The John Muir Award's Role in the Complex Formation of Lasting Nature Connectedness: A Fuzzy Cognitive Mapping Study with Scottish Outdoor Learning Practitioners

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Abstract

Evaluations of outdoor learning interventions consistently report improvements in participants' nature connectedness, yet evidence for sustained impact is scarce. This gap persists because nature connectedness comes from numerous factors interacting over time, frustrating understanding of how to foster strong human-nature bonds for lifelong health and environmental behaviours.

To understand how fixed-duration interventions might contribute to lasting change within complex systems, this study pursued three progressive objectives: mapping the complex system shaping lasting nature connectedness in Scottish children and young people; identifying the most influential concepts where strategic intervention might achieve maximum impact; and exploring how the John Muir Award, may contribute to connectedness under different system conditions. I engaged Scottish outdoor learning practitioners to collaboratively map factors shaping nature connectedness using Fuzzy Cognitive Mapping (FCM).

Through workshops and interviews, practitioners identified key system concepts and assigned numerical weights representing relationship strengths. Degree centrality analysis identified which concepts practitioners view as most influential. *Child-led outdoor play* emerged as the most critical direct factor, though heavily dependent on parental support and community attitudes. The model showed how key influences change with age: parental guidance is key in childhood while peer influence and community norms grow dominant in adolescence. Simulations explored conditions that support or impede the Award's sustained impact. Practitioners understand the Award's primary impact to be indirect, building leader confidence and motivation to facilitate ongoing outdoor learning. While the Award showed positive impacts across all simulations, improvements were modest and constrained by disabling community norms.

This study concludes that outdoor learning interventions may achieve long-term impact by reinforcing the wider system that sustain engagement. As the first application of FCM to the fields of outdoor learning and nature connectedness, this work provides researchers with a pioneering demonstration for modelling complex nature-human dynamics, and offers practitioners a 'thinking tool' to design interventions for lasting impact.

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Acknowledgements

Four years ago, a version of myself without eyebags took an induction course on PhD life. The takeaway: PhDs are hard, lonely, and disorienting at times. And, at times, it really was. But while I prepared for the worst, I'm now suspicious that I got the best. This eerie shortage of adversity compels me to credit those who made my studies enjoyable, collaborative, and purposeful. Thanks to:

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The tree outside my bedroom window.

Author's Declaration

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other Institution.

I acknowledge the use of Claude Sonnet 4 (Anthropic, https://claude.ai) and ChatGPT (OpenAI, https://chat.openai.com) for outlining, proofreading, and improving the clarity and readability of my writing. These tools were used to enhance my own work and ideas; all analysis, critical evaluation, and original thought remain my own.

I have no competing interests to declare.

Abbreviations

ABM	Agent-based modelling or agent-based model
The Award	The John Muir Award
C1	Access to quality local natural space
C2	Child-led outdoor play
C3	Disabling community norms
C4	Guided nature engagement
C5	Leader confidence and motivation to deliver outdoor learning
C6	Nature connectedness
C7	Negative outdoor experiences
C8	Parent/carer affinity for nature
C9	Parent/carer aversion to nature-related threats
C10	Peer affinity for nature
C11	Perceived access to quality local natural space
C12	Perceived academic/outdoor learning divide
C13	Screen time
C14	Unsupportive organisation culture
C15	Vicarious outdoor experiences
CfE	Curriculum for Excellence
CLD	Causal loop diagram
FCM	Fuzzy cognitive mapping or fuzzy cognitive map
JMT	John Muir Trust
LfS	Learning for Sustainability
PEB	Pro-environmental behaviour
RQ1, RQ2, RQ3	Research questions 1-3
SDM	System dynamics modelling or systems dynamics model
SES	Social-ecological system(s)
SLE	Significant life experience
UK	United Kingdom
UN	United Nations

Chapter 1 Introduction

1.1 Chapter overview

This introductory chapter establishes the motivation and scope for my study's investigation of how outdoor learning interventions contribute to lasting nature connectedness in Scottish children and young people. Section 1.2 situates my research within the wider study of human-nature relationships and defines the construct of nature connectedness. Section 1.3 summarises the evidence for the health and environmental benefits associated with nature connectedness, framing the construct as a timely topic of study. Section 1.4 introduces outdoor learning as a promising vehicle for fostering strong relationships with nature. Section 1.5 narrows the focus to Scotland and the John Muir Award as the specific context for this investigation. Section 1.6 concludes the chapter by stating the research problem this thesis addresses and by outlining how each subsequent chapter builds toward an original contribution to knowledge and practice.

While evaluations of outdoor learning programmes consistently report immediate gains in nature connectedness, evidence for lasting impact remains fragmented because most evaluations capture only short-term changes rather than the complex system dynamics that shape enduring connections with nature. To address this gap, I employ a novel systems modelling approach, engaging Scottish outdoor learning practitioners to collaboratively map interrelated factors shaping nature connectedness and to explore how the John Muir Award contributes to lasting outcomes under different system conditions.

1.2 Human-nature relationships and nature connectedness

1.2.1 The study of human-nature relationships

The concept of humans having a ‘connection to nature’ is rooted in long-standing philosophical traditions and has recently emerged as a critical area of transdisciplinary research (Beery et al., 2023; van Heel et al., 2023). Widespread acknowledgement of urgent health and environmental crises over the past two decades has given rise to a heightened demand for scholarly reassessment of our relationship with the natural world (Freeman et al., 2021).

At the core of the various conceptualisations of 'connection to nature' and 'nature connectedness' (defined in Section 2.3.1) is the biological fact that humans are not separate from nature but an integral part of it (Zylstra et al., 2014). We breathe plant-produced oxygen, eat vegetables, and host microbiomes in our guts (Richardson, 2023). This recognition, however, comes with several philosophical implications about our interdependence with other living things and our obligation towards them (Mynott, 2024). Laying the theoretical groundwork for much of the current research and practice promoting engagement with natural environments is the ‘biophilia hypothesis’ (Wilson, 1984), which posits that humans have an innate affinity for other living things (Holland, 2024; Richardson, 2023; Lengieza and Swim, 2021).

The perspective that humans are part of nature has been revitalised in response to what scholars have identified as a modern human-nature ‘dualism’ or ‘human exceptionalism’ that characterises post-industrial society (Richardson, 2023; Christens et al., 2025). The roots of this dualist paradigm can be traced back to the Enlightenment and individualistic thinking, which positioned mankind as separate from and dominant over nature, viewing it as a resource to own and exploit (Barragan-Jason, 2021; Richardson, 2023; Christens et al., 2025). This conceptual separation between people and nature has been exacerbated by a literal distancing from the rest of the natural world (Louv, 2013). Mass urbanisation, extensive supply chains, and technological advancement have steadily reduced direct contact with natural environments, furthering the notion that nature is 'other' than human (Barragan-Jason, 2021; Richardson, 2023; Christens et al., 2025).

The result is an increasingly fractured human-nature relationship that scholars and environmentalists blame for the degradation of global ecosystems and various health crises. Kessler (2019, p.3) writes, “Environmental problems are first and foremost problems of relationship, where faulty interactions between individual human and more-than-human beings scale up to create various large-scale environmental crises.” A growing disconnect is compounded by what Kahn (2002) describes as environmental generational amnesia. As each generation grows up in an increasingly degraded and urbanised environment, their baseline for what constitutes a healthy ecosystem also shifts, making them less likely to recognise or act upon environmental losses (Kahn, 2002, Price et al., 2022). Other concepts such as 'nature deficit disorder' (Louv, 2013) and 'extinction of experience' (Pyle, 1993; Soga and Gaston, 2016; Cazalis et al., 2023) have been used to highlight the negative health and environmental consequences of diminishing contact with nature, particularly for children and young people in urbanised settings (Ives et al., 2018). I detail these consequences further in Section 1.3.

More than a theoretical premise, there is growing evidence that people in Western developed countries are becoming increasingly separated from nature, both physically and psychologically, though this pattern varies considerably among individuals and communities (Kesebir and Kesebir, 2017). Because survey tools for measuring 'nature connectedness' (defined in subsections 1.2.2 and 1.2.3) are relatively recent, there is a scarcity of longitudinal data showing whether psychological bonds with nature have declined across generations at a population level. Nonetheless, related changes in behaviour, lifestyle and culture provide strong grounds for inference.

In the UK, surveys suggest a marked reduction in children's outdoor play. According to a 2009 survey, only around one in ten children reported playing regularly in natural environments, compared with about four in ten adults who recall doing so in their own childhoods (Childhood and Nature, 2009; Moss, 2012). Independent mobility studies also show large reductions in children's unsupervised outdoor activity since the mid-twentieth century, largely driven by parental safety concerns (Valentine and McKendrick, 1997), with more recent evidence indicating this trend has continued into the 21st century (Shaw et al., 2015). Time-use research shows that people in high-income countries now spend approximately 85–90% of their time indoors or in vehicles, substantially limiting incidental encounters with nature (Klepeis et al., 2001, Matz et al., 2014). Children's leisure time is increasingly dominated by screen-based activities, often at the expense of outdoor play (Price et al., 2022; Holland et al., 2024; Ofcom, 2024). Analyses of cultural products further reveal that references to common species and landscapes have declined in books, song lyrics, and film storylines over the past century, while references to man-made environments have not (Kesebir and Kesebir, 2017).

Taken together, these convergent behavioural and cultural indicators provide compelling evidence of a multi-generational shift away from nature. These trends are used to underscore the urgency of studying human-nature relationships to find solutions to the interlinked crises of environmental degradation and human wellbeing (Sheffield et al., 2022). Indeed, recent years have seen a proliferation of 'nature connection' rhetoric in popular and policy discourse. The United Nations' "Making Peace with Nature" report (2021, p. 13) explicitly calls for "transforming humankind's relationship with nature" as a key strategy for addressing global environmental crises. The UK government's 25 Year Environment Plan (2018, p.71, cited in Richardson, 2023) emphasises "connecting people with the environment to improve health and wellbeing."

1.2.2 Defining nature connectedness

While the call across public and policy discourse to connect with nature may be intuitively appealing, the phrase has been used inconsistently and can make interpreting research findings difficult (Ives et al., 2018).

Although commonplace, the word 'nature' resists simple definition. As Zylstra et al. (2014, p.121) note, "'Nature' is largely a social-cultural construction and its conceptualisation will vary across—and inevitably be influenced by—such contexts, including disciplinary epistemologies." This is not to suggest that nature is entirely a human idea (Chawla, 2001; Mynott, 2024). There is a natural world that has preceded and may outlive humanity; nature sometimes defies human perceptions and understanding (Chawla, 2001). However, as naturalist Jeremy Mynott (2024, p.315) explains, "The history of nature is (…) a human history since, as far as we know, we are the only species that consciously finds meaning and significance in it." In this sense, any attempt to define 'nature' is never neutral but inherently informed by historicised cultural and political biases (McPhie and Clarke, 2021). The fact that most empirical research on human-nature connection has been conducted in Western developed countries ought to raise eyebrows about any presumed universality of the term (Ives et al., 2018; Holland, 2024; McPhie and Clarke, 2021; Mynott, 2024).

Admittedly, my study continues this anthropocentric and Western-centric perspective by focusing on the formation of nature connectedness in the Scottish context. However, while I acknowledge this inherent bias, this is also an intentional aspect of my research design and objectives. As I detail further in my introduction of social-ecological system research in Chapter 2, my goal is not to achieve a universal understanding of nature connectedness and its formation, but to capture and explore the perspectives of a specific group of practitioners who live and work within Scotland. These parameters allow for a more nuanced, context-specific exploration of nature connectedness, particularly as it relates to my focal intervention, the John Muir Award, and its impact on children and young people (see Section 1.6).

For this study's purpose, I adopt Zylstra et al.'s (2014) definition of nature as "any element of the biophysical system which includes flora, fauna, and geological landforms occurring across a range of scales and degrees of human presence" (p.121). This intentionally broad definition aligns with the John Muir Award's inclusive conceptualisation of 'wild places', which I present in my overview of the John Muir Award in subsection 1.6.2.

The use of 'connectedness' in the context of 'nature connectedness' presents its own set of challenges (Freeman et al.,2021). Fletcher (2017) raises concerns that the term inherently contradicts its own philosophical roots by implying that humans are separate from nature in that they can ‘connect’ or ‘disconnect’ from it. McPhie and Clarke (2021) caution that the careless use of the term by outdoor learning interventions (defined in Section 2.3) may inadvertently reinforce the very human-nature dualism these programmes seek to overcome (Fletcher, 2017; McPhie and Clarke, 2021; Holland, 2024).

Drawing from the field of environmental psychology, Holland et al. (2024) clarify that while humans are objectively part of nature, our relationship with nature is shaped by our subjective experiences, thoughts, and feelings. Despite our biological interdependence with nature, humans may still perceive the natural world with apathy, fear, and even hostility (Richardson, 2023).

This objective versus subjective distinction clarifies my study’s conceptualisation of nature connectedness as a psychological construct that can be defined and even measured to better understand how outdoor learning interventions (defined in section 1.4) might influence participant's perceptions and feelings about nature. Following several leading researchers in the field (Mayer and Frantz, 2004; Lengieza and Swim, 2021; Richardson, 2023), I define nature connectedness as encompassing two reinforcing dimensions:

1. Cognitive: How people understand themselves in relation to nature, the extent to which they identify as part of it. Connectedness is a character trait and part of an individual's identity. In this sense, it is relatively stable.

2. Emotional: How people feel when interacting with or noticing nature, and their sense of 'oneness' with it. Connectedness, in this sense, may fluctuate on a moment-to-moment basis.

These dimensions often merge into a single definition, conceptualised as both a state and trait. Scholars like Lengieza et al. (2023, p. 50) describe nature connectedness as "the psychological joining of nature and the self, which manifests as a sense of oneness with nature." Likewise, Richardson (2023, p. 58) frames it as "a realisation of our shared place in nature, which affects our being – how we experience the world here and now; our emotional response, beliefs, and attitudes towards nature." The cognitive, trait dimension of nature connectedness provides a stable foundation of self-identity that shapes how environmental encounters are interpreted, while the emotional, state dimension creates meaningful experiences that can gradually reinforce or reshape one's identity over time (van Heel et al., 2023). As this study investigates the potential for fixed-duration interventions to contribute to lasting change, I am primarily focused on the trait dimension, the cognitive foundation of self-identity associated with pro-environmental behaviour and long-term well-being (Richardson et al., 2019; Wyles et al., 2019).

The conceptualisation of nature connectedness as a psychological construct not only provides a clear definition for this study but also enables its measurement when conducting empirical research on its causes and consequences (van Heel et al., 2023). Nature connectedness is predominantly understood to be on a continuum (van Heel et al., 2023; Richardson et al., 2019). At any point in time, people are connected to nature to an “extent” or “level” (van Heel et al., 2023, p.361). Various scales have been developed to measure nature connectedness levels, including the Nature Relatedness Scale (Nisbet et al., 2009), the Inclusion of Nature in Self Scale (Kleespies et al., 2021), and the Nature Connection Index (Richardson et al., 2019). All scales rely on self-reported surveys as nature connectedness is being understood as a subjective construct.

While my study does not directly employ these scales, the measurability of nature connectedness has facilitated the identification of key determinants and enabled evaluations of intervention effectiveness. These quantitative approaches have established the empirical foundation upon which the field has built evidence for the health and environmental benefits discussed in the previous section (Richardson, 2023).

However, I remain critically aware of the limitations inherent in reducing complex human-nature relationships to quantifiable constructs. As Richardson (2023, p.57) notes, "When attempting to understand something through numbers, the measurable becomes primary and reality secondary." Such numerical representations risk oversimplifying the nuanced reality of our connections with nature and its diversity of meanings across cultural and individual contexts (van Heel et al., 2023). However, Richardson also acknowledges that "to communicate there is a need for a shared language, and to convince others of facts there is a need for evidence" (2023, p.57). This tension between accurately representing complexity while still ensuring a pragmatic clarity is a repeating theme for this study.

1.3 Health and environmental benefits of nature connectedness

The development of surveys to measure an individual's nature connectedness has enabled a growing body of empirical research to reveal a compelling array of benefits associated with high nature connectedness that span personal wellbeing, health, pro-environmental behaviours, and environmental advocacy (Barragan-Jason et al., 2023). Rather than attempting an exhaustive account of these benefits, this subsection aims to emphasise the broadly positive impact of nature connectedness on both human and planetary health (Holland et al, 2024).

While the focus of this thesis is on how outdoor learning may cultivate lasting nature connectedness, I recognise that high connectedness is not an end in itself. It is a pathway for positive outcomes: enhanced wellbeing, healthier behaviour, and environmental action. I thus frame efforts to increase nature connectedness through outdoor learning interventions as more than a vague and feel-good idea, but as a health and environmental imperative worthy of further investigation.

1.3.1 Associations with health and wellbeing

A substantial body of evidence demonstrates strong positive associations between nature connectedness and various health and wellbeing outcomes. Children reporting high nature connectedness are more likely to spend time outdoors (Barrable, 2019, Molina-Cando et al., 2021), reaping health benefits associated with nature exposure, such as increased physical activity, enhanced immune function, better respiratory health, and improved sleep quality (Fyfe-Johnson et al., 2021). However, the greatest benefits of nature connectedness go well beyond nature contact. Martin et al. (2020), analysing a decade of nationally representative data, found that the psychological relationship individuals feel with nature predicts wellbeing independent of the amount of time they spend outdoors. This suggests that fostering a deeper sense of connection with nature—rather than only increasing exposure—may be particularly important for supporting children's wellbeing. Meta-analyses by Capaldi et al. (2014) and Pritchard et al. (2020) find significant relationships between nature connectedness and both hedonic and eudaimonic wellbeing, suggesting that feeling connected to nature contributes to children's happiness, life satisfaction, and sense of purpose. A recent systematic review of 63 articles focused on adolescents and young adults (age 11–26) reports robust associations between higher nature connectedness and lower stress, anxiety, and psychosomatic symptoms, as well as enhanced mental wellbeing and social cohesion (Madera et al., 2025). These findings suggest that fostering a deeper sense of connection with nature—rather than merely increasing exposure—may be particularly important for supporting children's wellbeing.

1.3.2 Associations with pro-environmental behaviours and advocacy

Nature connectedness has also been consistently linked to pro-environmental behaviours (PEBs) and environmental advocacy. PEBs traditionally encompass 'direct' actions that individuals take to either minimise environmental harm or actively restore the natural environment, such as reducing energy consumption or participating in conservation work (Anderson and Krettenauer, 2021). Environmental advocacy represents what has historically been termed 'indirect' PEBs—actions aimed at creating systemic change through public support for environmental protection (Jensen and Schnack, 1997). While this distinction between direct and indirect environmental action has been useful analytically, contemporary understanding increasingly recognises these behaviours as interconnected and mutually reinforcing aspects of environmental stewardship (Siegel et al., 2018).

The relationship between nature connectedness and environmental action is well-documented. A meta-analysis by Whitburn et al. (2020) found moderate positive correlations between nature connectedness and self-reported PEBs across various demographics. Richardson et al. (2019) demonstrated that nature connectedness was a stronger predictor of conservation behaviours than time spent in nature alone. For children and adolescents specifically, higher levels of nature connection correlate with increased engagement in both direct environmental actions (e.g. feeding birds, saving energy) and advocacy behaviours like environmental volunteering and discussing environmental protection with others (Chawla, 2020). Otto and Pensini (2017) found that nature connectedness mediates the relationship between environmental knowledge and ecological behaviour, suggesting it plays a crucial role in translating awareness into action. A recent systematic review of 29 studies echoes these findings, reporting that across numerous contexts stronger connectedness is repeatedly associated with higher likelihood of engaging in sustainable, conservation, and environmentally conscious actions (Guazzini et al., 2025).

Connectedness is thus presented as an important goal of interventions as it transforms otherwise abstract environmental knowledge into a motivation rooted in personal identity and care. As I discuss later in Section 2.3.2, interventions that succeed at increasing connectedness are argued to be more effective than mere education campaigns focused solely on knowledge or contact for generating long-term environmental stewardship and advocacy (Sheffield et al., 2022). I further detail in Chapter 2, Section 2.4, that positive outdoor experiences in childhood are frequently cited by environmental professionals and activists as formative influences on their career choices and commitments (Chawla, 2020).

1.3.3 Knowledge gap and disclaimers

While the evidence broadly supports positive associations between nature connectedness and various health and environmental outcomes, several important nuances and limitations are worth noting. Firstly, the relationship between nature connectedness and its reported benefits is not always straightforward, but varies with individual circumstances, cultural contexts, and specific aspects of nature engagement. Martin et al. (2020), analysing a decade of nationally representative survey data, found that different types of nature contact and varying levels of nature connectedness were differentially associated with specific aspects of health, wellbeing, and pro-environmental behaviours. This suggests that realising specific health or PEB outcomes may require more targeted approaches than simply increasing nature connectedness generally (Martin et al., 2020).

While the links between nature connectedness and various benefits are consistently observed, much remains unknown about the mediating factors and causal mechanisms underlying these relationships (Liu et al., 2022). This gap in understanding makes it challenging to determine how best to facilitate and support specific outcomes through nature connection interventions. As I discuss in greater depth in Chapter 2, this limited understanding of interrelationships is a persistent challenge for the field of nature connectedness research and the design of effective outdoor learning interventions.

Fostering nature connectedness also carries the risk of unintended consequences, such as eco-anxiety and climate-related distress (Chawla, 2020; Innocenti et al., 2023; Wullenkord et al., 2024). Individuals that closely identify with the natural world, while more likely to benefit from and care for nature, may also experience greater sensitivity to environmental degradation and climate impacts (Chawla, 2020). Threats to nature are experienced as threats to the self (Wullenkord et al., 2024). Binder and Blankenberg (2017) report that strong environmental concern stemming from nature connectedness can reduce life satisfaction and, more recently, Wullenkord et al. (2024) find that individuals high in nature connectedness tend to report greater anxiety and feelings of overwhelm in the face of climate change. Innocenti et al. (2023) notes that while climate anxiety may serve a powerful motivator for pro-environmental behaviours, it can also inhibit them by reducing perceived self-efficacy and lead to eco-paralysis.

Nature connectedness, therefore, should not be promoted without safeguarding against the potential for negative consequences (Chawla, 2020). The full benefit of high connectedness is likely contingent on the presence of supporting psychological resources, such as coping skills, social support, and self-efficacy (Innocenti et al., 2023). Chawla (2020) emphasises that interventions aimed at building nature connectedness must simultaneously cultivate 'constructive hope', a sense that positive environmental change is possible through action, to prevent heightened awareness of environmental problems from diminishing participants' well-being.

I note the above nuances to acknowledge that the study of nature connectedness and its effects is far from exhausted. That said, there is a compelling body of evidence that demonstrates broadly positive associations between nature connectedness and various health and environmental outcomes. For the purposes of this study, these associated benefits provide powerful motivation to investigate how nature connectedness might be strengthened and sustained through outdoor learning interventions while safeguarding against potential distress and overwhelm. Individuals who feel part of nature are more likely to benefit from and care for it. Understanding how to foster this relationship constructively is therefore a matter of both health promotion and environmental sustainability (van Heel et al., 2024).

1.4 Defining outdoor learning

The widely acknowledged benefits of nature connectedness, alongside its theorised decline, have spurred growing interest in designing interventions capable of repairing relationships with the natural world (Mann et al., 2022). Outdoor learning is a source of optimism on the premise that facilitating direct experiences in nature can foster in participants a sense of affinity with and care for the natural world (Sheffield et al., 2022, Gray, 2018).

The past decades have produced a wide range of terms describing facilitated experiences with potential to build nature connectedness, including outdoor learning (Fiennes et al., 2015) outdoor education (Cilingir, 2016) environmental education (Činčera et al., 2020), forest schools (Harris, 2021), and nature-based outdoor learning (Jucker et al., 2022) and more. These terms are often used interchangeably and inconsistently, reflecting the multidisciplinary nature of research in this field (Anderson, 2021).

For this study, I follow the advice of the Institute for Outdoor Learning (IOL) and define outdoor learning as an umbrella term for both structured and unstructured educational experiences that occur predominantly outdoors and aim to foster nature connection, wellbeing, and environmental awareness through facilitated activities (Anderson, 2021; Jucker and von Au, 2022; Mann et al., 2022). I have selected this broad definition as it aligns with the ethos of my focal intervention, the John Muir Award, which, as detailed in subsection 1.6.2, prioritises adaptability and accessibility over prescriptive activities and locations.

1.5 Scotland and the John Muir Award

Having established nature connectedness as both measurable and consequential for human and environmental wellbeing, the question becomes how outdoor learning interventions can most effectively foster these connections in practice. Scotland provides a rich context for this investigation, combining ambitious policy frameworks with diverse implementation approaches across varied geographical and social contexts. Likewise, the John Muir Award, as one of Scotland's most widely implemented outdoor learning schemes, offers insights into how current theory translates into practice and lasting impact. This section provides a brief overview of outdoor learning in Scotland, introduces the John Muir Award, and details why I have selected it as a fitting focus for my study.

1.5.1 Outdoor learning in Scotland

While outdoor learning is broadly lauded as a vehicle for fostering nature connection, questions remain about effective implementation and lasting impact (Lengieza et al., 2023). Scotland provides an informative context for examining this challenge, given its ambitious policy framework and varied implementation.

The Scottish Government's support for outdoor learning is underpinned by the Curriculum for Excellence (CfE) and Learning for Sustainability (LfS) frameworks. These policies position outdoor experiences as an entitlement for all children and young people, calling for regular, frequent and progressive outdoor learning opportunities (Taking Learning Outdoors; Learning and Teaching Scotland, 2011).

The Scottish CfE summarises the broad aims behind providing greater opportunity for outdoor learning in Scotland:

> Well-constructed and well-planned outdoor learning helps develop the skills of enquiry, critical thinking and reflection necessary for our children and young people to meet the social, economic and environmental challenges of life in the twenty-first century. Outdoor learning connects children and young people with the natural world, (…) (Learning and Teaching Scotland, 2010, p.7).

While provision varies across Scotland—influenced by factors including resources, staff confidence, and local priorities—this policy context has nevertheless created conditions for a diversity of structured programmes and schemes to develop, offering different approaches to outdoor learning implementation (Mannion et al., 2023). Local authorities, schools, outdoor centres, and third sector organisations deliver programmes ranging from curriculum-integrated activities to residential experiences and structured award schemes, including both formal educational initiatives and non-formal learning opportunities (Amazing Things, 2011). In Chapter 2, subsection 2.3, I outline key characteristics cited in the wider literature that make for a 'well-constructed and well-planned' outdoor learning intervention that is likely to build nature connectedness in participants.

Outdoor award schemes represent a popular subcategory within this landscape, offering structured frameworks that typically require participants to complete certain outdoor activities over a specified period (Amazing Things, 2011; Education Scotland, 2015). These awards often provide recognition through certificates or qualifications. Several award schemes operate in Scotland—including the Duke of Edinburgh Award, RSPB's Wild Challenge, and the John Muir Award—each with distinct approaches and objectives (Amazing Things, 2011; Education Scotland, 2015).

1.5.2 The John Muir Award

The John Muir Award was established in 1997 to be the main engagement initiative of the John Muir Trust (JMT), a conservation charity inspired by the life and work of the environmentalist John Muir (JMT, 2019). In response to research showing that fewer than 0.1% of young Scots were members of environmental organisations, the Trust sought to develop an inclusive award scheme to work in partnership with existing youth and education providers to integrate environmental awareness and action into their activities (JMT, 2017).

Until recently, the John Muir Award (the Award) has offered three progressive levels—Discovery, Explorer and Conserver—though the Discovery level accounted for approximately 90% of participation (JMT, 2023). In March 2024, the Trust announced it would pause accepting new Award proposals due to a "serious financial deficit" (Alt, 2024). After a year of consultation and redesign, the Trust relaunched the Award in March 2025 with updated systems and a new 'Wild Places Guardian' level as a relabelling of the 'Discovery' level (JMT, 2025b). Given this predominance, my study examines only the Guardian level, and subsequent references to 'the Award' refer specifically to this entry level. To complete the Award, participants must commit a minimum of four days (or equivalent) to meeting four challenges: Discover a 'wild place', Explore it, Conserve it, and Share experiences (JMT, 2025a).

The Award's definition of ‘wild place’ is intentionally inclusive. The Award Handbook (JMT, 2019, 2025a), the primary guidance document for providers and participants, recognises an "almost limitless range of wild places," spanning from "school grounds, a local park, beach, woods, river, mountain or national park" to any space that possesses "some natural character, and scope for at least 4 days' worth of activity."

The Award operates through 'Award Providers'—organisations or groups registered to deliver the Award within their existing programmes. These include schools, outdoor centres, ranger services, youth groups, and community organisations (JMT, 2019). While the John Muir Trust maintains oversight through registration, completion certificates, monitoring and support processes, providers have considerable autonomy in designing and delivering Award experiences that suit their context and participants (Amazing Things, 2022). The Award is open to all ages, though most participants are between 8 and 15 years old, typically engaging through school-based provision (Mitchell and Shaw, 2010). In 2023, the Trust reported that over 30,000 awards were granted across the UK, with Scotland accounting for 56% of activity (John Muir Award Landmarks, 2023).

1.5.3 Rationale for selecting the John Muir Award

I have selected the John Muir Award as this study's focal intervention for both its theoretical alignment with my research objectives and practical advantages for investigation. First, while the Award primarily focuses on environmental advocacy and stewardship, it explicitly recognises nature connectedness as a key pathway and outcome, aligning with my research interests. As stated in the Award Handbook (JMT, 2019, p.3), the Award “supports people to connect with, enjoy and care for nature, landscape, and the natural environment—wild places.” I have already noted the established relationship between nature connectedness and environmental behaviours in Section 1.3.

Second, the Award's unique approach to implementation combines consistent guidance with local adaptation. Unlike more prescriptive schemes such as the Duke of Edinburgh Award or the RSPB's Wild Challenge, the Award provides a flexible framework through its Four Challenges while encouraging adaptation to local contexts and demographics. This balance between consistency and adaptability makes the Award an ideal case study for examining how different conditions across a complex system influence lasting nature connectedness.

While the small Award staff may provide support and recommendations, they rely on each provider to interpret and implement the framework appropriately for their specific groups and participants. As Rob Bushby, former director of the Award in Scotland, explains, "the John Muir Award offers a map; Providers/participants are encouraged to plan an appropriate route of their own choice" (Bushby, 2003, p. 103). That said, this intentional flexibility means that the quality of Award experiences may vary significantly across settings and leaders (OECD, 2016). As Heyman et al. (2023) observe, even the most theoretically sound outdoor learning interventions may face practical implementation barriers that prevent their full potential from being realised.

Third, the Award's design explicitly incorporates evidence-based characteristics for building nature connectedness, particularly through direct contact with nature and active psychological engagement. This theoretical foundation provides a valuable reference point for examining current evidence on intervention effectiveness while highlighting crucial gaps in our understanding of how these interventions contribute to lasting nature connectedness. I discuss these characteristics in greater depth in Section 2.3.2.

Several practical advantages further support a focus on the Award. An established research partnership between the University of Glasgow and the JMT provides valuable access and trust for meaningful engagement with JMT staff. Additionally, the JMT's extensive network of providers across diverse settings and organisations offers access to practitioners with varied experiences and objectives. Seeking this diversity of perspective aligns with the practical implications of social-ecological systems research (presented in Chapter 2, Subsection 2.2.2.3), which emphasises the value of integrating multiple viewpoints when building transdisciplinary understanding of complex phenomena. Rather than developing only a critique of the wider study of outdoor learning, I have positioned my study to offer something practically useful for outdoor learning practitioners and researchers. This goal led me to select Scotland and the John Muir Award as my focal context and intervention, allowing me to work directly with experienced practitioners and design tools to support strategy and implementation.

Finally, this investigation is especially timely as the Award has recently undergone various reforms and restructuring following its March 2024 pause (JMT, 2025b). This context presents an opportunity for my study to contribute both scholarly insights and practical recommendations. I have sought to use the research process as a platform for shared learning among JMT staff and Award providers during this time of reform. While several outdoor learning interventions could have offered valuable insights into the complex formation of lasting nature connectedness, I contend that the Award presents distinct theoretical and practical advantages that make it particularly fitting for this study.

1.6 Chapter Conclusion: Research problem and thesis structure

This introductory chapter has situated my research within the broader study of human-nature relationships, which is motivated by concerns that humanity's growing separation from nature contributes to intertwined health and environmental crises. I have presented nature connectedness as a useful psychological construct that enables measurement of how people understand themselves in relation to nature. Even a brief review makes a compelling case for the urgency of fostering nature connectedness, with a growing body of research linking the construct to enhanced wellbeing and pro-environmental behaviours. I subsequently identified outdoor learning as a promising though varied approach for building stronger relationships with nature. I then narrowed my focus to Scotland's policy context and specifically the John Muir Award as my focal intervention. This progression from broad motivation to specific investigation establishes the real-world grounding and importance for my research.

While this chapter has provided context and motivation for studying outdoor learning's role in fostering nature connectedness, what remains is identifying the specific research problem my thesis addresses. The chapters that follow will progressively build understanding of this problem, its origins and consequences, and apply a fitting methodological response, offering original and valuable contributions to future research and practice.

While outdoor learning interventions receive increasing attention as vehicles for fostering nature connectedness, there is a fragmented understanding of whether and under what conditions they contribute to lasting connectedness (Sheffield et al., 2023; Holland et al., 2024). Chapter 2 substantiates the research problem through a critical literature review. Evaluations of fixed-duration outdoor learning interventions, programmes with defined start and end points like the Award's four-day minimum requirement, reliably report positive improvements in nature connectedness (Harris et al., 2025). Yet evidence for whether these time-bounded experiences translate into sustained engagement is limited and inconsistent. In many cases, scholars make no distinction between immediate and sustained impact (Harris et al., 2025). This leaves room for the misleading presumptions: that short-term gains in nature connectedness automatically translate into lasting health and environmental improvements.

Chapter 2 also explains why this gap exists by introducing principles of complex systems theory, how multiple interacting components create patterns and behaviours that cannot be predicted from individual parts alone (Preiser et al., 2021). I show how this theoretical lens, applied through social-ecological systems research, reveals important limitations in how we currently evaluate interventions. Through reviewing determinants of nature connectedness, I argue that the development of lasting relationships with nature requires ongoing engagement mediated by numerous interacting factors that make up a complex system (Sheffield et al., 2022). I conclude by echoing growing calls for nature connectedness and outdoor learning scholarship: Understanding lasting effects requires systems approaches capable of investigating how fixed-duration interventions interact with broader dynamics over time.

Informed by the identified knowledge gap and the practical implications of conducting social-ecological systems research, Chapter 3 presents my study's three research objectives:

1. To map the complex system of factors that influence the lasting nature connectedness for Scottish children and young people.

2. To identify leverage points within this system where strategic intervention might achieve disproportionate impact.

3. To explore how the John Muir Award might contribute to lasting outcomes under different system conditions.

The rest of Chapter 3 details my journey toward selecting an appropriate method. I evaluate various approaches to complex systems modelling against these objectives, ultimately demonstrating why fuzzy cognitive mapping, a method that captures stakeholder understanding of system relationships through visual models that can be analysed quantitatively, offers unique advantages for this investigation (Jetter and Kok, 2014). I explain the stepwise process through which I applied this method with Scottish outdoor learning practitioners.

Chapter 4 presents the results from this application. The model developed by seventeen practitioners reveals their collective understanding of the system shaping nature connectedness. Through analysis of the model's structure, I identify which system components practitioners consider most influential for lasting outcomes. Simulations are then used to explore how the Award contributes to lasting nature connectedness under different conditions, revealing both its potential impact and limitations within the context of a broader system.

Chapter 5 discusses and interprets these findings in relation to existing literature. I examine how practitioner perspectives complement and bridge findings from existing research, interpreting what the model structure and simulations suggest about conditions that enable or constrain the Award's lasting positive impact. This discussion offers a systems perspective on intervention effectiveness, shifting focus from measuring isolated programme outcomes to understanding how interventions contribute to ongoing processes within dynamic contexts.

Chapter 6 synthesises the research journey and articulates its contributions. While acknowledging methodological limitations, I demonstrate how this study addresses each research objective. I detail this study’s valuable implications for both future research and practice. For researchers, this study provides the first complex systems map of nature connectedness development in children and young people. It demonstrates how practitioner knowledge can be elicited and explored to understand phenomena that traditional methods struggle to capture. For practitioners, the model offers a shared object for discussion and learning; it provides a framework for understanding how their efforts interact with broader system factors, potentially informing more strategic programme design. While this thesis cannot definitively prove causal relationships or capture every aspect of this complex phenomenon, it offers a novel and valuable thinking tool that embraces the inherent complexity of human-nature relationships.

Chapter 2 Literature Review

2.1 Chapter overview

Chapter 1 presented nature connectedness as crucial for human and planetary health, yet humanity's growing separation from nature threatens these benefits. I also introduced outdoor learning interventions like the John Muir Award (Award), which are increasingly promoted as promising vehicles for rebuilding these relationships. This chapter critically examines current knowledge on the lasting impact of outdoor learning interventions on nature connectedness in children and young people. I demonstrate that understanding of how interventions contribute to lasting connectedness is severely limited, not merely due to practical constraints like insufficient longitudinal data, but because of fundamental assumptions about how change occurs. I argue that this challenge necessitates a social-ecological systems approach capable of capturing the complex dynamics that shape human-nature relationships over time.

I structure this chapter to progressively build the case for applying complex system approaches to the study of nature connectedness and the lasting impact of fixed-duration interventions. Section 2.2 introduces complex systems theory and social-ecological systems research, providing the epistemological framework and practical implications necessary to critique predominant linear assumptions in outdoor learning research. Section 2.3 examines evidence-based characteristics that make interventions immediately effective at fostering nature connectedness, using the John Muir Award as a concrete example of how these principles are operationalised in practice. This demonstrates that the field has made important progress in understanding short-term programme effects.

However, Section 2.4 draws from complex systems principles to reveal why this focus on programme characteristics is insufficient for understanding lasting impact. I reframe outdoor learning interventions as events within complex social-ecological systems, demonstrating that while fixed-duration interventions consistently show immediate improvements, evidence for lasting impact remains opaque and contradictory. The literature reveals that lasting nature connectedness requires ongoing, repeated engagement facilitated by numerous interrelated factors that compete and evolve over time. These insights expose the limitations of traditional research approaches that locate effectiveness primarily within intervention components rather than examining how those components interact with broader system dynamics. This progression from theoretical foundations through current evidence to systems critique establishes the research problem my study addresses and justifies the methodological approach I present in Chapter 3.

2.2 Human-nature relationships as part of complex social-ecological systems

In Chapter 1, I argued that the current understanding of how outdoor learning interventions contribute to lasting nature connectedness is severely limited. To substantiate this critique, I first establish what complexity means and why predominant research approaches neglect it when evaluating outdoor learning interventions. The recognition that humans and the rest of the biophysical world are intrinsically linked (see Section 1.2) has evolved in tandem with shifts in scientific worldview about how we conceptualise and study human-nature relationships (Preiser et al., 2021; Biggs et al., 2021; Schoon and Van der Leeuw, 2015). In this subsection, I position my study within the field of social-ecological systems (SES) research, which offers theoretical frameworks and methodological approaches for understanding intertwined human-nature relationships and possible interventions for a more sustainable future. More than a rejection of human-nature dualism, I trace how SES research emerged as an alternative to mechanistic approaches of traditional research paradigms and introduce five key principles of complex systems theory. I note that by critiquing traditional epistemologies, SES presents several practical implications and challenges for the study of linked human and environmental issues (de Vos et al., 2021).

Subsection 2.2.1 traces the shift from mechanistic to complex systems worldviews in scientific thinking that has emerged alongside growing criticism of human-nature dualism. Subsection 2.2.2 outlines five key principles of complex systems theory that distinguish complex phenomena from mechanical ones. Subsection 2.2.3 explains how social-ecological systems research operationalises these principles to study intertwined human-nature relationships, while subsection 2.2.4 details the practical implications for conducting such research. This progression from epistemological foundations to practical research implications informs my subsequent review and critique of the current body of knowledge on how outdoor learning interventions may contribute to lasting nature connectedness in Scottish children and young people. These principles later explain why current research approaches are inadequate for understanding lasting impact and justify the complex systems approach I select in Chapter 3.

2.2.1 From a mechanistic to a complex systems worldview

Social-ecological systems research (detailed further in 2.2.3) developed as part of a consequential shift in how science conceptualises and studies the natural world. Modern scientific thinking followed from Newtonian physics and the Scientific Revolution, establishing what has become known as a 'mechanistic' view of nature (Preiser et al., 2021). This perspective posited that natural phenomena behave according to fixed mechanisms—such as the laws of motion or reproducible chemical reactions under controlled conditions (Preiser et al., 2021). Scientists assumed that the entire biophysical world was fundamentally stable, orderly, and predictable and could thus be understood by breaking phenomena into quantifiable and isolated parts—much like a machine (Schoon et al., 2015; Preiser et al., 2021). In this scientific epistemology, a theory can be verified as true through independent observation and reproducible experiments, uninfluenced by context or subjective interpretation (Preiser et al., 2021; Merchant, 2018). This view of the natural world has profoundly shaped modern scientific disciplines, offering a conceptual and methodological basis for establishing universal knowledge and predicting how phenomena would behave once initial conditions were known (Anand et al., 2010; Preiser et al., 2021).

