
4		dog face	4	NA	NA
5		sparkles	3	3	NA
6		seedling	3	NA	NA
7		deciduous tree	3	5	NA
8		clinking beer mugs	3	6	NA
9		party popper	3	NA	NA
10		paw prints	3	3	NA
11		person with folded hands	NA	7	NA
12		dizzy symbol	NA	4	NA
13		hundred points symbol	NA	4	NA
14		face with medical mask	NA	4	NA
15		heavy black heart	NA	3	NA
16		hot beverage	NA	NA	3
17		round pushpin	NA	NA	3
18		man	NA	NA	2

Park	Emoji	Text Description	Pre-Covid	Covid	Recovery
19		woman	NA	NA	2
20		blue heart	NA	NA	2
21		smiling face with smiling eyes	NA	NA	2
22		face throwing a kiss	NA	NA	2
TTP					
1		water wave	1	2	NA
2		maple leaf	1	3	NA
3		tomato	1	NA	NA
4		grapes	1	NA	NA
5		melon	1	NA	NA
6		watermelon	1	NA	NA
7		tangerine	1	NA	NA
8		lemon	1	NA	NA
9		banana	1	NA	NA
10		red apple	1	NA	NA
11		blue heart	NA	4	NA
12		fire	NA	4	NA
13		bicyclist	NA	3	NA
14		cherries	NA	2	NA
15		multiple musical notes	NA	2	NA
16		collision symbol	NA	2	NA
17		grinning face	NA	2	NA
18		smiling face with heart-shaped eyes	NA	2	NA
19		eyes	NA	NA	5
20		rabbit	NA	NA	1
21		snake	NA	NA	1
22		dancer	NA	NA	1
23		face throwing a kiss	NA	NA	1
24		crying face	NA	NA	1
All Parks					
1		cherry blossom	86	34	26
2		heavy black heart	34	23	NA
3		maple leaf	34	21	16
4		smiling face with heart-shaped eyes	29	NA	11
5		grinning face	21	18	NA
6		sparkles	18	16	6
7		deciduous tree	17	14	NA
8		person raising both hands in celebration	17	NA	NA
9		face with tears of joy	16	13	NA

Park	Emoji	Text Description	Pre-Covid	Covid	Recovery
10		smiling face with smiling eyes	16	NA	9
11		person with folded hands	NA	19	7
12		blue heart	NA	14	NA
13		fallen leaf	NA	13	6
14		paw prints	NA	NA	7
15		eyes	NA	NA	7
16		two hearts	NA	NA	7

*Only parks with a statistically significant sentiment score are shown. Park Abbreviations: SP (Sherwood Park), TBP (Trinity Bellwoods Park) and TTP (Tommy Thompson Park)

Table C.9: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and emoji sentiment score (index). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	0.82	0.67	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	2.21	0.33	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Humber Bay Park	0.85	0.66	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	7.60	**<0.05**	Pe-COVID>COVID COVID=Recovery Pre-COVID>Recovery	-2.13 1.46 2.69	**<0.05** 0.22 **<0.05**
Tommy Thompson Park	8.17	**<0.05**	Pre-COVID=COVID COVID>Recovery Pre-COVID=Recovery	1.87 2.52 1.11	0.09 **<0.05** 0.40
Trinity Bellwoods Park	21.85	**<0.001**	Pre-COVID>COVID COVID<Recovery Pre-COVID=Recovery	-4.24 -3.37 -0.39	**<0.0001** **<0.01** 1
All Parks	10.95	**<0.01**	Pre-COVID>COVID COVID=Recovery Pre-COVID=Recovery	-3.27 -1.80 0.54	**<0.01** 0.12 0.88

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05. H values and z-scores are rounded to 2 decimals places.

Table C.10: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and sadness sentiment (word count). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	3.76	0.15	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	1.56	0.46	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Humber Bay Park	1.90	0.39	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	2.55	0.28	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Tommy Thompson Park	1.01	0.61	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Trinity Bellwoods Park	6.60	**<0.05**	Pe-COVID=COVID COVID>Recovery Pre-COVID>Recovery	-0.32 2.42 2.16	1 **<0.05** **<0.05**
All Parks	5.24	0.07	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05.
H values and z-scores are rounded to 2 decimals places.

