

Home for future Earth lovers

Foundations of nature-connecting habitats for children

Matteo Giusti

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Abstract

Modern childhood is increasingly segregated from nature. Yet, children's nature experiences are first steps for sustainable futures. In this thesis, I research the foundations of habitats that can connect children to nature. I call them *nature-connecting habitats*.

Five papers in this thesis answer: (RQ1) *what is children's human-nature connection (HNC)?*; and (RQ2) *what are the requirements of nature-connecting habitats for children?* The **preschools paper** shows that five-year-olds with *nature-rich routines* have higher HNC than children with nature-poor routines, but it cannot understand which nature experiences are most influential. Hence, the **salamanders paper** assesses children's participation in a nature conservation project. Discrepancies between the qualitative and quantitative results reveal an *assessment gap* with theoretical roots, which impedes the assessment of nature experiences in practical time-frames. To close this gap, the **review paper** surveys the literature and shows that attributes of the mind, qualities of nature experiences, and attachment to places are all aspects of HNC. The **embody paper** conceptualizes an embodied approach to HNC to overcome the barriers identified previously, and the **toolbox paper** operationalises it to develop a toolbox to assess children's HNC and nature-connecting habitats.

Answering RQ1, results show that *children's HNC is a complex set of embodied abilities*. Human-nature relationships that could enable, promote, or assist sustainable development are a set of abilities that children can learn. These abilities are relationships between mind, body, culture, and environment, and progress following non-linear dynamics. This thesis identifies 10 of these abilities of HNC and finds that children learn them in three consecutive phases. Phase one – being *in* nature – includes feeling comfortable in natural spaces, and being curious about nature. Phase two – being *with* nature – includes reading natural spaces, acting in natural spaces, feeling attached to natural spaces, knowing about nature, and recalling memories with nature. Phase three – being *for* nature – includes taking care of nature, caring about nature, and being one with nature.

Answering RQ2, two requirements of nature-connecting habitats are found: *significant nature situations* and *various nature routines*. Nature situations that can connect children to nature are characterised by configurations of 16 qualities – *qualities of significant nature situations*. These qualities are: entertainment, thought-provocation, awe, surprise, intimacy, mindfulness, self-restoration, creative expression, physical activity, challenge, engagement of senses, child-driven, involvement of mentors, structure/instructions, social/cultural endorsement, and involvement of animals. This set of qualities delineates the kinds of nature situations that nature-connecting habitats have to provide. These qualities should be various and recurring to allow children's HNC to progress – hence, *various nature routines*. These lists of abilities and qualities form a toolbox capable of assessing where and how children connect to nature, named ACHUNAS.

This thesis sets the stage to develop nature-connecting habitats. Children's HNC and nature-connecting habitats are not the only intervention to promote sustainable futures, but they might be necessary conditions to meet the ever-shifting target of sustainable civilizations.

Keywords: *Human-nature connection, nature-connecting habitat, children, sustainability, human-nature relationship.*

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To my family.
Past, present, and future.



In our environmental wars, the emphasis has been on saving species, not becoming them.

Brenda Petersen



Abstract

Modern childhood is increasingly segregated from nature. Yet, nature experiences during childhood might very well be essential first steps for sustainable futures. How nature will be integrated into the design of new and existing human habitats therefore matters for sustainability. In this thesis, I research the theoretical and practical foundations of habitats that can connect children to nature. I call them *nature-connecting habitats*.

Five papers in this thesis answers two research questions to inform the development of nature-connecting habitats: *what is children's human-nature connection (HNC)?*; and *what are the requirements of nature-connecting habitats for children?* The **preschools paper** explores whether access to nature-rich habitats relates to children's HNC. The results show that five-year-olds with *nature-rich routines* have higher awareness and concern of environmental degradation, empathy for animals, and understanding of human's dependence on nature than children with nature-poor routines. Hence, the **preschools paper** shows a link between habitats and HNC, confirming that nature-connecting habitats can be developed, but it does not help to understand what kind of nature experiences are most influential. The **salamanders paper** uses quantitative and qualitative research methods to answer this question. In this paper, children are assessed before and after they participate in a nature conservation project. Results from the qualitative methods show that children's HNC changed after participating in the project, but the results from the quantitative methods do not confirm this outcome. This discrepancy revealed an *assessment gap* with theoretical roots, which impedes the assessment of nature experiences in practical time-frames. To investigate ways to close this gap, the **review paper** systematically surveys how HNC has been empirically researched up to now. This paper shows that attributes of the mind, qualities of nature experiences, and attachment to local places are all important aspects of HNC. Still, there are barriers to the integration of these bodies of knowledge. The **embody paper** conceptualizes a theoretical approach to fill the assessment gap and to overcome the theoretical barriers identified in the **review paper**. This paper defines an embodied approach to HNC combining mind, body, culture, and environment. The **toolbox paper** operationalises the embodied approach to HNC, integrates knowledge from professionals in the field of children's HNC, and develops a toolbox to assess children's HNC and nature-connecting habitats. As a whole, this thesis combines insights from children (**preschools paper**, **salamanders**

paper), academics (**review paper, embody paper**), and professionals (**toolbox paper**), and employs a variety of inductive and deductive methodologies including interviews, psychometric scales, questionnaires, on-line surveys, GIS analysis, and statistical analysis and modelling.

In answer to the first research question, the results indicate that *children's HNC is a complex set of embodied abilities*. Human-nature relationships that could enable, promote, or assist sustainable development are, first of all, a set of abilities that children can learn. These abilities emerge from relationships between mind, body, culture, and environment, and progress following non-linear dynamics. This thesis identifies 10 of these abilities of HNC and finds that children learn them in three consecutive phases. Phase one – being *in* nature – includes feeling comfortable in natural spaces, and being curious about nature. Phase two – being *with* nature – includes reading natural spaces, acting in natural spaces, feeling attached to natural spaces, knowing about nature, and recalling memories with nature. Phase three – being *for* nature – includes taking care of nature, caring about nature, and being one with nature.

In answer to the second research question, two requirements of nature-connecting habitats are found: *significant nature situations* and *various nature routines*. Nature situations that can connect children to nature are characterised by configurations of 16 qualities – *qualities of significant nature situations*. These qualities are: entertainment, thought-provocation, awe, surprise, intimacy, mindfulness, self-restoration, creative expression, physical activity, challenge, engagement of senses, child-driven, involvement of mentors, structure/instructions, social/cultural endorsement, and involvement of animals. This set of qualities delineates the kinds of nature situations that nature-connecting habitats have to provide. These qualities should be various and recurring to allow children's HNC to progress – hence, *various nature routines*. These lists of abilities and qualities form the foundations of a practical toolbox capable of assessing where and how children connect to nature, named ACHUNAS.

The findings of this thesis set the stage for nature-connecting habitats to be further developed in research and practice. While children's HNC is not a panacea for all sustainability issues, and nature-connecting habitats are not the only intervention to promote it, both are likely necessary conditions to meet the ever-shifting target of sustainable civilizations.

Keywords

Human-nature connection, nature-connecting habitat, children, sustainability, human-nature relationship

Sammanfattning

Dagens barn är i ökande grad isolerade från naturen. Direkta naturupplevelser under barndomen påverkar dock vår förmåga att knyta an till naturen. I denna avhandling undersöker jag teoretiska- och praktiska grunder rörande livsmiljöer som stödjer barns naturanknytning (*eng.* human-nature connection). Jag kallar dessa för naturanknytande livsmiljöer (*eng.* nature-connecting habitats).

Avhandlingen svarar på två forskningsfrågor: *Vad innebär naturanknytning för barn? Vilka egenskaper har barns naturanknytande livsmiljöer?* **Förskolartikeln (FA)** undersöker om rumslig tillgänglighet till naturmiljöer korrelerar med barns anknytning till naturen. Resultaten visar att 5-åringar med rutiner innehållande frekventa naturupplevelser har högre miljömedvetenhet; är mer missnöjda med miljöförstöring; är mer empatiska mot djur; och har bättre kunskap om människans beroende av naturen, jämfört med 5-åringar som inte har sådana rutiner. **FA** upptäcker således ett samband mellan livsmiljön och barns naturanknytning. **Salamanderartikeln (SA)** använder både kvalitativa och kvantitativa metoder för att utvärdera barn före och efter deltagande i ett naturvårdsprojekt. Kvalitativa data visar att barnens naturanknytning förstärks av deltagande, men kvantitativa data stödjer inte denna förändring. Resultaten synliggör istället en kunskapslucka i hur man utvärderar barns naturanknytning, vilket försvårar utvärderingar relaterat rimliga tidsramar för barns deltagande i naturvårdsprojekt. För att utforska de teoretiska rötterna i denna utvärderingslucka skrevs en **översynsartikel (ÖA)**. **ÖA** är en systematisk genomgång och klassificering av existerande empirisk forskning om naturanknytning. Resultaten visar att naturanknytning innefattar tre distinkta kunskapslinjer i litteraturen; psykologiska attribut, naturupplevelsers egenskaper, och anknytning till områden. **Embodimentartikeln (EA)** använder ett förkroppsligat perspektiv för att bättre förstå både utvärderingsluckan och de teoretiska barriärer som identifierades i **ÖA**. **Verktysartikeln (VA)** använder både induktiva och deduktiva angreppssätt för att integrera insikter från professionella som arbetar med att anknyta barn till naturen. Artikeln utvecklar också *verktyg* för att utvärdera barns anknytning till naturen och för att utvärdera livsmiljöer som stödjer sådana anknytning.