This mechanistic approach is evident in how researchers have traditionally studied human-nature relationships. These research designs assume a dose-response relationship where natural exposure acts as a stimulus producing direct effects. For instance, in Ulrich’s (1984) study, surgery patients are randomly assigned to rooms with tree views or brick walls. Patients with views of trees had shorter hospital stays than matched patients facing a brick wall. In this study approach, nature is identified as a discrete input that produces measurable health outcomes.

As I discuss in Section 2.4, evaluations of outdoor learning interventions take a similarly linear approach. Liefländer et al (2013) found that a four-day environmental education programme increased students' connectedness to nature immediately after participation, with effects lasting four weeks. The study treats the intervention as a contained input that directly raises connectedness levels, measuring participants before and after to isolate the programme's effects. This approach assumes the intervention's impact operates independently of participants' broader social and environmental contexts. While such study designs have established important links between nature exposure and outdoor learning experiences, this mechanistic framing also limits understanding of how interventions contribute to lasting change in real-world settings where multiple factors interact over time.

By the mid-20th century, scientists across multiple fields began recognising the limitations of this mechanistic approach, particularly when studying living systems (Schoon and Van der Leeuw, 2015). Living organisms and their environments demonstrated behaviours and patterns that defied consistent explanation and prediction. Ecologists, for instance, found that ecosystem dynamics emerged from complex webs of relationships between adaptable organisms and their environments over time, making it impossible to understand and predict system behaviour by studying species in isolation (Anand et al., 2010).

This ecological perspective extended to social phenomena as humans—being living organisms—cannot be understood in isolation from their natural and social environments or by a set of universal rules (Schill et al., 2019; Hawe et al., 2009; Preiser et al., 2021). Traditional economic models, for example, assumed individuals were "self-interested, perfectly disciplined rational economic agents" whose environmental behaviours could be predicted through simple calculations of costs and benefits (Schill et al., 2019, p.1076; Preiser et al., 2021). These assumptions were confounded, however, as the same environmental policy or interventions were found to produce dramatically different outcomes across communities with similar demographics and knowledge levels (Schill et al, 2019). This recognition of unpredictability necessitated new language and theory for studying the interactions between living things and social phenomena (Preiser et al., 2021; Hawe et al., 2009). I provide some examples of how SES research has been used to broaden linear assumptions about human-nature relationships in subsection 2.2.4.

2.2.2 Principles of complex systems theory

To appreciate how SES research advances understanding of human-nature relationships, I first clarify what constitutes a 'system' and what makes certain systems 'complex' (Schoon and van der Leeuw, 2015; Preiser et al., 2021). A system can be broadly understood as a set of interconnected parts—including people, organisations, and environmental features—that interact to produce patterns of behaviour over time (Meadows and Wright, 2008; Preiser et al., 2018; McGill et al., 2021; Khan et al., 2018). Systems are deemed 'complex' when they exhibit additional properties that distinguish them from mechanical systems, including the capacity to adapt, self-organise, and generate surprising behaviours that cannot be predicted from studying individual parts (Biggs et al., 2021). A complex systems perspective emphasises "seeing the bigger, changing picture" and explains system behaviour with the maxim ‘more than the sum of its parts’ (McGill et al., 2021, p.; Preiser et al., 2018; Meadows and Wright, 2008).

Complex systems theory has evolved across numerous disciplines (Schoon et al., 2015). Rather than attempt a full history, my aim here is to introduce principles of complexity that highlight an ontological shift specifically for the study of human-nature relationships, which is operationalised by SES research (Preiser et al., 2021; CECAN, 2021). Drawing from Preiser et al. (2021) and building on Meadows's (2008) seminal work, these principles include:

1. Made up of relationships: Complex systems comprise interactions between multiple and diverse components, creating networks of relationships that shape overall system behaviour. They are defined by how each part influences and is influenced by all other parts of the system (Preiser et al., 2021; CECAN, 2021). In SES research, phenomena under study arise from the interplay between both social and ecological processes rather than from either domain in isolation (Biggs et al., 2021). In Chapter 3, I delineate between types of relationships that may exist between system

components (direct, indirect, positive, and negative) and their causal implications.

2. Non-linear dynamics: The relationships within complex systems do not follow linear, proportional patterns of cause and effect (Folke et al., 2016; Preiser et al., 2021). Non-linearity means that small changes can trigger large effects throughout the system and vice versa. Disproportionate outcomes result in part from system components influencing each other simultaneously (bidirectionally) and/or because they are part of feedback loops, where changes cycle through the system and outcomes flow back to affect causes (Berkes et al., 2003; CECAN, 2021). Through these feedback processes, initial changes may either amplify or dampen over time as they ripple through the network of relationships.

3. Adaptive and Self-organising: Complex systems have the capacity to learn and reorganise in response to change without a centralised or external source of control (Berkes et al., 2003; Folke et al., 2016; Preiser et al., 2021). A system changes as its components influence and adjust to one another and coevolve, making change rather than stability the norm (Preiser et al., 2021). This adaptive behaviour means that relationships formed in the past have shaped present conditions, while present conditions will influence future possibilities (Carpenter et al., 2009).

4. Cross-scale Interactions: System complexity intensifies as the above principles operate across multiple interconnected scales. Khan et al. (2018) describe complex systems as nested levels, from micro to macro, that influence each other over different timeframes. In human-nature relationships, individual behaviours and experiences are embedded within local community norms, social networks, regional policies, cultural frameworks and global phenomena like economic globalisation and climate change (Barthel et al., 2014). Changes at one scale may permeate throughout the wider system, creating feedback loops that cross multiple abstractions (Preiser et al., 2021). Evidence for such cross-scale dynamics is discussed further in subsection 2.4.3.

5. Emergence: A result of the adaptive and nonlinear dynamics, emergence refers to the often surprising appearance of system-level properties that cannot be predicted or reduced to the properties of individual components (McGill et al., 2021). While these emergent properties arise from many interactions between system components and are not easily quantifiable (e.g. cultural norms or an individual's personality), they may become powerful forces that shape how the system behaves (Kauffman, 2008).

These five principles of complex systems (relationality, non-linearity, adaptation, cross-scale dynamics, and emergence) critique traditional scientific approaches that seek to understand and predict the lasting impact of interventions by studying isolated parts under controlled conditions. The following subsection briefly examines the implications of how SES research operationalises these principles of complexity to understand and solve human-environment challenges.

2.2.3 Epistemological implications for practicing SES research

The diverse field of social-ecological systems (SES) research—also called coupled natural-human systems, coupled human-environment systems, and socio-environmental systems—represents the convergence of two crucial developments in scientific theory and practice: the recognition of complex systems dynamics and the philosophical rejection of human-nature dualism (Schoon et al., 2015; Preiser et al., 2021). Rather than treating nature as merely context for human activities or viewing human impacts as simple disturbances to ecosystems, SES approaches examine how social and ecological processes are interdependent and characterised by dynamic, non-linear relationships evolving over time (Biggs et al., 2021; Masterson et al., 2019; Christens et al, 2025).

The critique of traditional scientific worldviews also comes with notable epistemological and practical challenges. Faced with the principles of complex systems, researchers must contend with the fact that they are limited to explaining only what can be observed (Preiser et al., 2021). The philosophical framework of critical realism highlights this tension by distinguishing between the 'real' world, which exists independently of the researcher's perceptions, and the 'observable' world that can be studied and understood (Preiser et al., 2021).

Because SES are characterised by ongoing and dynamic change, researchers are investigating a moving target. Moreover, complex SES phenomena are highly contextual—a successful intervention made in one environment may not work in another because of the hidden milieu of historical patterns, cultural values, or institutional arrangements. As a result, rather than seeking predictable outcomes and universal truths, SES research focuses on understanding how patterns of behaviours emerge in specific places and histories (Balázsi et al., 2019).

This acknowledgement of the observer’s limitation overlaps with the related premise of psychological constructivism, which contends that individuals, including researchers and policymakers, actively construct knowledge by creating mental frameworks to catalogue, interpret and respond to the complex world around them (Gray et al., 2014). While these mental models are always incomplete and influenced by personal perspective, constructivism suggests we can improve our internalised models through transdisciplinary collaboration and iterative cycles of learning (Jucker et al., 2022, Gray et al., 2014).

Given these limitations in what we can know, the goal of SES research shifts from trying to completely understand the world to "critically dealing with the fact that we never do" (Preiser et al., 2021, p. 41). In practice, this means creating useful simplified versions of reality that can help us avoid oversimplified assumptions while still guiding effective action (Masterson et al., 2019, McGill et al., 2021).

2.2.4 Practical implications for conducting SES research

Understanding complex systems principles is only useful if they can be translated into research practice. The practical implications I outline here serve to underpin my later critique of conventional approaches to studying outdoor learning interventions and point toward alternative, complementary methods that can better capture complexity, which I explore in Chapter 3. Three practical implications of conducting SES research have guided my own research approach: the need for pragmatic system boundaries, transdisciplinary methods, and incorporating diverse perspectives (Preiser et al., 2021).

The first practical implication is that researchers must establish boundaries around their system of study, despite appreciating that everything is ultimately connected. As the namesake of the John Muir Trust is often quoted, "When we try to pick out anything by itself, we find it hitched to everything else in the universe" (Muir, 1911, p. 110). Faced with an evolving universe of causation, researchers make strategic choices about which elements to include or to exclude based on their specific objectives (Schoon and Van der Leeuw, 2015). While these boundaries are artificial constructs, they enable focused investigation while acknowledging connections to broader phenomena within and across multiple levels of abstraction (Preiser et al., 2021). Researchers studying related phenomena might therefore choose quite different system delineations based on their research questions (Schoon and Van der Leeuw, 2015). This study's system of interest is the complex formation of nature connectedness in Scottish children and young people. In Chapter 3, I detail the process by which I worked collaboratively with outdoor learning practitioners to iteratively select and reject system components towards reaching a parsimonious and useful model (McGill et al., 2021).

Second, given the multiple dimensions of complexity, no single research method or data set is likely to fully explain complex SES phenomena on its own. Preiser et al. (2021, p.40) refer to "methodological pluralism" and "epistemological agility", the necessity of working towards a more holistic understanding by thoughtfully combining and valuing the strengths of different worldviews and approaches. This means that while SES research challenges the mechanistic thinking of traditional science, it is not entirely rejecting established methods and evidence (Vos et al., 2021). Rather, it advocates integrating conventional approaches with methods that better account for complexity and context (Vos et al., 2021; Biggs et al., 2021).

The third implication follows from both constructivist epistemology and the contextual nature of complex systems: Effective SES research requires structured integration of diverse perspectives (Vos et al., 2021). Given the non-linear dynamics and contextual dependencies of complex systems discussed above, any single perspective or mental model will capture only partial aspects of system behaviour (Jucker et al., 2022). This inherent limitation of individual understanding has led SES researchers to increasingly value transdisciplinary approaches that deliberately bring together researchers, practitioners, and stakeholders who hold different types of knowledge and occupy different positions within the system under study (Jucker et al, 2022; Vos et al., 2021; Preiser et al., 2021).

However, opening research to diverse participants and perspectives also introduces significant normative and practical challenges. The context-dependent nature of SES means there are no standardised protocols for collaboration (Vos et al., 2021). Researchers must carefully navigate what Vos et al. (2021) term a 'gradient of participation,' weighing the benefits of broader perspective integration against practical constraints of time and resources. Moreover, decisions about whose perspectives to include or exclude shape not only what aspects of the system are illuminated or obscured, but also whose interests are represented in system understanding (Preiser et al., 2021). In Chapter 3, I present a detailed justification for my focus on outdoor learning practitioners as key knowledge holders, while in Chapter 5 I critically examine both the insights gained and the potential blind spots created by these selection choices.

The epistemological basis for SES research comes with several challenges. The SES researcher is required to set artificial boundaries around interconnected systems, combine different research methods, and juggle multiple perspectives—all while acknowledging the limits of human cognition to comprehend complexity. Yet by transparently contending with these limitations and carefully justifying methodological choices, one may develop more nuanced and useful understandings of social-ecological phenomena that escape traditional scientific paradigms.

As I detail in Section 2.4, traditional research methods have established crucial foundations for understanding the development of nature connectedness and the potential impact of outdoor learning interventions. However, complementing these with SES approaches offers opportunities to reduce tendencies toward oversimplification in previous research (Masterson et al., 2019).

Health research, a field that has historically favoured controlled trials, increasingly incorporates systems principles for evaluating the impacts of interventions (Cambon et al., 2019). Braithwaite et al (2018), for instance, investigate Australian hospitals implementing the same medical intervention. Despite identical training and resources, some hospitals achieved success while others failed. Whereas traditional experimental methods offered little explanation for these stark differences, systems analysis revealed hidden and highly context-dependent factors, including hospital culture, informal staff networks, and local adaptation processes. As the authors note, "an effect observed through well-controlled experimentation in one environment would be assumed to occur similarly in other situations; this may have worked in some cases, but by no means always" (p. 3).

Similarly, Hunter et al. (2019) conduct a meta-analysis of health behaviour interventions and find that traditional individual-focused studies had been systematically underestimating intervention effectiveness. They use systems principles to highlight social contagion effects that occur when behaviour changes ripple through an adapting network of family, friends, and communities. By accounting for these dynamics, interventions that appeared modestly effective in controlled trials revealed much stronger real-world impacts.

Rather than simply asking whether interventions work, researchers can investigate how context shapes effectiveness, why identical programmes succeed or fail, and what conditions enable lasting change. This deeper understanding transforms both research and practice by revealing the mechanisms that determine intervention success in complex real-world settings. In the following sections, I apply these insights to the study of nature connectedness, a construct that comes from complex social-ecological interactions and has meaningful associations with both human and planetary health.

2.3 Outdoor learning interventions for building and sustaining nature connectedness

Having established the theoretical foundations of complex systems thinking, I now examine what current research offers about outdoor learning interventions and their potential for fostering nature connectedness. I demonstrate how existing knowledge, while valuable, remains constrained by linear assumptions and short-term perspectives that prevent a deeper understanding of lasting impact.

Because outdoor learning interventions may vary considerably in their design and implementation, a growing body of research has sought to identify the key characteristics that make these interventions effective at fostering nature connectedness (Mann et al., 2022; Jordan and Chawla, 2022; Holland et al., 2024). While a comprehensive review of intervention typologies is beyond this study's scope, this section examines key intervention characteristics consistently associated with increasing nature connectedness in the wider literature—at least in the short-term (Mann et al., 2022; Jordan and Chawla, 2022; Holland et al., 2024). I reference the Award as a helpful case study for how these characteristics are operationalised in practice. Rather than presenting these characteristics as a complete formula for success, I argue that they represent important system components between which researchers must begin to explore and understand broader interrelationships.

Meta-analyses and systematic reviews consistently identify four interrelated characteristics as crucial for improving nature connectedness following an outdoor learning experience: direct contact with nature, active psychological engagement, enjoyment/autonomy in nature, and social reinforcement (van Heel et al., 2023; Sheffield et al., 2022; Lengieza and Swim, 2021; Pritchard et al., 2020; Barrable and Booth, 2020).

2.3.1 Direct contact with and experiential learning in nature

Direct physical contact with nature is perceived to be a prerequisite for developing nature connectedness. In their systematic review of connectedness antecedents, Lengieza and Swim (2023, p. 51) conclude that "to have a relationship with nature, one needs to interact with it." This finding is shared by multiple reviews demonstrating that interventions involving direct nature experiences yield significantly larger effects on nature connectedness compared to indirect or virtual alternatives—such as nature documentaries or literature (Pritchard et al., 2020; Sheffield et al., 2022; Lengieza and Swim, 2021).

Focusing specifically on children, Barrable and Booth's (2020) review of interventions reaches similar conclusions. Likewise, a lack of exposure to and time in nature has been found to hinder the development of nature connectedness (Soga and Gaston, 2016).

As noted in subsection 2.3.1, the Award's inclusive definition of "wild places" is intended to increase physical accessibility to diverse natural settings and thereby counteract 'extinction of experience' and associated nature aversion (Humphreys, 2018, James and Bixler, 2023). The Award encourages direct contact through the provision of 'experiential learning', an approach developed by educational theorists like John Dewey (1963), which prioritises firsthand experience over abstract instruction (Quay et al., 2013). The Award Handbook (JMT, 2019) stresses hands-on engagement throughout its challenges: participants must "Discover a wild place" through direct exploration, "Explore it" through active investigation, "Conserve it" through practical conservation activities (p. 8-9).

The Award illustrates its conceptualisation of direct contact and experiential learning through its 'Heart, Hand, Head' model (Figure 1). Direct interactions with and care for a wild place (Hand) serve as the foundation for experiential learning, where concrete experiences lead to deeper understanding (Head) through observation, reflection, and active experimentation. The model's bidirectional arrows illustrate how direct contact and learning are mutually reinforcing processes—each new hands-on experience builds upon previous learning while promoting further exploration and discovery.

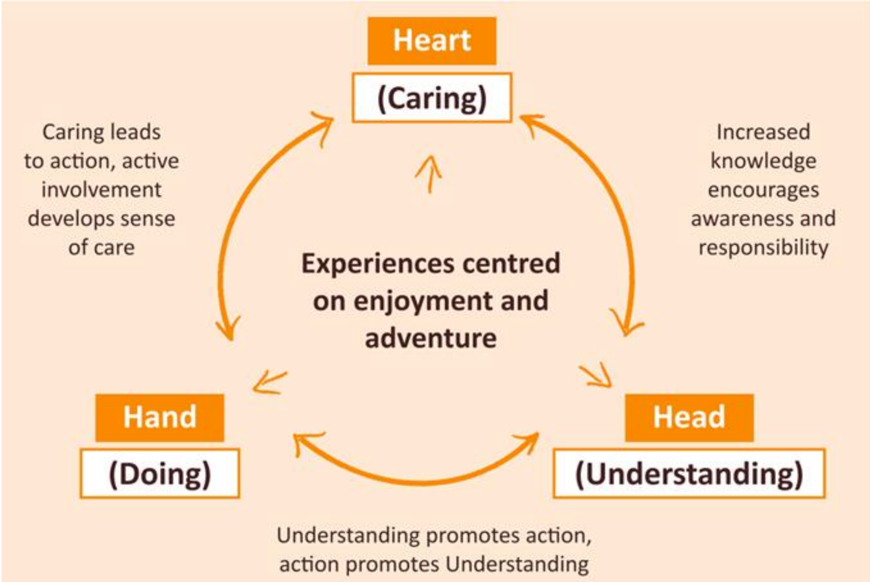

Figure 1. Heart, Hand, Head Model (JMT, 2019, p.22)

Notably, the model's 'Heart' component acknowledges that to foster care and advocacy for nature (via increased nature connection), interventions must go beyond simply building knowledge about and providing opportunity for physical contact with nature. As the following section explores, fostering emotional bonds with nature through active psychological engagement is viewed as essential for increasing nature connectedness.

2.3.2 Active psychological engagement with nature

Multiple studies demonstrate that simply providing opportunities for nature contact or outdoor learning does not inherently strengthen nature connectedness (Passmore et al., 2021, Richardson, 2023). To build a personal relationship with nature, an individual must engage with nature on an emotional level (Lumber, 2017). This explains why some nature-based activities, such as water sports, going to the beach, or outdoor exercise, often have no significant impact on nature connectedness as they treat the natural environment merely as a backdrop or resource (Lengieza and Swim, 2021; Price, 2022). Similarly, outdoor learning experiences that prioritise information delivery over emotional engagement have resulted in null or even negative effects on participants' connection to nature (Kossack and Bogner, 2012; Otto and Pensini, 2017; Barragan-Jason et al., 2022). The Award Handbook (JMT, 2019, p. 22) emphasises "the need for moving beyond traditional routes of 'knowledge and identification' activities to more emotional and meaningful experiences."

Richardson et al. (2021) explain that meaningful connection develops not from accumulating *minutes* in nature, but from engaging deeply with *moments* in nature. Sheffield et al.'s (2022) meta-analysis found that 'active' interventions, those explicitly inviting participants to notice and appreciate nature yielded significantly greater improvements in nature connectedness compared to 'passive' interventions, those which provide no specific guidance for engagement. Notably, some studies suggest that emotional attachment to nature can develop through indirect means, such as nature-related art or digital experiences, further emphasising that active psychological engagement, rather than physical contact alone, is the key ingredient (Mustapa et al., 2019; Sheffield et al., 2022). That said, meaningful psychological engagement with nature is less likely without opportunities for direct contact (Mustapa et al., 2019).

Stressing the importance of psychological engagement with nature, the Award references the 'five pathways' to nature connection as proposed by Lumber et al. (2017), and recently adapted by The University of Derby's The Nature Connection Handbook (Richardson and Butler, 2022), outlining "ways of being in, engaging with, and relating to nature" that can be flexibly applied by interventions across a range of contexts (Lumber et al., 2017, p.10). Lumber et al. (2017) found that it was only by engaging with these pathways—senses, emotions, beauty, meaning and compassion—that nature connectedness can be increased. These five pathways are readily apparent in the Award challenges and guidance. With active psychological engagement being the key characteristic of a nature connection building intervention, the 'Heart, Hand, Head' model and the '5 pathways' emphasise the value of enabling individuals to engage with nature through multiple dimensions which might compound and reinforce one another towards a stronger and more personal relationship with it (van Heel et al., 2023).

While not prescriptive in its guidance, the Award also encourages enjoyment, autonomy, and social support as integral elements that further help to facilitate and reinforce relationships with nature beyond mere physical contact. The John Muir Trust's multifaceted mission to encourage "people to connect with, enjoy and care for nature" recognises that pleasure in nature-based activities often catalyses deeper engagement (JMT, 2025, p. 5). Studies show that when children find enjoyment in nature, they demonstrate increased attention to natural surroundings (Schneider et al., 2017), stronger emotional resonance (Collado et al., 2013), and greater motivation to seek future experiences (Mullenbach et al., 2018). Chawla et al. (2020) note that enjoyment—encompassing appreciation for nature's sensory qualities, beauty, and opportunities for play—appears across all major nature connectedness measurement scales.

The Award also emphasises individual autonomy, encouraging even young participants to contribute to shaping their Award experience based on personal context and interests. This approach aligns with evidence that self-directed nature experiences are particularly effective at fostering connectedness. For example, Yılmaz et al. (2020) found that children develop stronger affinity for nature when given freedom to direct their own play. Van Heel et al.'s (2024) review concludes that different pathways will suit different people and recommends diverse activities to stimulate these pathways.

Social support may further mediate deeper engagement with nature throughout the Award experience. Leaders are positioned as facilitators rather than instructors, what Humphreys (2018) describes as accompanying learners to offer novel opportunities while supporting self-directed exploration. Award providers are tasked with ensuring "each participant takes part willingly, and benefits from their participation" (JMT, 2019, p.19). Moreover, the final 'Share' challenge is designed to create opportunities for participants to reflect on and express their experiences with others (Lumber et al., 2017). Chawla (2022) notes that group conservation activities can generate feelings of pride and solidarity that deepen individual connections to nature. The Award Handbook (JMT, 2019) tells participants to "Celebrate!" what they have accomplished together.

The Award framework incorporates characteristics consistently identified as crucial for fostering nature connectedness, particularly its emphasis on direct contact with and active psychological engagement in nature. The following section (2.4) revisits complex systems principles to reframe outdoor learning interventions as 'events' within an evolving system rather than isolated solutions (Hawe et al., 2009). By positioning the Award within a complex systems framework, researchers can begin to explore not just what makes an intervention immediately effective, but how it might better support sustained nature connection within a constantly changing social and ecological context.

2.4 Reframing the Award as an ‘event’ within complex social-ecological systems shaping nature connectedness

In the previous section, I presented the Award as a promising framework for fostering nature connectedness. Numerous studies consistently report immediate gains in nature connectedness following interventions that support active psychological engagement with nature (Barrable and Booth, 2020; Sheffield et al., 2022). However, in this section, I scrutinise current evidence on the lasting impact of fixed-duration interventions through a SES lens. The principles of complex systems and implications of SES research (introduced in Section 2.2) challenge how researchers conceptualise and evaluate intervention effectiveness over time (Hawe et al., 2009). Importantly, SES frameworks intend to offer more than a critique of mechanistic methods. They provide practical tools for addressing wicked problems, complex challenges that resist simple solutions because they arise from countless interactions between social and ecological systems (Knox et al., 2023; Biggs et al., 2021). Specific methods for addressing such problems are covered in Section 2.5.

Traditional approaches to evaluating intervention design and impact are often linear, relying on past outcomes to justify future implementations (Biggs et al., 2021; Preiser et al., 2021; CECAN, 2021). However, the complex systems principles of adaptation and non-linear dynamics (outlined in Section 2.2) suggest past evidence may be misleading as system responses and outcomes may dramatically change over time (CECAN, 2021; Biggs et al., 2021; Masterson et al., 2019). Instead, Hawe et al. (2009) and subsequent scholars propose viewing interventions as ‘events’ in systems that either leave lasting impacts or fade away depending on how well they harness existing system properties. They argue that "the most significant aspect of complexity possibly lies not in the intervention per se (multi-faceted as it might be), but in the context or setting into which the intervention is introduced and with which the intervention interacts" (Hawe et al., 2009, p.269).

This is not to dismiss the previously discussed research identifying outdoor learning intervention characteristics needed for building nature connectedness. Researchers have understandably sought to counter notions that all outdoor learning will be equally effective (Sheffield et al., 2023; Hawe et al., 2009). Outdoor learning—which may widely vary in definition, activities, location, duration, and leadership—is not a magical black box (Campbell-Price, 2022; Hawe et al., 2009). However, the issue being raised here is that the current literature does not take understanding of complexity far enough, as it still largely locates effectiveness *within* intervention components rather than how those components interact with the broader system (Hawe et al., 2009).

Over the following subsections, I provide an overview of the collective body of research on the lasting impact of fixed-duration outdoor learning interventions on nature connectedness. I note there is little evidence to support the stance that a single, fixed-duration intervention will lead to lasting nature connectedness (2.4.1). Instead, recent literature reviews and meta-analyses contend that the sustainability of connectedness will depend upon regular and repeating engagement with nature over time (2.4.2). Looking beyond a single intervention, the collective research on the causes of nature connectedness emphasises that human-nature relationships are shaped by numerous, interrelated, cross-scale, and often competing variables (2.4.3), which may change as children age (2.4.4). To understand the John Muir Award's lasting impact involves answering recent calls in both outdoor learning and nature connectedness research to establish a complex system perspective, evaluating an intervention by first seeking to understand its place and function within a dynamic system.

2.4.1 The state of research on the lasting impact of fixed-duration outdoor learning interventions

The ability to measure the nature connectedness levels of individuals through self-assessment surveys (noted in Chapter 1, subsection 1.2.3) has enabled a growing body of quantitative research to compare the effect size of interventions on nature connectedness, assessed before and after (Barrable and Booth, 2020; Sheffield et al., 2022). The collective findings have been instrumental in identifying qualities of outdoor learning interventions that are most likely to improve nature connectedness (as discussed in Section 2.3) (Barragan-Jason et al.,2021; Barrable and Booth, 2020; Sheffield et al., 2022; Wyles et al., 2019). However, despite this quickly growing evidence base, “work on targeted interventions to deliver sustained improvements is at a relatively early stage” (Sheffield et al., 2022, p.3).

At present, there is limited longitudinal evidence that fixed-duration experiences lead to lasting nature connectedness (Barrable and Booth, 2020; Chawla, 2022; Sheffield et al., 2022). Most studies use short-term before and after assessments with rare follow-up (Chawla, 2022). Sheffield et al.’s (2022) meta-analysis found that only 14 of the total 36 studies included follow-up measures between one and 12 weeks, and in two of those studies, response rates were too low for inferential analysis. Likewise, Chawla’s (2022) review of 24 quantitative and mixed-methods studies identified only 9 with any length of follow-up. This short-term focus raises questions about the durability of observed gains and the potential for fixed-duration interventions like the Award to foster lasting change (James and Bixler, 2023).

One explanation for the lack of follow-up is a lingering presumption that outdoor learning interventions—if only designed with the right checklist of characteristics and activities—will provide transformational and epiphanic experiences capable of instigating a sudden and lasting change in a young person’s relationship with the natural world (Humphreys, 2018). Naor and Mayseless (2020) describe ‘peak transformational experiences’ in nature. Just as a single negative experience may result in lifelong trauma, the authors collect qualitative accounts of “a profound shift in one’s experience of consciousness that results in long-lasting changes in worldview or ways of being, and in changes in the general pattern of the way one experiences and relates to oneself, others, and the world” (Noar and Mayseless, 2020, p.868). Practitioners interviewed by Giusti et al. (2019, p.16) gave accounts of how single outdoor learning experiences may transform children’s relationship with animals from one of apathy to recognising them as "animals with feelings, pain, and life struggles to which children can relate."

In complex systems theory, such a sudden shift might be described as a tipping point, defined by Milkoreit et al. (2018) as "the point or threshold at which small quantitative changes in the system trigger a non-linear change process that is driven by system-internal feedback mechanisms and inevitably leads to a qualitatively different state of the system, which is often irreversible" (p. 9). While possible in theory, researchers increasingly recognise that outdoor learning interventions are unlikely to be a quick fix (Humphreys, 2018). Sheffield et al. (2022, p.18) puts it bluntly, "[t]here is little to no evidence to suggest that brief one-off activities have any impact on nature connection over the medium to long-term as few such studies have included a follow-up."

The few studies that do include follow-up assessments offer inconsistent results about whether gains in nature connectedness last over time. Richardson et al. (2018) found that participants maintained their increased nature connectedness two months after completing the 30 Days Wild campaign, though the authors noted their study needed longer follow-up periods and control groups to draw firm conclusions. Conversely, Stern et al. (2008) found that students' enhanced connection to nature had largely disappeared three months after their residential program in a national park. Holland et al. (2024), with an even longer follow-up period, found that while participants showed initial increases in nature connectedness after a residential outdoor learning experience, these gains had completely vanished when measured 8-16 weeks later, with participants returning to their pre-intervention levels of connection. This is not to suggest that single fixed-duration intervention does not have any lasting impact, but that immediate improvements in nature connectedness are no guarantee of lasting change.

These findings raise hard questions about whether interventions using the Award framework will foster lasting improvements in nature connectedness. The residential experience evaluated by Holland et al. (2024), for example, has notable overlap with the Award scheme; the experience lasted between 2 and 5 days, targeted young people ages 6-18 from across England, and was designed to activate Lumber et al.'s (2017) five pathways to nature connectedness for active psychological engagement with nature. Mitchell and Shaw (2010) conducted an observational study of the Award. While they did not specifically measure nature connectedness in their evaluation, a follow-up survey conducted 18 months after the Award experience revealed that while most respondents reported a sustained desire to spend more time outdoors, there was “no clear impact on the frequency with which young people were actually visiting wild places”

(Mitchell and Shaw, 2010, p.3). As I note in subsection 2.4.2, frequent and deepening experiences in nature are crucial for maintaining and deepening connectedness.

What limited longitudinal evidence is available suggests there is still considerable uncertainty about the lasting impact of these experiences (Humphreys, 2018). It has become a common refrain among recent work to call for more longitudinal research that tracks the nature connectedness levels of the same participants over longer periods (Wyles et al., 2019; Chawla, 2022; Barrable, 2019; Price et al., 2022). According to Barragan-Jason (2021), such longitudinal studies are especially lacking for children and young people. The relative scarcity of longitudinal studies is most likely due to practical methodological challenges. Tracking participants over time is expensive, time-consuming, and complicated by participant dropout and multiple variables requiring control (Holland et al., 2024; Asah et al., 2012).

While some of these practical challenges might be resolved as the field matures, the urgent need to foster lasting nature connectedness for human and planetary health makes waiting decades for longitudinal data an unsatisfactory solution (Sheffield et al., 2022). Moreover, an increase in longitudinal studies may still not adequately explain how outdoor learning interventions contribute to lasting nature connectedness if research continues to view causation too narrowly (van Heel et al., 2023). As detailed in the following section, nature connectedness requires repeated experiences rather than single transformational events. This reorients how the lasting impact of interventions should be evaluated, as contributors to a broader system of ongoing influence.

2.4.2 The importance of regular and repeating engagement with nature for lasting connectedness

Given the limited evidence for lasting impacts of single fixed-duration interventions, attention turns to the potential impact of multiple and progressive experiences. A short-term increase in nature connectedness following active psychological engagement (discussed in 2.3) is most likely to be sustained and even deepened if repeated regularly during especially formative periods of a child's life (Barrable and Booth, 2020; Barragan-Jason et al., 2021; Sheffield et al., 2022).

While longitudinal data is limited, the importance of multiple and deepening experiences may be partially captured by observational studies comparing similar outdoor learning interventions with differing durations. Typically, longer interventions that offer many experiences over multiple days have been found to have a greater and more sustained impact on nature connectedness (Barrable and Booth, 2020; Barragan-Jason et al., 2021; Sheffield et al., 2022). Harris (2021), for example, studied the integration of outdoor learning into children's everyday school setting, finding that forest schools have been shown to enable children to connect with nature as they grow accustomed to their outdoor surroundings, developing a personal connection and desire to care for it.

Various qualitative retrospective approaches have also been used to investigate the origins of lasting nature connectedness by asking adults to reflect on their past experiences and relationships (Chawla, 2006). Retrospective studies thereby enable researchers to explore long-term and cumulative outcomes without the need for decades-long data collection (Asah et al., 2012). These studies consistently attribute lasting nature connectedness to cumulative rather than single experiences. James and Bixler (2023, p.170) note that "adult conservationists recall many and varied frequent, recurring and expanding formal and informal experiences with (wild) nature."

This is a simple but crucial departure from the view that a single outdoor learning experience establishes irreversible nature connectedness on its own (Sheffield et al., 2022). Asah et al. (2012) posit that childhood engagement with nature is an incrementally learned behaviour. Repetition, they argue, serves to build motivation and establish strategies for mitigating barriers to future experiences and strengthening connectedness.

The Award, like many structured outdoor learning interventions, is designed as a fixed-duration experience (Sheffield et al., 2022). It has a clear beginning and endpoint, intended to introduce participants to new ways of interacting with nature beyond their everyday routines (JMT, 2019). As noted in my introduction of the Award in subsection 1.5.2, participants must complete four Challenges over a minimum of four days to receive their Discovery/Guardian Award certificate (JMT, 2019, 2025). While this defined timeframe may provide an attainable goal and sense of accomplishment for participants, it raises crucial questions about how these temporary experiences interact with broader and changing patterns of influence. Can such time-limited experiences foster lasting connections with nature, or do they merely provide enjoyable but ultimately fleeting experiences? Mitchell and Shaw (2010) caution that the Award is “not a magic bullet” (p.4).

However, this emphasis on repeating experiences is not meant to dismiss the value of the Award as a single intervention but to reframe and investigate its role and potential for lasting impact beyond its conclusion. A short intervention may still have a permeating impact by contributing to mechanisms that support frequent active psychological engagement with nature throughout childhood and beyond (Hawe et al., 2009). Sheffield et al. (2022) found that the studies reporting sustained improvements in nature connectedness typically prompted participants to engage with nature on a regular basis. The authors suggest that "the gold standard” for nature connectedness interventions involves establishing routine engagement practices, encouraging participants to repeat meaningful elements of their initial experience (Sheffield et al., 2022, p. 18). Nicol (2014) argues that this long-term perspective on intervention impact serves to distinguish between experiences that serve clear developmental purposes and those that lack meaningful direction and purpose (cited in Humphreys, 2018).

In the next subsection, I demonstrate that even a brief overview of the literature on the determinants of nature connectedness suggests that to contribute to participants’ long-term relationships with nature, the Award will face a myriad of interrelated, cross-scale, context-dependant, and often competing variables. This further builds the case for utilising research methods capable of reframing the Award as an event within a complex social ecological system.

2.4.3 The multiple and interrelated influences and dimensions shaping Nature connectedness

An individual's connection to nature results from variables operating across multiple scales of influence, from in-the-moment psychological states to longstanding societal structures (Lengieza and Swim, 2021; Chawla, 2020; van Heel et al., 2023). This exemplifies the complex systems principle of cross-scale interactions discussed in Section 2.2.2.2. The intent of this subsection is not to provide a comprehensive review of the many scales and interrelationships identified in wider literature, but to continue broadening the scope of the discussion away from attributing impact solely to the internal dynamics of an outdoor experience. I demonstrate that there is persistent uncertainty about the many possible determinants and mechanisms that impede and enable ongoing engagement with nature in the Scottish context

Several recent meta-analyses and reviews highlight the breadth of interrelated and cross-scale determinants represented in the collective nature connectedness literature (Lengieza and Swim, 2021, 2023; Chawla, 2020; van Heel et al., 2023). In environmental psychology, where nature connectedness is defined as a subjective psychological construct (see Section 2.3), most research into its causes focuses on the individual (Lengieza and Swim, 2021, 2023; Giusti et al., 2018; Ives et al., 2018). As Beery et al (2023, p 471) explains, “[e]ngaging with the inner world of emotions and identities has been considered a critical way to assess possibilities for rapid transformations toward sustainability." Several studies stress that even seemingly straightforward experiences like direct contact with nature will still be mediated by emotional states, personality differences, and philosophical worldviews, suggesting that no single factor can adequately explain how people develop lasting relationships with nature (Ives et al., 2018; Lengieza and Swim, 2021; Lumber et al., 2017).

An interest in designing interventions and policies to foster connectedness has broadened the research scope. Lengieza and Swim (2021) and Chawla’s (2020) thorough reviews present nature connectedness as resulting from a long list of psychological traits (e.g. mindfulness, self-awareness, affect), individual differences (e.g. demographics, personality traits, worldviews), as well as immediate situational contexts (e.g. environments, specific activities, contact with nature, frequency of contact). Other scholars focus on the social and communal dimension and frame connection to nature as a ‘collective identity’, suggesting the relationship between one’s connection to nature and activist behaviour is enabled by politicised environmental identity (Mackay et al., 2021). At this group level, peer and parental values and attitudes are consistently associated with their children’s connectedness (Oh et al., 2021; Lengieza et al., 2023; Wu and Ji, 2023). Scholars like Richardson et al. (2022) and Soga and Gaston (2025) go broader still to compare country-level factors shaping societal relationships with nature, like urbanisation patterns, technological penetration, land use, and cultural norms.

This expanding catalogue of multi-scale influences do not simply accumulate to shape nature connectedness but may actively compete (Beery et al., 2023; Chawla, 2020). Even when positive influences are present, such as access to natural spaces, supportive adults, and opportunities for outdoor experiences, opposing factors like screen time, peer pressure, and community attitudes can work against connection formation (Chawla, 2020; Barrable and Booth, 2022).

Research into aversive variables is still in its early years (Lengieza and Swim, 2021). However, recent work has taken great strides to steer discussions of nature disconnection, defined as “the lack of awareness or disregard for human identity within the natural world,” beyond merely a list of factors that cause people to fear, avoid, and act indifferently towards nature (Beery et al., 2023, p.472; Barrable and Booth, 2022). Beery et al. (2023) map how disconnection derives from "interrelated processes of individual and societal drivers," presenting a 'wheel of disconnection' that illustrates how factors like "ideological orientations, political relations, sociocultural norms and institutional arrangements" actively prevent awareness or create apathy for human-nature co-dependency (p. 472). Disconnectedness research thus reinforces the point that relationships with nature cannot be understood through single variables or linear relationships but requires examining how individual experiences interact with broader societal structures.

Soga and Gaston (2022) help conceptualise some of the interplay between an individual's relationship with nature and variables that have a broad and societal dimension. They propose that the extent of an individual’s engagement with nature depends on immediate environmental factors that create 'opportunity', ‘motivation’ and ‘capacity’ which are, in turn, shaped by collective elements like socioeconomics and infrastructure. This echoes affordance-based theory (Gibson, 2014) and more recent iterations that present individuals as ‘embodied ecosystems’ to “express the relational values of ecosystems that dynamically emerge by the sets of relations existing between mind, body, culture, and environment” (Giusti et al., 2018, p.4; Gaston, 2024).

A focus on relationships comes with the recognition that the formation of nature connectedness will be highly context-dependent (Giusti et al., 2018). Similar interventions may result in dramatically different outcomes as each participant faces a varied internal and external context (Cambell-Price, 2022). While most quantitative studies indicate that higher socioeconomic status correlates with greater access to green spaces and nature connection (Wolch et al., 2014, Jennings et al., 2017) and Keespies and Dierkes (2023) found that lower levels of nature connectedness are significantly associated with higher national income, Passmore et al. (2020) found that children from more deprived backgrounds reported stronger bonds with nature despite having less access. Similarly, both urban and rural settings have been linked to higher nature connectedness, challenging assumptions about the relationship between access and connection (Beery et al., 2023; Richardson, 2023). Such varied findings are not inexplicably contradictory or evidence of botched analyses but suggest that there are more complex interacting factors left unexplored (van Heel et al., 2023).

