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SCALES OF HUMAN-NATURE CONNECTEDNESS

INFLUENCES ON SUSTAINABILITY ASPIRATIONS AND PRO-ENVIRONMENTAL BEHAVIORS

Faculty of Sustainability

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8. **Klaniecki, K.,** Duse, I.A., Lutz, L.M., Leventon, J., and Abson, D.J. 2019. Applying the Energy Cultures Framework to a rural Romanian microregion. Submitted to *Sustainability*.

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Abstract

Global climate change and environmental degradation are largely caused by human activity, thus progress towards a sustainable future will require large-scale changes to human behavior. Human-nature connectedness—a measure of cognitive, emotional, spiritual and biophysical linkages to natural places—has been identified as a positive predictor of sustainability attitudes and behaviors. While calls to 'reconnect to nature' in order to foster sustainability outcomes have become common across science, policy and practice, there remains a great deal of uncertainty, speculation, and conceptual vagueness around how this ought to be implemented. The overarching aim of this thesis is to advance conceptual and empirical understandings of human-nature connectedness as a leverage point for pro-environmental outcomes and sustainability transformation. In particular, the thesis attempts to assess the nuances of the HNC-PEB relationship by investigating the scalar relationships between *where* someone feels connected to nature and *where* someone acts pro-environmentally. This research was conducted through conceptual exploration (**Chapters II, III, IV**, and **VI**), systematic literature reviews (**Chapter I** and **V**) using hierarchical cluster analysis, and empirical case studies (**Chapters VII** and **VIII**) relying on structural equation modeling and two-step cluster analysis. In this thesis, the relationship between human-nature connectedness and pro-environmental attitudes and behaviors was investigated in a small microregion of Transylvania, Romania, where traditional relationships with the land and changing socio-economic characteristics provided an interesting case study in which to explore these connections. The key findings can be organized into three sections: **Section A**, which addresses human-nature connectedness and its potential for sustainability transformation; **Section B**, which addresses human-nature connectedness as a determinant of pro-environmental behavioral outcomes, and **Section C**, which explores the relationships between human-nature connectedness and energy conservation norms, attitudes, and behaviors. Results cumulatively suggest that human-nature connectedness is a multidimensional construct that requires greater integration across heterogeneous disciplinary and methodological boundaries in order to reach its potential for meaningful sustainability transformation. Results also highlight the critical need to adopt systemic approaches to understanding how interactions between human-nature connections, norms, attitudes, and behaviors are hindering or promoting sustainability outcomes. This thesis makes two main contributions to the literature: first, it considers the human-nature connectedness and pro-environmental behavior literature within a systems-thinking and

sustainability transformation lens; and second, it extends the human-nature connectedness and pro-environmental behavior literature by investigating the multidimensional aspects of these constructs. Overall, these insights point to the deep leverage potential of human-nature connectedness when conceptualized and operationalized as a multidimensional construct.

Keywords: human-nature connectedness; pro-environmental behavior; attitudes; norms; behavioral intentions; energy systems; energy conservation; Energy Cultures Framework; structural equation modeling; cluster analysis; sustainability science; interdisciplinarity; sustainability transformation; Leverage Points; Sustainable Development Goals

Acknowledgements

Living in Europe and conducting PhD-level research on the determinants of pro-environmental behavior has been my personal ambition since 2012. I'm thankful for the Leverage Points leadership team for giving me the opportunity to fulfill this goal and contribute to the research of this project. I fully enjoyed living and researching in Lüneburg, having the space for academic exploration and debate, and the flexibility to travel throughout Europe for conferences, workshops, and summer schools. Thank you to the VolkswagenStiftung for funding my research through the Leverage Points for Sustainability Transformation project and to the Leuphana University's Fund for Young Researchers for funding my participation at multiple conferences. I am grateful for my PhD supervisors David J. Abson and Julia Leventon for providing outstanding supervision and guidance during the course of this PhD. My ambition and desire to participate in *everything* can be my greatest strength, but also my greatest weakness. Thank you for your encouragement when I wanted to explore new lines of inquiry, participate in '*just one more*' conference, or take on another paper. I'm equally appreciative for the times when you advised me to pull back or drop frustrating projects.

I also extend the warmest and most appreciative '*thank you*!' to my Leverage Points colleagues for their kindness, humor, generosity, and listening ear over the past three and a half years. Especially to those that joined me for the coffee chats, OV movies, lunch breaks, and after work drinks that kept me sane, focused, cheerful and motivated throughout this process. This project was complicated, challenging, and upsetting at times, but the camaraderie of the research team was invaluable and such an uplifting force in my PhD journey. Thank you to Ioana Duse and Tamara Schaal for exploring the Pogany-hávas microregion together and supporting each other in our fieldwork season in winter 2017. I'm grateful for the time we spent together in that cozy apartment in Păuleni-Ciuc. I have an infinite about of gratitude to Ioana for facilitating communication with the residents in our case study and teaching me about Romanian culture and traditions. Finally, I want to thank my family and friends for being a source of comfort, inspiration and motivation over the past several years. Your support and encouragement meant the world to me as I navigated this PhD process halfway across the globe.

Preface

This is a cumulative dissertation consisting of a series of articles (4 published, 4 submitted) presenting conceptual studies, systematic reviews, and empirical research conducted in Transylvania, Romania. Each chapter of this cumulative dissertation stands on it's own, though the findings from each contributes to the overarching narrative of this PhD research. The dissertation begins with the framework paper, a single-authored synthesis chapter that introduces the conceptual framework of the dissertation, the aims and objectives of the research, and explains the internal coherence of the articles, the methods employed and the results. **Section A** (**Chapters I-III**) follows and addresses human-nature connectedness and its potential for sustainability transformation. **Section B** (**Chapters IV-VI**) addresses human-nature connectedness as a determinant of pro-environment behavior. Lastly, **Section C** (**Chapters VII** and **VIII**) is an empirical investigation of the determinants of energy behaviors and attitudes in a rural Romania case study. All papers were published in, or submitted to, international peer-reviewed publications and are reprinted in their latest version.

Each articles has several co-authors and are the outcomes of collaborative scientific research in a large interdisciplinary research project titled *Leverage Points for Sustainability Transformation*. This thesis draw upon theory and methodology from the field of environmental psychology, but also rely on theory from the fields of environmental science, environmental economics, sociology, systems thinking, and other social sciences to ground my research and results. Experts in the fields of environmental economics and environmental governance supervised this thesis and co-authors hail from the fields of ecology, environmental management, political science and social ecological economics. I am the lead author of five of the articles (**Chapter IV-VIII**) and provided significant scientific contributions to the manuscripts presented in **Chapters I**, **II**, and **III**. The references for each manuscript are presented within the respective chapter, rather than in a summated reference list at the end of the dissertation. Due to the stand-alone nature of the articles, some repetition in the text of these chapters was unavoidable. Similarly, the formatting of the articles varies and is a reflection of the style requirements of the journals where the articles were submitted.

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List of papers

The following papers are included in this thesis:

Section A: human-nature connectedness and its potential for sustainability transformation

Chapter I. Ives, C.D., Giusti, M., Fischer, J., Abson, D.J., **Klaniecki, K**., Dorninger, C., Laudan, J., Barthel, S., Abernethy, P., Martín-López, B. and Raymond, C.M., 2017. Human–nature connection: a multidisciplinary review. *Current Opinion in Environmental Sustainability*, 26, pp.106-113.

Chapter II. Ives, C.D., Abson, D.J., von Wehrden, H., Dorninger, C., **Klaniecki, K**. and Fischer, J., 2018. Reconnecting with nature for sustainability. *Sustainability Science*, 13(5) pp.1389-1397.

Chapter III. Abson, D.J., **Klaniecki, K**., Dorninger, C., Riechers, M., Ives, C.D., and von Wehrden, H. 2019. Human-nature connections: aligning biophysical and socio-psychological approaches for sustainability. Submitted to *People and Nature*.

Section B: human-nature connectedness as a determinant of pro-environment behavior

Chapter IV. **Klaniecki, K.,** Wuropulos, K., and Persson Hager, C. 2019. Behavior Change for Sustainable Development. In: Leal Filho W. (eds) *Encyclopedia of Sustainability in Higher Education*. Springer, Cham.

Chapter V. **Klaniecki, K.**, Abson, D.J., Ives, C.D. 2019. Investigating the nuanced relationship between pro-environmental behavior and nature connectedness: a systematic review. Submitted to *Environment and Behavior*.

Chapter VI. **Klaniecki, K**., Leventon, J., Abson, D.J. 2018. Human-nature connectedness as a 'treatment' for pro-environmental behavior: making the case for spatial considerations. *Sustainability Science*, 13(5) pp. 1375-1388.

Section C: determinants of energy behaviors and attitudes in a rural Romania case study

Chapter VII. **Klaniecki, K.,** Duse, I.A., Engler, J.O., Leventon, J., and Abson, D.J. 2019. Energy conservation attitudes and intentions: investigating place attachment in Eastern Transylvania, Romania. Manuscript under review at *Psyecology*.

Chapter VIII. **Klaniecki, K.,** Duse, I.A., Lutz, L.M., Leventon, J., and Abson, D.J. 2019. Applying the Energy Cultures Framework to a rural Romanian microregion. Submitted to *Sustainability*.

Contribution to papers:

The research in **Chapters I-IV** was conceptualized and written together with the co-authors. For **Chapters V-VIII**, I conceptualized the research, collected the data, performed the analysis, wrote the majority of the text, and coordinated contributions from co-authors. Information on the specific contributions of all authors, weighting factors, publication status, and conference contributions are included in a table in the annex.

Related work not included in the thesis

Being a member of the *Leverage Points for Sustainability Transformation* research team and a student in the Faculty of Sustainability at Leuphana Universität Lüneburg led to co-authoring a number of collaborative outputs during the duration of my PhD. While these papers are outside the core scope and aims of this thesis, they greatly contributed to my thinking on sustainability transformation and shaped the research lenses that I employed throughout my PhD.

- Dorninger, C., von Wehrden, H., Abson, D.J., Derwort, P., **Klaniecki, K.,** Ives, C.D., Apetrei, C., Lang, D., Spittler, N., Langsenlehner, M., Riechers, M., Leventon, J., and Lam, D. Interventions in food and energy systems and their leverage potential for sustainability transformation. 2019. Manuscript to be submitted to *Ecological Economics*.

- Duse, I.A., **Klaniecki, K.,** Leventon, J., and Abson, D.J. 2019. Social Acceptability of Renewable Energy Technologies in Transylvania, Romania. Manuscript to be submitted to *Sustainability*.

- Fam, D., Clarke, E., Freeth, R., Derwort, P., **Klaniecki, K.,** Kater-Wettstädt, L., Hilser, S., Peukert, D., Meyer, E., Horcea-Milcu, A.I. 2019. Interdisciplinary and transdiciplinary research and practice: Balancing expectation of the 'old' academy with the future model of universities as 'problem solvers.' Manuscript under review at *Higher Education Quarterly*.

- Fischer, J., Horcea-Milcu, A.I., Lang, D., Thale-Bombien, L., Abson, D.J., Apetrei, C.I., Clarke, E., Derwort, P., Dorninger, C., Duse, I.A., Freeth, R., Jager, N.W., **Klaniecki, K**., Lam, D., Leventon, J., Newig, J., Peukert, D., Riechers, M., and Schaal, T. 2019. *Balance Brings Beauty: Strategies for a Sustainable Southern Transylvania*. Pensoft, Sofia.

- Williams, A., **Klaniecki, K.,** Dorninger, C., and Whiteman, G. 2019. Transformative Innovation for the SDGs: UNLEASH Innovation Lab 2017. Manuscript to be submitted to *Academy of Management Discoveries*.

Introduction

There is growing evidence that humans are now the driving force of global environmental change (Ellis, 2015; Steffen et al., 2011), with global climate change and environmental degradation largely caused by human activity at local, regional and global scales (Millennium Ecosystem Assessment, 2005). Human impact is implicated in ecosystem function decline, biodiversity loss, fisheries collapse, and ocean acidification (Rockström et al., 2009) and these threats cannot be understood without accounting for the influence of human activity (Beery et al., 2015; Millennium Ecosystem Assessment, 2005). Yet, despite considerable efforts to address environmental degradation and move towards a sustainable future, progress has been minimal and sustainability has remained primarily a goal rather than a day-to-day practical reality (United Nations Secretary-General's High-level Panel on Global Sustainability, 2012). So, what then is to be done in order to transform unsustainable lifestyles and consumption patterns in the face of climate change and environmental thresholds being breached? Researchers and policy makers agree that given the current state of environmental destruction and the urgency of combating anthropogenic climate change, a fundamental transformation of human behaviors towards sustainable behaviors is required (Fischer et al., 2012; Gifford, 2008; O'Brien and Sygna, 2013; World Bank, 2015). While responses from government and industry play a critical role in minimizing environmental destruction, additional focus must be placed on the role of individual behavior. In particular, how significant changes to individual behavior and consumption can slow, reverse or stunt the destruction of ecological systems and emissions contributing to global climate change (Dietz et al., 2009; IPCC, 2014).

At the core, transforming human behaviors will require knowledge of environmental problems, greater levels of environmental concern, and the adoption of actions that counteract these problems (Beery and Wolf-Watz, 2014). It has been argued that our ability to separate ourselves from natural processes and the biophysical world can be largely to blame for environmental degradation and that 'reconnecting' to nature and the biosphere is a necessity in order to transform individual environmental concern and actions (Beery et al., 2015; Folke et al., 2011). Humans are innately part of, and connected to, nature (Dutcher et al., 2007; Kellert and Wilson, 1993). Individuals with a strong sense of connection to the natural world tend to place greater value on protecting and caring for nature (Leopold, 1949; Wilson, 1984), yet current trends in urbanization, population, affluence, and technology are distancing humans from the natural world and reducing this sense of connectedness (Leach

et al., 2010). Awareness of the growing disconnect from nature and the potential for transformation of individual behavior through reconnecting to nature, sparked the growth of a body of research on human-nature connectedness (Chawla, 1999; Clayton, 2003; Davis et al., 2009; Kals et al., 1999; Mayer and Frantz, 2004; Nisbet et al., 2009; Schultz, 2001, 2002; Stedman, 2002). Calls to 'reconnect to nature' have emerged (e.g. Folke et al., 2011) and some have argued that reconnecting to nature might have the potential to serve as a deep leverage point that could lead to sustainability transformation (e.g. Abson et al., 2017).

However, despite the emergence and growth of this field, the complexities of the relationship between human-nature connectedness and pro-environmental outcomes remain largely unknown and demand additional examination and added perspectives. In order to address current environmental challenges and move towards a sustainable future, a thorough understanding of what it means to reconnect humans to nature and what are the behavioral and attitudinal outcomes associated with nature connectedness is needed. In this thesis, I focus on the relationship between human-nature connectedness, pro-environmental behavior, and environmental attitudes and aim to add dimension to our understanding of the ways in which people to connect to nature and further contextualize how these connections act as a determinant of sustainability outcomes. I contextualize my research in larger sustainability transformation narrative and focus on the ways in which our connections with nature may serve as a lever for transforming individual behavior and societies towards a more sustainable trajectory.

Adopting an interdisciplinary lens, this thesis investigates the multidisciplinary nature of human-nature connectedness, conceptualizes the scalar relationship between human-nature connectedness and pro-environmental behavior, and analyzed the ways in which connections to nature influence energy conservation attitudes and behaviors in Transylvania Romania, a rural region of Europe with traditional human-nature relationships and rapidly changing natural and political landscapes. The aim of this introductory chapter is to clearly outline the motivation for this research, summarize the articles included in this thesis, and synthesis the conclusions within the larger sustainability narrative. First, I present the rationale for researching human-nature connectedness in relation to global sustainability transformation and the ways in which reconnecting to nature can serve as a determinant of pro-environmental outcomes. Second, I discuss the conceptual background and theory that shaped our research questions and the research gap that motivated the aims and objectives of our papers. I then summarize the papers that make up this thesis, briefly discussing the data collection methodology, findings, and contributions to addressing the research gaps. Lastly, I synthesis my findings, discuss crosscutting themes that emerged from my research,

and situated my research in a larger sustainability narrative, with implications for future research and practice.

Theoretical and Conceptual Background

Situating this Thesis

This thesis is an interdisciplinary endeavor that draws heavily on theories and methods from environmental psychology and sustainability science, as well as engaging with discourses on human-nature connectedness, energy transitions and sustainable development, in order to advance understanding of human-nature connections as a deep leverage point for sustainability transformation. Sustainability science is an interdisciplinary field that studies complex environmental problems and recognizes the need for integration of multiple perspectives, frameworks, and methodologies in order to effectively tackle 'super wicked' problems (Levin et al., 2012; Salas-Zapata et al., 2017). Given the unique positioning of this thesis and the breadth of topics and concepts engaged with during an interdisciplinary sustainability science PhD, it is necessary to briefly describe the concepts and theories that informed this research and to situate this research within the larger narrative. In addition, I identify and discuss the gaps in conceptual and empirical understanding that motivated this research. Lastly, I introduce the overarching research question that guided this work, discuss the four aims that guided the eight individual articles of this thesis, and present an integrative figure.

Environmental Problems are Human Behavior Problems

First, this thesis draws upon the notion that environmental problems can largely be conceptualized as problems of human behavior. While humans have always modified their environments, the pace and scale of today's environmental impact and change is occurring at an unprecedented scale and escalating rate (Amel et al., 2017). Human activity has rapidly and fundamentally changed the function of the world's ecosystems, degraded ecosystem services, and profoundly changed the diversity of life on earth (Millennium Ecosystem Assessment, 2005). Climate change, loss of biodiversity, resource depletion, water shortages, ocean acidification, and changes to land cover can be attributed to human activity, increasing populations, and "rapidly growing demands for food, fresh water, timber, fiber and fuel" (Millennium Ecosystem Assessment, 2005, p. 1). As population continues to grow and material consumption increases, the quantity and quality of environmental resources will continue to decline (Vlek and Steg, 2007). Growing evidence suggests that we have entered the 'Anthropocene', a new geological epoch where human activity has become the dominant driver of global environmental change (Steffen et al., 2011; Waters et al., 2016).

Therefore, contemporary environmental challenges are not 'environmental problems' but rather a problem of human behavior (Amel et al., 2017; Clayton et al., 2015; Griggs et al., 2013; Scott et al., 2016). Human impact is driving almost all environmental problems and these problems cannot be understood without accounting for the influence of human activity. Slowing human impact on the planet and moving towards a sustainable future demands fundamental changes in human behavior and transitions to sustainable lifestyles (Griggs et al., 2013). Yet, despite decades of knowledge and efforts to slow environmental degradation, climate change, and resource depletion, human impact on the planet has only accelerated and societies continue along pathways that further environmental destruction (Amel et al., 2017).

Addressing these problems, while preserving human well-being and quality of life, will require a focus on human-environment interactions and an understanding of how environmental factors influence behavior and how behaviors impact the environment (Steg et al., 2013). It will require recognition that environmental problems are situated in a dynamic social context, wherein "ecologically incompatible beliefs, values, worldviews, and actions are ultimately responsible for the rapid deterioration of the natural systems on which every creature depends for survival" (Scott et al., 2016, p. 5). Environmental problems are the result of human behavior, thus it is human behaviors that must be adapted in order to reduce global environmental change (Stern, 1992). Shifting human behavior, addressing barriers to change, and promoting beliefs, attitudes, values, and worldviews in line with sustainability is challenging, however, when 'nature' and 'humans' are often separated and dichotomized (Beery et al., 2015).

From Innate Connections to Severed Connections

In order to evaluate human behavior in the context of sustainability, this thesis investigated the role human-nature connectedness—an overarching concept to describe the relationships, bonds, attachments, and affinities that humans form with nature—plays in shifting human behavior and promoting attitudes and worldviews in line with sustainability. The study of the relationship between humans and nature has long been of interest to scholars and thinkers. Ralph Waldo Emerson's *Nature* (1836), Aldo Leopold's *Sand County Almanac* (1949), and Rachel Carson's *Silent Spring* (1962) prominently shaped Western thinking on humanity's relationship with the natural world. Humans are intrinsically part of the natural world, interacting with nature, reliant on natural resources, and bound to natural phenomenon and events. This affinity to the natural world is innate rather than acquired and motivates contact with animals, plants and landscapes (Wilson, 1984). Humans have an instinctive need to affiliate with nature, which is reflected as humans repeatedly place

greater value on nature than the built environmental and prefer natural settings over human-influenced settings (Clayton, 2003). When people are asked to describe their favorite places, places in nature are prominently mentioned and associated with emotional well-being (Korpela et al., 2001).

Humans were once psychologically and physically closer to nature than today's industrialized societies (Kellert and Wilson, 1993). The forces of industrialization, urbanization and technological advancements split humans from nature and led to alienation from nature (Vining et al., 2008) and an extinction of experience (Louv, 2005; Pyle, 1993). Drivers of humanity's disconnection from nature can be classified into four categories: psychological severance and physical severance (which initiative disconnection) and psychological maintenance and psychical maintenance (which perpetuate or exacerbate disconnection) (Zylstra et al., 2014). Major drivers of disconnection are impacting when and how humans spend time in nature, access resources, and connect with nature on a psychological basis. Modern society has transformed daily life and routines, physically and psychologically distancing humans from the outdoors, natural environments, and other species.

The "biophilia hypothesis" (Kellert and Wilson, 1993) contends that as societies industrialized and humans began to live in cities, innate connections to nature were weakened and humans became separated from the natural world. We are spending less time in nature, associating with natural systems less and less, and are often interacting with nature only through managed and controlled excursions or outings. In the process, our sense of connection to the natural world has been nearly severed. 'Nature deficit disorder' is a term used to describe the change in childhood recreation activities from outdoor play and exploration, to primarily indoor experiences with electronic devices (Louv, 2005). Similarly, the 'extinction of experience' refers to a sense of alienation from nature and a loss of connection to nature that would motivate concern and conservation (Pyle, 1993). Even when we do have experiences in nature, they may be in subpar conditions, ecologically degraded settings, or semi-natural spaces; yet, due to 'environmental generational amnesia' younger generations may grow adapted to degraded environments and see these conditions as normal (Kahn, Jr., 2002). Similarly, given the widespread loss of biodiversity, species extinctions, and habit destruction, we may be losing the elements and opportunities necessary to trigger and nurture our innate biophilia (Thomashow, 1998).

Given these changes, which influence the ability to connect to nature or recognize one's impact on the environment, humans may find themselves unable to form values and attitudes about protecting and caring for nature, given they do not know nature, value

nature, or have a sense of relatedness to nature (Leopold, 1949). As a result, humans have drifted apart from nature and become materially, spatially, and psychologically disconnected from nature. As these connections have diminished, environmental degradation has intensified (Pyle, 2003). It can be argued that our separation from nature may be largely to blame for large-scale environmental degradation (Beery et al., 2015) and that reconnecting to nature and changing human-nature relationships is critical for slowing the pace of today's environmental degradation (Sabloff, 2001). The idea that an individual's affiliation with nature can support environmental concern and pro-environmental behavior is the basis of human-nature connectedness research, which describes the affective, cognitive, and material relationships humans hold with nature (Beery and Wolf-Watz, 2014; Wilson, 1984). It is argued that the degree to which individuals understand other organisms and feel a sense of connection to natural organisms and processes, the greater value they will place on them (Kellert and Wilson, 1993). When individuals perceive themselves as separate from nature and feel no sense of connection or identification to nature, they are less likely to care or protect nature.

Recognition of the impact of human activity on the planet and the changing relationships between humans and nature led authors to publish works on these topics. Given the emerging scholarly literature about changing in human-nature connections, an increasing alienation of humans from nature, and the potential for positive sustainability outcomes from restoring these relationships, calls to 'reconnect to nature' emerged. This suggested there was value in studying how people connect to nature, individual differences in levels of connectedness, and outcomes associated with varying degrees of connectedness (Nisbet and Zelenski, 2013). A strong individual sense of connection to nature is an essential building block in order to find a balance between human activity and ecosystem health and revert the trends of ecological destruction (Pyle, 2003). In order to develop pro-environmental worldviews, then it may be necessary to reconnect with nature and develop an understanding of interdependence of humans and natural systems (Amel et al., 2017).

Growth of HNC research

The academic study of connectedness to nature has emerged primarily in the last three decades, with a great explosion of interest in the topic since the start of the 2000s (Restall and Conrad, 2015). As a result of the calls to 'reconnect to nature' a vast field of literature formed around these topics and studies began to advocate that people need to connect to nature at a deep and personal level (Clayton and Opotow, 2003). In the environmental psychology literature, connectedness with nature is defined as "a stable state of consciousness comprising symbiotic cognitive, affective, and experiential traits that reflect, through consistent attitudes and behaviors, a sustained awareness of the interrelatedness

between one's self and the rest of nature" (Zylstra et al., 2014, p. 119). Scholars are interested in whether humans see themselves as part of or separated from nature (e.g. Bruni et al., 2008; Mayer and Frantz, 2004; Schultz and Tabanico, 2007) as well as emotional affinity for nature (e.g. Duffy and Verges, 2010; Kals et al., 1999).

With the growth of the field, there has been a great diversity of publications in the field and a diversity of understandings of the topic. This has results in many terms used to describe the construct (e.g. nature connectedness (Schultz, 2002), love and care for nature (Perkins, 2010), nature relatedness (Nisbet et al., 2009)) and various psychometric scales created to empirically measure levels of connectedness (e.g. The Connectedness to Nature Scale (Mayer and Frantz, 2004) (see Table 1 for a list of concepts and measurements of human nature connectedness).

Table 1. Concepts and measurements of aspects and traits of human-nature connectedness

Concept	**Author**
Commitment to Nature	(Davis et al., 2009)
Connectedness to Nature Scale (CNS)	(Mayer and Frantz, 2004)
Connectivity with Nature Scale (CwNS)	(Dutcher et al., 2007)
Emotional Affinity toward Nature (EAN)	(Kals et al., 1999)
Environmental Identity Scale (EIS)	(Clayton, 2003)
Inclusion of Nature in Self (INS)	(Schultz, 2001, 2002)
Nature Relatedness Scale (NRS)	(Nisbet et al., 2009)
Love and Care for Nature (LCN)	(Perkins, 2010)
Social Psychology of Place	(Stedman, 2002)
New Ecological Paradigm (NEP)	(Dunlap et al., 2000)
Implicit Associations Test (IAT)	(Schultz et al., 2004)
Connection to Nature Index (CNI)	(Cheng and Monroe, 2012)
Disposition to Connect with Nature (DCN)	(Brügger et al., 2011)
Nature Connectedness Inventory (NCI)	(Ernst and Theimer, 2011)
Dispositional Empathy with Nature Scale (DENS)	(Tam, 2013)

As well as growing conceptualizations of human-nature connectedness, a number of assessment tools and psychometric scales were developed to measure nature connections. Kals, Schumacher, and Montada (1999), introduced *emotional affinity toward nature* as a measure of emotional inclinations towards nature and a feeling of love and oneness with nature. The *Inclusion of Nature in Self* scale (Schultz, 2001; Schultz et al., 2004) measures the extent to which humans see themselves as separate from nature or included in nature and

include nature in their self-concept. Individuals with stronger connections to nature and greater biospheric concerns report more pro-environmental behaviors that individuals that feel stronger to the built environment and have egoistic concerns (Schultz et al., 2004). Clayton (2003) developed the 24-item *Environmental Identity Scale* to measure degree to which an individual includes a connection to the natural environment in their self-concept and identity. The *Connectedness with Nature* scale, proposed by Mayer & Frantz, measures an individual's levels of feeling emotionally connected to the natural world (2004). This scale was shown to be an important predictor of environmental behavior. Nisbet et al (2009) proposed the *Nature Relatedness Scale*, which measured cognitive, affective, and experiential facets of human-nature relationships. Nature relatedness may be an indication of how much biophilia has (or has not) been nurtured (Nisbet and Zelenski, 2013). Davis, Green and Reed (2009) proposed the concept of *commitment to nature scale*, which suggests that humans experience commitment to nature which predicts pro-environmental behavior. Dutcher et al (2007) introduced the concept of *connectivity with nature*, which is a measure of an individual's perceptions of the sameness between oneself and nature.

Place attachment is also considered within the umbrella of human-nature connectedness, as it is the emotional link that people establish with specific geographic locales, a form of people-place bonding wherein nature is contained in a person's self and social identity (Raymond et al., 2011; Rollero and De Piccoli, 2010). Place attachment is defined as people-place bonding (Low and Altman, 1992) and as "a positive affective bond between an individual and a specific place (Hidalgo and Hernandez, 2001, p. 274). Raymond, Brown & Robinson (2011), developed a widely used 29-point place attachment scale that measures five dimensions of place attachment. Measuring such attachments provides insight into why individuals form positive and negative bonds with specific places (Wynveen et al., 2014). Place attachment is one measurement of the degree to which an individual develops a sense of connection to specific locations and natural places. Place attachment has been hypothesized to be a predictor of stewardship behaviors for that location, though studies have reported mixed findings (Korpela, 2012).

HNC and Pro-Environmental Outcomes

One driver of the growth of human-nature connectedness research was accumulating evidence of a positive relationship between connectedness levels and pro-environmental outcomes such as attitudes, behavioral intentions, and measureable behavior. Several authors and studies argue that stronger connections and attachments to nature are potential drivers of significant pro-environmental outcomes (Kals et al., 1999; Vaske and Kobrin, 2001). Schultz and colleagues (2002, 2001; 2004) argued that the degree to which one sees themselves as a part of the natural environment serves as the foundation for the

development of environment environmental attitudes and concerns. Mayer and Frantz (2004) found that individuals with higher levels of nature connectedness were more empathetic to nature and more willing to protect nature than those with lower levels of connectedness. Similarly, Geng et al. (2015) found that connections with nature are an effective predictor of pro-environmental behavior. Direct contact with nature has also been shown to increase love and care for nature (Wilson, 1984) and strong commitments to nature can lead to higher interest in environmental protection (Perkins, 2010). Place attachment and place meaning has also been shown to predict environmental concern and commitment to act pro-environmentally (e.g. Brehm et al., 2012; Ramkissoon et al., 2013; Raymond et al., 2010; Tonge et al., 2014).

Though the positive linkages between human-nature connectedness and pro-environmental outcomes has been established and connecting to nature is a potentially useful concept for promoting sustainable change, findings on the relationships are sometimes contradictory and far from conclusive (e.g. Ramkissoon et al., 2013; Scannell and Gifford, 2010). The relationship between human-nature connectedness and environmental outcomes requires further scrutiny and invites additional conceptual and empirical exploration.

Pro-environmental outcomes: behaviors, attitudes and intentions

Given that most environmental problems have an anthropogenic origin (Stern, 1992), it is necessary to understand the ways in which individuals perceive the environment and the variables that underlie individual behavior. The field of environmental psychology can inform us about the catalysts and barriers that prevent or enable sustainability outcomes and explanations for why individuals do or do not act pro-environmentally (McIntyre and Milfont, 2016). In this thesis, I measured and assessed pro-environmental behaviors, behavioral intentions, attitudes, and norms in order to understand the determinants and outcomes of human-nature connectedness. Each of these concepts is briefly summarized in the sections below.

Pro-environmental behaviors

Understanding and changing pro-environmental behavior—also referred to as 'environmentally responsible behavior' (e.g. Vaske and Kobrin, 2001), 'environmentally significant behaviors' (e.g. Stern, 2000), 'conservation behaviors' (e.g. Gosling and Williams, 2010), and 'environmentally friendly behavior' (e.g. Dolnicar and Grün, 2009)—is the focus of much of environmental psychology research. Pro-environmental behaviors can be defined as *goal-directed*—"behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world" (Kollmuss and Agyeman, 2002, p. 240)—or as *general behavior* motivated by other goals—"behavior that harms the environmental as little as

possible, or even benefits the environment" (Steg and Vlek, 2009, p. 309). Similarly, Stern (2000) separates behavior in terms of *impact* and *intent*. *Impact-oriented* behaviors are those that "change the availability of materials or energy from the environment or alters the structure and dynamics of ecosystems or the biosphere itself" (Stern, 2000, p. 408). Resource extraction, agriculture, and fossil fuel use, for instance are human behaviors than have an impact on the environment. *Intent-oriented* behaviors are those that individuals undertake with the intention to change the environment, but that may not necessarily have a large environmental benefit. Impact-oriented and intent-oriented behaviors are not necessarily the same, and there is often a discrepancy between the environmental intent of an individual and the true environmental impact (Whitmarsh, 2009).

Pro-environmental behavioral intentions

Pro-environmental intentions are an individual's preparedness to behave in a way that is beneficial to the environment (Schultz and Zelezny, 1998; Walker and Chapman, 2003) and reflect the inclination to perform a behavior (Abrahamse, 2019). According to the Theory of Reasoned Action (Fishbein and Ajzen, 1975) and the Theory of Planned Behavior (Ajzen, 1991), intent to act is the most proximal determinant of behavior. When behavioral intentions are strong and the intention is set to do a specific behavior, it is more likely that the behavior will be performed. Additionally, measuring behavioral intentions is often used as a substitute for measuring behavior (Halpenny, 2010; Walker and Chapman, 2003), since measuring actual behaviors can be challenging. Perceived behavioral control, the degree to which an individual feels ease or difficulty to perform a behavior, can influence behavioral intentions. Individuals with a stronger sense of control and self-efficacy are more likely to have strong pro-environmental intentions and behaviors (Gifford, 2014). Additionally, values and self determination can be strong predictors of pro-environmental intentions (De Groot and Steg, 2010)

Pro-environmental attitudes

Environmental attitudes are "the collection of beliefs, affect, and behavioral intentions a person holds regarding environmentally related activities or issues" (Schultz et al., 2004, p. 31). Encompassed in this definition is also environmental concern, in that environmental attitudes are a measure of concern about environmental issues and are a reflection of how an individual values themselves, other people, plants and animals (Stern and Dietz 1994). Schultz proposed that environmental attitudes reflect the degree to which an individual characterizes the interconnectedness of nature and self (Schultz, 2001). Most often environmental attitudes are measured using self-reports on questionnaires or interviews, though there is no consistent methodological practice—over 700 measures exist in the literature (Dunlap and Jones, 2002). The most widely used measure of environmental

attitudes is the New Ecological Paradigm (NEP) (Dunlap et al., 2000; Dunlap and Van Liere, 1978). This scale measures ecological worldviews using 15 items, which reflect the degree to which an individual believes humans are a part of nature or independent from nature (Dunlap et al., 2000; Dunlap and Jones, 2002).

Norms

Norms are another factor that can exert powerful influence on pro-environmental behavior. Social norms are "rules and standards that are understood by members of a group, that guide and/or constrain human behavior without the force of laws" (Cialdini and Trost, 1998, p. 152) and generally inform individuals about which behaviors are approved or disapproved in a specific setting (Keizer and Schultz, 2013). Descriptive normative beliefs refer to what an individual thinks others do in a particular situation (the *is* typical or normal*)*, while injunctive normative beliefs describe what an individual thinks others approve or disapprove of (what *ought* to be done*)* (Cialdini et al., 1990). Environmental personal norms are rules and standards for one's own behavior (Kallgren et al., 2000), which are experienced as moral obligations to engage in a specific behavior (Schwartz, 1977). Personal norms are standards for one's own behavior, instead of beliefs about how other act (Kallgren et al., 2000). Strong environmental personal norms are a strong predictor of pro-environmental behaviors (e.g. de Groot et al., 2013; Thøgersen and Ölander, 2006), though some studies show this is an indirect impact completely mediated by behavioral intentions (Bamberg and Möser, 2007).

Energy system behaviors and attitudes

This thesis investigates human-nature connectedness as a driver of pro-environmental behaviors and attitudes within an energy system. There has been a reframing of the global climate change debate to view the problem as a societal challenges and to integral social science research and methods (Nichols et al., 2014). Wide-scale shifts in energy behavior are needed in order to realize a sustainable energy transition (Steg et al., 2015) and social science methodology is employed to understand the general antecedents and determinants of behaviors that contribute to sustainable energy transitions (Sovacool, 2014; Sovacool et al., 2015; Steg et al., 2015).

Studying determinants of energy behavior is particularly pressing, as CO_2 emissions from the combustion of fossil fuels for energy and transportation are the primary human activity that contributes to global climate change. Individuals have a responsibility to contribute to energy use reduction and changes to consumption behaviors can be significant (Ehrhardt-Martinez, 2010). This will occur through curtailment behaviors (e.g. reducing the energy use of existing technologies) or through energy efficiency behaviors (e.g. purchasing new

technologies) (Lesic et al., 2018). While energy consumption is largely determined by household income and household size, energy conservation intentions and actual energy savings are more strongly related to individual values and attitudes (Abrahamse and Steg, 2009).

Total energy consumption in developed countries must be reduced and scholars must investigate the factors that motivate individuals to change their daily energy behaviors or refrain entirely from certain high-impact activities (e.g. flights). Additionally, a sustainable energy transition will require a complete transformation of the current fossil fuel-dominated system to a system characterized by low-carbon technologies. Within these systems, scholars have interest in investigating the factors that determine sustainable energy behaviors, the factors that influence social acceptability of new technologies and policies, and the circumstances under which sustainable behaviors are adopted and sustained (Stern, 2014). To reach wide-spread implementation and dissemination of these technologies, we need to understand the factors that influence when individuals are willing to accept, and adopt, new energy sources (Steg et al., 2015).

Research Gaps and Aims

Despite growing scholarly, political, and practical interest in human-nature connectedness and recent scholarly contributions to the conceptualization and quantification of human-nature connectedness and pro-environmental outcomes, research gaps remain that warrant increased attention and empirical exploration. At the onset of this PhD research, the field was defined by rapid growth, uncertainty, and disunity. There was little information or agreement about where to connect people to nature, uncertainty about the mechanisms by which HNC influences PEB adoption, and a lack of information about how connectedness to nature could be best leveraged for sustainability transformation. There was growing recognition that HNC was a multidimensional construct and that issues of scale, place, and geography would shape the relationship with pro-environmental outcomes, but the research was still lacking specificity in this area. The rapid growth of this field, the lack of scientific knowledge on the nuances of the relationship between these constructs, and the opportunities for meaningful sustainable change served as the drivers of this PhD research and served as the points of departure for this thesis. This research aimed to contribute to this research gap and shed light on the multidimensional construct of HNC and the nuances of the scalar relationship with pro-environmental outcomes.

Research Gaps

Human-nature connectedness is a topic that has gained interest from many disciplines, but there is confusion around: (a) what are the drivers of connectedness, (b) what does it mean

to be connected, (c) how to reconnect to nature, and (d) what are the expected outcomes of reconnecting to nature? Many disciplinary fields—from psychology to education to economics—have contributed to answering these questions but this diversity has led to fragmentation and conflicting information. Most notably, calls to 'reconnect to nature' have remained rather vague and there is little clarity nor consensus about how to reach more a more connected state (Restall and Conrad, 2015). There is a need to integrate research on human-nature connectedness and develop theoretical approaches that integrate the multiple concepts and perspectives that exist within the literature.

Additionally, current measurements of nature connectedness are not designed to capture the diversity of connections individuals may hold nor the scope of connections to specific types of nature or geographic areas. While scholars have reported on the positive relationship between human-nature connectedness and pro-environmental outcomes (e.g. Mayer and Frantz, 2004), there is conceptual vagueness regarding how the *where* and *how* people connect to nature influences the *where* and *how* people act pro-environmentally. Human-nature connectedness is either thought of as localized and place-based (e.g. Cammack et al., 2011; Soga et al., 2016), or as a general concept with no geographic boundaries (e.g. Bruni and Schultz, 2010; Verges and Duffy, 2010). Similarly, pro-environmental behavior is often conceptualized as having local, place-based impacts (e.g. Davis and Carter, 2014) or measured as a large set of interchangeable and independent behaviors (e.g. Scannell and Gifford, 2010). Few studies examine geographic links between nature connectedness, sustainability aspiration, and pro-environmental behavior. Thus, integrating expanding conceptualizations of the scalar relationships between these constructs could bring greater clarity to understandings of human-nature connectedness as a determinant of pro-environmental behavior.

Another gap in the literature is that most studies on pro-environmental behavior and human-nature connectedness have focused on behaviors that are inexpensive, convenient, and easy to perform (Diekmann and Preisendörfer, 2003; Gosling and Williams, 2010). Studies have shown a strong association between nature connectedness and 'low-cost' behaviors (i.e. recycling, composting, activism) but have struggled to show a strong association to 'high-cost' behaviors (i.e. land reallocation, mobility) (Raymond et al., 2011). Similarly, current scales of measurement often measure outdated environmental topics or measure vague beliefs and opinions about nature that aren't applicable to specific environmental challenges (Hawcroft and Milfont, 2010). While the existing scales produce consistent results, the results that are published are criticized as being unreliable and inaccurate for dealing with current environmental challenges. Thus, there is an opportunity for scholars to: (a) investigate how human-nature connectedness influences more impactful

or challenging behaviors; (b) study how connectedness levels influence attitudes towards current and localized environmental issues; and (c) how theses interactions can be leveraged for more impactful sustainability outcomes.

Research Questions

This PhD thesis aimed to address the above-mentioned gaps in the literature. While nature connectedness has been shown to be a positive and significant predictor of sustainability outcomes such as pro-environmental attitudes and behaviors, there is still much uncertainty about how to build connections to nature, which types of connectedness are most impactful for sustainability outcomes, and which types of behaviors or attitudes are most heavily influenced by connections to nature. Specifically, this thesis explores the nuances of the relationship between human-nature connectedness and pro-environmental outcomes, and empirically investigates how these relationships play out within a rural Romanian community. Greater conceptualization of these distinctions will help improve our understanding of how human-nature connectedness can shape development of pro-environmental outcomes that may serve as a leverage point to transform communities towards a more sustainable state.

Thus, this thesis aims to shed light on the role of human-nature connections in sustainable attitudes and behaviors, as well as societal sustainability transformation. The research was designed to address one overarching research question: '*How can human-nature connectedness serve as a deep leverage point for sustainability transformation of individual attitudes and behaviors?'* Building on the identified research gaps and the overall research question, I identified four research aims, each of which is addressed by one or more of the articles in this thesis.

- ***Aim #1.*** To conceptualize human-nature connectedness as a multidimensional concept and a lever for sustainable change (**Chapters I**, **II** and **III**)
- ***Aim #2.*** To conceptualize and quantify the relationship between human-nature connectedness and pro-environmental behavior outcomes (**Chapters IV**, **V** and **VI**)
- ***Aim #3.*** To empirically measure and quantify the relationship between individuals' attachments, worldviews and attitudes and sustainability aspirations and behaviors (**Chapters VII**)
- ***Aim #4.*** To apply a systems-thinking perspectives to understand how interactions between system parts are enabling or hindering sustainability transformation **(Chapter VIII**)

To meet these aims, I present several new conceptual frameworks for understanding dimensions of human-nature connectedness and pro-environmental behavior (**Chapters II,**

III, IV and **VI),** systematic reviews of the literature that aim to identify trends and research gaps (**Chapters I, V**), and empirical research in a Romanian case study that investigates the determinants of nature connectedness and pro-environmental behavior and attitudes in an energy system (**chapters VII** and **VIII)** (see Figure 1).

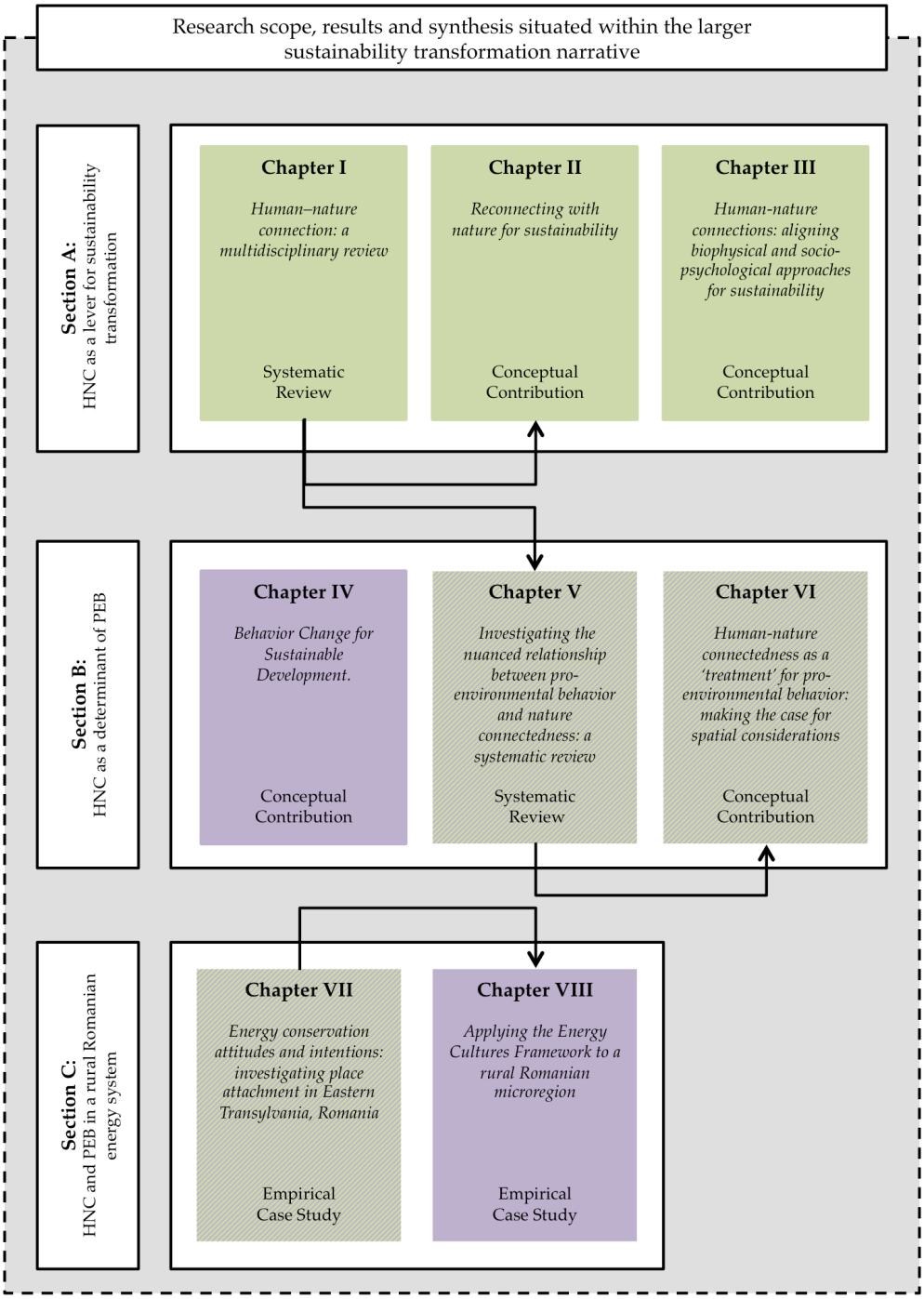

Figure 1. Thesis structure according to key themes, focus areas, and methodology The border indicates the use of sustainability transformation as a boundary object for the thesis. Sections A, B, and C refer to thematic focus of the articles in the respective row. Arrows depict sequential methodological and conceptual relationships between articles. Colors highlight focus areas considered in the articles: green=human-nature connectedness; purple= pro-environmental behaviors, striped= focus on both constructs.