I sin helhet kombinerar denna avhandling empiriskt grundade insikter uppfångande från barn (**FA; SA**), från akademiker (**EA; ÖA**), och från professionella praktiker (**VA**), och den använder en metodkombination

bestående av intervjuer och frågeformulär, kvantitativa psykologiska mätinstrument, kvantitativa enkäter, GIS-analyser och statistisk modellering. Som svar på den första forskningsfrågan indikerar resultaten att barns naturanknytning är en komplex uppsättning förkroppsligade förmågor. Det innebär att naturanknytning för det första är en uppsättning förmågor som barn kan lära sig - för det andra uppkommer dessa förmågor genom relationer mellan sinne, kropp, kultur och miljö - och för det tredje - förmågorna uppkommer under icke-linjära och dynamiska lärandeprocesser. Avhandlingen identifierar tio av dessa förmågor relaterat naturanknytning, som inlärs gradvis av barn i tre på varandra följande faser. Fas ett - *att besöka naturen* - täcker förmågan att känna sig bekväm och nyfiken i naturmiljöer. Fas två - *att vara i naturen* - täcker barns förmåga att läsa av, tycka om och verka i naturlig miljöer, samt ha kunskap och minnen om dessa. Fas tre - *att vara för naturen* - täcker barns förmåga att värna om naturen, bry sig om naturen och att känna samhörighet med naturen. Svaret på den andra forskningsfrågan blev *betydande natursituationer* och *naturrutiner*. Sexton egenskaper karaktäriserar naturupplevelser i sådana situationer och rutiner. Dessa egenskaper är: underhållning; tankeprovokation; vördnad; överraskning; närhet; koncentration; återhämtning; skapande; fysisk aktivitet; utmaning; sinnlighet; fri lek; stöd från vuxna; tydliga instruktioner; kulturell acceptans och kontakt med djur. Det andra kravet är att en mångfald av dessa kvaliteter ska tillhandahållas, i olika kombinationer och att dessa ska vara frekvent återkommande - i form av naturrutiner-- för att barnens naturanknytning ska kunna utvecklas. ACHUNAS (VA) är en verktygslåda baserad på dessa insikter. Verktuget kan bedöma var, hur och varför barn anknyter till naturen.

Resultaten producerade i denna avhandling bidrar till vår kollektiva kunskap om hur naturanknytande livsmiljöer ska utformas och hur de ska studeras. Barns naturanknytning inte är en standardlösning för alla hållbarhetsfrågor, men det har bäring på uppkomsten av miljövänliga val och vanor i framtiden, och på vår kollektiva förmåga att föreställa oss hållbara scenarier.

Nyckelord:

naturanknytning, naturanknytande livsmiljöer, barn, hållbarhet, människa-natur relationer

Sintesi

L'infanzia moderna è sempre più distante dalla natura. Tuttavia, le esperienze naturali che si hanno durante l'infanzia sono un essenziale punto di partenza per un futuro sostenibile. Come la natura sarà integrata nella progettazione dell'attuale e futuro habitat umano ha quindi conseguenze dirette per la sostenibilità. In questa tesi, ricerco le basi teoriche e pratiche di habitat che consentono ai bambini di connettersi con la natura. Li chiamo *habitat di connessione naturale*.

Cinque articoli in questa tesi rispondono a due domande di ricerca: *cos'è la connessione uomo-natura (CUN) nei bambini?*; e *quali sono i requisiti degli habitat di connessione naturale per bambini?* L'**articolo preschools** esplora se l'accessibilità ad habitat ricchi di natura sia collegata al CUN dei bambini. I risultati dimostrano che bambini di cinque anni con una routine ricca di esperienze naturali hanno maggiore consapevolezza e preoccupazione per il degrado ambientale, empatia per altri animali, e comprensione della dipendenza dell'uomo dalla natura, rispetto a bambini che hanno avuto poche esperienze naturali. L'**articolo preschools** mostra un link tra habitat e CUN, ed assicura che è possibile creare habitat di connessione naturale. Tuttavia, non aiuta a capire quali esperienze naturali siano più influenti. L'**articolo salamanders** utilizza metodi quantitativi e qualitativi per colmare questo vuoto. In questo articolo, I bambini sono valutati prima e dopo aver partecipato a un progetto di conservazione naturale. I risultati dei metodi qualitativi dimostrano che il CUN dei bambini è cambiato dopo la partecipazione al progetto, ma i metodi quantitativi non confermano questo esito. Questi risultati sottolineano un *divario di valutazione* che ha radici teoriche e che impedisce la valutazione di esperienze naturali in tempi pratici. Per capire come colmare questo divario, l'**articolo review** esamina sistematicamente come il CUN sia stato ricercato empiricamente fino ad ora. Questo articolo mostra come CUN incorpori attributi psicologici, qualità di esperienze naturali, e attaccamento al luogo. Tuttavia, ci sono barriere teoriche che impediscono l'integrazione di questo corpus di conoscenze. L'**articolo embody** concettualizza un approccio olistico al CUN per colmare il divario di valutazione e superare le barriere teoriche identificate nell'**articolo review**. L'**articolo strumenti** integra le competenze di professionisti nel settore, e sviluppa degli strumenti olistici per valutare il CUN dei bambini e gli habitat di connessione naturale. Nel complesso, questa tesi combina considerazioni di bambini (**articolo preschools**, **articolo salamanders**), accademici (**articolo**

review, articolo embody) e professionisti (**articolo toolbox**), e una utilizza metodologie sia induttive che deduttive comprendendo interviste, scale psicometriche, questionari, sondaggi on-line, analisi GIS, e analisi e modellazione statistica.

In risposta alla prima domanda di ricerca, i risultati indicano che, *il CUN dei bambini è un insieme complesso di abilità olistiche*. Ciò significa che i rapporti con la natura in grado di abilitare, promuovere, o aiutare lo sviluppo sostenibile suono, in primo luogo, un insieme di capacità che i bambini possono apprendere. Queste abilità emergono da relazioni tra mente, corpo, cultura, e ambiente, e maturano seguendo dinamiche non lineari. Questa tesi identifica 10 di queste abilità di CUN che i bambini apprendono progressivamente in tre fasi consecutive. La prima fase - essere *nella* natura – include sentirsi a proprio agio negli spazi naturali ed essere curiosi della natura. La seconda fase – essere *con la* natura – include leggere gli spazi naturali, agire negli spazi naturali, sentirsi attaccati a luoghi naturali, conoscere la natura, e avere ricordi con la natura. La terza fase – essere *per la* natura – include preoccuparsi della natura, prendersi cura della natura, e essere tutt'uno con la natura.

In risposta alla seconda domanda di ricerca, i risultati mostrano due requisiti degli habitat di connessione naturale: *situazioni naturali significative* e *routine naturali varie*. Le esperienze naturali che possono connettere i bambini alla natura sono caratterizzate da 16 qualità – *qualità di situazioni naturali significative*. Queste qualità sono: svago, stimolazione mentale, stupore, sorpresa, intimità, consapevolezza, ristabilimento, espressione creativa, attività fisica, difficoltà, coinvolgimento dei sensi, auto conduzione, coinvolgimento di mentori, istruzioni, sostegno sociale/culturale, e coinvolgimento degli animali. Questo insieme di qualità definisce le situazioni naturali che gli habitat di connessione naturale devono fornire. Per consentire al CUN dei bambini di progredire queste qualità devono essere varie e ricorrenti – pertanto, *routine naturali varie*. Questi elenchi e principi formano ACHUNAS, uno strumento in grado di valutare dove e come i bambini si connettono alla natura.

Questi risultati sono il fondamento per sviluppare habitat di connessione naturale sia nella ricerca che in pratica. Anche se il CUN dei bambini non è la soluzione a tutti i problemi della sostenibilità, e gli habitat di connessione naturale non sono l'unico intervento per promuoverlo, entrambi sono condizioni necessarie per raggiungere il mutevole obiettivo di civiltà sostenibili.

Parole chiave

Connessione uomo-natura, habitat di connessione naturale, bambini, sostenibilità, relazione uomo-natura

List of papers included

This thesis consists of the following five appended papers. These are referred to in the text with the running titles provided below. Table 1 shows my contributions to each of the papers.

Preschools paper

Giusti, Matteo, Stephan Barthel, and Lars Marcus. 2014. “Nature Routines and Affinity with the Biosphere: A Case Study of Preschool Children in Stockholm.” *Children, Youth and Environments* 24 (3):16–16. <https://doi.org/10.7721/chilyoutenvi.24.3.0016>.

Salamanders paper

Giusti, Matteo (manuscript)

“Saving salamanders: a gap in assessing hands-on conservation on children’s relationship with nature”

Review paper

Ives, Christopher D., **Matteo Giusti**, Joern Fischer, David J. Abson, Kathleen Klaniecki, Christian Dorninger, Josefine Laudan, et al. 2017. “Human–nature Connection: A Multidisciplinary Review.” *Current Opinion in Environmental Sustainability* 26–27 (June):106–13. <https://doi.org/10.1016/j.cosust.2017.05.005>.

Embodiment paper

Raymond, Christopher, **Matteo Giusti**, and Stephan Barthel. 2017. “An Embodied Perspective on the Co-Production of Cultural Ecosystem Services: Toward Embodied Ecosystems.” *Journal of Environmental Planning and Management*, no. May:1–9. <https://doi.org/10.1016/j.aqpro.2013.07.003>.

Toolbox paper

Giusti, Matteo, Ulrika Svane, Christopher M. Raymond, and Thomas H. Beery. 2018. “A Framework to Assess Where and How Children Connect to Nature.” *Frontiers in Psychology* 8 (January). <https://doi.org/10.3389/fpsyg.2017.02283>.

Table 1. Personal contribution to each of the papers included in this thesis

	<i>Preschools</i>	<i>Salamanders</i>	<i>Review</i>	<i>Embody</i>	<i>Toolbox</i>
<i>Conception of study</i>	X	X			X
<i>Research design</i>	X	X	X		X
<i>Data acquisition</i>	X	X	X	X	X
<i>Data analysis</i>	X	X		X	X
<i>Interpretation of results</i>	X	X	X	X	X
<i>Paper writing</i>	X	X	X	X	X
<i>Paper revision</i>	X	X			X

List of papers not included

Paper A

Samuelsson, Karl, **Matteo Giusti**, Garry D. Peterson, Ann Legeby, S. Anders Brandt, and Stephan Barthel. 2018. "Impact of Environment on People's Everyday Experiences in Stockholm." *Landscape and Urban Planning* 171 (March):7–17.