2.4.4 Temporal dynamics and age-related changes

Thus far, I have emphasised that nature connectedness comes from interrelated factors operating across numerous scales. Equally crucial is the temporal dimension: systems evolve over time as components adapt and interact in changing ways. This temporal aspect is particularly significant when examining the John Muir Award's impact, as most participants (ages 8-15) are in a highly formative period of life. A child's relationship with nature at age 8 may differ substantially from their relationship at age 15, not merely because of changing external circumstances, but because their internal priorities, cognitive capacities, and social orientations undergo profound shifts during this period (Price et al., 2022). Understanding how the Award might contribute to lasting nature connectedness, therefore, requires examining not just where and what influences connectedness, but when these influences are most relevant or effective (Richardson et al., 2019).

In the absence of longitudinal data, cross-sectional studies serve to highlight associations between nature connectedness levels and various factors across different life stages and demographics. The association between age and nature connectedness is exemplified by the widely observed 'adolescent dip', a phenomenon that hints at the complex process by which connectedness is developed and maintained over time. Multiple studies analysing data from Natural England's Monitor of Engagement with the Natural Environment survey (MENE) have identified a significant decrease in nature connectedness among teenagers, with the lowest point occurring at ages 15-16, after which connectedness begins to recover and plateau into adulthood (Hughes et al., 2019; Passmore et al., 2019; Richardson et al., 2019). Price et al. (2022) corroborated these findings in their study of over 1,800 school-aged children in Jersey, observing that nature connectedness levels decreased steadily from age 7-8 onwards.

Scholars suggest that this dip in connectedness can in part be attributed to children's changing context and priorities as they age (Keith et al., 2021). An increase in autonomy along with a heightened focus on peer relationships and academic pressure may result in a reprioritisation of engaging with nature (Keith et al., 2021; Price et al., 2022). However, causal explanations behind these changes remain understudied (Price et al., 2022).

While the adolescent dip is an averaged trend and there may be many children who maintain high levels of connectedness well into adulthood, the consistent finding further underscores the limited insight of measuring short-term impacts of outdoor learning interventions (Richardson, 2023). Such studies neglect to consider the potential fluctuations and drops in connectedness over an individual's lifetime—if not over the weeks immediately following an intervention (Richardson, 2023; Sheffield et al., 2022; James and Bixler, 2023).

These findings also hold practical implications for interventions (Richardson et al., 2019). Some scholars reference the adolescent dip to propose more targeted efforts to increase nature connectedness in the formative years of early childhood for more sustained results as they age (Chawla, 2020; Price et al., 2022; Barrable, 2019). Related observational studies suggest the same. Liefländer et al. (2013), for example, found that while both younger pupils (ages 9-10) and older pupils (ages 11-13) showed increased nature connection levels immediately after an intervention, only the younger group sustained this increase at the four-week follow-up.

A sizable body of work known as significant life experience (SLE) research employs mixed methods to retrospectively explore the formative experiences of adults who report having a strong connection to nature. These often use structured surveys and cross-sectional analyses to examine associations between past experiences and current nature connection levels in adult populations (Chawla, 2006; Barrable et al., 2024). Although conducted in many countries, key findings from these studies are highly consistent (James and Bixler, 2023). Adult environmental educators and conservationists cite childhood nature experiences, particularly self-directed play in nature, as the most important factor shaping their lifelong environmental attitudes and behaviours (Rosa et al., 2018; Drescher et al., 2022; James and Bixler, 2023). Likewise, recent cross-sectional retrospective studies find that childhood nature experiences significantly predict adult nature connection (Cleary et al., 2020; Chawla, 2020). Barrable et al. (2024) surveyed a sample of Greek adults and found that childhood nature experiences were more closely associated with adult nature connectedness than ongoing adult nature experiences.

Nature connectedness can develop at any life stage and requires regular experiences over time (Richardson, 2023). However, retrospective research suggests that childhood experiences play a disproportionately important role in establishing lasting relationships with nature. Early nature experiences shape preferences and habits that influence whether people continue seeking nature engagement throughout their lives (Price et al., 2022; Chawla, 2022; Barrable and Booth, 2020). While these findings underscore the potential significance of interventions like the John Muir Award that target children and young people, they do not diminish the ongoing importance of repeated experiences over one's lifetime (James and Bixler, 2023). Understanding how such interventions contribute to lasting impact requires examining how single experiences function within an evolving system that continues to shape engagement and connectedness over time. This systems perspective avoids viewing childhood interventions as one-time solutions that guarantee lifelong connection.

2.4.5 Calls for complex systems approaches in nature connectedness and outdoor learning research

The current body of research suggests that fixed-duration outdoor learning interventions contribute to lasting connectedness by supporting ongoing active psychological engagement with nature, experiences which are also mediated by a myriad of dynamic, context-dependant, facilitating and/or impeding relationships that evolve over time (van Heel et al., 2023).

Outdoor learning scholars increasingly caution against placing too much emphasis on optimising the design of interventions as the panacea for achieving lasting improvements in nature connectedness (Beery et al., 2023; Giusti et al., 2018; Humphreys, 2018). Giusti et al. (2018) observe that despite the wide range of research approaches, most studies “operationalise a disembodied ontology of [nature connectedness], in which contextual factors are independent and often dismissed objects of investigation” (p.3). Likewise, Beery et al. (2023) call for a “broadening” of the outdoor learning research agenda and argue that insufficient attention has been given to the many interconnected factors that shape nature connectedness beyond the intervention itself (Beery et al., 2023, p.2,10). By attempting to attribute lasting changes in nature connectedness to immediate spikes in an individual’s emotional state or to the characteristics of a single intervention, researchers risk overestimating their interventions' impact by ignoring the broader context in which these interventions operate (Beery et al., 2023; Humphreys, 2018).

In the opening chapter of the special issue on High-Quality Outdoor Learning (2022), the editors state:

> We are left with a clear obligation to modesty and even humility. The insight that education and learning are complex systems means that we will only master them reasonably well if we face up to this complexity. Simplifications simply won’t help and the ‘one-size-fits-all’ guru-solution for everything does not exist. (Jucker and von Aue, 2022, p.7).

Richardson (2023) reaches the same conclusion for the study of nature connectedness, arguing that while complex relationships can never be fully understood, this uncertainty itself demonstrates why researchers must move beyond simple assumptions. He emphasises that systems thinking is essential for achieving meaningful societal change (Richardson, 2023).

While the principles of complex systems are increasingly acknowledged in many reviews and conceptual works, examples of studies that go as far as to employ complex systems methods (see Chapter 3) in their investigation of specific outdoor learning contexts are rare. Quantitative retrospective short-term studies remain the dominant approach to measuring an intervention's lasting impact on an individual's relationship with nature (van Heel et al., 2023).

2.5 Chapter conclusion

This chapter has established both the promise and limitations of outdoor learning interventions for fostering lasting nature connectedness. Research consistently demonstrates that interventions facilitating active psychological engagement with nature produce immediate improvements in participants' nature connectedness (Sheffield et al., 2022; Barrable and Booth, 2020). The John Muir Award incorporates many of these evidence-based characteristics, suggesting its potential for positive impact.

However, there is a consequential mismatch between how intervention effectiveness is typically measured and how nature connectedness is understood to develop over time. While the literature is rich in short-term evaluations, it offers only fragmented and contradictory evidence regarding sustained impact (Sheffield et al., 2022; Chawla, 2022). The few longitudinal studies that exist show inconsistent results, with some studies observing sustained gains while others find that initial improvement in nature connectedness seems to fizzle out (Holland et al., 2024; Richardson et al., 2018).

Even a brief overview of the wider literature on the determinants of nature connectedness reveals complex, multi-scale, competing influences over time. Lasting nature connectedness requires ongoing, repeated experiences rather than single transformational events (James and Bixler, 2023; Sheffield et al., 2022). Repeating experiences with nature are mediated by a myriad of individual, social, and environmental influences that compete and interact in unpredictable ways (Chawla, 2020; Beery et al., 2023). The widely observed adolescent dip further illustrates how system dynamics evolve as children age (Richardson et al., 2019; Price et al., 2022).

This recognition of complexity ought to reorient how interventions should be evaluated, not solely by immediate impact but by how they contribute to cycles of continued engagement (Hawe et al., 2009). The principles of complex systems theory suggest that the Award’s impact is highly contextual and part of numerous, interrelated factors spanning individual, social, and environmental domains.

Addressing this gap matters because a reductionist and wishful-thinking approach to evaluating intervention impact risks implementing what Haluza-Delay (2013, p. 394) calls "an ineffectual band-aid on the wounds of the earth and its inhabitants." Without frameworks capable of exploring how specific interventions interact with the broader systems shaping nature connectedness over time, our understanding of how to design, defend, and implement truly transformative outdoor learning will remain severely limited (van Heel et al., 2023; Lengieza and Swim, 2021).

My study does not intend to diminish the value of traditional research approaches and the potential of outdoor learning interventions but rather highlights the need for new perspectives capable of exploring their current and potential role within a complex system. The theoretical and practical implications of SES research established in this chapter directly inform the methodological approach I present in Chapter 3. Rather than studying the Award through conventional pre-post evaluations that neglect system complexity, I employ system modelling, namely fuzzy cognitive mapping, to capture outdoor learning practitioners' understanding of the complex relationships shaping nature connectedness in Scottish children and young people. This systems approach enables investigation of how the Award might function within—rather than separate from—the broader social-ecological context that ultimately determines whether temporary gains become lasting connections with nature.

Chapter 3 Methodology

3.1 Chapter overview

This thesis began by presenting nature connectedness as crucial for both human wellbeing and environmental stewardship while identifying a critical gap in understanding how outdoor learning interventions contribute to lasting connectedness beyond immediate programme effects. In Chapter 2, I argued that, despite calls for systems perspectives in both nature connectedness and outdoor learning scholarship, complexity has not been adequately captured through research approaches that study factors in isolation. I thus positioned my investigation within social-ecological systems (SES) research, embracing the fundamental principles of complex systems theory: that nature connectedness comes from dynamic relationships between multiple interacting components across various scales and contexts. Chapter 2 concluded that understanding the lasting impact of interventions like the John Muir Award requires methods capable of capturing the broader system dynamics within which these interventions operate.

This chapter is structured into two parts reflecting a progressive sequence of decisions in which I narrow in on smaller sub-categories of methodological approaches. Having already identified my research as broadly part of social-ecological systems (SES) research, I now choose a specific complex systems method that will best meet my research objectives.

In the first half of the chapter, I provide an overview of complex systems modelling (Section 3.2) and clarify my study objectives (Section 3.3). In Section 3.4, I progressively consider different modelling methods—from empirically-backed computational simulations to participatory systems mapping—evaluating their respective benefits and shortcomings against my stated objectives and context. In Section 3.5, I describe the rationale for selecting fuzzy cognitive mapping (FCM) and detail the method's distinctive combination of characteristics, limitations, and analytical capacity for addressing all three of my research objectives.

In the second half of this chapter, I detail the stepwise process through which I apply FCM in practice. I first detail the five-step process I used to collect practitioner knowledge and build the model (Section 3.6), explaining the specific FCM approaches I selected at each stage. In Section 3.7, I outline the analytical techniques I employed to address each research question: static analysis to identify system structure and leverage points, and dynamic analysis to explore the John Muir Award's potential impact under different scenarios (Section 3.8). Throughout, I offer examples of how preliminary results at each stage directed subsequent methodological decisions and shaped the final model's development and interpretation.

3.2 Complex systems modelling

While no single study can fully capture the complexity of how nature connectedness forms over time and across contexts, researchers are not without tools for better eliciting and exploring complex phenomena (Preiser et al., 2021). Over the previous sections, I have argued that understanding the lasting impact of specific outdoor learning interventions requires examining their role within broader social-ecological systems. I also noted in Section 2.2.2.3 that SES research in practice is not intent on capturing every possible system component but is carefully parameterised around specific contexts and phenomena (Preiser et al., 2021). Explanations that attempt to comprehensively explain the many evolving, interrelated and cross-scale variables which may shape nature connectedness would end up being just as overwhelming as the complex reality researchers seek to clarify (van Heel et al., 2024).

SES research thus involves the development of useful abstractions through complex systems modelling (Preiser et al., 2021). Drawing from Sayama (2015) and Barbrook-Johnson and Penn (2022), I define models as purposeful and simplified representations of a perceived reality. As Meadows and Wright (2008, p.88) observe, "[e]verything we think we know about the world is a model (...) None of these mind models is or ever will be the whole truth (...) but some of them will be more useful than others." A model's utility comes from its ability to capture salient system features while remaining sufficiently parsimonious to enable investigation and insight (McGill et al., 2021).

Of course, parsimony is not everything. For a model to be useful it must also have validity (Sayama, 2015). While not an exact reproduction of reality, a model's value stems from a demonstrable alignment with observed patterns, empirical trends, and/or expert understanding of system behaviour (Preiser et al., 2021). As I discuss in 2.5.2, this is particularly relevant for studying nature connectedness, where empirical data about long-term dynamics is scarce, but considerable practitioner knowledge exists about how outdoor learning interventions interact with broader social and environmental factors to shape lasting connections with nature (Gray et al., 2014).

When developing a model that is parsimonious and valid, a SES researcher may choose from several overlapping approaches and techniques. I found the Routledge Handbook of SES Research Methods provided a useful categorisation of methods based on their primary characteristics and common applications (Biggs et al., 2021). However, in practice, these categories are fluid. Many methods can generate and incorporate multiple types of knowledge and serve various purposes depending on how they are applied. Some are highly specialised, while others offer considerable flexibility. In recent years, modelling methods have been increasingly combined to complement their respective strengths and limitations (Biggs et al., 2021).

The methodological plurality of SES research (as noted in Section 2.2) means that rather than simply selecting from discrete categories, researchers must carefully consider where different methods sit on a spectrum of opportunities, and how their relative strengths align with specific research objectives, context, and resources (Biggs et al., 2021). Rather than detail the many possible methods and variations that could have been utilised in this study, this section provides a window into my methodological decision-making process which began by first clarifying my research objectives.

3.3 Research objectives

This subsection presents my study’s research objectives, which stem from identified limitations in the wider literature concerning the relationship between nature connectedness and fixed-duration outdoor learning interventions. Following Biggs et al.'s (2021) framework, each objective requires a corresponding type of knowledge—descriptive, exploratory, and explanatory—which collectively directed my choice of methodology and sub-approaches.

My study has three overarching research objectives, which I later translate into method-specific research questions in subsection 3.6.1:

1. Elicit a complex system perspective of the development of nature connectedness in Scottish children and young people.

2. Identify determinants and relationships likely to be most influential (‘leverage points’) for fostering lasting nature connectedness across different age groups.

3. Explore how the John Muir Award contributes to lasting nature connectedness by interacting with key leverage points under different system conditions.

The following subsections detail how these objectives and the specific knowledge requirements they require.

3.3.1 Objective 1: Establishing a holistic systems perspective

As Hawe et al. (2009, p.270) puts it, "the systems-approach starts first and foremost with studying and understanding the context." In Section 2.4.3, I stressed that while numerous studies identify isolated factors influencing nature connectedness, these insights remain fragmented across disparate research contexts and variables (Lengieza and Swim, 2021; Chawla, 2020; Beery et al., 2023). This fragmentation led scholars like van Heel et al. (2023, p.362) to stress an "urgent need" for research that elucidates the mechanisms underlying the interplay between different context-dependent influences.

The first step to establishing a whole-systems perspective requires what Biggs et al. (2021) term 'descriptive knowledge'. This involves selecting a method to collect and identify the components, connections, and processes of a system through which nature connectedness develops. This descriptive foundation is essential not only for addressing the lack of systems thinking in nature connectedness research broadly but also for subsequently locating the John Muir Award specifically within its context.

3.3.2 Objective 2: Identifying leverage points

I have presented SES research as a problem-oriented field which broadly seeks to address real-world challenges (Biggs et al., 2021). My second objective thus involves moving beyond system description towards strategic insights (Preiser et al., 2021).

While I have identified several studies that catalogue factors influencing nature connectedness, these rarely distinguish their relative importance (Chawla, 2020; Lengieza and Swim, 2021). In subsection 2.4.2, I stressed that lasting nature connectedness requires regular engagement with nature (Sheffield et al., 2022). In Section 2.4.4, I highlighted consistent age-related changes in connectedness (Richardson et al., 2019; Price et al., 2022). However, as noted in subsection 2.4.3, these findings exist in isolation, with little research examining which variables might be most influential at different developmental stages or which relationships might be most strategic to target for ensuring ongoing interactions with nature.

My second objective thus focuses on identifying what complex systems theorists' term 'leverage points', places within a system where a small shift can produce large changes in a system's behaviour (Meadows and Wright, 2008). While the concept of leverage points is increasingly referenced in both nature connectedness and outdoor learning literature, it is typically used to position nature connectedness itself as a lever for broader sustainability transitions rather than examining what influences connectedness formation in the first place (Ives et al., 2018; Richardson, 2023; Zylstra et al., 2014). I contend that this represents a significant gap in current understanding. Identifying which factors may have a disproportionately positive or negative influence on nature connectedness could guide future intervention design.

Identifying these important system components requires methods capable of generating what Biggs et al. (2021) term 'exploratory knowledge', involving an analysis of the system structure and dynamics without being constrained by predetermined hypotheses. Such knowledge would be particularly valuable given the high uncertainty and limited causal evidence that characterise the literature on the lasting impact of fixed-duration outdoor learning interventions across different contexts and age groups.

3.3.3 Objective 3: Exploring the impact of the John Muir Award within a complex system

Once I have identified the system structure and potential leverage points, my final objective focuses on exploring how the John Muir Award might function within this complex system under different conditions. Section 2.4.1 demonstrated that while outdoor learning interventions like the Award consistently show immediate gains in nature connectedness, evidence for lasting impact is opaque (Sheffield et al., 2022; Holland et al., 2024; Mitchell and Shaw, 2010). In Section 2.4, I reframed interventions as events within complex systems, arguing that their impact depends on interactions with their broader context rather than their internal characteristics (Hawe et al., 2009). Yet few studies have employed systems methods to explore how interventions might function under different conditions or how their impact might be enhanced through strategic modifications. As Elsenbroich and Badham (2023, p.210) explain, “Only by keeping the contextual aspects of an intervention and then trying to find out the underlying mechanisms can we hope to understand the consequences of future policy interventions.”

This final objective involves explanatory knowledge, understanding why certain outcomes emerge and how interventions might be optimised (Biggs et al., 2021). Often these types of knowledge require methods capable of simulating potential system responses to different intervention approaches or contextual conditions. Such insight would be particularly valuable given the Award's current reform process, offering an opportunity to translate theoretical insights into practical explanations that could be used to enhance its lasting impact on nature connectedness.

The breadth of knowledge types for each of the above objectives marks my study as ambitious but also comes with the recognition that any method selected will inevitably address some objectives more effectively than others and produce certain types of knowledge with greater nuance or depth. As I detail in the following sections, my objectives and the practical constraints of doctoral research directed me toward methods capable of both representing system structure and exploring dynamics while integrating diverse practitioner knowledge.

3.4 Selecting a complex systems modelling method

This subsection offers a window into my methodological decision-making process, which progressed through a consideration of both computational simulation methods and qualitative knowledge-integration approaches. I evaluate each method against its respective alignment with my research objectives, compatibility with available data, and practical feasibility within doctoral research constraints. I select fuzzy cognitive mapping (FCM) as the most appropriate methodology for capturing outdoor learning practitioners' expertise while still supporting opportunities for quantitative simulations to explore the Award's impact under different system conditions.

3.4.1 Computational simulation approaches

Early in my review of methods I was drawn to computational simulation models, described simply as computer programmes that take information, process it according to set rules, and produce results (Wilensky and Rand, 2015). Relevant to the constructivist and critical realist epistemologies noted in Section 2.2.2, computational approaches caught my attention for their potential to reveal patterns and behaviours that emerge from complex interactions that human thinking often misses (Preiser et al., 2021; Jucker et al., 2019).

The two primary contenders were systems dynamics models (SDM) and agent-based models (ABM). SDMs simulate system behaviour through stock and flow diagrams using differential equations to model changes in system state variables over time (Cassidy et al., 2019). ABMs simulate individual entities making decisions and interacting with each other and their environment based on predefined rules (Elsenbroich and Badham, 2022). From these individual interactions, larger patterns emerge across the whole system (Smaldino et al., 2015; Davis et al., 2019; Schlüter et al., 2021).

SDM was ruled out as it requires quantification of 'flow rates' between system components and mathematical functions governing temporal dynamics. Setting a flow rate, for example, might involve specifying how many positive experiences per month are needed to shift a child's nature connectedness from low to medium. Such specifications would likely have exceeded what stakeholder knowledge and the current literature can provide.

ABM seemed particularly promising for my research. Since nature connectedness research typically focuses on individual psychological processes but rarely explores how these connect to broader social patterns, ABM offered a way to bridge this gap (Beery et al., 2023). The method could potentially simulate how the initial impact of the John Muir Award translates into lasting nature connectedness across a population of heterogenous children and young people interacting with their social and physical environments (Lengieza and Swim, 2021; Richardson et al., 2019). A notable strength of ABM is its capacity to simulate temporal dynamics, which was exciting given the "adolescent dip" phenomenon and our limited understanding of long-term impacts (Wilensky and Rand, 2015; Richardson et al., 2019).

Recent studies by Kamphuisen et al (2025) and Richardson (2025) provide precedent for the use of ABM in nature connectedness research as well as highlight a growing interest in complex system modelling. Kamphuisen et al. (2025) demonstrated tipping point dynamics where greenspace availability below 23% triggered self-reinforcing cycles of declining nature experience and connectedness. Richardson (2025) developed an ABM calibrated with historical urbanisation data to model individuals across their lifespans within evolving environmental conditions. The study captured population-level trends and revealed how intergenerational parental influence emerged as a powerful determinant of long-term nature connectedness decline from 1800 to 2020.

Despite these strengths and recent examples, closer examination revealed that ABM was not the best fit for addressing my research objectives and context. ABM requires starting with specific theories about how individuals behave, translating these into computer code, then testing whether these rules produce realistic system-level patterns (Taghikhah et al., 2021; Elsenbroich and Badham, 2023). However, I did not yet have clear behaviour rules to test. Rather, my objectives were to describe and explore the complex system shaping nature connectedness to subsequently develop a plausible explanation of how the John Muir Award may have a lasting impact. This exploratory approach was motivated by the fragmented state of knowledge I identified in Chapter 2, where numerous isolated factors have been identified, but their causal relationships and the specific role of fixed-duration interventions remain unclear. While ABM could potentially generate system descriptions as byproducts, its primary strength lies in testing hypotheses about how individual rules produce system-level outcomes.

Moreover, pursuing ABM would have potentially detracted from my most significant research advantage, access to enthusiastic practitioners across the John Muir Trust's outdoor learning network. While longitudinal data on intervention impact is limited, practitioners possess years of observational and experiential knowledge about how nature connectedness develops and about the role of outdoor learning interventions in Scotland. While forms of 'participatory ABM' have been used to translate non-academic perspectives into modelling rules and parameters (Abrami et al., 2021; Frerichs et al., 2020), the technical nature of developing ABM could create barriers to meaningful practitioner involvement. Edwards and Kok (2021) caution that stakeholder technical capacity must be carefully considered, or model usefulness for addressing complex system challenges will be undermined. As a novice modeller, ABM would have required extensive time for learning to code and debug computational models, which would reduce opportunities for engaging practitioners. This realisation prompted me to position my study toward greater involvement with stakeholders and practitioners.

This assessment of practical constraints, available resources, and comparative advantages led me to pivot toward methods better suited to my objectives, leveraging my access to practitioner knowledge while requiring less technical overhead. I therefore turned my attention to participatory systems mapping approaches, namely fuzzy cognitive mapping, which occupies a useful middle ground between computational simulations and purely conceptual diagrams (Wilensky and Rand, 2015; Barbrook-Johnson and Penn, 2022).

3.4.2 Participatory systems mapping approaches

Having decided against computational simulation models, I sought modelling methods that would facilitate high stakeholder participation and collaboration in model development. Participatory systems mapping encompasses approaches that involve stakeholders in constructing representations of complex systems rather than researchers building models in isolation (Abrami et al., 2021; Barbrook-Johnson and Penn, 2022). These approaches are often a form of 'expert' modelling, which focuses on eliciting perspectives from stakeholders with specialised knowledge of the system under investigation (Gray et al., 2014; Abrami et al., 2021). For this study, 'experts' are outdoor learning practitioners who collectively possess extensive observational knowledge about nature connectedness development in Scottish contexts and the John Muir Award's role within this system (detailed selection criteria are provided in Section 3.6.x).

A ‘systems map’ refers to the visual representation of a complex system as a network of interconnected elements (Barbrook-Johnson et al., 2022). Systems mapping typically involves building a model comprised of boxes and connections, where the boxes (also referred to as nodes, factors or concepts) represent variables that can meaningfully increase or decrease, and the connections (arrows or edges) represent direct causal relationships between factors (Barbrook-Johnson and Penn, 2022). This visual network structure makes explicit the feedback loops and non-linear dynamics central to complex systems thinking introduced in Chapter 2.

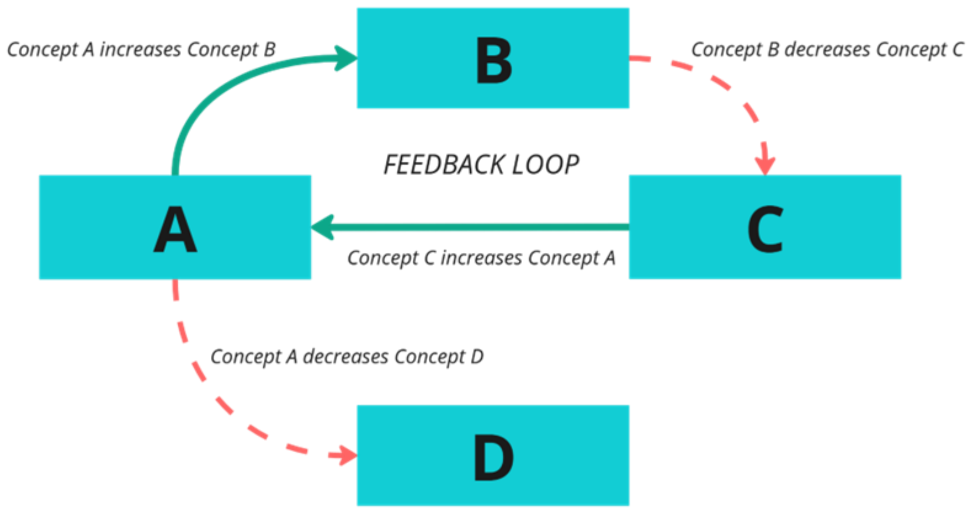

Figure 2. Basic Components of a Systems Map: Concepts (represented by blue boxes A, B, C, D) are the key factors or variables within the system. Arrows show causal relationships between concepts: solid green arrows indicate positive relationships where an increase in one concept leads to an increase in another, while dashed red arrows indicate negative relationships where an increase in one concept leads to a decrease in another. A feedback loop is noted where Concept C influences Concept A, which in turn affects Concept B, creating a cycle of interconnected causation.

Systems mapping serves to address key epistemological challenges identified in social-ecological system research (Section 2.2.2): while individuals are limited in their cognitive capacity to comprehend the complex systems they inhabit, they may collaboratively critique and improve their understanding through the development of transdisciplinary models (Edwards and Kok, 2021; Giabbanelli and Nápoles, 2024; Preiser et al., 2024). By externalising experts' tacit knowledge into visual formats, systems maps function as 'boundary objects', artefacts that facilitate discourse and shared learning among stakeholders with diverse perspectives (Gray et al., 2014; Abrami et al., 2021). By making implicit perspectives explicit, mapping affords stakeholders the opportunity to jointly question the everyday assumptions and beliefs that guide action (Jetter and Kok, 2014).

Systems mapping approaches vary along three primary dimensions: quantitative data requirements, system scope (whole-system versus intervention-focused), and the extent of stakeholder participation (Barbrook-Johnson and Penn, 2022). For my research objectives, I required a mapping method that could be built with little to no quantitative data, that was highly participatory, and that focused on describing and exploring a whole social-ecological system.

These criteria excluded several prominent approaches. Bayesian belief networks, for instance, are probabilistic models that use statistical inference to represent uncertainty in complex systems (Barbrook-Johnson and Penn, 2022). They allow stakeholder involvement in model construction but are not suited for my study as they require extensive empirical data or in-depth knowledge to determine the conditional probabilities that govern how each concept influences one another (Penn et al., 2013). Theory of Change models, though highly participatory and capable of examining multi-level dynamics, are intervention-centred (Montano (Montano et al., 2025). They begin with specific interventions and map pathways toward predetermined outcomes rather than exploring the full complexity of system relationships that exist independent of any particular intervention (Davies, 2018). This approach would arguably perpetuate the tendency in outdoor learning research to locate causation primarily within intervention components rather than examining how those components interact with broader system dynamics (Beery et al., 2019; Hawe et al., 2009).

I found several participatory mapping methods that could potentially satisfy my first and second research objectives of describing the system shaping nature connectedness and identifying potential leverage points. Causal loop diagrams (CLDs) emerged as a leading contender. CLDs are designed to emphasise non-linearity by mapping perpetual feedback loops within systems that can be developed entirely from stakeholder knowledge without empirical data requirements (Barbrook-Johnson and Penn, 2022). Notably, Zucca et al. (2023) recently employed CLDs to examine factors influencing nature-based play implementation in early learning settings, demonstrating through stakeholder workshops how these methods can capture shared understanding of complex interrelationships in Scottish outdoor learning contexts. The researchers, moreover, conducted structural analysis to identify which concepts are most central and may function as key leverage points (detailed further in Section 3.7.2), showing clear precedent for addressing my first two research objectives (see Section 3.3).

However, my research motivation extends beyond system description toward exploring how the John Muir Award may influence lasting nature connectedness under varying conditions. This third research objective requires the ability to simulate how changes to the Award or surrounding system conditions might propagate through the network and affect outcomes over time. While CLDs excel at quickly identifying how factors interrelate, they do not estimate the relative magnitude of these influences or simulate how interventions might impact the system under different scenarios.

This analytical limitation directed me toward Fuzzy Cognitive Mapping (FCM) (Makris, 2024). While FCM shares the participatory and visual benefits of CLDs, it offers additional analytical capacity by assigning numerical weights to relationships, transforming qualitative stakeholder judgments into a semi-quantitative format that enables simple simulations to explore the Award's impact under different conditions (Jetter and Kok, 2014).

3.5 Fuzzy cognitive mapping

Among participatory systems mapping approaches, I contend that Fuzzy Cognitive Mapping (FCM) offers a distinctive combination of characteristics that address all three of my research objectives. In this section, I detail how FCM integrates the accessibility of qualitative systems mapping with mathematical properties that enable quantitative analysis and simulations, all without requiring empirical data for validation (Kosko, 1986; Jetter and Kok, 2014).

Like the mapping methods already discussed, FCM was explicitly developed from the principles of constructivist psychology and designed to capture the implicit mental models of individuals or groups as ‘cognitive maps’ (Kosko, 1986; Gray et al., 2014). FCM similarly functions as a boundary object which facilitates expert modelling by externalising knowledge into formats that enable discourse among diverse stakeholders (Jetter and Kok, 2014). Structurally, FCMs share the same network architecture of boxes and connections as other systems maps: concepts are connected by directional relationships that represent causal influences between system factors (Groumpos, 2010; Barbrook-Johnson and Penn, 2022). What distinguishes FCM from purely visual mapping methods like CLD is captured in Giabbanelli and Nápoles's (2024, p. 3) definition: "A [fuzzy cognitive map] is a semi-quantitative representation of individual and/or group knowledge structures consisting of variables and their causal relationships, which are directional and weighted." The terms ‘semi-quantitative', 'fuzzy', and ‘weighted’ require further clarification as they enable important analytical capabilities needed for meeting all three of my research objectives.

3.5.1 The semi-quantitative properties of FCM

FCM is often referred to as a ‘semi-quantitative’ approach because it occupies a methodological middle ground between purely visual mapping approaches and mathematical computational modelling that requires extensive empirical data (Barbrook-Johnson and Penn, 2022). Rather than marking relationships as simply present or absent like CLDs, FCM assigns numerical weights on a scale from -1.0 to +1.0 to represent the perceived strength and direction of causal influences. As Gray et al. (2014, p. 3-4) explain, this approach "permits individuals to interpret and express the complexity of their environment and experiences by combining their knowledge, preferences and values with quantitative estimations of the perceived relationships."

The term 'fuzzy' refers to how FCM handles the inherent uncertainty in stakeholders' causal judgments (Jetter and Kok, 2014). Instead of requiring precise flow rates or behavioural rules (like those needed SDM and ABM), FCM works with the imprecise nature of human reasoning about causality (Giabbanelli and Nápoles, 2024). Stakeholders can meaningfully distinguish between 'strong' and 'weak' influences even when they cannot quantify them precisely. These approximate judgments become numerical weights that can only be interpreted relative to one another rather than as absolute measures (Kok, 2009). For example, when comparing factors that influence children's time in nature, practitioners might agree that having supportive parents is more important than living next to a public park, even if they cannot precisely quantify how much stronger parental influence is.

Given my study objectives, semi-quantitative weights offer a useful analytical opportunity. More than a visual description of a system, an FCM is also a mathematical object and can be represented as a matrix where concepts form rows and columns, and relative relationship weights occupy the intersecting cells (Barbrook-Johnson and Penn, 2023; Giabbanelli and Nápoles, 2024). This mathematical representation enables two analytical capabilities relevant for my research objectives: static analysis is used to identify which concepts are most important to the system (addressing my second research objective), and dynamic analysis to run simple simulations exploring how interventions might function under different conditions (addressing my third research objective).

3.5.2 The static and dynamic analytical capabilities of FCM

FCM static analysis examines the mathematical structure of the network to calculate which concepts are most important within the system (Schuerkamp and Giabbanelli, 2024). This is essentially asking: based on how many relationships each concept has and how strong those relationships are, which concepts appear most central to the overall system? To answer this question, the modeller calculates centrality measures, a process I detail in Section 3.7.2 (Schuerkamp and Giabbanelli, 2024; Jetter and Kok, 2014). These measurements produce numerical scores that rank each concept's relative influence within the network structure. While high centrality scores can indicate concepts with significant potential for system-wide impact, they represent only one dimension of strategic importance and do not automatically identify optimal intervention targets. As I discuss further in Chapter 5, static analysis provides a useful analytical foundation for exploring which concepts practitioners perceive as most influential, offering initial insights into potential leverage points according to their shared understanding of the system shaping lasting nature connectedness.

Dynamic analysis uses FCM's numerical properties to run simple simulations (scenarios) that explore the causal implications of practitioners' perspectives (Jetter and Kok, 2014). To run a scenario, the FCM network is recreated in FCM software (Felix et al., 2019). Each system concept then functions like a simple processing unit that receives signals from adjoining concepts and sends signals onward. Specific concepts are given starting values, and through repeated rounds of multiplication and updating of these values using the weight matrix, the model eventually settles into a stable pattern representing the consequences of initial changes (Schuerkamp and Giabbanelli, 2024; Barbrook-Johnson and Penn, 2022). I detail scenario design and FCM software in subsection 3.6.5.1.

Much like computational models such as ABM, FCM scenarios are analytically valuable because, while practitioners can describe individual concepts and relationships within complex systems, the combined effect of multiple interrelationships and feedback loops is difficult to predict through mental reasoning alone (Jetter and Kok, 2014). Scenarios allow stakeholders and modellers to ask ‘what-if’ questions about the system, exploring how hypothetical changes might propagate through the network to produce desired outcomes (Barbrook-Johnson and Penn, 2022).

In short, FCM’s analytical capacity enables a deeper exploration of practitioner knowledge to gain insights about system-wide patterns and intervention outcomes. I detail specific methods for conducting these analyses in Sections 3.7 (static analysis) and 3.8 (dynamic analysis), present results in Chapter 4, and interpret implications in Chapter 5.

3.5.3 FCM limitations and interpretive caution

FCM occupies a distinctive position in the methodological spectrum between purely visual aids like CLDs and empirically-based versions of computational models like ABM and SDM. This positioning offers advantages but also creates interpretive risks. FCM extends beyond visual mapping by enabling quantitative analysis and simulations, yet it lacks the empirical grounding and predictive capacity of computational approaches that rely on validated real-world data and mechanisms. This intermediate status can lead to over-interpretation, treating FCM outputs as more predictively accurate than they actually are. Barbrook-Johnson and Penn (2022, p. 117) caution that FCM outputs may "seem like magic (…) and offer a false sense of certainty, truth, and scientific rigour."

FCM is helpfully characterised as a 'thinking tool' rather than an empirical model (Penn et al., 2013). Unlike ABM or system dynamics models that aim to reproduce real-world patterns through empirically validated mechanisms, FCM is deemed valid if it accurately reflects the views of participating experts (Jetter and Kok, 2014). Scenarios represent "the subjective knowledge of respondents about uncertain driving forces that shape the future" rather than objective predictions (Jetter and Kok, 2014, p. 47). While choosing FCM meant that I could avoid depending on sparse longitudinal data to study the complex system shaping lasting connectedness, I instead needed to contend with the challenge of faithfully capturing and representing the knowledge of my chosen group of experts. In Section 3.6, I detail the specific steps taken to ensure accurate representation of practitioner knowledge, drawing on established FCM methodological guidance (Jetter and Kok, 2014; Olazabal et al., 2018).

FCM still addresses my initial interest in computational methods by providing opportunities to extend beyond the limitations of individual cognitive capacity to comprehend complex system dynamics. Like ABM simulations, FCM scenarios may reveal counterintuitive system behaviours and unintended consequences that practitioners might not anticipate through mental reasoning alone. FCM cannot, however, simulate emergent behaviours or self-organisation processes (Jetter and Kok, 2014; Preiser et al., 2024). The model structure remains relatively fixed during simulations, without capacity for components to adapt independently (Schuerkamp and Giabbanelli, 2024). Moreover, time in FCM is represented as abstract iterations rather than clearly defined periods, making temporal dynamics less precise than other modelling approaches (Jetter and Kok, 2014).

It is worth noting the potential for FCM-ABM hybrid models that leverage the strengths of both methods (Davis et al., 2019; Mehryar et al., 2020). I considered such a combination to address the respective limitations of each approach. However, this undertaking would exceed the time and resources available for doctoral research. The coming years will likely produce more longitudinal studies tracking how multiple variables influence nature connectedness, potentially supporting empirically grounded modelling approaches (van Heel et al., 2023). That said, future empirical studies will still depend on asking the right questions and measuring appropriate variables to move beyond traditionally linear views of impact (Lengieza and Swim, 2021).

I contend that FCM offers a fitting 'gateway' method for encouraging the wider literature on nature connectedness and outdoor learning to engage with complex systems approaches (Barbrook-Johnson and Penn, 2022). FCM is appropriate precisely because it acknowledges the current state of knowledge about lasting nature connectedness (discussed in Chapter 2), which is characterised by uncertainty, limited longitudinal data, and dependence on retrospective qualitative accounts. FCM is particularly valuable, argues Kok (2009, p. 122), "in situations where factors shaping the future are highly uncertain and largely uncontrollable." For instance, FCM allows inclusion of important but difficult-to-quantify concepts such as social norms, risk tolerance, or environmentalism (Jetter and Kok, 2014).

I delve deeper into the specific limitations and pitfalls that become more apparent when applying FCM to nature connectedness research in Chapter 5. For now, this general critique establishes the interpretive framework necessary for understanding the method's application to my research objectives, which I detail in the following sections.

3.6 FCM Implementation: A stepwise process

The purpose of this chapter's remaining sections is to detail the stepwise process through which I designed and implemented my FCM study for this specific research context. While the basic components of FCM are largely standardised, the process by which maps are developed, analysed and interpreted varies considerably depending on research questions and stakeholder contexts (Gray et al., 2013). I therefore focus on detailing key methodological decisions that were most relevant to my study while directing readers to other scholars who offer more comprehensive overviews of alternative FCM approaches and their implications (Özesmi and Özesmi, 2004; Penn et al., 2013; Schuerkamp and Giabbanelli, 2024). I draw primarily from the methodological frameworks of Jetter and Kok (2014), Edwards and Kok (2021), and Olazabal et al. (2018) to present a structured approach that systematically funnels diverse practitioner knowledge into a coherent, analytically useful model.

The following sections present 5 key steps: 1) defining research questions and model boundaries, 2) selecting and recruiting practitioners, 3) capturing stakeholder knowledge, 4) qualitative and quantitative aggregation, and 5) model calibration and sensitivity testing. In Section 3.7, I present my approach for conducting static and dynamic analyses to generate results for my research questions. This stepwise process was designed to transparently and progressively funnel practitioners' initially broad and fragmented knowledge into a parsimonious and aggregated representation that could support the analysis of the complex system shaping lasting nature connectedness in Scottish children and young people.

While each step is presented sequentially, this process was highly iterative. Many steps were revisited to incorporate stakeholder feedback, refine model boundaries, and ensure the developing model continued to serve the study's evolving objectives. The numerous micro-decisions involved in this iterative process carried out both by myself and participating practitioners would be unfeasible to document exhaustively. Where appropriate, I include some preliminary findings to demonstrate the iterative nature of FCM development and to provide readers insight into how practitioners and I collaboratively developed the model. I reserve Chapter 4 for presenting results from the final aggregated model.