Research Approach

This research was conducted within a large interdisciplinary and transdisciplinary research project titled Leverage Points for Sustainability Transformation (LP; Box 1). The structure and objectives of the LP project provided much of the inspiration and guidelines for the papers in this thesis. In addition, the project selected a study region of Transylvania, Romania, which provided an interesting case study for exploring human-nature connectedness and pro-environmental outcomes. In addition, the interdisciplinary nature of this project and research team inspired interdisciplinary collaboration and the use of theories, concepts, and methodologies from several research fields. The specific methods are described in detail in each of the respective chapters, while an overview of the methodologies is provided in Table 2. The papers presented in this thesis consist of three types of papers: conceptual contributions, systematic reviews, and empirical studies.

Box 1—Leverage Points for Sustainability Transformation

Leverage Points for Sustainability Transformation (LP) was an international, interdisciplinary and transdisciplinary research project funded by the Volkswagen Stiftung, via the "Science for sustainable development" call, and hosted by Leuphana University Lüneburg. The project aimed to address the underlying, foundational issues of how complex socio-ecological systems can be transformed via leverage points—places in complex systems, where a small shift can lead to fundamental changes in the system as a whole. The project was made up of eight Principal Investigators, two Project Coordinators, five Postdocs and ten PhD students in the Faculty of Sustainability.

The project aimed to generate new conceptual and empirical insights into the role of three deep leverage points for sustainability:

1. RESTRUCTURE institutional arrangements;
2. RECONNECT people with nature;
3. RETHINK how knowledge for sustainability is created and acted upon.

Website: https://leveragepoints.org/

Table 2. Summary of analytical and statistical methods used in **Chapters I-VIII**

Chapter	Type of paper	Statistical Analysis	Study Area
I	Systematic literature review	Systematic review; hierarchical cluster analysis; descriptive statistics	Desk study
II	Conceptual contribution	Literature review; framework development	Desk study
III	Conceptual contribution	Literature review	Desk study
IV	Encyclopedia article	Literature review	Desk study
V	Systematic literature review	Systematic review; hierarchical cluster analysis; correlational analysis	Desk study
VI	Conceptual contribution	Archetype creation	Desk study
VII	Empirical study	Confirmatory factor analysis; structural equation modeling	Transylvania, Romania
VIII	Empirical study	TwoStep cluster analysis	Transylvania, Romania

Chapter II, **Chapter III**, and **Chapter VI** are conceptual explorations of themes and concepts at the center of research on human-nature connectedness. These chapters bridge topics though theoretical exploration and introduce useful heuristic tools and archetypes to guide further research of these topics. **Chapter I** and **Chapter V** are systematic literature reviews that review the state of the art on human-nature connectedness and pro-environmental behavior topics and identify patterns, research gaps, and opportunities for greater understanding of the concepts in order to drive future research. These chapters used hierarchical cluster analysis to segment the literature into distinct clusters that could be analyzed and discussed. **Chapters VII** and **VIII** are empirical articles that explore the energy system of a case study in Romania and investigate determinants of energy attitudes, behaviors, norms, and values. These final chapters are based on a quantitative questionnaire that was collected through door-to-door surveys between October and December 2017. The data was collected at the individual level but analyzed at the system level. The statistical analysis of this data was carried out using Confirmatory Factor Analysis, structural equation modeling, TwoStep cluster analysis, and descriptive statistics and correlations.

In the following subsections, I will introduce the study area, briefly outline the methods used in this thesis, the motivation for using these methods, and an explanation of their implementation.

Study Area

The empirical component of this thesis was conducted in Transylvania, Romania, a historical region located in central Romania. Transylvania was one of the two case studies selected in the 'Leverage Points for Sustainability Transformation' project[1], which built upon previous research carried out in the by the project 'Sustainable Landscapes in Southern Transylvania[2]'. The aim of research in this study area was to study and understand sustainability transformation processes within a region with rich cultural and natural heritage, high biodiversity, and changing aspirations for development and prosperity. The region is also an interesting case study due to a series of political and cultural changes (e.g. shifts in political orientation, EU membership, changing property ownership, changing farming practices) that have the potential to change the sustainability trajectory of the region in a positive or negative direction (Horcea-Milcu et al., 2018; Sólyom et al., 2011). Within this larger case study, we identified and assessed several smaller regions appropriate for a quantitative investigation of the relationship between human-nature connectedness and pro-environmental behaviors and attitudes.

We selected the Pogány-havas microregion in Eastern Transylvania (see Figure 2) as the study area for the empirical elements of this thesis. The decision to select the Pogány-havas microregion as our area of exploration was based on a series of factors. Practically speaking, the region's administrative boundaries and population were ideal for collecting a representative sample within our time constraints. The region consists of six communes—the lowest level of administrative subdivision in Romania—and thirty-two villages, with a total population of ~21,000 residents. This made it both feasible and realistic to systematically sample (with a 95% confidence rate and 5% margin of error) all of the villages in the region within a three-month fieldwork season. Additionally, the research team spoke the languages of this region (i.e. Romanian and Hungarian) and had connections within the Pogány-Havas Association that could aid in hiring local field assistants with knowledge of the region. From a theoretical perspective, the microregion was an interesting case study because the region's geographic and demographic characteristics reflect many of the challenges and opportunities being faced across Transylvania.

[1] https://leveragepoints.org/

[2] https://peisajesustenabile.wordpress.com/

[3] Reprinted by permission from Springer Nature: AMBIO, Vol. 46/1. Leverage points for sustainability transformation. David J. Abson, Joern Fischer, Julia Leventon et al., pp. 30-39. Copyright (Jan 1, 2016).

[2] https://peisajesustenabile.wordpress.com/

[4] Reprinted from Energy Research and Social Science, Vol. 7, Janet Stephenson, Barry Barton, Gerry

The microregion boundaries were created by the Pogány-Havas Association in 1999 when the local councils came together with the purpose of forming common goals, expanding the local economy, supporting traditional agriculture, preserving cultural heritage, and promoting nature conservation ("Pogány-Havas Association," n.d.). Geographically, the region consists of: (1) the Csík Basin which is characterized by large meadows, gentle slopes, and many small streams; and (2) the Csík Mountains, which consist of steep slopes, narrow valleys, and a patchwork of forest cover (Demeter et al., 2011). Due to the topography of the region, almost every valley in populated and farmed. The region is of exceptional natural value and there are high levels of biodiversity across the landscape. The species-rich mountain hay meadows in the region are among the most botanically diverse in Europe (Csergő et al., 2011). The high diversity of flora and fauna in the region (Dorresteijn et al., 2013; Loos et al., 2014) can be observed across the region's wetlands, fens, forests, and grasslands, many of which have been traditionally and sustainably managed by local communities for generations (Biró et al., 2011).

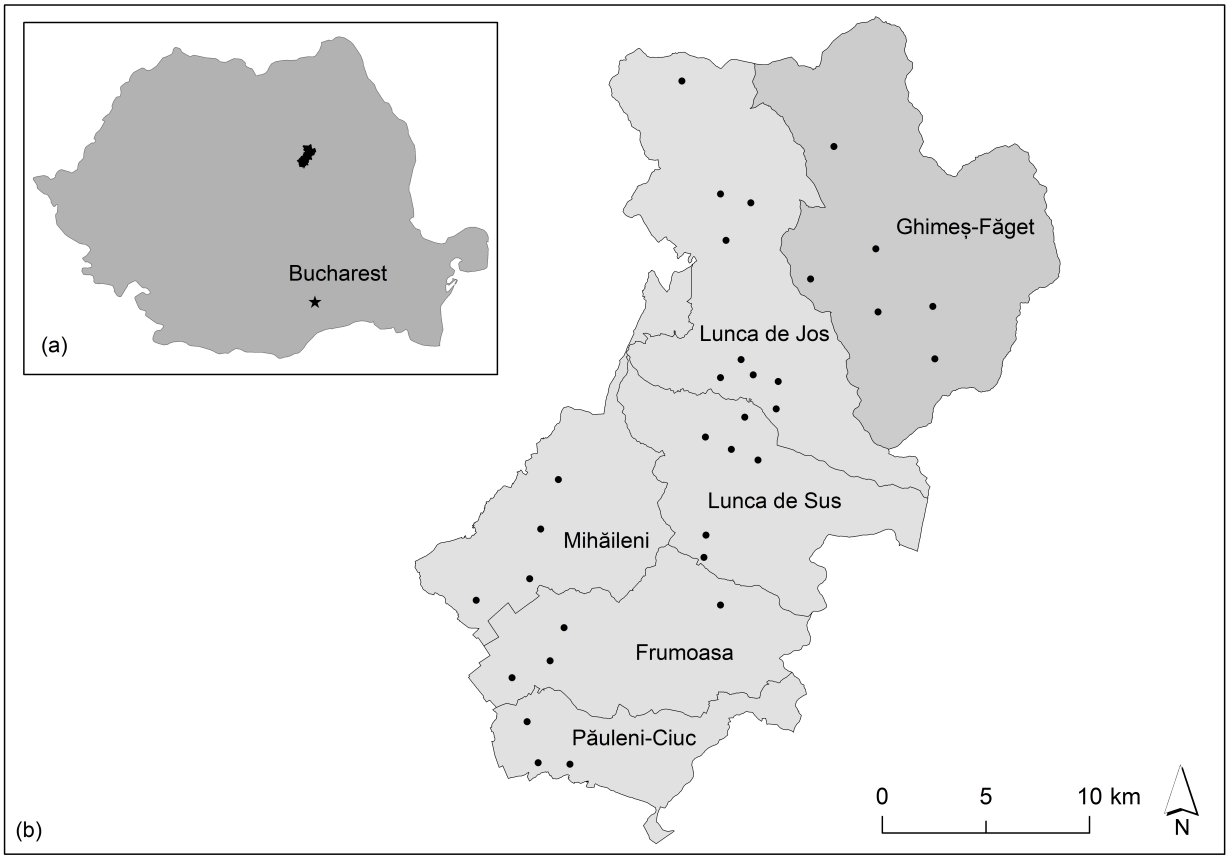

Figure 2. Map of the Pogány-havas microregion (a), with the six communes and thirty-two villages indicated. The insert in top left corner (b) shows the location of the region in Romania, with the capitol of Bucharest starred.

The region's population is characterized by strong ethnic and cultural traditions, as well as by traditional small-scale farming. The region is primarily populated by two Hungarian-speaking ethnic groups, the Székelys and the Csángós, which make up more than 80% of the population (Demeter et al., 2011). These communities have strong cultural and historical practices and are known for their folk costumes, dances, music and architecture. In addition, the rural communities in this region practice traditional semi-subsistence farming with small arable land holdings and small pastures (Biró et al., 2011). Many residents keep domestic animals such as cows, sheep and chickens for personal use and to sell products to local markets. The rural communities in this microregion live in close connection with the land, where generation of traditional farming methods have maintained landscape structure and local habitats (Csergő et al., 2011). There are high levels of traditional ecological knowledge and traditional knowledge of land management among the local population, which are inherited and learned from childhood (Demeter et al., 2011).

However, the region is also under transition. Like many other Eastern European countries, rural regions in Romania are experiencing challenges related to low incomes, rural flight and aging populations, lack of economic opportunities, and a decline in local traditions and traditional products (Buta et al., 2014; Milcu et al., 2014). A study in the region found that many residents believe that their children will not continue farming in the region because they plan to move to big cities or other countries for educational and career opportunities (Biró et al., 2011). In addition, the period of post-communism and EU membership has led to increased challenges related to farming practices, land ownership, and selling agricultural products, as well as differing aspirations for future development (Mikulcak et al., 2013; Milcu et al., 2014; Sólyom et al., 2011). This region also is seeing meadow abandonment, which may have implications for meadow biodiversity as well as for traditional human-nature relationships (Biró et al., 2011). These challenges, partnered with the geographic and population characteristics, make this microregion an interesting case study for investigating human-nature connectedness and the ways in which these connections shape how individuals view, interact with, and value the natural world.

Methods

This thesis embraced interdisciplinarity—the integration of methods, concepts, and knowledge from multiple disciplines in order to approach and better understand complex sustainability challenges (Yarime et al., 2012)—as a core research approach. This approached allow us to understand the complexity and multifaceted nature of sustainability and to observe interlinkages among system properties. Theoretically, this thesis drew upon literature from the fields of sustainability science, environmental psychology, environmental

science, ecology, tourism, and geography. Methodologically, this work primarily relied upon methods from environmental psychology, geography, and ecology. Here I briefly outline the motivation for the main methods used in this thesis: (1) conceptual contributions with framework development, (2) systematic reviews using hierarchical clustering, and (3) quantitative surveys analyzed with structural equation modeling and TwoStep cluster analysis. Additionally, I introduce two analytical frameworks—Leverage Points and the Energy Cultures Framework—that emerged from interdisciplinary systems-thinking literature and provided structure for analyzing and contextualizing our findings within a larger sustainability transformation narrative.

Conceptual Contributions with Framework Development

This thesis contains several conceptual contributions to the literature: **Chapter II, III, IV** and **VI**. The aim of these articles was to add to the conceptualization of human-nature connectedness and pro-environmental behavior by explicitly delineating patterns and challenging and extending existing knowledge. These articles each took a structured approach and included an extensive literature review to build the conceptual arguments. In **Chapter II**, we developed a conceptual platform to better understand human-nature connectedness. Methodologically, this involved organizing the vast literature and presenting: (1) a visual conceptualization of human-nature connectedness along a spectrum and (2) clustering and segmenting the literature according to it's emphasis on causes, consequences, or treatment. This conceptual contribution aims to bring clarity to the multidimensionality of concepts and perspectives that characterize the literature. **Chapter III** is a conceptual perspective piece that aims to integrate the field of human-nature connectedness by pointing out the divide between biophysical and socio-psychological human-nature connectedness research. This article used a literature review to explain the two approaches and then draws upon methods, models, and meaning to generate new lines of conceptual inquiry for the field of human-nature connectedness. **Chapter IV** is an entry in an encyclopedia focused on sustainability. This chapter aims to summarize the vast literature on pro-environmental behavior and sustainable development by presenting a concise review of the field. In **Chapter VI**, we identified three distinct archetypes to understand the scalar relationships between human-nature connectedness and pro-environmental behavior. Building on existing relationships described in the literature, we defined and refined the archetypes until we reach the three archetypes. The aim of archetype generation is to recognize reoccurring trends and groupings in the literature and to delineate these groups and discuss their commonalities in order to support future inquiry.

Systematic Reviews with Hierarchical Clustering Analysis

This thesis also used systematic review methodology and hierarchical cluster analysis to describe the literature, report on trends and gaps, and set a future research agenda. Systematic reviews start with a clearly formulated research question and use systematic methods to identify, select, and evaluate a field of research (Moher et al., 2009). In **Chapter I** and **Chapter V** we followed the systematic review methodology and used hierarchical cluster analysis to cluster and summarize the included studies. The dataset was collected from the SCOPUS database using a defined search string and studies were selected based on a series of screening and eligibility criteria. A strict coding protocol and data collection process was followed and reported on in each article. The use of hierarchical cluster analysis was selected, as it allows for segmentation of the literature and the calculation of the variables that strongly determine cluster membership. The aim of this methodology was to clearly segment the literatures into distinct groups and highlight trends in the way human-nature connectedness and pro-environmental behavior have been studied to date.

Quantitative Questionnaires Analyzed Using Structural Equation Modeling and TwoStep Cluster Analysis

For our empirical exploration, we selected a correlational design to describe the relationship between independent (i.e. human-nature connectedness) and dependent variables (i.e. energy attitudes and behaviors) in a naturally occurring setting (i.e. Transylvania, Romania) (Pelham and Blanton, 2007). In the field of environmental psychology and human-nature connectedness literature, correlational designs are typically used to examine research questions (Abrahamse et al., 2016). Correlational studies tend to possess high external validity and have a greater degree of generalizability to other situations and other populations (Abrahamse et al., 2016). **Chapter VII and VIII** relied on a quantitative community survey strategy to answer research questions about the relationship between human-nature connectedness and pro-environmental behaviors and attitudes. Surveys are a popular method of collecting self-report data on individual behaviors and attitudes, and are usually used to measure correlations among variables (Hine et al., 2016). We employed a cross-sectional design to measure a single group of respondents (i.e. residents of the Pogány-havas microregion) at one point in time (i.e. October-December 2017). This research design best fit the needs of our research objectives, as we were interested in investigating how individuals' connections to nature correlated with energy conservation attitudes and behaviors. We chose a systematic sampling method for our research and aimed to get a representative sample for the microregion. We pretested the survey on small convenience sample to establish the timing of the survey, evaluate comprehension of the items, and identify confusing or ambiguous items (Hine et al., 2016).

In an attempt to use measures that had high reliability and validity, we employed several existing measures that had previously demonstrated to be reliable and valid (e.g. the New Ecological Paradigm scale; Dunlap et al., 2000) and a place attachment scale (i.e. Nature Bonding; Raymond et al., 2010). For the constructs we were interested in measuring that didn't have an existing scale, we either modified a similar scale from the literature (e.g. the four items on energy attitudes) or created entirely new items (e.g. items measuring cost barriers). With the exception of a final open-ended question, the survey consisted of closed-ended questions. Given the number of items that we were measuring, closed-ended questions were selected because they are typically easier to analyze, and less demanding on both the respondents and the interviewers (Bradburn et al., 2004). The closed-ended questions used a mix of rate scale response formats. The majority of questions used a 5-point scale that ranged from "*strongly agree"* to "*strongly disagree*," while a 6-point scale was used for measuring social acceptability of renewable energies (i.e. "*totally unacceptable"* to "*perfectly acceptable"*). Scales between 5 and 7 points tend to be highly reliable and valid (Visser et al., 2000). A final open-ended question was added to the survey to elicit richer and more nuanced perspectives on renewable energy and energy conservation, as well as to leave space for additional comments, clarification of previous responses, or unexpected perspectives that were not addressed in the close-ended questions (Bradburn et al., 2004). The order of the items was carefully considered, so as to minimize potential order effects (Visser et al., 2000). While we couldn't vary the order of the questions, given that it was a paper survey, we gave careful consideration to the order of the questions, presented questions in the easiest to understand format, and tried to avoid stakeholder fatigue (Hine et al., 2016; Visser et al., 2000).

Chapter VII used Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to analyze the relationship between place attachment and energy conservation attitudes and behavioral intentions. CFA was used to confirm the three-dimensional structure of the place attachment construct and SEM was used to test the influence of place attachment on attitudes and behavioral intentions. In environmental psychology, SEM is commonly used in cross-sectional designs and has been found to be well suited to addressing research questions interested in the determinants of pro-environmental behavior, attitudes, and norms. SEM is a "hypothesized pattern of directional and nondirectional linear relationships among a set of MVs [measured variables] and LVs [latent variables]" (MacCallum and Austin, 2000, p. 202). **Chapter VIII** used the TwoStep clustering algorithm in SPSS 25.0 to segment the data into distinct clusters. The use of this methodology was an iterative process, as we selected various numbers of input variables and forced various cluster solutions to determine the best cluster segmentation for the data based on silhouette scores and descriptive statistics of the clusters.

Use of Two Analytical Frameworks to Situate Results in a Larger Systems Context

Along with being an interdisciplinary research effort, this thesis called upon two analytical frameworks to help situate our research within the larger systems perspective. The first was Donella Meadows' concept of 'leverage points', which are places within complex systems where a small shift in one system element can produce large scale and fundament changes across the system (Meadows, 1999) (see Figure 3). The leverage points concepts argues that sustainability interventions applied to date have primarily targeted shallow leverage points that are easy to implement, but are unlikely to lead to transformational change (Abson et al., 2017). The leverage points concept was used in our research to highlight the potential of human-nature connectedness to incite change in pro-environmental values, goals and worldviews of societies, which are deep leverage points potentially capable of large-scale sustainability transformation. This framework was not used to structure specific research methodology, but was use extensively throughout the thesis to think systemically about the deep causes of unsustainability and to situate our research findings within a larger narrative of sustainability transformation.

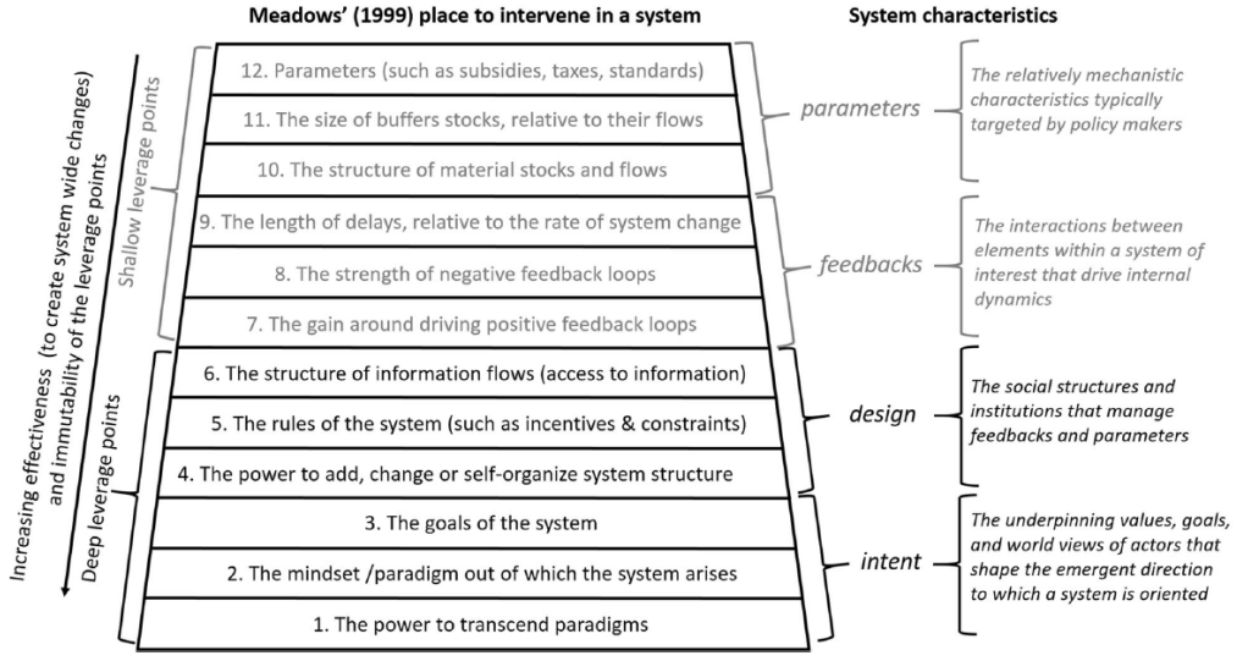

Figure 3. The twelve Leverage Points and four system characteristics[3]

The second framework used in this thesis was the 'Energy Cultures Framework,' which looks at interactions between the material culture, norms, and practices across an energy

[3] Reprinted by permission from Springer Nature: AMBIO, Vol. 46/1. Leverage points for sustainability transformation. David J. Abson, Joern Fischer, Julia Leventon et al., pp. 30-39. Copyright (Jan 1, 2016).

system (Stephenson et al., 2010) (Figure 4). The framework is an integrating heuristic designed to support interdisciplinary research into the sustainability transitions of energy systems by theorizing energy behavior in a wider social and material context (Stephenson et al., 2015). The framework highlights the interactions between elements of an energy system and highlights the wider systemic influences on behavior. The framework was designed to take into account the broad range of factors that have been identified as driving energy behavior, in order to identify 'levers' for change towards more energy efficient behaviors. Along with being a conceptual framework that guided the empirical exploration in **Chapter VIII,** we also applied this framework post-doc to structure and analyze our results. We made use of this framework in **Chapter VIII** because it allowed us to analyze the entirety of our large and complex dataset, to identify patterns of similar energy behaviors within the population, and to explore interactions between the material culture, norms, and practices that are either constraining the system from moving towards a sustainable energy future or providing opportunities for a more sustainable trajectory. Because the Energy Cultures Framework is a heuristic tool that can be applied at various stages of the research project, it allowed us flexibility to examine interactions within our data that we hadn't originally planned to study when we drafted the questionnaire. In this way, we increased our understanding of the energy system in the case study region and identified interactions between elements that are constraining and supporting a sustainable energy future.

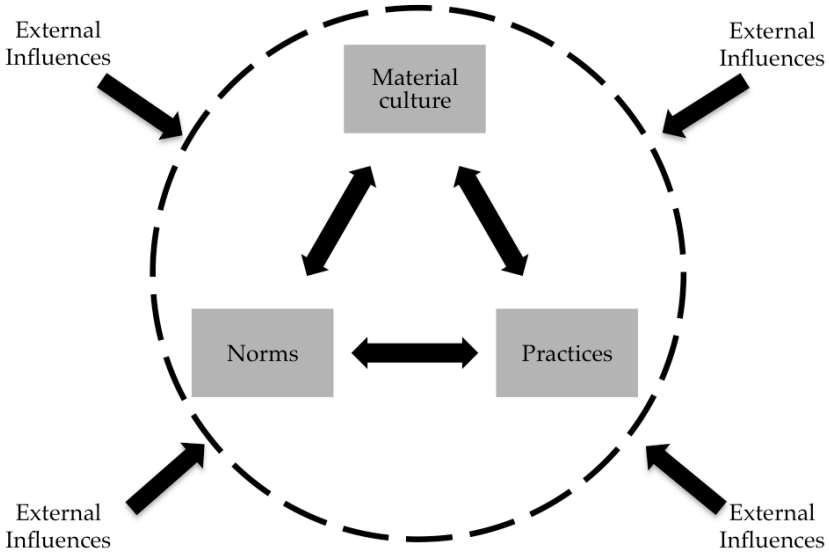

Figure 4. The Energy Cultures Framework (Stephenson et al., 2010)[4]

[4] Reprinted from Energy Research and Social Science, Vol. 7, Janet Stephenson, Barry Barton, Gerry Carrington, Adam Doering, Rebecca Ford, Debbie Hopkins, Rob Lawson, Alaric McCarthy, David Rees, Michelle Scott, Paul Thorsnes, Sara Walton, John Williams, and Ben Wooliscroft, The energy cultures framework: Exploring the role of norms, practices and material culture in shaping energy behaviour in New Zealand, 117-123, Copyright (2015), with permission from Elsevier.

Key Findings

This chapter presents an overview of each of the chapters included in this cumulative dissertation. For ease of presenting the key results and synthesizing the findings from the papers, the articles are organized into three subsections: Section A, Section B, and Section C.

The first three papers (**Chapters I-III**) are included in **Section A**, which addresses human-nature connectedness and its potential for sustainability transformation:

Chapter I. Ives, C.D., Giusti, M., Fischer, J., Abson, D.J., **Klaniecki, K.**, Dorninger, C., Laudan, J., Barthel, S., Abernethy, P., Martín-López, B. and Raymond, C.M., 2017. Human–nature connection: a multidisciplinary review. *Current Opinion in Environmental Sustainability*, 26, pp.106-113. https://doi.org/10.1016/j.cosust.2017.05.005

Chapter II. Ives, C.D., Abson, D.J., von Wehrden, H., Dorninger, C., **Klaniecki, K.** and Fischer, J., 2018. Reconnecting with nature for sustainability. *Sustainability Science*, 13(5) pp.1389-1397. https://doi.org/10.1007/s11625-018-0542-9

Chapter III. Abson, D.J., **Klaniecki, K.**, Dorninger, C., Riechers, M., Ives, C.D., and von Wehrden, H. 2019. Human-nature connections: aligning biophysical and socio-psychological approaches for sustainability. Submitted to *People and Nature*.

Three papers (**Chapters IV-VI)** are included in **Section B,** which addresses pro-environmental behavior and human-nature connectedness as a determinant of behavioral outcomes:

Chapter IV. **Klaniecki, K.,** Wuropulos, K., and Persson Hager, C. 2019. Behavior Change for Sustainable Development. In: Leal Filho W. (eds) *Encyclopedia of Sustainability in Higher Education*. Springer, Cham. https://doi.org/10.1007/978-3-319-63951-2_161-1

Chapter V. **Klaniecki, K.**, Abson, D.J., Ives, C.D. 2019. Investigating the nuanced relationship between pro-environmental behavior and nature connectedness: a systematic review. Submitted to *Environment and Behavior*.

Chapter VI. **Klaniecki, K**., Leventon, J., Abson, D.J. 2018. Human-nature connectedness as a 'treatment' for pro-environmental behavior: making the case for spatial considerations. *Sustainability Science*, 13(5) pp. 1375-1388. https://doi.org/10.1007/s11625-018-0578-x

Chapters VII-VIII are included in **Section C**, which explores energy systems in eastern Transylvania, Romania, and the connections, attachments, values, attitudes, behaviors, and norms that are driving energy behaviors in the region:

Chapter VII. **Klaniecki, K.,** Duse, I.A., Engler, J.O., Leventon, J., and Abson, D.J. 2019. Energy conservation attitudes and intentions: investigating place attachment in Eastern Transylvania, Romania. Under review at *Psyecology*.

Chapter VIII. **Klaniecki, K.,** Duse, I.A., Lutz, L.M., Leventon, J., and Abson, D.J. 2019. Applying the Energy Cultures Framework to a rural Romanian microregion. Submitted to *Sustainability*.

Findings from Articles in Section A

In **Section A** (**Chapters I-III**), we address human-nature connectedness as a leverage point for sustainability transformation. In **Chapter I, "Human–nature connection: a multidisciplinary review",** we conducted a systematic review of the human-nature connectedness literature. The aim of the review was to understand the existing scholarship and to characterize the diversity of disciplinary approaches, theoretical and conceptual perspectives, methodology, and suggested pathways for reconnection. Our findings showcase the heterogeneous nature of the field, which is segmented into three main strands of HNC research: *HNC as mind*, *HNC as place*, and *HNC as experience*. These findings highlight the need to integrate insights across methodological, epistemological, and geographic boundaries in order to address key gaps in the literature. We also highlight the need to (1) specify the characteristics of nature that people are connected to and (2) conduct more research at the community or society level. There is an overarching need to connect HNC research to sustainability challenges and explicitly offer practical recommendations for sustainability.

Chapter II, "Reconnecting to nature for sustainability", lays a conceptual platform to better understand human-nature connectedness. We conceptually expand the discussion of human-nature connectedness in three ways. First, we propose that the human-nature connectedness should be conceptualized a multidimensional construct consisting of five interacting types of connectedness—material, experiential, psychological, philosophical, and emotional. We created a conceptualization that occurs along a spectrum from: (a) inner to outer worlds, and (b) scales of social aggregation. Second, we showed that research varies according to whether it emphasizes: (1) the *causes* of nature disconnection, (2) the *consequences* of disconnection, or (3) reconnecting to nature as a *treatment* for some problem. Lastly, we apply the Leverage Points framework (Abson et al., 2017; Meadows, 1999) to bring clarity to the literature on human-nature connection. We argue that this perspective helps clarify which interventions for reconnecting humans with nature could bring about the most transformational changes.

Observations of the opportunities for integration across disciplinary boundaries in HNC research motivated **Chapter III, "Human-nature connections: aligning biophysical and socio-psychological approaches for sustainability".** We argue that the human-nature connectedness literature can be broadly split into two approaches: (1) biophysical connectedness, which argues for reconnecting to the biosphere and material flows, and (2) socio-psychological connectedness, which argues for greater affective and emotional connections with nature. We discuss how these dominant approaches have very different problem framings, operationalization and methodologies, as well as different in terms of scales of analysis, structure and agency, and places to intervene in systems. Both approaches aim to deal with the complexity of the system, but they have tended to operate in distinct and distant fields. In order to align these two approaches, we point out the need to draw system boundaries so that the biophysical approach considers the root causes of disconnection and the socio-psychological approach considers the structural factors of disconnection. We propose that bridging meaning (e.g. defining what it means to be connected to nature), models (e.g. focusing on the formal and informal institutions, rules and structures that shape connections to nature), and methods (e.g. using place-based or landscape-based research approaches) will be crucial for moving towards more sustainable human-nature connections.

Findings from Articles in Section B

Section B consists of three papers (**Chapters IV-VI**) that focus on pro-environmental behavior and the ways in which human-nature connectedness can serve as a determinant of such behavior. **Chapter IV, "Behavior Change for Sustainable Development"**, is a chapter in the Encyclopedia of Sustainability in Higher Education. The chapter reviews and

summarizes the literature on pro-environmental behavior. The paper gives an overview of theories and models on behavior and behavior change relating to pro-environmental behavior, insights for planning successful behavior change programs, and examples of successful behavior change interventions. The paper also discusses critiques of the behavior change approach. This article is a tertiary contribution that attempts to collect, summarize, and consolidate the literature on pro-environmental behaviors into a concise overview article. This article went through a peer-review process, but does not contribute any primary data or original findings to the thesis.

Chapter V, "Investigating the nuanced relationship between pro-environmental behavior and nature connectedness: a systematic review", explores how the relationship between human-nature connectedness and pro-environmental behavior has been studied in the literature. We conducted a systematic review of a subset of data from the dataset gathered in **Chapter III**, reviewing only the papers that focused on describing or measuring the relationship between PEB and HNC. Our results show that HNC-PEB research is characterized by a dominance of psychology methods and approaches, which tend to rely on tourists and visitors, general samples, and university students for study participants. In addition, the studies rely on Likert-type scales and infrequently measure actual behavior. The current state of HNC-PEB can be categorized into three clusters, which can be characterized by whether or not you're interested in: (1) how local connections influence local behavioral outcomes; (2) how visits to natural areas influence behaviors to protect those areas, or (3) how a general connection to nature influences your overall behaviors. Further analysis of the data revealed that little attention has been paid to the relationships between scale and type of HNC and PEB. We argue that there is a need for greater justification for how PEBs are measured and greater consideration of the scale at which nature connectedness is experienced and the scale at which impacts of behaviors are felt. The field must evolve towards more interdisciplinary and transdisciplinary studies, embrace qualitative methods that unearth deeper drivers of connectedness and highlight the complexity of behavior, and select case studies outside of the convenient spheres of universities and protected areas. By embracing these diverse research practices, we suggest this field of inquiry will contribute to a more nuanced understanding of how connectedness to nature can serve as a lever for the adoption of pro-environmental behaviors and sustainability.

Based on our understanding of the relationship between HNC and PEB and our exploration of the current state of the art, we propose a framework in **Chapter VI ("Human-nature connectedness as a 'treatment' for pro-environmental behavior: making the case for spatial considerations")** for thinking about the relationships between where individuals

connect to nature and what type of pro-environmental behaviors might be related to these connections. We argue that calls to 'reconnect to nature' as a 'treatment' for PEB are lacking dimensionality and fail to adequately describe how *where* one feels connected to nature may relate to *where* one acts pro-environmentally. In order to facilitate future conceptual and empirical research to address this research gap, we classify HNC and PEB according to grain and extent, with small to large extents of HNC and PEB and fine to coarse grain HNC and PEB. Based on these conceptualizations, we introduce three archetypes that are crafted to further integrate spatial considerations into HNC-PEB research. Archetype 1, *equal interactions*, is characterized by PEB and HNC at the same grain and extent. Archetype 2, *embedded interactions*, reflects connectedness at coarser spatial grains and PEBs at fine spatial extents. Archetype 3, *extended interactions*, refers to fine grain and small extent connectedness that promoted PEBs with large extent impacts. Our intention with introducing these three archetypical interacts is to aid in the specification of HNC-PEB research and to provide a framework for empirical testing and practical application.

Findings from Articles in Section C

Chapters VII and VIII in **Section C** focused on the empirical work conducted in the Pogány-havas microregion of Transylvania, Romania. **Chapter VII ("Energy conservation attitudes and intentions: investigating place attachment in Eastern Transylvania, Romania")** explores place attachment and energy conservation attitudes and behavioral intentions in a traditional cultural landscape. It explores three dimensions of place attachment—place identify, place dependence and nature bonding—and the degree to which these dimensions predict positive attitudes and behaviors towards energy conservation. Using Principal Component Analysis and Structural Equation modeling to analyze the data and report on statistical relationship between the measured constructs, we found that residents in the region report a high level of attachment to place, with the strongest attachments to nature. However, our data did not support previous studies published in the field. Our research found negligible relationships between place identity and attitudes, and between nature bonding and attitudes. Additionally, our researched revealed significant negative relationships between place dependence and attitudes and between place identity and behavioral intention. Our results emphasize that in rural areas the hypothesized relationships between place attachment and pro-environmental attitudes and behaviors might be meditated by several other socio-economic factors. We call for more systemic research approaches that consider the material and structural dimensions of the system that are shaping how individuals view and perceive nature and use and consume energy.

Lastly, **Chapter VIII ("Applying the Energy Cultures Framework to a rural Romanian microregion")** applies the Energy Cultures Framework (Stephenson et al., 2010) post-hoc to

analyze the system interactions occurring within a rural energy system. We used the framework to structure our analysis and to examine the interactions between norms, practices, and material culture in the region. TwoStep cluster analysis revealed a nearly homogenous material culture that was defined by similar uses of energy, types of energy used, number of appliances, and building infrastructure. While findings point to strongly positive attitudes towards conservation and stewardship, most residents are already consuming at the lowest possible rate and than any more conservation would reduce their quality of life. We find that factors such as incomes, attitudes towards conservation and frugality, and aging infrastructure are heavily shaping energy behaviors in this region. The traditional cultural values and practices of the region are keeping consumption behaviors low and contributing to positive attitudes towards conserving resources. Our results suggest that in rural areas under transition, studies on energy systems must consider reducing energy poverty and promoting rural development within the context of energy system transformation. Our findings highlight the importance of including the human-dimension in the study of rural energy transitions and contribute to the development of the Energy Cultures Framework though application in a new case study region.

Discussion

Key Insights

This thesis investigated human-nature connectedness as a determinant of pro-environmental outcomes and contributed new information about the nuances of this relationship. This thesis will not radically change the sustainable trajectory of the world nor does it present groundbreaking findings that will completely transform unsustainable human behavior; however, when looked at as a whole body of work, this research unequivocally makes a contribution to the scientific literature on human-nature connectedness and pro-environmental outcomes and expands our current understandings of the ways in which these constructs are related. The strength of this work is that it draws from an interdisciplinary background and uses systems-thinking frameworks to situate the research within larger sustainability narratives. Here, I aim to synthesize the findings of the eight individual papers, define the red thread that ties the independent pieces of work together, and situate these findings within the context of reconnecting to nature for sustainability outcomes. I identify crosscutting themes that shed light on human-nature connectedness as a determinant of pro-environmental outcomes for sustainability transformations. Based on the themes that emerged from this work, we address the ways in which this research contributes to addressing the previously discussed research gaps and what questions it opened up for future conceptual research and empirical exploration.

The key contributions of this thesis to the field of human-nature connectedness and pro-environmental outcomes can be summarized as follows:

1. By redefining the conceptualization of human-nature connectedness, so as to expand the ability of these approaches to address the root of disconnection and positively impact sustainability transformation

2. By investigating and describing the nuanced HNC-PEB relationship, so as to define the research agenda, and contribute to making HNC as a 'treatment' for PEB change more effective

3. By empirically investigating the linkages between HNC and sustainability outcomes in a new case study region, so as to improve our understanding of the linkages between these concepts outside a convenience sample or a high-consumption region

4. By applying systems-thinking lenses in order to observe interactions between systems elements and to conceptualize the HNC-PEB relationship within the framing of deep sustainability transformation and change.

In the following sections, I discuss each of these crosscutting contributions in turn and consider the implications of this joint body of work.

Redefining the conceptualization of human-nature connectedness

At the onset of this research, the field of human-nature connectedness research was rapidly expanding and 'reconnecting to nature' had become a buzzword within the sustainability community. While the field had developed to include cognitive dimensions (e.g. Schultz, 2002), affective dimensions (e.g. Kals et al., 1999; Mayer and Frantz, 2004; Stedman, 2003), and experiential dimensions (e.g. Keniger et al., 2013; Nisbet et al., 2009; Soga and Gaston, 2016) of connectedness, the overarching field was still largely undefined and research was operating within strong disciplinary boundaries of theory and methods (Zylstra et al., 2014). Furthermore, the explosion of the field was leading to the development of ever more expansive psychometric scales of nature connectedness. This led to a fragmentation of the literature and an inability to integrate the approaches for considering society-scale phenomena of connection or disconnection. Our research took several steps to define the state of the art, point out the gaps in current conceptualizations, and to further specify human-nature connectedness as a multidimensional construct.

Our research impacted the development of HNC research by expanding the conceptualization of HNC and inviting integration across methodological, epistemological and geographic boundaries. We showcased the heterogeneous nature of the field and offering insights for integrating disparate approaches and targeting the application of HNC in order to foster sustainability transformation. As this is a rapidly developing field, integrations between the diversity of the field should be embraced and called upon to aid in the greater operationalization of HNC. In particular, our research highlighted how keeping biophysical and socio-psychological approached siloed prevents either approach from fully describing the root causes of human-nature disconnections and limits the ability of these approach to offer solutions. Gaps in our understanding of human-nature connectedness are preventing scholars from seeing greater system interactions and identifying opportunities for change. The new conceptualization of human-nature connectedness introduced in this

thesis will enable research to move past vague speculation about reconnecting to nature and instead generate additional knowledge and tools for addressing the root causes of disconnection and further identifying opportunities for deep sustainability transformation.

Investigating and describing the nuanced HNC-PEB relationship

Our research showed that HNC research varies according to whether it emphasizes: (1) the *cause*s of nature disconnection, (2) the *consequence*s of disconnection, or (3) reconnecting to nature as a *treatment* for some problem. This thesis contributed to the field of nature as a treatment (e.g. how reconnecting to nature can cultivate pro-environmental attitudes and behaviors and address patterns of unsustainability) by improving the understanding of the ways in which these constructs interact, the directionality of the relationship, and the nuances of the relationship. While some scholars had previously added geographic thinking to enhance conceptualizations and visualizations of nature connectedness (e.g. Beery and Wolf-Watz, 2014; Brown et al., 2015), there was a general lack of attention paid to the ways in which *where* an individual connections to nature may influence *where* they act pro-environmentally. It was evident that there was likely to be a relationship, but scholars had mostly failed to address these types of questions. This thesis added dimension to our understanding of the relationship between HNC and PEB by pointing out gaps in our understanding of the scalar relationship between these construct and my providing archetypes designed to aid and set the future research agenda of the field.

The field of HNC and PEB research has been reliant on the use of Likert-scales to measure HNC and PEB and correlational analysis to explore the statistical relationship between the two constructs. While this has been helpful in defining the field and kicking off inquiry into these areas, it is now too mechanistic and limited to show us true opportunities to lever the system for change. This is somewhat hypocritical to argue, because this thesis also used correlational studies and quantitative methods to discuss the connections between HNC and PEB. However, in our studies we found that the strictly statistical relationships did not tell us much about how these constructs interacted in our case study area. This idea that HNC=PEB is very simplistic, too mechanistic, and isn't based in what actually happens in the world. Rather, we found that more systemic approaches, where interactions between system properties were examined, were far more useful for gaining information about the current state of the system and potential for a sustainable trajectory.

Empirically investigating the linkages between HNC and sustainability outcomes in a new case study region

The ways in which HNC and PEB have been studied in the literature have primarily been interested in local connections and local behaviors (e.g. Cammack et al., 2011; Guiney and

Oberhauser, 2009) or general connections and general behaviors (e.g. Davis et al., 2011; Mayer and Frantz, 2004). There has also been an overreliance on convenience samples in the HNC-PEB literature, particularly university students and tourists as the primary study participants. While these types of studies built the foundation of our understanding of the HNC-PEB relationship, there is a greater need now for studies that look at underrepresented populations and geographies. Our research contributes to this need by studying the HNC-PEB relationship in a new location—a rural cultural landscape in Transylvania, Romania—and at a representative regional-level scale. Our research was also novel because it had a narrow focus on energy conservation attitudes and behaviors. In two ways we pushed the dominant methodology of the field—we studied HNC in a place that has largely been unrepresented in the literature, as well as looking at linkages to a specific genre of PEBs. Our findings confirm that the level of which one feels connected to nature can be a positive predictor of pro-environmental attitudes and behaviors. However, my research adds complexity and dimension to this rather straightforward assumption that raising HNC levels will result in raised PEBs or environmental attitudes. Within our case study, we see that individuals report a very high attachment to place and the natural world. As well, these individuals are practicing extremely frugal consumption behaviors. However, our statistical results showed a week connection between place attachment and environmental attitudes and behaviors. This suggests that there are many contextual and systemic factors that contribute to how individuals act and think about the environment in this region. This suggests that HNC research could benefit from replicating studies in new case studies and with new populations, as well as adopting integrative or interdisciplinary approaches that highlight previously unidentified factors that strongly shape the interaction between nature connectedness and sustainability outcomes.