Paper B

Haider, Jamila, Hentati-Sundberg Jonas, **Matteo Giusti**, Julie Goodness, Maike Hamann, Vanessa Masterson, Megan Meacham, et al. 2017. "The Undisciplinary Journey: Early-Career Perspectives in Sustainability Science." *Sustainability Science*, June. <https://doi.org/10.1007/s11625-017-0445-1>.

Paper C

Masterson, Vanessa, Richard C. Stedman, Johan Enqvist, Maria Tengö, **Matteo Giusti**, Darin Wahl, and Uno Svedin. 2016. "The Contribution of Sense of Place to Social–ecological Systems Research: A Review and Research Agenda." *Ecology and Society* 22 (April). <https://doi.org/10.5751/ES-08872-220149>.

Paper D

Marcus, Lars, **Matteo Giusti**, and Stephan Barthel. 2016. "Cognitive Affordances in Sustainable Urbanism: Contributions of Space Syntax and Spatial Cognition." *Journal of Urban Design*, June, 1–14. <https://doi.org/10.1080/13574809.2016.1184565>.

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Introduction

An eight-year-old in the UK spends 16 minutes a day in natural locations, and those minutes drop to 10 by the time these children are 15 (Gershuny and Sullivan 2017). At the same time, children in the USA spend seven and a half hours a day in front of a screen (Rideout, Foehr, and Roberts 2010). Rather coincidentally, children can identify Pokémons better than animals (Balmford 2002), prioritize the protection of animals seen on the Internet rather than local animals (Ballouard, Brischoux, and Bonnet 2011), and can recognise several hundreds of corporate logos, but name only a few local plant or animal species (Armitage 2010).

The absence of direct nature experiences in modern childhood is worrying for three main reasons. First, because the health benefits derived from interacting with nature permeate every aspect of the human mind and body (Hartig et al. 2014; Keniger et al. 2013). So much so in fact, that nature experiences are now prescribed by doctors (see Park America RX project) and academically discussed in ‘doses’ (Barton and Pretty 2010; Jiang, Chang, and Sullivan 2014). Second, because nature experiences improve short and long-term cognitive and physical development (Burdette and Whitaker 2005; Ginsburg 2007; Rickinson et al. 2004). And third, because there is growing recognition that experiencing nature during childhood shapes key premises of sustainable lifestyles in adulthood (Chawla 1998, 1999; Kellert 2002; Evans et al. 2007; Hsu 2009).

Most of the concerns discussed above emerge from children living in man-made environments designed to be isolated from natural systems (Turner, Nakamura, and Dinetti 2004; Grimm et al. 2008). This is the most common human habitat and, in the next 35 years, it will become the habitat of another 2.7 billion people (United Nations 2014). However, separating human and natural habitats does not have to be the norm in planning our living environment. If designed with nature in mind, building new and retrofitting existing habitats is a substantial opportunity to provide the benefits of nature to most of the world population, children included. Importantly, incorporating nature into everyday habitats can also set the scene for promoting a sustainable culture in new generations. In this thesis, I present the theoretical and practical foundations for habitats that enable a connection between children and nature to grow. I call these places *nature-connecting habitats*.

Connecting humans with the rest of nature

How humans relate to the rest of nature is a subject widely discussed in the academic literature (**review paper**). Due to the heterogeneity of this literature, clear terminology is critical. In this thesis, I use *human-nature relationships* as a neutral term to describe how humans relate to the rest of nature. Which of these relationships are desirable or not is often in relation to the discipline that discusses them. For instance, in conservation biology, human-nature relationships are desirable if they support biodiversity conservation (J. R. Miller 2005), in environmental psychology if they promote pro-environmental behaviours (Gifford 2014), and in sustainability science if they enable sustainable development (Folke et al. 2011). There are obvious overlaps between these goals and in the broadest sense, human-nature relationships can be assumed desirable when they enable, promote, or assist environmentally-conscious societies or sustainable development. In this thesis, I coin the term *human-nature connection* or *HNC* to isolate a set of human-nature relationships – yet unknown – that enable, promote, or assist such environmentally-conscious societies. HNC is both an assumption and the scope of this thesis. That is, I assume the existence of a desirable set of human-nature relationships for sustainable development, I call this set HNC, and this thesis investigates its content. Investigating HNC does not imply that humans are *dis*-connected – can humans ever be disconnected from the biosphere? – or in need to *re*-connect to nature – did humans ever had a sustainable relationship with nature? Humans inherently relate to and rely on nature, but *how* they do so is important here. Human-nature relationships can have sustainable outcomes, or not. They can promote species oppression and natural resource exploitation, or promote harmonious species co-existence and use of natural resources sustainable over generations. In this thesis, I deem the latter desirable. HNC is therefore normatively defined by a set of human-nature relationships desirable for sustainability, and yet its exact constituents are still unknown.

The existing literature provides some initial insights into the constituents of HNC. Philosophers explore human-nature relationships in terms of environmental ethic and morality and categorise them, for example, into mastery, stewardship, partnership, or participation (De Groot, Drenthen, and De Groot 2011). Evolutionary biologists coin the term ‘biophilia’, as an innate appreciation for nature to be rediscovered and relived (Kellert and Wilson 1993). Environmentalists propose conceptualizations of human-nature relationships based on the moral use of the land such as ‘land ethic’ (Leopold 1948). Conservationists suggest distinguishing the values derived from human-nature relationships as intrinsic, extrinsic, or relational (Chan et al. 2016). Lastly, environmental and conservation psychologists contribute greatly to understanding desirable human-nature relationships through a variety of conceptualizations that describe an environmentally-conscious

mind (for a historical review see Kollmuss and Agyeman 2002). Some of these conceptualizations include biospheric values (Steg et al. 2014), environmental identity (Clayton 2003), connection to nature (Cheng and Monroe 2012), connectedness to nature (Mayer and Frantz 2004), nature relatedness (Nisbet, Zelenski, and Murphy 2008), environmental concern (Schultz 2001), general ecological behaviour (Kaiser 1998), environmental attitudes (Kaiser et al. 2011), love for nature (Perkins 2010), and environmental worldviews (Dunlap et al. 2000). It is unfair to summarise all this literature as one, but at its core is how, more or less consciously, human-nature relationships are valued in individuals' emotions, thoughts, or intentions (Ives and Kendal 2014; Schultz 2002). These values are often considered the anchors of a chain of beliefs, attitudes, and norms that motivate pro-environmental choices and behaviours (Fulton, Manfredi, and Lipscomb 1996; Stern et al. 1999). This reasoning has been empirically validated for a diversity of pro-environmental behaviours, including using public transportation (Hunecke et al. 2001), mindful use of energy (Black, Stern, and Elworth 1985), recycling (Guagnano, Stern, and Dietz 1995), eco-friendly purchasing behaviours (Thøgersen 2005), acceptance of climate change policies (Nilsson, von Borgstede, and Biel 2004), acceptance of energy policies (Steg et al. 2011), everyday pro-environmental habits (Thøgersen & Ölander, 2002), limited car use (Jakovcevic and Steg 2013), and donating money to environmental organisations (de Groot and Steg 2008).

The potential of this body of knowledge for sustainable development is evident even in such a brief literature review. Many authors have indeed remarked that the set of human-nature relationships endorsed in modern societies is both the root cause of unsustainable patterns of development, and the crux of large-scale changes towards sustainability (Beddoe et al. 2009; Brooks et al. 2018; Kinzig et al. 2013; Meadows 2008). In different words, a sustainable form of development for humankind requires a “mind shift at the scale of a ‘Copernican revolution’ [...] to put our minds in harmony with the earth system we depend on” (Rockstrom and Klum 2012, 49). Connecting humans with the rest of nature – that is promoting HNC at the social level – is a recognised strategy in sustainability science to transform to sustainable forms of development (Abson et al. 2017; Folke et al. 2011; Brooks et al. 2018). Deliberately shifting the set of human-nature relationships that are valued in societies is indeed an intervention debated in nature conservation (Ives and Fischer 2017; Manfredi, Bruskotter, Teel, Fulton, Oishi, et al. 2017; Manfredi, Bruskotter, Teel, Fulton, Schwartz, et al. 2017). One conclusion is evident from this academic discussion: despite the transformative potential of cultural changes in human-nature relationships being widely recognised, vast unknowns impede the development of interventions that intentionally promote HNC. Below, I propose one. This is a practical intervention to stimulate HNC at the social level and in this thesis I research its theoretical and practical foundations.

Conceiving nature-connecting habitats for children

By valuing and combining a variety of knowledge sources, sustainability science confronts unsustainable human development with two parallel research programs (de Vries 2016). The first one investigates the complex dynamics of sustainability problems. This branch of sustainability science confirms beyond doubt that human activities are the underlying cause of climate change (Barker 2007), the acidification and warming of oceans (Hoegh-Guldberg and Bruno 2010; Halpern et al. 2008), and the sixth mass extinction of life on Earth (Barnosky et al. 2011; Ceballos et al. 2015). The second, more recent one, researches evidence-supported solutions that can be practically implemented to promote sustainable changes in society (de Vries 2016; T. R. Miller et al. 2014). Here, the focus of the scientific investigation is the system which contains the solutions, rather than the system which contains the problem (Sarewitz et al. 2012). This research program is called ‘transformational sustainability research’ and defines the ‘sustainability solution agenda’ (T. R. Miller et al. 2014; Sarewitz et al. 2012). This is the agenda to which this thesis contributes.

In this thesis, I conceive and research a strategic intervention to promote children’s HNC by developing designated human habitats. These are what I call *nature-connecting habitats* for children. The potential value of this intervention is based on three considerations about HNC and systemic cultural changes found in the existing literature.

The first consideration is that direct nature experiences during childhood are fundamental to developing HNC. Human-nature relationships are shown to emerge in children (Chawla 1998, 1999; Kellert 2002; Evans et al. 2007; Hsu 2009) and to remain stable in adulthood (Kaiser et al. 2014). What children learn at this age is a blueprint for their adult life, and how they relate to nature is no exception. During this period of life *direct* – hands-on – nature experiences are essential to promote HNC (Cheng and Monroe 2012; Kellert 2002; Van der Werff, Steg, and Keizer 2014). This is particularly important to note considering that most human populations live in man-made habitats in which direct nature experiences are often alienated from everyday life (Turner, Nakamura, and Dinetti 2004; Grimm et al. 2008). Interventions on human habitats are therefore urgently required and have the potential to influence the next generation of policy makers, conservationists, and businessmen.