3.6.1 Define research questions and model boundaries

Having established this study's objectives (Section 3.3) and selected FCM as a fitting complex systems method to address them (Section 3.5), the first step in FCM development involves translating research objectives into specific research questions and establishing clear boundaries that guide all subsequent methodological decisions (Jetter and Kok, 2014; Olazabal et al., 2018).

For this study, I first translated my three research objectives into corresponding research questions, each designed to exploit distinct FCM analytical capabilities. These questions are progressive, beginning with broad system description before narrowing toward strategic insights about model structure and behaviour explicitly relevant for understanding the Award's contributions:

> *RQ1: According to outdoor learning practitioners, what is the complex system shaping Scottish children and young people's lasting nature connectedness?*
>
> *RQ2: What concepts do practitioners consider most important for shaping nature connectedness and may serve as strategic leverage points?*
>
> *RQ3: How can we simulate the system to explore the lasting impact of the John Muir Award under different plausible scenarios?*

These research questions contain parameters that shape the scope and focus of this study's investigation. Following Jetter and Kok's (2014) guidance, I established four key boundary criteria to ensure model coherence while maintaining relevance to the John Muir Award context: Level of abstraction, spatial, temporal, and demographic boundaries.

Level of abstraction: Setting a level of abstraction involves choosing which types of factors to include in the model and the degree of generality versus specificity at which the model represents the formation of nature connectedness. In my case, the model is intended to capture factors that operate as recurring influences on children's ongoing experiences with nature. Emphasis is placed on the concepts and relationships that practitioners (selected in subsection 3.6.2) understand to shape connectedness over months and years, beyond the immediate impact of a fixed-duration intervention. While the level of abstraction is not necessarily precise, it serves as a useful guide for developing a focused and coherent model. As Barbrook-Johnson and Penn (2022, p.87) explain, "Though factors can be anything, they normally need to have some level of comparability in their abstraction or simplification."

The focus is therefore on describing key concepts and relationships that operate over similar timeframes and within similar spheres of influence as the John Muir Award, factors that persist in children's lives and continue shaping their relationship with nature long after a four-day outdoor experience has ended. Setting this overarching parameter means that micro-level factors (individual neurological differences, moment-to-moment emotional states) are excluded because, while they may be highly relevant when measuring immediate effects, they are highly variable over time and operate at finer temporal scales than sustained connectedness development. Likewise, macro-level factors (national education policies, global economic trends) are slower to change and their impacts are mediated through the meso-level variables that form this study's focus. Setting these boundaries directs attention toward the persistent social and environmental conditions and recurring experiential patterns most applicable to understanding how the Award contributes to lasting nature connectedness in Scottish children aged 8-15.

Spatial Boundary: Similar interventions may produce different outcomes depending on where they take place (Giusti et al., 2018). While this study is likely to have relevance for the wider UK context, the model focuses specifically on nature connectedness formation in Scotland, where the Award originated. This boundary was established to create focused selection criteria for participants (practitioners who live and work in Scotland) and to ensure the model captures the Scottish context within which the John Muir Award operates. Rather than prescribing what makes Scotland distinct, this guiding boundary serves to emphasise that where differences exist between Scotland, the wider UK, and beyond, the model should prioritise capturing the Scottish perspective through practitioners' knowledge and experience.

Temporal Boundary: The model focuses on contemporary factors influencing nature connectedness, reflecting practitioners' current understanding based on their recent professional experience. This excludes historical trends that are no longer relevant (such as past policy frameworks or outdated social norms) and future projections or speculative changes that have yet to occur. Idealised or wishful-thinking system components and behaviour were also excluded. This temporal boundary aims to capture the system as it currently operates, drawing on practitioners' accumulated knowledge from recent years to represent factors and relationships that remain active and influential today.

Demographic Boundary: The model focuses on children and young people aged 8-15, corresponding to the primary demographic served by John Muir Award programmes. RQ1 is thus concerned with two broad age groups (children and young people). This age range captures both childhood and early adolescence, enabling examination of how factor importance shifts as children mature (Richardson et al., 2019; Price et al., 2022). I explain this decision further in subsection 3.6.3.2.

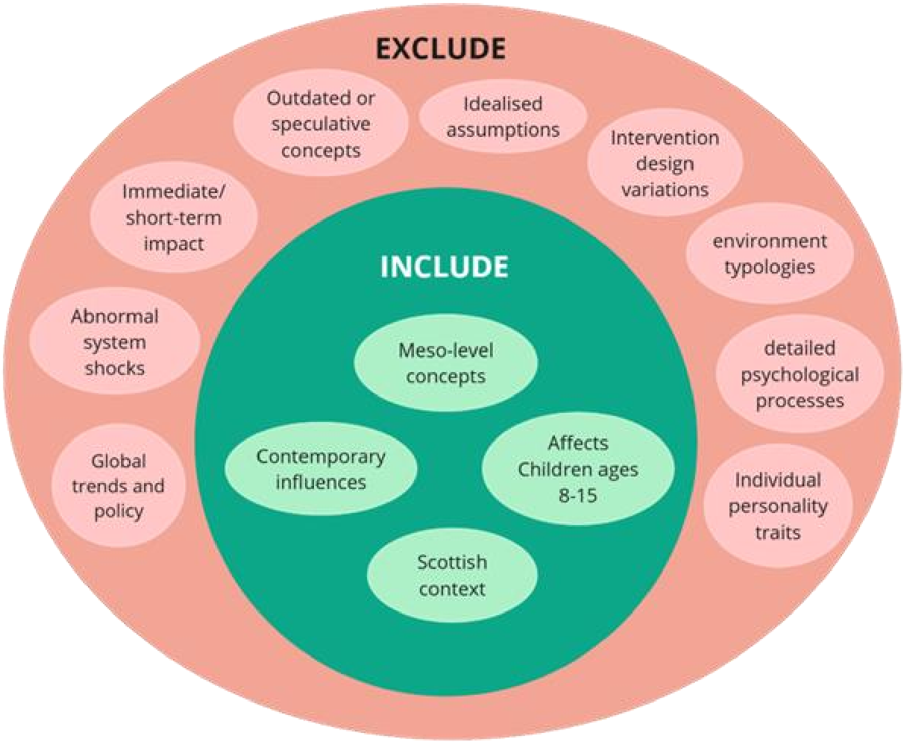

Figure 3. Boundary Diagram for FCM Concept Inclusion and Exclusion: This diagram shows the inclusion and exclusion criteria for FCM concept selection. The green zone represents the focused scope of the model: meso-level concepts within the Scottish context, reflecting contemporary influences on children ages 8-15. The red zone shows excluded elements that fall outside these boundaries, factors that are too broad, too narrow, temporally irrelevant (outdated or speculative), or beyond the demographic focus. Concepts proposed during model development were evaluated against these boundaries to determine inclusion or exclusion

These boundaries created a clear framework for practitioner contributions and guided my aggregation decisions (detailed in Section 3.6.4). The resulting model focuses on contemporary, local-level antecedents that shape children's routines within Scotland, specifically examining variables where the John Muir Award exerts its most significant impact.

3.6.2 Select stakeholders

Stakeholder selection is crucial in FCM development because the resulting model will be based on the knowledge and perspectives of a specific group (Özesmi and Özesmi, 2004). This step involves identifying which stakeholders or 'experts' possess the most relevant knowledge for answering the study's research questions and determining how to capture and elicit their perspectives effectively (Gray et al., 2014; Jetter and Kok, 2014; Knox et al., 2023). The term 'expert' may take on different meanings depending on the topic under investigation (Gray et al., 2014). Given this study's scope (defined in 3.6.1) and the high uncertainty and complexity that characterise the development of lasting nature connectedness, no single person is expected to have full knowledge of all aspects of the system. Moreover, individual experts differ in which parts of the system they understand most deeply. A practitioner who works primarily with teachers, for example, might have a nuanced understanding of educational contexts but a more limited insight into family dynamics (Gray et al., 2014). This provides compelling rationale for developing the model through diverse teams where different and overlapping areas of expertise can balance toward a more holistic and shared understanding of the system (Jucker et al., 2022).

3.6.2.1 Identifying a group of experts

For this study, experts are identified as outdoor learning practitioners who possess experiential and observational knowledge about nature connectedness development in Scottish contexts, as well as the role and impact of the John Muir Award's system. I contend that this expertise represents the best available knowledge source for answering my research questions. As established in Section 2.4, empirical data about long-term nature connectedness dynamics remains scarce.

While the development of children and young people's nature connectedness is the focus of this study, I chose to engage adult outdoor learning practitioners rather than children directly. This methodological decision was informed by several strategic considerations grounded in established FCM practice and my study objectives:

First, practitioners offer a macroscopic perspective better suited to understanding complex system dynamics than children's more individualised views (Giusti et al., 2019). Having observed and designed children's nature experiences across diverse contexts, age groups, and settings over time, practitioners possess the breadth of knowledge necessary for systems-level analysis. Children's perspectives, while valuable, would be more likely to reflect their singular, personal experiences rather than the systemic patterns and relationships that FCM seeks to capture. I further reflect on the implications of focusing solely on adult practitioners in Chapter 5.

Second, practitioners' mental models directly influence real-world decision-making, planning, and implementation of outdoor learning interventions (Özesmi and Özesmi, 2004). The practitioners in this study are not merely observers but are actively designing and delivering outdoor learning programmes, including the John Muir Award, based on their understanding of how nature connectedness develops. Whether explicitly acknowledged or not, their mental models already inform practice (Knox et al., 2023). By externalising these shared assumptions into a visible systems map, this study creates an opportunity to examine, discuss, and critique the causal logic that currently guides intervention design and implementation (Knox et al., 2023).

Lastly, enthusiastic practitioners were readily accessible through established John Muir Trust networks, enabling efficient recruitment of knowledgeable participants. Working with children and young people, as a more vulnerable population, would have presented greater hurdles for gaining ethical approval and required working with multiple intermediaries such as schools, parents, and guardians. These additional challenges would have potentially limited the depth of insights captured and the study's timeline. That said, focusing on adult practitioners does not preclude future research that integrates children's perspectives. FCM has been successfully used to compare and integrate different stakeholder viewpoints across multiple model iterations. Subsequent studies may examine how children and young people’s mental models reinforce or diverge from practitioner understanding of the same system (Jetter and Kok, 2014).

3.6.2.2 Selection guidelines and purposive sampling

I leveraged established research partnerships with the John Muir Trust to access practitioners across the John Muir Award's provider network (Knox et al., 2024). Clear selection guidelines ensured appropriate expertise and diverse professional representation (Penn and Babrook-Johnson, 2019): A participant had to be an adult practitioner (18+ years) with current or recent involvement (within the last 12 months) in the provision of outdoor learning and the John Muir Award for children and young people between the ages of 8-15 in Scotland. The selection of participants prioritised representation from different outdoor learning sectors (Penn and Babrook-Johnson, 2019).

Guided by the selection criteria, I identified 28 practitioners within the Trust network. Invitations were forwarded by the John Muir Trust staff. Of the 28 invited, 14 agreed to participate in the first stage of model development (a group workshop), though most others expressed interest in future engagement. For the second stage of knowledge capture (individual interviews), the same 14 were invited, but only 10 of this initial group committed to participation. An additional three practitioners who had not been available for the initial workshop participated in the interview stage. The views of a total of 17 practitioners were thus captured by the model, though only 10 were present for both phases.

The 17 participants represented a range of professional sectors including Scottish Government, Youth Awards, Youth Work, Family Practitioners, Inclusion, Park Rangers, Teachers/Schools, Residential Centres, and Outdoor Education. Note that these categories are fluid as many participants identified with multiple sectors or had worked across different areas and age groups throughout their careers.

This sample size was appropriate for meeting my research objectives and aligned with established FCM practice. I found previous FCM studies to range widely between 7 and 51 participants (van Vliet et al., 2010; Knox et al., 2023). Studies with the largest sample sizes, such as Knox et al. (2023), typically seek to develop multiple systems maps for comparing diverse expert perspectives across different groups. My objective, however, was to create a single aggregated map representing the shared understanding of one group. I thus placed emphasis on keeping the group small enough to ensure that each practitioner would have equal opportunity to contribute and have their individual perspectives represented in the shared model (Jetter and Kok, 2014). To this end, my study met Eden and Ackerman's (2004) recommendation for no more than 14 participants in a single workshop. A larger sample size would have also required more time and energy dedicated to the post-processing of data (Özesmi and Özesmi, 2004).

FCMs are designed to capture specific expert perspectives—including their biases—about complex systems rather than achieve statistical representativeness (Jetter and Kok, 2014). The 17 practitioners were thus selected to acknowledge professional diversity across outdoor learning sectors while allowing time for multiple rounds of data collection as well as for the in-depth analysis needed to address all three research questions.

3.6.3 Capturing stakeholder knowledge

The knowledge capture step is foundational to FCM validity; the model is valid to the extent it accurately represents the understanding of my selected practitioners (Jetter and Kok, 2014). Capturing practitioner knowledge is therefore a crucial step though approaches to doing so in FCM study take many forms, including questionnaires, literature review, individual interviews and group workshops, using either predetermined concepts or freely associated variables (Gray et al., 2014; Olazabal et al., 2018; Jetter and Kok, 2014). Generally, approaches are broadly distinguished by the level of input the researcher/modeller has in the process and by the model being built by individuals, groups, or both (Jetter and Kok, 2014). Each approach involves trade-offs between depth of individual insight, group learning, practical constraints, and model validation opportunities (Jetter and Kok, 2014). For a more comprehensive review of approaches for knowledge collection and their respective trade-offs see Gray et al. (2014).

A critical early decision concerns the extent of researcher involvement in model development. At one extreme, researchers provide predetermined concepts and initial system structures for stakeholders to refine and validate (Olazabal et al., 2018; Gray et al., 2014). This approach is efficient but also potentially constraining because it may privilege researcher priorities over accurately representing stakeholder knowledge (Gray et al., 2014). At the other end of the spectrum, stakeholders are given free rein to develop the model while researchers provide only methodological training and facilitation. This approach prioritises stakeholder perspectives but often produces unwieldy models that are difficult to interpret and apply to specific research questions (Penn et al., 2013; Edwards and Kok, 2021).

For this study, I leaned more toward the stakeholder-led end of this spectrum. As a researcher who is not an outdoor learning practitioner working in Scotland, I recognised that practitioners possess the contextual expertise my study required despite my extensive review of the literature. All concepts and relationships in my map originated from practitioners' knowledge and experience. However, this stakeholder-led approach does not eliminate my influence on model development as I played an important role in aggregation and calibration of the model (detailed in section 3.6.4). This back-and-forth process of researcher interpretation followed by stakeholder validation is recognised as necessary for producing coherent, usable models from diverse stakeholder input (Olazabal et al., 2018). The resulting model present in Chapter 3 is therefore best characterised as ‘co-designed’ by practitioners and myself, prioritising stakeholder representation while acknowledging that my methodological decisions greatly shaped the presentation and interpretation of the final product (Edwards and Kok, 2021). Practitioners were given multiple opportunities to critique and to validate the various iterations of the model to ensure their perspectives remained accurately reflected.

With the goal of developing a single stakeholder-led model, I sought to facilitate an approach to knowledge collection that would provide multiple opportunities for practitioners to collaboratively develop a model while ensuring individual voices were represented. I opted for a hybrid approach, conducting a group workshop followed by a series of individual interviews and a final opportunity for written feedback to leverage the complementary strengths of all approaches (Jetter and Kok, 2014; Penn et al., 2013).

3.6.3.1 Workshop design and implementation

Group modelling workshops in which participants work together to discuss and design the model collaboratively are common in participatory FCM studies (Barbrook-Johnson and Penn, 2022). They provide a forum for diverse stakeholders to deliberate towards reaching a shared understanding of wicked problems (Knox et al., 2023; Penn et al., 2013). Stakeholders working together can aggregate multiple cognitive maps over the course of the workshop session. This serves to support shared insights that emerge from the collaborative process while also reducing the burden on researchers to make decisions about which perspectives, concepts, or relationships to prioritise (Gray et al., 2014; Jetter and Kok, 2014). Additionally, workshops are often deemed more time-efficient compared to individual model collection and can produce a shared model within a single day session (Penn et al., 2013; van Vliet et al., 2010).

I opted to conduct a workshop to establish a foundational map representing practitioners' shared understanding of the system. The recommendations of Barbrook-Johnson and Penn (2022) on facilitating participatory mapping workshops were instrumental in my design. Here I provide a brief account of key stages: pre-workshop concept generation, concept identification and grouping, relationship mapping, and the creation of a single merged map.

To prepare practitioners for systems thinking while maintaining stakeholder ownership, I employed a pre-workshop concept generation activity (Olazabal et al., 2018). Practitioners were instructed to contribute concepts, both barriers and facilitators, which they considered influential for the development of nature connectedness. Concepts were collected through an online list-making platform (Listmoz.com). Practitioners submitted 52 concepts. I refined this list by removing duplicates and clarifying language, selecting 20 as starter concepts to accelerate the workshop process and provide a manageable foundation for group discussion, while ensuring practitioners retained the opportunity to add, modify, or remove concepts during the workshop itself. For example, an anonymous practitioner proposed “opportunities to guddle about without adults interfering,” which I rephrased as “child-led outdoor play”.

Within the workshop, I divided 14 practitioners into three tables of 4-5 people each, with each table receiving identical starter concepts on notecards. To encourage participants to speak freely, the workshop was not recorded or transcribed. Instead, two supporting researchers or ‘listeners’ were tasked with capturing key themes, challenges, and discussions. The listeners sat with the participants at their respective tables throughout the day but did not participate in the mapping process. Both listeners submitted a written summary of their observations to support the analysis and discussion of the systems map. I also noted my own observations immediately following the workshop.

Following a presentation introducing FCM theory (detailed in section 3.5), defining study boundaries (section 3.6.1), and establishing nature connectedness as the central outcome concept (Knox et al., 2024), practitioners at each table arranged the 20 starter concepts into thematic groups to scaffold the identification of additional concepts. Each table then brainstormed concepts beyond the starter list. They were free to remove, reword, and add concepts as they saw fit.

Practitioners then mapped causal relationships by drawing directional arrows between concepts, indicating whether relationships were positive (an increase in one concept causes an increase in another) or negative (an increase in one causes a decrease in another) (Knox et al., 2024). Throughout this process, cross-table learning occurred through ambassador rotations, where representatives visited other tables to compare models.

The workshop concluded with all 14 practitioners deliberating to create a single merged map. I facilitated this consolidation process by drawing on a whiteboard as practitioners discussed which overarching concepts and relationships were most essential. The session ended with a validation exercise where I retraced the map's causal logic, allowing practitioners to confirm the model adequately represented their collective understanding.

3.6.3.2 Interview design and implementation

While workshops offer efficiency and collaborative aggregation, these settings can drown out certain voices due to power imbalances, and consensus-seeking may suppress individual perspectives (Edwards and Kok, 2021; Jetter and Kok, 2014; Olazabal et al., 2018). Individual interviews are often used to collect more in-depth knowledge of the system (Olazabal et al., 2018). A trade-off is that interviews may produce heterogeneous data requiring extensive researcher interpretation and aggregation (Olazabal et al., 2018).

To establish a shared conceptual foundation and minimise large divergences in how practitioners describe their system understanding, I conducted group modelling in advance of individual interviews. Within interviews, each practitioner was shown the merged map and refinements made by any previous interviewees. This snowball approach aimed to ensure that individual perspectives could enrich the shared model while maintaining collaborative momentum (Barbrook-Johnson and Penn, 2022).

Interviews were also conducted to address research objectives that had not been adequately covered in the workshop. The collaborative workshop process had successfully identified key concepts and basic relationships, but interviews provided the opportunity to delve into more nuanced aspects of the model. Due to time constraints, the workshop did not involve assigning numerical weights to concept connections or locating the John Muir Award within the system. Following initial aggregation of workshop results (detailed in Section 3.7), I conducted 13 individual interviews over May-June 2023, over Zoom.

All interviews were conducted with full ethical approval and informed consent (see Appendix 2). Sessions were audio-recorded with participants' explicit permission to enable accurate transcription and subsequent data analysis. To protect participant confidentiality and encourage candid discussion about professional practices and the Award's impact, all practitioners were assigned anonymised identifiers (Pract1, Pract2, Pract3, etc.) throughout the study.

These 90-minute video conversations met four specific objectives: refining and sense-checking the workshop map, assigning relationship weights, exploring age-related variations, and locating the John Muir Award as a new concept within the map.

Refining and sense-checking involved reintroducing each practitioner to the merged map initially created in the group workshop and since aggregated by the researcher. Practitioners were asked to consider whether relationships accurately represented their understanding of the key concepts and interrelationships shaping lasting nature connectedness. They were encouraged to suggest changes to the model structure and wording to better represent their understanding and provided explanatory examples from their professional experience. This iterative process ensured individual perspectives were incorporated while maintaining the collaborative foundation established in the workshop.

Relationship weighting introduced the semi-quantitative aspect of FCM, translating qualitative understanding into values suitable for mathematical analysis. To do this, I directed each practitioner to assign numerical values from -1.0 to +1.0 to each connection, preserving the type of causal relationship (positive or negative) identified during mapping while indicating relative strength. While numerical values were assigned, they were explicitly anchored to corresponding linguistic categories much like a Likert scale (see Table 1 below).

Table 1. FCM relationship weighting scale and qualitative descriptors

Weight Range	***Linguistic Category***	***Example Interpretation***
0.1 – 0.2	Very weak	Minimal influence on the relationship
0.3 – 0.4	Weak	Some influence but easily overridden
0.5 – 0.6	Moderate	Noticeable influence in most contexts
0.7 – 8.0	Strong	Substantial influence in most situations
0.9 – 1.0	Very strong	Dominant influence, difficult to override

Practitioners were first asked to assign weights based on the system shaping lasting connectedness for children aged 8-11, establishing the foundational model before exploring age-related variations. They were reminded that weights do not represent precise empirical measurements but derive their meaning in relation to one another. I prompted practitioners to consider relationships comparatively: compared to other concepts, how strongly does concept A influence concept B? Practitioners were invited to explain their reasoning for each weight, providing qualitative justification that I recorded and transcribed to inform post-processing.

RQ1 focuses on identifying the complex system that shapes nature connectedness for two distinct age groups: children (ages 8-11) and young people (ages 12-15). This distinction, although generalised, is crucial, as prior literature consistently highlights age as a significant factor in understanding the development of an individual's connection to nature (Chawla, 2020; Cleary et al., 2020; Richardson et al., 2019). Moreover, given that most Award participants range from 8-15 years of age, it was of high interest among practitioners to consider the Award's varying impact for both children and young people. As discussed in Chapter 2, age is likely to have several important implications for how an individual connects with nature, although the specific causal relationship between aging and nature connectedness remains under-researched (Lengieza and Swim, 2021).

During the workshop, practitioners noted that system structure and the importance of key concepts would likely shift as children age. To reflect this understanding and support RQ1's explicit focus on both children and young people, I asked practitioners to review the initial map (now weighted for ages 8-11) and identify which mechanisms they understood to change from childhood to adolescence (ages 12-15). Rather than building an entirely new model for the older age group, making changes to the existing structure enabled practitioners to think chronologically about how the system changes from one age group to the next. This served to identify key shifts in system structure while ensuring that the two model variations remained comparable in later analysis. Practitioners were given the opportunity to modify relationship weights and add or remove concepts to reflect developmental shifts, producing two age-differentiated models, presented in Chapter 4.

The final step of each interview prompted practitioners to locate the direct impacts of the John Muir Award within the wider system for both children and young people. By direct impact, I refer to the Award's immediate causal influence on specific system concepts, the primary pathways through which its effects enter and propagate through the network. I asked practitioners: "When the Award is introduced into this system, what factors are directly affected? What lasting changes (if any) occur in the system itself, even after the Award experience ends?" The John Muir Award was added to the model as a new concept from which practitioners drew arrows and weighted these connections to reflect their understanding of the Award's relative impact on different concepts. This step was crucial for addressing RQ3 by positioning the Award within the broader system dynamics rather than treating it as an isolated intervention.

3.6.3.3 Practitioner feedback on the aggregated model

The final step in knowledge collection involved soliciting feedback from practitioners on the aggregated model via email. Because post-processing, calibration, and initial analysis were conducted independently of stakeholders following the interview stage (detailed in Section 3.7), practitioners were given the last word on if their individual contributions had been sufficiently integrated into the collective model (Jetter and Kok, 2014; Barbrook-Johnson and Penn, 2022).

To make the model as accessible as possible for review, I developed an interactive version using the online mapping platform Kumu.io that practitioners could explore at their convenience (Kumu.io, n.d.). This digital format allowed users to select specific concepts and relationships to read detailed definitions and trace causal logic, avoiding the potential overwhelm of a one-dimensional network diagram (Olazabal et al., 2018). I provided guiding questions to help practitioners evaluate different aspects of the model: whether concept definitions resonated with their understanding, if relationship explanations seemed reasonable, whether arrow thickness accurately reflected relationship strength, and if any pivotal elements remained absent. A screenshot of the interactive online version of the model as well as the full URL link is provided in Appendix 5.

3.6.4 Processing and aggregating data

This subsection addresses the systematic processing of stakeholder-generated data, a critical yet often under-documented aspect of FCM development (Olazabal et al., 2018). The goal was to create a model that adequately represents practitioner views while maintaining parsimony and enabling robust analysis to address my research questions. More than a technical step, processing involved numerous decisions by myself to ensure that the model adequately represents the views of practitioners while being appropriately parameterised to address the study's research questions. This can be a challenging balance to strike as excessive processing risks distorting the authentic stakeholder perspectives that give the model its validity and legitimacy (Voinov et al., 2016). My approach navigated this tension through the documentation of key processing decisions, grounding choices in practitioner transcripts and seeking validation with practitioners throughout the process (Olazabal et al., 2018; Jetter and Kok, 2014). Once again, I consider the model to have been ‘co-developed’ between practitioners who contribute their knowledge and myself as the modeller (Jetter and Kok, 2014).

Each knowledge collection phase generated a mix of heterogeneous data in need of processing. The workshop produced predominantly qualitative data including 87 written variables from sticky notes and the pre-workshop online list, 4 hand-drawn systems maps capturing causal relationships, and 2 'listener' reports. The interview phase generated semi-quantitative data including weighted relationship matrices from 12 practitioners, 90 minutes of transcripts per interview documenting reasoning behind weights and structural modifications, and systematic feedback on age-related variations and John Muir Award positioning.

This heterogeneous dataset required two processing phases: qualitative aggregation involved harmonising concepts and relationships into a coherent system representation, and quantitative aggregation and calibration involved averaging numerical weights and optimising model sensitivity to support plausible model behaviour and later analysis (Jetter and Kok, 2014). Both phases involved multiple iterative cycles.

3.6.4.1 Qualitative aggregation

Qualitative aggregation seeks to combine diverse practitioners' perspectives and terminology into a coherent representation of the system they described. Aggregation decisions ranged from straightforward data cleaning to more nuanced interpretive choices requiring engagement with practitioner transcripts and nature connectedness literature. While I cannot detail every decision made, this subsection offers examples of different instances of qualitative aggregation to demonstrate the systematic approach taken. Following Olazabal et al. (2018) recommendations, I created a 'workbench' diagram tracking the evolution of concepts throughout the study; each stage is demarcated, highlighting instances when concepts were added, rephrased, combined, or removed from the map. The workbench is provided in Appendix 3.

Over the course of the workshop and interviews, many concepts proved redundant, poorly defined, deviated from FCM methodology, and/or fell outside the scope of the study (Jetter and Kok, 2014; Olazabal et al., 2018). Many of my processing decisions thus involved consolidating conceptually related but distinct factors for model parsimony while preserving essential meaning. For example, the concept *time outdoors* was introduced during the workshop but became redundant following interviews because it was better covered by the more descriptive concepts of c*hild-led outdoor play* and *guided nature engagement* Likewise, practitioners proposed numerous concepts pertaining to physical access to nature, including *accessible travel*, *proximity to child-friendly nature*, quality local green infrastructure, and *green school grounds*. While distinct, these were consolidated under the overarching concept of *access to quality local natural spaces*.

Some concepts proposed were removed for being too vague to be given an explicit causal logic. For example, practitioners initially proposed *physical and mental disability* as a concept influencing children's access and time spent outdoors. However, individual disability types are wide-ranging and may create vastly different relationships with nature, some serving as barriers, others as facilitators. Moreover, making such a concept more specific would have required identifying causal relationships between individual attributes, which falls outside the model's intended scope and practitioner expertise.

Other concepts required removal or rescoping as they operated at scales beyond the model's intended boundaries, as detailed in section 3.6.1. *Government influence* and *enabling policy*, for example, were proposed by practitioners concerned about the far-reaching impacts of Scottish government support for outdoor learning. However, these operate at national and regional policy levels and were deemed to be too removed from children's daily experiences. Over the course of interviews, practitioners helped identify more proximate mediating concepts that translated these macro-level influences into factors more directly experienced by children and young people. Through this collaborative refinement process, these concepts were eventually rescoped to the driver *unsupportive organisation culture*, focusing on the institutional level where policy impacts are most immediately felt in schools and youth organisations. Some practitioners also proposed *employment and training opportunities* and *accessibility of green jobs/skills* as influencing lasting nature connectedness. While conceptually relevant for long-term career pathways, these operate on timelines extending well beyond adolescence and were therefore outside the model's temporal scope.

In some cases, concepts and relationships were proposed that were incompatible with the standard FCM functionality and thus introduced logical inconsistencies, such as conditional relationships (Jetter and Kok, 2014). For example, practitioners identified *child independence* as influencing the extent to which an individual may engage in *child-led outdoor play*. However, this relationship was contingent on whether a child desires outdoor engagement over other activities. Increased independence might equally lead to more indoor activities, depending on individual preferences. This concept was removed since the FCM cannot accommodate concepts with conflicting relationships.

Some qualitative aggregation decisions required deeper investigation when practitioners appeared to disagree. For example, during interviews practitioners seemed to conflict about whether *bad weather* constituted a universal barrier to nature connectedness in Scotland or was too subjective to include in the model.

Rather than arbitrarily choosing one perspective, I reviewed interview transcripts to understand practitioners' underlying reasoning. I found practitioners to be implicitly distinguishing between physical conditions (objective barriers) and individual perceptions of those conditions (subjective barriers). I then reviewed other concepts that had been removed from the model for being labelled as individual attributes, such as *feeling safe in nature* or *sense of quality of nature*. These seemingly individual concepts could be reframed as shared subjective perceptions that vary between individuals but also represent common community-level barriers that influence how people interpret their local environment. Rather than removing these concepts entirely or inappropriately consolidating them under physical access, I created the new concept of *perceived access to quality local natural space* to capture how subjective interpretations of safety, quality, and belonging influence nature connectedness. This distinction was presented to practitioners for validation at the feedback stage (section 3.6.3.3).

3.6.4.2 Quantitative aggregation

While qualitative aggregation created a shared conceptual map (presented in Chapter 4, Section 4.2) the visual representation alone would not support the analysis needed to identify leverage points or test intervention scenarios, answering RQ1 and RQ2 (Barbrook-Johnson and Penn, 2022). I conducted quantitative aggregation to combine the relationships weights that individual practitioners assigned throughout the interview stage of knowledge collection. The average of these weights thus represented shared knowledge across the Scottish outdoor learning community (Gray et al., 2015).

FCM literature presents several approaches to combining individual weights, each with distinct implications. Knox et al. (2023), for instance, demonstrate expertise-based aggregation, where participants are grouped by professional background before maps are combined within and across groups. Alternatively, cognitive diversity approaches group participants based on mental model similarity rather than professional identity. Both methods can reveal important stakeholder differences but require larger sample sizes and sophisticated clustering techniques (Knox et al., 2023).

For this study, I conducted simple mathematical averaging, treating each practitioner's knowledge as equally valid regardless of expertise differences (Özesmi and Özesmi, 2004; Gray et al., 2015; Edwards and Kok, 2021). This decision served my research objectives in that my goal was to develop a single aggregated model representing collective understanding rather than comparing different stakeholder perspectives. Moreover, while the Scottish outdoor learning community spans diverse professional backgrounds, there was not a clear hierarchy in practitioner expertise, making artificial divisions inappropriate.

During individual interviews, each practitioner assigned numerical weights (from -10 to +10) to the relationships in the qualitatively aggregated map, indicating their perceived strength of each causal connection. For the quantitative aggregation, I calculated the average weight for each relationship across all practitioners who provided a weight for that connection. This simple averaging approach meant that even where practitioners disagreed about relationship strength, the final weight represented the mathematical mean of their individual judgements, preserving diverse perspectives while representing a ‘shared understanding’ (Gray et al., 2015).

3.6.5 Model calibration and sensitivity testing

Calibration is the process of fine-tuning the FCM to ensure it behaves in ways that align with practitioner understanding while remaining suitable for the analytical objectives of this study. This involves choosing activation functions, running simulations to test the model’s sensitivity to simple changes and adjusting model structure to achieve stable, interpretable outputs (Barbrook-Johnson and Penn, 2023). The topic of calibrating and optimising FCM behaviour to better match ‘real-world’ observations has been explored at great length. For more comprehensive coverage of advanced activation functions, learning algorithms, and convergence optimization, see Jiya et al. (2023), Nápoles and Giabbanelli (2024), and Felix et al. (2019).

Calibrating FCM models is challenging, particularly without empirical benchmarks (Jetter and Kok, 2014). As recommended by Jetter and Kok (2014), my calibration approach focused on making the model transparent to stakeholders and facilitating discussions about how model behaviour aligns with practitioner expectations of how the system should respond under different conditions. In this subsection, I focus on detailing the essential calibration decisions made and why they were appropriate for this study's objectives.

3.6.5.1 Selecting FCM software and an activation function

Two interrelated calibration decisions involved selecting the activation function and appropriate software tools. The activation function (aka transfer function) is the mathematical algorithm that updates concept values across iterations of a simulation until the model reaches steady, interpretable state (Felix et al., 2019). The choice of function can greatly impact model behaviour during the running of scenarios, making it essential to understand the available options and their implications for my research context (Penn et al., 2013).

The FCM literature identifies four main activation functions: bivalent, trivalent, hyperbolic tangent, and sigmoid functions (Bueno and Salmeron, 2009; Nápoles and Giabbanelli, 2024). The bivalent and trivalent functions are attractive as the most computationally simple options; concepts are activated into 2 or 3 discrete states. However, these were not fitting for my study as I required functions that could represent the subtle, gradual changes that characterise how children develop relationships with nature over time. For instance, a child's nature connectedness cannot be realistically described as simply "on, off, or neutral" but is understood by practitioners to exist on a spectrum.

This left two viable candidates: hyperbolic tangent and sigmoid functions. Both are continuous functions capable of modelling complex, non-linear relationships, but they differ in important ways. The hyperbolic tangent function produces outputs within a range from -1 to +1, allowing concepts to take negative values. While this can be useful for some systems, it presented interpretive challenges for many concepts in my model. For instance, a negative value for the concept 'Access to Quality Local Natural Spaces' could lead to confusion because individuals can either have some degree of access or no access at all. A negative value for such a concept does not have a real-world equivalent (Penn et al., 2013).

The sigmoid function, in contrast, constrains concept values above zero, matching the nature of most concepts in my model where absence is represented by zero rather than negative values (Nápoles and Giabbanelli, 2024). The trade-off is that sigmoid functions typically require more iterations to reach stability and tend to produce outputs with moderate values rather than extreme positions (Bueno and Salmeron, 2009). While the hyperbolic tangent function might have highlighted the potential for dramatic system changes, I selected the sigmoid function because it aligned closer with my system boundaries where most concepts represent gradual developmental processes rather than immediate outcomes.

The testing of the various activation functions was enabled by FCM software. This iterative testing helped to make informed decisions about which outcomes would be easiest to analyse and to interpret. I employed both Mental Modeler (Gray, n.d.) and FCM Expert (Nápoles et al., 2018), capitalising on their complementary strengths. Mental Modeler's web-based interface was valuable for quickly visualising and calculating basic structural statistics about each model iteration (described in the section 3.8 on static analysis). FCM Expert required a steeper learning curve but provided greater flexibility for calibration and simulations, including the ability to test multiple activation functions and examine model behaviour across multiple iterations (Felix et al., 2019). This software-enabled experimentation ultimately confirmed that the sigmoid function produced the most interpretable and stable results for my research purposes. For a more comprehensive review of FCM software options, see Felix et al. (2019).

3.6.5.2 Sensitivity analysis and adjustments

Having selected the sigmoid function and FCM software, I calibrated the model by conducting a sensitivity analysis, iteratively testing how changes to individual concepts or relationships affect overall system behaviour. I then could make informed adjustments to the model structure and weights to counter any illogical or extreme outcomes (Barbrook-Johnson and Penn, 2022). This process is important for FCMs because the interconnected nature of concepts means that small adjustments can propagate throughout the system in unexpected ways, potentially producing outcomes that contradict stakeholder knowledge or common sense.

My calibration approach used two complementary methods to understand system behaviour and to identify structural issues requiring adjustment. First, I slowly rebuilt the model, starting with the most central concepts (identification of these concepts is detailed in the static analysis section), and progressively adding concepts and relationships while running simulations at each stage (Jetter and Kok, 2014). This process revealed how each addition changed model outcomes, allowing me to identify unexpected, extreme, or illogical results and trace them back to specific concepts or relationships that needed adjustment.

For example, the concept *carer affinity for nature* was initially modelled as a driver, meaning it only influenced other concepts but was not influenced by them. This was based on practitioners' explanations that parents and carers draw from their own prior experiences with nature to determine their affinity, making it seem like a relatively stable, self-reinforcing trait. However, when this concept was added to the model it produced dramatically unrealistic improvements in nature connectedness—more than doubling the impact of adding non-driver concepts like *leader confidence and motivation to deliver outdoor learning*. This prompted a review of practitioner transcripts which clarified that while carers' past experiences do shape their current attitudes, their affinity can still evolve based on new information and experiences. The relative stability of carer attitudes was thus better captured through the strength of relationship weights rather than making the concept completely unchangeable. Changing c*arer affinity for nature* from a driver to an ordinary concept produced much more realistic outcomes.

The second calibration approach involved extreme conditions testing, which involved dramatically increasing or decreasing the activation values of key driver concepts to see if the model responds predictably. For example, when I boosted *disabling community norms* to its maximum activation value of +1 (representing very strong negative community attitudes toward nature-based activities), I expected to see a corresponding decrease in nature connectedness levels. However, the model showed no negative impact, which was illogical and contradicted practitioner descriptions of how community resistance can undermine children's relationships with nature. This unexpected result revealed that the model had developed a positive bias because practitioners had predominantly described factors that increase nature connectedness, with fewer explicit pathways for decreases. To address this, I added the concept *negative outdoor experiences* to ensure the model could simulate reductions in connectedness. This addition was grounded in practitioner interviews where they had noted various factors that directly decrease connectedness (feeling unsafe outdoors, physical discomfort, and injury).

Additional adjustments involved modifying relationship weights when outcomes appeared unbalanced or when certain concepts dominated system behaviour disproportionately. However, I constrained these adjustments to increments of 0.1 to preserve the relative strength of relationships as expressed through practitioners' averaged assessments. For instance, if practitioners had collectively rated a relationship as “strong” (0.8), I might adjust it to 0.7 or 0.9 based on sensitivity testing, but never to 0.3, which would dramatically alter its character and importance within the system (Jetter and Kok et al., 2014).

The goal of this calibration was not to create a perfect model but to smooth out obvious illogical behaviours that would compromise more nuanced analysis and interpretation. The iterative process of testing, identifying issues, making targeted adjustments, and retesting continued until the model behaved in an understandable and consistent manner (Jetter and Kok et al., 2014). The result is a calibrated model ready for the static and dynamic analyses needed to address my research questions, while remaining open to further discussion and refinement based on stakeholder feedback and analytical insights, which I detail in Chapters 4 and 5.

3.7 Model statistics and static analysis

With the FCM calibrated, I now detail the specific calculations and metrics used to conduct static analysis and address RQ1 and RQ2. Static analysis examines the structure and properties of the FCM without running dynamic simulations, providing insights into the relative importance and roles of different concepts within the system as understood by participating stakeholders (Schuerkamp and Giabbanelli, 2024).

3.7.1 Basic model statistics

Static analysis begins with calculating descriptive statistics about the FCM's structure, offering immediate insights into practitioners' shared understanding and priorities. In this study, the aggregated and calibrated FCM was input into the software Mental Modeler to calculate the following metrics (Gray, n.d., Knox et al., 2023):

- Total Concepts: the number of distinct concepts (nodes) in the model
- Total Connections: the number of relationships (arrows) between concepts
- Connections per Concept: the average number of relationships each concept has
- Driver Concepts: those with only outgoing connections

- Receiver Concepts: those with only incoming connections
- Ordinary Concepts: those with both incoming and outgoing connections
- Density: the proportion of actual connections relative to all possible connections in the model

Most of these metrics are straightforward to calculate and understand. I present this study's results and their implications in Chapter 4. However, the density score warrants further explanation as its interpretation depends on the study's objectives. Density measures how close the FCM is to being a complete graph where every concept connects to every other concept, calculated as the number of actual relationships divided by the total number of possible relationships (Gray et al., 2013, 2015).