Applying systems-thinking lenses to observe interactions between systems elements

To study human-nature connectedness and it's potential for transformative sustainability outcomes requires new methodological and analytical approaches. The findings of this thesis were largely shaped by the interdisciplinary nature of the researchers and the application of two analytical frameworks: Leverage Points (Abson et al., 2017; Meadows, 1999) and the Energy Cultures Framework (Stephenson et al., 2010). Both perspectives widened the scope of the research and encouraged connections to other disciplines and concepts from an early stage. The interdisciplinary nature of the research shaped the findings and allowed us to link perspectives that had previously not been linked and "provide a more holistic theoretical and empirical understanding of the ways in which the drivers of human behaviour place a role within current economic, social, cultural and political contexts" (Abrahamse, 2019, p. 6).

The use of systems-thinking frameworks also allowed for greater opportunity to situate our research. Both are integrating models that take a systems perspective and are designed to understand the systemic context. The strengths of using these frameworks are that it allowed our findings to be situated within a larger narrative of meaningful change, rather than simply considering the statistical output.

Limitations of this Research Approach

The limitations faced in this thesis were not unique or unheard of nor did they heavily shape the outcome of our research, however they merit being acknowledged so as to contextualize the results in the larger scientific narrative. While we aimed to integrate interdisciplinary approaches into our work, the empirical aspects of this thesis primarily relied on a quantitative questionnaire and correlational studies. This approach, while commonly used and seen as more representative of real world interactions, is criticized because it only shows relationships between measured variables and doesn't uncover or address the complexity of human-nature relationships. There is no experimental manipulation and results simply show a correlation but not that the independent variable caused the behaviors or attitude to occur (Hine et al., 2016). While our approach allowed us to study the relationships between a wide range of variables and to collect responses from a large community sample, designing a mixed-methods approach with interviews or focus groups might have revealed additional explanations and motivations for pro-environment behaviors and attitudes.

Limitations to our dataset were also evident in the data analysis phase. Scale reliability and validity issues forced us to drop several items from the structural equation model analysis in **Chapter VII**. Several of the constructs were measured using only a few items (e.g. 2 items to measure behavioral constraint, 4 items to measure knowledge) and we experienced psychometric issues such as low internal reliability (McIntyre and Milfont, 2016) that required us to remove these items from our analysis. Additionally, the choice of cluster analysis for determining the dominant energy culture in **Chapter VIII** introduced some limitations into that study. While cluster analysis has been applied previously to segment populations into distinct energy cultures (e.g. Lawson and Williams, 2012), it is inherently an exploratory data technique. Based on the cluster technique used, the number of variables included in the analysis, and the limitations placed on the clustering solutions, different clusters may emerge from the same dataset (Kaufman and Rousseeuw, 2005). This method was appropriate for our data set, since we were interested in examining overarching similarities and separations within the dataset. However, different statistical approaches may have yielded different results and conclusion about the factors that are maintaining the energy culture of that region.

There is also inevitable bias in our research. One downside to a face-to-face survey methodology is that there is an increased risk of socially desirable responding, wherein respondents over-report socially desirable behaviors and underreport socially undesirable behaviors (Hine et al., 2016), and acquiescence bias, wherein respondents tend to agree or disagree with all or most of the questions asked (McIntyre and Milfont, 2016). It's hard to measure the degree to which this happened in our research, but there was bound to be a degree of socially desirable responding because the interviewer was asking the questions. Disguising the purpose of the study or reassuring respondents that there is no right or wrong answer can typically avoid response bias. However, given we were two foreign researchers visiting very small villages and asking about renewable energy and conservation it was challenging to hide the purpose of our research and impressions about the socially desirable responses. We did not observe any extremity bias in our research (i.e. tendency to choose extreme ratings), since there seemed to be a social norm of simply agreeing or disagreeing with the items without feeling 'strongly' about either option.

Conclusions

The overarching aim of this thesis was to examine if human-nature connectedness is a deep leverage point for sustainability transformation. This thesis contributed to addressing this research question through empirical exploration and the introduction of conceptual frameworks to support future research and development of the field. Through eight independent papers, this thesis contributed to a more robust understanding of scales of nature connectedness and attachment and highlighted the associations between human-nature connectedness and pro-environmental behaviors. Based on our findings, it is evident that reconnecting to nature can play a role in influence pro-environmental outcomes and addressing ecological and sustainability challenges. However, in order to leverage human-nature connectedness for such outcomes, it is necessary to move past vague speculation about the need to reconnect people to nature. This thesis contributed to this movement by specifying the multidimensional nature of nature connectedness, calling for integration between disparate fields of research, and adding dimension and nuances to our understanding of the relationship between place attachment, nature connectedness and pro-environmental outcomes.

Moreover, this thesis supports previous findings that found a positive relationships between human-nature connectedness (e.g. Geng et al., 2015; Halpenny, 2010; Mayer and Frantz, 2004), though our results contributing more strongly to the literature reporting mixed or very modest relationships between the constructs (e.g. Beery and Wolf-Watz, 2014; Gosling and Williams, 2010). Thus, while our results do not indicate that connectedness to nature will automatically imply a person engages in pro-environmental behaviors, they do point to a evidence of complex relationship that has positive elements. Future research demands further examination of nuances of this relationship, particular through investigation of the scalar relationships between these constructs and application of integrated methods in new study areas with more representative samples.

Our aim with this overarching body of work is that it contributes to the conversation about human-nature connectedness, sparks additional lines of research and inquiry, and contributes to the development of nature connectedness approaches for sustainability transformation. In order to address the wicked environmental problems facing the planet today, we will need a complete transformation of human behaviors towards sustainability.

It is my hope that the findings from this research contribute to understanding the drivers of sustainable behaviors and play a small role in advancing the field of knowledge.

Future research

The work presented in this thesis focuses on investigating human-nature connectedness as a determinant of pro-environmental outcomes. Given increasing population and urbanization, interactions with nature, exposure to nature, and connections to nature are likely to continue to change and transform. Scholars, practitioners and policy makers must consider the implications of the current framings of nature (e.g. pristine nature versus everyday nature) and the stories that are told about human-nature relationships (e.g. masters or stewards or partners). Many have argued that what we know about connecting people to nature is knowledge already held by practitioners and societies with close bonds to nature. Perhaps in order to understand the relationship between human-nature connectedness and pro-environmental outcomes, the next step in this field of research is to listen to the information and knowledge that is already out in the world and to conduct longitudinal, interdisciplinary and transdisciplinary research where these ideas can be shared and disseminated. In the process, we must identify ways in which meaningful connections to nature can be formed that promote a sense of stewardship and conservation, while acknowledging the complex interactions that occur within systems.

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SECTION A

Chapter I

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Current Opinion in Environmental Sustainability

Human–nature connection: a multidisciplinary review

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In sustainability science calls are increasing for humanity to (re-)connect with nature, yet no systematic synthesis of the empirical literature on human–nature connection (HNC) exists. We reviewed 475 publications on HNC and found that most research has concentrated on individuals at local scales, often leaving 'nature' undefined. Cluster analysis identified three subgroups of publications: first, *HNC as mind*, dominated by the use of psychometric scales, second, *HNC as experience*, characterised by observation and qualitative analysis; and third, *HNC as place*, emphasising place attachment and reserve visitation. To address the challenge of connecting humanity with nature, future HNC scholarship must pursue cross-fertilization of methods and approaches, extend research beyond individuals, local scales, and Western societies, and increase guidance for sustainability transformations.

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Introduction

The relationship between people and nature has attracted rising interest among scientists, given evidence of health and well-being benefits from human interaction with nature [1,2,3••] and its contribution to addressing sustainability challenges [4,5•,6]. Indeed, while humanity is ultimately dependent on natural resources, the urgent need for human populations (particularly those in the West) to be reconnected to nature or embedded within ecological limits has been recently emphasised by many sustainability scientists [7,8•,9–12]. These calls for (re)-connection to and embeddedness within nature have implied more than physical dependence, but active development of cognitive, emotional and biophysical linkages that positively shape human–nature interactions. Research on this topic has been characterised by a plurality of disciplinary and conceptual perspectives, language, methods and research approaches. With this heterogeneity, the literature has become fragmented, compromising the consolidation of ideas and their application to practice. A first step towards consolidation is to generate a coherent overview of existing scholarship.

In reviewing this literature, clear terminology is critical. We adopt the term 'human-nature' connection (HNC) as an umbrella concept, encompassing a broad range of terms from different disciplines and applications [13•], for instance connectedness with nature [14] or nature relatedness [6] in environmental psychology and (re-)connection to the biosphere [7,11] in sustainability science. Some reviews of HNC have emerged recently [3••,5•,15], but they are couched within particular disciplinary perspectives and use narrow definitions of 'connection'. In this study we elected not to prescribe a strict definition of 'nature', but were guided by the perspective of articles reviewed. Reviewed literature reported on places, landscapes and ecosystems that are not completely dominated by people, but also include non-human organisms, species and habitats. With this review we intend to provide a multidisciplinary space for academic and cultural integration, extension and cross-fertilization.

We report the findings of systematic review of scholarly publications from a range of disciplinary backgrounds that

have empirically investigated HNC. We sought to first, assess the diversity of subjects, methods and motivations of research on HNC; second, identify clusters of papers and their distinguishing characteristics; and third, consider how future research on HNC can better inform sustainability science.

Methods

The Scopus database was queried with a search string comprised of 41 components that combined a variety of terms related to 'nature', 'people' and 'connection' (see Supplementary appendix 1a for full search string). The search was applied to Abstract, Title and Keywords on 16 November 2015 and returned 3849 papers, which was reduced to 2649 after restricting results to articles in English. Only English literature was selected because of the difficulties in systematically reviewing literature across multiple languages (e.g. the necessity of reviewers subjectively translating concepts into a common language, and the loss of meaning or misinterpretation this would likely entail). Articles were screened to ensure they were peer reviewed and published in an academic journal, reported on empirical data (i.e. excluding reviews, conceptual papers or critical commentary), and studied a type of relationship people have with green or natural environments (full inclusion criteria provided in Supplementary appendix 1b). We note that since the review focussed on articles studying connections between people and nature, literature that assumed this connection but did not address it explicitly (e.g. some research in forestry or agriculture) was not included. Screening returned a final set of 475 papers published between 1984 and 2015 (Supplementary appendix 2).

Each paper was coded for: (i) descriptive information about the article (e.g. country, journal and discipline); (ii) conception of 'nature'; (iii) social group analysed (e.g. individuals versus communities); (iv) class of HNC(s) studied; (v) methodological details; and (vi) the purpose of the study. Response categories for all questions were developed iteratively by the author team. The final typology distinguished between five classes of HNC: material (e.g. resource extraction), experiential (e.g. activities), cognitive (e.g. attitudes, values), emotional (e.g. fear, joy) and philosophical (e.g. ontological frameworks) (see Supplementary appendix 1c for full details and definitions). The first 10% of papers were coded by multiple authors, and response categories were clarified where inconsistencies were found.

Data on all reviewed publications were analysed in R [16] to generate descriptive statistics, multivariate clusters, and an ordination. Agglomerative hierarchical clustering was performed using the 'agnes' function in the 'cluster' package using a Euclidian measure of dissimilarity and Ward's clustering method. 'Indicator species analysis' was used to identify which variables most influenced these groups using the 'indval' function within the 'labdsv' package. Ordination of data was performed via Detrended Correspondence Analysis using the 'decorana' function in the 'vegan' package.

Results

Overview

Research on HNC is increasing (Figure 1), with 345 papers (72.6%) published from 2010 onwards. Nondescript or 'unspecified' forms of nature were most commonly studied (30.9%), followed studies on human connections to urban nature (14.1%), and protected areas (11.9%) (Figure 2). Most HNC research targeted individuals (76%), especially local people (24.3%). Most research has studied cognitive (35.9%), experiential (22.0%), emotional (21.8%), and philosophical (13.9%) connections to nature, whereas material connections (6.5%) have received less attention (Figure 2). Most studies addressed one (161 papers; 33.9%) or two (169 papers; 35.6%) types of HNC, 97 papers (20.4%) studied three types of connections, 38 papers (8.0%) four types, and 10 papers (2.1%) studied five types of connection.

Methodological patterns

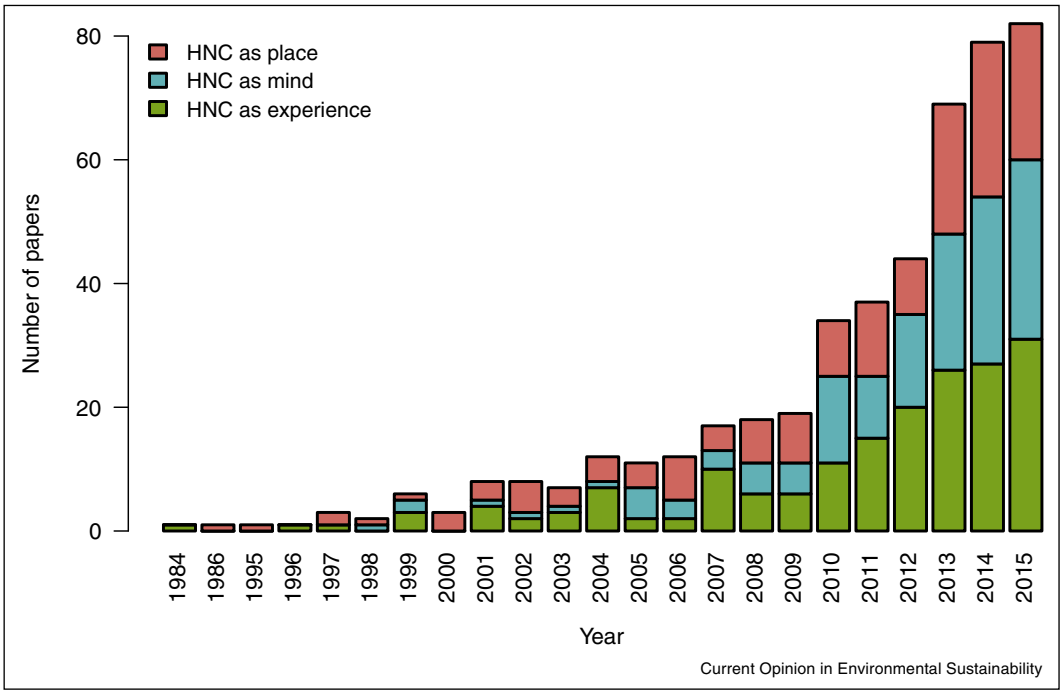
Empirical research on HNC has been biased towards western countries. The top five countries represented were USA (152 papers; 32.0%), Australia (54 papers; 11.4%), Canada (42 papers; 8.8%), United Kingdom (27 papers; 5.9%) and The Netherlands (22 papers; 4.6%). HNC has been mostly observed (87.8%), rather than experimentally tested (12.2%), using quantitative (48.8%), qualitative (32.0%), or mixed datasets (19.2%) (Figure 2).

Similar numbers of studies explored HNC as a predictor variable (31.2%), response variable (26.7%), or both a predictor and response (17.3%), suggesting that scholars have been equally interested in the drivers and effects of HNC. However, 24.8% of papers studied HNC as a variable in itself (i.e. neither as a predictor nor response). Substantial proportions of studies used psychometric scales (24.6%) or assessed place attachment (28.6%). Psychology was the most represented discipline in the literature (29.4%), followed by the social sciences (21.4%), environmental disciplines (15.2%), tourism (10.4%), education (10.3%), planning (7.0%), and health (6.4%).

Multivariate analysis

Cluster analysis revealed three distinct subgroups of publications (Figure 3), characterised by different indicator variables (Table 1). We labelled the clusters as follows: *HNC as mind* (145 papers), *HNC as experience* (178 papers), and *HNC as place* (152 papers). The fastest growth in research over time occurred in publications in the *HNC as mind* cluster (Figure 1), characterised by studies that address cognitive and philosophical aspects of HNC at the individual level. These studies commonly investigated

Figure 1



Increase in the number of published studies on human–nature connection (HNC) by year. Colours within bars relate to the three groups as identified by the cluster analysis: HNC as mind, HNC as experience, and HNC as place.

students using quantitative research methods to explain, describe, and predict psychological dynamics and pro-environmental behaviours. However, in this cluster the concept of nature was generally undefined, and policy guidance was less common than in other clusters. In contrast to *HNC as mind*, both *HNC as experience* and *HNC as place* focussed on relationships between specific peoples and places. *HNC as experience* described qualitatively people's experiences of particular local areas and were characterised by an observational research approach. An example of this is Cosquer et al.'s study of people's interactions with everyday nature as part of a butterfly citizen science programme in France [17]. In contrast, research in the *HNC as place* cluster typically used quantitative questionnaires to study emotional connections to specific natural spaces, often at the landscape scale. These studies often also provided policy guidance to address sustainability issues. For example, Tonge et al. [18] applied place attachment concepts to explore how visitors related to the Ningaloo Marine Park in Australia and how this influenced conservation actions.

Discussion

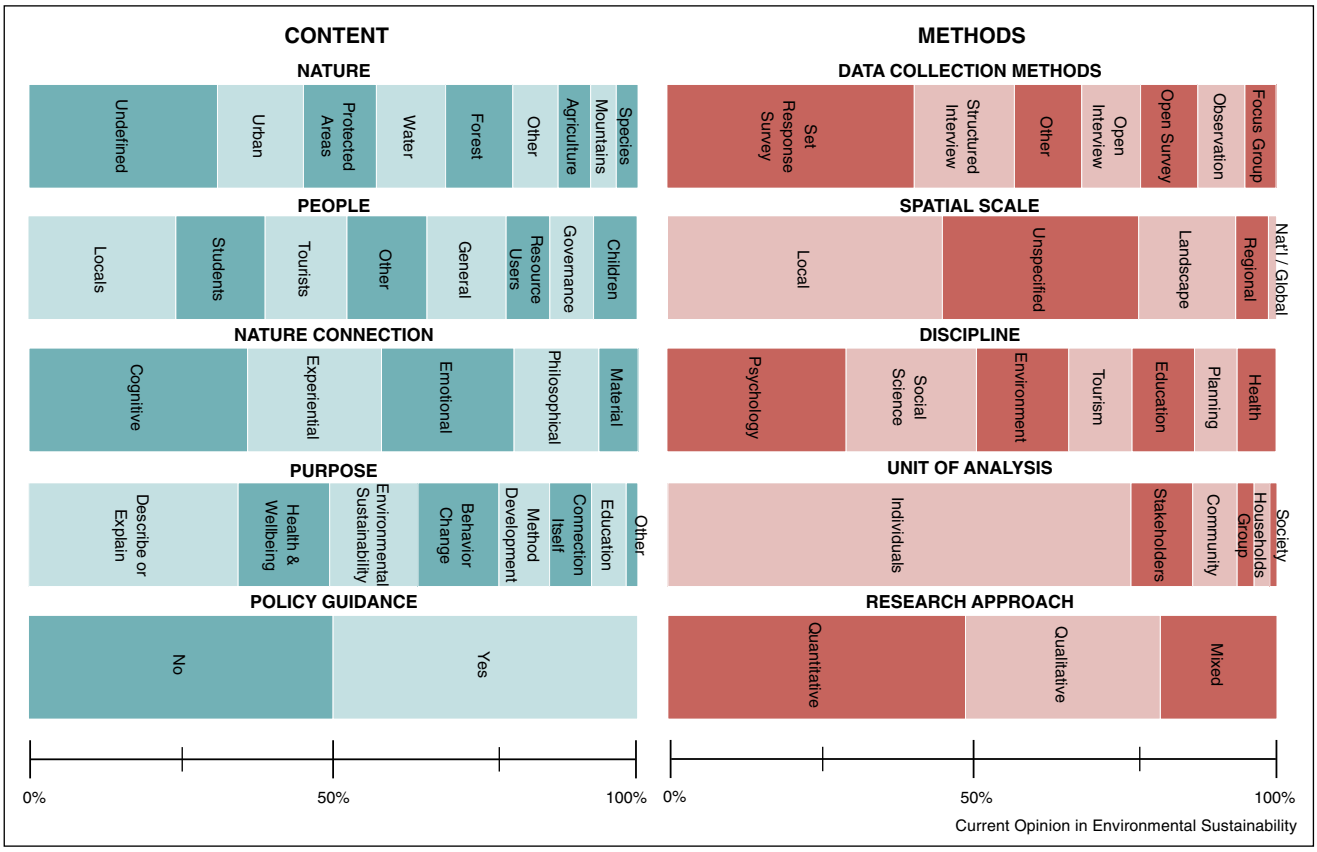
Our findings suggest that research on HNC is receiving increasing interest, but, being highly heterogeneous, has yet to reach its full potential in supporting humanity on a pathway towards sustainability. To this end, we propose three key priorities: first, greater integration of complementary perspectives in HNC research; second, further extension of HNC research; and third, more targeted application of insights to foster sustainability transformation.

Complementarity and integration

The research clusters identified highlighted disciplinary, methodological and contextual differences (Table 1), which seem to represent co-existing epistemological positions in HNC research. The *HNC as mind* cluster typically encapsulates an objectivist epistemology. These publications draw upon theory and methods from psychology to understand nature connection as a real psychological entity that affects behaviour [see 6,14]. In contrast, the *HNC as place* cluster largely operates within a constructionist epistemology, with knowledge of nature connection derived through exploring relational interactions between people and specific places (see also [19••]). The *HNC as experience* cluster often adopts a subjectivist epistemology, observing and describing the uniqueness of individuals' experiences of nature. These epistemological differences suggest that resolving the longstanding challenge of defining nature (and non-nature) [see 20] in a way that unifies disciplines is likely to be difficult.

These perspectives are fundamentally different but they contribute complementary insights that may be integrated in future research. First, since *HNC as mind* rarely

Figure 2



Overview of the proportions of studies focusing on particular content or using particular methods. Each bar represents a question that was applied to reviewed papers.

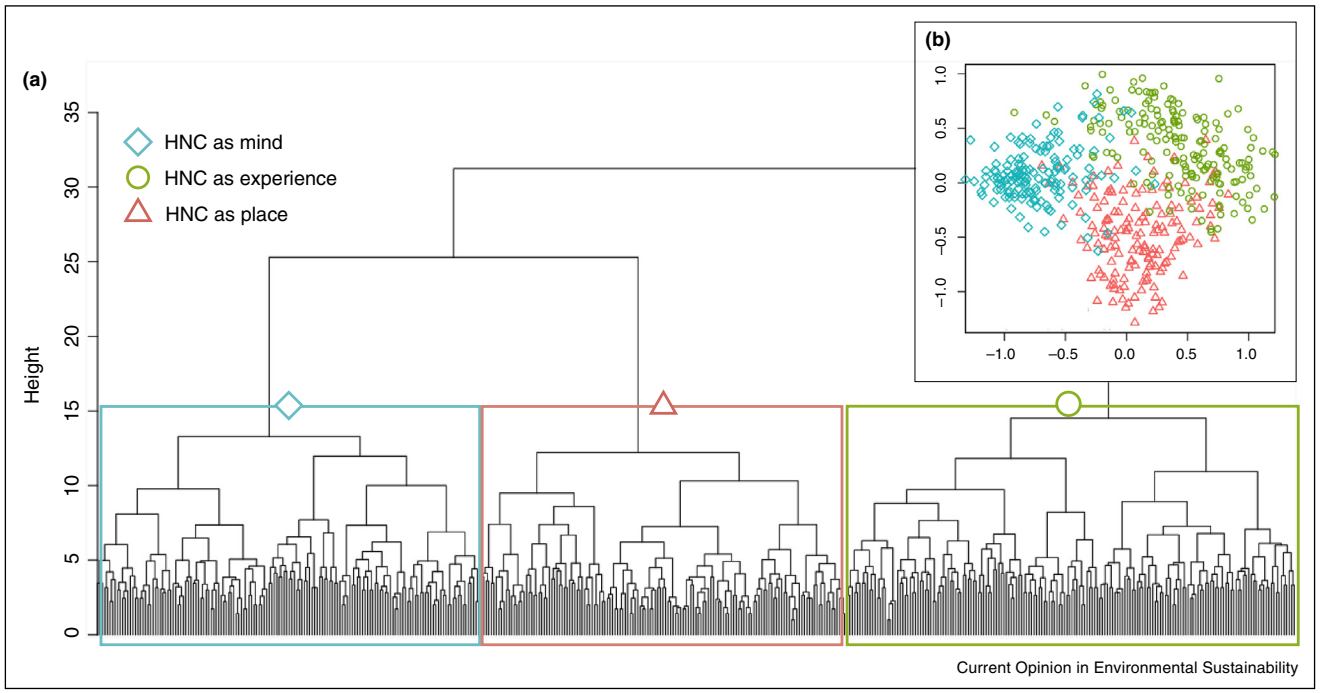
specifies the type of nature that people are connected to and focuses predominantly on individuals, *HNC as place* can contribute to this literature with an understanding of how HNC of communities is situated in geographical locations, while *HNC as experience* may offer deeper understandings via qualitative descriptions. Second, research on *HNC as place* could be enhanced by the quantitative and more generalisable perspectives of *HNC as mind*, along with the deep and nuanced insights offered by *HNC as experience*. Finally, the *HNC as experience* literature could benefit from the statistical rigour of *HNC as mind* and the applied focus of *HNC as place*. Full integration of these perspectives is likely to be difficult [21] and may not be feasible or even appropriate in every case. However, it would be worth exploring how sustainability science could facilitate cross-fertilization of HNC knowledge in order to pursue 'theoretically and empirically rich solutions-oriented research' [22].

Extension

An integrated HNC research agenda for sustainability must address key gaps in the current literature. Of particular concern for sustainability is the relatively minor focus on material connections to nature (Figure 2). While there are many fields that study material connections to nature (e.g. natural resource management), our study focussed on the specific subset that explores human connections. Material HNC must be better understood as it shapes patterns of resource consumption, which in turn drive environmental sustainability outcomes [12,23,24]. Moreover, understanding the relationships between material connections and other 'internal' connections to nature (e.g. cognitive, emotional) will help to explore potential feedbacks and points of intervention for sustainability transformation [see [20]].

Second, HNC should be studied in and communicated across a greater diversity of cultural contexts. Of the published articles included in this review, the vast majority have largely been undertaken in post-industrial, Anglo-Saxon countries. However, this result may be biased due to restricting our review to articles in English. Relevant literature in non-western cultures might be published in other languages and express conceptualisations of HNC that are altogether different from those dominant in Anglo-Saxon cultures [26]. Thus, given the

Figure 3



(a) Dendrogram of the papers on human–nature connection (HNC) coded in this review. Each coded paper is represented by a vertical line at the bottom of the chart. The similarity between papers is indicated by their distance from one another along the lines of the 'tree'. **(b)** Ordination of reviewed papers highlighting three distinct clusters of articles: *HNC as mind* (blue diamonds), *HNC as experience* (green circles), and *HNC as place* (red triangles).

key sustainability challenges at play in the Global South [27], there is an urgent need for more research from these countries, increased support for publication of these studies in international journals, and extending HNC research beyond western cultural framings.

Third, future research (particularly in psychology) must specify the characteristics of nature that people are connected to. Without such information, it is difficult to know how policies and decisions for sustainability should be formulated. For example, there is scant evidence on whether interactions with forests, rivers, grasslands or urban parks are more effective in promoting health and well-being, or pro-environmental attitudes and behaviours.

Fourth, our review revealed an underrepresentation of research at the community or society level. Theories of sustainability transformation highlight the critical importance of action and change at this level [28–30,31•]. Therefore, we encourage future exploration of how groups of people, initiatives and organisations within society are connected to nature as a way of moving beyond the current focus on individuals.

Finally, there is a need to more strongly relate HNC to specific sustainability issues. Only a small portion of the literature addressed the importance of HNC for sustainability. Most literature simply described or explained people's connection to nature, and only publications within the *HNC as place* cluster regularly offered policy guidance. Directing future research to pressing sustainability challenges and explicitly offering practical recommendations appears important.

Application

There are increasing calls in the literature for a 'biosphere-based sustainability science' [8•] whereby human development progress is intimately connected with stewardship of the planet. We affirm these calls, and suggest that such an integrated sustainability science could greatly benefit from incorporating the diverse insights from literature on HNC. These insights are critical for identifying which social–ecological settings can allow people to enhance their connection with nature, establishing how the multiple types of HNC can foster pro-environmental behaviours, and defining both the characteristics of a sustainable future and the pathways by which it can be reached.

A strong connection between people and nature is emphasised in key global sustainability agreements. For example, one target under Goal 12 (responsible consumption and production) of the Sustainable Development Goals is to

Table 1

Results of the 'indicator species analysis' showing the most pertinent distinguishing characteristics of three clusters of papers on human–nature connection (HNC). The coded variables are listed as relating to either the content of the study, or methodological aspects for all of three clusters identified: *HNC as mind*, *HNC as experience*, *HNC as place*. Indicator value coefficients are listed (only those ≥0.2 reported), and denoted as follows: ***if coefficient ≥ 0.4; **if 0.4 > coefficient ≥ 0.3; *0.3 > coefficient ≥ 0.2.

Variable	HNC as mind	HNC as experience	HNC as place
Content			
Type of nature	*** Undefined (0.45)		
People studied	*** Students (0.44)	* Other (0.21)	** Locals (0.31) * Tourists (0.27)
Type of connection	* Cognitive (0.29)	* Experiential (0.21)	* Emotional (0.22)
Purpose		* Other (0.22)	
HNC related to other variables		* HNC as a variable in itself (0.23)	
Research on place attachment	*** No (0.46)		*** Yes (0.47)
Spatial scale	*** Unspecified (0.52)	* Local (0.28)	* Landscape (0.22)
Policy guidance	* No policy guidance (0.28)		* Provides policy guidance (0.22)
Methods			
Discipline	*** Psychology (0.50)	* Social sciences (0.26)	* Environmental studies (0.22)
Research approach	* Experimental research (0.28)	** Observational research (0.37)	
Data type	*** Quantitative (0.45)	*** Qualitative (0.81)	
Data collection		** Structured interviews (0.36)	*** Set response survey (0.45)
		* Open interviews (0.21)	
Unit of analysis	** Individual (0.38)		
Type of analysis	*** Quantitative analysis (0.47)	*** Qualitative analysis (0.56)	
Use of psychometric scales	*** Yes (0.54)	*** No (0.44)	

'ensure that people everywhere have. . .awareness for. . .lifestyles in harmony with nature'. Similarly, Goal 11 (sustainable cities) includes a target to provide 'universal access to safe, inclusive and accessible, green and public spaces'. The recent UN New Urban Agenda also seeks to promote 'healthy lifestyles in harmony with nature' [(32,s 14c)]. The implementation of these goals should draw on HNC research.

Finally, HNC research can help inform transformative or transitional pathways towards sustainability. Scholars have highlighted that the scale of change needed to reach a sustainable future is beyond what can be achieved via incremental adjustments to current systems [25•,33]. Accordingly, theories of social change have considered socio-technological transitions [34] and social–ecological transformations [35]. In this context, incorporating knowledge of how HNC influences environmental worldviews, values, attitudes and behaviours may help identify effective 'seeds' of change [29], 'protected niches' [36] and 'deep leverage points' [25•] for sustainability transformation. For example, insights from HNC research could inform the Smart Cities (IT-based sustainable cities) discourse, which has inadequately considered how technological solutions may affect people's interactions with nature. This is especially important for children, as deep seated environment-related attitudes are acquired during childhood [37] and persist through adulthood [38]. Furthermore, rapid land conversion for urbanisation, combined with increased internet access, population density and new technologies challenge people's direct sensory experience of nature, and will likely have negative implications for human health and well-being [39,40].

Conclusion

The importance of HNC for sustainability is increasingly recognized. The task of sustainability scientists now is to establish how different types of nature connections may contribute to positive change for sustainability. This review has provided a foundation for this agenda. It has shown that a substantial body of empirical research has accrued, yet has remained disparate. We call for researchers and practitioners to take stock of this existing evidence, integrate insights across methodological, epistemological and geographic boundaries, and pursue novel interdisciplinary research that can generate knowledge for a sustainable future characterised by strong connections between humanity and the biosphere.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cosust.2017.05.005.

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Chapter II

Sustainability Science
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ORIGINAL ARTICLE

Reconnecting with nature for sustainability

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Abstract
Calls for humanity to 'reconnect to nature' have grown increasingly louder from both scholars and civil society. Yet, there is relatively little coherence about what reconnecting to nature means, why it should happen and how it can be achieved. We present a conceptual framework to organise existing literature and direct future research on human–nature connections. Five types of connections to nature are identified: material, experiential, cognitive, emotional, and philosophical. These various types have been presented as causes, consequences, or treatments of social and environmental problems. From this conceptual base, we discuss how reconnecting people with nature can function as a treatment for the global environmental crisis. Adopting a social–ecological systems perspective, we draw upon the emerging concept of 'leverage points'—places in complex systems to intervene to generate change—and explore examples of how actions to reconnect people with nature can help transform society towards sustainability.

Keywords Human–nature relationship · Social–ecological systems · Sustainability · Transformation

Introduction

Humanity's relationship to the natural world has been a topic of scholarship since ancient times, yet with growing recognition of environmental crises over the past decades, society's disconnection from nature has been proposed as a root cause of unsustainability (e.g., Pyle 1993; Folke et al. 2011; Dorninger et al. 2017). Recently, calls for society to 'reconnect with nature' have grown louder (Zylstra et al. 2014), with new research emerging in sustainability science, conservation biology, environmental psychology, and environmental education (Nisbet et al. 2009; Folke et al. 2011; Fischer et al. 2012a; Frantz and Mayer 2014). Yet, most calls for 'reconnection' have remained speculative and vague, with relatively few concrete insights regarding the characteristics of a connected society or how to achieve this goal. The literature is fragmented across disciplinary boundaries, resulting in low coherence in the ways central concepts are understood and applied (Ives et al. 2017). For example, there is confusion around the concept of connection to nature and whether a state of disconnection is a response to or a driver of social–ecological change, or both. On this basis, it is timely to assess together the disparate strands of scholarship to scrutinise if pursuing an agenda of reconnecting people with nature is worthwhile, and if so, how this aim ought to be pursued.

In this article, we lay a conceptual platform to better understand human–nature connectedness. First, we argue that human–nature connectedness is a multifaceted concept incorporating (1) material connections such as resource extraction and use; (2) experiential connections such as recreational activities in green environments; (3) cognitive connections such as knowledge, beliefs and attitudes; (4) emotional attachments and affective responses; and (5) philosophical perspectives on humanity's relationship to the natural world. Second, we show that existing literature frames connection to nature as either the cause of some outcome (such as human health or environmentally-responsible behaviour), the consequence of some driver (such as shifting societal values or technological change), or the treatment for social or environmental problems. Finally, having laid

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this conceptual platform, we outline ways in which people's connections with nature can be strengthened. We argue that stronger connections—in several of the above-mentioned dimensions—have potential to help leverage deep societal change for sustainability (Meadows 1999; see; Abson et al. 2017). In particular, we discuss the need for 'reconnection strategies' that work to change not only the behaviour of individuals, but also address the systemic structures and paradigms that underpin the actions and behaviours contributing to the current global environmental crisis.

Conceptualising human–nature connections

Many terms related to connections to nature have arisen from various disciplinary schools and normative agendas. One of the earliest concepts is the "biophilia hypothesis" (Wilson 1984), which asserts that humans have an innate desire to connect with nature. The biophilia paradigm underpins much scholarly and practical work to promote interactions with green environments (Kahn and Kellert 2002). "Nature deficit disorder" is a related, more recent concept, which sees children's reduced contact with outdoor environments as having negative results for their development (Louv 2005). Similarly, "extinction of experience" (Pyle 1993; Soga and Gaston 2016) refers to the phenomenon of urbanisation reducing everyday nature experiences, with implications for health, emotions, attitudes, and behaviour.

From a global sustainability perspective, phrases such as "reconnecting to the biosphere" (Folke et al. 2011), "teleconnections" between local consumption and global land use (Yu et al. 2013) or "telecoupling" of socioeconomic and environmental systems over geographic distance (Liu et al. 2013) are used to emphasise the dependence of human society on natural systems and processes. The literature from a social–ecological systems perspective calls for "recoupling social and ecological systems" (Fischer et al. 2012b) to foster sustainability. Other literature has introduced the term "distance from nature". Seppelt and Cumming (2016) suggest that humanity must decrease its distance from the natural world in terms of knowledge of contact with nature while increasing 'distance' in the sense of direct impacts of human activities on ecosystems to maintain the earth's life support system.

Similarly, environmental psychologists have amassed a voluminous literature on the concept of "connectedness to nature", addressing the cognitive and affective domains of individuals' psyches (see Restall and Conrad 2015 for a review). Key literature from this perspective includes Wesley Schultz' (2001) work on the notion of "inclusion of nature in self, Mayer and Frantz's (2004) "Connectedness to Nature Scale", and Nisbet's (2009) work on individual "nature relatedness". These measures typically consider emotional connections, beliefs, and attitudes, and often correlate with other psychological constructs such as value orientations and pro-environmental behaviour (Tam 2013).

The current diversity of approaches to conceptualising and measuring connections with nature has led to a fragmentation of the literature. This is partly due to the term 'connection' being applied to qualitatively different concepts. In some instances, connection to nature refers to a cognitive appreciation of being embedded within nature, in others to an emotional attachment, while still others focus on material dependence on nature. Although this diversity of meanings is being addressed by psychologists through ever more expansive psychometric scales of nature connectedness (e.g., Nisbet et al. 2009), these remain focused on the individual scale and cannot integrate society-scale phenomena of connection or disconnection.

In their recent review, Ives et al. (2017) called for more integrated research on human–nature connectedness. To facilitate this and to clarify why and how to reconnect people with nature, we develop our discussion around the five categories of nature connections Ives et al. (2017) proposed: (1) material, (2) experiential, (3) cognitive, (4) emotional, and (5) philosophical connections (Fig. 1.). These can be considered to operate along a spectrum from external connections to nature (e.g., physical appropriation or interaction) through to internal connections to nature (e.g., emotions or worldviews). An additional dimension to consider is the scale at which these connections operate and can be analysed: some connections are understood primarily at the individual scale, while others can be readily aggregated to the societal scale. Descriptions of these dimensions of nature connections are provided in Table 1.

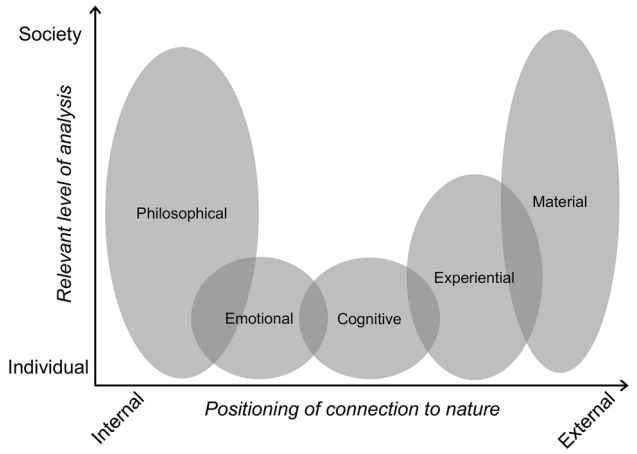

Fig. 1 Conceptualisation of different types of human–nature connections, along a spectrum from people's inner to outer worlds (*x*-axis), and their relevance at different scales of social aggregation (*y*-axis). While presented as independent categories here in this figure, in reality, each type of human–nature connection may interact with the others

Table 1 Descriptions of different types of nature connection

Connection	Description	Analytical scale	Key literature
Material	Consumption of goods/materials from nature (e.g., food, fibre)	Can be analysed for individuals or societies. Often connected to system characteristics. Needs to be spatially explicit (e.g., material flows within or between focal landscapes)	Material flow analysis (Haberl et al. 2004) Human Appropriation of Net Primary Productivity (HANPP) (Haberl et al. 2009) Teleconnections (Yu et al. 2013) Ecological Footprint (Wackernagel et al. 1999)
Experiential	Direct interaction with natural environments (e.g., parks, forests). Note that qualities of connections may vary substantially	Normally measured for individuals, but can be aggregated to the societal scale	Soga and Gaston (2016) Keniger et al. (2013)
Cognitive	Knowledge or awareness of the environment and attitudes/values towards nature	Individual	Bradley et al. (1999) Schultz (2001)
Emotional	Feelings of attachment to or empathy towards nature	Individual	Emotional affinity towards nature scale (Kals et al. 1999) Place attachment to natural areas (Stedman 2003)
Philosophical	Perspective or world view on what nature is, why it matters, and how humans ought to interact with it (e.g., master, participant, steward)	Relevant to individuals, as well as to dominant views at the societal scale	Van den Born (2008) Raymond et al. (2013)

These various dimensions of connection to nature do not operate in isolation—in reality, they interact with and are influenced by one another. For example, physical interactions with natural environments (experiential connections) can shape environmental knowledge and positive attitudes towards the environment (cognitive connections) (Collado et al. 2013). Conversely, people with positive psychological orientations towards nature (emotional and cognitive connections) have been shown to be more likely to visit parks and reserves (experiential connections) (Lin et al. 2014). Ewert et al. (2005) also found that early-life outdoor activities (experiential connections) were related to environmental beliefs (cognitive connections) in adulthood, and Lumber et al. (2017) showed that direct contact with nature along with emotional engagement and contemplation of meaning are associated with a psychological measure of nature relatedness. Many other interactions are likely to exist, but have yet to be examined in depth.

The concept of human–nature connections as outlined above might be considered a theoretical perspective that integrates different relationships between social and natural systems. Other frameworks have been proposed that derive from different applied or theoretical perspectives (see Muhar et al. 2017 for a synthesis of concepts). One of the most commonly applied concepts in environmental management and sustainability is ecosystem services (Millenium Ecosystem Assessment 2003). While related, we consider ecosystem services to be a separate but complementary framework to connection to nature. First, ecosystem services is commonly understood as anthropocentric in focus, since it emphasises the benefits people derive from nature (Schroeter et al. 2014; Silvertown 2015). In contrast, connection to nature is not inherently normative, but describes interactions that may be positive, negative, or benign. Second, ecosystem services have its roots in economic thought, as highlighted by the emphasis on quantifying the 'value' of different goods and services that are derived from ecosystems (Silvertown 2015). Human–nature connection represents a broader approach, as highlighted by the 'philosophical' dimension which explicitly considers different forms of conceptualising human–nature relationships. Therefore, human–nature connection as a concept is likely to be better positioned to describe and address environmental and sustainability challenges across different socio-cultural contexts.

Causes, consequences, and treatments

Literature on connection to nature is fragmented beyond differences in the types of connection and scale of analysis. Research also varies according to whether it emphasises (1) the *causes* of nature disconnection, (2) the *consequences* of disconnection, or (3) reconnecting to nature as a *treatment* for some problem. Soga and Gaston (2016) reviewed the literature on the causes and consequences of experiential connections to nature. Yet, similar work to separate causes, consequences, and treatments will be equally important for other dimensions of nature connection.

Causes of disconnection from nature

Disconnection from nature is often considered as a symptom of broader-scale societal changes (Pyle 2003; Seppelt and Cumming 2016). However, the literature varies according to whether immediate or more fundamental causes of disconnection from nature are considered. Claims about the fundamental causes underpinning disconnection from nature are largely speculative, particularly when considered at the societal scale. Some scholars have argued that disconnection is symptomatic of underlying philosophical or functional shifts such as the dominance of materialism and over-consumption (Pyle 2003). While this may have intuitive appeal, there is little concrete evidence for this assertion. The notion of 'reconnecting to the biosphere' proposed by Folke et al. (2011) also implies a historical separation of people from nature, namely, a cognitive disconnection between people's understanding of the impacts of their activities and biophysical reality. Evidence for such cognitive disconnection is stronger, and can be traced to the increased complexity of global resource systems (see Steffen et al. 2011). Other studies have considered more immediate causes of nature disconnection, and are generally more firmly grounded in empirical evidence. Examples of variables contributing to nature disconnection include urbanisation (Cumming et al. 2014), reduced access to green spaces (Lin et al. 2014), changing social norms and perceptions (Valentine and McKendrck 1997), and rise in electronic media (Pergams and Zaradic 2006).

Consequences of disconnection from nature

Other studies focus on consequences of being disconnected from nature. Research has spanned fields from child development to sustainability and has addressed matters such as health benefits of outdoor experiences, and individual behaviours associated with emotional or cognitive attachments to nature. One widely publicised consequence of connecting to nature is that of learning and development benefits for children (e.g., Taniguchi et al. 2005). Recent research has pointed to benefits of interactions with natural environments for happiness and general wellbeing (Capaldi et al. 2014) and mental and physical health (Keniger et al. 2013). Furthermore, other literature has demonstrated links between individual nature connectedness and sustainable behaviours (Geng et al. 2015).