The second consideration derives from the complex dynamics underpinning the human systems. The unsustainable nature of human development emerges from complex interactions between social, economic, and ecological systems (Liu et al. 2007). These are often described as social-ecological systems (Folke 2006). The seminal work of Meadows (2008) shows the leverage points to change them. Changes in complex social-ecological systems can be promoted at the level of parameters (e.g. subsidies

for recycling), feedbacks (e.g. rewarding recycling behaviours), or design (e.g. creating schools to teach recycling behaviours). However, *transformative* changes can only be promoted by addressing the underpinning worldviews, values, and goals of the system (Abson et al. 2017). Developing nature-connecting habitats is an intervention conceived to define the environmental determinants of such worldviews, values, and goals, which could then potentially lead to transformative sustainable changes. Still, nature-connecting habitats do not ensure solutions to sustainable problems. Complex systems rarely subdue to determinism and by definition their problems have no single or simple solution (Funtowicz and Ravetz 1992; Wiek et al. 2012). Emergence and self-organization are fundamental dynamics of systems in which uncertainty and unpredictability rule. Nature-connecting habitats will therefore not dictate sustainable norms, traditions, and culture, but they will enable, promote, and assist them.

Lastly, nature-connecting habitats focus on the premises of sustainable biases, defaults, and habits. Existing research shows that most decision-making processes behind human behaviour are automatic, not deliberate (World Bank Group 2015). Similarly, in the literature of HNC, many authors emphasise the ‘primitive’ and unconscious dimensions of desirable human-nature relationships (Geng et al. 2015; Bruni and Schultz 2010). It is also not news that humans are creatures of habits (Wood et al. 2014), and experiential and contextual cues have a defining role in shaping them (Wood, Quinn, and Kashy 2002; Neal et al. 2012). Nature-connecting habitats are therefore conceived to guide a sustainable trajectory for these automatic decision-making processes and habits, rather than specifically promote single pro-environmental behaviours. Nature-connecting habitats do *not* focus on changing intentional behaviours to solve *one* sustainability issue, but they allow unknown solutions to unknown sustainable challenges to emerge. This intervention works in synergy with existing strategies of cultural transformation towards sustainability to provide fertile ground to avoid, solve, or mitigate sustainability problems in future generations. Nature-connecting habitats are the landscape for continuous environmental education, bottom-up support to feed political debate, and social acceptance of new sustainability legislations.

Two research questions for nature-connecting habitats

There are two critical questions that must be answered in order to initiate the development of nature-connecting habitats. The first research question in this thesis is: *what is children’s human-nature connection?* Several gaps impede answering this question using the existing literature. First, the brief review of literature presented above shows that there is no single, accepted, or working definition of what desirable human-nature relationships are or should

be. This is not to say that there is – or should be – *one* sustainable human-nature relationship, but that the variety of conceptualizations impedes the identification of a target HNC to aim for in practice. The existing literature offers methodological groundedness of great value to appreciate the nuances of human-nature relationships. However, strong reliance on deductive methodologies and emphasis on universal psychometric scales make these methods overlapping and seemingly over-conceptualized (Brügger, Kaiser, and Roczen 2011; Tam 2013a). A second gap is that the role of human-nature relationships beyond the intentional choices of single individuals is largely ignored in the literature (**review paper**). As a consequence, the social level of human-nature relationships is often just assumed as the sum of values from separated individuals. This assumption is unsuitable to describe cultural dynamics of complex social-ecological systems, whether sustainable or not (Andersson 2014). A third limit is that much research on pro-environmental behaviours relies on self-reports, which are proven to be just an indication of what real behaviours are (Kormos and Gifford 2014). Lastly, existing literature lacks integration of contextual influences (Gifford 2014), which are shown to directly affect assessment methods (Duffy and Verges 2010). What defines children's HNC is therefore still unknown, and it is examined in this thesis.

The second research question is: *what are the requirements of nature-connecting habitats for children?* Where and how nature experiences occur is a question of obvious importance to define nature-connecting habitats. So, what counts as a 'connecting' natural area? For example, living in a rural area allows children to have reoccurring interactions with 'nature', but only of the 'rural' kind. Such areas might provide experiences of domesticated animals, small-scale cultivation, and farmers' markets, and yet miss nature experiences of recreation or wilderness. Reoccurring rural experiences might be important for children's HNC, but it is not only the quantity of nature experiences that matters, but also their quality. Nature experiences available in smaller, but potentially more diverse green areas of a city might have a great impact on children's HNC. A nation-wide study performed in the UK shows indeed that British children have higher connection to nature in urban than in rural areas (RSPB 2013). So, what are the requirements for landscapes that provide nature experiences formative for children's HNC? Criteria that can assess and eventually compare landscapes in practical time-frames do not exist in the literature and identifying them is the second unknown that this thesis engages with.

Aim of this thesis

In this thesis, I aim to **research the theoretical and practical foundations of nature-connecting habitats for children**. The knowledge produced here is intended to inform transformative interventions to promote children’s HNC via the design of their habitats. Each paper in this thesis has complementary objectives to contribute to this aim (Table 2).

Table 2. Aim of this thesis and objectives of all included papers

Aim of the thesis	
Researching theoretical and practical foundations of nature-connecting habitats for children	
Objectives of papers	
Preschools paper	Validating the feasibility of children’s nature-connecting habitats
Salamanders paper	Exploring practical indicators to assess direct nature experiences
Review paper	Identifying theoretical gaps in how human-nature relationships have been researched
Embody paper	Conceptualizing a framework to address theoretical and practical gaps in researching children’s HNC
Toolbox paper	Complementing research on HNC with professionals’ insights to develop the assessment toolbox needed for children’s nature-connecting habitats

The **preschools paper** is an empirical analysis of how space relates to children’s HNC over a long period of time. In doing so, it determines whether children’s HNC can be intentionally promoted by the design of human habitats, and hence if nature-connecting habitats can be developed. The **salamanders paper** analyses the effects that direct participation in a nature conservation project has on children’s HNC. The **review paper** surveys the literature to identify synergies and gaps between different strands of empirical evidence. The **embody paper** conceptualizes a theoretical approach to fill gaps and overcome barriers identified in previous papers. This paper conceptualizes HNC as relationships amongst mind, body, culture, and

environment, and develops a useful framework to further explore nature-connecting habitats. Lastly, the **toolbox paper** complements existing research on HNC with the insights of professional practitioners in the field of connecting children to nature and develops a toolbox to assess children’s HNC and nature-connecting habitats. Overall, the thesis addresses long-term (**preschools paper**) and short-term direct nature experiences (**salamanders paper**), reviews the empirical and theoretical constitution of HNC (**review paper**), and understands how HNC and nature-connecting habitats can be theoretically (**embody paper**) and practically (**toolbox**) assessed (Figure 1).

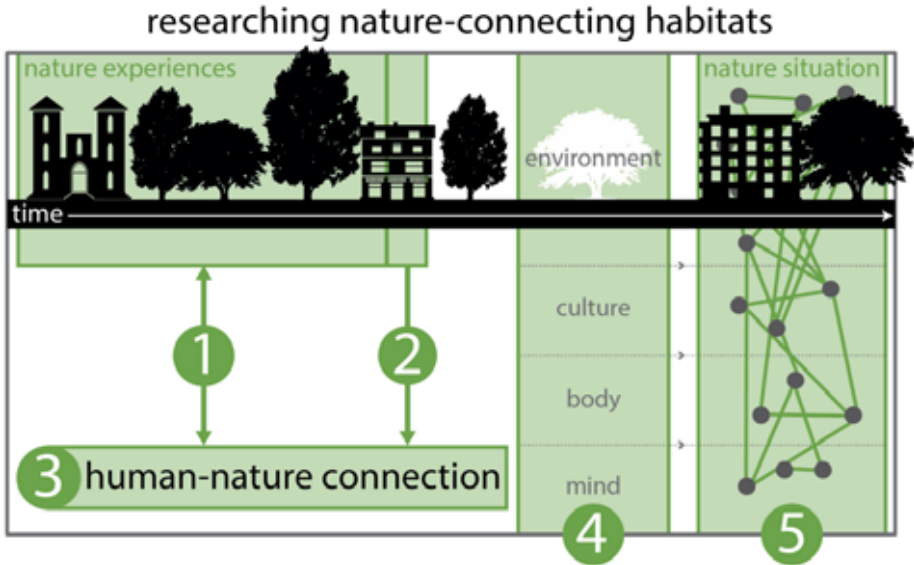


Figure 1. Visualization of the focus of each paper in researching nature-connecting habitats and human-nature connection (HNC). The preschools paper (1) focuses on the relationship between nature experiences occurring over a long period of time and children’s HNC. The salamanders paper (2) focuses on the effects of participating in one short-term nature conservation project on children’s HNC. The review paper (3) focuses on how HNC has been studied in the literature. The embody paper (4) is a theoretical paper that focuses on the role of mind, body, culture, and environment in the definition of valuable human-nature relationships. The toolbox paper (5) focuses on developing a toolbox to assess nature situations and children’s HNC as relationships between mind, body, culture, and environment.

Summary of papers

This section provides a summary of the papers included in this thesis. For each paper, I briefly present the objective, methods, and main results before providing its insights for the overall aim of this thesis.