For some FCM studies, low density might be undesirable, suggesting the model is missing important relationships (Nápoles and Giabbanelli, 2024). FCMs built from historical data, for example, typically require high density to produce accurate predictions. For my study, however, relatively low density is preferred because it indicates that practitioners were selective in identifying relationships, suggesting a focused representation of the system (Schuerkamp and Giabbanelli, 2024). My objective is to capture practitioners' shared understanding of the most salient factors and interrelationships shaping nature connectedness (see RQ1 and RQ2), rather than attempting to model every possible relationship. This prioritisation of developing a parsimonious model also makes it easier to identify areas needing further modification and discussion following static and dynamic analysis (Jetter and Kok, 2014).

3.7.2 Centrality analysis and leverage point identification

The intent behind RQ2 is to move beyond merely listing the concepts that practitioners understand to shape nature connectedness by identifying each concept's relative role and influence within the system. Centrality measures are calculated in FCM studies to rank system concepts by their relative importance, though each of the various measures available defines importance differently (Caldarelli and Catanzaro, 2012; Schuerkamp and Giabbanelli, 2024).

For this study, I selected degree centrality as the primary measure for identifying the most important concepts. Degree centrality quantifies each concept's importance based on the combined weights of its direct connections to other concepts. This was calculated in Mental Modeler by summing the absolute values of both incoming and outgoing relationship weights, ignoring positive and negative signs (Kosko, 1986). For example, a concept with one incoming arrow weighted 0.7 and two outgoing arrows weighted 0.3 and -0.8 will have a centrality score of 1.8 (0.7 + 0.3 + 0.8). Concepts with high degree centrality are highly active within their immediate neighbourhood, meaning they are directly involved in several strong relationships and changes to their values can propagate to many other concepts through direct connections (Schuerkamp and Giabbanelli, 2024).

My choice of degree centrality was driven by three considerations. First, degree centrality is straightforward to calculate and to interpret, avoiding complex assumptions about information flow patterns within the network that might not align with how practitioners understand the system to operate. Second, given that my FCM is likely to have a low density and concepts will have relatively few direct connections, degree centrality is sufficient for identifying concepts with the strongest overall influence, considering both the number and strength of their relationships. Third, degree centrality provides a practical starting point for understanding which concepts are most active within the system, though this activity does not automatically translate to being optimal intervention targets as discussed further in Chapter 5.

The FCM literature offers several alternative centrality measures that define importance differently and were considered for complementary insights. Betweenness centrality identifies concepts critical for spreading effects between different parts of the system by measuring how often they appear on the shortest paths between other concepts. Closeness centrality determines concepts that can most efficiently reach all other concepts in the system. Eigenvector centrality takes a recursive approach where a concept's importance depends on the importance of the concepts connected to it, potentially revealing concepts that are influential because they connect to other influential concepts (Schuerkamp and Giabbanelli, 2024). For this study's objectives and given the model's sparse structure, these additional measures were deemed unnecessary for the initial analysis. However, future research, as I note in Chapter 5, could benefit from incorporating multiple centrality measures to provide a more comprehensive understanding of concept importance and leverage points.

3.8 Dynamic simulation methods

Static analysis alone can meet many study objectives, and some FCM studies conclude their investigation at this stage (Edwards and Kok, 2021; Barbrook-Johnson and Penn, 2022; Chiang et al., 2024). However, this study is particularly interested in exploring the impact of a specific intervention, the John Muir Award, on the wider system. Dynamic analysis through scenario simulation enables exploration of how the Award might influence nature connectedness development under different system conditions, directly addressing RQ3.

3.8.1 Scenario design and implementation

While FCM models can potentially simulate countless scenarios, this study's capacity was constrained by time and resources (Kok, 2009; Jetter and Kok, 2014). Rather than attempting comprehensive scenario coverage, I focused on demonstrating the model's functionality while generating sufficient insights to adequately address RQ3. Given these constraints, I made the pragmatic decision to design scenarios through a collaborative workshop with John Muir Trust staff, ensuring that the limited number of scenarios would be directly relevant to the Award's present-day priorities and reflect common participant demographics that staff encounter regularly.

This collaborative approach served dual purposes: it maximised the practical value of the research for Award practitioners while ensuring scenarios were grounded in real-world experience rather than purely theoretical possibilities. Scenarios were thus designed according to three key criteria: compatibility with FCM parameters and level of abstraction, reflection of plausible real-world conditions faced by Award participants, and relevance to John Muir Trust staff interests and mission priorities.

The scenario design workshop involved leading 4 Trust staff members through the aggregated FCM's causal logic and the principles of FCM scenarios. Since the model was designed as a generalised representation of the system shaping nature connectedness among Scottish children and young people, scenarios provided an opportunity to prime the model to reflect conditions faced by more specific demographics while maintaining the model's broader applicability. I then facilitated discussion about which demographics (including age groups) on which to focus on and how to translate their understanding of different participant contexts into appropriate model conditions.

3.8.2 Translating Scenarios into simulation conditions

Once the workshop identified plausible scenarios of high interest that aligned with both research objectives and practical constraints, I translated these conceptual scenarios into specific modelling conditions (Kokkinos et al., 2018; Jetter and Kok, 2014). Using FCM Expert software, I set initial conditions for each scenario by ‘clamping’ driver concepts, which means fixing their activation levels at specific values to reflect the system conditions being explored (Nápoles et al., 2018, Kok, 2009). Clamping is necessary because it allows me to draw controlled comparisons between scenario outcomes. For example, clamping the driver *disabling community norms* at a value of 0.8 means I'm holding certain system conditions constant, specifically a system characterised by strong community attitudes that impede nature connectedness development.

Once drivers were clamped to reflect the system conditions of interest, I ran simulations to establish baseline steady state scenarios. A steady state in FCM refers to the point where concept values no longer change with successive iterations (Carvalho, 2013). Given the absence of comprehensive empirical data that could definitively establish the real-world state of concepts in the model, the baseline approach was used to isolate the John Muir Award's impact as understood by practitioners (Kok, 2009; Kokkinos et al., 2018). First, drivers were clamped to reflect specific system conditions and an initial simulation was run to establish the baseline outcome. Next, the same drivers were clamped at identical values, but this time the John Muir Award was introduced to the model as a new concept along with its direct influences (as described by practitioners during interviews). The difference between these two outcomes highlighted the impact the Award has in that specific context, without the results being muddied by changing background conditions.

This process is repeated across different conditions, clamping drivers at different activation values, to enable further comparison and analysis. I assessed scenario outcomes by examining the steady-state activation values reached by all concepts after each simulation and examined both absolute differences in activation values and relative changes (Özesmi and Özesmi, 2004). As I detail in Chapter 4, this approach enabled meaningful comparison of the Award's effectiveness across different educational contexts, age groups, and system conditions.

Similar approaches have been used by Özesmi and Özesmi (2004), Penn et al. (2013), and Kok (2009) to compare current situations against potential outcomes of new ecological policies or interventions, demonstrating the established precedent for this analytical strategy. Kok (2009), for instance, uses this approach to explore Amazon deforestation policies, comparing a baseline scenario against potential interventions, such as restricting agricultural exports and limiting infrastructure expansion.

3.9 Chapter summary

This chapter has documented the methodological decisions that led from the theoretical positioning established in Chapter 2 to a concrete research design and method for addressing my three research questions. While no methodological approach can fully capture the complexity of how nature connectedness develops, the comparison of computational simulation and participatory systems mapping methods marked FCM as a suitable and pragmatic choice for operationalising complex system principles to meet this study's research objectives, available data, and practical constraints. My choice and application of FCM prioritises eliciting the knowledge of 17 practitioners while accepting that the resulting model is necessarily simplified and partial.

This chapter has detailed how I reached three analytical outputs corresponding to my research questions: the aggregated FCM as a visual representation of the complex system shaping nature connectedness (RQ1), static analysis for identifying central concepts (RQ2), and dynamic simulations for exploring the John Muir Award's impacts under different system conditions (RQ3). Chapter 4 presents the results of applying this methodological framework, showing what novel insights can be produced while remaining mindful of the method's inherent limitations.

Chapter 4 Results

4.1 Chapter overview

The previous chapter details the development of an FCM designed to funnel practitioners' initially broad and fragmented perspectives into a parsimonious and aggregated model. This chapter presents the resulting aggregated model and its use case for each of my study's research questions. While no complex systems model is ever truly complete, the results presented in this chapter serve as a proof of concept and demonstrate how the FCM development, structural analysis, and simulations offer novel insights for all three of my research questions. I structure this chapter to progressively address each of my three research questions (RQ1, RQ2, and RQ3):

> *RQ1: According to outdoor learning practitioners, what is the complex system shaping Scottish children and young people's lasting nature connectedness?*
>
> *RQ2: What concepts do practitioners consider most important for shaping nature connectedness and may serve as strategic leverage points?*
>
> *RQ3: How can we simulate the system to explore the lasting impact of the John Muir Award under different plausible scenarios?*

Starting with RQ1, I provide a general overview of the aggregated FCM (Section 4.2), which captures outdoor learning practitioners shared understanding of the complex system shaping children and young people's nature connectedness in Scotland. Following a short recap of the FCM's intended scope and boundaries, I present the label and definition of each concept that practitioners iteratively selected for the aggregated model (Section 4.2.2). This is to ensure the clarity and consistent interpretation of the FCM moving forward. In Section 4.2.3, I present a full visualisation of the aggregated model (Figure 3) along with its general statistics (Table 3), including the FCM's total concepts, total relationships, density, number of drivers, receivers, and ordinary concepts. I define and present the relevance of these statistics for answering RQ1. RQ1 seeks to investigate the development of nature connectedness for two age groups: children (ages 8-11) and young people (ages 12-15). Section 4.2.4 presents practitioners' insights on how the influence of various factors changes between these age groups. These insights are captured by creating two variations of the FCM, illustrating a generalised shift in the relative importance of specific concepts as children mature into adolescence. In Section 4.2.5, I highlight the concepts which practitioners identified as having a direct impact on nature connectedness (child-led outdoor play, guided nature engagement, and negative outdoor experiences). I briefly summarise the underpinning reasoning behind these notable features with references to supporting literature.

RQ2 is addressed by analysing the structure of the aggregated FCM to identify which concepts, according to the contributing practitioners, are most important and may serve as strategic leverage points to bring about desired changes (Kok, 2009). In Section 4.3, I calculate the degree centrality score for each concept (subsection 4.3.1). I then present the rankings of concepts based on their centrality (subsection 4.3.2), providing detailed interpretations of the five most important ordinary concepts and highlight the significance of key driver concepts (C3). Throughout this analysis, I identify notable changes in concept importance as children age into adolescence, offering insights into how the system's dynamics shift across different age groups. Particular attention is given to concepts that emerge as potential leverage points for interventions like the Award, setting the stage for the dynamic analysis in Section 4.4.

To address RQ3, which seeks to explore the Award's lasting impact under various plausible scenarios, I employ FCM's dynamic simulation capabilities. Subsection 4.4. begins by presenting practitioners' views on how the Award fits within the complex system, identifying the concepts it directly impacts and translating these insights into FCM components (subsection 4.4.1). I then detail the process of designing plausible scenarios in collaboration with John Muir Trust staff, reiterating the criteria used and the progression of simulations conducted (subsection 4.4.2). The results of these simulations are presented and analysed in subsection 4.4.3, structured around three broad patterns that emerged: the Award's impact across different school settings, age group differences, and persistent barriers to nature connectedness. This analysis is supplemented by additional scenarios exploring potential enhancements to the Award (subsection

4.4.4) and the effects of decreasing disabling community norms (subsection 4.4.5). Throughout this dynamic analysis, I connect simulation outcomes back to the FCM structure, making explicit the consequences of practitioners' causal reasoning to transition into a deeper discussion in Chapter 5.

4.2 Overview of the aggregated FCM

As detailed in Chapter 3, the FCM is intended to capture practitioner views on the sustained influences that shape nature connectedness over time. It operates at a local, meso-level of abstraction, capturing recurring experiences and relationships that outdoor learning practitioners consider most influential in shaping children's nature connectedness. While the model is not intended to represent a specific timeframe, it aims to reflect the cumulative impact of factors over the course of childhood (ages 8-11) and adolescence (ages 12-15). This approach facilitates the exploration of how nature connectedness is understood to develop during this formative period without extending into long-term predictions or highly individualised, short-term effects. Refer to Chapter 3, subsection 3.6.1 for more details on model boundaries.

While setting clear boundaries involves deliberately excluding some factors, it allows for a clearly defined focus and enhances the model's interpretability (Kok, 2009). The model’s limitations are intentional and contribute to its utility as a thinking tool (Jetter and Kok, 2014). Setting these model parameters directed the researcher and seventeen outdoor learning practitioners in developing a parsimonious and aggregated FCM. The following subsections introduce the model's key concepts and definitions, present its overall structure and statistics, examine how practitioners understood developmental differences between age groups, and highlight the concepts they identified as having direct impact on nature connectedness itself.

4.2.1 Key concepts and definitions

The final aggregated FCM (Figure 4) represents outdoor learning practitioners' shared understanding of the complex system shaping nature connectedness in Scottish children and young people. To answer RQ1, I begin by presenting what practitioners identified as the key and generalised antecedents for shaping nature connectedness. The aggregated FCM is composed of 15 key concepts (Table 2). These concepts were iteratively selected and agreed upon by practitioners throughout the knowledge capture stages of the FCM process as described in the previous chapter (group workshop, interviews, and literature review) and lastly submitted to the practitioners for feedback and approval.

To facilitate clarity and consistency in the interpretation of the model, Table 2 presents each concept's label and definition. I have also included precursory concept labels that were mentioned by practitioners throughout the FCM process to give the reader a sense of each concept's qualitative history (Edwards and Kok, 2021). Concepts are listed in alphabetical order and assigned concept abbreviations (C1-C15). Each concept is defined as a variable, capable of increasing or decreasing in some way. Note that the following labels and definitions are not intended to replace or challenge existing or similar terminology from the wider literature but to articulate practitioner views as accurately and clearly as possible (Olazabal et al., 2018; Jetter and Kok, 2014).

Table 2. FCM concepts labels and definitions

Precursory Concept Labels	**Generalised Concept Label**	**Concept Definition**
Proximity to natural spaces; Availability of outdoor clothing/equipment; Physical health; Mental health; Affordability of transport to natural spaces; Financial resources; Safety of transport to natural spaces; Opportunity for positive nature experiences; Accessibility of green jobs/skills; Employment and training opportunities for underrepresented communities in the sector; Structural barriers/ opportunities for ethnic minorities; Lack of places to connect with nature; Proximity to high quality (high biodiverse) natural/wild spaces; Existing health and wellbeing barriers; Close proximity to child-friendly nature; Biodiversity; Lack of natural places; Affluence of family; Urbanisation; Green/Outdoor infrastructure; Quality local green outdoor infrastructure; Access to child-friendly nature	Access to quality local natural space (C1)	The extent and ease with which a child or young person is objectively able to interact with natural environments/wild spaces. This includes access to practical resources like safe and convenient transportation options, the proper outdoor gear and attire to participate in outdoor activities, and financial support or sponsorships that make such experiences more attainable.
Time spent in nature; Frequency of positive experiences in nature; Encouragement of outdoor play/creativity; Adventure experiences in nature; Outdoor play in early years; Non-directed outdoor play; Experiences with animals, pets, wildlife;	Child-led outdoor play (C2)	The extent to which a child or young person engages in unstructured and/or spontaneous activities that are self-directed, whether alone or with

Enjoyment/fun being outdoors; Leisure time; Pleasure in nature; Child independence; Contact with nature; Sensory contact with nature; Self-led nature education		adults/peers, in outdoor environments, allowing them to explore, interact with, and learn from the natural world around them.
Faith-led appreciation for nature; Cultural storytelling; Cultural representation of nature; Media (popular culture, TV); Egocentric societal values; Pro-nature social norms; Materialistic values	Disabling community norms (C3)	The extent to which the social or cultural expectations within a local community discourage or devalue interactions with the natural environment because of (but not limited to) safety concerns, a high emphasis on technological or indoor leisure activities, exclusionary biases, or indifference to environmental matters.
Opportunity to attend an outdoor residential; Participation in youth work; Environmental volunteer opportunities; Outdoor experiences as part of the Curriculum; Clubs/activities in nature; Experiences with animals, pets, wildlife; Time spent outdoors with family/significant others; Contact with nature; School experiences; Experience with nature with a significant adult as a young child; Supervised outdoor play; Carer leisure time; Formal supervised experiences;	Guided nature engagement (C4)	The extent to which a child or young person participates in structured outdoor experiences supervised by adults (parents, educators, leaders) that are designed to enrich children's understanding and appreciation of nature through direct instruction or guided discovery.
Relatable role models; Training of teachers; Educator training; Educator time; Educator confidence; Educator time/capacity/motivation	Leader confidence and motivation to deliver outdoor learning (C5)	The extent to which a teacher or youth leader has an intrinsic belief and enthusiasm regarding their ability to effectively deliver and integrate outdoor learning into their curriculum/activities.
Empathy for nature; Emotional responses to nature; Values aligned to nature; Emotional connection; Meaning making; Care for nature; Knowledge of natural world; Affinity for nature; Perceived utility of nature; Pleasure/fun in nature; Emotional knowledge of nature; Mindfulness in nature; Noticing nature; Nature literacy	Nature connectedness (C6)	An individual's sense of their relationship with the natural world, reflecting how children/young people think about, feel about and relate to nature.
Discomfort in nature; Feeling unsafe	Negative outdoor experiences (C7)	Experiences outdoors that cause or reinforce a child or young person’s feelings of discomfort, fear, disgust, and/or apathy towards the natural world.
Parental respect for nature; Guardian respect for nature; Pro-nature philosophy; Carer Respect for nature; Carer confidence in nature; Carer nature connectedness; Sibling nature connectedness	Parent/carer affinity for nature (C8)	The degree of interest, enthusiasm, and emotional connection that parents or caregivers demonstrate towards natural spaces. This concept encompasses their appreciation for

		outdoor activities, value placed on the benefits of nature for well-being, and the desire to engage with and protect natural spaces.
Nature adverse family; Carer resilience to threats; "Bad" weather	Parent/carer aversion to nature-related threats (C9)	The extent to which parents or caregivers perceive and react negatively to potential risks associated with natural spaces, such as wildlife encounters, strangers, injuries, or poor weather. This aversion influences their willingness to engage with and support outdoor activities and experiences, potentially limiting their own and their children's opportunities to connect with nature.
Shared value of nature among peers; Outdoor play with peers; Time spent outdoors with family/significant others; Time in nature with peers; Peer nature connectedness; Group nature identity; Sibling nature connectedness	Peer affinity for nature (C10)	The extent to which a child or young person’s friends and peers enjoy being in and value natural spaces.
Knowledge of the natural world; Perceived threat/risk level; Perceived ability to influence spaces; Feeling unsafe because of protected characteristics (gender, race, disability, sexuality, class); Individual personal world view; "Bad" weather; Sense of quality of nature; Feeling unsafe	Perceived access to quality local natural space (C11)	The extent to which a child or young person subjectively understands nearby natural spaces/wild places to be safe, enjoyable and appropriate for them to use.
Use of green spaces at/with school; Opportunity for positive nature experiences at school; Overemphasis on academic achievement; Pro-nature approach; Normalisation of pro-nature education	Perceived academic/outdoor learning divide (C12)	The extent to which outdoor learning is viewed as incompatible with and/or distracts from academic achievement goals.
Screen time/digital distraction; Fun experiences indoors; Time indoors	Screen time (C13)	The cumulative duration a child spends in front of digital screens. This does not include pro-nature digital exposure (see vicarious outdoor experiences), but screen time that is neutral to the natural world or even anti-nature.
Use of green spaces at/with school; Environmental volunteer opportunities; Opportunity for positive nature experiences; Outdoor experiences as part of the Curriculum; Government influence; Pro-nature school culture; Training of teachers; Pro-nature policy (shared national local/agendas); Enabling policy; Inclusive Policy; Senior management (policy/ethos)	Unsupportive organisation culture (C14)	The extent to which a youth work organisation or educational institution's ethos and management practices do not support or actively hinder the integration of outdoor learning into their programming and curriculum.

Watching nature documentaries; Creative methods of engagement for people with disabilities (poetry, dance, etc); Pro-Nature social media signposting; Pro-nature screen time; Media (popular culture TV); Pets/indoor plants; Positive indirect nature experiences; Nature at home (pets/plants); Pro-nature non-digital media (books, magazines)	Vicarious outdoor experiences (C15)	Second-hand interactions with the natural world. Such experiences might include watching nature documentaries, engaging with nature-based stories and art, and viewing nature through digital platforms.

4.2.2 Overview of the aggregated FCM and its general statistics

Figure 4 presents the aggregated Fuzzy Cognitive Map (FCM) resulting from the qualitative synthesis of practitioner knowledge, as detailed in Chapter 3. This network diagram visually represents the complex system shaping nature connectedness in Scottish children and young people as understood by the participating practitioners. As detailed in Chapter 3, Section 3.5, the FCM consists of nodes (circles) representing key concepts and arrows indicating the nature and direction of causal relationships between these concepts as understood by outdoor learning practitioners.

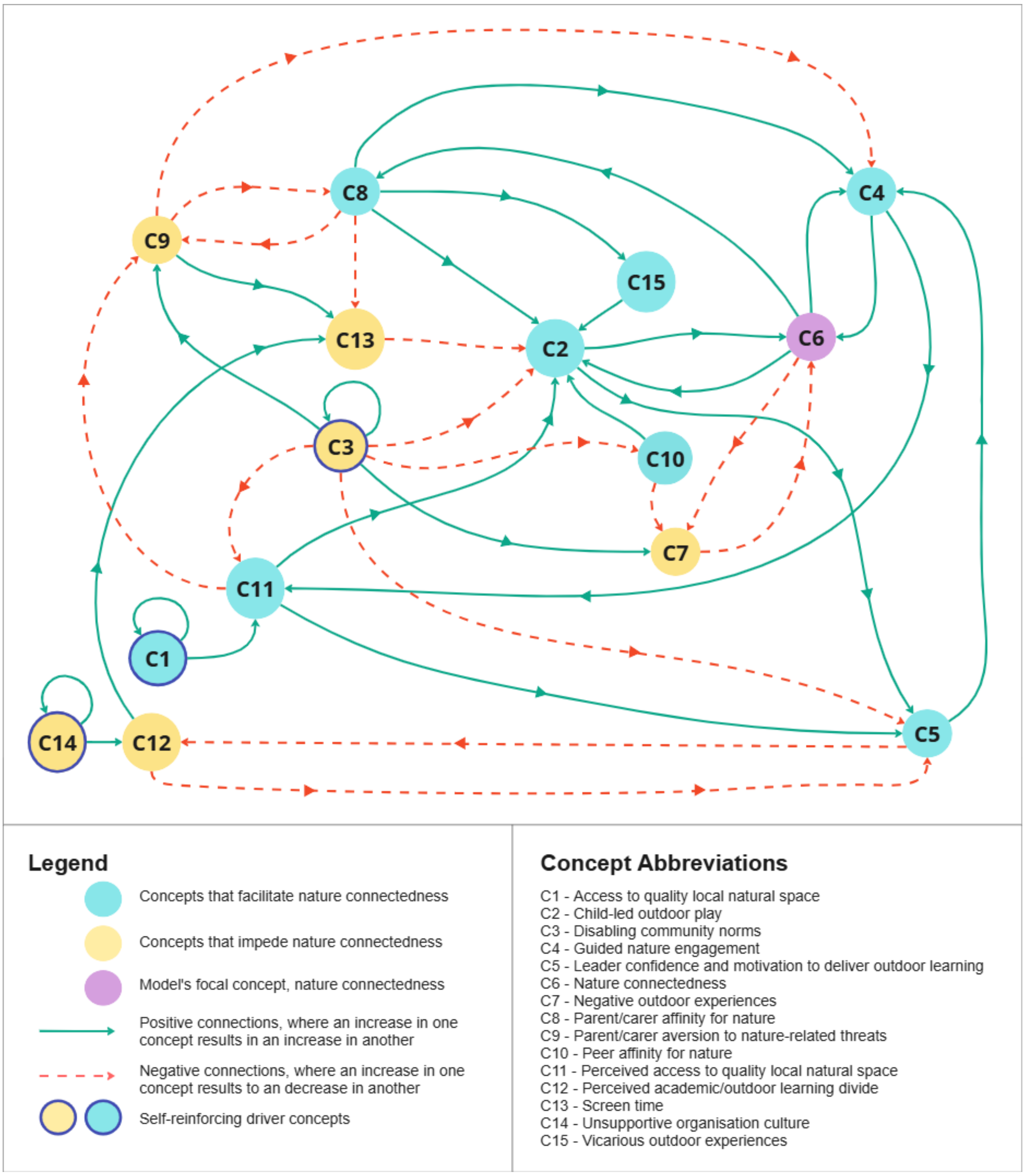

Figure 4. Aggregated map of the system shaping lasting nature connectedness in Scottish children and young people : This figure presents the aggregated Fuzzy Cognitive Map (FCM) representing 17 outdoor learning practitioners' shared understanding of the complex system shaping nature connectedness for Scottish children and young people. Fifteen circles represent concepts (C1-C15) within the system, while arrows represent causal relationships and their direction. The map is the culmination of the qualitative aggregation process described in Section 3.4.3.

Table 3 presents the aggregated model’s general statistics (described in Chapter 3, subsection 3.7.1), offering an initial snapshot of how practitioners conceptualise the development of lasting nature connectedness in Scottish children and young people.

Table 3. FCM general statistics

FCM Properties	Value
Total Concepts	15
Total Connections	38
Density	0.18
Connections per Concept	2.5
Number of Ordinary Concepts	12
Number of Driver Concepts	3
Number of Receiver Concepts	0

To fully appreciate the significance of these statistics in answering RQ1, I present the interpretation and applicability of each metric over the following three subsections (4.2.2, 4.2.3, and 4.2.4).

4.2.3 Ordinary and receiver concepts

The FCM presents nature connectedness to be the result of an interconnected system of 15 concepts and 38 causal relationships. 12 of the model’s total 15 concepts are ‘ordinary’, meaning they have both incoming and outgoing connections (Özesmi and Özesmi, 2004). This means that the majority of concepts were identified by practitioners as simultaneously exerting influence on and being influenced by other concepts (see section 4.2.1 for labels and definitions of each concept). Notably, the model does not have any ‘receiver’ concepts, which only have incoming connections (in-arrows) (Jetter and Kok, 2014).

4.2.4 Drivers

The aggregated FCM has three drivers: access to quality local natural space (C1), disabling community norms (C3), and unsupportive organisation culture (C14). Drivers are concepts that only have outgoing connections (out-arrows) (Knox et al., 2023). Practitioners identified these drivers as important factors influencing the wider system behaviour, but they are distinguished from the ordinary concepts in the model by their slower rate of change and relative stability.

Figure 5. System drivers with self-reinforcing relationships : This figure shows the three driver concepts from the aggregated FCM. Each oval represents a concept, with blue indicating concepts that facilitate nature connectedness and yellow indicating concepts that impede it. The circular green arrows represent self-reinforcing relationships, meaning these concepts have been modelled to maintain their own values and remain stable within the system.

Within the boundaries of this FCM (see section 4.2), the value of drivers, once assigned by the modeller, remain fixed because they are not influenced by any other concept in the map. In the real-world, these concepts may change over time, but generally at a slower pace than the ordinary concepts. This simplification of holding drivers at a steady value is necessary due to the model's focus on a narrow timescale and level of abstraction (Jetter and Kok, 2014). To maintain their value, they are modelled as 'self-reinforcing' (Figure 5). Drivers are thus an important area of analysis because they mark the edge of the model's scope and serve as stable starting points for exploring the more dynamic interactions between the ordinary concepts (Kok, 2009). I demonstrate the use of these drivers for initiating simulations and exploring system behaviour in Section 4.4.

4.2.5 Density

As detailed in Chapter 3, a FCM density score is a measure of how many connections exist in the map compared to the maximum possible connections between every concept (Özesmi and Özesmi, 2004). While indicative of a system with many meaningful interconnections, the model's density score of 0.18 suggests that the system is relatively sparse despite roughly 2.5 connections per concept. Since the objective of this model is not to be comprehensive, a low density is expected and even preferable, indicating that participants were selective in their choice of connections (Nápoles and Giabbanelli, 2024).

4.2.6 Perceived impact of aging

RQ1 focuses on identifying the complex system that shapes nature connectedness for two distinct age groups: children (ages 8-11) and young people (ages 12-15). Throughout the group workshop and interviews, practitioners noted significant differences in the factors influencing nature connectedness for children and young people, emphasising the need to capture these age-related distinctions in the FCM.

Because FCM is a static model and time steps during simulations do not correspond to real-world time, a single model was not sufficient to capture the system for both age groups (Jetter and Kok, 2014). This limitation, which is discussed further in Chapter 5, led to the development of two variations of the aggregated FCM that share the same concepts but have different relationship weights. By adjusting the weights of specific relationships, practitioners were able to represent their understanding of how the relative influence of various concepts may shift as children age into adolescence. The resulting two FCM variations provide valuable insights into the complex system shaping nature connectedness for children and young people, contributing to a more nuanced answer to RQ1.

During the interview stage of knowledge collection (see Chapter 3, subsection 3.6.3.2) practitioners identified five generalised themes regarding how the system shaping nature connectedness changes as children age into adolescence:

1. Increased independence (decreased parental influence): As children age, the influence of parents and carers on their outdoor experiences decreases. While younger children (8-11) largely rely on parental support, permission, and guidance, older children gain more autonomy for seeking out or avoiding nature-based activities.

2. Increased peer influence: Peer influence becomes more significant as children enter adolescence. They spend more time with friends and widen their social circles, which can impact their nature-related activities. The role of peers and other social influences grows in importance, potentially outweighing the influence of parents and carers (Price et al., 2022).

3. Increased sensitivity to community norms: The community's perception of outdoor activities changes as children age, with less tolerance shown for teenagers compared to younger children. Older children become more

aware of and responsive to societal and cultural representations of nature spaces, which can affect their engagement.

4. Increased academic pressure: As children progress through the education system, there is a greater focus on academic achievement, which can limit their opportunities for nature engagement. The requirement for outdoor experiences in the Scottish educational curriculum decreases as children get older, leading to fewer school-facilitated nature activities for adolescents.

5. Increased screen time: Screen time, particularly gaming and social media, tends to increase as children grow older, potentially reducing the time spent outdoors. While parents may manage screen time for younger children, adolescents often have more control over their media consumption, which can compete with nature-based activities for their time and attention.

The FCM process enabled practitioners to quantify these age-related changes by updating the weights of specific relationships corresponding to the identified themes. As I detailed in Chapter 3, subsection 3.5.1, FCM relationship weights represent the strength of influence between concepts, ranging from -1.0 to +1.0. An increase in weight (e.g., from 0.4 to 0.7) indicates practitioners believe that relationship becomes stronger as children age into adolescence. A decrease in weight (e.g., from 0.8 to 0.4) indicates the relationship becomes weaker with age. For negative relationships, changes toward zero (e.g., from -0.8 to -0.3) represent weakening negative influence, while changes away from zero represent strengthening negative influence.

Table 4 presents the generalised areas of change that practitioners believe influence nature connectedness as children age into adolescence and how practitioners reflected these themes by updating 13 FCM relationship weights (out of the total 37). All other relationship weights were left unchanged, meaning that the relative strength of these relationships was not understood to be significantly impacted by age.

Table 4. Age-related changes in FCM relationship weights from children (ages 8-11) to young people (ages 12-15)

Developmental Theme	Corresponding Causal Relationships	Weights for ages 8-11	Weights for ages 12-15
Increased independence (decreased parental influence)	*Parent/carer affinity for nature → Child-led outdoor play*	0.8	0.4
	Parent/carer affinity for nature → Guided nature engagement	0.7	0.4
	Parent/carer aversion to nature-related threats → Perceived access to quality local natural space	-0.8	-0.3
	Parent/carer aversion to nature-related threats → Screen time	0.5	0.2
	Child-led outdoor play → Nature connectedness	0.7	0.9
	Guided nature engagement → Nature connectedness	0.7	0.6
Increased peer influence	*Peer aversion to nature → Child-led outdoor play*	-0.4	-0.8
	Peer aversion to nature → Negative outdoor experiences	0.3	0.6
	Peer aversion to nature → Screen time	0.2	0.5
Increased sensitivity to community norms	*Disabling community norms → Child-led outdoor play*	-0.3	-0.5
	Disabling community norms → Perceived access to quality local natural space	-0.5	-0.7
	Disabling community norms → Peer aversion to nature	0.4	0.7
Increased academic pressure	*Unsupportive organisation culture → Perceived academic/outdoor learning divide*	0.6	0.8
	Perceived academic/outdoor learning divide → Leader confidence and motivation to deliver outdoor learning	-0.6	-0.7
	Leader confidence and motivation to deliver outdoor learning → Guided nature engagement	0.7	0.9
Increased screen time	*Perceived academic/outdoor learning divide → Screen time*	0.2	0.4

Although they had the freedom to do so, practitioners did not choose to add new concepts or relationships to the system representing how young people (ages 12-15) develop nature connectedness. Instead, they updated the weights of specific relationships they believed to change as a child ages into adolescence. This indicates that practitioners considered the map's concepts and relationships to be sufficiently generalised and applicable for both children ages 8-11 and young people ages 12-15. Only the relative importance of specific concepts and relationships change between the two age groups. Later in Section 4.3, I present the results of a static analysis to further highlight the consequences of these changes on the relative importance of concept importance for the different age groups.

Tables 5 and 6 present the FCM matrices for the Children FCM and the Young People FCM variations. The following matrices reformat the visual map (Figure 3) into numerical values that show how strongly each concept influences others. These matrices serve as the mathematical foundation for subsequent analyses, enabling calculation of concept centrality (Section 4.3), dynamic simulations (Section 4.4), as well as the direct comparison of relationship strengths between age groups. Concepts in the far left column influence concepts in the top row. Values in each intersecting cell show the strength and direction of the relationship from the row concept to the column concept. The grey cells denote self-reinforcing relationships for driver concepts. Concept abbreviations are as follows: C1 = Access to quality local natural space; C2 = Child-led outdoor play; C3 = Disabling community norms; C4 = Guided nature engagement; C5 = Leader confidence and motivation to deliver outdoor learning; C6 = Nature connectedness; C7 = Negative outdoor experiences; C8 = Parent/carer affinity for nature; C9 = Parent/carer aversion to nature-related threats; C10 = Peer aversion to nature; C11 = Perceived access to quality local natural space; C12 = Perceived academic/outdoor learning divide; C13 = Screen time; C14 = Unsupportive organisation culture; C15 = Vicarious outdoor experiences.

Table 5. Matrix representing the complex system shaping children's nature connectedness (drivers' self-reinforcing relationships are marked in grey)

	C9	C8	C13	C3	C1	C11	C14	C10	C2	C7	C4	C5	C6	C12	C15
C9		-0.5	0.5			-0.8					-0.5				
C8	-0.7		-0.3						0.8		0.7				0.6
C13									-0.7						
C3	0.7			0.0		-0.5		0.4	-0.3	0.5		-0.5			
C1					0.0	0.4									
C11									0.4						
C14							0.0							0.6	
C10			0.2						-0.4	0.3					
C2												0.4	0.7		
C7													-0.6		
C4						0.3							0.7		
C5											0.7			-0.3	
C6		0.3							0.6	-0.3	0.3				
C12			0.2								-0.4	-0.6			
C15									0.2						

Table 6. Matrix representing the complex system shaping young people's nature connectedness (drivers' self-reinforcing relationships are marked in grey)

	C9	C8	C13	C3	C1	C11	C14	C10	C2	C7	C4	C5	C6	C12	C15
C9		-0.5	0.2			-0.3					-0.4				
C8	-0.7		-0.3						0.4		0.4				0.6
C13									-0.7						
C3	0.7			0.0		-0.7		0.4	-0.5	0.5		-0.5			
C1					0.0	0.4									
C11									0.6						
C14							0.0							0.8	
C10			0.5						-0.8	0.6					
C2												0.4	0.9		
C7													-0.6		
C4						0.3							0.6		
C5											0.9			-0.3	
C6		0.3							0.6	-0.3	0.3				
C12			0.4								-0.4	-0.7			
C15									0.2						

4.2.7 Concepts that directly influence Nature Connectedness

Within the scope of the FCM, practitioners identified three concepts that directly influence nature connectedness: *child-led outdoor play* (C2), *guided nature engagement* (C4), and *negative outdoor experiences* (C7). These concepts play a crucial mediating role in the FCM as all other concepts must eventually connect to at least one of these three concepts to influence nature connectedness (Figure 3). Like the driver concepts, these direct influences mark the boundary of the FCM's scope and the extent of the study's investigation into the complex system shaping nature connectedness (RQ1).

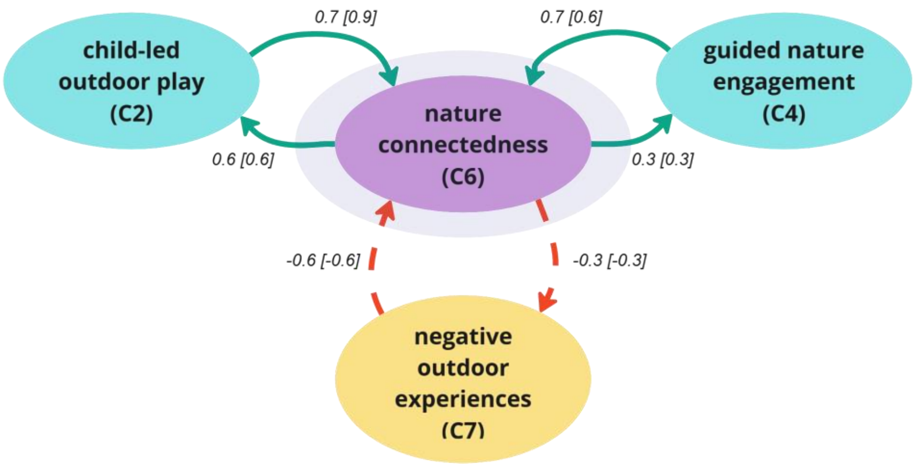

Figure 6. Concepts with direct influence on nature connectedness : This figure shows the three concepts that practitioners identified as having direct causal relationships with nature connectedness (C6). Each oval represents a concept, with blue indicating experiences that facilitate nature connectedness and yellow indicating experiences that impede it. The solid green arrows represent positive causal relationships, while dashed red arrows represent negative causal relationships. All connections are bidirectional to reflect the reinforcing cycles between experiences and connectedness. The weights displayed show the strength of each relationship, with the first value representing the children's FCM variation (ages 8-11) and the bracketed value representing the young people's FCM variation (ages 12-15).

Notably, each of these three concepts (C2, C4, C7) has been modelled to have a bidirectional relationship with nature connectedness (C6). For example, increased child-led outdoor play may enhance nature connectedness, which in turn may motivate a child to engage in more outdoor play. Similarly, negative outdoor experiences (C7) may decrease a child’s nature connectedness, while a stronger connection to nature reduces the likelihood of a child perceiving outdoor interactions negatively. This cyclical dynamic underscores practitioners' understanding of nature connectedness as part of an ongoing, self-reinforcing process rather than a linear cause-and-effect relationship.

4.2.8 Summary of the aggregated FCM and its general statistics

Section 4.2 has presented an overview of the aggregated FCM, directly addressing RQ1 by revealing outdoor learning practitioners' understanding of the complex system shaping nature connectedness in Scottish children and young people. This model presents 38 causal relationships between 15 key concepts, both a visualised network and a mathematical object, offering a structured representation of practitioners' shared knowledge.

The FCM has successfully transformed practitioners' initially broad perspectives into a shared and quantified artifact designed to facilitate analysis and deepen discourse. Its practical boundaries and parsimony enhance its interpretability and focus on the most salient concept and relationships. However, to fully appreciate the relative importance of each concept within this system and identify strategic leverage points, further analysis is required.

4.3 Static Analysis

Having provided an overview of the aggregated FCM's concepts and structure, this section builds on this foundation to address the study's second research question: What concepts do practitioners consider most important for shaping nature connectedness and may serve as strategic leverage points?

While all 15 generalised concepts were selected by practitioners as ‘important’, static analysis reveals the varying extent of their respective influence within the system. To capture this perceived importance, I calculated each concept’s degree centrality (see Chapter 3, subsection 3.7.2). Because concepts in this network were found to have relatively few connections to each other (see Section 4.2.3 on model density), degree centrality was deemed sufficient for pinpointing concepts with the strongest overall influence, considering both the number and strength of their connections.

In the following subsections, I present the results of the degree centrality analysis for both the children (ages 8-11) and young people (ages 12-15) FCM variations. I identify the most central concepts for both age groups, provide a brief explanation of the modelling factors behind rankings, and interpret these findings with reference to practitioner insights and relevant literature. This analysis provides a foundation for exploring how interventions like the John Muir Award might interact with these key concepts, as I demonstrate in the dynamic simulations presented in Section 4.4.

4.3.1 Calculating degree centrality

I calculated degree centrality separately for the two FCM variations representing children (ages 8-11) and young people (ages 12-15). This was necessary because practitioners identified several key relationships that change in strength as children age, resulting in different relationship weights in each FCM variation (see Section 4.2.6). By analysing both age groups, I observe how the relative importance of concepts shifts as children mature, providing further insight into how practitioners understand the system shaping nature connectedness to evolve with age.