Table C.11: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and fear sentiment (word count). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	1.41	0.50	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	2.06	0.36	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Humber Bay Park	3.62	0.16	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	0.72	0.70	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Tommy Thompson Park	0.87	0.68	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Trinity Bellwoods Park	11.60	**<0.01**	Pre-COVID<COVID COVID>Recovery Pre-COVID=Recovery	2.71 2.50 0.20	**<0.01** **<0.05** 1
All Parks	5.77	0.06	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05. H values and z-scores are rounded to 2 decimals places.

Table C.12: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and anticipation sentiment (word count). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	0.58	0.75	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	6.09	**<0.05**	Pre-COVID>COVID COVID=Recovery Pre-COVID=Recovery	-2.46 -1.0 1.33	**0.02** 0.48 0.28
Humber Bay Park	0.37	0.83	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	2.95	0.23	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Tommy Thompson Park	2.33	0.31	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Trinity Bellwoods Park	1.38	0.50	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
All Parks	0.90	0.64	Pre-COVID-COVID COVID=Recovery Pre-COVID=Recovery	NA	NA

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05. H values and z-scores are rounded to 2 decimals places.

Table C.13: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and surprise sentiment (word count). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	1.09	0.58	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	3.38	0.18	Pre-COVID=COVID COVID=Recovery Pre-COVID-Recovery	NA	NA
Humber Bay Park	0.87	0.65	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	1.25	0.54	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Tommy Thompson Park	7.78	**<0.05**	Pre-COVID=COVID COVID>Recovery Pre-COVID=Recovery	1.89 2.58 0.64	0.09 **<0.05** 0.78
Trinity Bellwoods Park	0.10	0.95	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
All Parks	2.76	0.25	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05.
H values and z-scores are rounded to 2 decimals places.

Table C.14: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and joy sentiment (word count). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	0.08	0.96	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	3.12	0.21	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Humber Bay Park	0.52	0.88	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	4.40	0.11	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Tommy Thompson Park	1.30	0.52	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Trinity Bellwoods Park	1.90	0.40	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
All Parks	1.41	0.49	Pe-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05. H values and z-scores are rounded to 2 decimals places.

Table C.15: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and anger sentiment (word count). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	2.48	0.29	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	3.94	0.14	Pre-COVID=COVID COVID=Recovery Pre-COVID-Recovery	NA	NA
Humber Bay Park	0.46	0.80	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	1.14	0.56	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Tommy Thompson Park	5.45	0.07	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Trinity Bellwoods Park	5.15	0.08	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
All Parks	5.68	0.06	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05. H values and z-scores are rounded to 2 decimals places.

Table C.16: Kruskal-Wallis Test (one-way Analysis of Variance on ranks) performed on pandemic categories and disgust sentiment (word count). Pairwise comparisons for the three mean values are also given using Dunn's Method with Bonferroni Correction.

Park	H	P Value	Relationship between groups	z-score	P value
Colonel Samuel Smith Park	5.21	0.07	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
High Park	0.75	0.69	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Humber Bay Park	1.32	0.25	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Sherwood Park	0.28	0.87	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Tommy Thompson Park	1.43	0.49	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
Trinity Bellwoods Park	3.43	0.18	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA
All Parks	2.83	0.24	Pre-COVID=COVID COVID=Recovery Pre-COVID=Recovery	NA	NA

Pairwise comparisons were made only in cases where the p value for the Kruskal-Wallis test was ≤0.05. H values and z-scores are rounded to 2 decimals places.