Preschools paper

The main *objective* of the **preschools paper** is to validate whether it is feasible to promote key aspects of children's HNC via the deliberate design of their habitats. This implies establishing a link between children's human-nature relationships and children's nature habitats. In other words, appreciating if *nature-routines* – recurring experiences of nature situated in the everyday habitat – relate to children's HNC. Here, I combine *methods* of spatial analysis with methods to assess emotional, cognitive, and attitudinal aspects of HNC in five-year-old children. I begin by using GIS analysis to evaluate the natural surroundings of all preschools in Stockholm in terms of availability and accessibility of nature experiences (recreation, natural beauty, wilderness, and rurality). All preschools are then ranked according to the frequency of combined nature experiences that children have access to during preschool time. Key aspects of HNC are then compared between children who have spent four consecutive years in preschools surrounded by nature-rich habitats versus children who have spent four years in preschools surrounded by nature-poor habitats. The emotional and cognitive aspects of children's HNC are tested with a set of image-based games, which I have developed specifically for this study. These games focus on empathy and concern for nature, and on basic awareness of humans' reliance on natural resources. An image-based interview focused on children's motivation to play in natural areas tests the attitudinal aspect of children's HNC. The *results* reveal that children in preschools with nature-rich habitats are statistically ($p < .05$, $d > .8$) more capable than the others in distinguishing living from lifeless entities, showing empathy towards nature and concern for environmental degradation, and being aware of humans' requirements for natural resources. Still, fear of nature – likely culturally-based – exists across children, and their motivations to play outdoors is shaped by contextual memories of lived experiences. The *insight* of this paper for the thesis is clear. *Nature-rich habitats surrounding*

preschools allow persistent direct nature experiences that significantly relate to key aspects of children's HNC.

Salamanders paper

The **preschools paper** shows that there is a relation between nature-routines and key aspects of children's HNC. However, its research design does not help to identify which kinds of nature experiences are more or less formative, and this detail is crucial for developing nature-connecting habitats. To explore this gap, the **objective** of the **salamanders paper** is to assess the effects of participating in a nature conservation project – the salamander project (SP) – on children's HNC and on their desire to work for nature in the future. The SP is a conservation project in which 10-year-old children directly save the lives of two endangered species of salamanders. I perform qualitative and quantitative assessments of participation in the SP using a variety of **methods**. I use semi-structured interviews with children (N=25) to understand the nuances of how their HNC changes before and after their participation in the SP. Together with these interviews, I use several psychometric scales to assess changes in children's connection to nature (as given in Cheng and Monroe 2012), connectedness with nature (as described in Bruni and Schultz 2010; and Schultz 2002), place-based human-nature relationships (based on Aron, Aron, and Smollan 1992), and desire to work for nature (written question). These quantitative assessments are performed before and after with children participating in the SP (N=67), and with a control group who do not partake (N=91). The **results** of the qualitative and quantitative assessments reveal a discrepancy that I call the *assessment gap*. From the interviews, it is clear that participating in the SP increases children's appreciation for salamanders, animals, and nature at large. Children overcome the emotional barrier of touching salamanders (i.e. 'yuck' barrier), develop the ability to imagine what the life of a salamander is like, and start considering salamanders as lovable animals. However, these results are not supported by any of the results of the quantitative assessment. The statistical analysis of the quantitative results shows indeed no significant difference before and after children participated in the SP. Still, it shows the high sensitivity of all these methods to gender – females were more 'connected' according to all metrics – and an inverse correlation between children's desire to work for nature and their place-based relationships with the city. A structural equation model confirms that the positive effects of HNC on children's desire to work for nature are counteracted by a form of human-nature disconnection indicated by home-city and self-city relationships. Combining both positive and negative place-based relationships with the results of the psychometric scales increases the capacity of the model to explain children's desire to work for nature. These latest results suggest that the *assessment gap* might not only be a

methodological problem that requires selecting ‘better’ methods of assessment, but that it might have theoretical origins related to the decontextualization of children’s HNC. **Two insights** are important from this paper. *First, there is an assessment gap with theoretical roots that impedes assessing direct nature experiences for children’s HNC within practical time-frames. Second, place-based relationships help predict children’s desire to work for nature, and home-city and self-city relationships have a counteracting effect.*

Review paper

The **salamanders paper** highlights a gap in how to assess children’s nature experiences that could be significant for their relationships with nature. Closing this gap is crucial for developing any intervention that aims to connect children to nature, including through nature-connecting habitats. If children’s HNC cannot be reliably measured, it means that nature-connecting habitats cannot be identified or promoted. Hence, the **objective** of the **review paper** is to examine the existing empirical evidence to conceive ways to close the assessment gap. The **methods** I employ in this paper are those required for a systematic literature review. I query Scopus with a search string that combines a variety of terms related to human-nature relationships. I then code all peer-reviewed papers resulting from the query for a variety of variables. The **results** show that despite addressing human-nature relationships, the largest proportion of empirical evidence does not describe the kind of ‘nature’ humans relate to. The unit of analysis is mostly individuals and only half of the papers provide policy guidance. Importantly, a cluster analysis of all variables coded shows three clear academic silos in the literature of HNC. This offers one **insight**: *human-nature relationships are studied as an attribute of the mind; as qualities of nature experiences; or as an attachment to local places.* These three clusters of research are evidently complementary, and they can contribute to environmental sustainability in different ways. Their distinctive values are recognised and embedded in the concept of HNC. However, the integration and extension of this body of knowledge require further research to be used as one in practical applications. The second **insight** is therefore that *HNC recognises and embeds existing considerations about mind, experiences, and places, but theoretical barriers impede their integration.*

Embody paper

The way in which HNC is studied separately as attributes of the mind, qualities of experiences, or attachments to local places, points to an obvious

question: how can the contributions of these isolated areas of knowledge be brought together for sustainable development? The *objective* of **embody paper** is to investigate theoretical approaches that can address the assessment gap shown in the **salamanders paper** and the theoretical barriers highlighted in the **review paper**. Ultimately, the **embody paper** aims to provide a framework of practical value allowing the research of HNC as one cohesive system. The starting points for this paper are cultural ecosystem services – non-material values that are co-produced by humans and environments. The *method* here is a theoretical comparison between disembodied (exemplified by cultural ecosystem services) and embodied approaches (exemplified by affordance theory) to explore how different theoretical assumptions influence the definition of desirable values in human-environment relationships. Here, I make theoretical considerations about the role of the body in human cognition, about how socio-cultural processes relate to individual behaviours, and about the role of socio-ecological contexts in defining human-nature relationships. These considerations *result* in a framework based on an embodied ontology that I call *embodied ecosystem*. In contrast to the concept of cultural ecosystem services, the embodied ecosystem framework suggests that the value of an ecosystem is indeed embodied. This means that it is (a) relational, it originates from the existing relationships between environment, culture, body, and mind, (b) situational, at any point in time its actualized by direct perception-action processes, and (c) dynamical, its evolution occurs through pathways of actualizations. Overall, the framework of embodied ecosystems enables the research of mind, body, culture, and environment as one integrated system. It valorises and accounts for cultural diversity in the definition of an ecosystem and therefore allows for contextual and cultural specific ecosystem management. The *insight* of this paper is that *the embodied ecosystem framework provides a conceptual approach to integrate mind, body, culture, and environment in the constitution of value for human-nature relationships*. This creates a theoretical bridge that can integrate and complement the literature reviewed (**review paper**) and address the theoretical roots of the assessment gap (**salamanders paper**).

Toolbox paper

Lastly, the **toolbox paper** operationalizes the embodied ecosystem framework to create a toolbox that guides the assessment of where and how children develop their HNC. The *objective* of the **toolbox paper** is to develop the assessment toolbox needed for nature-connecting habitats. This paper complements existing literature on HNC with practitioners' inputs and utilises this information to fill the assessment gap identified by the **salamanders paper**. A sequential mix of qualitative and quantitative *methods* constitutes the exploratory and confirmatory phases of development for this toolbox.

First, I interview professionals in the field of connecting children to nature (N=26) about what human-nature connection is and what connected children are, and then I validate and further explore these results with an online survey with another set of professionals (N=275). The **results** elaborate three overarching principles: (a) *significant nature situations are various and with differing consequences for children's HNC*; (b) *children's HNC is a complex embodied ability*; (c) *children's HNC progresses over time through diverse nature routines*. Professionals identify 10 abilities of children's HNC that are progressively learnt in three phases. The first HNC phase is being able to be *in* nature and the distinguishing abilities are: feeling comfortable in natural spaces, and being curious about nature. The second HNC phase is being able to be *with* nature and the distinguishing abilities are: reading natural spaces, acting in natural spaces, feeling attached to natural spaces, knowing about nature, and recalling memories with nature. The third HNC phase is being able to be *for* nature and the distinguishing abilities are: taking care of nature, caring about nature, and being one with nature. Additionally, 16 qualities are identified as markers of nature experiences that significantly promote children's abilities of HNC. These are called *qualities of significant nature situations* in order to be coherent with the embodied approach used in this paper, and to distinguish them from the mostly undefined concept of 'nature experience' in which context and culture are not necessarily considered defining components of the experience. Nature situations are indeed constituted by relationships between mind, body, culture, and environment; exist only when actualized; and their actualization define pathways of future nature situations. The 16 qualities that define nature situations with the potential to nurture children's HNC are: entertainment, thought-provocation, intimacy, awe, mindfulness, surprise, creative expression, physical activity, engagement of senses, involvement of mentors, involvement of animals, social/cultural endorsement, structure/instructions, child-driven, challenge, and self-restoration. Altogether, these results are used to produce the *Assessment framework for Children's Human Nature Situations (ACHUNAS)*. ACHUNAS shows what to quantify or qualify when assessing where and how children connect to nature. The **insights** of this paper for the thesis relate to the three principles of ACHUNAS highlighted above, and the requirements for nature-connecting human habitats. *Qualities of significant nature situations and children's abilities of HNC shape the requirements for nature-connecting habitats.*

Synthesis

Philosophical considerations

This thesis is the product of an ‘undisciplinary’ journey (**paper B**). What is presented here is the endpoint of an iterative process that has balanced breadth and depth in researching both theoretical and practical foundations of nature-connecting habitats. This process gives the thesis three characterizing attributes.