At a broader scale, it is commonly asserted in disciplines such as conservation science, environmental psychology, and sustainability science that humanity's growing disconnection from the natural world is contributing to the global environmental crisis (Nisbet et al. 2009; Zylstra et al. 2014). Kareiva (2008) argued that an experiential separation from nature, as demonstrated through a decline in visitation rates to national parks, "may well be the world's greatest environmental threat". While it is difficult to prove empirically that such experiential disconnection poses a threat to biodiversity and sustainability, some evidence has emerged that shows experiences of nature are correlated with willingness to donate to conservation causes (Zaradic et al. 2009) and that psychological connectedness to nature is positively correlated with vegetation protection behaviours by farmers (Gosling and Williams 2010).

Reconnecting to nature as a treatment

Finally, studies have considered reconnecting people to nature as a treatment, often focused at the individual scale. For example, nature experiences have been explored as treatments for psychological illness such as depression and anxiety (Townsend 2006). Proven health benefits of nature interaction have also led to research modeled on medical approaches such as exploring the nature 'dose' necessary to achieve health outcomes (Shanahan et al. 2016). In education, programs that focus on nature experiences as ways of fostering curiosity and resourcefulness are being developed to counteract the dominance of indoor-only play (Mainella et al. 2011). Citizen science has also been explored as a mechanism by which people can connect experientially with nature so as to foster environmental knowledge, concern, and pro-conservation behaviour (Conrad and Hilchey 2011).

Beyond the scale of individuals, a growing body of the literature asserts a need for society to reconnect with nature to facilitate societal transformation towards sustainability (Folke et al. 2011; Abson et al. 2017). Yet, despite the high stakes, nature reconnection as a treatment for society-scale system change has received scant empirical attention to date. We consider that framing human–nature connections as a treatment for social and environmental problems has great merit in the context of myriad challenges facing contemporary society. Yet, researchers must be clear about the motivation for these studies and the mechanisms by which reconnecting people with nature might address the problem at hand, as well as clarifying the overarching narrative they are speaking to (i.e., disconnection from nature as a cause or a symptom).

While some have argued for a reconnection between people and nature, others have called for society to be decoupled from the environment to ensure planetary sustainability. Two aspects of decoupling are often conceptualised: (i) resource decoupling, which denotes a separation of economic activity from resource use, and (ii) impact decoupling, which conceptualises a separation of economic activity from environmental impacts (UNEP 2011). We consider that disconnections from nature and eco-economic decoupling are related, but distinct terms, and are compatible in different contexts. The typology of nature connections we present

can help demonstrate this. Reconnection with nature in a cognitive sense might be necessary for a decoupling of economic growth from environmental impacts. Furthermore, issues of scale are critical, since decoupling of economic activity from natural resources almost always conceptualises human–nature connections at the societal scale. By reconnecting people materially to *local* ecosystems and reducing global teleconnections, any impacts to the environment will be recognised more easily, thus decoupling human economic activity from degradation elsewhere.

Reconnecting people with nature for sustainability?

The preceding sections sought to bring clarity to the multidimensionality of concepts and perspectives that characterise the literature on human–nature connections. Specifically, we distinguished five types of nature connections and the societal scales at which they operate, and found that the existing literature can be characterised as framing nature connectedness as a cause, consequence, or treatment to a problem. Here, we explore how reconnecting people with nature can act as a treatment for key sustainability challenges by looking at the five types of nature connectedness from social–ecological systems perspective. Social–ecological systems (or coupled human and natural systems) are complex systems, characterised by multiple interactions and feedbacks between human and natural elements (Fischer et al. 2015). Such a framing is therefore important when addressing sustainability problems, because these problems arise from a complex interplay between environmental and socio-political factors (Fischer et al. 2015). While social–ecological system thinking has been critiqued for subjective definitions of systems boundaries (e.g., Epstein et al. 2013) and under-theorising political and economic dynamics in environmental management (Cote and Nightingale 2012), the framework outlined below provides a useful heuristic way of organising actions for reconnecting people with nature.

Leverage points

Assuming that "reconnecting" people with nature could be a treatment for the global sustainability crisis, how exactly might an agenda of reconnecting people and nature bring about systemic change? In this section, we draw on the notion of "leverage points" to scrutinise the logic underpinning a possible reconnection agenda. Following Meadows (1999), leverage points are places within complex systems, where interventions can be directed to bring about change in overall system behaviour.

Leverage points can be shallow or deep according to the type of influence they have on a system. Changes to shallow leverage points are relatively ineffective, whereas even minor changes to deep leverage points can alter overall system behaviour. Shallow leverage points relate to (1) system parameters and (2) feedbacks between variables. In contrast, deep leverage points relate to (3) the system design or architecture and (4) the goals or intents pursued through the system. In a sustainability context, this means that changing certain parameters in a system (e.g., the proportion of protected land) is likely to be a less effective leverage point than changing its design (e.g., the rights of biodiversity to persist) or overarching goal (e.g., respect for rather than exploitation of nature). Here, it is important to note that shallow leverage points, such as increasing the amount of protected land, are crucial. However, our ability to increase this parameter is fundamentally constrained by the design of the system and the goals to which the system is oriented. Therefore, focusing only on shallow interventions is unlikely to bring about major changes in system behaviour (Abson et al. 2017).

This framing around deep versus shallow leverage points provides a working hypothesis regarding how different types of "reconnection" may be more or less effective in fostering sustainability (Fig. 2). Particularly, we propose that connections to nature related to the design or goal implicit in a given system are more likely to have a strong effect on sustainability outcomes than connections related to parameters or feedbacks. It follows that addressing "inner" connections (such as philosophical and cognitive connections) is necessary to bring about sustainability transformation. Strengthened "outer" connections (such as experiential and material connections) can potentially play supporting roles, but,

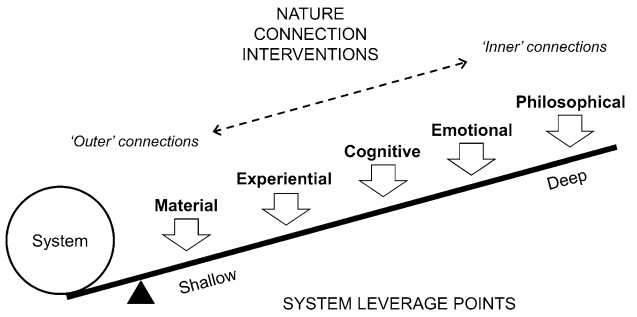

Fig. 2 Hypothesised mechanisms by which interventions for reconnecting people with nature can bring about system change. More externally-defined connections to nature (e.g., material and experiential connections) are more likely to influence system parameters (such as resource stocks and flows), while internally-defined connections (such as philosophical perspectives and emotional responses to nature) are more likely to influence the underlying goals and values embodied in a system. We note that connections to nature may affect system properties in more complex ways than are represented here, and system attributes and different types of interventions are likely to interact

by themselves, are unlikely to bring about transformative change. In reality, many interventions relating to strengthened connections to nature need to occur in concert, because they can be expected to interact.

From theory to practice

Numerous practical examples exist for how types of connections between people and nature can be strengthened. Materially reconnecting people to local ecosystems can influence the parameters of a system to enhance sustainability. On a fundamental level, humanity is connected to the biosphere through the consumption of energy, goods, and other resources, but increased consumption of these is not ecologically desirable. Thus, the type of material reconnection that we advocate is a local strengthening of ties to nearby ecosystems to decouple consumption of wealthy, urban populations from impacts elsewhere in the world and increase regional self-sufficiency. Specific interventions could include restaurants serving locally grown produce, urban dwellers growing food in community gardens, or houses being built with locally sourced timber. Shortening food chains in these ways can reduce food miles with resulting benefits for CO_2 emissions (Smith et al. 2005). Materially reconnecting to local ecosystems can also relate to other nature connections and system attributes. For example, food mile or source country labelling on products can enhance cognitive feedbacks between consumers and production landscapes. Alternatively, growing food for personal consumption can simultaneously promote sustainability, enable experiences of nature, enhance knowledge of natural processes and ecosystem functions, and contribute to emotional attachment to place (Hawkes and Acott 2013).

Many of the aforementioned material connections are closely tied to direct sustainability outcomes such as reducing carbon emissions and reducing biodiversity loss. However, these parameter changes may depend upon more fundamental systemic change. Wholesale sustainability transformation may require interventions at deep leverage points, since sustainability solutions ultimately hinge upon "value and belief systems, at levels ranging from individuals to societies" (Fischer et al. 2012a). Interventions that connect people to nature emotionally and philosophically have the greatest potential here. For example, art has the capacity to transcend the cognitive mind and convey meaning through visceral experience, and thus has considerable potential to influence the goals people pursue in life (Thomsen 2015). There is also increasing recognition of the importance of worldviews for sustainable lifestyles (Hedlund-de Witt et al. 2014). Here, the role of spirituality and religion in reorienting people towards nature is one under-researched area that has potential to function as a deep leverage point (Hitzhusen and Tucker 2013). Formal religious faiths contain teachings that promote environmental stewardship and challenge prevailing paradigms of consumption and growth (Gottlieb 2006) and can motivate action for sustainability (The Alliance of Religions and Conservation 2015). Furthermore, their spiritual practices can be powerful in shaping the deep values and beliefs people hold. Contemplative practices, such as mindfulness, even outside of a religious context are indeed powerful levers that have been found to relate to psychological nature connectedness (Howell et al. 2011) and can help promote sustainability (Wamsler et al. 2017).

Some activities that connect people with nature may simultaneously impact shallow and deep leverage points. A good example of this is community gardening. Research has shown that in addition to growing food (materially connecting to nature), allotment gardening can promote environmental learning (Bendt et al. 2013), offer therapeutic benefits (Pitt 2014), and build social cohesion and resilience (Firth et al. 2011). Similarly, nature-based education such as forest kindergartens (Waldkindergarten), popular in Germany, Sweden, and Denmark, may help Children develop deep empathy for nature in addition to developmental benefits (Kane and Kane 2011). Furthermore, interactions among forms of nature connectedness—as evident in allotment gardening or outdoor education—can offer potentially stronger leverage potential. For example, one recent study demonstrated relationships among exposure to urban nature, tree planting behaviour, and psychological connectedness to nature (Whitburn et al. 2018). Many of these initiatives are likely to be particularly powerful in urban contexts, where populations are often disconnected from experiences of nature (Miller 2005; Soga and Gaston 2016). Relating research and practice on urban greening concepts such as green infrastructure (Andersson et al. 2014), biophilic cities (Beatley 2011), and nature-based solutions (Lafortezza et al. 2017) to scholarship on sustainability transformations is, therefore, an important area for future attention in sustainability science.

Structural change may often be necessary to enable interventions for connecting people with nature to be implemented or benefits realised. For example, educational policy may need revising to allow school students' greater interaction with nature as part of curricula, planning law may need reform to increase biological diversity within cities, and transport networks may need modification to enable people to access natural areas easily. Thus, reconnecting people with nature may both effect and depend upon deep structural change.

How interventions at deep leverage points can be scaled up is a question that sustainability scientists should actively pursue. For example, which "shallow leverage points" must be addressed in tandem for interventions at "deep leverage points" to achieve their full potential? Similarly, it is important to consider which kinds of shifts are appropriate and

necessary in different social, economic, and environmental contexts. Arguably, application of the leverage point framework coupled with the typology of human–nature connections could be an effective heuristic for directing research along these lines.

Conclusion

It is evident that reconnecting people with nature can play a useful role in addressing many of today's ecological and sustainability challenges. To meaningfully progress a "reconnection agenda", tangible actions must be directed towards specific changes, whether in health, education, or conservation. To this end, specifying particular types of nature connections to be enhanced is a key first step. A second step is to couch these within the literature of demonstrated causes and consequences of nature connections and a plausible theory of change (such as the concept of leverage points for sustainability transformation). Building on this theoretical foundation will enable research to move past vague speculation about the need to reconnect people with nature, and instead build an evidence base that can support research and practice.

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Chapter III

Title: *Human-nature connections: aligning biophysical and socio-psychological approaches for sustainability*

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Abstract

1. Human-nature connections are recognized, across multiple scientific fields, as important factors in various aspects of sustainability. The scientific literature is broadly split into biophysical and socio-psychological approaches to conceptualizing such human-nature connections.
2. Both approaches provide useful insights; however, the linkage between biophysical and psychological human-nature connections has received very little attention.
3. The two approaches are interdependent, yet retain specific (siloed) focuses on structural (biophysical) and agency (socio-psychological) related connections, addressing different scales of analysis and different potential places to intervene in complex systems in order to lead to transformative change towards sustainability.
4. In this paper we briefly outline the characteristics of these two broad approaches to human-nature connections, noting the key differences and commonalities. We then discuss the potential advantages of aligning these two approaches, and the potential challenges in doing so. Finally, we suggest some directions for future research on sustainability and human-nature connections.

1. Introduction

Individuals and societies are increasingly disconnected from nature, as a result of urbanization and globalized patterns of natural resource usage (e.g., Seto et al., 2012) as well as adopting lifestyles with infrequent contact with natural environments (Soga & Gaston, 2016). These disconnections have consequences for human wellbeing and health (Sandifer, Sutton-Grier & Ward, 2015), attitudes and behaviours towards nature (Nisbet, Zelenski & Murphy, 2009), and material use and consumption (Folke et al., 2011). Recognition of the adverse consequences of human-nature disconnections has led to calls for a better understanding of human-environmental interactions as a key component of sustainability (Folke et al., 2011, Ives et al., 2017, Schultz, 2002).

Within this research field, which for brevity we refer to as human-nature connections (HNC), two main narratives/perspectives have arisen that engage with the (dis)connection between people and nature and the need to reconnect with nature for sustainability: (1) the first perspective, which here we call 'biophysical HNC' (Dorninger, Abson, Fischer & Von Wehrden, 2017) focuses on notions of sustainable resource use and material and energy flow between societies and the environment (e.g., Fischer-Kowalski et al., 2011, Haberl et al., 2007, Wackernagel et al., 1999). This perspective primarily focuses on 'systems' – rather than individuals – highlighting the need to consider the impact of human activity on the environment. (2) The second perspective, which for brevity we refer to 'socio-psychological HNC' focuses on the emotional, experiential, philosophical and cognitive connections with nature (e.g., Ives et al., 2018) and how these relate to well-being, pro-environmental values and attitudes, and behaviours (e.g., Andersson et al., 2014, Nisbet et al., 2009, Soga & Gaston, 2016). This perspective focuses on individual behaviours, and calls for increased cognitive, emotional, and psychological connections to nature.

These two perspectives (biophysical and socio-psychological) have conceptualized and operationalized HNC from different theoretical and disciplinary position, which has led to a diverse but sometimes conflicting perspectives on the role of HNC in transformative change towards sustainability. Moreover, each perspective provides insights into different places in which intervention can be made to halt or reverse human-nature disconnections. While each approach is of considerable value, in this paper we argue that there is a pressing need to better align and integrate these approaches due to the unavoidable interdependence between

29 biophysical and socio-psychological HNC. It is not simply that they share the same underpinning causes
30 (urbanization, globalization, materialism, technological changes etc.), but that they are two parts of a single
31 reinforcing feedback loop. As societies become biophysically disconnected from nature, this leads to the loss
32 of opportunity and ability to experience nature, which in turn reduces humanity's emotional affinity with
33 nature. This loss of affinity with nature (loss of socio-psychological HNC) decreases concern for further
34 erosion of biophysical connections (Soga & Gaston, 2016). This reinforcing feedback loop has been described
35 by Robert Pyle in his memoir *The Thunder Tree* as the "extinction of experience" (Pyle, 1993). The artificial
36 separation of socio-psychological and biophysical aspects in current HNC research crucially misses this
37 reinforcing feedback dynamic.
38
39 In this paper we discuss the characteristics of the biophysical and socio-psychosocial HNC perspectives,
40 challenges and opportunities for better aligning these perspectives, and suggest some tentative approaches to
41 bridge biophysical and socio-psychological HNC research. We are aware that characterizing large, diverse
42 and vibrant bodies of work in a few paragraphs is likely to lead to oversimplification. Therefore, the intention
43 is not to provide a detailed review of the literature, or authoritative definitions of these two perspectives on
44 HNC; rather, we attempt to highlight some overarching characteristics, the value of their individual
45 contributions, and the potential of better aligning the two approaches in the context of sustainability. We note
46 there are other important approaches to conceptualizing human environment interactions in relation to
47 sustainability including socio-ecological systems research (e.g., Fischer et al., 2015, Ostrom, 2009);
48 ecosystem services approaches (e.g., Riechers, Strack, Barkmann & Tscharntke, 2019, Schröter et al., 2017)
49 and relational values (e.g., Chan et al., 2016, Díaz et al., 2015) that are beyond the scope of this current
50 discussion.
51
52 ## 2. **Biophysical human-nature connections**
53 Biophysical human-nature connections (Dorninger et al., 2017) encompass different methodological
54 approaches for assessing humanity's appropriation of material and energy flows from the environment. From
55 a biophysical perspective, societies are intrinsically connected to nature through their social metabolism of
56 material and energy via economic activity (e.g., de Molina & Toledo, 2014). This research strand has a long

history including early earth system dynamic models that sought to understand the material and ecological limits to economic growth (e.g., Meadows, Meadows, Randers & Behrens, 1972). The research encompasses ideas such as emergy— all the energy used to generate a product or service— analysis and environmental carrying capacity (Odum & Odum, 1976) and attempts to quantify ecological 'footprints' of human activity in terms of available productive land (e.g., Rees, 2006). The 'planetary boundaries' concept (Rockström et al., 2009) is a recent example of this broad biophysical HNC research strand, situating human activity within maximum material and energy flows to the environment while maintain a "safe operating space for humanity".

Specific biophysical HNC approaches include measures of material and energy flow accounting (e.g., Fischer-Kowalski & Haberl, 2015), and human appropriation of net primary production (e.g., Haberl et al., 2007) used to operationalize spatio-temporally explicit interactions between humans and the environment. More recently, scholars have begun to explore material and energy flows between spatially distant systems, giving greater emphasis to understanding teleconnected, distal environmental impacts (e.g., Liu et al., 2007) and the unequal appropriation of material and energy flows through trade (Dorninger & Hornborg, 2015, Hornborg & Martinez-Alier, 2016).

Despite the diversity of approaches found within the biophysical HNC literature, the research shares some key characteristics. An important commonality of biophysical HNC research is the creation of integrated and robust quantitative measures of biophysical human-nature connections used to evaluate the ecological or social consequences of socio-economic activities. Quantitative biophysical assessments are considered important in providing decision-makers with evidence about unsustainable biophysical human-nature connections. Most biophysical HNC research employs societal entities, such as urban populations, or the nation state, as units of analysis. Biophysical HNC research primarily applies a systems perspective on society-environmental relations where humans shape the environment via socio-economic institutions related to economics, resource use and trade relations (Challies, Newig & Lenschow, 2014), with little consideration of individual human agency. Human-nature disconnections are conceptualized in terms of resource

84 appropriation that exceeds the carrying capacity of a given system, or that is dependent on appropriation of
85 resources from distal systems.
86
87 ## 3. **Socio-psychological human-nature connections**
88 Socio-psychological HNCs reflect the degree to which one considers or experiences a personal relationship,
89 bond, commitment, or affinity with the natural world. While efforts to understand and describe how humans
90 interact with nature have occurred throughout time, the last 30 years brought a wave of research focused on
91 the growing gap between humans and nature, and the implications of this gap for sustainability. While humans
92 have been purported to have an innate attraction to and dependence on nature (Wilson, 1984), scholars argue
93 that these relationships have been strained and fractured due to technological advancements, urbanization
94 trends, and increasingly indoor lifestyles, leading to an extinction of experience (Pyle, 1993).
95
96 The scope of socio-psychological HNC research is broad. Various scholars have characterised these
97 relationships in terms of emotional (e.g., Kals, Schumacher & Montada, 1999), identity and self-concept (e.g.,
98 Clayton, 2003), commitment (e.g., Davis, Green & Reed, 2009), and belonging (Mayer & Frantz, 2004) (for
99 similarities and differences between these concepts, see Tam, 2013). Socio-psychological HNC has been
100 measured and operationalised in many ways; often encompassing emotional, experiential, philosophical and
101 cognitive relationships that occur between humans and nature (several reviews show the breadth of this field;
102 see, Ives et al., 2017, Restall & Conrad, 2015, Zylstra, Knight, Esler & Le Grange, 2014).Social sciences have
103 primarily studied socio-psychological HNCs, with conceptual and empirical contributions from the fields of
104 environmental psychology, human geography, education, and tourism (Ives et al., 2017).
105
106 While the strands of socio-psychological HNC research operate with different aims and investigate different
107 outcomes, the field can be characterized by a series of overarching trends. Psychological HNC research
108 primarily measures connections to nature at the individual scale and uses on a mix of quantitative (e.g.
109 psychometric scales) and qualitative (e.g. semi-structured interviews) methods. This approach is primarily
110 focused on positive outcomes related to environmental attitudes and beliefs (e.g., Nisbet et al., 2009) and pro-
111 environmental behaviours and actions (e.g., Geng, Xu, Ye, Zhou & Zhou, 2015). Findings from socio-

112 psychological HNC studies have been used to inform projects and interventions with the aim of influencing
113 the adoption of pro-environmental attitudes, values and behaviours (e.g., DEFRA, 2018).
114
115 ## 4. Challenges of aligning biophysical and socio-psychological HNC research
116 The very different problem framings, operationalization and methodologies employed in the biophysical and
117 socio-psychological HNC research (Table 1) represents a particular challenge for integrating the two
118 approaches.
119
120 At the most basic level socio-psychological HNC research focuses on individual agency, well-being, identity
121 and pro-environmental behaviours or intentions that arise from individual experience of and connections to
122 the natural world. In contrast, biophysical HNC research focuses on systemic patterns of resource use and
123 their relation to societal level sustainability outcomes. Biophysical and socio-psychological HNC research
124 also differs in terms of their scale and units of analysis, problem framings, methodological approaches and
125 terminologies. Table 1 highlights a number of key characteristics that distinguish the two HNC approaches.
126
127 Socio-psychological HNC research primarily measures connections to nature with individuals as the unit of
128 analysis and uses a mix of quantitative (e.g. psychometric scales) and qualitative (e.g. semi-structured
129 interviews) methodology to investigate the relations between degree of connectedness and environmental
130 attitudes and beliefs (e.g., Nisbet & Zelenski, 2013) and pro-environmental behaviours and actions (e.g., Geng
131 et al., 2015). Human-nature disconnections are concpetualized in terms of loss of cognitive, affective or
132 experiential links to nature. In contrast, most biophysical HNC research employs societal entities, such as
133 urban populations, nation states, as units of analysis. Biophysical HNC research primarily applies a systems
134 perspective on society-environmental relations where humans shape the environment via socio-economic
135 institutions related to economics, resource use and trade relations (Challies et al., 2014), with little
136 consideration of individual human agency. Human-nature disconnections are conceptualized in terms of
137 resource appropriation that exceeds the carrying capacity of a given system, or that is dependent on
138 appropriation of resources from distal systems.

139 **Table 1: Characteristics of and key integration points for biophysical and socio-psychological HNC**

140 **approaches**

Characteristics	Biophysical HNC	Psychological	Key Integration point
Problem framings	Connections via resource and land usage related to ecological limits, and distributional issues.	Disconnection from nature as a cause, symptom or treatment of unsustainable behaviours (Ives et al 2018).	Recognition that these phenomena are mutually reinforcing; problem framings that focus on the feedback between individual agency and societal structures.
Level/scale/focal unit of analysis	Societies, or socio-ecological systems.	Individuals, or individual human-nature interactions.	Conceptual approaches such as landscape sustainability science (Wu, 2013) that explicitly seek to integrate such cross scale issues.
Human-nature relationship terminology	Interactions: relatively neutral, passive and descriptive (what is), interactions as 'means'.	Connections/disconnections: relatively normative (what could be) and alterable; connections as both 'means and 'ends'.	Common language to improve shared problem understanding.
Methodology	Descriptive-systems dynamics and system behaviour.	Hypothesis driven relating to individual agency and behaviour or descriptions of lived experiences of people in different environments.	Linking community level socio-psychological HNC connections to nature to structural patterns for biophysical HNC.
Targeted sustainability	Decreased pressure on ecosystems from	Increased pro-environmental behaviour	Focus on barriers to transformative change, particularly across the

outcomes	resource use systems.	of individuals or their health/well-being.	biophysical socio-psychological divide.

From a biophysical HNC perspective transformative sustainability solutions are generally related to identifying, and living within, societal scale biophysical or ecological limits (e.g., Daly, 1991, Folke et al., 2011). While biophysical HNC research generally has a strong focus on sustainability outcomes in relation to distributional justice (inter- and intra-generationally equitable resource use), increasingly procedural elements via governance of teleconnections (e.g., Challies et al., 2014, Hornborg, McNeill & Alier, 2007) investigate how biophysical states of systems are generated and institutionalised. In contrast, the overarching aim of socio-psychological HNC approach is to understand "the broad underlying structure of relational motives for environmental behaviours" (Davis et al., 2009 p258). While scholars recognize that social and environmental factors shape opportunity to connect with nature, the socio-psychological HNC approach is oriented to means by which individuals can strengthen or build connections to nature through changes in individual activity and behaviour (e.g. spending more time in nature). The socio-psychological approach reflects societal-level trends, highlighting underpinning worldviews, values, and attitudes of societies that shape human-nature relationships and interactions (Schultz, 2011).

Aligning biophysical and socio-psychological approaches begins with acknowledgement of the interdependences between these two aspects of human-nature connections. This will include the need to draw system boundaries explicitly including the feedback between societal scale patterns of natural resource use and individual opportunities for and attitude towards experiencing nature. Here we argue that doing so will not just enrich both fields of research, but provide new insights about where to intervene in human-nature connections in the pursuit of more sustainable human-nature relations.

5. **Opportunities to align biophysical and socio-psychological HNC research**

Human-nature connections have been conceptualized as both a symptom of, and a treatment for, unsustainable behaviour (Ives et al., 2018). Biophysical HNC research largely describes the symptoms of unsustainability

(often in terms of unsustainable resource use), without explicitly addressing the perceived root causes (e.g., the worldviews, and economic and institutional paradigms) that shape those outcomes. For example, while ecological footprint (e.g., Wackernagel et al., 1999) and planetary boundaries (e.g., Rockström et al., 2009) concepts describe important aspects of biophysical disconnections they do not directly explain the reasons for such disconnections. In contrast, socio-psychological HNC research focuses increasing on human-nature connections as a possible treatment for unsustainable behaviour (via changing individuals' value systems and relations to the natural world), without considering the structural factors that disconnect people from nature. As such, neither approach alone is capable of fully describing the reinforcing feedback that relate human-nature disconnections to unsustainable human-nature relations. This in turn limits the ability of these approaches to suggest solutions to the problems of human-nature disconnection.

To bridge the gap between biophysical and socio-psychological HNC research in relation to sustainability it is enlightening to consider how the approaches relate to the types of interventions that they help facilitate. In 1999, Donella Meadows published a seminal heuristic framework that identified 12 'leverage points' – places in complex systems where a small intervention in one part of the system can lead to systemic change—ranging from parameters (such as subsidies, taxes, standards), through to the "mindsets and paradigms out of which a system arises" (Meadows, 1999 p3).

The framework has recently been adapted to reduce the 12 leverage points to four broad system characteristics where interventions can occur (Abson et al., 2017): the first characteristics are tangible, physical 'system parameters' (resources consumed; time spent in nature etc.); the second 'System feedbacks' - the interactions and feedbacks that drive system dynamics. The third characteristic, 'System design', is the characteristic rules, social structures and institutions that manage feedbacks and parameters. Finally the fourth, 'system intent', describes the characteristics of the underpinning values, goals and worldviews that shape the emergent direction to which a system is oriented (Abson et al., 2017) and therefore system design.

Biophysical HNC research is largely focused on understanding key 'system parameters' (the scale and nature of resource use) and the 'system design' (trade relations etc.) that determines the ecological and socio-

194 economic impact of particular patterns of human activity with regard to ecological and environmental limits
195 of material and energy flow. Biophysical HNC research has generally not considered the agency of
196 individuals within such systems of resource use, or considerations of the individual values and intentions that
197 shapes institutional design and resource usage. In contrast, socio-psychological HNC research is strongly
198 focused on the how worldviews, values and mindsets determines individuals' intentions and behaviours. This
199 research has relatively little focus on how these values and worldviews are shaped and constrained by the
200 system design within which agents act, or what might constitute system level, rather than individual level,
201 intents. The difference between these two approaches is important because transformative change toward
202 sustainability is likely to require multiple interventions that together address all four of these key system
203 characteristics. While socio-psychological HNC can provide knowledge regarding how interactions with the
204 environment shape the intentions that influence behaviour, it has limited ability to investigate the system
205 structures that shape and constrain such environmental interactions. Similarly, while biophysical HNC
206 research can describe the material and energy flow that shape and define human society and its relation to the
207 environment, it has relatively little to say regarding the underpinning societal values that ultimately drive such
208 flows. Here, we suggest that the key notion of feedbacks provides a bridge between the two approaches and
209 the missing system characteristic that would allow for a complete system model to operationalize Pyle's
210 notion of the reinforcing mechanism of the extinction of experience (Pyle, 1993).
211
212 ## 6. **Strategies for aligning biophysical and socio-psychological HNC research**
213 We propose three broad strategies for bridging the divide between biophysical and socio-psychological HNC
214 approaches.
215
216 *Meaning and HNC research*
217 In order to bridge the divide that has arisen between these two approaches there is a need to explicitly
218 acknowledge what it means to be connected to nature. Specifically, this means acknowledging that
219 biophysical and socio-psychological HNCs are not distinct phenomena. Our connections to nature result from
220 the complex interplay between: (1) the societal structures that influence our material use of the environment,
221 and (2) the experiences, beliefs, values and worldviews that shape individual environmental behaviours.

Expanding the definition of HNC to encompass both the notion of biophysical and socio-psychological connections opens the space to ask key questions such as: how do societally shaped biophysical connections to nature mediate individuals' affective, cognitive and experiential connections to nature? How does an individual's experience of nature affect their acceptance of societal structures that biophysically disconnect them from nature? Are pro-environmental intentions mediated via socio-psychological connections to nature constrained by systemic biophysical connections of natural resource use (the classic values-action gap (e.g., Kollmuss & Agyeman, 2002))? To what degree are individuals' worldviews about humanity's rights and obligations towards nature reflected in the values of social, institutional, political and financial systems?

Models and HNC research

Biophysical and socio-psychological HNC research approaches have created very different formal and mental models of human-nature connections, with the former focused on describing the biophysical parameters of societies' connections to nature and the later focusing on individual behaviour intents arising from connections to nature. Yet, neither set of models emphasises issues of systemic characteristics that determine these connections to nature. From a conceptual perspective, research that focuses on 'system design' may be particularly fruitful for relating biophysical and socio-psychological HNC research. This requires a shift from the more descriptive, indicator-based models that dominate research to the material and energy connections between people and their environments, as well as towards consideration of formal and informal institutions that shape such patterns (e.g., Borgström Hansson & Wackernagel, 1999, Challies et al., 2014, Hornborg et al., 2007, Seto et al., 2012). From the socio-psychological HNC perspective, a shift is required from modelling HNC as a 'treatment' that can influence pro-environmental behaviour (Ives et al., 2018) towards a better understanding of the underpinning drivers of socio-psychological disconnections to nature (e.g., Castree, 2008, Dickinson, 2013). This in turn may require a move away from individuals as the primary unit of analysis in socio-psychological HNC research.

Focusing on the formal and informal institutions, rules, and structures that shape both societal-level material and energy connections to nature, as well as individuals' experiential, cognitive and philosophical connections to nature, may provide a boundary object that links these two crucial aspects of HNC in the context of

sustainability. Such an approach not only provides specific places where interventions may be effective in transforming both biophysical and socio-psychological HNC, but also potentially enables and integration across scales as well as units of analysis.

Methods and HNC research

One methodological approach for aligning biophysical and socio-psychological HNC approaches is the use of place-based (e.g., Fischer, Sherren & Hanspach, 2014, Stedman, 2002), or landscape-based (e.g., Wu, 2013), research approaches, where a physical space acts as a boundary object that transcends disciplinary boundaries (e.g., von Wehrden, Luederitz, Leventon & Russell, 2017). For example, regional based assessments of material and energy flow analysis (e.g., Dorninger et al., 2017) could be linked to quantitative assessments of socio-psychological HNC across the same regions (for a discussion of spatial scale in socio-psychological HNC research see Klaniecki, Leventon & Abson, 2018). To move beyond the individual as the unit of analysis, researchers may assess socio-psychological HNC through a random sample with a fitting sample size for the given population (i.e. all inhabitants in that area) using standard empirical social science methods, such as questionnaires. By statistically extrapolating the results of the sample to the population, one can give probability estimates on the variance of socio-psychological HNC of the regions inhabitants. Finally, research that focuses on individuals with the ability to shape system dynamics (e.g. leaders or managers of key institutions could help link personal HNC to their structural decision-making. Aligning biophysical and socio-psychological HNC in such a way might highlight patterns of co-occurrence between the broad system characteristics captured by the two approaches.

6. **Conclusions**

Many sustainability challenges, including social and economic inequality, biodiversity loss, and over exploitation of the environment, are driven by how we as individuals, and as societies, relate to, and interact with, each other and the environment (Glaser, Krause, Ratter & Welp, 2012). Currently, societal and individual connections to nature are largely studied in isolation from each other. Acknowledging the interdependencies and relations between these societal (biophysical) and individual (socio-psychological) connections to nature is likely to be crucial for understanding how those working for positive change

intervene in such relations order to move towards more sustainable human-nature connections. Utilizing place and landscape based approaches to bridge the methodological divide between the two HNC approaches and focusing on institutional drivers of such relations may provide to be fruitful means of better aligning a currently fragmented and siloed research field.

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SECTION B

Chapter IV

B

Behaviour Change for Sustainable Development

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Definition

Human impact on the planet is intensifying due to rapid globalization, economic and population growth, and changing lifestyles. In addition to technical and regulatory solutions, sustainable development must include a transformation of human consumption behaviors.

Introduction

Human effects on the environment are so significant that some scholars propose we have entered a new geological epoch called the Anthropocene, where humans are now the dominant driver of earth system processes at a planetary scale (Steffen et al. 2011). Climate change, biodiversity loss, ecosystem degradation, and ocean acidification are undoubtedly caused and accelerated by unsustainable human activity. While humans throughout history have modified the natural environment to meet their needs, human impact on the planet is now exponentially greater due to rapid globalization, economic and population growth, and changing lifestyles (IPCC 2014). Current demands on Earth's resources far outpace what the planet can produce, absorb, and neutralize, leading to widespread environmental depletion and degradation (UNDP 2012).

An increased awareness of the scale and scope of human impact on the planet has led to international efforts to curb environmental degradation and promote sustainable development. Policies and regulations, technical solutions, international agreements, economic tools, and informational tools have been applied to facilitate transitions towards sustainability. While regulatory and technical solutions have been beneficial in addressing significant cases of environmental pollution (e.g., regulations on CFC emissions and DDT pesticides), widespread environmental destruction continues due to unsustainable and intensifying human consumption behavior (Steg and Vlek 2009).

Given the magnitude of today's environmental challenges, sustainable development must include human dimensions of change, specifically behavior change for sustainable development. Since the 1992 Rio Earth Summit, there has been increased focus on the role of individual consumption patterns and production systems for sustainability. Achieving the sustainable development goals requires a critical understanding of "how people

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make decisions and act on them, how they think about, influence, and relate to one another, and how they develop beliefs and attitudes" (UNDP 2016, pp. 1–2).

Behavioral science theories and behavior change tools inform the creation of behavior change interventions for sustainable development. Such interventions are "coordinated sets of activities designed to change specified behavior patterns" (Michie et al. 2011, p. 1) and can focus on increasing, decreasing, or maintaining behaviors, as well as enhancing or improving behaviors (Morra Imas and Rist 2009).

This article addresses three main elements of behavior change for sustainable development: theories and models of human behavior and behavior change, behavior change intervention tools and methodologies, and selected examples of successfully implemented behavior change interventions. The article ends with a brief discussion of critiques of the behavior change approach and conclusions.

Understanding the Need for Sustainability

The impact of individual consumption behaviors can be traced to increasing demands for natural products and services such as food, water, timber, minerals, and fuel. The intensity of resource use and environmental degradation is responsible for fundamentally and irreversibly changing the planet. Household consumption contributes to more than 60% of global greenhouse gas emissions and between 50% and 80% of total land, material, and water use (Ivanova et al. 2016). The Food and Agriculture Organization of the United Nations estimates that one-third (~1.5 billion tonnes) of all food produced for human consumption in the world is wasted (FAO 2013). Moreover, water demand will surpass supply by 40% within 15 years as populations and demands on resources increase (UNEP 2017).

Curbing unsustainable behavior can reduce the acceleration of environmental degradation and contribute to sustainable development. For instance, the adoption of sustainable energy behaviors has the potential to reduce US household direct emissions by 20% (Dietz et al. 2009) and transitions towards environmentally sustainable diets could reduce food-related GHG emissions by 29–70% (Springmann et al. 2016).

An understanding of the impact of human activity on the planet gave way to programs designed to shift human impact through behavior change. Many of these programs relied on theories of human behavior and behavior change to inform the structure and aim of the program and to effectively target behaviors.

Theoretical Approaches to Behavior Change

This section gives an overview of theories and models on behavior and behavior change relating to pro-environmental behavior. The first group of theories explains behavior as a result of individual motivational factors, the second group includes contextual factors to explain behavior, and the third group explains permanent behavior change.

Behavior Theories and Models Focusing on Motivational Factors

The roots of many human behavior modelling approaches lie within economic theory and the assumption that human decisions are a result of a rational consideration of available alternatives to increase benefits and reduce costs (e.g. Consumer Preference Theory). Behavioral economists, such as Simon (1982) and Tversky and Kahneman (1992), have shown that behavior is not necessarily rational, by revealing how mental heuristics and cognitive biases often make choices predictably irrational (e.g., Prospect Theory and Bounded Rationality Theory).

Specific concepts, such as information, values, beliefs, attitudes, norms, and agency, have played an important role in social-psychological behavior theory. The concepts of attitudes, social norms, and agency informed Ajzen's Theory of Planned Behavior (TPB) (1991), which is the most used theoretical framework in environmental behavior research (Klöckner 2015). TPB explains behaviors mainly as a result of individual intentions.

Behavior intentions are formed by a rational choice weighing of the three factors: attitudes toward the behavior, perceptions of social norms, and perceptions of behavioral control. Triandis' Theory of Interpersonal Behavior (1977) includes habits as an additional variable to explain why behaviors do not always align with behavioral intentions.

The concepts of social comparison, norms, and identity form the basis of theories such as Schwartz's Norm Activation Theory (NAM) (1977). NAM explains positive social behavior through personal norms, which are rooted in the feeling of a moral obligation to help. Such norms are activated by awareness of consequences of performing or withstanding a particular behavior and the perceived responsibility of the behavior and its consequences. Value Belief Norm Theory (VBN) by Stern is an extension of NAM and also explains behavior as determined by a moral obligation to act, but includes the individual's degree of ecological worldview as a contributing factor (2000). Noteworthy is also the decision-making context of Goal-framing Theory (Elliott and Fryer 2008), which states that an individual will have several different, hierarchically ordered goals at the same time and their behaviors can be understood as result of trying to achieve their most prioritized goal at that point in time. Cialdini et al.'s Focus Theory of Normative Conduct (1990) looks at how social norms, i.e., descriptive and injunctive norms, influence behavior. The norms ability to affect behavior depends on their salience in the consciousness of the individual at the time of the behavior.

Behavior Theories and Models Focusing on Contextual Factors

Contextual factors are important in explaining pro-environmental behavior, but these variables are often overlooked (Klöckner 2015) and are not as extensively examined for their effect on behavior as individual motivational factors (Steg and Vlek 2009). One theory that includes contextual variables as an explanation of behavior is Vlek et al.'s Needs Opportunities Abilities Model (2000). It portrays consumer behavior as influenced by societal factors and vice versa. The Comprehensive Action Determination Model of ecological behavior (Klöckner and Blöbaum 2010) combines TPB and NAM, including the concepts of context and habits for better predictability of pro-environmental behavior. Similarly, Kollmuss and Agyeman's Model of Pro-Environmental Behavior (2002) takes a holistic approach and includes both internal and external factors to explain pro-environmental behaviors.

Theories and Models Focusing on Behavior Change

In addition to understanding behavior, scholars have also developed theories and models to understand changes in behavior. Lewin's Change Theory (1951) was created around habits defined as resistance to change, in relation to behavior in groups. More permanent individual change and new habits will primarily occur if the whole social field adjusts. Lewin's Change Theory conceptualizes change as a process, instead of an event.

The Transtheoretical Model of Health Behavior Change (or Stages of Change Model) sees behavior change as a process of six different stages of change that an individual must go through for lasting behavior change (Prochaska and Velicer 1997). Bamberg adds that people can proceed from one stage to the next based on varied intentions and suggests different variables that contribute to forming the intention of each respective stage (2013).

The abovementioned theories each seek to explain behavior change at the individual level. To contribute to sustainable development, there is, however, a need for behavior changes to happen across large populations. In order to achieve this, Rogers' Diffusion of Innovations Theory and Model (2003) integrates the impact of social networks and interactions within the networks to develop more effective behavior change programs.

Planning Successful Behavior Change Programs

Behavior change theory provides important insight into the accumulated knowledge of

human behavior and behavior change. This section describes recommended steps in planning effective and efficient behavior change programs and presents some of the most effective intervention tools. In general, behavior change programs should: (1) identify and analyze suitable behaviors for change, (2) choose and implement suitable intervention tools, and (3) evaluate the effectiveness of the program (McKenzie-Mohr 2011; Steg and Vlek 2009).

Identify and Analyse Suitable Behaviors

Identifying suitable behaviors and target groups is crucial to maximize a behavior change program's impact. The most suitable behaviors to target are those with (1) a large environmental impact, (2) that are performed by many, and (3) where people are willing to change (McKenzie-Mohr and Schultz 2014). Environmental impact assessments such as life-cycle assessment and input-output analyses can be used to identify and prioritize behaviors based on environmental impact. Behavior plasticity – the proportion of people who could be convinced to adopt a given behavior – can be used to rank and prioritize target behaviors (Dietz et al. 2009). Target group segmentation can be useful to identify populations most receptive to change or groups that require different types of interventions (Klöckner 2015). Additionally, measuring baseline levels of selected behaviors – i.e., current penetration rates – can aid in further identifying which population to target (Steg and Vlek 2009).

Behavior Change Tools

There is a wide range of behavior change tools used to foster behavioral changes (see Table 1). Tools are segmented into antecedent tools – those changing factors that precede a behavior – and consequence tools – those changing the consequences of a behavior (Lehman and Geller 2004). An additional distinction is made between informational and structural intervention tools: the prior seeks to change perceptions, motivations, knowledge, and norms, while the latter changes the circumstances under which behavioral choices are made (Steg and Vlek 2009). Nudges, which can be both informational and structural, are aspects of the choice architecture that "alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein 2008, p. 6).

Informational Intervention Tools

One of the most common informational tools is providing information or education. These tools may lead to changes in attitudes and motivation; however, merely providing information does not often result in behavior change (Steg and Vlek 2009). Informational interventions tailored and framed to the needs, worldviews, and perceived barriers of the targeted population are more effective (Abrahamse et al. 2007; Nisbet 2009). Balancing the need for urgent action with emotions such as optimism and hope can also increase the effectiveness of information (Moser 2007). Providing information as a prompt is also used to induce behavioral change. Prompts – informational cues that draw attention to a desirable behavior – are most effective when the targeted behavior is easy to perform and when the prompt is in close proximity to where the behavior is performed (see Lehman and Geller 2004, for a review).

Another informational tool is the use of descriptive norms. Descriptive norms provide information on how most people in a situation behave and inform individuals of the most effective or appropriate behavior (Cialdini 2003). Social role models, individuals demonstrating or communicating how a particular behavior should be performed, can be used similarly (Lehman and Geller 2004). The use of norms is most effective when social proof – the number of other people performing the desired behavior – is high or the number of people behaving in an undesirable way is low (Cialdini 2003).

Goal setting, commitment, and feedback are also informational intervention tools. Goal setting is a tool where individuals set goals for future behavior and is most effective when used in combination with commitments and feedback (McCalley and Midden 2002). Asking individuals to commit to performing certain behaviors has also been shown to be an effective intervention

Behaviour Change for Sustainable Development, Table 1 Intervention tools and empirical applications

Intervention tool	Case example
Informational	
Prompts	Recycling (Austin et al. 1993)
Commitment	Transportation habits (Matthies et al. 2006)
Goal setting	Energy savings (Becker 1978)
Social model	Energy conservation (Nolan et al. 2008)
Feedback	Energy conservation (Abrahamse et al. 2007)
Structural	
Change in physical, technical or organizational systems	Cycling rates (Pucher and Buehler 2008)
Legislation	Plastic bags (Ritch et al. 2009)
Price mechanisms	Public transport (Fujii and Kitamura 2003)
Nudges	
Default settings	Green electricity (Pichert and Katsikopoulos 2008)
Simplification and framing of information	Food choice (Wansink et al. 2012)
Changes in physical environment	Food waste (Kallbekken and Sælen 2013)
Eliciting social norms	Hotel towel use (Goldstein et al. 2008)

tool (Lehman and Geller 2004). Public and written commitments are more effective than personal and oral commitments (Bell et al. 2001). Feedback, information on the effects of a behavior provided after the behavior is performed, has also shown positive results, especially in regard to energy savings (e.g., Van Houwelingen and Van Raaij 1989). Feedback is most effective when individually tailored and given frequently (Abrahamse et al. 2007).