Tables 7 and 8 present concepts ranked in descending order of centrality importance. As I detailed in Chapter 3, subsection 3.7.2, indegree represents the sum of absolute weights of incoming connections (how much a concept is influenced by others), outdegree represents the sum of absolute weights of outgoing connections (how much a concept influences others), and degree centrality is the sum of indegree and outdegree, providing an overall measure of each concept's connectivity and importance within the system. Higher centrality scores indicate concepts that are more active within their immediate network through stronger and more numerous direct relationships.

Table 7. Degree centrality rankings for children's FCM (ages 8-11)

Ranked Concepts	Indegree	Outdegree	Degree Centrality
Child-led outdoor play (C2)	3.4	1.5	4.9
Parent/carer affinity for nature (C8)	0.8	3.1	3.9
Parent/carer aversion to nature-related threats (C9)	1.4	2.3	3.7
Guided nature engagement (C4)	2.6	1.0	3.6
Nature connectedness (C6)	2.0	1.5	3.5

Leader confidence and motivation to deliver outdoor learning (C5)	2.0	1.2	3.2
Disabling community norms (C3)	0.0	2.9	2.9
Perceived access to quality local natural space (C11)	2.0	0.4	2.4
Perceived academic/outdoor learning divide (C12)	0.9	1.2	2.1
Screen time (C13)	1.2	0.7	1.9
Negative outdoor experiences (C7)	1.1	0/6	1.7
Peer aversion to nature (C10)	1.4	2.3	1.3
Vicarious outdoor experiences (C15)	0.6	0.2	0.8
Unsupportive organisation culture (C14)	0.0	0.6	0.6
Access to quality local natural space (C1)	0.0	0.4	0.4

Table 8. Degree centrality rankings for young people's FCM (Ages 12-15)

Ranked Concepts	**Indegree**	**Outdegree**	**Degree Centrality**
Child-led outdoor play (C2)	3.8	1.7	5.5
Nature connectedness (C6)	2.1	1.5	3.6
Disabling community norms (C3)	0.0	3.3	3.3
Guided nature engagement (C4)	2.4	0.9	3.3
Parent/carer affinity for nature (C8)	0.8	2.4	3.2
Leader confidence and motivation to deliver outdoor learning (C5)	2.0	1.2	3.2
Parent/carer aversion to nature-related threats (C9)	0.8	2.4	2.8
Perceived academic/outdoor learning divide (C12)	1.1	1.5	2.6
Peer aversion to nature (C10)	0.4	1.9	2.3
Perceived access to quality local natural space (C11)	1.7	0.6	2.3
Screen time (C13)	1.4	0.7	2.1
Negative outdoor experiences (C7)	1.4	0.6	2.0
Unsupportive organisation culture (C14)	0.0	0.8	0.8
Vicarious outdoor experiences (C15)	0.6	0.2	0.8
Access to quality local natural space (C1)	0.0	0.4	0.4

4.3.2 Interpretation of concept centrality

The FCM centrality scores in Table 7 capture the most important concepts within the complex system representing practitioner's shared understanding of how nature connectedness in children and young people forms, directly addressing RQ2. In this sub-section, I present the top five concepts with the highest centrality—*child-led outdoor play*, *parent/carer affinity for nature*, *parent/carer aversion to nature related threats*, *guided nature engagement*, and *nature connectedness*. I further note the high influence of the driver concept disabling community norms. Each concept is discussed in terms of its relative centrality ranking for both age groups, a brief modelling explanation behind the ranking, any significant changes in ranking between age groups, and the underpinning knowledge that the ranking reflects from both practitioner insights and the wider literature.

Child-led outdoor play (C2) consistently ranks as the most central concept across both age groups, with centrality scores of 4.9 for children and 5.5 for young people. This high centrality is due to the concept's seven incoming connections from influential factors such as parental, peer, and community influences, as well as its strong outgoing connection to *nature connectedness* (see Figure 7 below). The increase (+0.6) in centrality as children age into adolescence reflects practitioners' view that children typically gain autonomy with age and take an increasingly active role in developing their own perceptions of and relationship with nature.

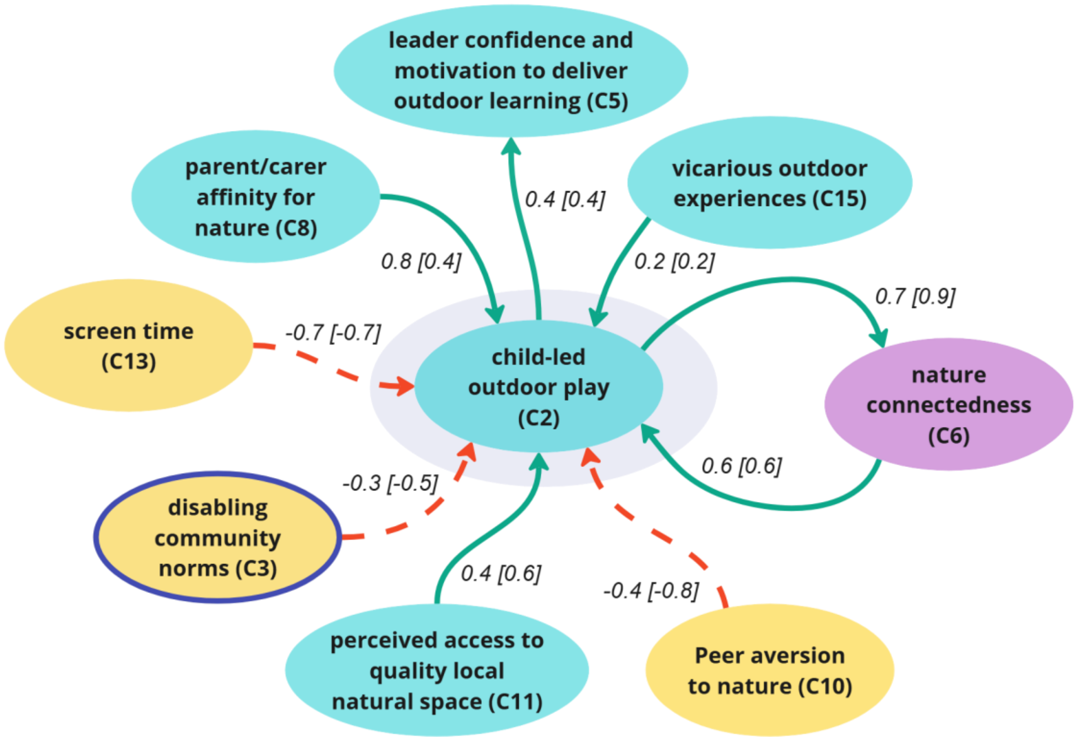

Figure 7. Incoming and outgoing connections of child-led outdoor play (C2) : This figure shows the network of relationships surrounding child-led outdoor play (C2), illustrating why it ranks as the most central concept in the system. Each oval represents a concept, with blue indicating concepts that facilitate nature connectedness, yellow indicating concepts that impede it, and the dark blue border identifying a driver concept. The solid green arrows represent positive causal relationships, while dashed red arrows represent negative causal relationships. The weights displayed show the strength of each relationship, with the first value representing the children's FCM variation (ages 8-11) and the bracketed value representing the young people's FCM variation (ages 12-15).

While centrality rankings have emphasised the paramount importance of self-directed experiences for fostering nature connectedness, this result does not negate the importance practitioners place on the role of adult and parental influence. In fact, the FCM design clarifies that practitioners understand *child-led outdoor play* to derive much of its importance from concepts representing adult influence. *Parent/carer affinity for nature* (C8) ranks second for children (3.9) and fifth for young people (3.2). The concept's high centrality is driven by its strong outgoing connections to both *child-led outdoor play* (C2) and *guided nature engagement* (C4), indicating the significant influence of parental support and enthusiasm in facilitating experiences that directly foster nature connectedness.

Parent/carer aversion to nature-related threats (C9) also ranks highly—third for children (3.7) and drops to seventh for young people (2.8)—highlighting potential barriers posed by caregivers' concerns over exposing children to nature. Once again, the decrease in ranking for both C8 and C9 as children age reflects the diminishing impact of parental influence and the growing significance of self-directed activities, peer influences, and perceived social norms. Practitioners stressed the critical role of parents and caregivers in shaping children's early nature experiences, a perspective supported by research on the intergenerational transmission of nature connection (Hughes et al., 2019; Richardson, 2025). The high centrality of parental influence is illustrated below in Figure 8.

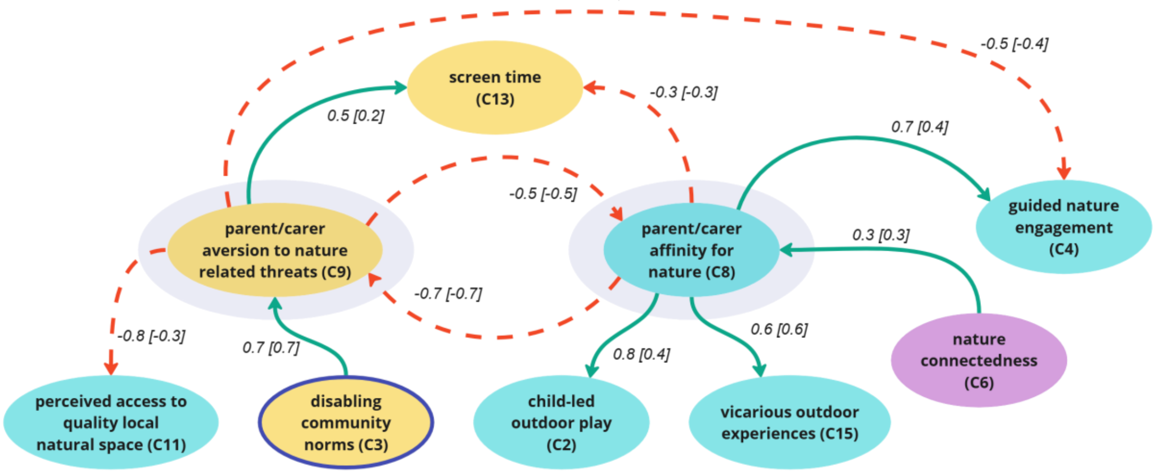

Figure 8. Incoming and outgoing connections of parent/carer affinity for nature (C8) and parent/carer aversion to nature-related threats (C9) : This figure shows the network of relationships surrounding the two key parental influence concepts, illustrating their high centrality within the system. Each oval represents a concept, with blue indicating concepts that facilitate nature connectedness, yellow indicating concepts that impede it, and the dark blue border identifying a driver concept. The solid green arrows represent positive causal relationships, while dashed red arrows represent negative causal relationships. The weights displayed show the strength of each relationship, with the first value representing the children's FCM variation (ages 8-11) and the bracketed value representing the young people's FCM variation (ages 12-15).

Continuing the theme of adult-mediated experiences, *guided nature engagement* (C4) ranks fourth for children (3.6) and tied for third for young people (3.3) in centrality, reflecting its importance in developing nature connectedness. The centrality of *guided nature engagement* comes primarily from two strong incoming connections from parent/carer affinity for nature (C8) and leader confidence and motivation to deliver outdoor learning (C5) as well as its outgoing connection to nature connectedness (C6) (see Figure 9). Both C4 and C2 were modelled to have cyclical, reinforcing relationships with nature connectedness (C6) (see Figure 7 in Section 4.2.5). However, the feedback loop between *child-led outdoor play* and *nature connectedness* is stronger (see Figure 6).

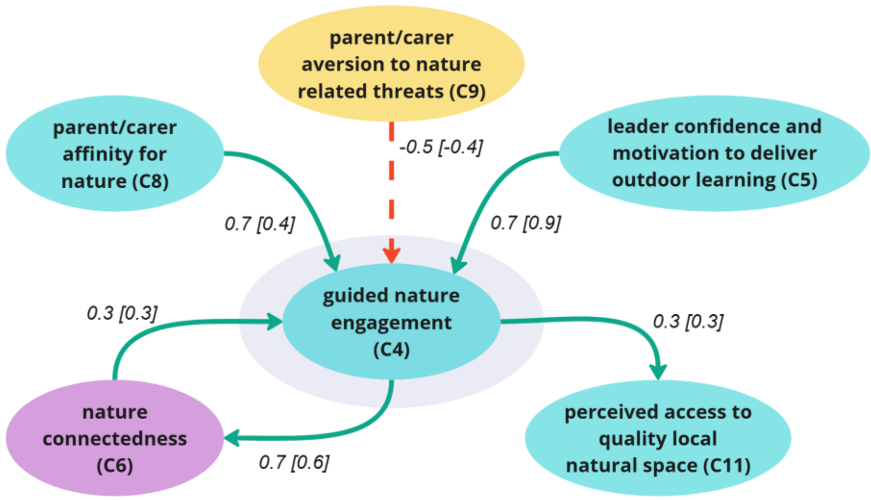

Figure 9. Incoming and outgoing connections of parent/carer affinity for nature (C8) and parent/carer aversion to nature-related threats (C9) : This figure shows the network of relationships surrounding guided nature engagement (C4), highlighting the factors that influence structured outdoor learning experiences and their outcomes. Each oval represents a concept, with blue indicating concepts that facilitate nature connectedness and yellow indicating concepts that impede it. The solid green arrows represent positive causal relationships, while dashed red arrows represent negative causal relationships. The weights displayed show the strength of each relationship, with the first value representing the children's FCM variation (ages 8-11) and the bracketed value representing the young people's FCM variation (ages 12-15).

Nature connectedness (C6) itself has high centrality for both age groups, ranking fifth for children (3.5) and second for young people (3.6). According to practitioners, the centrality of *nature connectedness* increases as children age because as young people gain autonomy their personal relationships with and perceptions of nature increasingly inform their decisions and activities. Its high centrality is primarily derived from its strong bidirectional connections with *child-led outdoor play*, *guided nature engagement*, and *negative outdoor experiences* (see Figure 6) as well as a weak influence on *parent/carer affinity for nature* (C8). Practitioners view nature connectedness as both an outcome and an influencer within the system, shaping and being shaped by various experiences and contextual factors. This perspective aligns with the growing body of literature that conceptualises nature connectedness as a multidimensional construct with reciprocal relationships to other psychological and behavioural variables (Ives et al., 2017; Zylstra et al., 2014). Zylstra et al. (2014) for example, explicitly conceptualise nature connectedness as a ‘leverage point’ for pro-environmental behaviours.

In my analysis so far, I've focused on ordinary concepts as potential leverage points due to their bidirectional relationships within the system. They are of particular interest because they are understood to be receptive to influence from other concepts, including interventions like the Award (Kok, 2009). However, this analysis reveals that one of the most influential factors in the system is a driver concept that exists outside the scope of typical intervention control.

Disabling community norms (C3) is a notably influential concept within the FCM (see Figure 10 below). When calculating degree centrality, I excluded the weight of self-reinforcing relationships (which can be set anywhere from 0.0 to 1.0) that maintain driver stability during simulations (as demonstrated in Section 4.4). Self-reinforcing relationships represent artificial modelling constructs rather than genuine causal relationships identified by practitioners (Olazabal et al., 2018). Even without including these self-loops, C3 ranks moderate to high in centrality: seventh for children (2.9) and up to third for young people (3.3). This is due to its six outgoing connections with relatively strong to moderate weights (ranging from 0.4 to 0.7) which directly influence other highly central concepts such as *parent/carer aversion to nature-related threats* and *child-led outdoor play*. Without any mediating incoming connections, C3 exerts a pervasive influence throughout the system. This is further demonstrated through simulations conducted in Section 4.4.

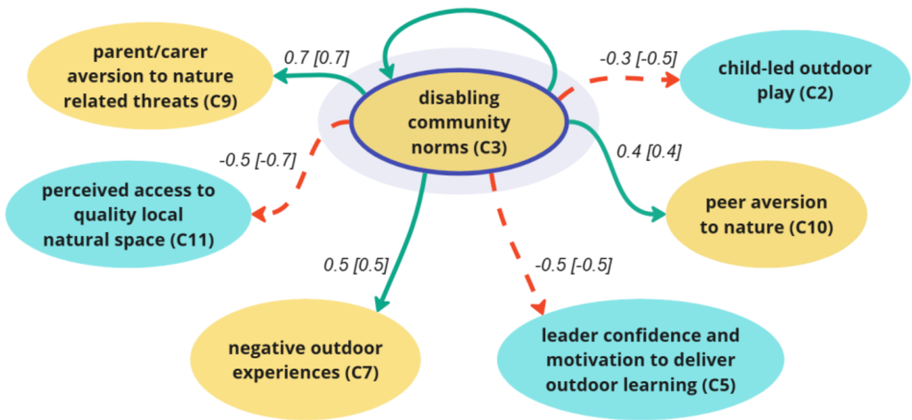

Figure 10. Incoming and outgoing connections of disabling community norms (C3) : This figure shows the network of relationships surrounding disabling community norms (C3), revealing how societal attitudes toward outdoor activities influence multiple aspects of the system. Each oval represents a concept, with blue indicating concepts that facilitate nature connectedness and yellow indicating concepts that impede it. The dark blue border identifies C3 as a driver concept with a self-reinforcing relationship. The solid green arrows represent positive causal relationships, while dashed red arrows represent negative causal relationships. The weights displayed show the strength of each relationship, with the first value representing the children's FCM variation (ages 8-11) and the bracketed value representing the young people's FCM variation (ages 12-15).

The concept's high centrality reflects that practitioners view societal and cultural attitudes towards nature as a powerful antecedent of nature connectedness, especially as children become more socially aware and independent. My static analysis thus identifies not only potential leverage points but also powerful systemic constraints and broader societal factors that interventions must navigate. As I discuss in Chapter 5, this ranking of concept importance enables a more nuanced and potentially more effective approach to fostering nature connectedness in challenging community settings.

4.3.3 Summary of the static analysis

Section 4.3 addressed RQ2 through a static analysis of the FCM for both age groups. By calculating degree centrality scores, I identified the concepts practitioners consider most important for shaping nature connectedness and potentially influential points within the system. My analysis revealed *child-led outdoor play* as the most central concept across age groups, followed by parent/carer influences (C8 and C9), *guided nature engagement*, and *nature connectedness itself*. I also identified significant shifts in concept importance with age, notably decreasing parental influence and increasing peer/community influence for adolescents. *Disabling community norms* emerged as a highly influential driver, particularly for young people.

While centrality indicates a concept's structural importance within the system, it does not automatically translate to strategic leverage for interventions. This is a distinction that becomes crucial when interpreting simulation outcomes and designing effective interventions, as I explore in the following dynamic analysis and discuss further in Chapter 5.

These findings advance my research from a descriptive overview of the system (Section 4.2) to a more nuanced, strategic understanding of its key components and dynamics. By identifying potential leverage points, I've laid the groundwork for exploring how interventions like the John Muir Award might be most effectively implemented and adapted for different age groups. Section 4.4 will build on this static analysis to investigate the system's dynamic behaviour through scenario simulations. This approach will address RQ3, exploring the John

Muir Award's potential impact under varied circumstances and the extent to which it interacts with the most important factors identified above.

4.4 Dynamic Analysis: Exploring the John Muir Award's impact through scenarios and simulations

The previous sections have presented outdoor learning practitioners' shared understanding of the complex system shaping nature connectedness for children and young people (RQ1) and identified the most important concepts within this system (RQ2). Building on this foundation, I now address RQ3: How can we simulate the system to explore the lasting impact of the John Muir Award under different plausible scenarios?

To answer this question, I employ FCM's capability to run simulations that reflect plausible what-if scenarios (Nápoles and Giabbanelli, 2024). While the earlier static analysis provides insights into system structure, dynamic simulations serve to make explicit the consequences of that structure and how it adapts to changes (Penn et al., 2013). As I detailed in Chapter 3, Section 3.8, these simulations work by setting initial activation values for driver concepts (which remain fixed throughout the simulation) and allowing the mathematical relationships between concepts to propagate through the network until the system reaches equilibrium (Kok, 2009). The primary value of FCM simulations lies in their ability to explore the behaviour of the system that are otherwise hidden or difficult to predict due to the numerous concepts, interrelationships, and varying relationship weights (Jetter and Kok, 2014).

In this study, simulations are being used to explore the John Muir Award's potential impact on system outcomes, its limitations, and how it interacts with influential concepts to potentially bring about sustained increases in nature connectedness. This knowledge can inform decision-making and guide efforts to enhance the Award's effectiveness in promoting nature connectedness (van Vliet et al., 2010).

In the following sections, I present a series of what-if scenarios, describe the corresponding simulation designs, and comparatively analyse their outcomes. Through these simulations, I not only address RQ3 but also demonstrate the practical application of my FCM model to a real-world intervention in a timely area of high complexity and uncertainty. This dynamic analysis complements and extends the structural analysis laid out in previous sections, offering a more comprehensive understanding of the complex system shaping nature connectedness and the potential role of the John Muir Award within it (Gray et al., 2014).

4.4.1 Incorporating the John Muir Award into the Complex System

To address RQ3, outdoor learning practitioners were asked to use the aggregated FCM to conceptualise how the Award impacts specific concepts within the complex system shaping nature connectedness. The following subsections (4.4.1.1 and 4.4.1.2) outline practitioners' views on the Award's impact and explains how these insights were translated into the Fuzzy Cognitive Map (FCM). They Identified two key impacts:

1. Enhancing leader confidence: Practitioners emphasized the Award's significant impact on educators' confidence and motivation to deliver outdoor learning. The Award's structured framework helps demystify outdoor learning and addresses common concerns about safety and curriculum alignment.

2. Influencing peer attitudes: The Award was seen to subtly influence peer aversion to nature by promoting a pro-nature group identity among participants.

The John Muir Award was introduced as a new self-reinforcing driver concept with an activation value of 1 to reflect practitioners' understanding that while the Award experience is a fixed-duration experience, its impact is resilient via the two key concepts above (see Figure 11 below). For instance, once leaders have gained confidence in delivering outdoor learning through the Award, the model assumes that they are unlikely to lose their knowledge of the Award framework which they may adapt to their ongoing delivery of outdoor learning. Two outgoing relationships from the new driver were also established to capture the Award’s direct impact:

1. A strong positive relationship (weight 0.8) to *leader confidence and motivation to deliver outdoor learning*, reflecting the Award's significant impact on educators.

2. A weak negative relationship (weight -0.3) to *peer aversion to nature*, representing the Award's subtle influence on peer attitudes.

The weight of each relationship reflects practitioners' views on the relative strength and immediacy of the Award's impacts within the system.

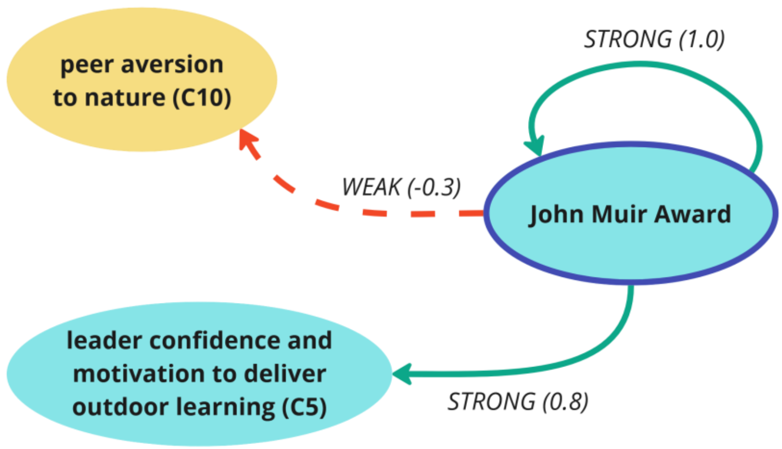

Figure 11. The John Muir Award's representation in the aggregated FCM : This figure shows how practitioners modelled the John Muir Award's direct influence within the system. The Award is represented as a driver concept (indicated by the dark blue border) with a self-reinforcing relationship. The solid green arrow shows the Award's positive influence, while the dashed red arrow shows its weak negative influence. The linguistic descriptors (STRONG, WEAK) indicate the relative strength of these relationships as determined by practitioners.

Two additional direct impacts on the model's focal concept *nature connectedness* (C6) were suggested by practitioners but were deemed to be outside the scope and functionality of the model (this is discussed further in Chapter 5):

1. Initial boost to nature connectedness: The Award can serve as a catalyst, particularly for younger children and those with limited prior nature experiences. However, practitioners noted that sustained impact likely depends on continued nature-based experiences beyond the Award. The Award's immediate effect on an individual's nature connectedness was excluded from the model.

2. Long-term influence: Some practitioners suggested that the Award might "plant a seed" for nature connectedness that manifests later in life. However, this long-term and potentially dormant impact is difficult to capture within the current model's scope.

This static representation of the Award within the FCM (Figure 9) provides a foundation for understanding its potential impact and limitations. To fully address RQ3 and explore the Award's lasting impact under different plausible scenarios, I now turn to dynamic simulations of the model. The next sub-sections present the scenarios and corresponding simulations used to investigate how the Award interacts with other concepts under various conditions to influence nature connectedness.

4.4.2 Designing Scenarios

To explore the John Muir Award's impact under various conditions, a series of scenarios were designed based on criteria ensuring relevance, plausibility, and fit within the Fuzzy Cognitive Map (FCM) parameters. Guided by the scenario workshop criteria noted in Chapter 3, subsection 3.7.2, a consultation with Trust staff resulted in scenarios designed to meet the following objectives:

- Compare the Award's impact in different school settings, characterised by a varying provision and support of outdoor learning.

- Examine the Award's impact on participants facing significant barriers to nature connectedness, particularly due to adverse social and community norms.

- Compare the Award's impact under similar conditions but with different age groups.

- Explore potential enhancements to the Award, identifying opportunities for age-specific intervention approaches.

Given that Scottish children and young people most commonly participate in the Award within a school setting, Trust staff expressed interest in exploring the

Award's impact across different educational environments. Two generalised but plausible school environments were identified for scenarios: a 'mainstream school' with a highly unsupportive organisation culture and a 'specialist school' with a more subtly unsupportive organisation culture. Award staff identified this distinction based on their experience that mainstream schools often follow more traditional, uniform approaches to curriculum delivery, while specialist schools, particularly those serving children and young people with additional support needs, tend to be more receptive to new teaching methods and outdoor learning approaches. This distinction was reflected in the model by increasing and decreasing the value of the driver concept unsupportive organisation culture (C14).

Trust staff also prioritised scenarios featuring the Award's impact under challenging circumstances, where participants face adversities in developing close relationships with nature. This focus stems from previous research indicating that outdoor learning interventions, including the Award, likely have the greatest impact on participants with limited opportunities for direct, nature connection-building experiences (Mitchell and Shaw, 2010). Ideal scenarios in which children's environments are already poised to foster strong nature connectedness would not as effectively highlight the Award's impact and limitations, as the model would likely produce desired outcomes even without the Award's presence.

Along with varying the activation value of unsupportive organisation culture (C14), adverse system conditions were captured in the model by assigning a high activation value of 0.8 to the driver concept *disabling community norms* (C3). The driver *access to quality local natural space* (C1) was clamped at a moderate activation value of 0.5, representing conditions in which there is some but limited opportunity for physical access to natural environments with some barriers such as transport or resource constraints (see Table 2 for full concept definitions).These changes make the model predisposed to impeding the development of nature connectedness to better isolate the impact of the Award.

With the above interests and objectives in mind, scenarios were designed to build upon each other, facilitating meaningful comparisons and insights into the Award's effectiveness across different school contexts and age groups. In

Chapter 3, subsection 3.8.1, I detail the process by which scenarios are designed and implemented. Table 6 outlines the progression of FCM simulations I conducted, designed to explore the Award's impact in different school settings, age groups, and with potential enhancements. The table outlines the specific conditions for each simulation, including clamped driver values, the presence or absence of the Award, and the age group under consideration. Additionally, it highlights the purpose of each simulation and key comparisons to be made, providing a clear roadmap for the analysis that follows.

Table 9. Progression of FCM simulations to explore the impact of the Award

Scenario	Simulation	Initial Conditions	Purpose
1. Mainstream School (children)	1a	Unsupportive Organisation Culture: 1.0 Access to Quality Local Natural Space: 0.5 Disabling Community Norms: 0.8	Establish baseline for children in an unsupportive mainstream school environment
	1b (with Award)	Same as 1a Introduce John Muir Award as a new driver	Assess Award impact on children in an unsupportive mainstream school environment
2. Specialist School (children)	2a	Unsupportive Organisation Culture: 0.3 Access to Quality Local Natural Space: 0.5 Disabling Community Norms: 0.8	Establish baseline for children in a more supportive school environment
	2b (with Award)	Same as 2a Introduce John Muir Award as a new driver	Assess Award impact on children in a more supportive specialist school environment
3. Mainstream School (Young people)	3a	Same as 1a	Establish baseline for young people in an unsupportive mainstream school environment
	3b (with Award)	Same as 1a	Assess Award impact on young people in an

		Introduce John Muir Award as a new driver	unsupportive mainstream school environment
4. Specialist School (young people)	4a	Same as 2a	Establish baseline for young people in a more supportive specialist school environment
	4b (with Award)	Same as 2a Introduce John Muir Award as a new driver	Assess Award impact on young people in a more supportive specialist school environment
5. Age-specific Enhancements	5a (with Award)	Same as 1b Add negative relationships (weight -0.4) from the Award to Parent/Carer Aversion to Nature-Related Threats	Explore tailored enhancement for children: Award reduces parental aversion to nature-related threats
	5b (with Award)	Same as 3b Add positive relationship (weight 0.4) from Award to child-led outdoor play (C2)	Explore tailored enhancement for young people: Award promotes self-directed nature experiences

4.4.3 Simulation Results and Analysis

This subsection analyses the outcomes of each simulation detailed in Table 9, which were designed to explore the impact of the John Muir Award across different educational contexts and age groups, thereby addressing RQ3. The following analysis highlights specific results that reveal notable patterns across scenarios, while complete simulation results for all concepts and scenarios are provided in the appendices.

I structure the analysis around three patterns that emerged from our simulations, moving from broad observations to specific insights relevant for each. I focus on the concepts identified as most important in Section 4.3.2 and the key drivers that shape the simulation scenarios. I connect key simulation outcomes back to the FCM structure to make explicit the consequences of practitioners' causal reasoning and support a more in-depth discussion and evaluation in Chapter 5 (Penn et al., 2013).

4.4.3.1 Impact of the John Muir Award across school settings

The first broad pattern of note is that the introduction of the Award leads to positive changes in nature connectedness and related high-centrality concepts across all scenarios, though the magnitude varies by context and age group. This comes as no surprise as the Award was modelled to have an entirely positive influence on the system. However, to understand the extent of Award's positive impact, I first examine the baseline scenarios without the intervention.

Comparing scenarios 1a (mainstream school) and 2a (specialist school) for children aged 8-11, the highly unsupportive organisation culture is found to dampen the values of key facilitators of nature connectedness concepts like child-led outdoor play and nature connectedness itself.

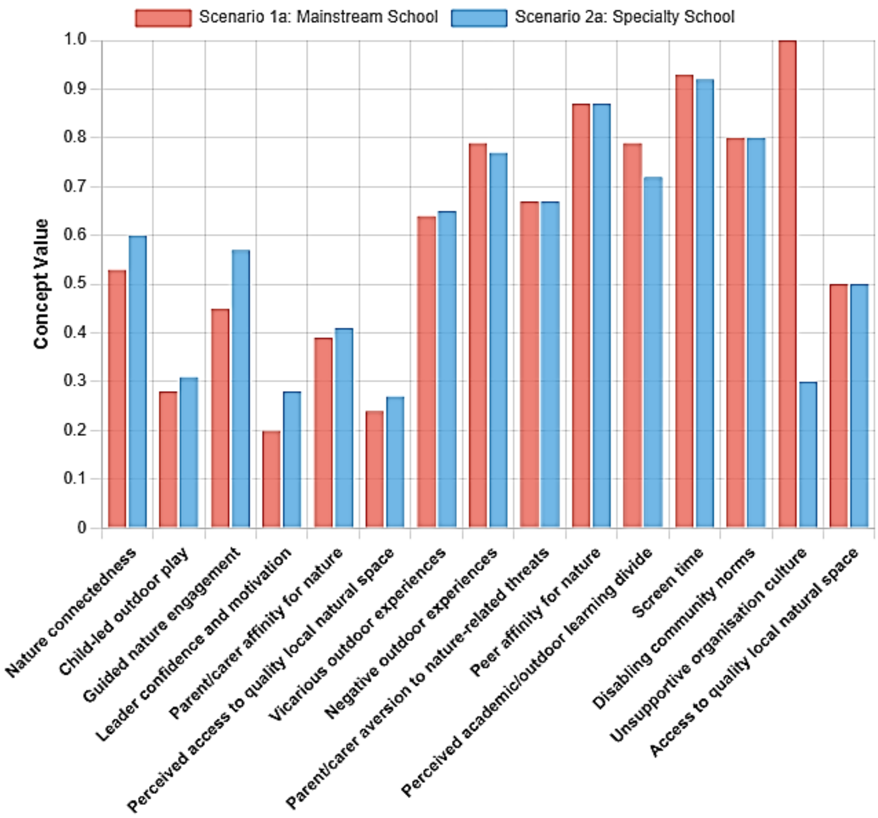

Figure 12. Baseline simulation results for children in mainstream versus specialty school settings : This bar chart compares how the system behaves in different educational contexts for children (ages 8-11) without the intervention of the John Muir Award. This baseline comparison establishes the different starting conditions that the Award must work within across school settings.

However, despite a significant difference in *unsupportive organisation culture*, which is clamped at 1.0 for scenario 1a versus 0.3 for scenario 2a, the resulting system outcomes show only modest differences. *Nature connectedness* reaches 0.53 in mainstream settings compared to 0.60 in specialist schools, a difference of just 0.07 points. Similarly, *child-led outdoor play* stabilises at 0.28 in mainstream settings versus 0.31 in specialist schools, while *guided nature engagement* shows the largest difference at 0.45 versus 0.57 respectively.

These modest differences can be explained by *unsupportive organisation culture*'s low centrality ranking (Section 4.3.2), indicating its limited direct influence on central concepts. As I note in sub-section 4.4.4.3, the highly influential driver *disabling community norms* has a far greater sway on the system behaviour and is likely dampening even dramatic changes in *unsupportive organisation culture*.

When the John Muir Award is introduced into the FCM as a new driver, consistent improvements are found across all scenarios (See Figure 13). In mainstream settings, *nature connectedness* increases from 0.53 to 0.72, representing a gain of 0.19, while in specialist schools it rises from 0.60 to 0.75, a gain of 0.15. This trend extends to other mediating concepts, with *child-led outdoor play* increasing by 0.14 in mainstream and 0.16 in specialist settings, while *guided nature engagement* shows strong responses in both contexts with increases of 0.29 and 0.25 respectively.

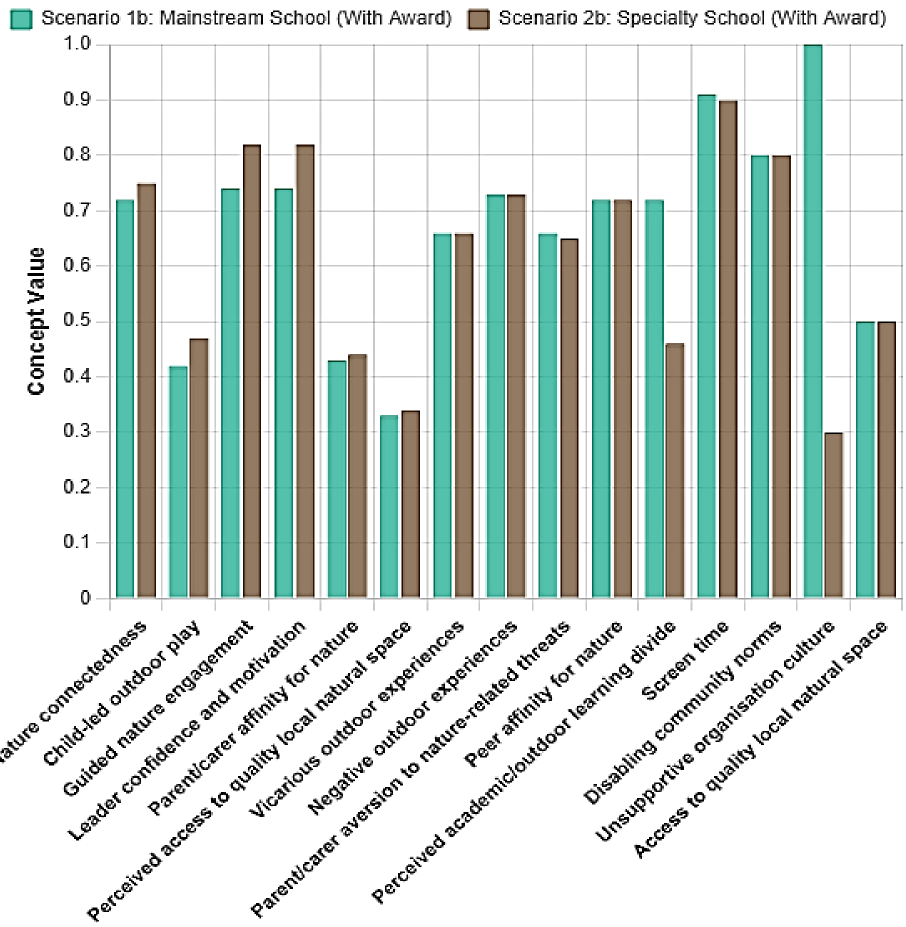

Figure 13. Simulation results with John Muir Award intervention in mainstream versus specialty school settings : This bar chart compares FCM simulation results for children aged 8-11 when the John Muir Award is introduced in mainstream schools (Scenario 1b, teal bars) versus specialty schools (Scenario 2b, brown bars). These simulations show how the Award affects each factor in different educational contexts.

As outlined in Section 4.4.1, practitioners modelled the Award to directly and strongly influence *leader confidence and motivation to deliver outdoor learning* (C5) as well as subtly countering peer aversion for nature (C10). The consistent improvements in concepts that facilitated nature connectedness reflect these added relationships, which function effectively regardless of changes in organisational culture.

4.4.3.2 Age group differences

Simulations consistently result in children (ages 8-11) having higher levels of nature connectedness and related positive factors compared to young people (ages 12-15). This pattern holds true across all scenarios, both with and without the John Muir Award intervention.

In baseline scenarios without the Award, the differences are stark. For example, in mainstream settings, *nature connectedness* (C6) stabilises at 0.53 for children, but only 0.31 for young people. Likewise, *child-led outdoor play* (C2) is 0.28 for children, compared to just 0.05 for young people.

These differences persist even after introducing the John Muir Award, though both age groups show improvements (see Figure 14). In mainstream settings, children's *nature connectedness* increases from 0.53 to 0.72, while young people's increases from 0.31 to 0.41. The absolute magnitude of change differs notably, with children experiencing an increase of 0.19 compared to young people's increase of 0.10.

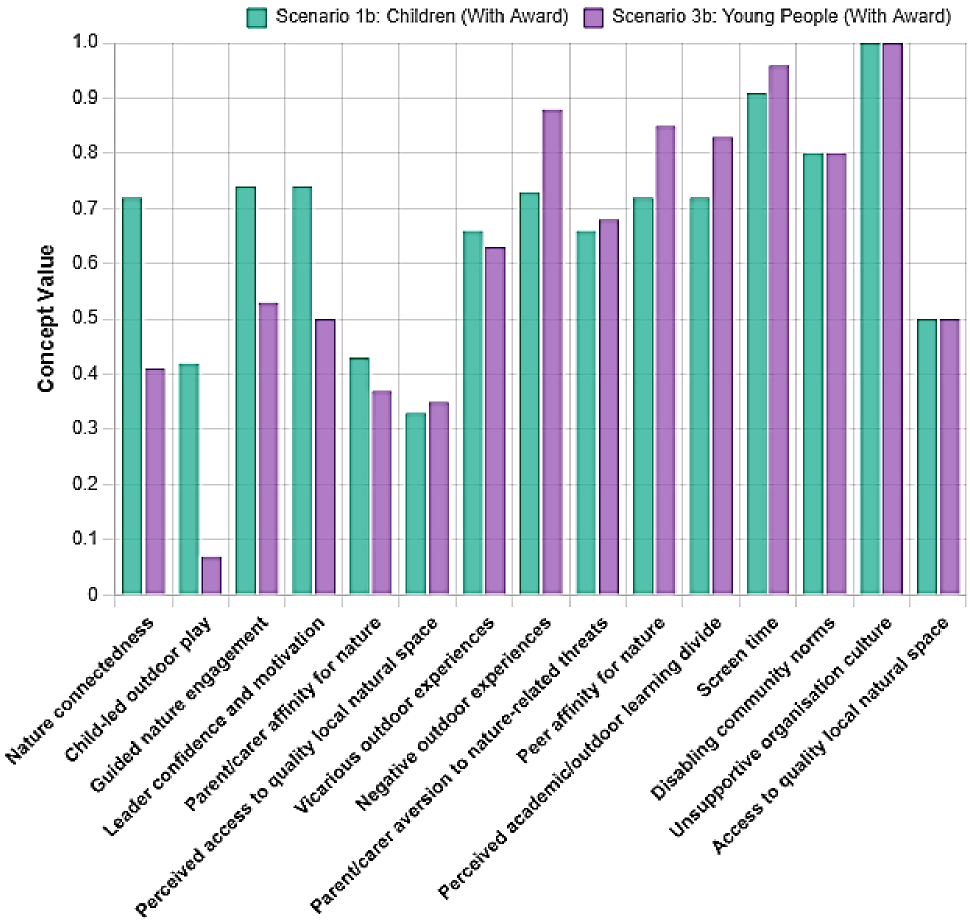

Figure 14. Simulation results with John Muir Award intervention comparing children versus young people in mainstream schools : This bar chart compares FCM simulation results with the John Muir Award intervention for children aged 8-11 in mainstream schools (Scenario 1b, teal bars) versus young people aged 12-15 in mainstream schools (Scenario 3b, purple bars). These simulations show how the Award affects each factor differently across age groups within the same school setting.