First, the methodology of each paper is chosen to help understand nature-connecting habitats both in theory and practice (Figure 2). This means that this thesis relies on a variety of methodologies. I use image-based (**preschools paper**) and semi-structured interviews (**salamanders paper, toolbox paper**); I develop methods to address empathic concern, nature perspective-taking, awareness of environmental degradation, and understanding of human’s ecological dependence in five-year-olds (**preschools paper**); I develop methods to understand place-based relationships important to children’s HNC (**salamanders paper**); I prepare questionnaires (**salamanders paper**) and on-line surveys (**toolbox paper**); I implement existing psychometric tools (**salamanders paper**); and I make geographical analysis of frequency and accessibility of natural spaces (**preschools paper**). I analyse the data obtained inductively using thematic analysis (**preschools paper, salamanders paper, toolbox paper**), and deductively using descriptive statistics (**preschools paper, salamanders paper, review paper, toolbox paper**), cluster analysis (**review paper, toolbox paper**) and structural equation modelling (**salamanders paper**). This broad methodological spectrum provides a rich variety of angles to examine the research questions.

Second, the knowledge produced here is representative of several communities of knowledge. In this thesis, I combine insights from children (**preschools paper, salamanders paper**), academics (**review paper, embody paper**), and professionals (**toolbox paper**) (Figure 2). This diversity of contributions ensures that the knowledge produced here supports the academic research front, as well as being practically implementable in comprehensive solutions. This also facilitates future transdisciplinary research efforts.

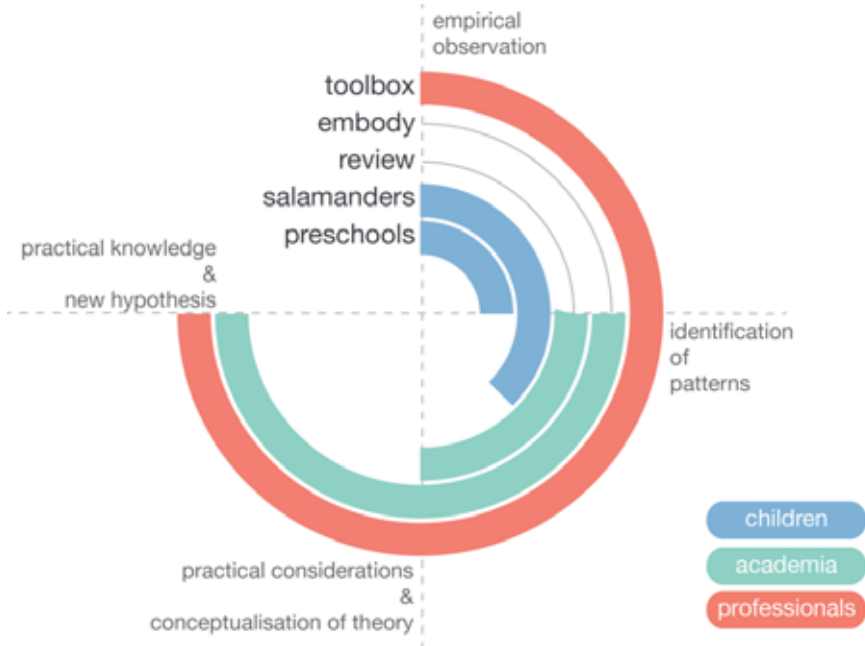


Figure 2. Methodological contributions of each paper. Contributions are colour-coded according to the community of knowledge represented.

The third characterising attribute of this thesis is the ontological shift from a disembodied (**preschools paper**, **salamanders paper**) to an embodied ontology (**embody paper**, **toolbox paper**). The background of these ontologies, their similarities, and the differences in how they value human-nature relationships are provided in detail in the **embody paper**. Here, I present the personal journey and reasoning behind this shift. Chronologically, the order of the papers is the same as presented in Table 2. The **preschools paper** was the beginning of this thesis, but its correlational results were insufficient to describe nature-connecting habitats. So, the **salamanders paper** used existing psychometric tools to understand the causality between children’s direct nature experiences and the development of HNC. These tools were found to be of limited practical use to comprehensively identify and distinguish nature experiences important for children’s HNC, hence also limited to understand nature-connecting habitats. These limits forced me to thoroughly examine the ontological assumptions behind psychometric methods of assessment for HNC. After having a complete picture of the literature on human-nature relationships (**review paper**), I realized the untapped value of place-based human-nature relationships (**paper C**) and of situated learning to understand HNC (Wilson and Madsen Myers 2000; Brown, Collins, and Duguid 1989). I studied the theory of affordances (Gibson 1979) and embodied cognitive science (Chemero 2009). I then further explored advantages and disadvantages of using a transactional approach

(Altman and Rogoff 1987) and the contributions that embodied approaches can provide for understanding human-nature relationships (**embody paper**). I examined the limits of embodied approaches in the realm of sustainable urban design (**paper D**) and then used their practical potential to develop embodied tools (**toolbox paper**). This is the ontological journey behind the concepts of *human-nature connection* and *nature-connecting habitats*.

I still believe that both disembodied and embodied approaches have explanatory power. I am not advocating for using only an embodied ontology, but I recognize its value. Disembodied ontologies have created most of the human progress as we know it – from cities to medical treatments – but I believe that embodied ontologies provide practical theoretical platforms that can integrate different sources of knowledge in a single holistic picture – as in the case of HNC. Human progress would then occur not only within an exclusive area of human life at the time – potentially leading to unliveable cities or overpriced medical treatments – but unfold harmoniously with ecological or social requirements. In this sense, embodied research is a step closer to answer the call for ‘biosphere-based sustainability science’ (Folke et al. 2016).

What is children’s human-nature connection?

Prior to starting this thesis, HNC was undefined in the literature. Many disciplines have examined a variety of human nature relationships (**review paper**), but there was not a single definition sufficiently comprehensive to be used for practical interventions. I began this work defining HNC as a set of human-nature relationships that enable, promote, or assist sustainable development, but its precise components were unknown. The research of this thesis unveils *a complex set of embodied abilities* that define children’s HNC (Table 3). This statement summarises the three core insights about children’s HNC that this thesis makes: children’s HNC is a set of abilities, these abilities are embodied, and they follow complex dynamics. These insights are separately discussed below and contribute to the theoretical foundations of nature-connecting habitats.

Table 3. List of abilities of children’s human-nature connection (HNC) with associated brief description and phase of progression (white text in green boxes).

Abilities of HNC	Brief description
Being IN nature	
Feeling comfortable in natural spaces	The child demonstrates ease in natural spaces and feels comfortable with natural elements in the outdoors (e.g., dirt, mud, rain, or the sun).
Being curious about nature	The child shows interest and motivation in exploring nature.
Being WITH nature	
Reading natural spaces	The child is able to see the possibilities for action in natural spaces.
Acting in natural spaces	The child is able to perform activities in nature, for example, nature playing, camping, or outdoor sports in nature.
Knowing about nature	The child demonstrates knowledge of animals, plants, and ecological dynamics.
Feeling attached to natural spaces	The child shows a sense of belonging to specific natural spaces, to which they feel part of.
Recalling memories with nature	The child is able to recall past nature experiences and tell stories of lived experiences with nature.
Being FOR nature	
Taking care of nature	The child is able to be responsible for nature and feels empowered to act for the wellbeing of nature.
Caring about nature	The child is able to feel care, concern, sensitivity, empathy, and respect for nature.
Being one with nature	The child is able to identify with nature and has a sense of profound personal attachment to nature that can be described as spiritual. Love for nature, humbleness in relation to nature, and assuming to be a small part of the immensity of nature are manifestations of this ability.

Children’s HNC is a set of abilities

The **toolbox paper** suggests that children’s HNC is defined by a set of abilities that children learn. Many of these abilities have similarities with existing conceptualizations of desirable human-nature relationships. For example, the ability of ‘knowing about nature’ is similar to the existing concepts of environmental literacy (Hollweg et al. 2011) or environmental awareness (Kollmuss and Agyeman 2002) operationalized in the **preschools paper**. ‘Caring about nature’ encompasses many other conceptualizations of care towards the environment (Chawla 2007), empathy towards nature (Tam

2013b), and environmental sensitivity, which was originally considered the foundation of environmentally-committed people (Peterson and Hungerford 1982; Chawla 1998). Lastly, ‘being one with nature’ is a multidimensional ability that has similarities with environmental identity (Clayton 2003), overlaps with love for nature (Perkins 2010), and links to philosophical human-nature relationships such as partnership and participation with nature (De Groot, Drenthen, and De Groot 2011). These similarities suggest that the potential for HNC to enable, promote, or assist sustainable development is at least equal to the potential that these individual conceptualizations have already empirically established (briefly reviewed in the introduction). Conversely, how HNC differs from these disembodied conceptualizations provides further insights that are discussed in the next section.

Children’s HNC is embodied

Considering HNC as an embodied set of abilities means that children’s HNC is an emergent property of relationships between mind, body, culture, and environment. The set of embodied abilities identified in HNC integrates the three, currently isolated, strands of literature shown in the **review paper** – literature on mind, on experiences, and on places. An embodied approach to HNC allows the needed integration of these disciplinary grounds, promoting their extension beyond disciplinary boundaries, and supporting their practical implementation in comprehensive interventions. Considering children’s HNC as an embodied set of abilities is an inevitable conclusion of the results of this thesis for the following three reasons.

First, because the abilities of HNC embody tangible natural environments. HNC goes beyond the abstract conceptualization of ‘nature’ often used in the literature to assess people’s human-nature relationships (**review paper**). HNC exists when children feel at ease in specific natural environments (i.e. ‘feeling comfortable in natural spaces’), when children learn to navigate the possibilities for action that these offer (i.e. ‘reading natural spaces’ and ‘acting in natural spaces’), or when children feel attached to them (i.e. ‘feeling attached to natural spaces’). These place-based relationships bring further support to the correlation between nature-rich habitats and high HNC shown in the **preschools paper**, and they help to justify how children’s motivations to play in natural areas is dominated by memories of contextual experiences (**preschools paper**). This is in line with the findings of the **salamanders paper**, which shows that place-based relationships significantly improve the prediction of children’s desire to work for nature. These insights mirror those in place attachment literature (**paper C**). Place-based abilities similar to those listed in HNC are shown to promote protective and restorative actions (Vorkinn and Riese 2001), stewardship practices (Chapin and Knapp 2015), motivate conservation behaviours (Raymond, Brown, and Robinson 2011), and foster care for the planet (Nassauer 2011). However, it is worth noting

that not all place-based relationships contribute positively to HNC (**salamanders paper**). Understanding place-based relationships is therefore essential for nature-connecting habitats and an embodied approach to HNC helps such an endeavour.