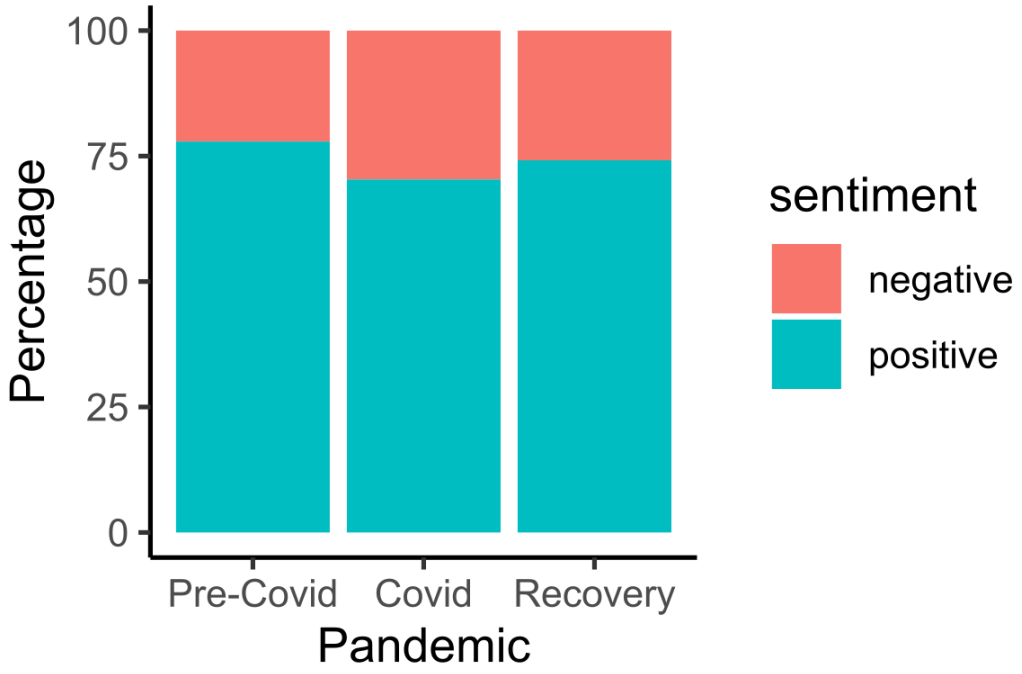


Figure C.1: Stacked bar plot showing the percentage of positive and negative sentiments across all parks by pandemic timeframe. The three timeframes are: Pre-COVID (January 1, 2019 -February 28, 2020) COVID (March 1, 2020-August 31, 2021) and Recovery (September 1, 2021- October 31, 2022).

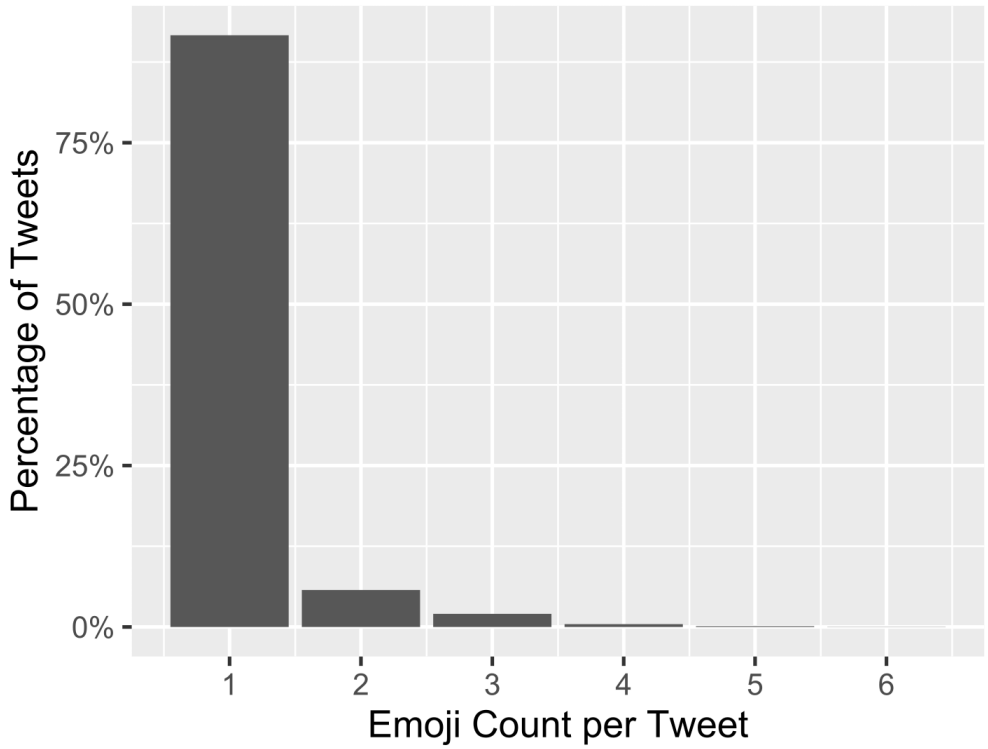


Figure C.2: Distribution of number of emoji per tweet.