Structural Intervention Tools

Structural tools change the costs, benefits, and availability of different behaviors by modifying physical, technical, and organizational systems, legislation, and price mechanisms (Steg and Vlek 2009). These tools impact perceptions of control (Klöckner and Blöbaum 2010) and may play a role in changing attitudes and motivation. Structural tools are most effective with behaviors that are costly and difficult to perform (Steg and Vlek 2009) and when dealing with habits (Verplanken and Wood 2006).

Structural tools often use reinforcements such as rewards or punishment to promote behavioral change (Lehman and Geller 2004). However, reinforcements can reduce intrinsic motivation related to the behavior and have negative consequences for the long-term effects of an intervention (see McKenzie-Mohr and Schultz 2014, for review). Interventions rewarding pro-environmental behavior are generally more effective than those punishing environmentally harmful behavior (Geller 2002).

Nudges

A nudge can be both an informational and a structural intervention, but it does not include economic incentives or the banning of behavior. Four of the most common and effective nudging tools are (1) deliberate use of default settings, (2) considerate simplification and framing of information, (3) changes in physical environment, and (4) eliciting of social norms (Lehner et al. 2015).

Evaluating Behavior Change Programs

The effectiveness and efficiency of behavior change interventions is measured using the following indicators: changes in behavioral determinants, changes in behavior and associated environmental impact, and the resource use of the program (McKenzie-Mohr 2011; Steg and Vlek 2009). A key for successful behavior change programs is finding the right tools for the targeted behavior and population. When there are both motivational and contextual barriers to behavioral adoption, combining several intervention tools

may result in the most impact (Klöckner 2015). New technological tools such as persuasive technology also hold promise, as they combine informational and structural tools and tailor interventions to specific target groups (Steg et al. 2012). Smartphones apps and games, for instance, can reach large numbers of individuals and potentially increase the effects of behavior change interventions (Klöckner 2015).

Successful Behavior Change Interventions

Government agencies, businesses, universities, and intergovernmental organizations have used behavioral science theories and methodology to design effective behavior change policy and programs. Until recently, most behavior change interventions were applied in developed counties with high per-capita consumption rates. More recently, interventions have been applied in developing country contexts to increase effectiveness of sustainable development projects (World Bank 2015). Interventions have targeted a range of behaviors, including water and energy consumption, green purchases, waste generation, and transportation (Table 2). In the next section we discuss how and where behavior change interventions have been applied and highlight examples of successful interventions.

Interventions in Governments and Municipalities

Governments, municipalities, and public organizations are increasingly incorporating behavioral science into policy making and regulations (OECD 2017). The government of the United Kingdom has an institution dedicated to the application of behavioral sciences and similar initiatives exist in Denmark, Australia, the United States, Singapore, and Canada (UNEP 2017). In California, the US Environmental Protection Agency used behavior change tools (including norms and addressing barriers) to reduce health effects associated with the consumption of a contaminated fish species (McKenzie-Mohr and Schultz 2014). In Toronto, Canada, a multi-agency partnership launched anti-idling programs that employed personal contact, prompts, and commitments to reduce emissions associated with vehicle engine idling. These strategies reduced idling by 32% and the length of idling by 73% (McKenzie-Mohr et al. 2012). In the USA, over 6.2 million households have received the "Opower report" that uses personalized feedback, social comparisons, and energy conservation information to reduce residential energy use (Allcott and Rogers 2012).

Interventions at Higher Education Institutions

Higher education institutions play a crucial role in fostering sustainable development and have implemented behavior change interventions (Filho 2011). Higher education institutions implement behavior change interventions through resource use competitions and campus-based sustainability programs. Nationwide competitions, such as RecycleMania, and university-organized energy and water conservation challenges, target resource consumption by employing public commitments, prompts, and social norms to promote sustainable behaviors. These types of competitions have seen reductions of 28% of electricity use and 36% of water consumption (Petersen et al. 2015).

Interventions at Businesses and Organizations

As companies and organizations increasingly prioritize corporate social responsibility and organizational sustainability, there has been an increase in efforts to engage employees and customers in behavior change programs (see Young et al. 2015, for a review). Organizations use behavior change strategies to address issues related to material use and disposal, commuting to work, and water and energy use. Energy conservation behaviors in the workplace have been targeted through online feedback and controls (Yun et al. 2017), gamification (Gandhi and Brager 2016), and goal setting and information (Mulville et al. 2017). Businesses have also applied behavior change tools to encourage resource conservation among customers and guests. Norm-based reuse messages in hotel bathrooms, for instance,

Behaviour Change for Sustainable Development, Table 2 Examples of successful behaviour change interventions

Country	Behaviours targeted	Intervention tools used	Results
Costa Rica	Household water consumption	Goal-setting; prompts; social norms	3.7–5.6% reduction in monthly water consumption
Denmark	Mobile phone purchases	Nudging	20% point increase in mobile phone repair; 7x increase in purchase of second-hand mobile phone
Norway, Switzerland, Denmark	Smart Grid technology uptake	Default settings	2.5x more likely to accept Smart Grid installation in the opt-out condition
Kenya	Water purification	Nudges	Uptake rates rose from 10% to 60%
India	Daily commuting	Incentives	13% point increase in commuters traveling before peak times
Japan	Sustainable transportation	Feedback; goal-setting	7.5% reduction in car use; 68.6% increase in public transportation use
United States	Recycling	Commitment; feedback	25.4–40% increase in paper recycling
South Africa	Office energy efficiency	Prompts; competition	13.5% reduction in energy use
Denmark	Vegetable purchases	Nudges	61.3% increase in sales of pre-cut vegetables

OECD (2017), UNEP (2017)

led to a 25–40% increase in towel reuse by hotel guests (e.g., Goldstein et al. 2008).

Interventions at Intergovernmental Organizations

Behavior change theories and approaches have also been employed by intergovernmental organizations. The United Nations Environment Programme (UNEP 2017), the Organisation for Economic Co-operation and Development (OECD 2017), the World Health Organization (Jenkins 2003), and the World Bank (World Bank 2015) have reports on the use and application of behavioral insights for sustainable development. The United Nations engages several Behavioral Science Advisors and launched the UN Behavioural Initiative (UNBI) to integrate behavioral science into UN programming and operations (UNDP 2016). UNBI has applied behavioral science in China to increase e-waste recycling (norms and commitments were used) and in Bangladesh to increase use of public bus transportation during peak commuting hours (using electronic prompts) (UNDP 2016).

Critiques of Behavior Change for Sustainable Development

While behavioral science can successfully inform interventions for sustainable development, there can be unintended consequences on behaviors outside the scope of the intervention. Negative spillover effects occur when interventions have counterproductive effects or when the adoption of one pro-environmental behavior is associated with a reduction in a different pro-environmental behavior – for example, when the purchase of a fuel-efficient vehicle results in more overall driving (Klöckner et al. 2013).

The ethicality of some interventions has also been debated. Nudges receive criticism for lacking transparency, as nudges seek to influence thinking and choice making without awareness of the individual (Lehner et al. 2015). This tool is viewed as more ethical when individual choice is not restricted and when individuals are able to identify when and how nudges are applied.

Additionally, some scholars deem the individual behavior change approach too simplistic to

solve complex environmental problems at the scale required. Scholars have questioned whether individual behavior change can effectively tackle problems like climate change or whether these problems require more systemic and structural transformations of society (Csutora 2012). Others argue that voluntary behavior change is too gentle and does little to change the status quo of unsustainable consumerism (De Young 2014). Nevertheless, many point out that small behavior changes accumulate, create demand for systemic change, and can lead to bottom-up momentum for sustainable development (Stoknes 2015).

Conclusions

Solving today's environmental problems will require large-scale shifts in human behavior. McMenzie-Mohr and Schultz state that "behaviour change is central to the quest for a sustainable future" (2014, p. 35). Behavioral theories and models focused on motivational and contextual factors provide structure to the field of behavior change for sustainable development by providing explanations and rationale for how people make decisions and act on them. These theories inform experiments on pro-environmental behavior change and the development of informational and structural tools that foster the adoption of sustainable behaviors. Behavior change programs that reference behavioral theory, carefully research selected behaviors, and utilize a range of tools to target barriers and benefits will be most successful for fostering behavioral change for sustainable development.

Cross-References

- Environmental Behaviour and Sustainable Development
- Sustainable Values, Attitudes and Behaviour
- Reduction in Consumption for Sustainable Development

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Chapter V

Investigating the nuanced relationship between pro-environmental behavior and human-nature connectedness: a systematic review

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Abstract:

Evidence of a positive correlation between human-nature connectedness (HNC) and pro-environmental behavior (PEB) sparked calls to 'reconnect' individuals to nature as a means of facilitating behavioral shifts towards sustainability. We conducted a systematic review (n=91) with the aim of understanding how PEB has been studied in the HNC literature, with a specific focus on understanding the relationship between types of HNC and specific realms of PEB. In this paper, we highlight key findings, focusing on methodological patterns in measuring PEB, trends in type of nature and behavior considered, and linkages between scale of HNC (local to global) and scale of PEB (local to global). We use the results of our systematic review as a point of departure to discuss the relationship between HNC and PEB with a particular focus on: (1) reducing conceptual fogginess and (2) implementing effective interventions that encourage PEBs.

Keywords: pro-environmental behavior; human-nature connectedness; place attachment; systematic review; sustainability

1. INTRODUCTION

Many of the environmental crises facing the planet—e.g. air and water pollution, resource depletion, climate change—are heavily rooted in unsustainable human behavior (Fischer et al., 2012; Vlek & Steg, 2007). The impact of human behavior is compounded due to increasing populations, increasing affluence, and increasing use of technology (Vlek & Steg, 2007; York, Rosa, & Dietz, 2002). Large-scale transformation of individual behaviors towards more pro-environmental behaviors (PEBs)—"behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world" (Kollmuss & Agyeman, 2002, p. 240)—will be necessary in order to achieve sustainable societies and healthy environments. In order to facilitate changes in behavior, scholars and policy makers have sought to understand the determinants of PEB, the elements that most effectively predict PEB, and the most effective strategies for wide-spread behavioral change (Steg, Bolderdijk, Keizer, & Perlaviciute, 2014).

One predictor of PEB that has recently generated a significant amount of attention in empirical research is the degree to which individuals have a connection to the natural world (for reviews, see: Ives et al., 2017; Restall and Conrad, 2015; Zylstra et al., 2014). Human-nature connectedness (HNC) is a measure of the strength or closeness of the relationship between humans and the natural world. While scholars who established connectedness to nature as a field of psychological enquiry have understood it as the degree to which one's concept of self encompasses the natural environment (see Schultz, 2002, 2004; Mayer & Frantz, 2004), in its broadest conceptualization it encompasses philosophical, emotional, cognitive, experiential and material connections (Ives et al., 2018). Connectedness can be based on direct experiences with nature, knowledge and awareness of nature, or worldviews about the relationship between man and nature. Despite the diversity of approaches in the field, scholars have long argued that if people see themselves as part of nature or have a stronger sense of connection to nature then they are less likely to engage in behaviors that negatively harm the environment (Leopold, 1949; Perkins, 2010; Schultz, 2002; Wilson, 1984). Moreover, research on this topic has empirically shown that HNC can be a positive predictor of PEB (e.g. Brügger et al., 2011; Dutcher et al., 2007; Geng et al., 2015; Mayer and Frantz, 2004).

Evidence of a correlation between HNC and PEB sparked calls to 'reconnect to nature' as a means of facilitating behavioral shifts towards sustainability. Despite growing interest in this topic and a rapid increase of publications in this field (Ives et al., 2017), a research gap remains in current understanding of the HNC-PEB relationship. Specifically, we know little about whether the places where individuals connect to nature influences the types of PEBs they adopt. This may be, in part, due to the conceptual and methodological challenges that arise when measuring constructs that are both multi-scalar and multidimensional (Klaniecki, Leventon, & Abson, 2018). That is, that HNC can be measured as place-based connectedness or general connectedness and PEBs can be measured as having place-based impacts or general impacts. If HNC is to be applied as an effective 'treatment' for unsustainable behavior (Ives et al., 2018; Klaniecki et al., 2018), then scholars must address these research gaps.

Given the rapid growth of this field, it is worthwhile examining how the HNC-PEB relationship has been studied in the literature and if an investigation of this literature will reveal patterns and opportunities for future research. Using a systematic literature review methodology, we aim to critically review the subset of the HNC literature focused on PEBs, with an emphasis on measurement. To address that aim, we propose the following research questions:

Q1: How can the current HNC-PEB literature be characterized?

Q2: What are the associations between: (a) the scale at which authors measure HNC and the scale at which PEBs are measured, and (b) the type of HNC and the type of PEBs measured?

To answer these questions, we reviewed a subsection of the Ives et al (2017) 475-paper systematic review on the HNC literature to gather an understanding of how HNC and PEB have been studied and related in the literature. Based on our findings, we aim to identify knowledge gaps and propose a new research agenda for understanding the relationship between the connections that individuals build to the natural world and the behaviors that individuals adopt to protect or conserve the environment.

2. METHODOLOGY

2.1 Data collection and search string

A comprehensive systematic search of literature on HNC was conducted in November 2015. The dataset of publications was collected from a query of the Scopus database on 16 November 2015, using a variety of terms related to 'nature', 'people' and 'connection. The search-string was designed to capture the largest set of relevant literature possible. The query resulted in 3,849 papers, which was reduced to 2,649 after removing duplicates and restricting results to English-language articles. Articles were screened by title and abstract according to a series of eligibility criteria, which excluded 2,147 articles from the review. Full-text analysis and coding was carried out on the final dataset of 475 papers. The data collection protocol, search terms, study inclusion criteria, and coding protocol are available in the supplementary material of Ives et al (2017).

These 475 studies, which represent the current state of empirical HNC literature, were used as the database for the present review. We screened these 475 papers for eligibility in the present review based on a new set of criteria. Although this dataset was not compiled explicitly for assessing the relationship between HNC and PEB, the search terms were sufficiently broad to capture all relevant publications for that time period.

2.2 Eligibility Criteria

Research that met a series of criteria was included in our review. First, the papers had to meet the original inclusion criteria set by Ives et al (2017), which stipulated that papers must be: (1) published in a peer-reviewed journal; (2) available in English; (3) empirical research (i.e. reviews and conceptual works were excluded); and (4) focused on one or more types of human-nature connections. Second, the papers had to have been coded as having a focus on 'behavior' in the first round of coding. This resulted in a set of 96 papers to review based on a new series of inclusion criteria specific to this review.

Based on our research aims of this paper, we applied an additional set of eligibility criteria to generate a subgroup of studies focusing on the HNC-PEB relationship. To be included in the present review, studies had to meet the following criteria: (1) focused on PEBs (i.e. studies that only measured values, attitudes, or preferences were excluded); (2) empirically measured PEBs; and (3) measured individual-level behaviors (i.e. societal- and regional-level behaviors were excluded). Studies were retained regardless of how PEBs were defined (e.g. environmental actions, conservation behaviors), how PEBs were measured (e.g. observed behaviors, self-reported behaviors, experiments), or the relative environmental impact of the PEBs. We were interested in casting the largest possible net to understand how the HNC-PEB relationship has been studied.

2.3 Coding protocol

Once the papers were identified, we coded each article to understand how authors selected, categorized and measured HNC and PEBs in each study. Each paper was coded for: descriptive information (e.g. title, year, discipline, country of study, participants); PEB methodology (e.g. term used to describe PEBs, type of behaviors, number of behaviors measured); HNC information (e.g. scale of nature, type of nature, type of nature connection); and PEB information (e.g. scale of impact, genre of behavior). Impact was categorized in terms of projected environmental impact of the behavior, though we recognized that categorizing the actual environmental impact of behavior is complex (Gatersleben, 2013). For measuring scale of HNC and PEB, we used a generalized spatial scale ranging from local to global. For the studies measuring connectedness to a general and unspecified type of nature (e.g. 'nature' or 'the environment' in a general sense without referencing a specific system), these were coded as 'general' for scale of nature and 'general' for type of nature. For a review of the categories used to code scale and type of HNC and PEB, refer to Table 1.

>>INSERT TABLE 1<<

Two researchers created the coding scheme (KK and DA) and one researcher (KK) coded the full-text papers. Any doubt that arose during the coding process was discussed with another researcher (DA) until agreement was reached. Categorical data was transformed into dummy variables before

being analyzed. SPSS 25.0 was used to generate descriptive statistics and determine relationships between variables. Hierarchical cluster analysis was selected to segment the literature and reveal patterns in empirical research in the HNC-PEB literature. The cluster analysis was conducted in R using the 'agnes' function in the 'cluster' package. We applied Ward's clustering method and Euclidean distances. These methods were selected as they aim to maximize within-cluster homogeneity and maximize heterogeneity across clusters. To identify the variables that most strongly indicated cluster membership, we used the 'indval' function in the 'labdsv' package.

2.4 Limitations of the review

Our review was limited to English-language articles published in scholarly journals. While academic research databases such as SCOPUS are the standard for systematic reviews, it is inevitable that studies were excluded from the review because they were published in a publication type (e.g. local journal, book chapter) outside the scope of the review or published in a language other than English.

3. RESULTS

In total, 96 papers had previously been coded as having a focus on behavior or behavior change. After screening their full texts, three papers were excluded due to their focus on behaviors at a scale other than the individual. Another two papers were excluded as they focused on preferences and values (e.g. willingness to pay), rather than behaviors. This resulted in a final set of 91 papers, published between 1997-2015. A PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) flow diagram (Moher et al., 2009), which shows the flow of information through the different phases of our systematic review, is provided in Figure 1.

>>INSERT FIGURE 1<<

3.1 Overview of studies

Of the studies included in this review, 86.8% were published since 2010. Just two studies (Dempsey et al., 1997; Kals, Schumacher, & Montada, 1999) were published before 2000. The interest in

HNC-PEB research represents a more recent field of inquiry among HNC researchers, as only 72.6% of the general HNC literature was published in the same timeframe (Ives et al., 2017). The *Journal of Environmental Psychology* (23 papers; 25.3%), *Ecopsychology* (6 papers; 6.6%), and *Environment and Behavior* (5 papers; 5.5%) published the largest percentages of the papers, though publications in business, geography, tourism, religion, and ecology journals were present in the review. This result is not surprising, given that many of the current quantitative measures of HNC (e.g. Inclusion of Nature in Self (Schultz, 2002), Connectedness to Nature Scale (Mayer & Frantz, 2004)) originated in the environmental psychology field.

The majority of studies were conducted in western countries, with the United States (27 studies; 29.7%), Australia (19 studies; 20.9%), Canada (8 studies; 8.8%), and Spain (6 papers; 6.6%) being most prevalent. Similar to other reviews on this topic (e.g. Restall and Conrad, 2015), we found that low-income and developing countries are poorly represented in the international scientific discourse on HNC and PEB. The dominant disciplinary backgrounds of the researchers or research institute were psychology (59 studies; 64.8%), tourism (17 studies; 18.7%), and environmental science (15 studies; 16.5%). The primary focus (86.8% of papers) was exploring the relationship between HNC and PEB; for 13.2%, understanding this relationship was a secondary aim. The study participants were primarily tourists and visitors (22.0%), general population (20.9%), and university students (18.7%).

3.2 Methodological patterns

PEBs were mostly commonly referred to as ‘environmental behaviors’ (10 studies), ‘pro-environmental behaviors’ (9 papers), ‘pro-environmental behavioral intentions’ (7 studies), ‘environmental actions’ (5 papers), or ‘ecological behavior’ (5 papers). Most authors (63.7%) included a complete list of measured behaviors in the manuscript or the supplementary information. PEBs were primarily measured using Likert-type scales (62.6%), interviews (15.4%), and mixed methods (7.7%). Very few studies observed actual behavior (2.2%) or conducted an experiment (3.3%). The average number of PEBs measured was 4, with 3 behaviors (22 studies) and 7 behaviors (19 studies) being the most common. Self-reported behavior was the most common way

to measure PEBs (61.5%), followed by self-reported intentions (20.9%), and observed behaviors (5.5%). Studies most frequently measured PEBs related to activism and education (occurring in 49.5% of the reviewed papers), waste and resource use (41.8%), energy (35.1%), and vegetation and land management (28.6%). In 48 papers (52.8%) the impact of the measured PEB could not be identified. Additionally, measured PEBs most commonly had mixed spatial impacts (50.6% of studies) and local environmental impacts (27.5% of studies).

As for HNC measurements, cognitive connections to nature were the most often studied (85.7%), followed by emotional connections (58.2%) and experiential connections (41.8%). Fewer studies measured philosophical connection (24.5%) or material connections (5.5%). Place attachment was measured in 34.1% of the included studies. Authors were primarily interested in measuring connectedness at the scale of local nature (37.4%) or general nature (37.4%). Similarly, the most common type of nature that people were connected to was general nature (52.8%), followed by urban green spaces (19.8%), and protected areas (13.2%).

In 81.3% of studies, authors reported on a correlation or statistical relationship between HNC and PEB. Only 18.7% of studies—primarily qualitative studies—did not statistically link the two constructs. Thirteen studies (14.3%) used a pre-test and post-test to measure changes to PEB as a result of an experiment, intervention, or passage of time, either through stated behaviors or observed behaviors. While more than half of the studies (59.3%) did not use an existing scale to measure PEBs, 24.47% of studies did apply an existing scale or a modified scale (13.2%). The most commonly used (6 studies; 6.6%) was the General Ecological Behavior Scale by Kaiser et al (2003). 71 studies (78.0%) reported a positive relationship between HNC and PEB, 6 studies (6.6%) reported no observed relationship, and 14 (15.4%) reported mixed findings. Interestingly, not a single study reported on purely negative HNC and PEB relationships.

3.3 Hierarchical cluster analysis

We transformed all of the categorical coded data into binary dummy variables and inputted the variables into a hierarchical cluster analysis in R. Inspection of the output tables and dendogram

suggested a three-cluster solution (Figure 2). Indicator analysis showed a total of 42 significant indicators (*p<0.05, **p<0.01, ***p<0.001): 13 for the first cluster (‘*localizing the HNC-PEB relationship’*), 13 for the second cluster (‘*expanding the HNC-PEB relationship’*), and 16 for the third cluster (‘*developing the HNC-PEB relationship’*) (see Table 2).

>>INSERT FIGURE 2<<

>>INSERT TABLE 2<<

The first cluster consisted of 34 papers (37.4% of the sample) and was labeled ‘*localizing the HNC-PEB relationship’*. This cluster was characterized by qualitative and mixed research methods, participants that were home and landowners, connectedness to local or urban nature, and PEBs that were specific to the place or time of the study. This segment of the field uses in-depth interviews and qualitative methods to gain a deeper understanding of how individuals’ connections to nature influence their involvement in a range of environmental behaviors. For example, Guiney and Oberhauser (2009) interviewed conservation volunteers to understand how a sense of connection to nature was tied to participating in conservation programs. Similarly, Cammack et al (2011) interviewed gardeners about how they connected to nature through their gardens and how this influenced their conservation action. This cluster is also characterized by studies that seek to understand drivers of pro-environmentalism, particularly among children and young people (e.g. (Gambino, Davis, & Rowntree, 2009; Lekies, Yost, & Rode, 2015; Linzmayer & Halpenny, 2013).

The second cluster was labeled ‘*expanding the HNC-PEB relationship.’* This cluster contained 21 papers (23.1% of the sample) and was dominated by the discipline of tourism. The cluster was characteristics by studies that: (1) focused on tourists and visitors as the participants (e.g. Tonge et al., 2014; Zhang et al., 2014); (2) measured place attachment at the dominant HNC (e.g. Buta et al., 2014; Kil et al., 2012; Ramkissoon et al., 2012); (3) measured PEB intentions using Likert-type scales (e.g. Halpenny, 2010); and (4) presented statistical correlations between HNC and PEB in the manuscript. For example, Lee (2011) surveyed tourists visiting wetlands to see if place

attachment to the wetlands impacted environmentally responsible behavior and conservation commitment.

The third cluster was labeled '*establishing the HNC-PEB relationship'* included 36 papers (39.6% of the sample) and consisted of primarily studies from the environmental psychology field. These studies tended to measure both PEB and HNC using existing scales, and conceptualized both nature and behaviors as general and unspecified. The participants in these studies tended to be university students or a general community sample. An example of this is Davis et al. (2011) who surveyed undergraduate students and developed a model of commitment to the natural environmental that predicted general ecological behavior. Several studies looked at consumption behaviors (e.g. Fröhlich et al., 2013; Meijers and Van Dam, 2012). Other studied aimed to distinguish factors that affect HNC, such as ostracism (Poon, Teng, Chow, & Chen, 2015), gratitude and regret (Naito et al., 2010), and moral responsibility and threat perception (Ogunbode & Arnold, 2012).

3.4. Associations between measurement of HNC and measurement of PEB

To address the second research question, we used the Phi coefficient to measure the degree of association between variables on measurement and type of HNC and PEB. We were primarily interested in two relationships: (1) is there an association between the scale at which HNC was measured and the scale at which PEBs were measured; and (2) is there an association between the types of nature and the types of PEBs that are studied together?

Several interesting results emerged from the statistical analysis of the association between the scale of HNC and the scale of PEBs (Table 3). First, studies measuring connectedness to local nature are primarily interested in PEBs at the same scale (φ = .390**). This refers to the section of studies that are interested in how individuals who connect to a specific place in nature act to protect or conserve that particular place. These studies are unlikely to study a mixed set of PEBs (φ = -.327**), which suggests that these researchers were interested in specific behaviors relevant to a specific area. Second, when studies use a generic, overarching definition of nature it is likely that

they use a generic PEB scale that includes PEBs with impacts at various scales (φ = .446**). This represents papers that, for example, use the Connectedness to Nature Scale (Mayer & Frantz, 2004) to measure HNC and the General Ecological Behavior Scale (Kaiser et al., 2003) to measure PEB. These studies are less likely to study PEBs with local (φ = -.374**) or regional impacts (φ = -.256**), as these general measures of PEBs tend to address PEBs with impacts across various scales or with no measureable impact.

>>INSERT TABLE 3<<

As for the association between type of nature and genre of PEBs, we found that studies measuring connectedness to an 'unspecified' type of nature often use general lists of PEBs. Thus, there are strong and positive associations between this type of nature and multiple genres of PEBs (e.g. waste PEBs, φ = .355**). We also found associations that suggest studies that investigate connections to a specific type of nature (e.g. marine areas or deserts) are often interested in how these connections influence behaviors that protect or care for that same type of nature. For example, measuring connectedness to forests is associated with measuring PEBs that impact plants and vegetation (φ = .244*) and measuring connectedness to protected areas is correlated with measuring PEBs that advocate for further protection and care of those areas (φ = .264*). However, measurements across the other types of nature and genres of PEBs were not found to be significantly related (Table 4).

>>INSERT TABLE 4<<

4. DISCUSSION

The aim of this systematic review was to provide a comprehensive overview of how the human-nature connectedness literature has conceptualized, measured, and analyzed pro-environmental behavior. In total 91 studies were identified that empirically investigate the relationship between HNC and PEB. Our findings highlight trends in the literature, reveal gaps in the ways these constructs have been studied, and suggest opportunities for future conceptual and empirical

exploration. The three clusters that emerged from the hierarchical cluster analysis highlight differences in the way HNC and PEB have been conceptualized, studied, and operationalized.

The '*Establishing the HNC-PEB relationship'* cluster (published between 1997-2015) represents the dominant narrative of the field and the literature that many scholars cite when discussing the positive relationship between HNC and PEB. These studies primarily originate from the field of environmental psychology and rely on the development of psychometric scales to measure the relationships between a general sense of connection to nature and a general set of PEBs. These papers aimed to understand the statistical relationship between the constructs and have played a prominent role in developing the field of research and providing the theory upon which many studies were created. The studies in this cluster have the highest average citation rate (x = 135.6), which may be attributed to the number of studies that developed psychometric scales that can be replicated, as well as reporting positive findings that support future inquiry.

The '*Expanding the HNC and PEB relationship'* cluster (published between 2005-2015) represents a development of the HNC-PEB field, primarily based on visitors and tourists experiences in nature. These studies built on the cornerstone studies in the field and developed methodologies for testing the dimensionality of these constructs in new settings and with new populations. These often happened in new locations outside of the university, such as in zoos, national parks, or tourist sites (e.g. Clayton et al., 2014; Lee and Moscardo, 2005). These studies are important because they shed light on how individuals develop a sense of attachment and connection to specific places and statistically link this to behavioral outcomes. The studies in this cluster, particularly those linking place attachment and PEBs among visitors at natural parks, are also well cited (x = 115.3). However, these studies tend to rely on short-term visitors and self-reported behavioral intentions, which makes it hard to draw conclusions about long-term adoption of PEBs and the lasting effect of the connectedness.

The '*Localizing the HNC-Local PEB relationship*' cluster (published between 2009-2015) represents studies that aim to understand the determinants of how and why people connect to nature and how

this is reflected in their behaviors. This is evident from the emphasis on qualitative research methods and the examination of nature-based interventions within this group. These studies emphasize complexity, often presenting mixed findings about the ways in which an individual's connection to nature influences their pro-environmental behavior. However, these studies are not as well cited ($x = 49.4$) and their applicability to the wider scientific audience is smaller due to a focus on specific local events or a small sample size.

Each of the three clusters considers the concept of HNC and its relationship to PEB, yet the separation of the clusters sheds light on how the field has developed in different directions. There is an opportunity for each strand of research to expand their current efforts by engaging with other sample populations. Scholars whose research fits within the '*Localizing HNC-Local PEB relationship*' cluster, for instance, could expand their qualitative studies to additional communities and geographical regions to see if similar narratives emerge from different respondents. This would strengthen the results of these studies and help to generate more generalizable insights. Similarly, '*Expanding the HNC and PEB relationship'*-type research could focus on conducting follow-up surveys or planning longitudinal studies to measure connections across a greater time frame than a one-off visit to a natural place. Lastly, the type of research characterized in '*Establishing the HNC-PEB relationship'* should pay greater attention towards validating the psychometric scales in populations that are underrepresented. There is a wealth of psychometric scales published and increased attention needs to be paid on replication studies with different populations, rather than creating additional scales. Additionally, there is an opportunity for a new wave of integrative research that bridges these three strands of research for greater collaborative and transformational potential.

4.2 Limitations of the studies

There are limitations to the studies included in this systematic review. First, all of the studies presented positive or mixed results between HNC and PEB. There were hardly any studies that presented negative results or reported on the lack of an observable relationship. This is a limitation of the field and of science in general (i.e. publication bias) that biases systematic reviews to present

a potentially skewed picture of the relationship between the constructs studied. Second, several quantitative studies did not provide a list of all PEBs measured in the text or in the supplementary material. This makes it challenging to understand fully what was measured and the relationship between HNC and PEB presented in that study. If researchers only publish partial data or only statistically significant items, it makes it challenging to conduct replication studies, to compare studies using similar PEBs, and to do a meta-analysis of all HNC-PEB studies.

5. IMPLICATIONS FOR FUTURE HNC-PEB RESEARCH

Systematically reviewing the literature on HNC and PEB revealed that while there is increasing interest in ways in which an individual's connections to nature influence the adoption of specific behaviors, to date relatively little attention has been paid to the relationships between scale and type of HNC and PEB.

For one, HNC research has a two-fold problem with scale. On one side, a segment of the field has defaulted to defining nature as one overarching concept with little recognition of how characteristics of nature might influence connectedness levels. This one-dimensional definition of nature provides insights about general connectedness and general PEBs, but provides little guidance when developing targeted policy and practice. On the other side, another segment of the field has defaulted to studying hyper-local places and neglected broader geographic representation. The hyper-local approach provides insights about connections to place and place-specific behaviors, but presents findings that are hard to apply on a broader scale or to generalize to larger populations. Many scholars examine connection to immediate surroundings or overarching connection to nature, while few investigate how nature connectedness might be expressed at various scales. This suggests that (a) connections do not occur at these scales, (b) authors have not considered connections at these scales, (c) there are not methods or measurement tools to study connections at these scales, or (d) it is too difficult to measure connections at these levels. In this regard, it is necessary for scholars to conceptualize and assess how people connect to nature more precisely and to consider how differences in landscape configuration, species abundances, or ecological communities may influence how individuals connect to nature. A promising direction in the field is

the use of map-based measurements to investigate HNC (e.g. Brown, Raymond, & Corcoran, 2015; N. Davis, Daams, van Hinsberg, & Sijtsma, 2016), which may provide richer insights about the places where individuals connect to nature.

Additionally, the literature has largely overlooked the relationships between the five types of HNC nature connectedness (i.e. emotional, philosophical, experiential, philosophical and material; see, Ives et al., 2018) and how each of these ways of being connected to the nature influence and interact with PEBs. To date, scholars have primarily conceptualized psychological and emotional connections to nature, with less attention paid to the ways in which material and spiritual connections to nature might shape behaviors. As the study of each type of connectedness tends to originate from one disciplinary community, interdisciplinary approaches that consider the problem framings and methodologies of other communities will be required. Investigating the types of connections that most strongly influence PEB and the ways in which connectedness in multiple categories result in differing PEB outcomes will provide important insights about the sustainability outcomes of reconnecting to nature.

In the same vein, there is a need for greater justification of how PEB is measured. Accurately measuring PEBs is a challenging exercise and most measurements still rely on self-reported behavior using Likert-type scales. However, self-reports of behavior or intentions to act may not reflect actual behavior or environmental impact (Gatersleben, 2013). If the aim of this field of research is to explore and describe the role that HNC has on shaping PEBs that contribute to reduced environmental impact, then scholars should integrate a greater deal of justification for the structure of the behaviors that are measured in questionnaires and interviews. This is especially true if the aim of this research is to identify determinants of PEBs that have a large sustainability impact or can be widely adopted. Simply relying on a designed set of PEBs will not give studies the depth that is necessary to fully understand the complex relationships that are at play. Thus, there is a need for additional studies need to implement methodologies that observe actual behavior or conduct experiments. Only 5.5% of the studies are currently using these types of methodologies,

but greater adoption of these methodologies will be crucial to understanding how nature connectedness can be used as an affective intervention or treatment for PEBs.

Publications in this field should also devote a greater focus to how human consumption behaviors might be radically changed to align with ecological limits. When scholars measure a long list of general PEBs it is likely to show those that check the most boxes as the most environmentally friendly, regardless of the actual impact of these behaviors (Gatersleben, 2013). The field of HNC-PEB should devote more time and energy towards researching if, and how, connections to nature influence: (1) the most environmentally significant behaviors (e.g. international travel, car ownership); (2) the behaviors most strongly influenced by structural constraints (e.g. the system properties that support specific behaviors); and (3) behaviors that seek to bring about systemic change (e.g. activism, innovation, and volunteerism). If this is the case, then more studies of the relationship between HNC and PEB should develop methodologies that measure behavioral outcomes in terms of environmental impact and transformational potential. There has been a greater push towards studies that measure actual behavior (e.g. KWh energy consumption; see, Frantz et al., 2014) or experimental studies with a measure of spontaneous environmental behaviors (e.g. taking a plastic bag; see, Geng et al., 2015), though these efforts must be coupled with investigations into the ways in which HNC is a determinant of the most transformative and significant behaviors.

The literature is not always explicit about why particular PEBs were chosen for measurement nor do studies provide a comprehensive list of all of the PEBs that have been measured. In order to better understand the relationship between HNC and PEB, greater transparency is needed about which behaviors are measured and reported in the literature. Without this information, it is difficult to expand the field and gain an understanding of which PEBs might result from increased connectedness to nature. Increasing transparency about the behaviors measured in studies (either through publication or supplementary materials) can help with future analysis of the linkages between concepts.

Lastly, the study of HNC as a determinant of PEB would benefit from more qualitative methodologies, longitudinal data, and transdisciplinary research. Coding the papers for this systematic review was significantly more challenging for qualitative papers that measured and reported on behaviors using semi-structured interviews or other qualitative methods. This points to an internal conflict within the field: measuring PEBs by Likert-scale makes measuring PEBs easier for researchers and academics, however in order to truly understand that rationale for acting in a certain way the field should devote more time to in-depth qualitative interviews, observations and experiments. It is possible that to truly understand the link between HNC and PEB that more scholars will need to adopt qualitative methodology with more in-depth interviews or focus groups about the determinants of PEB. We especially need these methods in case studies that have not been traditionally studied in this discipline.

6. CONCLUSIONS

The purpose of this systematic review was to map the state of the literature on human-nature connectedness and pro-environmental behavior, with a focus on the relationship between the type of connectedness and the type of behaviors that were measured. Unpacking the complex relationship between HNC and PEB can be challenging. Based on this literature review, we suggest that increased attention on how behaviors are selected and organized in studies could lead scholars one step closer to understanding the interplay between these constructs. This review of the literature reveals that there is a need for greater consideration of the scale at which nature connectedness is experience and the scale at which impacts of behaviors are felt. A greater understanding of the ways in which connectedness to nature is a determinant of pro-environmental behavior is necessary in order to understand what it means to ‘reconnect to nature’ both individually and as a society.

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Table 1. Descriptions of codes using in systematic review

Scale of nature	*Local*	Town, city, local green space etc. 0-999 km^2
	Landscape	Typically 1000-9999 km^2
	Regional	Typically 10,000-99,999 km^2
	National to global	>100,000 km^2
	General	Nature' or 'the environment' in a general sense
	Multiple scales	Connection to nature at multiple scales
Type of nature	*Agriculture*	Crops, horticulture, grazing land
	Urban	Urban forests, parks, green spaces, gardens
	Mountains	Mountains, hills
	Forest	Natural or planet forests
	Water	Marine, freshwater, coastal or wetland environments
	Protected areas	Reserves, zoos, nature parks, recreational areas
	Species	Animals and pets
	Other	Types of nature not otherwise included
	Unspecified	'Nature' or 'the environment' in a general sense
Type of connectedness	*Material*	Consumption of goods and materials from nature
	Experiential	Direct interaction with nature
	Cognitive	Attitudes and values towards nature
	Emotional	Feelings of attachments or empathy towards nature
	Philosophical	Perspectives or worldviews on human-nature relationships
Scale of PEB	*Local*	Behaviors with impact at the scale of a town, city, local park or household
	Regional	Behaviors with impact at the scale of a watershed or society
	Global	Behaviors with an impact at the scale of global environmental processes (e.g. climate change, ozone depletion)
	Unspecified	Behaviors with unknown impact (e.g. no impact,

		unquantifiable impact)
	Multiple	Behaviors with an impact at multiple scales
Genre of PEBs	*Waste*	e.g. littering, recycling, reuse
	Energy	e.g. energy consumption, reduction, curtailment
	Food	e.g. food consumption, purchasing, waste, type
	Purchasing	e.g. selection and purchase of products
	Activism and education	e.g. talking to others, signing a petition
	Transportation	e.g. carpooling, bike riding, ride sharing
	Water & marine	e.g. water conservation, water pollution
	Toxins and environmental health	e.g. use of chemicals, cleaning products
	Plants and vegetation	e.g. weeding, native species, pruning
	Unknown/other	Behaviors not included in the other categories
Specificity of behaviors	*Place-specific behaviors*	Behaviors that are tied to a specific location
	Time specific behaviors	Behaviors that are tied to a specific time window
	General behaviors	Behaviors that are not tied to the study area nor a specific point in time

Table 2. Results of the indicator analysis showing the variables that strongly distinguish the three clusters. Indicator value coefficients (only those >0.2 reported) are listed.

Variable	**Cluster 1:** *'localizing the HNC-PEB relationship'*	**Cluster 2:** *'expanding the HNC-PEB relationship'*	**Cluster 3:** *'developing the HNC-PEB relationship'*
PEB specificity	*Time/place-specific (0.54)****		*General PEBs (0.77)****
PEB measurement	*Modified PEB scales (.54)****		*Existing scales (0.27)**
Methodology	*Interview methods (0.36)**** *Mixed methods (0.21)***	*Likert-scales (0.42)***	
Scale of Nature	*Local Nature (0.29)**	*Landscape (0.28)***	*General (0.59)****
Discipline	*Env. Science (0.27)****	*Tourism (.39)****	*Psychology (0.41)****
PEB scale	*Local PEBS (0.25)**		
Type of nature	*Urban (.22)**	*Protected areas (0.50)**** *Water/marine (0.28)****	*Unspecified (0.54)****
Participants	*Home/landowners (0.20)**	*Tourists/visitors (0.73)****	*General community (0.28)**** *University students (0.22)**
Place attachment		*Yes (0.43)****	
Type of PEBs		*Intentions (0.42)****	*Mixed (0.53)**** *Waste (0.50)**** *Energy (0.45)**** *Transportation (0.39)**** *Purchasing (0.34)***
Genre of PEBs		*Activism/education (0.33)**	
Type of HNC			*Philosophical (0.26)***
Number of PEBs measured	*Unknown (0.40)**** *One (0.21)***		

***p<0.001, two-tailed. ** p<0.01, two-tailed. * p<0.05., two-tailed.

Table 3. Phi coefficient relationships between scale of HNC measured and scale of PEBs measured.

Scale of HNC measured	*Scale of PEBs measured*				
	Local	*Regional*	*Global*	*Mixed*	*Unspecified*
Local	.390**	0.048	-0.116	-.327**	-0.028
Landscape	0.126	-0.11	-0.05	-0.04	0.014
Regional	-0.065	-0.035	-0.016	-0.107	.318**
National to Global	-0.065	-0.035	-0.016	0.104	-0.035
General	-.374**	-.256*	0.194	.446**	-0.028
Multiple scales	-0.094	.415**	-0.058	-0.134	-0.02

***p<0.001, two-tailed. ** p<0.01, two-tailed. * p<0.05., two-tailed.

Table 4. Phi coefficient relationships between type of nature respondents were connected to and genre of PEBs that were measured.