A second reason to approach HNC as an embodied attribute is because the cultural background plays a decisive role in defining children's HNC. Property rights that define access to natural environments, existing codes of conduct in natural areas, or a sense of belonging to a social group that promote nature-ameliorating rather than nature-degrading actions are just some of the cultural settings that evidently relate to HNC. The defining role of culture is evident in all abilities of HNC, from what is socially acceptable to feel and do (e.g. 'feeling comfortable in natural spaces') to what kind of caring actions are promoted or taught (e.g. 'taking care of nature'). The role of the social background in defining HNC is also clear in the **salamanders paper**. Children in the school organising the SP are constantly exposed to a salamander-friendly culture. Over time, such a culture significantly promotes higher empathy towards salamanders in children attending this school in comparison to those children in schools nearby. A quote from the **preschools paper** further contributes to this consideration. "Deer and dinosaurs do not feel pain because they can hit back" (Karolina). The fear of deer and dinosaurs is likely product of cultural transmission rather than of personal encounters with a Tyrannosaurus. Culture is a defining variable of human-nature relationships and this provides further support for approaching HNC as embodied.

Last but not least, considering children's HNC as embodied is important because it highlights the role of the body in the abilities of HNC. For instance, the ability of 'feeling comfortable in natural spaces' cannot be seen in isolation from bodily sensations. Curiosity about nature emerges in combination with the bodily possibility to explore. Despite being separated in the list of abilities of HNC, reading and acting in natural spaces are inevitably two sides of the same coin. They indeed resemble the very co-occurring processes of perception and action that defines embodied ontologies (**embody paper**). The body is also central in defining a set of abilities that can promote sustainable development. In the **salamanders paper**, the actions required to save salamanders are as important – if not more – than children's concern for the lives of salamanders.

In contrast to the dominant vision that sees HNC as a psychological trait (**review paper**), I support here an embodied approach to children's HNC based on the set of abilities listed in Table 3.

Children's HNC is complex

The set of abilities constituting children's HNC reflect complex and non-linear dynamics of development. The **toolbox paper** shows different phases of HNC progression – being *in* nature, being *with* nature, being *for* nature –

suggesting that, even within one individual, HNC cannot be understood linearly. For instance, progressing from being *in* nature to being *with* nature might be possible only when the abilities to be in nature are developed in depth. Non-linear dynamics of development for HNC are also supported by the ‘yuck barrier’ – threshold effect – shown in the **salamanders paper**. Overcoming the emotional barrier of touching salamanders has opened the possibility for children participating in the SP to enjoy salamanders, feel empathy for them, and consider them worth caring for. Additionally, different configurations of abilities play defining roles in understanding children’s HNC as a whole. This means that despite HNC being a list of abilities, its definition and impact cannot be simply reduced to the sum of the single abilities. Different configurations of abilities nurture different outcomes. For example, having a strong ability to feel comfortable, read, and act in natural spaces might facilitate children’s sense of attachment to specific natural areas and desire to conserve them. However, without being able to take care of these spaces, these children might not be able to suggest any interventions to protect them.

Limits and next steps for human-nature connection

There are a number of limitations to the concept of HNC as it is now. First and foremost, conclusive evidence on how children’s HNC enable, promote, or assist sustainable development is not yet available. The findings in this thesis provide further support for the potential of HNC for sustainable development, but this link remains a hypothesis and a noteworthy unknown in sustainability science. A literature review to unveil the empirical linkages between children’s HNC and sustainable development is therefore urgent. This thesis offers some insights on how to stimulate this research area. For instance, approaching HNC from an embodied perspective allows well-developed professionals’ knowledge to be integrated. Transdisciplinary efforts are needed to understand how HNC develops, which phase of development is most important at which age, which abilities of HNC best promote sustainable culture or environmentally-conscious behaviours, and which ones support sustainable biases, defaults, and habits. Moreover, distinguishing which abilities of HNC are required to nurture sustainable societies and which ones are more useful to trigger transformative changes towards sustainability is also important. These are just a few examples of how HNC can be further researched in relation to sustainable development.

The second limitation is that the list of abilities that constitute HNC is comprehensive, but not complete (**toolbox paper**). Further research is required to validate and complement the list of abilities of HNC, paying particular attention to the interdependencies and synergies amongst abilities. Of special importance here are undesirable human-nature relationships. The **salamanders paper** shows that these are not simply the absence of HNC.

Home-city and self-city relationships contribute to a different set of unknown human-nature relationships with *undesirable* potential for sustainable development, which I termed human-nature disconnection. HNC and human-nature disconnection do *not* constitute the extremes of *one* gradient, but they are different sets of relationships likely to have polarising effects on promoting sustainable development – or at least on promoting children’s desire to work for nature. As it has been important to unveil HNC, it is important to unveil its opposing factors in future research for sustainability.

What are the requirements of nature-connecting habitats?

This thesis is set up to provide the theoretical and practical foundations of nature-connecting habitats for children. To date, similar research is limited to biophilic design (Beatley 2010; Kellert, Heerwagen, and Mador 2008), which, with few exceptions (Tidball 2012; Tidball and Krasny 2010), considers almost solely internal design. This is an inadequate strategy to reach broad social-ecological sustainability. Also, the founding theory behind this literature – biophilia – is seen as a genetic disposition, which poorly integrates with promoting or transforming human-nature relationships (Kellert and Wilson 1993). The practical attempts to create children’s nature-connecting habitats are limited the design of playgrounds (Moore 2014), and to the ‘Cities Connecting Children to Nature’ initiative (see www.nlc.org). The latter lacks the theoretical ground provided in this thesis, hence still struggles to find an assessment framework valid across cities. The three requirements for nature-connecting habitats proposed below provide fresh starting points to promote these efforts, and, first of all, confirm that nature-connecting habitats can be developed.

Nature-connecting habitats can be developed

Even without being intentionally designed for the purpose, nature-rich habitats surrounding preschools relate significantly to key aspects of children’s HNC (**preschools paper**). Place-based relationships – most likely developed over a long time (Lewicka 2011) – have a direct influence on children’s desire work for nature (**salamander paper**). Nature-connecting habitats can therefore be deliberately designed. Important knowledge that could contribute to their design already exists in the literature and it is already a valuable starting point for sustainable social-ecological systems (**paper B**). The **embody paper** facilitates this integration and the **toolbox paper** further confirms that ‘child-nature-connectedness’ is a property of an environment

that can be assessed. Their qualitative and quantitative requirements are reported below.

Nature-connecting habitats require significant nature situations

Understanding the qualitative requirements of nature-connecting habitats means being able to distinguish between habitats that promote children's HNC from habitats that do not. Doing so requires a set of criteria to assess - and eventually compare - habitats in practical time-frames. Moving towards this goal, the **preschools paper** distinguishes between nature-rich and nature-poor habitats but cannot pinpoint which nature experiences are more or less formative. It is self-evident that not all nature experiences are equally significant in promoting children's HNC. Still, a list of all nature activities that could possibly promote or hamper HNC does not have any practical value. Such a list would be endless and always incomplete. A key contribution of this thesis has therefore been to identify the qualities of nature experiences that have the potential to connect children to nature. These are 16 *qualities of significant nature situations (SNS)* that professionals have identified and that relate to existing academic literature (Table 4).

The list of qualities of SNS together with the list of abilities of HNC shown in Table 3 are the backbone of the embodied toolbox of assessment called ACHUNAS. ACHUNAS defines *what* to assess to identify nature-connecting habitats. Such assessments could be performed using participatory observations, interviews, or PPGIS, amongst other methods. It is worth noting that in a hypothetical assessment of a natural area using ACHUNAS, identifying a quality of SNS like 'entertainment' implies that children are, first of all, already there. The area is somehow accessible and children's entertainment is socially accepted. 'Entertainment' emerges – therefore can be assessed – from relationships between children's mind ('what is considered fun'), their body ('how to act to have fun'), the social context ('what is socially accepted as fun'), and the environment ('what the environment allows to have fun with'). Thus, 'entertainment' exists only if children actualize it in SNS. The same can be said for all other qualities of SNS. As a consequence, one assessment is likely to be insufficient to provide conclusive information about the connecting quality of a natural area. For example, a natural area should not be assessed for 'entertainment' during a yearly festivity. Such an assessment would provide information that is not indicative of children's routines but merely of an isolated occurrence. As qualities are relational in terms of space, culture, and children, they are also in relation to time.

Table 4. List of qualities of significant nature situations (SNS) with associated brief descriptions and related academic categorisation (white text in red boxes).

Qualities of SNS	Brief description
Entertaining	
Entertainment	SNS that are fun, joyful, amusing, or enjoyable.
Environmental epiphanies	
Thought-provocation	SNS that create new ways of conceiving human-nature interaction.
Awe	SNS that are amazing, of overwhelming attraction, or mesmerizing, that create a 'wow effect'.
Surprise	SNS that are unpredictable or unexpected. In these nature situations children's line of thought is interrupted, and nature draws their attention.
Restorative experiences	
Intimacy	SNS that are private or intimate and allow a personal experience with nature.
Mindfulness	SNS that grasp children's focus and alertness, that make children 'be in the flow'.
Self-restoration	SNS of psychological, physical, or social relief. For example, relief from stress, fatigue, or gender stereotypes.
Nature free-play	
Creative expression	SNS that involve arts, myths, stories, music, or role-play.
Physical activity	SNS that require body movement or any form of physical activity.
Challenge	SNS in which children overcome psychologically or physically adverse conditions, such as fear or cold.
Engagement of senses	SNS that activate children's senses (smell, touch, hearing, etc.)
Child-driven	SNS that are chosen by the child, child-initiated, and open-ended (children decide when to start and stop).
Nature school	
Involvement of mentors	SNS that involve persons, such as teachers, experts or relatives, who are capable of inspiring, encouraging, or leading the nature experience for the child.
Structure / instructions	SNS characterized by a set of rules that define the frame within which the child can act.
Social / cultural endorsement	SNS that involve positive peer pressure, support from significant others, social acceptance, or cultural reinforcement.
Animal engaging	
Involvement of animals	SNS that involve interaction with animals.