The Children FCM generally outputs larger absolute increases in key concepts with the inclusion of the Award. One notable exception is that, when comparing scenarios 2b and 4b, which represent the specialist school setting with the John Muir Award for children and young people respectively, we observe that young people show a strong response in *guided nature engagement*. In scenario 4b, *guided nature engagement* increases by 0.33 (from 0.37 to 0.70) for young people, slightly larger than the 0.25 increase (from 0.57 to 0.82) seen for children in scenario 2b. However, children still maintain a higher absolute value of 0.82 compared to young people of 0.70 when participating in the Award.

These results stem from how practitioners modelled each age group. The young people FCM gives more weight to peer influence and community norms, while reducing the impact of parental factors (C8 and C9). As a result, the young people FCM is more sensitive to consistently high *disabling community norms*, resulting in lower values for important facilitators of nature connectedness and more constrained responses to the inclusion of the Award.

4.4.3.3 Persistent barriers to nature connectedness

Simulations reveal that barriers to nature connectedness remain consistently high across all scenarios, even after the introduction of the John Muir Award. This persistence can be traced to the initial simulation conditions, which deliberately set high activation values for drivers that practitioners identified as key barriers to nature connectedness in children and young people. *Disabling community norms* (C3) is clamped at 0.8 across all scenarios. *Unsupportive organisation culture* (C14) is set at 1.0 for mainstream schools and 0.3 for specialist schools. The influence of the clamped driver concepts results in persistently high values for ordinary concepts identified as barriers to nature connectedness.

Even comparing specialist school scenarios 2a and 2b, where organisational culture is more supportive, the fundamental constraint imposed by *disabling community norms* at 0.8 maintains high values for barrier concepts. *Screen time* sits at 0.92 in scenario 2a and 0.90 in scenario 2b with the Award, while *peer aversion for nature* decreases from 0.87 to 0.72.

This persistence of adverse conditions demonstrates how driver concepts with high centrality and strong relationship weights can constrain system-wide improvements, limiting the magnitude of change achievable through single interventions. The strength and centrality of *disabling community norms* as a driver in our model means its influence permeates the entire system. As a result, concepts like *child-led outdoor play* show limited improvement. As the most central concept in both FCM variations, child-led play receives direct negative influence from multiple barrier concepts that remain persistently high due to the clamped driver conditions.

4.4.3.4 Scenarios exploring the enhancement of the John Muir Award

Simulation results from scenarios 1a through 4b suggest that improving school settings and introducing the John Muir Award does not shift the balance; the system remains characterised by high barriers rather than transitioning to one with relatively high opportunities for fostering nature connectedness. This subsection examines the results of two additional scenarios (5a and 5b) that explore potential enhancements to the Award, targeting plausible leverage points identified through the centrality analysis for respective age groups.

Scenario 5a explores the potential impact of the Award developing strategies to work more closely with parents and caregivers of children aged 8-11. To model this enhancement, I introduced a negative relationship between the Award and *parent/carer aversion to nature-related threats* (C9) with a weight of -0.5. This modification reflects a hypothetical version of the Award that actively engages parents in nature-based activities and education, potentially mitigating their aversion to nature-related risks. As noted in Section 4.3.2, *parent/carer aversion to nature-related threats* ranks third in centrality for children aged 8-11. This indicates a potential leverage point for this age group. The results show substantial improvements compared to scenario 1b (see Figure 15). *Nature connectedness* increases to 0.82 in scenario 5a compared to 0.72 in scenario 1b, while *child-led outdoor play* increases to 0.60 compared to 0.42 in scenario 1b. *Parent/carer aversion to nature-related threats* decreases to 0.30 compared to 0.66 in scenario 1b, while *parent/carer affinity for nature* increases to 0.56. Additional positive effects included reductions in *screen time* to 0.85 and increases in *perceived access to quality local natural space* to 0.55. By directly influencing an additional and highly central concept for children, this enhanced version of the Award leads to larger improvements in key outcomes.

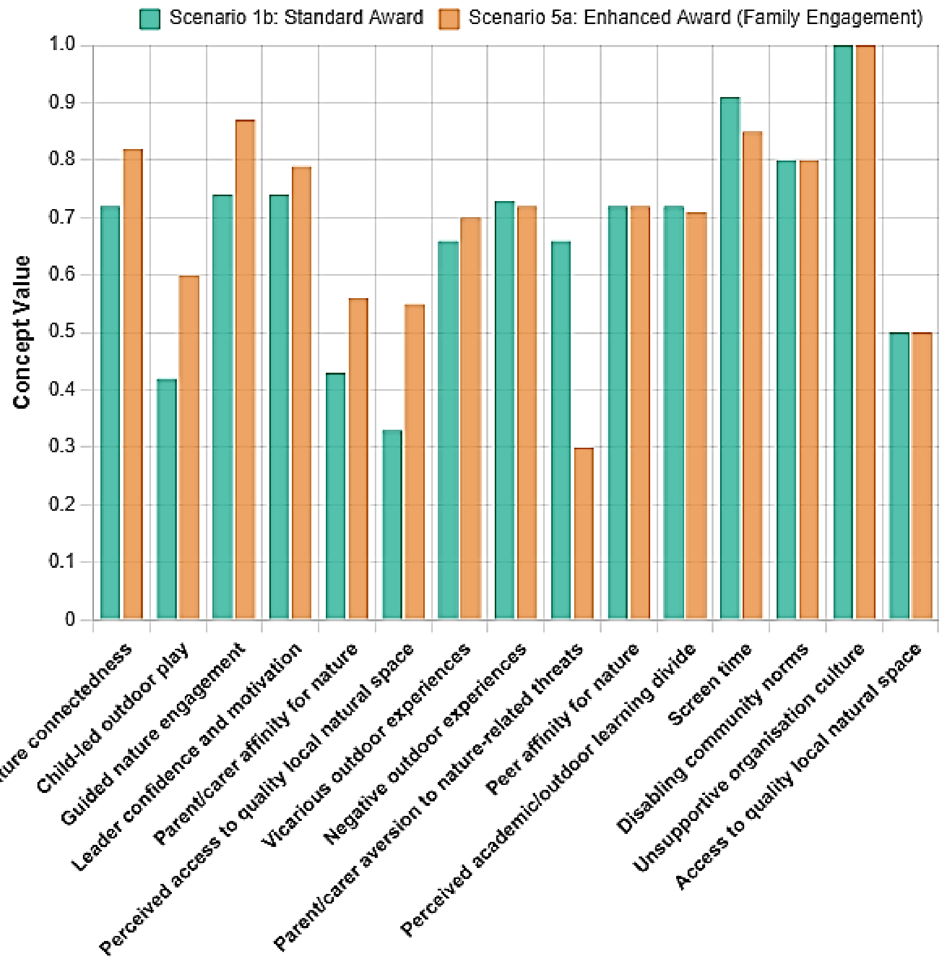

Figure 15. Simulation results comparing standard versus enhanced John Muir Award with family engagement: : This bar chart compares FCM simulation results for children aged 8-11 in mainstream schools with the standard John Muir Award (Scenario 1b, teal bars) versus an enhanced Award that includes family engagement (Scenario 5a, orange bars). The enhanced scenario explores what happens when the Award also reduces parent/carer aversion to nature-related threats.

Scenario 5b models the Award's potential to directly influence *child-led outdoor play* (C2) for young people aged 12-15, representing efforts to facilitate local advocacy and self-directed experiences. To model this hypothetical enhancement, I added a new relationship from the Award to *child-led outdoor play* with a weight of 0.4. The results show modest but meaningful improvements compared to scenario 3b.

Nature connectedness increases to 0.51 in scenario 5b compared to 0.41 in scenario 3b, while *child-led outdoor play* increasing from 0.07 to 0.21. *Guided nature engagement* increases to 0.60 compared to 0.53 in scenario 3b, while *leader confidence and motivation to deliver outdoor learning* rose slightly from 0.50 to 0.57.

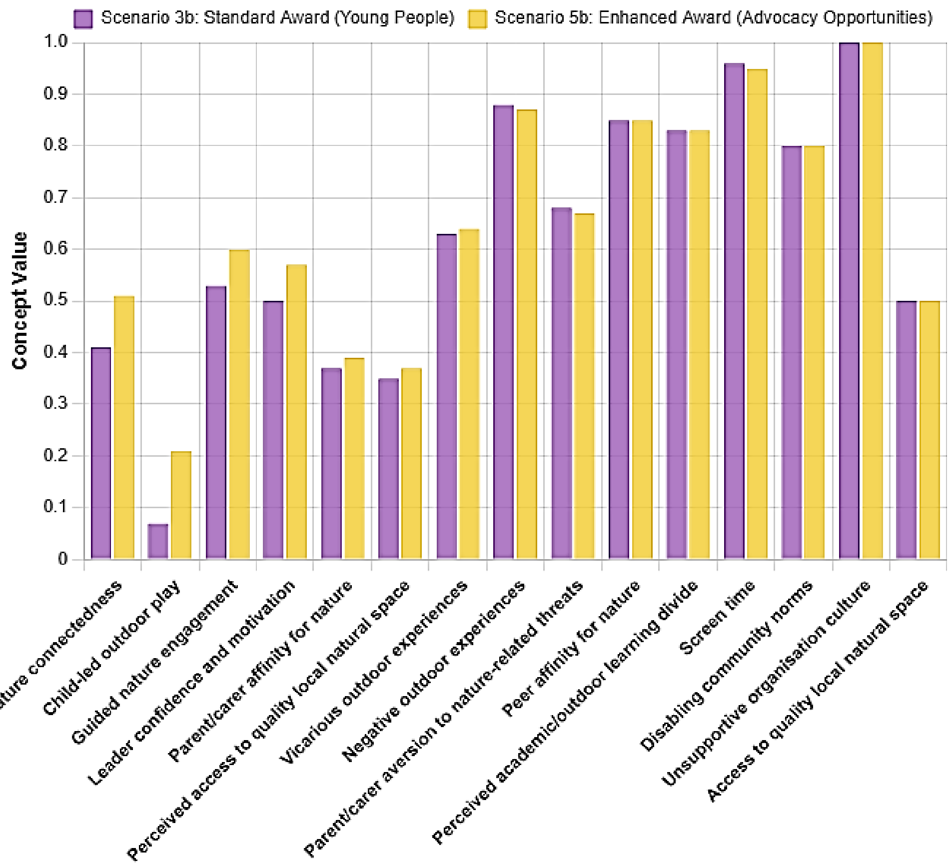

Figure 16. Simulation results comparing standard versus enhanced John Muir Award with increase advocacy opportunities : This bar chart compares FCM simulation results for young people in mainstream schools with the standard John Muir Award (Scenario 3b, purple bars) versus an enhanced Award that includes advocacy opportunities (Scenario 5b, yellow bars). The enhanced scenario explores what happens when the Award also directly increases autonomous experiences for young people by signposting advocacy opportunities.

While the improvements are less dramatic than those seen in the younger age group (Scenario 5a), they represent a still notable relative increase. Both enhancement scenarios demonstrate how targeting important age-specific concepts identified through the centrality analysis can amplify intervention effectiveness. The family engagement approach for children capitalises on the continued importance of parental influences at ages 8-11, while the advocacy approach for young people addresses their greater capacity for self-directed experiences and reduced parental dependency.

4.4.3.5 Scenarios with a decrease in disabling community norms

Simulation outcomes consistently demonstrated the pervasive influence of *disabling community norms* on the system's behaviour, often dampening the potential positive impacts of the John Muir Award and other facilitating factors. To further explore the sensitivity of our model and gain deeper insights into the role of community norms, I conducted additional simulations with progressively lower activation values for *disabling community norms*. This iterative approach further features the value of an adaptive FCM model and enables the examination of how the system might respond to gradual improvements in community attitudes towards nature engagement alongside the involvement of the Award. By systematically varying this influential driver, I aim to better understand the conditions under which interventions like the John Muir Award might be most effective, and how the system's behaviour changes as the broader social context becomes more conducive for fostering nature connection.

I conducted a series of simulations decreasing the activation value of *disabling community norms* from 0.7 to 0.2 in increments of 0.1, while maintaining all other initial conditions consistent with scenario 1b (Mainstream School with the John Muir Award for children).

As *disabling community norms* decreases from 0.8 to 0.2, there is a steady improvement in most concepts related to the fostering of nature connectedness. *Nature connectedness* increases progressively from 0.72 to 0.90, while *child-led outdoor play* rises from 0.42 to 0.80. *Guided nature engagement* advances from 0.74 to 0.89, and *leader confidence and motivation* (C5) grows from 0.74 to 0.92. Changes appear to be relatively linear, without any sudden jumps or tipping points. A key transition point appears take place *when disabling community norms* is clamped at 0.5, where most facilitators of nature connectedness begin to have higher values than most barriers, with the notable exception of *screen time* and *unsupportive organisation culture*. *Nature connectedness* reaches 0.84, while *negative outdoor experiences* decreases to 0.61 and *peer aversion for nature* drops to 0.63.

Guided nature engagement starts at a much higher level (0.74) compared to *child-led outdoor play* at 0.42. This is due to the direct impact of the Award on *leader confidence and motivation*. However, as community norms improve, the values for *guided nature engagement and child-led outdoor* play converge, with child-led play nearly catching up to by the end of the simulation.

While the driver *access to quality local natural space* (C1) is clamped at 0.50, *perceived access* (C11) increases substantially from 0.33 to 0.71. This reflects practitioners' view that community norms significantly influence how people perceive their environment, potentially more than the actual physical access.

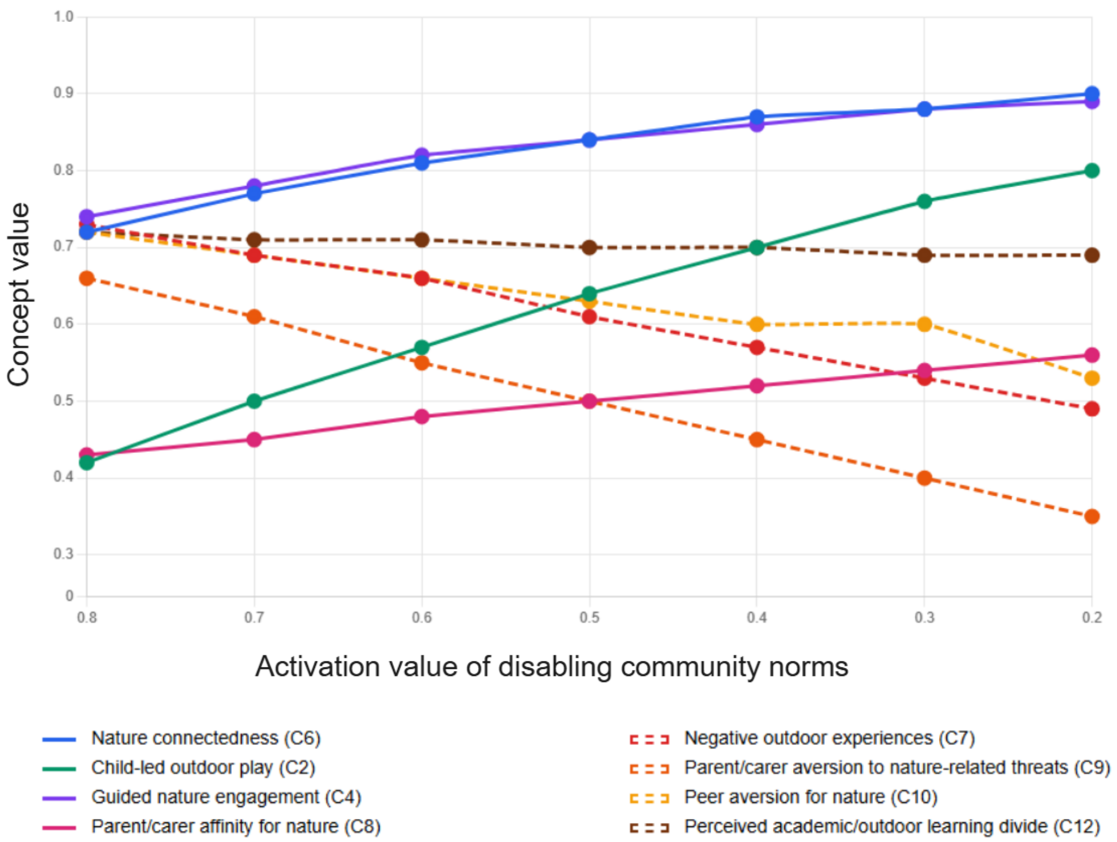

Figure 17. System responses to progressive reduction of disabling community norms : This figure illustrates how key system concepts respond to systematic decreases in disabling community norms (C3) from 0.8 to 0.2, while maintaining the John Muir Award and all other conditions consistent with scenario 1b. Solid lines represent facilitating concepts that support nature connectedness development, while dashed lines represent barrier concepts that impede it.

These progressive scenarios reveal how reducing this single influential driver may shift system-wide outcomes. When community norms become more supportive, the Award's positive contributions may propagate more effectively throughout the system, enabling facilitating factors to outweigh persistent barriers and creating conditions more conducive to sustained nature connectedness development.

4.5 Chapter Summary

In this chapter, I set out to explore the complex system shaping nature connectedness in Scottish children and young people through the static and dynamic analysis of the aggregated FCM developed by Scottish outdoor learning practitioners. To address each of my three research questions, I have translated practitioners' broad perspectives into a visual and mathematical representation of the system, identified key concepts and potential leverage points, and simulated the John Muir Award's impact under various scenarios.

The aggregated FCM, comprising 15 key concepts and 38 relationships, revealed *child-led outdoor play*, parental influences, *guided nature engagement*, and *nature connectedness* itself as the most central ordinary components of the system. Dynamic analyses demonstrated the John Muir Award's positive impacts across different contexts, while also highlighting age-related differences and the pervasive influence of community norms. These findings underscore both the potential and limitations of interventions like the Award in fostering nature connectedness.

While the FCM methodology proved valuable in integrating practitioner knowledge and simulating complex system dynamics, it also revealed limitations that require critical examination. The model's inability to capture temporal changes and long-term impacts became evident, particularly when attempting to represent age-related shifts in concept importance. That said, these limitations and inconsistencies demonstrate the FCM's functionality as a novel tool for iteratively refining and clarifying our understanding of the system, bringing to light faulty or incomplete reasoning.

In the following chapter, I critically examine these findings, exploring their significance for the John Muir Award and for broader efforts to connect children and young people with nature in Scotland and beyond. I pay particular attention to the strengths and limitations of my FCM methods, considering how future research might address gaps and further refine understandings of this complex system.

Chapter 5 Discussion

5.1 Chapter Overview

This discussion chapter interprets and contextualises the previous chapter's findings within the broader literature on nature connectedness and outdoor learning interventions. I argue that the participatory FCM process and the final aggregated model mark a crucial step toward understanding the complex formation of nature connectedness in children and young people and clarifying the potential contributions of the John Muir Award as part of a complex social-ecological system (SES).

This chapter is structured to address my three research questions in turn. For each question (RQ1, RQ2, RQ3), I provide an initial interpretation of results and discuss their significance as a novel contribution to the wider field. As this study is the first to use FCM for the study of nature connectedness, I critically evaluate its methodological advantages and limitations to inform future study. While limited to eliciting the static perspectives of a select group of practitioners, I maintain that this study represents exciting 'gateway research' and is well-positioned to support further learning among both researchers and stakeholders (Barbrook-Johnson and Penn, 2022).

The iterative and collaborative nature of the FCM development process, combined with the inherent complexity of nature connectedness as a topic, raised several interesting themes and tangential questions. Semi-structured conversations with practitioners produced substantial qualitative data on their varied and evolving understanding of the important factors and dynamics that influence nature connectedness in Scotland. It is beyond this study's scope to address all findings. I have therefore sought to limit this chapter to the discussion of results directly relevant for each of my three research questions. Before engaging in an in-depth discussion of my study's findings, I briefly retrace the research narrative up to this point.

5.2 Summary of research narrative

This research is situated at the intersection of urgent environmental and health concerns stemming from humanity's fractured relationship with nature. As noted in Chapter 2, there is a growing call among scholars for approaches that can capture the complexity of human-nature relationships, moving beyond mechanistic thinking toward complex systems perspectives. This shift in thinking, implemented through SES research, is particularly relevant for understanding how outdoor learning interventions like the John Muir Award might contribute to lasting nature connectedness in Scottish children and young people.

My review of the wider literature identified a consequential gap: while a growing body of research documents the immediate benefits of outdoor learning on nature connectedness, understanding of how these interventions contribute to lasting connectedness remains severely limited by methodological constraints and a tendency towards linear thinking. Traditional approaches have typically located impact primarily within intervention components rather than examining how those components interact with broader system dynamics. Although researchers regularly call for complex systems thinking in outdoor learning and nature connectedness studies, the practical application of these approaches has been limited (Jucker et al., 2022; Richardson, 2023, 2025). Due to a lack of longitudinal empirical data on the causes of lasting connectedness, I sought to elicit the shared knowledge and experience of outdoor learning practitioners as the best available source. This gap led to the formulation of three research questions:

> RQ1: According to outdoor learning practitioners, what is the complex system shaping Scottish children and young people's lasting nature connectedness?
>
> RQ2: What concepts do practitioners consider most important for shaping nature connectedness and may serve as strategic leverage points?
>
> RQ3: How can we simulate the system to explore the lasting impact of the John Muir Award under different plausible scenarios?

After evaluating various systems modelling approaches, Fuzzy Cognitive Mapping (FCM) was selected for its unique capacity to integrate diverse practitioner knowledge while supporting quantitative analysis and simulations. In chapter 3, I detailed collaborative development of the FCM through workshops, interviews, and validation with Scottish outdoor learning practitioners, resulting in an aggregated model representing their shared understanding of the complex system shaping nature connectedness.

Chapter 4 presented the findings from this process, including a visual representation of the complex system, a static analysis identifying the most central concepts and potential leverage points for both children and young people, and dynamic simulations exploring the John Muir Award's impact under different scenarios.

5.3 RQ1: The Complex System Shaping Nature Connectedness

RQ1 aims at capturing outdoor learning practitioners' shared knowledge and perceptions of the complex system shaping Scottish children and young people's lasting nature connectedness. This foundational objective required descriptive knowledge that could capture the system's context-specific composition, connections and dynamics in a structured representation (Biggs et al., 2021).

The FCM process answered this grounding question by producing an aggregated diagram that makes explicit the key components and relationships practitioners perceive as most influential in shaping nature connectedness. To summarise, the participatory FCM process resulted in the identification of a complex system characterised by:

- 15 key concepts and 38 causal relationships that outdoor learning practitioners perceive as shaping nature connectedness in Scottish children and young people.

- Three driver concepts (*access to quality local natural space*, disabling community norms, and *unsupportive organisation culture*) that exert unidirectional influence

- Twelve ordinary concepts that both influence and are influenced by other concepts
- No receiver concepts, indicating that all system elements participate in feedback relationships
- A relatively sparse network (density of 0.18) reflecting practitioners' selective focus on the most salient relationships
- Three direct pathways to nature connectedness: *child-led outdoor play*, *guided nature engagement*, and *negative outdoor experiences*
- Age-specific variations in relationship strengths between children (8-11) and young people (12-15)

The following discussion of RQ1 seeks to broadly interpret and contextualise how practitioners understand the complex system shaping nature connectedness. While there is much more I could analyse about specific concepts and relationships, my primary objective here is to demonstrate how the FCM bridges existing research approaches and focuses attention on the dynamic nature of variables typically studied in isolation. This foundational understanding of system structure, nonlinear dynamics, and age-related changes is essential for interpreting how interventions like the John Muir Award operate within this complex context. The analysis of leverage points and intervention impact follows in my discussion of results pertaining to RQ2 and RQ3, where I draw specific implications for outdoor learning practice.

5.3.1 Interrelationships

In Chapter 2, I identified a critical gap in nature connectedness research: while scholars increasingly acknowledge complexity in theory, the dominant methodological approaches (including population-level surveys, evaluations of single determinants, and mixed retrospective studies), continue to examine factors in isolation rather than as interconnected systems. These approaches, often underpinned by mechanistic assumptions about linear causality and intervention effectiveness, struggle to capture the dynamic relationships and feedback loops that shape lasting connectedness (Section 2.4.3). This gap presents an opportunity for complex system modelling to complement and reframe findings from existing research traditions. The absence of 'receiver' concepts indicates that no factor in this system is understood as a dead end. Every variable, including nature connectedness itself, is modelled to feed back to influence the conditions that shaped it.

5.3.1.1 The FCM as a bridging approach

In answering RQ1, the FCM developed in this study offers a strategic middle ground that builds upon and connects insights from established approaches in nature connectedness research: literature reviews, population-level surveys, and mixed-method case studies.

Comprehensive literature reviews and meta-analyses (Chawla, 2020; Lengieza and Swim, 2021) provide invaluable synthesis of disparate research and identify numerous potential influences on nature connectedness. These reviews have been essential for establishing the foundational knowledge upon which this study builds. However, these synthesising approaches typically organise variables into thematic categories with limited explanation of how factors interact dynamically across contexts.

Chawla's (2020) conceptual diagram illustrates this challenge well, organising variables into themed clusters connected by single, unidirectional arrows, with individual variables within each cluster remaining disconnected from one another (Figure 18). This approach effectively summarises diverse research but is not designed to capture the complex interplay between factors—a limitation Chawla acknowledges when calling calls for more sophisticated research examining bidirectional relationships, mutual reinforcement, and complex developmental pathways.

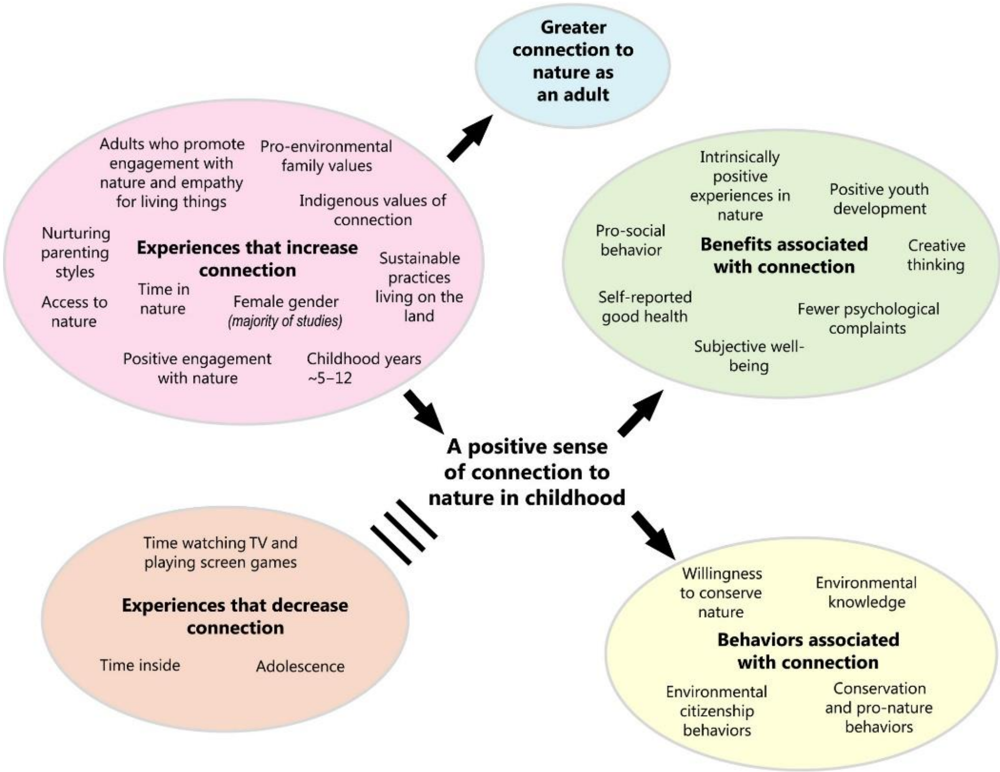

Figure 18. Contributions to nature connection in childhood and associated benefits and behaviours (Chawla, 2020, p. 630).

Large-scale cross-sectional studies face similar challenges. For example, research using the Monitor of Engagement with the Natural Environment (MENE) dataset (Richardson et al., 2019; Hughes et al., 2019) has established significant associations between nature connectedness and variables like socioeconomic status, gender, age, and urbanisation. Their statistical power enables identification of important population-level patterns, but, as I note in Chapter 2, these studies often struggle to distinguish direct determinants from proxy variables or to explain the causal mechanisms underlying these associations (Richardson, 2023).

At the other end of the spectrum, in-depth mixed-method investigations of specific relationships and contexts provide greater nuance. Studies examining select determinants—such as Soga et al. (2018) on barriers to children's nature experiences, Ahmetoglu (2019) on parental influence, and Michaelson et al., (2020) on screen technology use—offer nuanced analyses of specific causal relationships. Similarly, case studies of interventions or demographics yield rich contextual understanding, often observing seemingly contradictory findings from population-level studies (Price et al., 2022). While valuable for their depth, these focused studies necessarily examine factors within narrowly defined boundaries, making it difficult to connect their insights to broader systemic processes.

The FCM provides a new perspective by deliberately operating at a meso-level of abstraction (see boundary diagram in Chapter 3), creating space to explore how specific factors interact without losing sight of the broader system context. That said, the model is limited in both breadth and depth compared to the above approaches.

The model's final iteration of 15 concepts makes for a compact list of determinants compared to comprehensive reviews. The model’s boundaries are evident in practitioners' choice of three self-reinforcing drivers: *access to quality local natural space* (C1), *disabling community norms* (C3), and *unsupportive organisation culture* (C14). While these concepts acknowledge different spheres of influence stemming from physical environments, social attitudes, and organisational policies, they serve as proxies for macro-level processes beyond the study's scope. Country-level factors influencing connectedness, for example, are intentionally excluded from the model (Richardson et al., 2022; Soga and Gaston, 2025).

Likewise, the model's relatively sparse density score of 0.18 reflects practitioners' selective focus on relationships they consider most consequential for lasting connectedness. The FCM includes only three concepts that directly influence nature connectedness: *child-led outdoor play*, *guided nature engagement*, and *negative outdoor experiences*. These concepts necessarily generalise diverse experience types and activities documented in the literature, while also simplifying the complex individual psychological processes described in environmental psychology research, such as the 'pathways to connectedness' (Lumber et al., 2017). With these constraints in mind, the FCM's distinct contribution lies not in replacing these methods but in explicitly mapping causal interrelationships between factors that other approaches typically study in isolation.

5.3.1.2 From isolated factors to interconnected networks

With 37 connections, an average of 2.5 per concept, the model locates otherwise isolated factors into an interconnected network where each element influences and is influenced by multiple others with varying degrees of strength. This shift from categorisation to explicit causation within an interconnected network addresses a critical evolution in the field's understanding.

As I note in Chapter 2, research has moved away from suggesting that mere contact with nature is sufficient on its own to increase nature connectedness (Section 2.4.2). Nature connectedness researcher have developed a more nuanced understanding of how individuals must engage with nature on an emotional level to build meaningful relationships, pushing research toward more sophisticated explanations of the kinds of experiences and aspects of interventions that shape this emotional engagement (Sheffield et al., 2022; Lumber et al., 2017).

However, as I argued in Section 2.4.3, insufficient attention has been given to the many interacting factors beyond experiences at the individual and intervention level (Beery et al., 2023; van Heel et al., 2023). The FCM addresses this gap by revealing how seemingly straightforward relationships become complex when viewed within their broader system context.

Consider how practitioners expressed their understanding of how access to nature operates within the model's interconnected structure. The FCM upholds the importance of *access to quality local natural space* (C1) as captured by population-level cross-sectional studies (Lin et al., 2014; Bratman et al., 2019) but positions this as only part of a broader puzzle. Practitioners distinguished between objective access and *perceived access to quality local natural space* (C11), capturing the more nuanced subjective element that links physical availability to meaningful engagement through *child-led outdoor play* (C2) and *guided nature engagement* (C4).

This objective-subjective distinction reveals why identical physical conditions produce different connectedness outcomes. It is compatible with Soga and Gaston's (2022) conceptual framework which distinguishes between physical opportunity (actual availability of environments) and social opportunity (family values, norms, public safety concerns). This interconnected view provides explicit causal logic for why leading scholars like Richardson (2023) argue that policy focused solely on improving access often fails to produce lasting connectedness.

According to practitioners, *disabling community norms* (C3) reduce *perceived access* (-0.5 weight) by conveying messages that nature spaces are inappropriate, unsafe, or irrelevant for children. Conversely, *guided nature engagement* (C4) increases *perceived access* (+0.3 weight) by helping children recognise and appreciate natural opportunities through structured positive experiences. This dynamic reveals why identical physical environments can be perceived as welcoming or threatening depending on the social and experiential context surrounding each child.

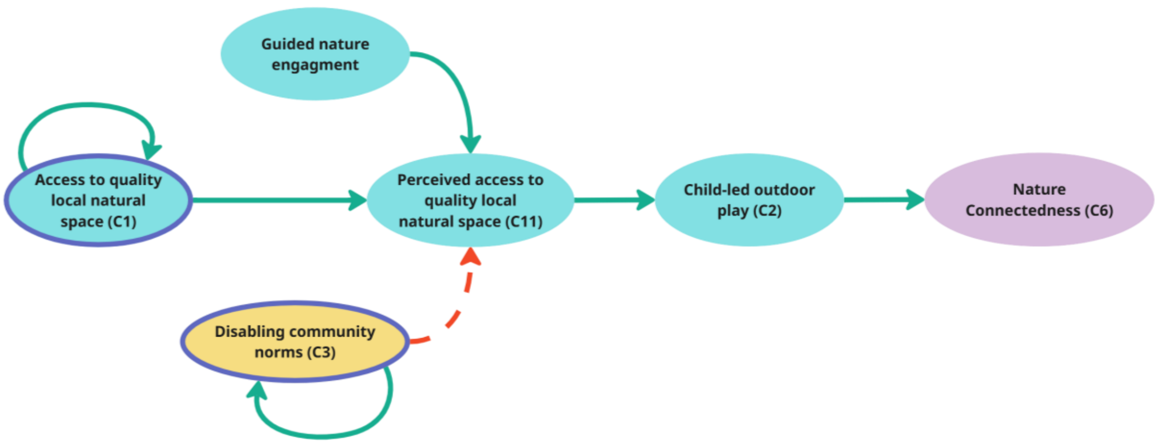

Figure 19. Simplified pathway from access to nature connectedness :This diagram illustrates the primary causal pathway through which access to quality local natural space leads to nature connectedness, showing how perceived access enables child-led outdoor play. Green arrows show positive causal relationships. The red dashed arrow represents a negative relationship

Additional layers of complexity and tension within different spheres of influence expand this understanding of context further. The model reveals how contradictory forces can operate simultaneously within the same domain, creating push-pull dynamics that shape children's nature experiences. *Unsupportive organisation culture* (C14) may devalue outdoor learning within schools, while *individual leader confidence and motivation* (C5) can simultaneously promote nature engagement, creating institutional tensions. Likewise, rather than labelling parental influence as either positive or negative, the model allows for parents to harbour genuine appreciation for nature alongside safety concerns about local environments. *While parent/carer affinity for nature* promotes both guided experiences and outdoor play, *parent/carer aversion to nature-related threats* restricts access and increases time indoors (*screen time*). These are co-existing tensions that the child may encouter.

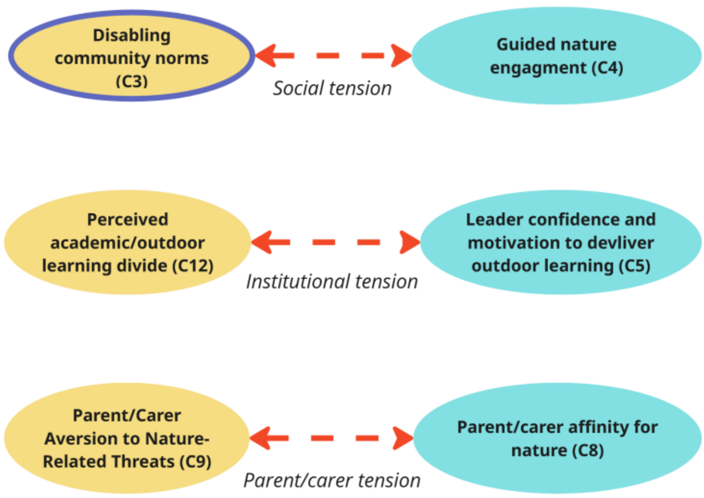

Figure 20. Tensions within spheres of influence shaping nature connectedness : This diagram highlights three key tensions identified by practitioners, where opposing forces within the same domain simultaneously enable and constrain children's nature experiences. Yellow ovals represent constraining factors while blue ovals represent enabling factors within each sphere of influence. Red dashed bidirectional arrows indicate situations where these opposing forces coexist and interact within the same domain.

This interconnected view demonstrates how different spheres of research literature—studies of community attitudes, parental influence, educational contexts, and individual experiences—operate as cross-scale, competing and reinforcing forces within a single dynamic system (van Heel et al., 2024). An appreciation of this wider context means avoiding black-and-white explanations, revealing how seemingly contradictory research findings reflect the inherent complexity of navigating multiple simultaneous influences on nature connectedness development (Jucker et al., 2022).

5.3.2 Nonlinear dynamics

In Chapter 2, I introduced nonlinear dynamics as a key principle of complex systems, where outcomes emerge from bidirectional relationships and feedback loops that allow changes to cycle through the system (Folke et al., 2016; Berkes et al., 2003). This principle is highly relevant for the study of lasting nature connectedness as researchers consistently emphasise repeated active psychological engagement over time, particularly during formative periods of childhood (Barrable and Booth, 2020; Barragan-Jason et al., 2021; Sheffield et al., 2022). Through RQ1, I sought to elicit practitioners' understanding of these ongoing, cyclical processes that shape lasting nature connectedness, moving beyond linear cause-and-effect thinking to capture how concept may reinforce or undermine each other over time.

The FCM results reveal practitioners' understanding of nature connectedness as nonlinear. With 12 ordinary concepts and no receiver concepts, the model represents a system where all concepts (except drivers) both influence and are influenced by others. *Nature connectedness* (C6) itself is represented as an ordinary variable with both incoming and outgoing relationships (see Figure 3). This structural choice reflects practitioners' understanding that connectedness is not simply a passive outcome to be measured, but an active force that shapes ongoing experiences and perceptions. The model's emphasis on cyclical relationships avoids what Ives et al. (2017) identify as an artificial division in the literature between studies examining either causes or consequences of nature connectedness. This division obscures the reality of continuous cycles where connectedness comes from experiences while simultaneously motivating and shaping future engagement patterns (Ives et al., 2017).

5.3.3 Age-related changes

Beyond cyclical relationships, the FCM captures a further temporal dimension by representing changes in relationship strength as children mature into adolescence. By creating two variations of the model with differing relationship weights, practitioners expressed their understanding that the causal pathways shaping nature connectedness shift in their degree of influence between ages 8-11 and 12-15.

Variations in causal weights operate across scales, highlighting both anticipated changes in children's developmental psychology as well as shifts in external pressures. Some of the most substantial changes occur in social relationships: peer influence on outdoor play doubles its impact (from -0.4 to -0.8), while parental influence simultaneously decreases on both guided experiences and outdoor play (from 0.7 to 0.4 and 0.8 to 0.4 respectively).

These shifts in influence, though simplified, provide causal explanations for the well-documented 'adolescent dip' in nature connectedness (Richardson et al., 2019; Price et al., 2022). The model reveals how adolescents face increasingly challenging conditions as peer pressure intensifies and parental influence weakens. These insights align with population-level survey findings while exploring multiple mechanisms behind the patterns they observe (Richardson et al., 2019; Price et al., 2022). By focusing on cyclical relationships, the model challenges deterministic thinking. As Richardson (2023) and Price et al. (2022) emphasise, age itself does not inevitably reduce connectedness and there are numerous exceptions observed despite the averaged trend.

The model could also serve as a critique of views which may overemphasise the asymmetrical impact of early childhood experiences on lasting connectedness (James and Bixler, 2023). While children may be less susceptible to disabling norms and peer pressures, providing nature connecting experiences in childhood offers no guarantee of lasting connectedness if wider system dynamics do not continue to support and develop the progress made in early years.

This aligns with James and Bixler's (2023) critique of significant life experience (SLE) research, noting that retrospective studies often focus on memorable childhood experiences while neglecting the many changes and more varied experiences encountered throughout adolescence and adulthood. According to practitioners, such changes may include shifting peer influences that discourage outdoor engagement, increasing academic pressures that limit time for nature experiences, weakening parental support as children gain independence, and persistent community norms that devalue outdoor play. Rather than a one-time fix, the FCM presents connectedness development as an ongoing process where reinforcing feedback relationships determines whether temporary gains become lasting relationships with nature.