Type of Nature	**Genre of PEBs**									
	Waste	Energy	Food	Purchasing	Activism & Education	Transportation	Water and Marine	Toxins and Env Health	Plants and Vegetation	Unknown/other
Unspecified	.355**	.309**	.324**	.309**	0.056	.362**	0.138	.216*	-.230*	-0.102
Other	-0.135	-0.098	-0.028	-0.146	0.003	-0.04	-0.132	-0.082	-0.168	0.074
Forests	-0.084	-0.104	-0.18	-0.192	-.207*	-0.109	-0.086	0.015	.244*	-0.09
Protected Areas	-0.067	-0.075	-0.12	0.018	.264*	-0.059	-0.194	-0.121	0.185	0.174
Mountains	0.036	0.072	-0.11	-0.117	0.002	-0.117	0.163	-0.067	-0.136	0.096
Agriculture	-0.161	-0.12	-0.047	-0.06	-0.121	-0.158	0.064	-0.09	0.091	-0.057
Urban areas	-.253*	-.241*	-0.187	-.207*	-.215*	-.207*	-0.039	-0.154	0.174	0.138
Water and marine areas	0.018	-0.083	-0.08	0.081	.261*	-0.094	-0.072	0.027	-0.128	-0.055
Species and animals	-0.032	-0.133	-0.095	-0.101	0.064	-0.101	-0.092	-0.057	0.156	0.051

***p<0.001, two-tailed. ** p<0.01, two-tailed. * p<0.05., two-tailed.

Figure 1. PRISMA flow diagram (Moher et al., 2009) showing systematic process and relationship between Ives et al (2017) review and current review

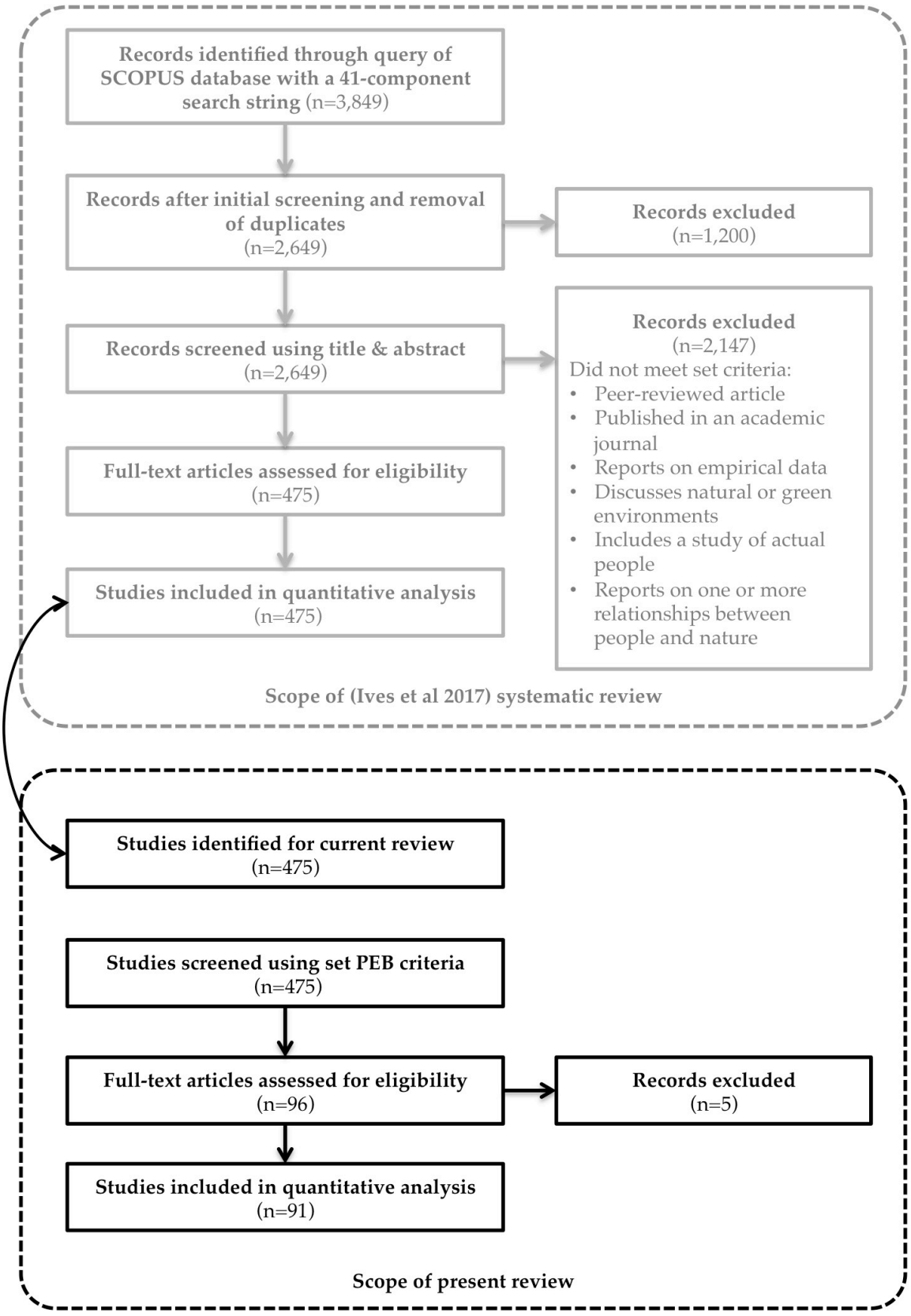
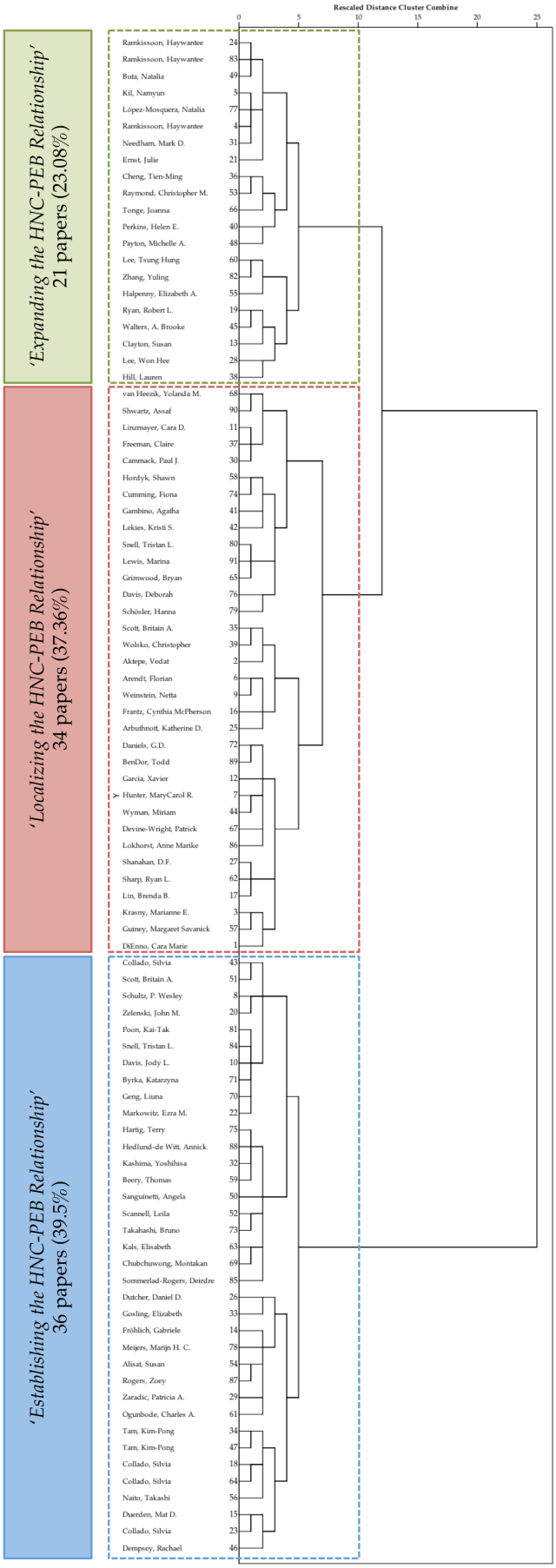


Figure 2. Dendogram from hierarchical cluster analysis showing three clusters: *Expanding the HNC-PEB Relationship; Localizing the HNC-PEB Relationship; and Establishing the HNC-PEB Relationship*



APPENDIX

Appendix 1. Studies included in the review

Authors	Title	Journal	Issue	Year
V. Aktepe	Implementation of a performance task for developing the value of love of nature	Educational Sciences: Theory and Practice	15	2015
S. Alisat, J. E. Norris, M. W. Pratt, M. K. Matsuba, D. P. McAdams	Caring for the Earth: Generativity as a Mediator for the Prediction of Environmental Narratives from Identity Among Activists and Nonactivists	Identity	14	2014
K. D. Arbuthnott, G. C. Sutter, C. T. Heidt	Natural history museums, parks, and connection with nature	Museum Management and Curatorship	29	2014
F. Arendt, J. Matthes	Nature Documentaries, Connectedness to Nature, and Pro-environmental Behavior	Environmental Communication	10	2016
T. H. Beery, D. Wolf-Watz	Nature to place: Rethinking the environmental connectedness perspective	Journal of Environmental Psychology	40	2014
T. BenDor, D. A. Shoemaker, J. C. Thill, M. A. Dorning, R. K. Meentemeyer	A mixed-methods analysis of social-ecological feedbacks between urbanization and forest persistence	Ecology and Society	19	2014
N. Buta, S. M. Holland, K. Kaplanidou	Local communities and protected areas: The mediating role of place attachment for pro-environmental civic engagement	Journal of Outdoor Recreation and Tourism	5	2014
K. Byrka, T. Hartig, F. G. Kaiser	Environmental attitude as a mediator of the relationship between psychological restoration in nature and self-reported ecological behavior	Psychological Reports	107	2010
P. J. Cammack, I. Convery, H. Prince	Gardens and birdwatching: Recreation, environmental management and human-nature interaction in an everyday location	Area	43	2011
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Chapter VI

Sustainability Science
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ORIGINAL ARTICLE

Human–nature connectedness as a 'treatment' for pro-environmental behavior: making the case for spatial considerations

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Abstract
The degree to which an individual feels connected to the natural world can be a positive predictor of pro-environmental behavior (PEB). This has led to calls to 'reconnect to nature' as a 'treatment' for PEB. What is not clear is the relationship between *where* one feels connected to nature and *where* one acts pro-environmentally. We propose that integrating spatial scale into the conceptualization of these constructs will provide insights into how different degrees of connectedness influence pro-environmental behavior. We discuss trends towards a spatial understanding of human–nature connectedness (HNC) and introduce three archetypes that highlight scalar relationships between scale of connectedness and scale of pro-environmental behavior: (1) equal interactions, (2) embedded interactions, and (3) extended interactions. We discuss potential policy and practice implications of taking a spatially explicit approach to HNC–PEB research, and propose a research agenda for investigating these scalar relationships that can inform nature as a 'treatment' intervention.

Keywords Nature connectedness · Pro-environmental behavior · Local-to-global scales · Nature as treatment · Sustainability

Introduction

The environmental challenges facing the planet are rooted, at least in part, in unsustainable human behavior (Vlek and Steg 2007; Klöckner 2013). Identifying variables that underpin behavioral decisions is therefore a crucial element in understanding and transforming behaviors for sustainability. One such variable, human–nature connectedness (HNC)—the cognitive, emotional, spiritual and biophysical linkages to places, landscapes and ecosystems that are not completely dominated by humans (see Ives et al. 2017)—has been positively correlated with pro-environmental behaviors, attitudes, and intentions (Kals et al. 1999; Mayer and Frantz 2004; Schultz et al. 2004). Pro-environmental behaviors (PEB) are those behaviors that seek to minimize negative impacts on the environment (Kollmuss and Agyeman 2002). While humans have an innate connection to nature and an inherent affinity for the natural world (Wilson 1984), technological advances, urbanization, and globalization have reduced direct interactions with nature and led to societies that are disconnected from nature psychologically, materially, and physically (Miller 2005; Cumming et al. 2014). Moreover, biophysical disconnectedness, driven by industrialization and global trade flows, has obscured the environmental impact of our behaviors (Dorninger et al. 2017). These disconnections have led to humans and nature being increasingly treated as separate entities (Folke et al. 2011). The growing disconnect from nature has been hypothesized to lead to a reduction of respect and appreciation of nature, which may breed apathy toward environmental issues (Schultz 2002).

Given the potential benefits of HNC and the problems that arise with loss of such connections, scholars have called for societies and individuals to 'reconnect with nature' or 'reconnect with the biosphere' as a means towards sustainability transformation (Pyle 2003; Abson et al. 2017). One potential avenue for such transformative change is

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to conceptualize HNC as a 'treatment' that can influence individual or societal attitudes and behaviors towards the environment (Ives et al. 2018). Due to growing disconnectedness from the natural world, individuals may not connect to nature nor receive the full benefits of nature exposure without targeted interventions designed to facilitate connectedness (Shanahan et al. 2015). Thus, programs and policies (i.e., treatments) might become the default way to connect individuals to nature. However, while conceptualizing HNC as a treatment is an established idea in relation to physical and psychological health and well-being (for a review, see Hartig et al. 2014), it is less well-established in relation to PEB. We argue this is, in part, because of difficulties in conceptualizing and quantifying the relationship between the multifaceted notions of HNC and PEB. Therefore, as societies rely to a greater degree on interventions and institutions to connect people to nature, more attention must be paid to the design and implementation of such treatments.

While higher reported degrees of HNC were shown to serve as a foundation for PEB (Bruni et al. 2008, 2012; Nisbet et al. 2009a; Verges and Duffy 2010; Hoot and Friedman 2011; Geng et al. 2015), the question remains as to which 'degrees' of HNC influence PEB. 'Degree' is used here to denote both the type of HNC and the relative strengths of those connections. Studies reporting positive correlations demonstrate the potential of HNC as a treatment for PEB change, yet conceptual vagueness regarding the relationship between degrees of HNC and PEB limit the applicability as a solution to sustainability issues. More clarity is needed to understand the richness of HNC and the interplay of degrees of HNC and PEB. We argue that one key facet of 'reconnecting with nature' as a treatment for PEB change is to understand the relationship between *where* individuals feel connected to nature and *where* individuals act pro-environmentally.

Both HNC and PEB can be considered to be multi-scalar constructs. That is, HNC can extend across spatial boundaries, from experiential connections to local landscapes (e.g., Freeman et al. 2012) through to philosophical and emotional connections to the global environment (e.g., Perkins 2010). PEB has a scalar dimension in both the environmental impact of the behavior and the location where the behavior occurs. However, HNC has generally been thought of either as localized and place-based (e.g., Cammack et al. 2011; Soga et al. 2016) or as a rather generalized notion having no specific scale (e.g., Bruni and Schultz 2010; Verges and Duffy 2010). Similarly, PEBs are often conceptualized as either specific, place-based behaviors (e.g., Raymond et al. 2011; Davis and Carter 2014) or as a set of broadly interchangeable, scale-independent actions or intentions (e.g., Davis et al. 2009; Scannell and Gifford 2010). Therefore, the notion of spatial scale is a potentially useful concept for clarifying applications of HNC as a treatment for PEB.

In this article, we briefly discuss the evolution of research on HNC and discuss current conceptualizations of scale in the HNC and PEB literature. We propose that a distinction between spatial grain (i.e., where HNC or PEB is observed) and spatial extent (i.e., the area over which HNC or PEB occurs) may bring greater conceptual clarity regarding spatial scale of HNC and PEB. We then introduce and define three archetypical HNC–PEB interactions for conceptualizing the relationship of scale of connectedness and scale of behavior: equal interactions, embedded interactions, and extended interactions. Lastly, we present a new research agenda for investigating the proposed scalar relationships and discuss the potential benefits and implications for policy and practice of taking a spatially explicit approach to HNC as a treatment for sustainable behavior change.

Emergence of HNC–PEB research

Increased awareness of changes to duration, frequency, and type of nature interactions and experiences prompted scholars to study and publish works on how and why societies are disconnecting from nature. Pyle (1993) introduced the phrase 'extinction of experience' and ignited a strand of literature devoted to understanding our disconnection with nature and its ramifications (for a review, see Soga and Gaston 2016). Miller (2005) argued that urbanization and decreased time outdoors has led to reduced exposure to nature and, when contact occurs, it is mainly structured activities within managed habitats. The decline of time in nature has been termed 'nature-deficit disorder' to account for numerous social and ecological problems associated with decreasing contact with nature (Louv 2005). This lack of connection impacts the value individuals place on nature (Wells and Lekies 2006) and the willingness to protect and conserve nature (Zhang et al. 2014b; Collado et al. 2015).

Over the last 20 years, there has been an increasing focus on revealing the correlations between different degrees of HNC (or disconnectedness) and PEB. Schultz et al. (2004) developed a modified Implicit Association Test for measuring implicit connections with nature that was positively correlated with environmental attitudes and concern. Likewise, the Connectedness to Nature Scale, "a measure designed to tap an individual's affective, experiential connection to nature," significantly predicted PEB (Mayer and Frantz 2004). Further psychometric scales were developed to quantify various dimensions and aspects of HNC such as emotional inclinations toward nature (Kals et al. 1999), sentiments and attitudes towards nature (Dunlap et al. 2000), commitment to the environment (Davis et al. 2009), and love and care for nature (Perkins 2010) (for a review, see Restall and Conrad 2015). Additionally, the proximity of nature (e.g., Ballouard et al. 2011; Nisbet and Zelenski 2011), the

proper 'dose' of nature (e.g., Barton and Pretty 2010; Shanahan et al. 2016), the location of nature experiences (e.g., Schultz and Tabanico 2007; Bruni et al. 2008), and the role of direct vs. mediated nature experiences (e.g., Mayer et al. 2009; Duerden and Witt 2010; Arendt and Matthes 2016) have been investigated as potential influencing factors in the strength of HNC or its links to PEB.

Studies show that HNC is a dynamic construct which can be adjusted after a short period of time in nature (such as a 1 day educational program) (e.g., Kossack and Bogner 2012) and modified through educational programs or self-directed experiences (e.g., Ernst and Theimer 2011). Keniger et al. (2013) reviewed the literature and identified six settings where people and nature interact (indoor, urban, fringe, production landscape, wilderness, and specific species) and three types of human–nature interactions (indirect, incidental and intentional). Clayton et al. (2017) presented six dimensions of nature experiences: observing vs. interacting, consumptive vs. appreciative, self-directed vs. other-directed, separate vs. integrated, solitary vs. shared, and positive vs. negative. Other dimensions of HNC that have been explored include temporal elements (Mayer et al. 2009; Duffy and Verges 2010; Scannell and Gifford 2010), built environment dimensions (Maller et al. 2009; Davis and Gatersleben 2013), psychological measurements (McDonald et al. 2015), beauty features (Zhang et al. 2014a), and experiences (Cheng and Kuo 2015; Kil et al. 2015). The literature provides compelling arguments regarding why to connect individuals to nature and an increasing evidence base for the positive relationship between PEB outcomes and increasing degrees of HNC. However, it remains unclear how these connections and outcomes are mediated by geographical location, or scale. Therefore, we propose that improving the effectiveness of HNC as a treatment for PEB change requires integrating a degree of spatial thinking.

Applying a spatial lens to HNC as a treatment

Given the globalized and interconnected state of the planet and the scope of environmental problems, there is a growing appreciation for including scale into socio-ecological research (Schulze 2000). Applying spatial thinking to socio-ecological systems has been useful in defining boundaries, overcoming scale mismatches, and understanding relationships between concepts and actors (Cash et al. 2006; Cumming et al. 2006). Defining the appropriate scale for examining environmental issues is important. Scale is both socially constructed and defined and the chosen scale should be useful for the specific issues or phenomenon being researched (Cash and Moser 2000). Incorporating geographic thinking into complex socio-ecological relationships can be challenging, but doing so can enrich understanding of the situation and interactions within the system. Additionally, addressing the relationships and interactions between concepts across scales is crucial for addressing global environmental problems (Cash and Moser 2000).

Defining spatial relationships and the distinctions between local and global has been useful for refining our understanding of the ways in which humans view, interact and connect with the natural world. Significant work has been done to understand how individuals perceive and relate to environmental problems based on proximity or distance (Uzzell 2000). Construal level theory argues that what one perceives to be psychologically proximate or psychologically distant (psychological distance) can influence individual decision-making (Trope and Liberman 2010). Psychological distance has been an especially useful construct for research on individual responses and reactions to climate change (Scannell and Gifford 2013; Brügger et al. 2016). This theory may also influence the ways in which individuals perceive their relationship with nature and where they are able to connect with nature, as construal level theory states that "the further away an object is from the present situation of a person, the more effort she has to make to construe it" (Brügger et al. 2016).

Recently, scholars have begun to recognize the role of spatial scale in HNC studies and trends towards spatially understood HNC have emerged (see Table 1 for an overview of current scale conceptualizations in the HNC literature). Scholars have made significant inroads towards understanding and mapping place attachment—the degree to which an individual feels an emotional connection to a place—(Jorgensen and Stedman 2011; Brown et al. 2015), exploring sense of place at various geographic scales (Lewicka 2010; Devine-Wright 2013; Ardoin 2014; Zia et al. 2014), and spatially mapping emotional connections to nature (Davis et al. 2016). Research also shows that individuals experience varied attachments to place at different spatial scales (i.e., local-to-global, across multiple scales, or detached at all scales), which influences environmental concern and willingness to take action (Brügger et al. 2015; Devine-Wright et al. 2015). However, a recent review of the HNC literature found that only 4% of papers attempted spatial mapping and called for future research on how HNC constructs might be represented spatially (Restall and Conrad 2015).

In addition to a gap in understanding of spatial expressions of HNC constructs, current conceptualizations and explorations of HNC lack spatial diversity. Devine-Wright (2013) points out that much of the HNC literature has focused on the local level and ignored the global scale, even though individuals may experience place-related attachments and identities at several scales. As well, a review of the HNC literature found that most papers concentrate on individual connectedness at locals scales and often leave

Table 1 Current conceptualizations of scale in human–nature connectedness (HNC) literature

Scale	Description
Local; place-specific	Connections to local or spatially proximate nature. Primarily experiential connections to nature. May be mediated by place attachment (e.g., Beery and Wolf-Watz 2014)
Regional; landscape	Connections to nature within a region. Connections may be built around political (the nature of a region), ecological (the landscape), or topographic (watershed) boundaries. May be mediated by 'values home range' (e.g., Brown et al. 2015)
National	Connections to nature of a nation or state. May be mediated by patriotism, national identity, or cultural values of nature (e.g., Devine-Wright et al. 2015)
Global	Connections to large-scale swaths of nature. Sense of interrelated with nature at many scales and at many places. May be mediated by global identity or global belonging (e.g., Lee et al. 2015)
All nature; undefined	General sense of connectedness or oneness with the natural world that is not characterized by specific places. May be mediated by worldviews or philosophical or spiritual ideologies about nature (e.g., Hedlund-de Witt et al. 2014)
Species-specific	Connections with a specific species or type of nature. These connections transcend scale, as they are based on ecological features. May be mediated by human attitudes towards biodiversity (e.g., Martín-López et al. 2007)

'nature' undefined (Ives et al. 2017). Few studies examine HNC at intermediate scales such as regional (e.g., Ardoin 2014) or how HNC is expressed over multiple scales. Despite increasing interest in the role of spatial scale in the HNC literature, the notion of scale captures a continuum from 'local' to 'global' as well as a continuum of the spatial specificity of HNC from experiential connections to a specific place, to cognitive or philosophical connections to unspecified nature (Table 1). Such conceptualizations are useful for capturing the diversity of HNC, but do not provide a clear distinction between extent and specificity. In an attempt to provide a differentiated and consistent notion of scales of HNC, we draw on characteristics of scale used extensively in the field of ecology. While it has been argued that there are potential pitfalls in using ecological concepts to describe social phenomena (e.g., Reed and Peters 2004), we do so to provide a more nuanced understanding of scale than the commonly used notions of 'fine' and 'broad scale' generally found in the HNC and PEB literature. In the ecological sciences, scale is generally conceptualized in terms of two characteristics: extent is the area over which a phenomenon occurs or is studied, and grain is the size over which individual expressions of the phenomena occur or at which those expressions are observed (e.g., Kotliar and Wiens 1990; Turner 1990). For example, the grain of an agricultural land cover map might be 1 ha (the average field size), while the map may have an extent of 1000 km^2 (the size of the landscape in which those land cover patterns occur). We take grain as analogous to spatial specificity of HNC (i.e., its location or place of occurrence) and extent as spatial 'reach' of such connections (see Table 2). Grain and extent are not intended to describe HNC or PEB, but rather specify the spatial occurrence of such social phenomena. We believe that conceptualizing the scale of HNC on a continuum from local-to-global extents and from fine to coarse grain spatial specificity, while not entirely problem free, provides a useful distinction not yet clearly expressed in the literature.

Scale in PEB literature

The ways in which PEB has been studied and conceptualized varies greatly. PEB are often operationalized using Likert-type scales, which has resulted in widely reproducible and generalizable results, though at the cost of measuring place-specific behaviors (Larson et al. 2015) and the most environmentally significant behaviors (Gatersleben et al. 2002). One-dimensional measures of PEB provide insights on relevant and common behaviors, though fail to recognize the heterogeneous nature of PEB (Ertz et al. 2016) or their spatial specificity and extent. Attempts at overcoming these

Table 2 Examples of the extent and grain of different human–nature connectedness (HNC)

	Small extent connections	Large extent connections
Fine grain connections	E.g., local experiences of nature; place attachment to specific local landscape features; biophysical attachments of subsistence farmers	E.g., multiple place attachments across large geographical extents; emotional attachments to iconic species; teleconnected biophysical connections of industrialized farmers
Coarse grain connections	E.g., regional cultural identities; cultural landscape connections; broader scale place attachment	E.g., philosophical sense of oneness to all nature; cognitive understandings of large-scale social-ecological functions

gaps have occurred, with scholars linking place attachment and place-specific PEBs (e.g., Halpenny 2010; Ramkissoon et al. 2013a) and HNC and realm-specific behaviors (e.g., food consumption, see Schosler et al. 2013). However, to our knowledge, there have been few efforts in the HNC literature to classify and measure PEBs based on grain or extent, or analogous spatial classifications.

Conceptualizing scale in relation to PEB is complicated by the need to differentiate between the scale of behaviors (e.g., individual or group action) and the scale of environmental impact of those behaviors (Gatersleben et al. 2002). The scale of PEB is a consequence of both the scale of behavior and the scale of impact. In this context, grain is more relevant when considering the scale of behavior; we can distinguish between a behavior taken by an individual (fine grain) or by a society or community (coarse grain). Extent becomes more important when considering the scale of impact. A PEB can have an impact over just a local area, or have a global impact, or have both. Weaving grain into the scale of behavior, and extent into the scale of impact, will be most useful for nature as treatment interventions that target specific environmental problems. However, this means that from here on, we will disregard coarse grain PEB because nature as treatment interventions are primarily targeted at individuals, whereas coarse grain behaviors are those instigated by a community or society as a whole and therefore tend to be institutionalized, either informally or formally (i.e., through legislation).

For thinking about the extent of impact of PEB, we propose groupings from place-specific impacts to global impacts. In adopting this approach, we must make assumptions about the scale of impact of PEB. Impact of PEB can be classified by either the individual's intended impact of the behavior undertaken (i.e., intent-oriented research) or by the direct environmental impact of PEB (i.e., impact-oriented research) (Stern 2000). We acknowledge that a precise measurement of the environmental impact of each PEB is challenging (and beyond the scope of this paper), as PEBs have dispersed impacts, cumulative impacts, delayed impacts, and impacts over various geographic scales. Global ecological processes mean that a behavior with a strong local environmental impact (e.g., car idling contributing to local air quality) could still contribute to large-scale environmental problems (e.g., car emissions contributing to global climate change). Furthermore, behaviors can be interlinked; an individual can adopt a PEB that raises awareness of an environmental issue that then prompts another individual to adopt a PEB that directly targets that issue. We argue that classifying PEBs according to the extent of their direct or primary intended environmental impact—while a simplification of the complex nature of the spatial impact of PEBs—is useful for relating such behaviors to the spatial scale of HNC that (potentially) promotes such behavior. We present such a classification in Table 3.

Spatial patterns in the HNC–PEB relationship: three archetypes

Interactions between scales of HNC and of PEB

As our understanding of the interplay between HNC and PEB has grown, research gaps in our understanding of the spatial interplay between these constructs remains. We focus our attention on one critique: that current HNC conceptualizations are too overarching to be applicable in the study or application of nature as a treatment for shaping or constraining PEB. Beery and Wolf-Watz (2014) state that failing to specify characteristics and location of HNC has kept the concept elusive, unplaced, and unhelpful. Jorgensen (2010) argues that these conceptualizations fail to recognize that these constructs "have spatial and physical referents that need to be made explicit." We argue that measuring HNC in this generalized way leads to generalized findings and correlations that, while interesting for academic advancement of the field, have limited applicability for nature as a treatment practice.

We challenge the existing HNC and PEB conceptualizations and suggest that richer interactions, mediated by spatial scale, exist between the two constructs. To facilitate this thinking, we discuss archetypical patterns of HNC–PEB relationships present in the literature and propose three scalar interactions that further integrate spatial considerations into research on the ways in which HNC and PEB are linked. Following the archetype approach of Eisenack (2012), we define archetypes as recurrent patterns of interaction between factors that have distinct characteristics that occur in various situations with similar outcomes. The

Table 3 Categories of pro-environmental behavior (PEB) by grain and extent

	Small extent (impact)	Large extent (impact)
Fine grain (individual behavior)	E.g., picking litter to clean a local beach	E.g., avoiding air travel to mitigate climate change
Coarse grain (societal behavior)	E.g., plastic bag ban to reduce local litter	E.g., carbon tax to mitigate climate change

archetypes proposed in this paper call attention to scalar patterns identified in the HNC–PEB relationship and define three interactions that align with findings in the literature. Defining archetypes is a useful tool for classifying scalar relationships between HNC and PEB, as archetypes provide generalizations that can be tested and refined through empirical research and illustrate patterns that can inform policy and practice (Eisenack 2012; Oberlack et al. 2016).

The three archetypes, which we refer to as 'equal interactions', 'embedded interactions' and 'extended interactions', (see Fig. 1) illustrate scalar relationships between the grain and extent of HNC and PEB. These archetypes are a conceptual depiction of the various spatial representations of individual nature connectedness and the corresponding affect on PEB adoption or intention. Each archetype presumes HNC as the independent variable and PEB as the dependent variable, reflecting the typical way these two constructs are most often related in the literature (e.g., Mayer and Frantz 2004; Halpenny 2010). As discussed earlier, literature has shown that individuals express multiple place attachments and experience different types of connections to nature. As such, the archetypes proposed in this paper are not mutually exclusive, nor do they represent a typology where every interaction is able to be explained by, or classified in, a single archetype (Eisenack 2012). Rather, these archetypes bring attention to existing spatial relationships and condense them into three categories to provide clarity and structure for considering the HNC–PEB relationship. Individuals can express HNC–PEB relationships consistent with each archetype and interventions could be designed to target one or more spatial interaction.

While the three archetypes apply spatial thinking to enhance our understanding of HNC–PEB relationships, there are HNC–PEB relationships that are unable to be described or categorized spatially. For instance, there are degrees of HNC that cannot be correlated with specific behavioral outcomes but rather with general changes in environmental attitudes or behavioral intentions. Interventions that aim for this general PEB outcome may employ strategies that build connectedness at various scales. There are also 'scaleless' connections, such as deep philosophical or spiritual connections to nature, which would be challenging to place along a nature connection extent from local-to-global or across multiple spatial grains. Furthermore, the archetypes do not

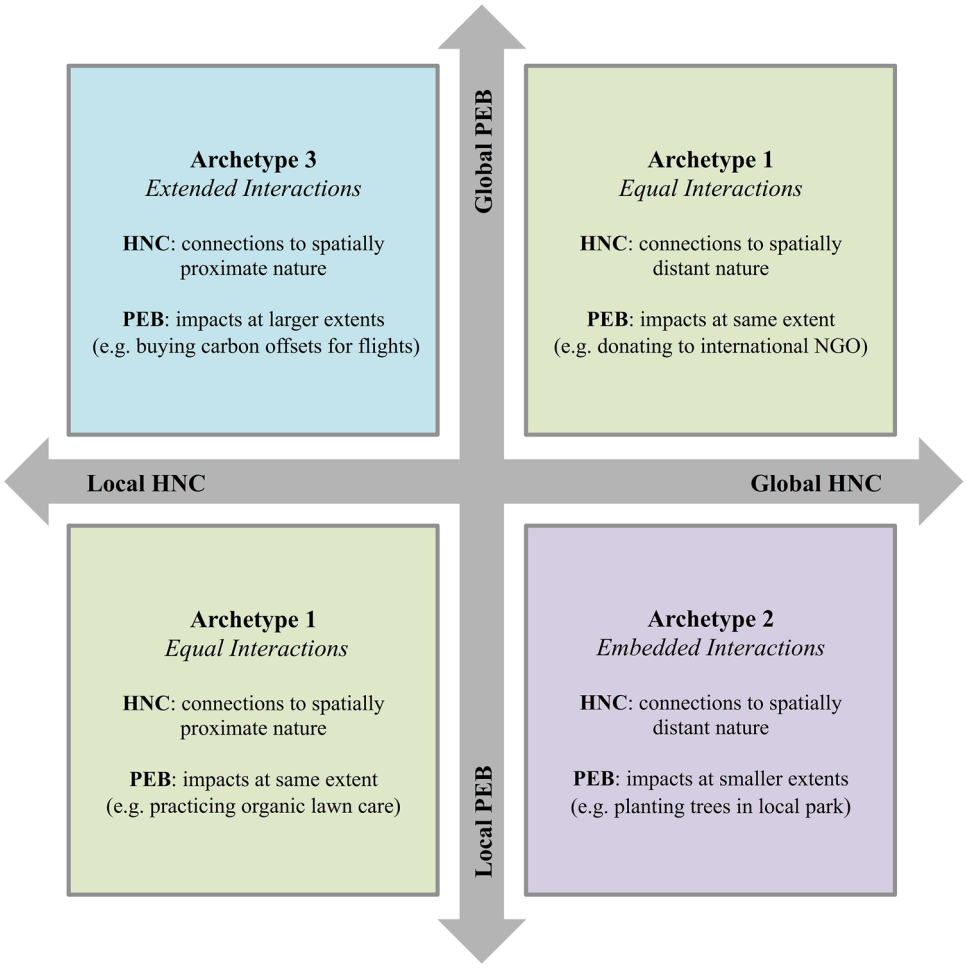

Fig. 1 Conceptualization of three archetypical interactions between scale of human–nature connectedness (ranging from locally to globally connected) and scale of pro-environmental behavior (ranging from local-to-global environmental impact)

account for degrees of connectedness that spur feelings of love or reverence (e.g., emotional attachments), though not the adoption of PEB.

Thus, the three archetypical interactions are a simplification of the complex relationship between HNC and PEB, which can be mediated by external and internal factors (e.g., attitudes and values, personal and group norms, costs and incentives, behavioral control; for a review, see Gifford and Nilsson 2014). The generalization of the archetypes is not designed to capture every dimension of this relationship, but rather to widen existing conceptualizations and provide concepts and questions for empirical exploration and practical application of scalar interactions. We define each archetype according to grain and extent and provide examples from scholarly literature and practical application that support the spatial direction in each interaction.

Archetype 1: equal interactions

'Equal interactions' (Fig. 1) are characterized by PEB and HNC that occur at the same grain and extent. Connectedness is generally experienced at finer grains, from small to large extents. Corresponding PEB is taken to create an impact at an extent aligned to the extent of the HNC. For example, individuals with connectedness to a local or spatially proximate environment (fine grain, small extent HNC) act pro-environmentally to conserve and protect that place (small extent PEB); individuals with connectedness to distant regions act to protect the flora and fauna of that region in situ or with distant behaviors such as donations (large extent PEB). This archetype suggests that interventions at any one scale of nature would encourage and promote PEB intentions or adoption at the same scale. In other words, a treatment designed to build connectedness to a local forest could prompt PEBs to protect and conserve this forest, whereas a campaign to build connectedness to arctic species would prompt PEBs to protect those species. This archetype aligns with existing 'localist' discourses about human–place relationships that argues individual value and act to protect what is spatially close (Devine-Wright 2013).

'Equal interactions' can be observed in several strands of literature that report findings consistent with this archetype. The most prominent is the place attachment literature, which shows that individuals who feel attached to a location will act to protect and care for that place (e.g., Scannell and Gifford 2010). Place attachment has been shown to predict place-related pro-environmental intentions (Halpenny 2010). Scholars suggest this relationship is due to individuals believing their behaviors play a role in improving local environmental quality (e.g., Walker et al. 2015). Evidence from other strands of HNC literature lends further support to the presence of 'equal interactions': gardeners with close connectedness to their gardens employ ecological gardening practices (Kiesling and Manning 2010), individuals with strong regional ties act pro-environmentally at the regional scale (Ardoin 2014), and individuals who visit national parks or protected areas are more likely to act to protect that place (Ramkissoon et al. 2012). Outdoor recreationists, such as hunters and birdwatchers, frequently engaged in conservation behaviors, but were less strongly associated with general PEBs (Cooper et al. 2015), suggesting PEBs have a spatial specificity that is linked to spatially relevant HNC. Much in the same way, students that were exposed to information about exotic species were more willing to protect exotic species than species in their local environments (Ballouard et al. 2011).

The 'equal interactions' archetype can be considered as the 'default' HNC–PEB relationship. For centuries, individuals built strong connections to their immediate environment where they worked and interacted with the land on a daily basis. These strong connections to the land helped foster a sense of responsibility and protection to keep the land viable and productive for future generations. Today, place-based nature interventions could foster these relationships. Nature excursions for families at a national park could be designed to foster a sense of connectedness to nature and a sense of responsibility to protect and care for the park. At larger extents, exposure to environmental issues can prompt care and concern for these places and subsequent PEB. This strategy is used by environmental NGOs (e.g., WWF; The Nature Conservancy) to build connectedness to distant, but specific, facets of nature as a means of prompting conservation behaviors at an extent that includes that location. Videos of orangutans being rescued from palm oil plantations and plush toys of charismatic megafauna are tools used to foster a sense of connectedness to distant ecosystems, which may lead to increased donations and conservation behaviors that support specific environmental concerns at that extent.

Archetype 2: embedded interactions

'Embedded interactions' (Fig. 1) are present when connectedness at coarser spatial grains is tied to PEB at relatively fine spatial extents. Individuals feel a generalized connectedness to nature (e.g., biomes, continents) or have a sense of connectedness to the entire natural world (coarse grain, large extent). However, due to degrees of behavioral agency or constraining factors at this grain of connectedness, individuals adopt PEBs that impact smaller extents. For example, individuals connected with rainforest ecosystems may feel unable to create meaningful change at that scale, so action is taken to conserve woodlands at the regional scale by planting native trees.

Studies have shown that national and global belonging is correlated with general measurements of PEB (Der-Karabetian et al. 2014). Walker et al. (2015) suggest that individuals

with high degrees of global attachment or belonging adopt PEBs with a local impact as they view local environments as a microcosm of global environments. This archetype is also prominent in the popular phrases 'Think Global, Act Local' and 'GLOCAL,' which have been employed by academics, policy makers, and practitioners to encourage global citizenship paired with PEBs at more spatially proximate scales.

The 'embedded interactions' archetype is reflected most strongly in the work and outreach strategies of environmental advocacy groups. Individuals receive educational information about the environmental challenges facing the planet but are encouraged to take action at the local scale where they have the most impact. This tactic is also employed in environmental outreach such as documentaries or communication campaigns. For example, a documentary may highlight the unsustainability of the global industrialized food system, but end by urging viewers to adopt specific behaviors that can influence their local food systems, such as buying locally grown organic produce.

Building connectedness at coarser grains of nature has been facilitated by globalization. Exposure to natural products through global trade, information about unfamiliar biomes through television and internet, and increased abilities to travel to new ecosystems have all facilitated increased connectedness to nature at grains other than the most spatially proximate. Clayton et al. (2017) reason that as virtual, mediated, and simulated experiences of nature become more prevalent, they should be embraced as a tool for helping influence PEB adoption. One potential avenue of research is to examine if these newer methods of building connectedness are more effective at prompting PEB with small or large extent impacts.

Archetype 3: extended interactions

The 'extended interactions' (Fig. 1) archetype refers to fine grain and small extent connectedness that promotes PEBs with large extent impacts. This archetype highlights a growing sense of responsibility wherein individuals extend their care for nature to include protection of other ecosystems and biomes. Individuals experience connectedness to spatially proximate or spatially specific nature, which leads to an expanded sense of self and PEBs that impact larger extents than where the connectedness is observed.

Nature connectedness at fine grains and across small extents is likely built through frequent experiences with local nature. Wells and Lekies (2006) found that exposure to nature in childhood has a significant, positive association with a set of general PEBs as an adult. Qualitative studies on HNC also provide support for 'extended interactions' being present in HNC–PEB relationships. Interviews with environmentally minded individuals reveal that PEB stems from a sense of concern and care for nature that was built as a result of time spent in spatially proximate nature (e.g., Guiney and Oberhauser 2009; Krasny et al. 2014). Respondents built connectedness to nature at a local, fine grain, but feel a growing sense of citizenship and responsibility to protect nature around the globe through their lifestyle and consumption behaviors.

This archetype reflects the basis of the current literature on HNC interventions. Since studies first reported a positive relationship between HNC and PEB (see, Mayer and Frantz 2004), educators and practitioners have developed and implemented programs to get people out into nature. These programs connect individuals to local nature through experiential nature exposure (e.g., walks in the woods; bird watching; tree planting), with an aim of affecting PEB adoption. Similarly, this archetype is often used in environmental education and citizen science programs. Teaching and inspiring individuals about their local environments and promoting immersive experiences in nature can aid in the development of an environmental ethic that will inspire general PEBs (e.g., Cosquer and Raymond 2012; Richardson et al. 2016).

Applying a spatially informed HNC–PEB approach

Introducing three archetypical interactions (equal, embedded and extended) serves two purposes. First, the archetypes aid in the categorization and specification of HNC–PEB research. Applying grain and extent to existing conceptualizations of HNC provides a more nuanced way of understanding variances in where individuals feel connected to nature. Applying extent to existing conceptualizations of PEB provides a more nuanced understanding of where individuals act pro-environmentally. Second, the archetypes provide three scalar relationships to explore and validate through empirical testing and practical application. It is hoped that the introduction of these archetypical interactions will prompt further discussion on scale as a mediating factor in HNC–PEB relationships and provide opportunities for targeted application. Expanding the conceptualization and measurement of HNC and PEB to include spatial thinking will provide insights on why and where individuals act sustainably, and consequently help direct HNC as a treatment for PEB interventions.

Conceptual application

The three archetypical interactions introduced in this paper provide new insights on the HNC–PEB relationship by introducing grain and extent to clarify spatial relationships. As the proposed spatial interactions are mitigated by factors such as degree of connectedness, geographic location

of individuals, and ability to connect to nature, additional insights will be gained by relating these archetypes to existing HNC frameworks. Relating our approach to existing models and frameworks provides richness to the scalar approach and assists in uncovering scalar relationships within and across existing conceptualizations of HNC.

For instance, Ives et al. (2018) describes five types of connection to nature: material, experiential, cognitive, emotional, and philosophical. Integrating our work on scalar interactions with this classification of HNC may reveal interactions between the five types of connection and the spatial scale over which these connections occur. Specifically, empirical exploration could observe variances in the spatial expression of each type of connectedness and report on links to specific PEBs. For instance, scholars interested in place attachment and emotional connectedness to place (e.g., Gosling and Williams 2010; Ramkissoon et al. 2013b) might investigate how these connections are linked to PEBs with impacts at extents greater than place-specific, while scholars interested in worldviews or philosophical connections (e.g., Hedlund-de Witt et al. 2014) might examine how these larger extent connections are linked to small extent PEBs. Integrating these approaches in future research may determine if the scale of HNC or the type of HNC plays a more prominent role in the adoption of PEB.

Additional insights could be gained by connecting our scalar interactions approach with Clayton et al's. (2017) six continuous dimensions of nature experiences. Linking grain and extent of HNC with dimensions of nature experiences will bring clarity to our understanding of the relationship between where, how, and when individuals experience and connect to nature and where individuals act pro-environmentally. Connecting these two approaches may explain why self-directed experiences at the local scale, for instance, have similar or different PEB outcomes than self-directed experiences at a landscape scale. By doing so, there is also the potential to understand how changes in how individuals are experiencing nature (e.g., towards technology-based interactions and managed experiences) are leading to connectedness at increasingly greater extents. Explorations of the use of virtual nature, in particular, is a growing field (e.g., Ahn et al. 2016; Arendt and Matthes 2016) and these studies could be complimented with the inclusion of a scalar lens to investigate how virtual and mediated experiences in nature are linked to PEBs at specific extents. Additionally, there is uncertainty about which PEB outcomes are tied to connectedness at large grains and extents and if nature experiences and connections at this scale in fact lead to unsustainable behaviors (e.g., flying long-distances to visit iconic species in the wild or purchasing imported products with large embodied emissions).

Similarly, our approach provides an additional lens to examine the influence of time scales, such as duration and frequency of nature exposure, on the grain and extent of HNC. Zelenski et al. (2015) state that a single nature exposure can foster HNC and PEB, though this is more likely developed over time and after repeated experiences in nature. Drawing linkages between the frequency of exposure and the spatial scale of exposure can provide insights on when individuals adopt PEBs (e.g., short term or long term) and if this is tied to the scale of PEB impact. By relating these approaches, we can bring greater conceptual clarify to our understanding of how PEB outcomes differ when, for example, individuals are connected at fine grains for a short duration or a long duration or for multiple short durations over a longer period of time. This can shed light on whether short-term connections most frequently reflect 'equal interactions' whereas long-term connections reflect 'expanding interactions'.

Lastly, our approach provides support for the argument that HNC can be levered as a tool for deep and meaningful change towards sustainability (e.g., Abson et al. 2017; Ives et al. 2018). Further conceptual thinking and empirical exploration based on the three archetypes may lead to more nuanced understandings of how degrees of HNC at different scales can be leveraged as a treatment for unsustainable lifestyles and the adoption of PEBs. Each archetype might represent different leverage points, ranging from shallow—easy to adopt, but unlikely to lead to deep sustainable changes—to deep—more challenging to adopt, but may lead to sustainability transformation (Meadows 1999). 'Equal interactions' might be most prevalent and easiest to promote, as individuals feel greater agency to act pro-environmentally at the grain they are connected to nature. These fine grain fine extent connections may be the easiest to foster and lead to adoption of the most convenient PEBs, but may not lead to deep transformational changes for sustainability. For these deeper systemic changes, 'expanding interactions' might prove to be the most effective HNC–PEB archetype to consider. In these instances, interventions and policies are employed with an aim of fostering connectedness at spatially proximate scales and deeply transforming attitudes and behaviors towards the planet as a whole. Furthermore, applying a scalar lens will draw greater attention to the relationship between reconnecting materially (e.g., Dorninger et al. 2017) and reconnecting psychologically (e.g., Mayer and Frantz 2004; Nisbet et al. 2009b), bridging the findings from these fields and shedding light on which type of reconnection leads to greater transformative PEB outcomes and deeper systemic change.

Practical application

Sustainability science is a practice-based science that relies on practical models for addressing real-world environmental challenges. In HNC studies, there is a need to

make research and models more useful for policy makers and practitioners (Restall and Conrad 2015). In that context, our archetype approach is not intended for application as a theoretical model but rather as an approach for guiding applications of nature as a treatment. Current calls to 'reconnect to nature' are lacking consideration of spatial scale, which makes it difficult to plan for and predict PEB outcomes. A primary implication of this approach is that scalar thinking should be considered and integrated into the design of nature as a treatment intervention programs and policies. The three archetypes provide insights on where to connect individuals to nature for certain PEB outcomes and can serve as a planning approach for nature connectedness practitioners.

Building an understanding of the relationship between HNC and PEB at certain scales provides tangible guidance for practitioners on how and why to connect individuals to certain types or locations of nature. Practitioners must determine where to implement interventions and at what spatial scale they are attempting to build connectedness. As these decisions are guided by geographic location, available resources, and the purpose of the organization, understanding scalar interactions between HNC and PEB can help constrain and shape programs. The archetypes can provide two directions of guidance during the design of HNC treatments. First, the archetypes can aid in planning by providing a tool for looking ahead to anticipated PEB outcomes based on interventions planned at a particular grain and extent of nature. Second, the archetypes can prompt thinking about the scale of nature to use in interventions by looking back and considering possible grain and extents that could contribute to the desired PEB outcomes of an intervention. The archetypes might also be useful for considering the types of PEBs that can be prompted, and whether or not these PEBs will deliver tangible benefits in the desired locations and scales. For example, 'equal interactions' suggests that nature intervention programs that target small grain HNC will likely be tied to PEB outcomes at a spatial extent that will include this location.

Practitioners and policy makers must also provide reasoning for the design of nature as a treatment programs to receive support and funding. A greater understanding of scalar relationships can help justify why interventions are implemented at certain scales and aid in prioritizing interventions by anticipated PEB outcomes. Programs that are designed with grain and extent in mind will have more precise goals, application strategies, targeted PEB outcomes, and consideration of the location at which PEBs can be made, leading to more effective use of resources and more effective interventions.