Another hypothetical assessment of SNS can be done using the salamander project (SP in the **salamanders paper**) as a background. If I had to use the qualities of SNS to assess the SP, I would assess that all children have fun ('entertainment'), are thrilled to hold a salamander for the first time ('awe', 'intimacy', 'involvement of animals', 'engagement of senses'), are enthusiastic to contribute to a real-world project of nature conservation ('involvement of mentors', 'structure/instructions', 'social/cultural endorsement') and that the SP makes them imagine the life of salamanders ('thought-provocation'). Given that the SP covers most of the qualities of SNS, I would conclude that the SP is influential for children's HNC. Assessing children's abilities of HNC might provide further confirmation of this hypothetical conclusion by showing that children feel more comfortable in nature, are more curious, they know and care more about salamanders, and – importantly – they are able to take care of them. This is still a thought-experiment, but the differences with the results obtained using psychometric methods are tangible. At the very least, ACHUNAS provides a further argument for embodied tools of assessments; at best, it confirms that the list of qualities in Table 4 can identify and distinguish nature-connecting habitats.

Nature-connecting habitats require various nature routines

In order for children's habitats to be nature-connecting not only do SNS have to occur, but their variety and reoccurrence are fundamental. The **toolbox paper** shows that children's abilities of HNC progress through the *routinization* of diverse SNS. The consequence is that nature-connecting habitats require a variety of significant nature routines. The importance of frequent nature experiences is not novel in environmental education (Chawla and Cushing 2007; Finch 2008; Nazir and Pedretti 2016), and both the **preschools paper** and the **salamanders paper** corroborate these results. In the **preschools paper**, nature-rich routines are linked to high environmental empathy, concern, and awareness. In the **salamanders paper**, recurring indirect experiences of salamanders through school culture nurture significantly higher salamander empathy than in nearby schools. Frequency and duration are indeed defining qualities of positive or negative experiences of space (**paper A**), and they play a central role in the definition and practical implementations of nature-connecting habitats. Ensuring nature routines means providing equitable access to nature-rich spaces that are safely accessible by all generations – indeed mentors and cultural endorsement from all generations are also important qualities of SNS. Everyday places used by children, such as schools, playgrounds, backyards, and city streets are the obvious starting points to design a distributed network of significant nature situations in which children's HNC can progress.

Limits and next steps for nature-connecting habitats

This thesis addresses the theoretical and practical foundations of nature-connecting habitats for children. Still, it does not suggest how to design them. This thesis is limited to the first steps without which it would however be impossible to start such an endeavour. Without the work presented here, it would not be possible to understand what is important to promote in children (i.e. abilities of HNC) or what kinds of nature experiences are important to promote in space (i.e. qualities of SNS). These elements are a stepping stone for the three following steps that are required to advance research and practice for nature-connecting habitats for children.

The first step is to assess the existing human habitats to understand *what kinds* of nature situations exist, and which ones are missing. This means quantifying or qualifying the ‘extinction of experience’ known to exist in most human habitat (Soga and Gaston 2016). To this end, assessing where and how children connect to nature can be done using the ACHUNAS framework (**toolbox paper**). One limitation of this tool is that it indicates *what* to assess – children’s abilities of HNC and the qualities of SNS – but not *how* to assess them. Hence, further research is required to validate tools to assess nature-connecting habitats.

The next step from here is to understand how different configurations of SNS, and the consequent nature routines, influence children’s HNC and its progression. For instance, *nature free-play* and *entertainment* are more often used to teach children’s ability to be *in* nature, whereas *thought-provoking* activities and *nature school* are more useful to develop children’s ability to be *for* nature (**toolbox paper**). Still, this information is of correlational nature and evidently insufficient to provide comprehensive practical guidelines.

Accomplishing these two first research steps should be sufficient to understand *where* to design *what* kind of natural areas to nurture children’s HNC. Yet, there are known and unknown barriers before reaching the third step – *how* to design nature-connecting habitats (**paper D**). This is inevitably a transdisciplinary effort between children, municipalities, urban designers, sustainability scientists, environmental educators, and environmental psychologists. Synergies and win-win situations exist amongst these different actors and they have to be exploited to ensure inclusive and durable solutions.

Conclusions

This work establishes the foundations for developing nature-connecting habitats. In 2006, Wells and Lekies stated: “encouraging children to become engaged with the natural world, preserving habitats where they can do so, and creating programs and opportunities for this to occur may be critical to the future of healthy children, healthy adults, and a healthy planet” (p.18). This remains highly relevant today and with much – or most – work still to be done. Through contributions from children, academics, and professionals, this thesis develops the theoretical and practical foundations to achieve Wells and Lekies’ vision. The theoretical foundation is a complex set of embodied abilities that defines children’s HNC. The practical foundation is a toolbox to assess children’s HNC alongside the human habitats in which it develops.

Children can *learn* to connect with nature. This learning process engages children’s mind and body, and does not occur in isolation from the socio-cultural context, nor from specific natural environments. This thesis identifies 10 abilities that define children’s HNC, ranging from ‘feeling comfortable in natural spaces’ to ‘being one with nature’. Children’s HNC is then embodied, and it is also complex. Feeling care and concern for the environment are products of complex learning patterns that start with feeling comfortable in the natural outdoors. Children learn first to be *in* nature and consequently progress into being able to be *with* it, and eventually think and act *for* it. This embodied approach to HNC offers novel and fertile ground for further academic research and practical applications. The first one being nature-connecting habitats. These are human habitats designed to support children’s HNC throughout its progression.

Developing nature-connecting habitats for children is possible, and it does not solely mean safe access to nature-rich areas. It is not only the quantity of nature situations that is important, but also their quality. This thesis identifies a comprehensive set of 16 qualities central to promote children’s HNC. These include, among others, nature free-play and restorative experiences. Importantly for their application in practical interventions, this thesis delivers a toolbox to assess them – ACHUNAS. Human habitats can now be assessed to understand where and how children find and nurture a personal or collective connection to nature.

This is not the end of nature-connecting habitats. Understanding, analysing, and promoting nature-connecting habitats is obviously not a finished task. By building on the work of this thesis, future research can quite easily produce

sufficient knowledge to understand *where* to design *what*, and eventually *how*. *Why* is assumed in the recognised impact that children's HNC has on sustainable civilizations, and the benefits that nature interaction has on children's overall health, well-being, and personal development. Nature-based solutions provide clear synergistic platforms to implement these interventions (Lafortezza et al. 2017; Raymond et al. 2017; Nesshöver et al. 2017) and future research should seek and emphasise these mutual benefits. Nature-connecting habitats and children's HNC might not be a sufficient condition to generate sustainable transformation alone, but they may very likely be a necessary condition to meet ever-shifting sustainability targets. While children's HNC is not a 'silver bullet', and nature-connecting habitats are not the only intervention to promote it, they form a novel strategy that complements a suite of approaches needed to achieve sustainability.

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Thank you all

I do not even know where to start. I feel privileged to be at this point in my life, but I don't think this is really my achievement. Despite the name on the cover of this book being mine, this is the accomplishment of the efforts of many many people. First, it is the accomplishment of those who taught me and fed me for most of my life. My mum Loreta and my dad Roberto. They sacrificed a lot in their lives to give me the opportunity of being here. I don't think I have yet merited that much. They should be proud of what they did, even if they still don't know what this PhD is about. Then, I have to thank those who taught me what *real* problems are, without ever depicting them as insurmountable. This is the Stockholm Resilience Centre. I have been here for 10 years. I arrived as an uncommitted semi-hippie and thanks to the teachings, patience, and – let's be honest here – funds, I leave as a doctor in Sustainability Science. Quite an accomplished regime shift. Over and over again, people gave me the possibility to keep playing with my thoughts. Stephan “the boss” Barthel being the clearest example. Thanks.

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Thank you all. You all have done a fantastic job. You all made me a doctor. So long, and thanks for all the hugs.

Navigating a PhD without sinking

There is so much that could be written here. Years ago, I began writing a document titled “how to navigate a PhD without sinking”. But I had little to write back then. Below, I list a collection of mottos that I learnt from mistakes or that helped me throughout my PhD.

Save time. Make time.

Shortcut keys, fast typing, reference managers, and time management methods save you a little time often. Win-win situations, rewarded self-imposed deadlines, asking for help from people that know your work better than you, and disappearing when people around you say: “it would be super interesting to discuss [insert irrelevant topic]” save you a lot of time all at once.

Plan in decades. Think in years. Work in months. Live in days. (and thanks to Diego) Breathe now.

This one always seems to put things in perspective. At least because every time I read it I breathe. And that’s good.

Work hard. Train hard. Relax hard. Play hard.

Or work little, relax little, train little and play little. I found that the harder I work the harder I have to *not* work. The point is that you need balance. After an intense period of work, there are few things that feel as good as pushing your body hard or dancing your heart out.

Keep It Simple Stupid (KISS).

I borrow this one from Stephan, who borrowed it from Leonardo da Vinci: “simplicity is the ultimate sophistication.” To me this is a standard of quality. If other people cannot understand it, can you really? Still, very hard to achieve.

Aim for perfection, but do not try to reach it.

Do what needs to be done very well, but do not try to achieve a perfect result. You will waste a lot of time and at the end, you will be disappointed. Be significantly better, with or without p-value, or be your best self. That’ll do.

Do not assume that everything you read or hear is right.

Different things work for different people. Be critical. It’s your job.

Appended papers

Preschools paper

Salamanders paper

Review paper

Embody paper

Toolbox paper