Recommended further development of this conceptual approach

The spatially informed approach presented in this paper is useful for conceptual and practical application, but has limitations. This approach is a first step towards integrating spatial thinking into HNC–PEB research and will require empirical exploration to operationalize and validate the archetypes. PEB may be shaped by feelings of connectedness at different scales, or by a sense of connectedness at one scale. The archetypes should be seen as potential scalar relationships between the two constructs but should not be viewed as mutually exclusive nor encompassing all cases. The archetypes are not a pegboard on which every individual can be positioned at one point along a gradient. Rather, HNC is likely to build and exist at many scales: building on one another, existing at the same time, or growing greater.

To overcome these limitations, future research and testing of these three archetypes and additional scalar relationships between HNC and PEB is required. The development of a psychometric scale to test connectedness at various spatial scales may be an important step towards understanding individual connectedness at each scale and the associated PEB outcomes. Additionally, the archetypes can serve as a guide for the development of methodology for empirical studies. Empirical exploration could provide additional clarification regarding the most effective scale to connect individuals for any given PEB outcome and the role of different framings of scale (e.g., by socio-political or ecological boundaries) on reported connectedness levels. Furthermore, empirical exploration could delve into the more nuanced ways that HNC influences PEB by examining how the grain and extent of HNC influence the domain where individual acts (i.e., private/public, home, community, nation), what nature an individual acts to protect (i.e., near/far, familiar/exotic, mine/others), or the stage of behavior (i.e., pre-contemplation, intention, self-reported). Finally, while we focused on scalar HNC–PEB interactions at the individual level (fine grain behaviors), it would be instructive to explore these relationships at coarse grains [i.e., the meso level (e.g., households) and macro level (e.g., regional or national) (Reid et al. 2010)].

Conclusions

Addressing current environmental challenges will require a transformation of human behavior towards sustainability. Reconnecting individuals to nature is seen as one avenue for fostering the adoption of PEBs, which has lead to nature as treatment interventions. However, applying HNC as an effective treatment for PEB requires bridging conceptual gaps in our understanding of where individuals

experience connectedness to nature and how these connections influence where individuals act pro-environmentally. In this paper, we propose that the integration of spatial scale into HNC–PEB research provides clarity and direction for understanding the interactions and linkages between these constructs.

We apply grain and extent to enhance our understanding of the relationship between HNC and PEB and introduce three scalar interactions useful for distinguishing spatial directionality of influence. This approach is useful for conceptual application for understanding PEB outcomes of HNC, as well as for practical application in the design of nature as treatment interventions. This conceptual approach suggests three scalar interactions and behavioral responses as a result of connecting an individual to nature at a particular geographic scale. Understanding the potential interactions and alignment of HNC and PEB along a spatial gradient may provide insights regarding where to target HNC interventions. The approach is timely as the ways in which we experience and connect to nature is transforming and we are using mediated and structured experience to connect with nature with greater frequency (Clayton et al. 2017).

A scalar approach to nature as a treatment cannot yet account for all behavioral responses to all degrees of HNC. However, the scalar relationships proposed in the archetypes above should provide guidance for scholars and practitioners delving into the most effective methods for promoting nature connectedness as a treatment for PEB change. This approach helps to clarify conceptual questions, which has implications for future sustainability science research. Integrating spatial thinking into HNC measures will lead to an increased understanding of how HNCs are shaped by place. This will add coherence to our understanding of how HNC differs across spatial gradients.

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SECTION C

Chapter VII

Energy conservation attitudes and intentions: investigating place attachment in Eastern Transylvania, Romania

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ABSTRACT

This study explores the relationship between place attachment and energy conservation attitudes and behavioral intentions in the Pogány-havas microregion of Romania. Confirmatory factor analysis (CFA) was used to examine three dimensions of place attachment: place identity, place dependence, and nature bonding. While place attachment in the region is high, structural equation modeling (SEM) revealed negative links between place dependence and energy conservation attitudes, and between place identity and behavioral intention. However, insignificant regression weights between the constructs suggest there are many unexplained factors that mediate the relationship between place attachment and energy attitudes and behavioral intentions in this region. These results suggest that future research on rural energy transitions should take a systemic perspective that includes additional constraints (e.g. material and structural) that may better explain how individuals develop energy attitudes and behaviors.

KEYWORDS

Energy transitions; pro-environmental behavior; nature bonding; sustainability; structural equation modeling

INTRODUCTION

Combatting global climate change will require radical alterations to individual attitudes towards energy conservation and reductions in energy consumption behaviors. It has been suggested that up to 20% energy savings could be achieved through changes in individual behavior (Gynther, Mikkonen, & Smits, 2012). In order to facilitate these behavioral shifts, scholars are interested in the determinants of pro-environmental attitudes and behavioral intentions. Place attachment—the degree to which individuals feel a connection with their natural, physical and social environments—has been identified as a positive and significant predictor of pro-environmental attitudes and behaviors (Scannell & Gifford, 2010; Vaske & Kobrin, 2001).

Studies have examined the influence of place attachment on pro-environmental behaviors related to native vegetation conservation (e.g. Raymond, Brown, & Robinson, 2011), national park usage (e.g. Ramkissoon, Weiler, & Smith, 2013), farming practices (e.g. Gosling and Williams 2010) and civic engagement (e.g. Buta et al. 2014). However, there is little research on how place attachment might contribute to energy conservation attitudes and behavioral intent. In this study, place attachment is explored in a rural European context in order to assess if the construct is useful for explaining energy conservation attitudes and behavioral intent.

Research on energy attitudes and behaviors has been more prevalent in urban areas with high aggregate energy consumption (e.g. Sovacool & Blyth, 2015), though there is growing recognition of the need to study these constructs across rural-urban and socio-demographic gradients (e.g. Balta-Ozkan & Le Gallo, 2018). Rural communities interact more frequently with the natural environment, depend more directly on natural resources, and report the highest level of place attachment (Lewicka, 2011). Within traditional cultural landscapes—areas where nature and people have co-evolved in sustainable ways (Milcu, Sherren, Hanspach, Abson, & Fischer, 2014)—energy transitions are likely and place attachment may play a significant role in shaping attitudes and behaviors towards energy use. Romania has

considerable potential for renewable energy projects, especially community-owned renewables as a means towards sustainable rural development (e.g. Cebotari, Cristea, Moldovan, & Zubascu, 2017). Studying place attachment in relation to energy related pro-environmental attitudes and intentions in rural Romania therefore provides the opportunity to test the validity of the place attachment as a determinant of pro-environmental behavior outside of the usual contexts in which it is generally studied.

In this study, we examine the socio-demographic predictors of place attachment in a traditional cultural landscape and the influence of place attachment on energy conservation attitudes and behavioral intention. We use confirmatory factor analysis (CFA) to examine the latent variables (i.e. place identity, place dependence, nature bonding, and attitudes) and structural equation modeling (SEM) to test relationships between place attachment and energy conservation attitudes and behavioral intention. Lastly, we situate our research within the larger narrative of place attachment and discuss implications for sustainability and energy transitions research.

LITERATURE REVIEW

Place attachment refers to the emotional, cognitive and functional bonding that occurs between individuals and their environments (Jorgensen & Stedman, 2001) and refers both to the depth and type of attachment (Chen & Šegota, 2015). The most common conceptualization of place attachment consists of two dimensions: place identity—an emotional attachment—and place dependence—a functional attachment (Low & Altman, 1992). Continued conceptualization and operationalization of the construct led to defining additional sub-dimensions including place social bonding and nature bonding.

Raymond et al proposed nature bonding as an additional measure of place attachment that is "related to experience or time spent in the natural environment (Raymond, Brown, & Weber, 2010, p. 425). Research suggests that nature-based place attachment is tied to and facilitates pro-environmental attitudes and behavior (e.g. Raymond et al., 2011). The feelings of

attachment and ascription of deep meaning to places in the natural environment can support attitudes and behaviors towards protecting that place and foster sustainable resource management (e.g. Buta et al., 2014; Gosling & Williams, 2010). This may be especially true for rural populations. Walker and Ryan (2008) found a strong positive relationship between place attachment and rural residents' support for conservation planning; Raymond et al (2010) found that place attachment was strong among rural landholders who have deep attachments to the physical and social environments.

However, the findings on the relationship between place attachment and pro-environmental attitudes and behaviors have been inconsistent. Studies have reported positive relationships (e.g. Halpenny, 2010), negative relationships (e.g. Ramkissoon, Graham Smith, & Weiler, 2013), and no observed relationships (e.g. Gosling & Williams, 2010). Additionally, some scholars have suggested that place attachment is likely to correlate more with behavioral intentions than with actual behavior (Gosling & Williams, 2010). These discrepancies may be due to inconsistency in how place attachment is theorized and measured. This suggests the need to analyze the associations between place attachment and attitudes and behaviors in additional settings and to look at specific attitudes and behaviors. Our research furthers the understanding of place attachment in rural populations with rural livelihoods and close ties to the land.

We adopt a three-dimensional model of place attachment adapted from Raymond et al: place dependence, place identity, and nature bonding (2010). Based upon existing research we developed the following hypotheses (see Figure 1):

H_1: Place dependence ($H_{1\text{-}A}$), place identity ($H_{1\text{-}B}$), and nature bonding ($H_{1\text{-}C}$) are directly and positively associated with energy conservation attitudes

H_2: Place dependence ($H_{2\text{-}A}$), place identity ($H_{2\text{-}B}$), and nature bonding ($H_{2\text{-}C}$) are directly and positively associated with energy conservation behavioral intention

H_3: Energy conservation attitudes are directly and positively associated with energy conservation behavioral intention.

>>Insert Figure 1<<

METHODS

We conducted an exploratory survey analysis between October and December 2017 in the Pogány-havas microregion—an administratively bounded area in Eastern Transylvania, Romania. The region consists of six communes (Păuleni-Ciuc, Mihăileni, Frumoasa, Lunca de Sus, Lunca de Jos, and Ghimeş-Făget) comprised of 32 villages and a total population of ~22,200 inhabitants (see Figure 2). The region is characterized by wide mountain basins, mountainous areas with deep valleys, large forested areas, and productive hay meadows (Sólyom et al., 2011). It is a rural region where small landholdings have been managed by traditional farming practices for generations, leading to high biodiversity (Biró, Demeter, & Knowles, 2011), However, changes such as farm consolidation and rural depopulation are likely to impact people-place relationships. The region's residents primarily rely on wood and butane gas for heating and cooking despite high renewable energy potential (e.g. wind, solar, biogas).

>>Insert Figure 2<<

We aimed to collect a representative sample of the microregion (95% confidence, 5% margin of error): for a population size of 21,617 this would require >378 surveys distributed proportionally by commune population. A total of 379 surveys were conducted; however, five surveys were not completed (e.g. a farmer left early when a bear broke into his paddock), leaving a final sample size of 374. We asked the first person we encountered at the household to participate and collected informed consent before administering the questionnaire. The questionnaire consisted of four sections: demographics, place attachment, energy conservation attitudes, and behavioral intention. The items were constructed in English and translated into Hungarian and Romanian (the two native languages of the region). Items were back translated to identify translation errors and ambiguities. The

questionnaire was pre-tested with a small convenience sample and revised to improve unclear items and survey flow.

Demographic information on gender, age, ethnicity, education, occupation, and income were collected to determine characteristics of the sample population, as well as to measure influence on place attachment. Three dimensions of place attachment—place dependence (5 items), place identity (6 items), and nature bonding (5 items)—were assessed. Environmental attitudes were measured using four items from Abrahamse and Steg (2009). Behavioral intent was measured using one item derived from Scherbaum, Popovich and Finlinson (2008). For all items, participants responded using a five-point Likert-type scale: 1=strongly disagree, 5=strongly agree. Summated scales were constructed by combining the items belonging to each construct.

Prior to analysis, the dataset was screened for accuracy and missing values. Missing values, representing 0.67% of the data, were replaced with the series mean. The four negatively worded attitude items were reverse coded. Statistical data analysis was carried out using SPSS version 25.0. A reliability analysis of the 16-item place attachment scale indicated a Cronbach's α of .89 (see Table 2). The reliability of the three sub-dimensions was also good: place dependence (α= .75), place identity (α= .86), and nature bonding (α= .73). The measures of energy attitudes were less reliable (α= .71), but within the recommended threshold of .70 (Nunnally & Bernstein, 1994). Consistency analysis was not done on the behavioral intention item as this was measured using a single item. CFA and SEM were conducted in AMOS version 25.

>>Insert Table 2<<

RESULTS

Residents in the sample predominantly identified as ethnically Hungarian (91.2%) and female (64.5%). The most represented age group was between 30-49 years old (40.4%) and 77.8% of

respondents had a high school degree or less. The average length of village residency was 39.7 years. The average household size was 3.20 and 48.6% reported a monthly household income of less than 1,200 Romanian Lei (RON). Mean place attachment scores for all respondents were 3.88 for place dependence (SD =.66, n =374), 4.06 for place identity (SD =.56, n =374), and 4.23 for nature bonding (SD =.46, n =374).

Bivariate correlations (Spearman's R) (see Table 1) indicated a significant, moderate relationship between length of residence and place dependence (r= .313, p<.01). Significant, but weaker, relationships were identified between: age and place dependence (r= .249, p<.01) and age and nature bonding (r= .183, p<.01); education and place dependence (r= -.180, p<.01) and education and place identity (r= -.136, p<.01); income and place identity (r= -.138, p<.01); and length of residence and nature bonding (r= .158; p<.01).

>>Insert Table 1<<

Prior to structural modeling, the measurement model of the latent variables was examined using standardized CFA with maximum likelihood estimation. Due to low factor loading, one nature bonding item was removed from the measurement model (i.e. item 2; β= .44); factor loadings greater than .50 were retained (Hair, Anderson, Tatham, & Black, 1992). Modification indices indicated that covariating several error terms (e1-e2; e6-e7; e7-e8) would improve model fit significantly. In psychological construct research the correlation of errors is generally acceptable, as this accounts for nonrandom measurement error (Byrne, Shavelson, & Muthen, 1989). Model fit was acceptable (x^2 = 395.155*; df* = 143; *p* = .000; x^2/df = 2.763; CFI = .905; RMSEA = .069; SRMR = .0594) (see Table 3).

>>Insert Table 3<<

The structural model tested the relationships between the three dimensions of place attachment, energy conservation attitudes, and behavioral intention. The model generated

good fit indices, which support that our hypothesized model fits and is consistent with the data (x^2 = 410.314*; df* = 158; p = .000; x^2/df = 2.597; CFI = .905; RMSEA = .065; SRMR = .058). Good model fit has a nonsignificant chi-square value (p >.05). However, this statistic is sensitive to sample size and alternative fit indexes are generally assessed.

In order to test the hypotheses, we examined value and significance of individual path coefficients (see Figure 3). Significant standardized path coefficients were found between place dependence and energy attitudes (β= -.441 ; p<.05), between place identity and behavioral intent (β= -.356 ; p<.05), and between nature bonding and behavioral intent (β= .208 ; p<.10). All other paths were not statistically significant, including no effect of energy attitudes on behavioral intent (β= .019). The model did not support our hypotheses (see Table 4).

>>Insert Figure 3<<

>>Insert Table 4<<

DISCUSSION

While place attachment has been found to be a predictor of pro-environmental behaviors and attitudes, there has been limited investigation of these variables in rural areas and on energy conservation issues. In this study, we investigated place attachment in a traditional cultural landscape, where close bonds to the land might result in high place attachment and nature bonding but where mediating factors (e.g. incomes and resource use) might more strongly influence attitudes and behaviors towards energy conservation. This study raised several points of discussion.

First, our results support previous studies on place attachment and confirm that place identity, place dependence, and nature bonding are valid and reliable measures of place attachment in

rural communities (Raymond et al. 2011). Within traditional cultural landscapes and rural villages, attachment to the natural environment (i.e. nature bonding) is especially relevant and strong. Our research supports previous studies that show residence length is a strong and positive predictor of attachment (Lewicka, 2011).

Second, the results of this study add evidence that place attachment has a mixed influence on pro-environmental attitudes and behavioral intentions. Sub-dimensions of place attachment were related to energy attitudes, though in different ways than we hypothesized. Place dependence was the only sub-dimension to have a significant relationship on energy attitudes and the effect was negative. Further, our model shows that place identity is the only sub-dimension with a strong relationship with behavioral intent, again with a negative effect. There is no relationship between energy attitudes and intention, which does not align with prominent theories (e.g. Ajzen's Theory of Planned Behavior, 1985) that suggest attitudes mediate behavior. The negative relation between place dependence and energy attitudes may reflect a desire to conserve traditional practices related to energy usage, although this would require further investigation. The explanation for the negative relations between place identity and behavioral intent is unclear and requires further investigation, but may, similarly, be related to a desire to maintain traditional customs (e.g. Blumstein et al. 1980) linked to inhabitants' sense of place.

Lastly, the relationships found in our dataset are fairly weak and very few paths are statistically significant. This sheds light on the complex relationship between these constructs and points to the presence of additional factors— such as education, residency, income and energy availability—that mediate the relationship between attitudes and behaviors in this region. For example, perceptions about the cost, or possibility, of energy conservation may be greater than the positive influences of place attachment as a determinant of pro-environmental behavior related to energy use. These mediating factors might be especially interesting in rapidly changing landscapes such as Eastern Europe. For example, the relative poverty in the study area may mean that energy conservation behavior may be limited to

'technological choices' (such as switching energy sources) rather than 'habitual' action (such as curtailment of energy use) (Stern, 1992). Such technological choices may be perceived as out of reach in poorer, rural communities.

CONCLUSION

Understanding the relationships people form with their social and natural environments is a crucial element for understanding pro-environmental attitudes and behaviors. This study tested the validity of three dimensions of place attachment in a rural Romanian context and examined the socio-demographic predictors of place attachment in this region. Additionally, SEM was used to test hypotheses about the relationship between place attachment, energy conservation attitudes, and behavioral intentions to reduce energy consumption.

Our findings contribute to the literature in two ways. First, our results support the three sub-dimensions of place attachment as a valid construct. Nature bonding, in particular, is a relevant sub-dimension to consider when studying rural communities and those with close ties to natural environments. This study reinforced the importance of studying human-nature bonds, though failed to provide evidence that these bonds influence energy conservation attitudes and behavioral intention in rural communities.

Second, our research highlights the need to contextualize place attachment research within a larger systems narrative about energy transitions. The low factor loadings in our structural model highlight that there are many unmeasured variables affecting energy attitudes and behaviors in this region, including structural and material constraints. Additionally, no significant relationship between energy attitudes and behaviors highlights the need to conduct more research on the relationship between place attachment and environmental attitudes and intentions in rural and transitioning regions.

Place attachment is one piece of understanding the social side of energy transitions. However, understanding, and intervening in, the energy system of a cultural landscape such as Eastern Transylvania, Romania, will require a systems approach that takes into account the various social, environmental, and economic forces that shape energy behavior. Applying a framework that integrates variables such as place attachment, norms, and physical and environmental factors (e.g. the Energy Cultures Framework; Stephenson et al. 2010) might provide an appropriate lens for understanding the energy system of this region and tailoring effective interventions.

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Table 1. Correlations between socio-demographic variables and place attachment sub-dimensions

	Place Dependence	Place Identity	Nature Bonding
Age (categorical)	.249**	.079	.183**
Education (categorical)	-.180**	-.136**	-.076
Income (categorical)	-.098	-.138**	-.074
Length of residence (0-100 yrs)	.313**	.251**	.158**

Significance level Spearman's R: *$p < 0.05$, ** $p<0.01$

Table 2. Construct reliability and factor loading

Construct	Factor mean	Item Mean	Cronbach's alpha	Factor Loading
Place Attachment (all)	**4.057**		**.899**	
Place dependence	**3.879**		**.750**	
This village is the best place for what I like to do		3.723		.51
I would not substitute any other area for the activities I do in this village		3.708		.60
No other place can compare to this village		3.959		.50
I get more satisfaction out of living in this village than any other place		4.075		.60
Doing my activities in this village is more important to me than doing them in any other place		3.930		.76
Place Identity	**4.057**		**.859**	
This village is very special to me		3.995		.57
This village means a lot to me		4.189		.73
I am very attached to this village		4.140		.77
I identify strongly with this village		3.908		.74
Living in this village says a lot about who I am		3.875		.72
I feel this village is a part of me		4.237		.69
Nature Bonding	**4.234**		**.733**	
When I spend time in the natural environment in this village, I feel a deep feeling of oneness with the natural environment		4.230		.63
I would feel less attached to this village if the native plants and animals that live here disappeared		4.276		.44*
I learn a lot about myself when spending time in the natural environment in this village		4.074		.54
I am very attached to the natural environment in this village		4.294		.70
When I spend time in the natural environment in this village, I feel at peace with myself		4.296		.77
Energy Attitudes (*reverse coded in analysis)*	**2.945**		**.706**	
Energy conservation is too much of a hassle		2.935		.53
Energy conservation means I have to live less comfortably		2.721		.65
My quality of life will decrease when I reduce my energy use		2.959		.66
It takes too much of my time to reduce energy use		3.165		.61
Behavioral Intention				
I would change my daily routine to conserve energy		3.127		

All items measured on a 5-point scale ranging from 1 = strongly disagree; 5 = strongly agree
*Removed from CFA and SEM analysis due to low factor loading

Table 3. Model fit summary

Model	x^2	df.	p value	RMSEA	CFI	IFI	SRMR
Measurement Model	395.155	143	.000	.069	.905	.906	.0594
Structural Model	410.314	158	.000	.065	.905	.906	.0578

Table 4. Results of hypothesis testing using SEM

Hypothesis	Estimates	t-value	p-value	Result
H_{1-A} PD → AT	-.441*	-2.029	.042	Rejected
H_{1-B} PI → AT	.116	.619	.536	Rejected
H_{1-C} NB → AT	.097	.776	.438	Rejected
H_{2-A} PD → BI	.074	.409	.683	Rejected
H_{2-B} PI → BI	-.356*	-2.235	.025	Rejected
H_{2-C} NB → BI	.208†	1.950	.051	Rejected
H_3 AT → BI	.019	.287	.774	Rejected

Significance level: *$p < 0.05$; † $p<0.100$

Figure 1. Hypothesized structural model

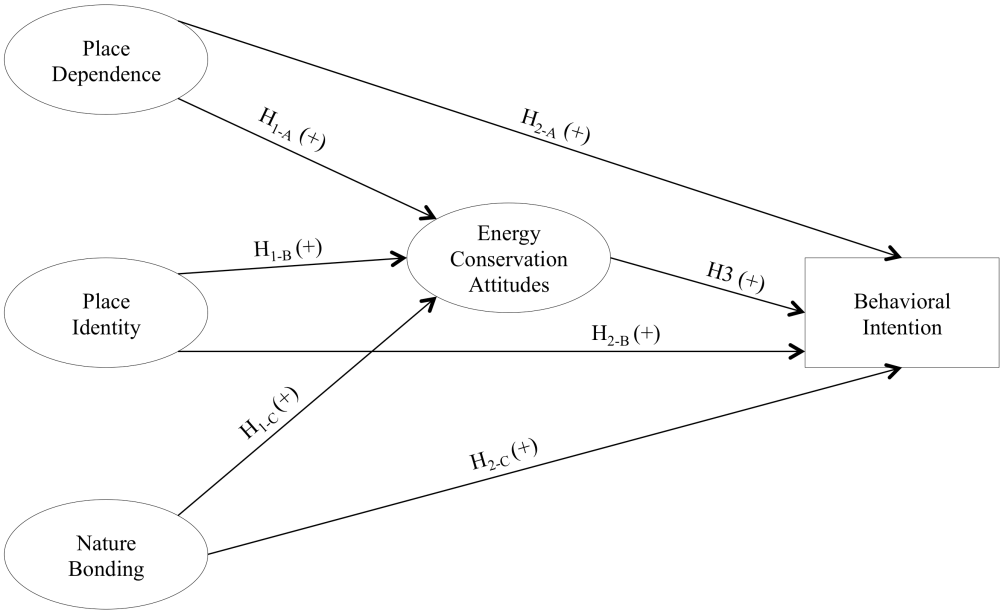


Figure 2. Location of (a) study area in Romania and (b) six communes of the Pogány-havas microregion. In (b) dots indicate villages, light grey indicates Harghita County and dark grey indicates Bacau County.

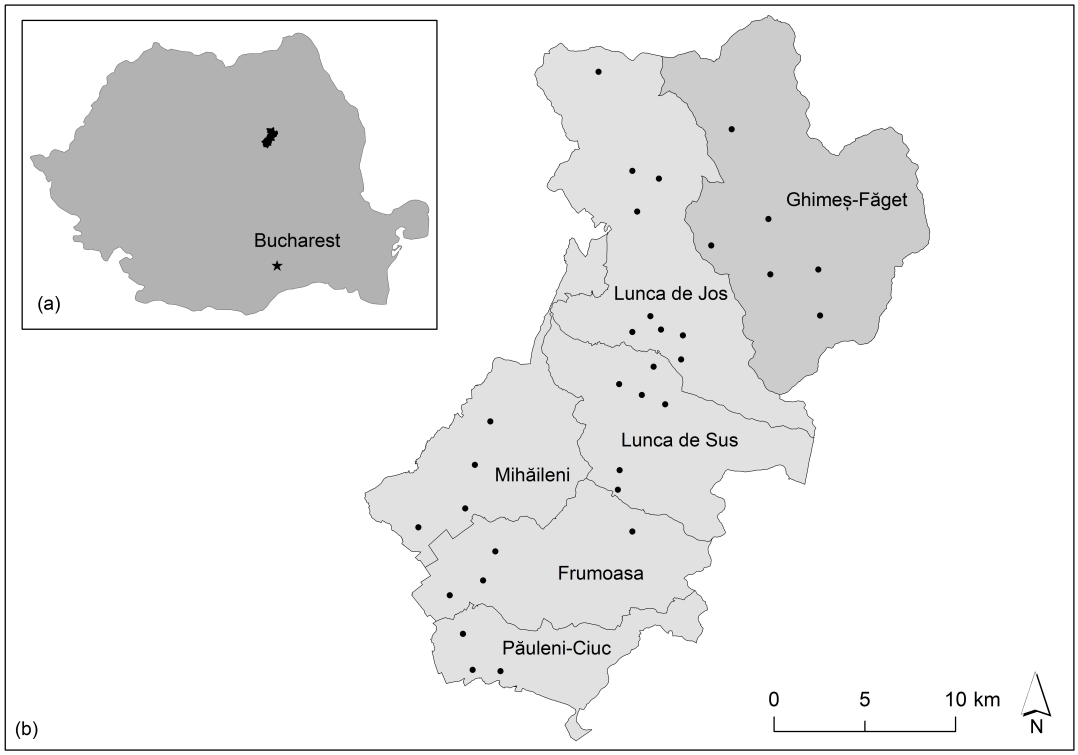
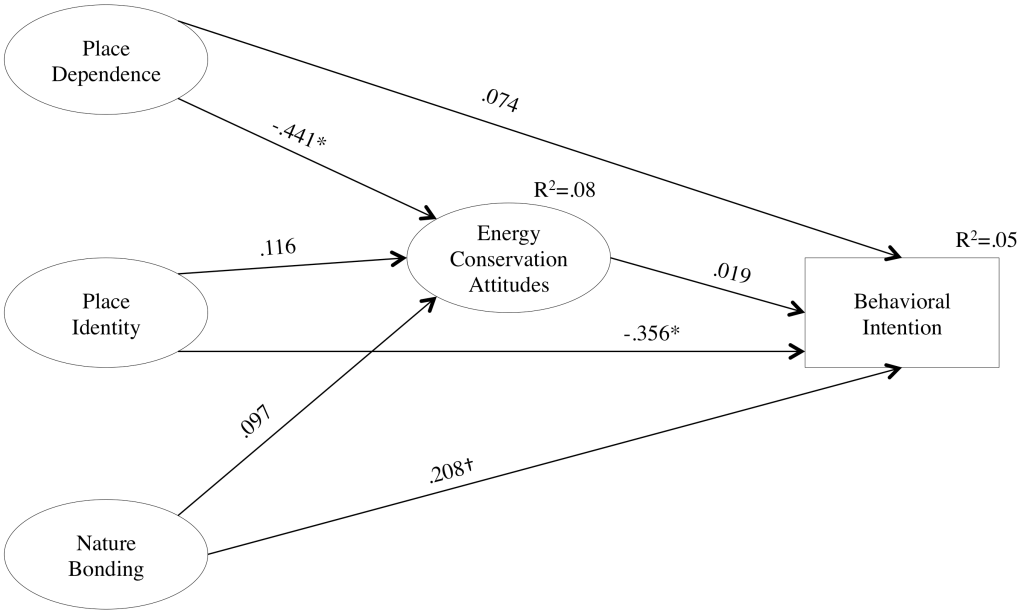


Figure 3. Standardized structural model. Significance level: *$p < 0.05$; † p<0.100



Chapter VIII

sustainability

MDPI

Article

Applying the Energy Cultures Framework to understand energy systems in the context of rural sustainability transformation

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Abstract:

Addressing the threat of global climate change will require large-scale transformation of our energy systems. Scholars are increasingly calling for a more systemic approach to studying energy transitions—one that incorporates human dimensions such as behaviors, attitudes, perceptions, and preferences [1]. Drawing on a exploratory representative study (n=379 surveys) conducted in the Pogány-havas microregion of eastern Transylvania, Romania, we employ the Energy Cultures Framework [2] to describe and discuss the social and material energy system of the region. We highlight the interactions between norms, energy practices and material culture, as well as external influences that are shaping the energy system. We discuss attitudes towards energy conservation and acceptability of community renewable energy schemes. Based on our findings, we define the dominant energy culture of the region and highlight elements of the system that are either reinforcing the status quo or shaping a more sustainable energy culture. We discuss implications for increasing the efficiency of the energy system of this region and factors that could inform energy policies and sustainability interventions. We conclude by situating our research within a larger narrative of rural energy transitions and discuss the value of a systems approach when undertaking energy systems research.

Keywords: energy transition; renewable energy; pro-environmental behavior; attitudes; norms; energy conservation; Energy Cultures Framework; rural energy

1. Introduction

Transitioning to sustainable energy systems is ever more urgent given the impacts of global climate change, fluctuations in energy prices, growing populations, and rising energy consumption [3,4]. In order to secure sustainable futures, societies must transform energy infrastructure, adopt low-carbon technologies, and promote changes to individual and community consumption behaviors [1,5–7]. However, such sustainability transitions are challenging given rapid changes in the energy sector, an increasing urgency to act on environmental problems, and changing socio-demographic characteristics of communities [8].

Energy systems are dynamic systems that are made up of complex interactions between policies, infrastructure, technologies, and human behaviors [9,10]. Scholars acknowledge that sustainable energy systems can only be secured by incorporating social science into the study of

energy transitions [11,12], yet these topics have traditionally been studied with a narrow technological lens and have primarily focused on the development of more efficient technologies [13]. A review of 15 years of energy research found that the field was dominated by physical sciences, engineering and economics disciplines, which tend to research innovations and hardware and devote less attention to human factors such as the attitudes, perceptions, and decision-making processes that shape energy consumption and use [13]. By heavily focusing on improving technical efficiencies and making the economic case for energy interventions, researchers have failed to recognize the human dimensions of energy use [14]. This approach has primarily ignored the social interactions that shape energy consumption (e.g. acceptability of energy technologies and attitudes towards changes in the energy system) or has seen these elements as operating independently from the technical aspects of the system. Moreover, this perspective fails to recognize that energy transitions are occurring under markedly different economic backgrounds, political systems, and socio-cultural conditions. Studies of energy transitions must take a more human-focused approach and integrate social science into methodological approaches. Integrated approaches that take a systemic perspective to understand energy use, aspirations, and perceptions are likely to offer enhanced insights to the study of energy transitions, as they integrate multiple disciplinary approaches [15,16].

1.1. Energy transitions in rural regions

Incorporating social science into the study of energy transitions may be particularly crucial in rural areas. Rural energy planning requires special attention of "both human and technical factors and the complex and dynamic interactions between them" [8] (p. 1418). Transitioning to low-carbon energy systems in rural areas requires different approaches than urban area transitions and usually comes with a different set of motivations, goals, and outcomes [17].

In rural contexts, energy transitions are usually coupled with reducing poverty, improving security and reliability of the energy system, and improving the livelihoods of rural residents [18]. Energy transitions must take into consideration a transition "towards a more sustainable energy system characterized by universal access to energy serves, and security and reliability of supply from efficient, low-carbon sources" [19] (p. 331). In some rural regions under transition, for example in eastern Europe and the former Soviet Union, the future of the energy system is less about universal access but is more about the affordability of the supply, the reliability of the energy system, and the source of the energy. In addition to this, some communities are 'trapped' in housing agreements and heating systems that do not allow them for switching towards affordable and more comfortable energy sources [20].

Transition to a low-carbon energy system can also be a key aspect of rural sustainable development. The goal of energy transitions in these regions are not typically on reducing high energy consumption, but rather to enable local income generation, increase security and independence of the energy system, and capitalize on local resources [8]. Renewable energy, for instance, can have the highest impact in "areas with low levels of socio-economic development and high RES [renewable energy sources] potential" [21] (p. 531). The implementation of renewable energy can have economic benefits in the form of new income sources, increased local participation in community issues, and decreases in energy-related costs over the long term. At the same time, it can also increase energy security, decentralize the energy supply, and fundamentally increase the quality of life in the rural regions [21].

1.2 The Energy Cultures Framework

One approach that considered the human dimensions of energy systems is the Energy Cultures Framework [2,22], which takes a multidisciplinary and systems thinking approach towards understanding interrelationships within an energy system. The Energy Cultures Framework is an exploratory tool designed to encourage interdisciplinary inquiry of energy transitions and sustainability outcomes. The aim of the framework is to understand and study energy behavior

within a wider social and material context, and to identify similar patterns of norms, practices and material culture [22] (Fig. 1). Norms are defined in this framework as "people's expectations and aspirations about their practices and material culture"; material culture is comprised of "the technologies, structures and other assets that play a role in how energy is used"; and practices refers to "both routinised activities and to actions that may occur relatively infrequently" [22] (p. 119). Additionally, the framework looks at the external influence of factors such as income, education, demographics, regulations, price structure, and available technologies [2]. These are described as the elements of the system that sustain the energy culture, lock in behaviors, promote system change, or create resistance to change [22].

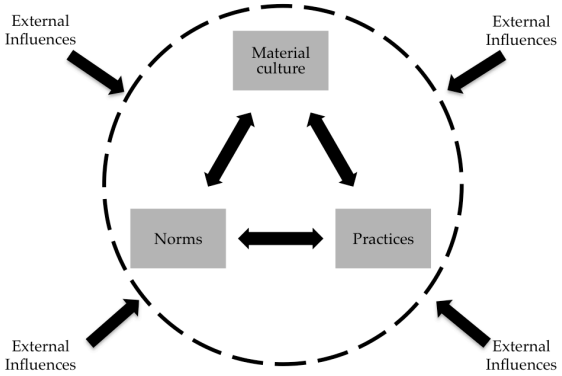

Figure 1. The Energy Cultures Framework [22][1]

The framework is useful for investigating the interplay of cultural factors, people's perceptions and aspirations, and material culture and technology. The Energy Cultures Framework is gaining ground across various sectors and contexts, as it is designed to be broad and integrative and applicable to scholars from different disciplinary backgrounds. The framework can be used as an interpretive lens, an organizing principal, or as a detailed analysis instrument.

In this study, we examine rural energy transitions and energy behaviors using the Energy Cultures Framework as an interpretative lens and extend the framework to a new context. In this research, we use the framework post-hoc to provide a structure for analysis of our data. Previous publications using the framework as an analysis tool have applied a variety of methodologies, including focus groups [23,24], quantitative questionnaires [25] and interviews [26–29]. Using cluster analysis to segment the population into distinct energy cultures is a prominent data analysis technique. For example, Hopkins [28] produced quantitative clusters of mobility practices and Lawson and Williams [30] used TwoStep cluster analysis to identify four clusters of energy consumption in households.

1.3 Aims and research questions

In this study we apply the Energy Cultures Framework to a microregion in Eastern Transylvania, Romania. In rural regions under transition, a systems approach to understanding the energy system may be particularly useful for identifying barriers and opportunities for energy conservation. Within complex systems and societies, which are composed of highly intricate

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127 interactions between individuals, structures, and materials, there are likely to be barriers,
128 constraints, and opportunities that do not emerge or become evident when studying one element of
129 the system (e.g. uptake of a particular technology) in isolation.
130 In this study, we are interested in exploring the drivers of energy behaviors and attitudes in
131 the region and, through the application of the Energy Cultures Framework, assessing which factors
132 are hindering or promoting a sustainable transition for the region. Specifically, we address four core
133 research questions, which were in part inspired by Stephenson's [31] questions for further research:
134
135 *Q1: What socio-cultural factors are influencing energy attitudes and energy behaviors in this region?*
136
137 *Q2: Can clusters of similar energy cultures be identified in our region that have similar sustainability*
138 *outcomes? What elements of material culture, norms and practices define these clusters?*
139
140 *Q3: Which elements of the system are reinforcing the current energy system and which elements are*
141 *constraining people's' behaviors and aspirations?*
142
143 *Q4: What does this analysis reveal about the sustainable trajectory of this region? What sustainability*
144 *outcomes are likely to occur if aspects of the energy culture change?*
145
146 In the following sections of the paper, we describe our study area and define the energy culture
147 of the region. We then draw upon the Energy Culture Framework to address each of our research
148 questions and conclude with insights on the usefulness of the Energy Cultures Framework in a
149 rural, low-income region and how our study contributes to the advancement of this framework.

150 **2. Materials and Methods**

151 *2.1. Study Area*

152 The data was collected in the six communes that make up the Pogány-havas microregion of
153 Transylvania, Romania. The region is an administratively bounded region that was delineated by
154 local councils in 1999 and consists of 6 communes[2]—Păuleni-Ciuc, Mihăileni, Frumoasa, Lunca de
155 Sus, Lunca de Jos and Ghimeş-Făget—with 32 villages (Fig. 2). According to 2011 census data, the
156 population of the region is 22,159. The six communes are connected by national road 12A, which
157 stems from the nearest city, Miercurea Ciuc (population=37,980). The microregion spans across two
158 counties: Harghita County and Bacău County. The region's population is primarily made up of a
159 Hungarian speaking ethnic group, the Székelys. The landscape consists of small land holdings, with
160 most residents practicing semi-subsistence farming, extensive livestock grazing, and maintaining
161 hay meadows and grasslands [32,33]. The surroundings of the region are made up of large swaths
162 of forests, hay meadows, mountainous areas with deep valleys and wide basins. The region is home
163 to some of the most biodiverse and productive pastures and meadows in Europe [32] and
164 numerous threatened species [34,35].
165

[2] Communes are a Romanian administrative unit made up of several villages (NUTS level 3).

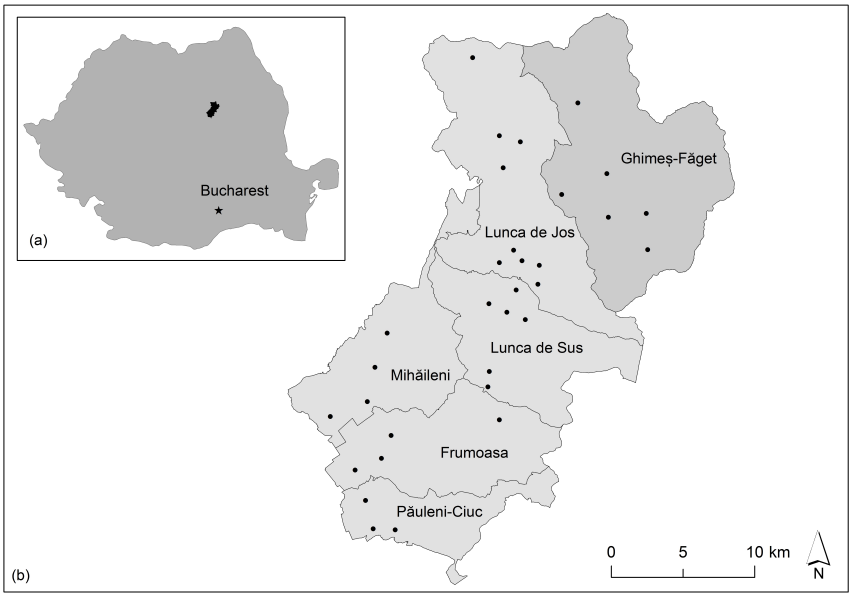


Figure 2. Map of (a) the location of the Pogány-havas microregion in Romania, and (b) the six communes and 32 villages (indicated as dots) that make up the microregion. In (b) Harghita County is indicated by the lighter grey and Bacău County in darker grey.

Romania has high renewable energy potential [21,36,37] and the topography and landscape of the Pogány-havas microregion makes portions of the region suitable for wind and solar energy generation [38]. In addition, the rural nature of the region, the high amount of forestry and agriculture, and livestock means the region has a wealth of biomass sources and may be well suited for biogas plants or biogas heating systems [21]. During the time of our data collection, plans for a biogas plant in one of the villages had just been approved and were mentioned by several respondents. The plant is designed to process agricultural waste and generate energy for the local dairy.

In terms of access to electricity, most of the rural areas of Romania were connected to the electricity network between 1950 and 1970, though today many of the networks are old, unreliable, and declining due to age and lack of maintenance [37]. In the Pogány-havas microregion, there are few options for energy providers. In Harghita County, Electrica Furnizare S.A. Transilvania Sud provides electricity and S.C. Hargaz Harghita Gaz S.A provides natural gas. The price of electricity ranges from 143RON/kWh to 215RON/kWh. In Bacău County, Delgaz Grid S.A is the electricity and gas provider. This region is highly reliant on traditional biomass use for heating and cooking needs. The preferred source of biomass is wood; primarily birch, pine and spruce harvested from personal property and unmanaged forests. The price for wood ranges from 185 RON/m^3 to 293 RON/m^3. The majority of households also use propane tanks for cooking. The cost of a 10kg propane tank ranges from 150-390 RON.

While energy prices in Romania are considerably below the European average, many households face problems with price affordability and energy poverty due to low incomes and low purchasing power [39]. Approximately 40% of the population experiences energy poverty [40] and rural households spend up to 18% of their net household income on energy costs [41]. In rural areas, approximately 90% of homes are only partially heated due to low incomes and inability to pay heating bills [39,42]. In Bacău County, only 20% of the households are energy secure and have proper heating systems installed.

2.2. Questionnaire Instrument

197 We developed a questionnaire to assess the energy culture of the Pogány-havas microregion.
198 The survey was developed between August and October 2017. The survey items were prepared in
199 English and translated into Hungarian and Romanian (the two languages of the region) by the
200 research team. Items were backtranslated to ensure that the meaning of the original items was
201 maintained.
202 The questionnaire consisted of items related to material culture, norms, practices, and external
203 influences (Table 1). Norms were measured using: (1) social acceptability of renewable energy
204 technologies (3 items) [43], (2) the New Ecological Paradigm (NEP) scale (15 items) [44], (3)
205 environmental personal norms (4 items) [45], and (4) energy conservation attitudes (4 items) [46]. In
206 addition, we collected information on barriers to adoption of renewable energy technologies using
207 one open-ended question. Material culture was assessed with items addressing the use of
208 electricity, natural gas, wood, renewable technology, and propane in the house (1 item each), as
209 well as a count of the number of major appliances (0-6). Practices were measured using: (1)
210 self-reported energy behaviors (2 items), (2) energy conservation intentions (2 items) [45], (3) cost
211 constraints (2 items), (4) energy knowledge (4 items), (5) behavioral constraints (2 items), (6)
212 monthly electricity costs (1 item), (7) knowledge of electricity costs (1 item) and (8) motivations for
213 conservation (1 item). External influences were measured using items on demographics (4 items),
214 occupation (1 item), household income (1 item), household size (1 item), and length of residency in
215 village (1 item). Items were measured using categorical responses, ordinal responses (Likert-type
216 scales), and continuous variables.
217

218 **Table 1: Variables used in analysis**

Variables	# of items	Measurement
Norms		
Acceptability of renewables	3	6-point Likert scale (*1= totally unacceptable to 6=perfectly acceptable)*
New Ecological Paradigm (NEP)	15	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*
Environmental personal norms	4	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*
Energy conservation attitudes	4	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*
Barriers to renewable adoption	1	Open-ended question
Material Culture		
Electricity	1	Categorical (*presence/absence)*
Natural Gas	1	Categorical (*presence/absence)*
Wood	1	Categorical (*presence/absence)*
Renewable	1	Categorical (*presence/absence)*
Propane	1	Categorical (*presence/absence)*
# of appliances	1	Continuous: 0-6
Practices		
Self-reported energy behaviors	2	Categorical (*yes/no)*
Energy conservation intentions	2	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*
Cost constraints	2	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*
Energy knowledge	4	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*
Behavioral constraints	2	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*
Monthly electricity bill	1	5-point Likert scale (1=*strongly disagree to 5=strongly agree)*

Knowledge of electricity costs	1	Categorical (*yes/no)*
Motivations for conservation	1	Categorical (*yes/no)*
External Influences		
Socio demographics	4	Categorical
Occupation	1	Open-ended question
Household income	1	Categorical
Household size	1	Continuous
Residency in village	1	Continuous

In our analysis we did not create summated scores or latent variables with our items (e.g. one 'attitude' score from the 4 attitudes items). The one exception was the way we treated the 15-item New Environmental Paradigm (NEP) scale [44]. We summed the odd and the even variables to create two latent variables for our analysis: biocentric and anthropocentric. A high score in the odd items indicates a biocentric or pro-ecological viewpoint, whereas a high score in the even items indicates an anthropocentric or negative ecological viewpoint [44]. All other items were treated as individual items in our analysis, as the focus of this paper was not on internal scale reliability or creating correlated latent variables. Additionally, this allowed us to examine responses to each survey item rather than one summated score.

Data was collected by paper questionnaires and was administered using a systematic sampling technique (n=379). The sampling approach aimed to be representative of the region and to get a diverse set of respondents. For the population size of the region, we calculated that 378 surveys were needed for a representative sample (95% confidence, 5% margin of error). We assigned a target number of surveys to each of the six communes proportionally by population. In the field, we approached every fifth house and asked the first adult on the property to participate in our survey. The respondent was asked to answer based on their own thoughts and opinions, though for income, household size and energy sources the respondent was asked to answer as a representative of their household. The survey was administered in Hungarian and Romanian by the research team and two local research assistants. Due to the rural nature of some of the villages and many empty houses, the sampling technique could not be applied in every instance (~10% of cases). Thus, while we aimed to collect a representative sample, we make no claims that the survey sample is entirely representative of the microregion.

2.3. Data Analysis

Prior to analysis, data was screened for errors in questionnaire completion and data entry. Missing data was deleted pairwise in our descriptive statistics and listwise in our cluster analysis. All statistical analysis was conducted in SPSS v.25. The organizing principles of the Energy Cultures Framework were applied post-hoc to our dataset as a tool to structure and analyze our results.

We used cluster analysis as our primary data analysis technique in an attempt to identify homogenous groups within our population that would be characterized by similar norms, practices, and material culture. Our aim was to segment the population into distinguishable Energy Cultures that could be described, compared and discussed. We applied a TwoStep cluster analysis [47] in order to segment and classify the Energy Cultures of the microregion. The TwoStep clustering method is useful when working with large datasets (> 200) and is able to create clusters based on both categorical and continuous variables. Log-likelihood distance measure and Schwarz's Bayesian Criteria (BIC) were selected. Before clustering we checked the levels of collinearity among the variables. No variables were highly correlated (correlation coefficients > 0.90), thus all variables were retained.

We took three approaches to clustering our data. The first approach used all 66 variables as inputs in the cluster analysis. SPSS determined the number of clusters automatically and produced a two-cluster solution. However, this solution was unstable and had a poor silhouette score. The

second approach was to fix a 3-cluster solution and analyze the output, followed by fixing a 4-cluster solution and analyzing the output. This is permitted in TwoStep cluster analysis methodology and is seen as a benefit of this method of clustering. Yet, the cohesion and separation of the solutions remained poor (0.1-0.2 range) in all solutions. This suggests that our data is not strongly matched with the defined clusters, nor are the clusters strongly separated. Additionally, few variables strongly predicted membership in any of the clusters. In our last approach, we narrowed the clustering input to 24 Likert-scale variables. We removed binary variables, as these variables 'swamped' our previous attempts and resulted in clusters determined solely by one or two binary variables with little variance. The clustering of 24 variables resulted in a 1-cluster solution. We used this final solution for analyzing the Energy Culture of the region.

Additionally, we conducted statistical analysis on the variables within the categories of Material Culture, Norms, and Practices. The Spearman rank-order correlation coefficient was used to measure correlations between variables. This enabled us to better understand the variables that characterized the dominant energy culture and the relationship between variables.

3. Results

3.1. Description of the sample

The sample was skewed towards female respondents (64.4% in our sample versus 49.24% reported in the 2011 census) but fairly representative for ethnicity (91.3% Hungarian/Székely ethnicity compared with 84.7% reported in the 2011 census) (Table 2). The age range was fairly dispersed, with 11.9% of the population aged 18-29, 40.4% between 30-49, 25.9% between 50-64, and 21.9% over 65 years of age. The mean length of residency was 39.73 years, with 31.7% of the population living in their village for over 50 years. Retirees made up 38% of the population, 12% reported their occupation as farmer, and 11% reported being a housewife. Other occupations reported reflect the nature of this rural region: tailor, mushroom collector, milk collector, mechanic, craftsman, gardener, farrier, carpenter, and beekeeper. Seventy seven percent of the population holds a high school diploma or fewer years of school, whereas 12.2% of the population holds an undergraduate or graduate degree. The income of this region is low compared to many European nations; 61.9% of the population earns the equivalent of less than 1600 RON [~350 EUR[3]] per month.

Table 2. Descriptive statistics of respondents

Variable	%
Gender	
Male	35.6
Female	64.4
Age	
18-29	11.9
30-49	40.4
50-64	25.9
65+	21.9
Ethnicity	
Romanian	5.0
Hungarian	91.3
Roma	0.8
Other	1.6
No response	1.3

Education	
No schooling	1.1
12th grade or less	58.0
High-school diploma	18.5
Professional or vocational school	10.3
Undergraduate	10.6
Graduate	1.6
Household income (RON/month)[3]	
0-400	9.5
401-800	16.4
801-1200	18.5
1201-1600	19.5
1601-2000	13.7
2001-2400	12.1
+2400	9.2
No response	1.1

3.2. The Energy Culture of the Pogány-havas microregion

The results of the TwoStep cluster analysis suggest a one-cluster solution. Cluster quality was not computed, as the data resulted in a single-cluster solution. These results highlight that this region cannot be easily segmented into clusters of satisfactory quality. The only variable that strongly predicted the clusters was whether or not the household used natural gas or propane for their cooking. While there is variation in the individual responses, the Energy Culture of the region can be thought of as one fairly homogenous culture. With 24 inputs and 379 responses, there was enough data to segment into clusters if strong clusters were present in the data. The variables that were used in the cluster analysis were primarily variables from the 'norms' and 'practices' subsections. This was due to all but two of the material culture items being dichotomous variables. However, due to the lack of variation in the material culture variables we were confident with the variables included in the analysis.

A description of the variables, stacked bar plots of Likert-type responses, and general descriptive information about each of the three dimensions of an Energy Culture will be described in the following sections.

3.3.1. Material Culture

The material culture of a region is defined by "the technologies, structures and other assets that play a role in how energy is used" [22] (p. 119). This can consist of items such as appliances, building materials and insulation, and energy production technologies (e.g. photovoltaic panels). The use of wood for cooking or heating is prominent (98.4%), though residents rely on several sources of energy for their heating and cooking needs. 52.2% of residents use two sources of energy for cooking (e.g. wood and propane gas), whereas only 14.2% of residents use two sources of energy for heating (e.g. electric radiators and wood). Natural gas is fitted in 32.5% of the homes, though this is concentrated in modern homes in the villages closest to the city of Miercurea Ciuc. Propane for cooking is primarily bought from local businesses and neighbors, while wood is harvested from personal property or bought from neighbors.

Most homes in the region (80.5%) are outfitted with the same three appliances: a refrigerator, a washing machine, and a television. It's also common to have an outdoor kitchen with a wood stove

[3] The exchange rate at time of data collection (October-December 2017) was ~ 4.63 RON = 1.00 EUR.

for preparing traditional foods. More energy-intensive appliances such as clothes dryers (0.8%), dishwashers (12.7%), and air conditioners (0.5%) are uncommon. In this region, the use of modern renewable technologies is very limited. Four respondents reported having a solar hot water heater fitted to the roof of their home.

We did not collect data on the structure of the homes in the region, the insulation type, or the energy efficiency of the building structures. From observation and discussions, we can state that most of the homes in this region are single-story, stand-alone homes. Some of the homes have central heating and radiators, but most homes do not have central heating and rely on traditional wood stoves to heat the home. Many respondents reported that they only heat one room of their home and leave other rooms cold to save on energy costs.

In terms of electricity supply, 99.5% of respondents had electricity in their home. However, 77.6% of the population reported feeling constrained in their ability to choose the type of energy they consume. This points to low choice of energy provider or alternatives to current energy supply. As is common in Romania, electricity providers are limited and much of the energy infrastructure is relatively old and outdated.

Nearly everyone surveyed (93.9%) could tell us exactly how much his or her household spent each month on electricity and many residents stressed that the bill was a large strain on their household budget. Per month, 8.2% of respondents pay between 0-49RON/month, 27.2% pay 50-99RON/month, 33.5% pay between 100-149RON/month, 11.9% pay between 150-199RON/month, and 13.7% pay more than 200RON/month[3]. Despite the high cost of electricity relative to incomes (Table 3), only six residents reported that they couldn't afford to pay their energy bill each month. Residents responded to this question in a practical manner, saying that since they are obliged to pay their bill they pay their bill, and thus can afford it.

Table 3. *Electricity Bill * Income Crosstabulation (% by income categories)*

	Income (RON*)						
Electricity Bill (RON*)	0-400	401-800	801-1200	1201-1600	1601-2000	2001-2400	2400+
0-49	27.30%	9.40%	7.00%	13.00%	4.30%	5.70%	1.70%
50-99	39.40%	31.30%	19.70%	37.00%	37.00%	25.70%	18.30%
100-149	12.10%	32.80%	56.30%	21.70%	39.10%	48.60%	26.70%
150-199	6.10%	18.80%	8.50%	8.70%	8.70%	14.30%	20.00%
200+	15.20%	7.80%	8.50%	19.60%	10.90%	5.70%	33.30%

*RON= Romanian New Leu

3.3.2. Norms

We measured energy norms by looking at social acceptability of renewable energy (3-items) (Fig. 3), the 15-item NEP scale, energy conservation norms (5-items), and energy conservation attitudes (4-items) (Fig. 4).

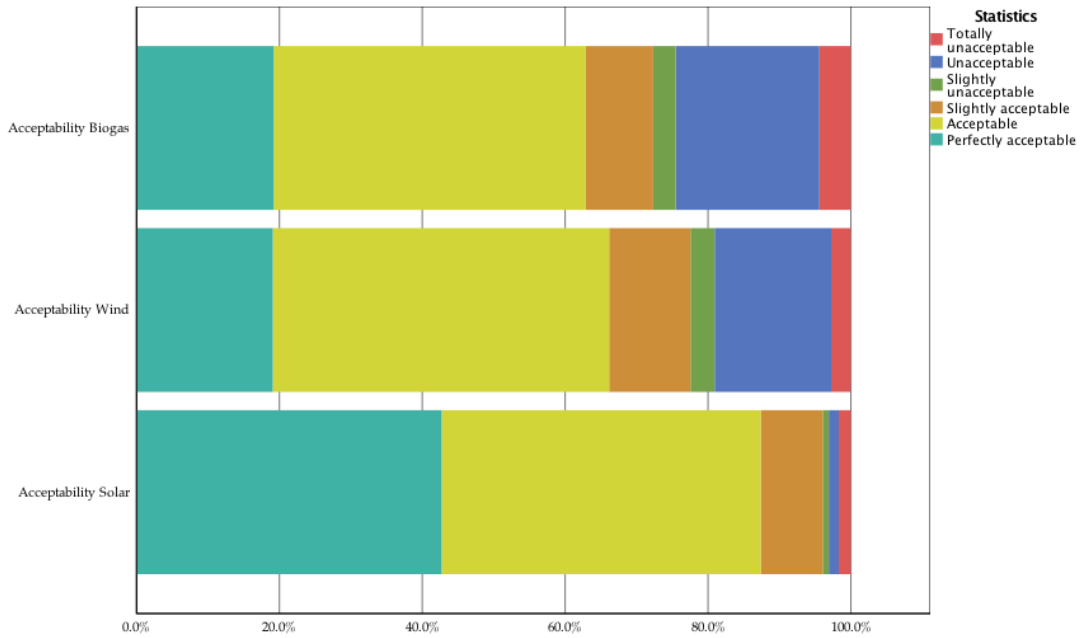


Figure 3. Survey responses to items on acceptability of community renewable energy (3 items) (n=379).

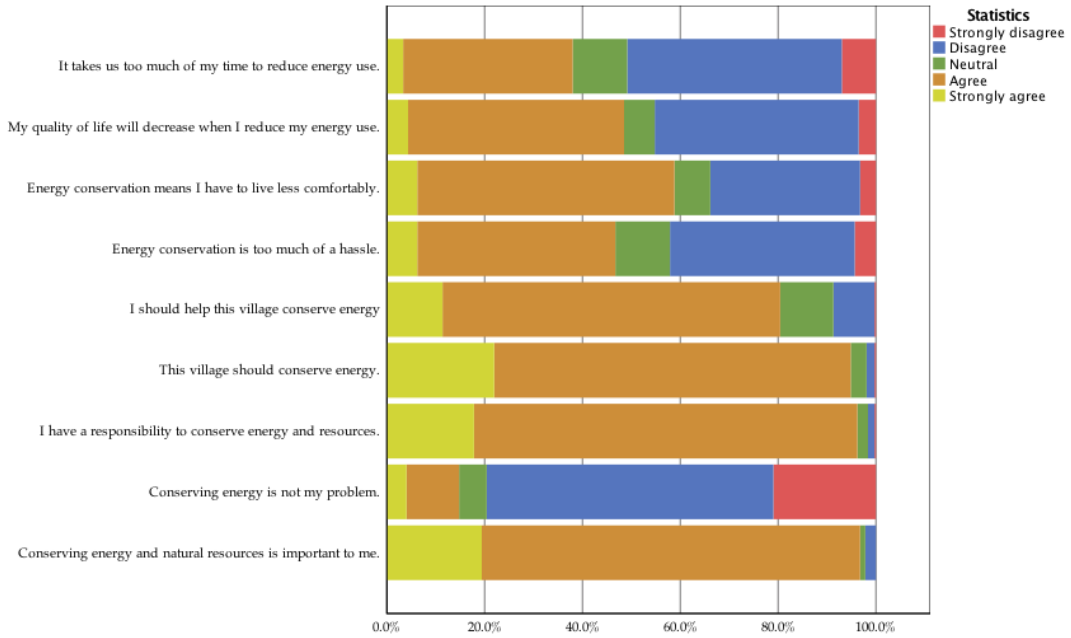


Figure 4. Survey responses to items on environmental attitudes (four items) and environmental personal norms (five items) (n=379).

Social acceptability of renewables was generally high and the mean responses for all items fell within the 'acceptable' range. Acceptability for a solar field in the village garnered the highest acceptance levels with a mean of 5.21 (SD=0.949). Wind farms (mean=4.41) and biogas power plants (mean=4.25) were slightly less acceptable. While the mean acceptability scores were high, differences in unacceptability were notable: only 3.9% of respondents found solar fields unacceptable, whereas 22.5% found a wind farm unacceptable and 27.7% found a biogas plant

unacceptable. During the survey collection, respondents commented on why they found these technologies more or less acceptable. Reasons mentioned included: their village not having the appropriate conditions for a wind farm, the negative aesthetics of a wind farm, a lack of knowledge about the technology, and distrust in government-run projects. Education was significantly associated with the acceptability of both solar (r_s = .140 , p = .008) and biogas (r_s = .147 , p = .008). Income was significantly associated with the acceptability of solar (r_s = .143 , p = .007) and biogas (r_s = .156 , p = .006).

The NEP scores were as follows: The biocentric scores were higher (mean=4.03) than the anthropocentric scores (mean=3.30). Many respondents had trouble with the wording of these survey items and needed clarification on what the item was asking. There was also a general tendency to 'agree' or 'disagree' with statements, leading to a low range of responses among respondents.

Environmental personal norms were measured using 5 items. The responses to these items suggest a high level of support for conserving natural resources and energy, but mixed opinions about whether they personally have a responsibility to conserve energy or if conserving energy is their problem. 'This village should conserve energy' was the statement respondents most strongly agreed with (mean=4.15), whereas the statements 'Conserving energy is my problem' (mean=3.82) and 'I should help this village conserve energy' (mean=3.83) had more mixed responses. A significant negative correlation was found between age and 'conserving energy is not my problem' (r_s = -.176 , p = .001). Significant associations were also found between education and 'conserving energy and natural resources is important to me" (r_s = .137 , p = .008) and 'this village should conserve energy' (r_s = .103 , p = .048). Income had a significant negative association with 'conserving energy is not my problem' (r_s = -.281 , p = .000) and a positive association with 'I should help this village conserve energy' (r_s = .166 , p = .002).

The four items to measure attitudes towards energy conservation were all negatively worded. Participants agreed most strongly (mean= 3.28) with the statement 'Energy conservation means I have to live less comfortably', and tended to disagree most strongly (mean=2.84) with the statement 'It takes up too much of my time to reduce energy use'. Age was significantly associated with 'my quality of life will decrease when I reduce my energy use' (r_s = .218 , p = .000) and 'energy conservation means I have to live less comfortably' (r_s = .144 , p = .005), whereas education was negatively associated with these two items (r_s = -.104 , p = .047) and (r_s = -.130 , p = .012).

3.3.3. Practices

The majority of our sample had already implemented some form of energy conservation practices (85%) and technologies in their home (81.5%). Participants stated that saving money was the driving reason for energy conservation measures, with 71.8% of the population reporting this as a reason for saving energy in their household. Similarly, 64.1% of the population agreed that cost considerations limited their energy consumption. Saving or reducing energy consumption for environmental reasons (25.3%), out of habit (23.5%) and to reduce resource use (12.7%) were less common explanations for energy conservation practices.

As for future behaviors, however, participants stated that they would purchase energy efficient products in the future (mean=4.03) but were less likely to change their daily routine to conserve energy (mean=3.13) (Fig. 5). Age was significantly and negatively correlated with future intentions to purchase energy efficient products (r_s = -.307 , p = .000), whereas education was positively correlated (r_s = .186 , p = .000). Approximately half of the sample (44.1%) felt constrained in their ability to reduce their energy consumption ('agree' and 'strongly agree'), while the other half of the sample felt less constrained (42.9%) ('disagree' and 'strongly disagree').

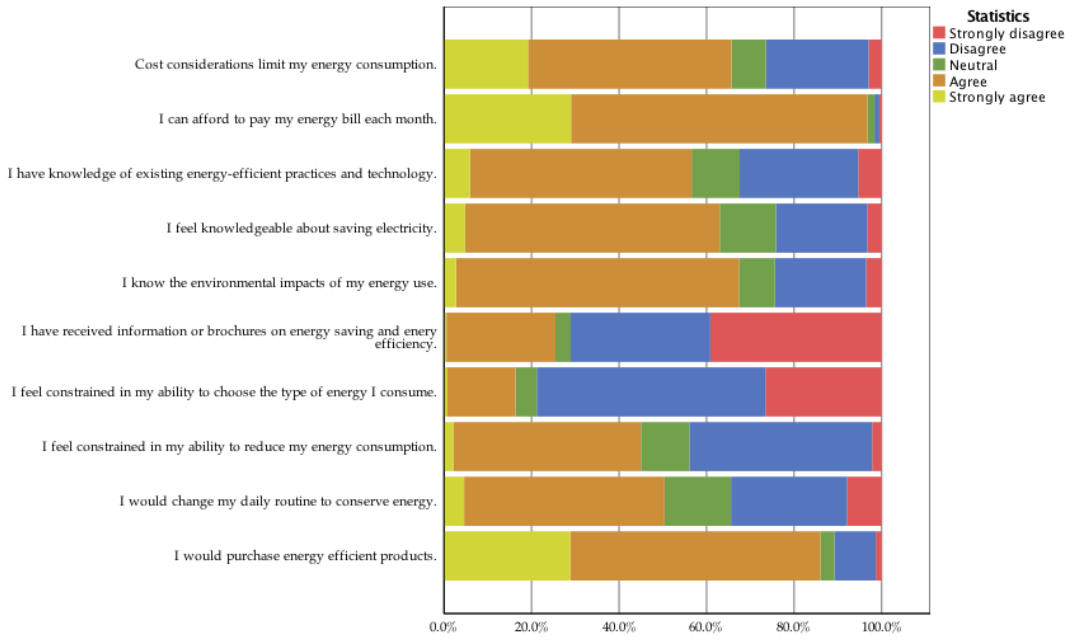


Figure 5. Survey responses to items on cost barriers (2 items), knowledge (4 items), behavioral constraints (2 items), and behavioral intentions (2 items) (n=379).

We also asked questions about knowledge of energy conservation practices and technologies. 69.9% of respondents hadn't receive information or brochures on energy savings and energy efficiency and 31.9% of respondents didn't feel knowledgeable about existing energy-efficiency practices and technologies. Yet, 64.9% reported knowing the environmental impact of their energy use and 62% felt knowledgeable about saving electricity. Age was positively correlated with feeling knowledgeable about saving electricity (r_s = .293 , p = .015) and having knowledge of energy-efficient practices and technology (r_s = .126 , p = .015). As well, education level and income were positively correlated with knowing the environment impacts of energy use (r_s = .135 , p = .010 ; r_s = .252 , p = .000) and having knowledge of energy-efficient practices and technology (r_s = .205 , p = .000 ; r_s = .215 , p = .000).

4. Discussion

Efforts to promote energy transitions and energy sustainability in rural regions are often impeded by our limited understanding of the complex interactions between norms, practices, and material culture that maintain and support energy behaviors. Our results show how these interactions are maintaining an energy culture in eastern Transylvania, Romania. The analysis of our sample found that factors such as incomes, attitudes towards conservation and frugality, and infrastructure are contributing heavily towards the current energy behaviors in this region.

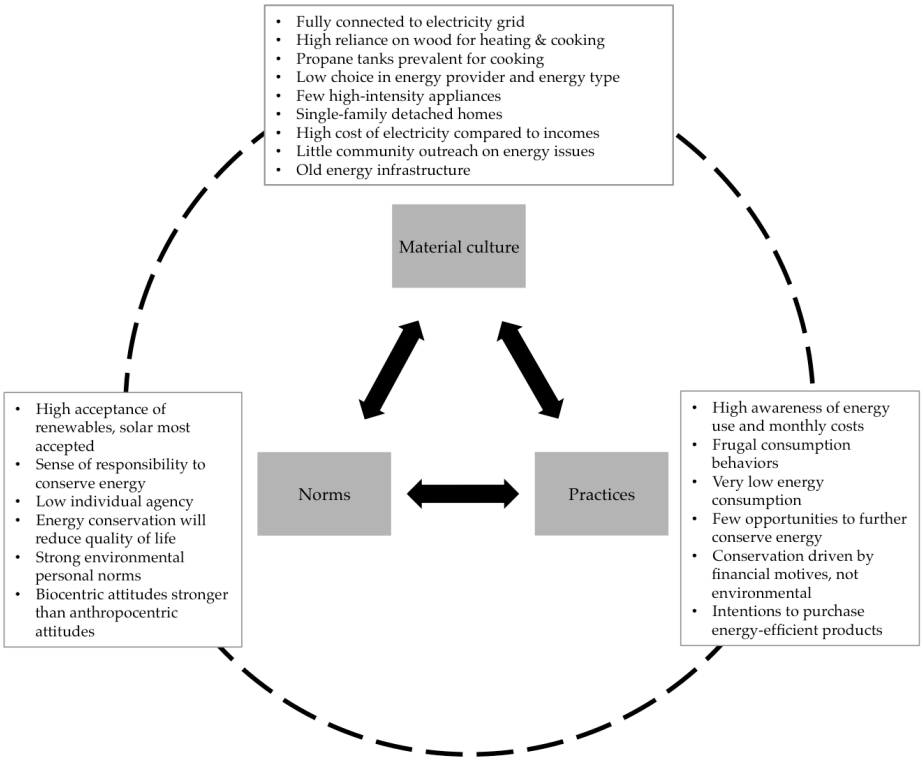
4.1. Socio-cultural factors that influence energy attitudes and energy behaviors in this region

This region is undoubtedly shaped by the age of the residents and the relocation of many young people to other regions of Romania and the European Union. Romania's population declined between 1990 and 2004, in part due to the migration of young people to other member states of the European Union in search of economic and educational opportunities [48]. This has led to an aging population. We heard from many respondents that the 'mindset' of the region is shaping the energy future of the region. This can either positively influence sustainable energy transitions or hinder it. For one, respondents who grew up in this region and have lived in their village for a long time spoke strongly about their frugal practices regarding resource use. This current ethos could be passed down to younger generations and be leveraged when the region transitions to new technologies or energy sources [33]. However, we also heard about how this mindset is holding

448 back innovation and advancements in the region. We heard that elderly people are set in their ways
449 and would not be accepting of large-scale changes to the energy system.
450 Household income is further shaping energy attitudes and behaviors in the region. Average
451 incomes are low, while the cost of electricity tends to be proportionally high. Many people are
452 retired and on low incomes, unable to meet their basic energy needs and experiencing energy
453 poverty. Energy consumption in this region is already very low per-capita and residents practice
454 frugal practices as a matter of habit and necessity. As was evident in the practices subsection, many
455 residents are already practicing energy consumption behaviors but don't intend to change their
456 routine in the future to conserve energy. This suggests that residents are already consuming the
457 minimum amount of energy to conduct their household tasks. This was further evident in the
458 reliance on wood for cooking and heating, the lack of energy-intensive appliances, and the
459 prohibitive costs of electricity in the region. The energy behaviors of residents in this microregion
460 are driven by frugality and cost considerations, rather than by environmental or sustainability
461 reasons.

462 *4.2 The Energy Culture of the region and the defining material culture, norms and practices*

463 Our analysis suggests a single dominant energy culture in the Pogány-havas microregion (Fig.
464 6). While we assumed that several clusters would emerge in the analysis (given the size of the
465 dataset and the number of items), the cluster analysis output suggesting a one-cluster solution
466 aligns well with observations made during fieldwork. We visited each of the 379 households and
467 observed similarities in building infrastructure, energy practices, and mindsets. While we observed
468 variances in the region, the differences in energy consumption and usage in this region are minor
469 when compared to more urbanized or modernized area of Romania or Europe. Vast differences
470 between the highest energy consumers and the lowest energy consumers were not evident in this
471 region, unlike in other studies where multiple energy cultures were identified [e.g. 12].



472

473 **Figure 6.** Characteristics of the Pogány-havas Energy Culture

The dominant energy culture of the region is defined by a fairly homogenous material culture, strong environmental norms and attitudes, and frugal practices. In terms of material culture, the energy culture is shaped by low energy use, low appliance use, and reliance on natural biomass for heating and cooking needs. These characteristics of the system can be attributed to the rural nature of the region, the abundance of natural resources and forests, aging infrastructure, and the low incomes of the residents. The norms of this region are fairly strong, with most respondents feeling a sense of responsibility to conserve energy and be smart stewards of resources. Likewise, practices in this region are defined by low overall consumption, an interest in purchasing energy efficient products in the future. Variances in norms and practices tend to be tied to incomes, age, and education levels. In general, practices are heavily determined by financial costs and not driven by environmental concern.

4.3 Elements of the system that are reinforcing or constraining the current energy system

We found that the study region has a fairly homogenous material culture, with 98% of the respondents relying on traditional use of wood for heating and cooking, while modern renewable energy installations are very sparse. This does not seem to be based on an aversion against renewable energy, because social acceptability of renewable energy use is generally high. Rather, the villages mostly host an ageing community with small incomes, while electricity prices are proportionately high. Respondents stated that they use electricity very sparingly for economic reasons and approximately half of the participants feel constrained to reduce their energy consumption. Respondents also pointed to the 'mindset' of the region as a factor that will shape the energy future of the region. This mindset is based on strong norms, with most respondents feeling a sense of responsibility to be smart stewards of the resources of their village. This mindset can help shaping an energy future that ensures a reliable and affordable energy supply that is based on relatively low use in resources and GHG emissions.

Many of the elements that are reinforcing and defining the current energy system are based in the traditional cultural values and practices of the region. This region of Romania can be described as a traditional cultural landscape, where traditionally managed landscapes have long supported small-scale farming and high biodiversity [32,49]. The rural nature of this region has promoted self-sufficiency and frugal practices. Residents have developed sustainable farming and agricultural practices and rely on semi-subsistence farming for their food needs [32,50]. Residents are highly reliance on ecosystem services (e.g. firewood) and interact with the land regularly through farming and shepherding [51]. These traditional practices shape values, attitudes, and behaviors towards the land and natural resources [51]. For instance, practices are heavily based on use of local resources for heating and cooking, while held norms and attitudes about conservation are tied to viewing themselves as stewards of the land. Despite changes to the region, residents are still holding onto a traditional value system and acting in line with these norms and values [52]. These elements of the system keep consumption behaviors low and contribute to positive attitudes towards conserving energy and not being wasteful.

Other elements of the system seem to be constraining behaviors and aspirations and holding the system back from reaching a more sustainable trajectory. This region has experienced rapid cultural, socioeconomic and institutional change in the last several decades [50], and is facing challenges related to low incomes, aging populations, low education levels, lack of opportunities, and complicated or ineffective bureaucracy [32,53]. In terms of material culture, the energy infrastructure in this rural region is outdated and aging. This hinders the development of modern energy systems and renewable energy technologies due to the costs associated with large-scale expansions and upgrades of the electricity grid [54]. While generation of renewable energy is feasible, distribution and transmission are far greater challenges in rural areas with old infrastructure. Additionally, due to Romania's political system the central government decides upon most interventions and policies in this region. Community-specific interventions designed to target community norms and practices are not as common, because local authorities are following

guidelines from the central government. As a result, energy development projects (e.g. renewable energy technologies) are often championed and implemented by NGO's and non-profit organizations. Although Romania met and exceeded its 2020 EU renewable targets by 2013, the years since have been characterized by a lack of implementation and an active effort to dismantle progress [54].

Despite constraints in the system, it is easy to identify elements that could foster a more sustainable energy system. For one, there is a strong sustainability ethic in this region that is built upon human-nature relationships and a respect for the land. While this moral belief is less motivated by a global environmental worldview, this feeling can be levered for continued sustainability transition of the region. There is also strong support for community renewable schemes, which can be used to build community cohesion and sustainable energy systems. Additionally, while membership in the European Union has led to challenges such as rural flight, there are European funded schemes that could be leveraged for sustainable change. For example, the National Rural Development Program (PNDR) 2014-2020 has allocated €9.36 billion towards the development of renewable energy projects in rural areas [55].

4.4 The sustainable trajectory of the Pogány-havas microregion

Our analysis aligns with previous research in Transylvania and in other rural regions [39,56,57], however the body of literature regarding energy transition in this microregion is limited and scarce. The same challenges and barriers that face sustainable development in the region also influence the consumption and use of energy in the region. Some of the main challenges faced in this area are low incomes, ageing populations, high unemployment rates, low education level, and a complicated bureaucracy [32]. These are factors that are likely to hinder the sustainable trajectory of the region, but other factors can be leveraged for positive sustainable transformation.

In this region, interventions in the energy system still need to focus on first meeting basic needs of the residents. While 99.5% of the households had electricity, there were still many elderly and low-income residents that were living extremely frugally due to the cost of electricity and wood. In transitions countries, such as Romania, connection rates are usually high but the affordability of energy consumption and the ability of households to pay their bills can be problematic [58]. Affordability is measured as the percentage of monthly household income that is spent on electricity and heating, and should be below 10% of household expenditures for electricity and 10% of household expenditures for heating to be considered affordable [58]. For the poorest residents in our region, it's evident that electricity costs are not affordable. 72.80% of residents in the lowest income bracket are paying more than 10% of their monthly income to their electric bill. As for heating, the price fluctuations for wood were a point of concern for many residents. First interventions in this region should not be on reducing consumption, but rather on ensuring constant and affordable supply.

Changing elements to this energy culture will most likely be an increase in energy-intensive appliances and greater overall consumption. If there were to be an increase in incomes, increase in subsidies or adoption of new more efficient technologies, this would certainly be paired with increased energy consumption (see the Khazzoom-Brookes postulate [59] for a discussion on the relations between efficiency increase and total energy usage) and a loss of small-scale sustainable land practices [33]. Therefore, the economic transition in the region needs to build on the high acceptance of community based renewable schemes, in order to bridge the transition between low-consumption and relatively low energy loads, to higher consumption and higher energy loads. This 'leapfrogging' [60,61] may allow the region to skip the stage of high consumption and high GHG emissions and instead reach a stage of higher consumption and lower GHG emissions.

While this region has socio-demographic challenges that hinder local development, other scholars point out the possibility for renewable energy and sustainable energy systems to transform these areas and respond to the challenges. In particular, that rural populations with a dispersed population, declining and aging populations, and a high dependence on agriculture could make these regions particularly suitable for renewable energy [62]. Transitioning to a sustainable energy

systems can provide a range of benefits to these rural communities by generating income, diversifying rural economic activities, and increasing social cohesion [21] or by encouraging more locally owned and managed energy projects and increase innovation and community interactions [57]. Such a transition could contribute to rural regional development and help local-scale societies become energy-independent [21].

4.5. Limitations

While our findings point to many of the elements reinforcing and constraining the energy culture, we acknowledge the limitations of our study. Our cluster analysis and determination of one dominant Energy Culture in the region was concluded based on the data that was collected in our questionnaire. Gathering additional data pertinent to energy consumption and use in the region (e.g. housing insulation types or current energy rebates at the national scale) may have provided additional information on the energy culture of the region. Additionally, the information that we gathered is all self-report measures. While it is possible to calculate energy use based on self-reports [e.g. 43,56], responses can be inaccurate due to imperfect knowledge of consumption patterns or response biases [64]. Lastly, with a researcher-administered survey there is bound to be response bias. Knowing that the researcher was interested in energy-related topics and recording your answer might have resulted in some respondents skewing their response towards the response they felt was 'socially acceptable' or desired by the research team. Additional issues may have impacted the results, including a societal norm of either agreeing or disagreeing with a statement. Asking individuals to distinguish between "slightly agree" and "strongly agree" was difficult for many individuals who said they simply agreed or disagreed with the statement.

5. Conclusions

Global climate change demands drastic transformations of energy infrastructure, the adoption of low-carbon technologies, and the reduction of individual and community consumption behaviors. In rural regions under transition, these transformations must also consider poverty reduction, rural development, and the reliability of the energy supply. As such, this paper sought to understand the defining elements of a rural energy system and to discuss interactions that are supporting or disrupting the sustainable trajectory of that energy system.

We used the Energy Cultures Framework as an analytical tool to explore how interactions between material culture, norms, and practices are shaping the energy system of a rural region in Transylvania, Romania. A quantitative survey conducted with 379 residents of the Pogány-havas microregion found that the energy system of the region can be described as one dominant energy culture, characterized by a homogenous material culture, frugal practices, and norms influenced by traditional values of stewardship and conservation. Our analysis found that residents have strong attitudes and norms towards conserving resources and that energy behaviors are strongly rooted in being a responsible steward of natural resources and in practicing frugality in the face of low incomes. We also found that energy use, number of appliances, energy attitudes, knowledge, and norms differed across age, education, and income categories. Interventions in this energy system should focus first on developing a reliable and affordable energy supply and support traditional stewardship values, conservation attitudes, and frugal practices.

Our contribution highlights the importance of including the human-dimension in the context of rural energy transitions, but only examined the characteristics of one small region. Future research could build upon this study by empirically investigating the norms, practices, and material culture of other rural regions under transition. Of particular interest would be if the elements of the system that are constraining or propelling sustainable growth were similar or dissimilar in other regions. Similarities could point towards an opportunity for broadly implemented initiatives and programs, whereas dissimilarities would highlight the need for more targeted and personalized interventions.

Regarding the application and advancement of the Energy Cultures Framework, we found the framework useful for examining the interactions between norms, practices, and material culture in

a rural cultural landscape in Romania. The flexibility of the framework makes it an applicable and useful tool for a range of case studies and research questions; however, when the framework is applied in so many ways it makes it challenging to compare results across case studies. We would suggest that the framework might be best applied to help to structure energy research design from a preliminary phase. Integrating the Energy Cultures Framework with the other systems-thinking heuristics may also be fruitful for gaining a greater understanding of energy behaviors and effective ways to move towards a more sustainable future. For example, using the Leverage Points framework [65] alongside investigations into energy cultures may help explain why there has been a tendency to focus on shallow leverage points in energy transitions—e.g. subsidies and new technologies—and less attention has been paid to the deeper opportunities for transformational change—e.g. shifts in cultural norms and attitudes towards energy use. Increased attention on deep, people-focused leverage points is warranted given that energy transitions must understand the attitudes, behaviors, and values that are shaping energy behavior.

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Annex

Authors' contributions to the articles and articles publication status (according to §16 of the guideline):

Article #	Short title	Specific contributions of all authors	Author status	Weighting factor	Publication status	Conference contributions
[1]	Human–nature connection: a multidisciplinary review.	**CDI**: conception of research approach; literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting; producing figures **MG**: literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting **JF**: literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting **DJA**: literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting **KK**: literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting; producing figures **CD**: literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting **JoL**: literature review; data collection and data preparation; **SB**: literature review; data collection and data preparation **PA**: literature review; data collection and data preparation **BML**: literature review; data collection and data preparation **CMR**: literature review; data collection and data preparation **DK**: literature review; data collection and data preparation **HVW**: conception of research approach; literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; analysis/interpretation of data or preliminary results; producing figures	Co-author with small contribution	0.0	Published in: *Current Opinion in Environmental Sustainability* Peer reviewed (CS=4.87; citations=42) https://doi.org/10.1016/j.cosust.2017.05.005	NC 2016 IAPS 2016†
[2]	Reconnecting with nature for sustainability.	**CDI:** conception of research approach; literature review; writing or substantive rewriting; development of research methods; producing figures **DJA:** conception of research approach; literature review; writing or substantive rewriting; development of research methods; producing figures **CD**: conception of research approach; literature review; writing or substantive rewriting; development of research methods; producing figures **KK**: conception of research approach; literature review; writing or substantive rewriting; development of research methods; producing figures **JF**: conception of research approach; literature review; writing or substantive rewriting; development of research methods; producing figures	Important contribution	0.5	Published in: *Sustainability Science* Peer reviewed (CS=3.57; citations=10) https://doi.org/10.1007/s11625-018-0542-9	TRANS2017†
[3]	Human-nature connections: aligning biophysical and socio-psychological approaches for sustainability.	**DJA**: conception of research approach; literature review; development of research methods; writing or substantive rewriting **KK**: conception of research approach; literature review; development of research methods; writing or substantive rewriting **CD**: conception of research approach; literature review; development of research methods; writing or substantive rewriting **CDI**: development of research methods; writing or substantive rewriting **HVW**: development of research methods; writing or substantive rewriting **MR**: development of research methods; writing or substantive rewriting	Co-author with equal contribution	1.0	Submitted to: *People and Nature* (CS=new journal)	LP2019†
[4]	Behavior Change for Sustainable	**KK**: conception of research approach; literature review; writing or substantive rewriting KW: literature review; writing or substantive rewriting	Co-author with	1.0	Published in: In Leal Filho W. (eds)	

	Development.	CPH: literature review; writing or substantive rewriting	predominant contribution		*Encyclopedia of Sustainability in Higher Education.* Springer, Cham. Peer reviewed https://doi.org/10.1007/978-3-319-63951-2_161-1	
[5]	Investigating the nuanced relationship between pro-environmental behavior and nature connectedness: a systematic review.	**KK**: conception of research approach; literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results **DJA**: development of research methods; writing or substantive rewriting; producing figures **CCI**: development of research methods; data collection and data preparation **JL**: development of research methods	Co-author with predominant contribution	1.0	Submitted to: *Environment and Behavior* (CS=3.88)	PSICAMB 2017
[6]	Human-nature connectedness as a 'treatment' for pro-environmental behavior: making the case for spatial considerations.	**KK**: conception of research approach; literature review; writing or substantive rewriting; producing figures **JL**: conception of research approach; writing or substantive rewriting; **DJA**: conception of research approach; literature review; writing or substantive rewriting;	Co-author with predominant contribution	1.0	Published in: *Sustainability Science* Peer reviewed (CS=3.57; citations=3) https://doi.org/10.1007/s11625-018-0578-x	CEU25 2016 VILM 2016 ICEP 2017
[7]	Energy conservation attitudes and intentions: investigating place attachment in Eastern Transylvania, Romania.	**KK**: conception of research approach; literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting; producing figures **IAD**: conception of research approach; development of research methods; data collection and data preparation **JOE**: analysis/interpretation of data or preliminary results; producing figures **JL**: conception of research approach; development of research methods; writing or substantive rewriting **DJA**: conception of research approach; development of research methods; analysis/interpretation of data or preliminary results; writing or substantive rewriting	Co-author with predominant contribution	1.0	Under review at: *Psyecology* (CS=0.38)	NEST 2018
[9]	Applying the Energy Cultures Framework to a rural Romanian microregion.	**KK**: conception of research approach; literature review; development of research methods; data collection and data preparation; analysis/interpretation of data or preliminary results; writing or substantive rewriting; producing figures **IAD**: conception of research approach; development of research methods; data collection and data preparation; writing or substantive rewriting analysis/interpretation of data or preliminary results **LML**: analysis/interpretation of data or preliminary results; writing or substantive rewriting **JL**: conception of research approach; development of research methods; analysis/interpretation of data or preliminary results **DJA**: conception of research approach; development of research methods; analysis/interpretation of data or preliminary results	Co-author with predominant contribution	1.0	Submitted to: *Sustainability* (CS=2.37)	CEP 2018 LP 2019 EST 2019*
			Sum:	**7.5**		

Explanations

Specific contributions of all authors

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Author status

According to §12b of the guideline:

> Single author [Allein-Autorenschaft] = Own contribution amounts to 100%.
>
> Co-author with predominant contribution [Überwiegender Anteil] = Own contribution is greater than the individual share of all other co-authors and is at least 35%.
>
> Co-author with equal contribution [Gleicher Anteil] = (1) own contribution is as high as the share of other co-authors, (2) no other co-author has a contribution higher than the own contribution, and (3) the own contribution is at least 25%.
>
> Co-author with important contribution [Wichtiger Anteil] = own contribution is at least 25%, but is insufficient to qualify as single authorship, predominant or equal contribution.
>
> Co-author with small contribution [Geringer Anteil] = own contribution is less than 20%.

Weighting factor

According to §14 of the guideline:

Single author [Allein-Autorenschaft]	1.0
Co-author with predominant contribution [Überwiegender Anteil]	1.0
Co-author with equal contribution [Gleicher Anteil]	1.0
Co-author with important contribution [Wichtiger Anteil]	0.5
Co-author with small contribution [Geringer Anteil]	0

Publication status

CS= CiteScore according to Scopus 2017

Conference contributions

CEU	Alumni Conference of the Department of Environmental Sciences and Policy, organized by Central European University, from 5-7 May 2016 in Budapest (Hungary) Webpage: https://envsci.ceu.edu/envalumni2016
VILM	Environmental Psychology Summer School, organized by Universität Koblenz-Landau, Universität Leipzig, and the Bundesamt für Naturschutz, from 6-9 June 2016 in Vilm (Germany) Webpage: https://vilmworkshop.jimdo.com/for-participants-2016/
NC	Nature Connections 2016, organized by the University of Derby, from 15 June 2016 in Derby (U.K.) Webpage: https://derby.openrepository.com/bitstream/handle/10545/621494/NCx2016+Report.pdf?sequence=1
IAPS	24th IAPS 2018 Conference, organized by the International Association People-Environment Studies Conference, from 27 June-1 July 2016 in Lund (Sweden) Webpage: http://www.iaps24.se/
PSICAMB	XIV Congreso de Psicología Ambiental, organized by PSICAMB Asociación de Psicología Ambiental, from 21-24 June 2017 in Évora (Portugal) Webpage: https://www.psicamb.org/index.php?option=com_content&view=article&id=35&Itemid=297&lang=en
ICEP	International Conference of Environmental Psychology, organized by the International Association of Applied Psychology from 30 Aug-1 September 2017 in A Coruña (Spain) Webpage: http://icep2017.serglo.es/
TRANS	Transformations 2017: Transformations in Practice, organized by the University of Dundee, from 30 August-1 September 2017 in Dundee (Scotland) Webpage: http://www.transformations2017.org/
NEST	3rd PhDs in Transitions/NEST Conference, organized by the PhD/ECR Transitions Network, from 15-16 March 2018 in Utrecht, (Netherlands) Webpage: https://transitionsnetwork.org/wp-content/uploads/2017/10/Call-for-Abstracts-3rd-NEST.pdf

IAPS	25th IAPS 2018 Conference, organized by the International Association People-Environment Studies Conference, from 8-13 July 2018 in Rome (Italy) Webpage: http://iaps2018.com/
CEP	Second Conference on Environmental Psychology in Norway, organized by Inland Norway University of Applied Sciences, from 29-30 November 2018 in Lillehammer (Norway) Webpage: https://eng.inn.no/conferences/conference-on-environmental-psychology-2018
LP	Leverage Points 2019 Conference, organized by Leuphana Universität Lüneburg, from 6-8 February 2019 in Lüneburg (Germany) Webpage: http://leveragepoints2019.leuphana.de/
EST	2nd International Conference on Energy Research and Social Science, organized by Elsevier, from 28-31 May 2019 in Tempe (USA) Webpage: https://www.elsevier.com/events/conferences/international-conference-on-energy-research-and-social-science

* Paper accepted for presentation

† Paper presented by co-author

Statement

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I hereby declare that I have neither undertaken nor applied to undertake any other doctoral assessment.

I further affirm that the dissertation with the title *Scales of Human-Nature Connectedness: Influences on Sustainability Aspirations and Pro-Environmental Behaviors* has not been submitted to any representative of any faculty and that I am submitting the dissertation only in this and no other doctoral procedure and that I have not previously failed any other doctoral assessments.

I furthermore declare that I composed the submitted dissertation *Scales of Human-Nature Connectedness: Influences on Sustainability Aspirations and Pro-Environmental Behaviors* independently and without having recourse to prohibited means. I have not used any aids or texts other than those I have indicated. All passages taken in verbatim or substance from other works have been identified.

Lüneburg, 29 March 2019

Kathleen Klaniecki