The FCM successfully exemplifies how systems thinking avoids deterministic conclusions, providing explanations for both population-level trends and individual exceptions that vary depending on the broader and changeable social-ecological context surrounding each child. It represents a step towards answering Chawla’s (2020) call for future research that "link[s] children's relations with the natural world to theory grounded in basic processes of child development” (Chawla, 2020, p. 636).

However, the discussion of age also highlights substantial limitations in the FCM's capacity to represent system adaptation over time. As I note in Section 5.5.4, the FCM may underrepresent the importance of memory and developmental psychology that is legitimately time-sensitive during formative periods. As noted in Chapter 2, while there is little evidence for one-off experiences determining long-term connectedness, certain time periods and experiences may still serve as powerful catalysts that the current model cannot adequately capture because it is fundamentally a bounded and static model.

5.3.4 Evaluating FCM for capturing practitioner understanding of complex system dynamics

While the aggregated FCM offers valuable insights into practitioners' understanding of the complex system shaping nature connectedness, critical examination of methodological limitations is essential for properly interpreting findings for RQ1. This section raises three key limitations specific to using FCM for eliciting practitioners' knowledge: challenges in knowledge aggregation and validation, the researcher's role in co-production, and FCM's limitations in representing age-related dynamics. Additional limitations more relevant to structural analysis (RQ2) and scenario simulations (RQ3) will be addressed in later sections.

5.3.4.1 Challenges in knowledge aggregation and validation

A simultaneous strength and limitation of this study stems from its epistemological foundation: the FCM represents a specific group of practitioners' perceptions rather than objective reality. As Penn et al. (2013, p.426) note, "an FCM is at its heart a representation of the opinions of a particular group of stakeholders on the causal structure of their system and as such cannot be separated from its intersubjective context." Thus, when I argue that FCM serves to bridge the scope and findings of other research approaches, I am referring to its capacity to elicit how a specific group of practitioners connects the dots between disparate knowledge.

Having already established FCM's epistemological premise in Chapter 3, I now critically evaluate the extent to which my application of the method accurately captured practitioners' views. I intentionally selected a small sample of practitioners (n=17), grouped together by their work in Scotland and use of the John Muir Award, to facilitate in-depth discussion and manageable data analysis. However, even within this relatively homogeneous group, there was ample room for differences in perspectives and priorities. In the initial workshop, for example, each table produced maps with distinct emphases: one table focused primarily on social justice dimensions, another on environmental issues, and a third on child-centred factors. These distinctions emerged organically through practitioner self-organisation rather than being predetermined by the research design.

It is notable that some studies have used FCM to expressly identify areas of overlap and disagreement between the mental models of different stakeholder groups and individuals (Özesmi and Özesmi, 2003; Gray et al., 2014; Edwards and Kok, 2021). However, this was not an objective of my study; I aimed to create a single aggregated map to examine the impact of the John Muir Award. Rather than compare and aggregate multiple models, which would have helped to identify differences in concepts and relationships most frequently referenced or excluded, I opted to have practitioners contribute to and refine the same model. This collaborative process was designed to provide frequent opportunities for practitioner critique and validation. Minor rhetorical differences were ironed out as the model developed and shared learning was encouraged as practitioners reflected on the views on other participants (van Vliet et al., 2010).

However, it is also likely that my prioritisation of aggregation and parsimony likely obscured nuances and variations in practitioners' understanding. In early iterations of the model, *gender*, for example, was put forward by some practitioners as an important concept. Some practitioners suggested that *gender* significantly shapes nature experiences, with boys being more interested in and encouraged towards riskier outdoor play while girls might be engaged in more contemplative activities. Others questioned *gender*'s relevance, suggesting that gendered behaviour and norms are primarily applicable for teenagers. This tension remained unresolved as the model developed and mirrors an ongoing discussion in the wider literature; results related to gender differences are inconsistent (Chawla, 2020; Colley et al., 2022).

For this study, *gender* as an individual attribute (personal identity and characteristics) fell outside the model's scope, which focuses on meso-level influences rather than individual differences. However, *gender* as a set of context-specific social pressures and expectations could still be represented by changes to concepts such as *disabling community norms*, *parent/carer aversion to nature-related threats*, and *peer aversion to nature*.

5.3.4.2 Dealing with persistent and uncomfortable uncertainty

I have argued that FCM is an exciting method for the study of nature connectedness because it is unencumbered by a scarcity of longitudinal empirical data when developing an explanation of dynamic causation. Incomplete assumptions and contradicting views are reframed as opportunities for discussion and shared learning (Jetter and Kok, 2014: Montano et al., 2025). That said, FCM does not magically remove the inherent uncertainty and partiality in practitioners' understanding (Barbrook-Johnson and Penn, 2022). As noted in Chapter 3, the term ‘fuzzy’ refers to the method’s capacity to work with imprecise human judgments about causality rather than requiring exact empirical measurements (Jetter and Kok, 2014). Given the high complexity and uncertainty that characterises nature connectedness development, practitioners themselves were often cautious about making causal claims and frequently qualified statements with phrases like ‘I suppose’, ‘I think’, and ‘maybe’.

While the ‘fuzziness’ that characterised practitioner knowledge came as no surprise, an unforeseen challenge was convincing participants that the map is intended to be iterative. Many practitioners appeared hesitant to commit their perspectives to paper, possibly concerned about oversimplification or the potential for public criticism of their reasoning. During the workshop, each table of participants chose to draw the connections between concepts in erasable pencil instead of pen or marker, suggesting they valued the ability to revise their thinking as discussions evolved.

This hesitancy among participants was somewhat mitigated during the workshop merging process and individual interviews when I facilitated the discussion. However, some still expressed discomfort with translating qualitative views about the relative strength of relationships into numerical values, finding it difficult to make generalised claims about children's variable circumstances. Participants would have benefited from regular reminders that the mapping process is intended to be iterative and would be refined over time (Penn and Babrook-Johnson, 2019).

5.3.4.3 Potential for researcher bias

As noted in Chapter 3, FCM studies are conducted on a spectrum of co-production and few can claim to be entirely stakeholder-led (Jetter and Kok, 2014). My participation in the model development, though necessary for model functionality, must still be acknowledged as introducing interpretive layers beyond pure practitioner knowledge (Olazabal et al., 2018).

I found the model development required me to make many micro-decisions whose consequences were not always apparent to practitioners (Olazabal et al., 2018). When consolidating over 100 initial concepts into 15 generalised concepts, I necessarily made numerous interpretive judgments about concept similarities and definitions. This was especially apparent for technical decisions like the selection of matrix equations and calibration, which can have significant impact on how the model functions during scenarios (Penn et al., 2013).

In some cases, I added concepts and relationships to improve the model's functionality. *Negative outdoor experiences*, for example, was added to ensure the model didn't have a positive bias and could simulate decreases in nature connectedness. This was inspired by practitioners having noted a range of factors that may directly decrease connectedness levels (feeling unsafe, discomfort, bad weather), but they had only drawn positive relationships that directly impact nature connectedness.

To mitigate the risk of researcher bias, I documented model changes and sought validation at each development stage (see Appendix 3). Validation involved: retracing the map's causal logic with practitioners during workshop sessions to confirm it represented their collective understanding; showing individual practitioners the evolving merged map during interviews to gather feedback on concept definitions and relationship accuracy; and providing practitioners with an interactive online version of the final aggregated model to review, with guiding questions about concept definitions, relationship explanations, and missing elements. However, this approach to validation greatly depends on practitioners' availability and willingness to engage critically with the model. When soliciting feedback on the final map, most practitioners offered minimal comments and suggested no substantial changes beyond refining some concept definitions. While the absence of critical feedback may indicate a successful representation of their perspectives, it could equally reflect the presence of barriers to sustained engagement in participatory modelling, including time constraints, technical complexity, and cognitive fatigue (Knox et al., 2023).

If more time and resources had been available, I would have sought additional opportunities for feedback and discussions with practitioners, both in groups and individual interviews. More targeted questions about specific relationships or concept definitions would have increased confidence that the model had been fine-tuned to accurately reflect practitioner understanding. I would have also liked to explore practitioners' views on the potential utility of the model for their future work, whether they envisioned using it for planning interventions, communicating with stakeholders, or reflecting on their practice. Following the lead of van Vliet (2010), a questionnaire could have been offered to further gage practitioners’ confidence in the model structure and identify any changes in their perceptions that took place over the course of model development.

It would have also been interesting to test the model's broader applicability by engaging a different cohort of practitioners—perhaps from England—to examine the model structure and incorporate and compare their perspectives (Jetter and Kok, 2014). This cross-validation approach, as used by Penn et al. (2013) and Edwards and Kok (2021), could have revealed whether the conceptual relationships identified by Scottish practitioners resonated across different geographical, economic, and cultural contexts. Unfortunately (and fortunately), the practical constraints of doctoral research necessarily limited the number of feedback rounds, stakeholders, and model iterations possible.

5.3.4.4 Limited capacity to represent age-related changes

As discussed in Chapter 3, no complex systems methods can fully capture all dimensions of a complex system. FCM is no exception. I will discuss limitations regarding self-organisation, adaptation, and emergence more fully when discussing RQ3, but for RQ1, the most glaring limitation concerns the model's representation of age-related changes in nature connectedness development.

Creating separate models for children (8-11) and young people (12-15) allowed practitioners to articulate key differences in developmental influence. However, this approach suggests that when a child turns 12, their sources of influence abruptly shift from one configuration to another, a representation that contradicts practitioners' and the wider literature’s more nuanced descriptions of gradual, individualised development over time (Sheffield et al., 2023; James and Bixler, 2023).

Creating multiple FCM variations for narrower age intervals might have captured more gradual transitions but would have required exponentially more time for knowledge capture and analysis. Even with additional variations, the static maps cannot represent continuous developmental processes, only discrete snapshots of system states (Jetter and Kok, 2014). Moreover, an increase in model granularity would potentially decrease the usefulness and plausibility of generalised differences between age groups. While it is relatively straightforward to make sweeping claims about the developmental differences of an 8 and 15 year old, there is likely too much variation to convincingly generalise the difference between how a 15 and 16 year old relate to nature.

The two-variant approach ultimately represents a pragmatic compromise between methodological feasibility and developmental nuance. It provides sufficient distinction to explore general differences in how nature connectedness forms at different developmental stages without overextending the methodology beyond its intended purpose as a thinking tool for exploring practitioners’ shared understanding.

5.3.5 Discussion of RQ1 summary

The FCM represents outdoor learning practitioners' collective understanding rather than objective reality, captured through a process that inevitably involved compromise and researcher interpretation. Its static nature limits representation of temporal dynamics. Its parsimonious and static structure, limited in both breadth and depth, cannot capture the full complexity practitioners described or replace insights gained from more traditional methods.

Despite these limitations, the FCM successfully answers RQ1 by eliciting practitioners' understanding of the multiple variables, interrelationships, feedback loops, and age-related changes that shape nature connectedness in Scottish children and young people. This represents a meaningful contribution to nature connectedness research eliciting the causal logic that guides practitioners' work. The FCM presents a network of interconnected and cyclical influence to inform non-deterministic explanations for both population-level trends and individual-level exceptions.

Having set this foundational interpretation and critique of the complex system described by practitioners, I now examine how this ‘thinking tool’ may offer strategic insights for better understanding the role of specific outdoor learning interventions (Penn et al., 2013; Jetter and Kok, 2014; Barbrook-Johnson and Penn, 2022). RQ2 and RQ3 shift focus from broad description of the system to specific questions about leverage points and intervention impact, exploring how the John Muir Award might contribute to lasting nature connectedness within the dynamic context practitioners have described.

5.4 RQ2: Identifying strategic leverage points for nature connectedness

As noted in Section 2.4.4, the concept of leverage points has gained traction in nature connectedness research, though its application has predominantly focused on positioning nature connectedness itself as a lever for broader societal transformations towards greater health and sustainability (Abson et al., 2017; Ives et al., 2018; Richardson et al., 2020; Riechers et al., 2021a, 2021b).

Richardson et al. (2020) apply the seminal work of systems theorist Donella Meadows (1999) to show how fostering nature connectedness via different pathways could catalyse transformations across multiple system levels, yet their focus remains on nature connectedness as the intervention rather than examining what drives and sustains connectedness formation itself.

While researchers acknowledge that lasting nature connectedness comes from numerous, interrelated factors over time (Section 2.4.3), analysis of which factors might serve as context-specific leverage points is notably absent. This gap motivated RQ2, asking which leverage points offer the greatest potential for fostering lasting nature connectedness in Scottish children and young people.

By calculating degree centrality scores for all 15 concepts, static analysis identified which factors practitioners perceive as most influential within the complex web of relationships shaping nature connectedness. The following subsections interpret these findings, first summarising the results (5.4.1), then examining how the highest-centrality concepts function as potential leverage points for intervention design. This discussion considers both the usefulness and limitations of using degree centrality as a measure for leverage potential, demonstrating how systems mapping may provide initial guidance for practitioners seeking to foster lasting nature connectedness with limited resources.

5.4.1 Summary of Static Analysis Results

The static analysis in Chapter 4 calculated degree centrality scores for all concepts in both age group variations. While all 15 concepts in the FCM were selected by practitioners as important, static analysis of the model's relationship weights suggest hierarchies of influence. Key findings include:

- *Child-led outdoor play* ranked as the most central concept for both age groups.

- Parental influences showed high centrality but declined with age: *Parent/carer affinity for nature* ranked 2nd for children and 5th for young people; *Parent/carer aversion to nature-related threats* ranked 3rd for children and 7th for young people.

- The driver *disabling community norms* is highly influential, increasing with age, ranking 7th for children and 3rd for young people.

- Concepts with lowest centrality included *vicarious outdoor experiences*, *access to quality local natural space*, and *unsupportive organisation culture* (C14)

5.4.2 Interpreting concept centrality

While centrality rankings reveal which concepts practitioners perceive as most influential, identifying strategic leverage points requires understanding how highly central concepts function within their relational context. Centrality scores provide a useful starting point by clearly distinguishing between concepts that practitioners consider most and least important for shaping nature connectedness, but this broad distinction is only a precursor to the more nuanced analysis required for strategic intervention design.

5.4.2.1 Low centrality

Centrality scores provide a useful shortcut for distinguishing between concepts at either end of the hierarchy. *Access to quality local natural space*, *vicarious outdoor experiences*, and *unsupportive organisation culture* rank lowest in centrality, indicating they represent suboptimal intervention points relative to concepts with higher centrality.

As discussed in subsection 5.3, objective access to green space impacts connectedness primarily when combined with social factors that shape how children perceive and use these spaces. Similarly, *vicarious outdoor experiences* (such as nature documentaries or social media content featuring natural spaces) support lasting connectedness by encouraging more *child-led outdoor play* rather than directly building nature relationships (Yue and Chen, 2023). Likewise, organisation culture refers to how supportive a school's leadership and policies are toward integrating outdoor learning. While this sets important initial conditions within school environments, it must still be enacted by individual teachers who may choose to affirm or challenge those institutional priorities. The low centrality of these concepts does not mean they lack relevance, but rather that their influence operates through indirect pathways that are susceptible to being dampened by stronger relationships.

5.4.2.2 High centrality

Practitioners identify *child-led outdoor play* as most central across both age groups. This paramount ranking aligns with sizable body of research emphasising autonomous play as crucial for developing nature connectedness (Chawla, 2020; Schneider and Schaal, 2017; Collado et al., 2013), as well as recent Scottish government policy which positions outdoor play as central to childhood wellbeing (Howe et al., 2021).

Pre-empting the static analysis results, Pract5 reasoned that *child-led outdoor play* is the "most important" concept because it implies active, emotional interactions with nature "that aren't impinged by the adult." A reinforcing feedback loop between *child-led outdoor play* and *nature connectedness* represents practitioners' understanding that increased play leads to stronger connectedness, which motivates further outdoor engagement (see figure x from chapter 4). At this level of analysis, children and young people are understood to influence their own levels of connectedness, their past experiences directing their ongoing motivation and interests (Humphreys, 2018; James and Bixler, 2023; Nicol, 2014).

However, when contextualised within the broader system, the high importance that practitioners place on *child-led outdoor play* takes on a new meaning. The concept is important because it serves as a convergence point where broader social and environmental influences manifest as individual experience that directly shapes nature connectedness. Static analysis reveals that its high centrality stems primarily from the combination of incoming connections from *parent/carer affinity for nature*, *peer affinity for nature*, *perceived access to quality local natural space*, and *leader confidence and motivation* (see Figure 7).

The importance of *child-led outdoor play* for building connectedness thus does not negate the wealth of research suggesting that adult influence still create the conditions for meaningful engagement (Chawla, 2020; Schneider and Schaal, 2017; Collado et al., 2013; Mullenbach et al., 2018). Passmore et al. (2020), for instance, found that parental nature connectedness predicts children's connectedness more strongly than frequency of nature visits. The FCM provides explicit causal logic for these findings by showing how *child-led outdoor play*'s leverage potential depends on the broader relational context that determines whether autonomous play opportunities arise. Similarly, *guided nature engagement* maintains high centrality through its role as a direct pathway to connectedness, yet its influence still depends on favourable conditions supported by parents and leaders.

5.4.2.3 Broad implications for intervention strategy

This relational understanding elicited by the FCM offers a causal logic for why research focusing solely on promoting outdoor play opportunities often produces inconsistent results across different contexts (Price et al., 2022; Soga and Gaston, 2022). *Child-led outdoor play*'s leverage potential aligns with Soga and Gaston's (2022) conceptual framework: while a child may be highly motivated to engage with nature, they still require the 'opportunity' and 'capacity' to do so, which are shaped by the broader social and environmental context captured in the FCM. This systems perspective also explains seemingly paradoxical findings where young people may both desire outdoor play while still choosing to avoid it due to social pressures and competing priorities (Price et al., 2022).

In contrast with *child-led outdoor play*, the concept *disabling community norms*, which ranks as the second-most central concept for young people, derives its influence entirely from outgoing connections as a pure driver concept. This structure suggests that community norms exert more control over the overall system conditions than *child-led outdoor play*, powerfully constraining or supporting multiple aspects of young people's nature engagement simultaneously.

However, *disabling community norms* is modelled as a driver concept, reflecting that community attitudes are slow to change and resistant to influence from other factors in the system. This means it represents a highly important concept but not necessarily an optimal leverage point for fixed-duration interventions to target. While community norms powerfully shape nature connectedness outcomes, short-term interventions like the John Muir Award are unlikely to meaningfully shift these deeply embedded social attitudes on their own. Likewise, understanding that *child-led outdoor play* sits at the receiving end of multiple influences suggests that some interventions might work more effectively by addressing its various inputs rather than targeting it directly. This distinction between system importance and intervention accessibility becomes crucial for understanding why even highly central concepts may not represent the most strategic intervention points, as the dynamic analysis in Section 5.5 will demonstrate.

Centrality analysis reveals leverage potential but cannot justify focusing exclusively on highly central concepts. These rankings provide a foundation for understanding how system structure creates both opportunities and constraints that shape the effectiveness of specific interventions. Highly central factors like *disabling community norms* are powerful system drivers but prove difficult for short-term programmes to change, while less central concepts may offer more practical starting points. This key difference between what matters most in the system and what interventions can realistically influence should reshape how we design interventions, moving from simply improving individual experiences to creating conditions that support ongoing, child-led engagement (Sheffield et al., 2022; James and Bixler, 2022). As the following discussion of RQ3's dynamic analysis will demonstrate, interventions like the John Muir Award must navigate these structural constraints by understanding how their specific capabilities align with the broader system context and the leverage opportunities available to them.

5.4.3 Critique of static analysis results

Because the model represents the perspective of a specific stakeholder group, centrality rankings likely reflect practitioners' distinct priorities and values. The consistently high centrality of *guided nature engagement*, for example, arguably represents where practitioners locate themselves and their professional roles within the system. Had other stakeholder groups, such as government officials or children themselves, been involved in model development, they might have emphasised different aspects of the system and altered the centrality hierarchy.

The acknowledgement of potential imbalances in the model also highlights the model’s usefulness as a boundary object and vehicle for prompting further critique and discussion. For example, static analysis revealed that practitioners developed notable nuance around parental influence, creating two distinct concepts—*parent/carer affinity for nature* and parent/carer aversion to nature-related threats—with multiple connections to other system components. In contrast, *peer aversion to nature* appears far more simplistic, with only two outward and one inward connection. This hierarchy may reflect an imbalance in the model where practitioners, many of whom are parents themselves, had more insight into carer/parental dynamics. Alternatively, this distinction may accurately reflect practitioner reasoning. A possible explanation might be that while parents directly facilitate or constrain children's outdoor experiences through permission, transportation, and resource provision, peer influence may operate more indirectly through social modelling and group dynamics that are harder to generalise and capture in explicit causal relationships. Either way, static analysis serves to signal an area where further discussion among practitioners and potentially with young people themselves could reveal additional complexity and rebalance centrality scores.

While the earlier discussion demonstrated that degree centrality effectively distinguishes between concepts with high and low influence and reveals how practitioners view their relative roles within the system, it captures only one dimension of importance that could be misleading without a qualifying discussion. Betweenness centrality, for instance, might have helped identify concepts that serve as bridges between different system components, potentially revealing intervention points that degree centrality misses (Schuerkamp and Giabbanelli, 2024). Similarly, calculating loop dominance would have provided insights into which feedback cycles exert the greatest influence on system outcomes, moving analysis beyond individual concepts to examine the relative importance of different cyclical processes . Should the model undergo further iterations and gain greater complexity, such additional metrics will likely become more useful, reducing dependence on a manual investigation of the system's causal logic.

For the scope of this study, I contend that degree centrality remained the most applicable and straightforward starting point for analysing leverage within the model's relatively sparse structure. The analysis demonstrates how even simple network metrics can advance understanding when thoughtfully applied and carefully interpreted, providing clear distinctions between concept importance while highlighting the need for relational context. Moreover, as the next section will show, FCM's advantage lies in its capacity to complement static analysis with dynamic simulations that explore how changes to various concepts impact system outcomes under different scenarios.

5.5 RQ3: Scenarios and impact of the John Muir Award

In Chapter 2, I proposed that a systems perspective reframes the Award’s impact as an event within a dynamic system (Hawe et al., 2009). This section applies that reframing to examine the Award's impact through scenario simulations which manipulate key drivers to explore the model's causal logic regarding how the Award's influence spreads through the system under different plausible conditions.

Each simulation produced a spread of values across all concepts that could be analysed in detail. A granular numerical analysis and comparison of each concept’s changing values is beyond the scope of this study. This discussion thus focuses on three overarching patterns: First, scenarios demonstrate how the Award operates primarily through empowering leaders rather than directly transforming participants, critiquing traditional evaluation approaches focused on immediate participant outcomes. Second, outcomes show how system conditions may override intervention design because adverse conditions constrain the Award's impact. Third, scenarios highlight model inaccuracies and methodological limitations, namely that the model cannot capture lasting individual-level changes which may occur during brief nature experiences, nor can it account for demographic and developmental variations in how different groups respond to interventions.

5.5.1 Summary of key scenario outcomes

The FCM scenario simulations explored the John Muir Award's impact across nine different conditions, comparing school settings (mainstream vs. special), age groups (children vs. young people), enhancement strategies, and varying levels of community support. These simulations produced several key patterns that establish the foundation for interpreting the Award's systemic role and limitations as understood by outdoor learning practitioners

Practitioners conceptualised the impact of the Award as primarily as a boost in *leader confidence and motivation to deliver outdoor learning* while also helping to counter *peer aversion for nature*. Successful outdoor learning depends both on capable, motivated facilitators and on creating social conditions where nature engagement is more attractive and accessible for young people.

The simulations consistently showed the Award having positive impacts across all contexts. However, these gains remained modest and were constrained by broader system dynamics. Even with the Award's positive influence, key barriers like *screen time*, *parent/carer aversion to nature-related threats*, *negative outdoor experiences*, and *disabling community norms* maintained relatively high values, suggesting that short-term interventions may face significant systemic resistance.

Children demonstrated higher baseline *nature connectedness* and showed larger improvements following Award implementation compared to young people, reflecting practitioners' understanding of the adolescent dip in nature connectedness. Differences between mainstream and special school environments had minimal impact on outcomes, suggesting that individual teacher motivation may matter more than institutional culture.

When *disabling community norms* were progressively reduced, the system shifted; concepts that support nature engagement (such as *child-led outdoor play* and *guided nature experiences*) achieved higher values than concepts that constrain it (such as screen time and negative outdoor experiences). This pattern suggests that while the Award can make meaningful contributions, its effectiveness depends heavily on the broader social context in which it operates.

5.5.2 The Award's lasting impact on nature connectedness

When prompted to consider lasting impacts, practitioners understand the Award to exert influence indirectly, primarily through educators and leaders rather than directly transforming participants during the fixed-duration experience. This represents a simple but meaningful reframing of the Award's impact compared to traditional evaluations that measure short-term changes in children's nature connectedness levels (Mitchell and Shaw et al., 2010). More than a one-off experience, the Award is a capacity and opportunity-building intervention within a dynamic system shaping lasting relationships with nature.

By providing frameworks and confidence to leaders who lack outdoor learning experience, the Award initiates ripple effects throughout the system. Leaders are empowered to continue using principles from the Award framework beyond the intervention period, identify local spaces for ongoing activities, and may implement the Award repeatedly with different cohorts. As James and Bixler (2023, p.173) observe, leaders function as "both producers and products" of outdoor learning experiences.

Static analysis identifies *leader confidence and motivation to deliver outdoor learning* as a moderately central concept, ranking 6th out of the total 15 for both children and young people. Across all scenarios in which the Award is introduced, there is consistent positive impact on nature connectedness, though this varies depending on other system-wide conditions.

Nature connectedness's impact on the system broadly aligns with wider literature. As discussed in Chapter 2, social learning theory emphasises leaders' role in modelling attitudes and behaviours, while recent studies identify lack of confidence in teaching outdoors as a key barrier to mainstream implementation (Prince, 2017; Knight et al., 2025). This finding was also reflected in Zucca et al.'s (2023) systems mapping study with practitioners, where overlapping concepts of 'leader confidence' and 'leader agency' emerged as highly central to the implementation of nature-based play in Scottish early learning centres.

To summarise the model's causal logic, a boost in *leader confidence and motivation to deliver outdoor learning* means that there will be increased opportunity and incentive for *guided nature engagement*, which in turn directly increases connectedness. An increase in guided engagement also means that children are more likely to perceive their local natural space as accessible, making *child-led outdoor play* more attractive and creating further opportunities for increased connectedness over time.

According to the model, the Award's greatest contribution to lasting nature connectedness may be indirect and through the educators who continue creating meaningful nature experiences long after the Award itself is complete. This represents a novel addition to outdoor learning research, which has predominantly focused on measuring immediate participant outcomes rather than examining how interventions build lasting capacity within the systems that shape children's ongoing experiences (Sheffield et al., 2022; Hawe et al., 2009). This understanding highlights how fixed-duration experiences can create sustained impact by strengthening relationships and building capacity within existing networks. Of course, this perspective likely reflects the professional backgrounds and roles of the practitioners involved in this study. As outdoor learning professionals who often deliver interventions like the John Muir Award, they may naturally emphasise the importance of educator capacity and ongoing facilitation.

5.5.3 When context overwhelms intervention

The scenarios starkly illustrate how system conditions can override intervention design, challenging dominant evaluation approaches that prioritise programme optimisation over system dynamics (Sheffield et al., 2023; Harris et al., 2025). When designing scenarios, Award staff opted to simulate the intervention's impact within a system characterised by adverse conditions. Though the Award consistently contributes to positive change across all scenarios, the magnitude of change remains constrained by system-wide factors beyond its direct influence. Barriers to nature connectedness maintained values above 0.7 across initial scenarios. These outcomes attest to the high centrality of *disabling community norms*, which maintains a constraining influence through multiple pathways that the Award—as currently modelled—does not directly disrupt. Improvements in leader confidence and peer influence, though important, are not the only forces shaping nature connectedness within the system.

Gradually reducing the activation value of *disabling community norms* over multiple scenarios revealed how changes to this single driver can shift system-wide outcomes (see Figure 15). As *disabling community norms* became less influential, *nature connectedness* increased from 0.72 to 0.84 for children, while *child-led outdoor play* nearly doubled (see Appendix 7). When communities became more accepting of children playing outdoors, the Award's positive effects could spread throughout the system more effectively.

Pract5 described restricting conditions under which parents fear being judged by the wider community as “hippie weirdos” for encouraging outdoor play. However, As the pressure of negative norms lifts, parents feel less compelled to restrict outdoor play based on social judgment, and local green spaces are reconceptualised from forbidden zones into welcoming environments. Outdoor play is validated rather than stigmatised. Likewise, the Award’s contribution to leader confidence is no longer consumed by fighting negative social headwinds. Instead, it serves to amplify an already growing momentum. However, the reduction of disabling norms also exposes stubborn areas of resistance. Despite the surge in outdoor play, *screen time* remains persistently high. While better community norms can grant social permission for outdoor play, they may not dissolve the independent pull of digital entertainment.

The model contributes an explicit causal logic to the existing literature on the pervasive influence of community norms (Humphreys, 2018). Giusti et al. (2019, p.15-14) notes that "social norms are inherently embedded in a place" and local traditions shape children's opportunities to value nature. Carver et al. (2008, p.224) writes of parents falling victim to "social traps" when conforming to local attitudes that deem outdoor environments unsafe for children. A recent report of the Raising the Nation Play Commission (2025) refers to a growing 'anti-play culture' in the UK, finding that 75% of surveyed parents agree that society is less accepting of children playing outdoors.

While researchers have long recognised that community norms create powerful behavioural constraints, intervention evaluations rarely examine these system-level factors. Scenario results suggest that this is a problematic omission. In Chapter 2, I noted that many studies report greater improvements in nature connectedness among children with little prior outdoor experience due to socioeconomic disadvantage, geographic isolation, or family circumstances (Mitchell and Shaw, 2010; Price et al., 2022). However, scenarios show that while disadvantaged children may demonstrate the most dramatic short-term gains, they are also likely to face the strongest systemic resistance to maintaining those gains. Without an appreciation of the wider context, traditional studies risk overemphasising asymmetrical benefits. Within the model, there is little justification to presume that the same adverse conditions limiting a child's initial engagement with nature would cease to be relevant after the intervention ends. Though, as I point out in the next section (5.5.4), it would also be misleading to suggest that the resilience of all immediate impacts of an outdoor learning experience is entirely reliant on wider system conditions.

Scenarios also show how some system concepts offer weaker resistance than others. Despite the modelled disparity between the culture of mainstream schools and special schools in the driver *unsupportive organisational culture*, baseline differences in nature connectedness were minimal (see Figure 12). The Award's impact remained similarly modest across both contexts. This pattern directly reflects organisational culture's low centrality ranking; institutional policy is structurally distant from the child's lived experience. Scenarios thus play out practitioners' views that while school management and policy may set initial conditions, individual teachers remain the primary gatekeepers for children's access to outdoor learning, especially at primary level. P5 describes as a 'pro-nature role model' who can facilitate outdoor learning even within unsupportive institutions. Thus, by focusing on empowering teachers, the model shows how the Award can exert positive influence regardless of wider school culture.

Scenarios also highlight why the resilience of intervention impacts may vary across age groups (Liefländer et al., 2013). The age-related patterns captured in scenario outcomes are underpinned by the centrality differences identified in Section 5.4, with children consistently showing higher baseline nature connectedness and larger gains following Award implementation compared to young people.

Scenarios thus provide a causal explanation for the adolescent dip: young people face stronger constraints on fostering nature connectedness because they are more sensitive to the community norms and peer influences that discourage outdoor engagement (Soga and Gaston, 2022). The Award is less effective in this demographic because it faces greater systemic resistance and comes up against strong social resistance without the previous support of parental guidance. For younger children, strong parental influence may act as a buffer, effectively countering negative community norms.

The Award's consistent but constrained positive influence in each scenario suggests that creating favourable system conditions may prove more effective than enhancing intervention components. Rather than viewing the Award as a standalone solution, its primary contribution is reframed as building capacity and momentum that among parents, teachers, and peers that may even contribute to shifting disabling community norms over time. The extent of the Award's impact will further depend on how well intervention design accounts for the age-related differences captured in shifts in concept and relationship importance.

While scenarios draw attention to the outcomes of the wider system conditions, they also highlight potential inconsistencies and blind spots in the FCM's causal logic. Some aspects of the Award's lasting impact are likely being missed, as I discuss in the following section on methodological limitations.

5.5.4 Capabilities and limitations of FCM scenarios

The scenario simulations presented above demonstrate the FCM's capacity to reveal system-level dynamics that would likely remain hidden in traditional intervention evaluations. However, these same scenarios also expose important limitations in the model's ability to capture the full complexity of how fixed-duration interventions such as the Award contribute to lasting nature connectedness. The model has an inability to capture lasting individual-level changes that may occur during brief nature experiences and assumes uniform response rates across demographic groups and developmental stages. This subsection critically examines these limitations while clarifying how they might inform, rather than diminish, the model's contribution to understanding system dynamics.

5.5.4.1 Lasting individual-level changes outside the model's scope

The FCM's focus on meso-level interrelationships likely misses potential changes at the individual level during brief nature experiences. As noted in Chapter 3, practitioners suggested that the Award might plant a seed for nature connectedness which manifests later in life or serve as a "learning to look" experience that transforms participants' perception of nature (Pract1). These manifestations of impact are difficult to capture in the FCM because they remain potentially dormant within the individual until activated by future experiences or developmental changes.

While there is limited evidence for lasting shifts in nature connectedness following single outdoor learning experiences, this does not negate the possibility of other kinds of transformations or resilient changes in participants' understanding that may prime future engagement with nature. For example, while a child's nature connectedness levels may dimmish in the months following an outdoor learning experience, they still retain positive associations and knowledge about a particular space, or natural phenomena they encountered (Campbell-Price, 2022).

Like static analysis, FCM scenarios serve as tools for exposing oversimplified assumptions and creating opportunities for deeper inquiry. For instance, under the model's current structure, *negative outdoor experiences* remain persistently high despite the Award's broadly positive impact on other system components. This outcome may not accurately represent practitioner views. In interviews, Pract1 and Pract7, for instance, describe how children's initial fears of mud, bugs, and briers may quickly give way to awe and curiosity about the natural world—even after a brief outdoor learning experience. In the current model iteration, community norms are modelled as the primary source of negative experiences. This may leave too little opportunity in the model for children and young people to challenge dominant social and cultural narratives as their perceptions of access to local natural spaces shift with growing familiarity and confidence.

The model's limitation in capturing resilient individual-level changes means it may underestimate the Award's potential for having a lasting and direct impact in addition to its influence on wider system conditions. However, this limitation reflects the study's explicit focus on understanding how system-level factors shape the conditions within which such transformations might be sustained or diminished over time.

5.5.4.2 Demographic and developmental variations in intervention response

A related limitation, highlighted by scenario outcomes, concerns the model's assumption that nature connectedness changes at uniform rates across different demographic groups and developmental stages. While the two model variations successfully capture broad age-related differences in system structure, they oversimplify how complex systems principles operate at the individual level.

In their review of outdoor learning interventions, Barrable and Booth (2020, p.4) note a that changes in nature connectedness in response to interventions may follow various patterns:

> [I]t may be that a hypothetical response to an intervention could rise quickly to a set level (asymptotic); have a threshold value resulting in a sharp increase to a levelling off point (logistic); have a constant rate of increase (exponential); or even in some rare cases the response could be linear.

The model created in the study only provides a relative approximation of nature connectedness levels after cumulative experiences. It is likely missing significant variations in how different groups respond to varying interventions and how children and young people’s memories and experiences inform ongoing resistance and openness to building nature connectedness.

This limitation reflects a broader challenge in operationalising all complex systems principles within the FCM framework. FCM has reduced the real-world capacity for system adaptation in response to change to static relationship weights that do not evolve over time or vary between individuals. While nature connectedness itself represents an emergent property arising from multiple interacting factors and bidirectional relationships, the model cannot produce entirely new concepts or relationships that might emerge through intervention experiences or developmental processes (Preiser et. al., 2021).

The model serves as a cautionary critique of studies that ignore wider system conditions when attributing lasting impact to brief interventions, particularly those targeting early childhood or disadvantaged participants. However, this does not mean that immediate individual responses have no influence on long-term nature connectedness trajectories. The FCM's strength lies in focusing on a particular knowledge gap: understanding how system conditions shape nature connectedness outcomes and the persistence or decay of intervention effects over time. It achieves this insight by abstracting away from the individual-level and intervention-level complexity.

5.6 Chapter Summary

This chapter has interpreted the FCM results within the broader context of nature connectedness and outdoor learning scholarship, demonstrating how practitioner knowledge complements and extends existing research understanding. Through static analysis of the model's structure and simulation outcomes, I have contextualised the findings to address each research question while acknowledging the inherent limitations of the FCM methodology.

The aggregated FCM successfully captured practitioner understanding of the complex system shaping nature connectedness, revealing a network of 15 key concepts connected by 38 weighted relationships. I presented FCM as a valuable methodological middle-ground that is currently absent from the wider body of research, integrating the rich contextual understanding valued in qualitative approaches with the analysis capabilities of quantitative methods. That said, the model's static nature and bounded scope mean it represents only a simplified snapshot of practitioner perspectives, necessarily excluding factors they considered less central or outside the defined temporal and demographic boundaries.

Static analysis identified *child-led outdoor play*, parental influences, and *guided nature engagement* as the most central concepts, with notable shifts in importance as children mature into adolescence. These findings aligned with existing literature while revealing practitioner-specific insights about the declining influence of family factors and increasing sensitivity to community norms with age. The degree centrality approach provided clear hierarchies of concept importance, though it captured only one dimension of potential leverage and may have overlooked concepts that serve as bridges between different system components.

Dynamic simulations demonstrated the John Muir Award's positive but contextually constrained impact across different scenarios. The simulations revealed how the Award's effectiveness varies by age group and setting, while highlighting the pervasive influence of *disabling community norms* that limit intervention impact. However, these simulations represent theoretical explorations of practitioner mental models rather than predictions of real-world outcomes. The model's inability to capture temporal dynamics means it cannot represent how relationships might evolve over time or account for the long-term impacts that some practitioners suggested could emerge years after the Award experience.

This chapter has demonstrated both the potential and limitations of applying complex systems modelling to understand the lasting development of nature connectedness and the contributions of fixed-duration interventions. In the next chapter, I synthesise these insights to articulate the study's contributions to both future research and practice.

Chapter 6 Conclusion

6.1 Chapter Overview

This chapter synthesises my research journey from identifying a critical gap in the study of human-nature relationships to developing a novel systems modelling approach that makes complex dynamics explicit and explorable. I reflect on how the John Muir Award may contribute to lasting nature connectedness in Scottish children and young people as part of a wider system that shapes their lives.

The chapter is structured to provide both synthesis and reflection. Section 6.2 retraces the overall progression of the study from problem identification through methodological design to interpretation of results. Section 6.3 addresses how each of the three research questions was answered within the parameters and limitations of the study. Section 6.4 considers the wider implications of this work for future research and outdoor learning practice. Finally, Section 6.5 offers concluding thoughts, highlighting the study's originality, methodological rigour, and value, while also recognising its inherent constraints.

6.2 Overview of thesis narrative

The overarching motivation behind this study stemmed from the recognition that humanity's growing separation from nature has profound implications for both environmental sustainability and human wellbeing (Freeman et al., 2021; Richardson, 2023; Kessler, 2019; Louv, 2013). I chose to investigate the positive impact of outdoor learning interventions on the development of lasting nature connectedness as a promising pathway for addressing these interlinked crises.

While scholars acknowledge that lasting nature connectedness requires sustained psychological engagement with nature, evaluations of outdoor learning interventions predominantly measure only immediate pre-post programme changes (Sheffield et al., 2022; Holland et al., 2024). This methodological limitation inadvertently focuses attention on what happens during interventions rather than whether these experiences contribute to ongoing engagement necessary for enduring connectedness (Beery et al., 2019; van Heel et al., 2023; Lengieza and Swim, 2021, 2023).

Outdoor learning researchers have attempted to look beyond immediate pre-post assessments through alternative approaches. Significant life experience research, for instance, has provided valuable long-term qualitative insights by retrospectively exploring the formative experiences of adults with strong nature connections (Chawla, 2006; Rosa et al., 2018; Rosa and Collado, 2019). Yet these retrospective methods may overemphasise childhood experiences and still do not capture how interventions interact with broader contextual factors to influence lasting outcomes overtime (James and Bixler, 2023).

In Chapter 2, I drew from complex systems theory and social-ecological systems research, arguing that understanding lasting impact requires approaches capable of capturing system dynamics (Preiser et al., 2021). I conceptualised nature connectedness not as a direct outcome of isolated experiences, but as an emergent property arising from multiple interacting factors over time. This perspective positions outdoor learning interventions as events embedded within complex systems, their impact both shaped by and shaping the contexts in which they operate (Chawla, 2020; Richardson, 2023).

To translate theoretical critique into empirical investigation, I selected the John Muir Award as my focal intervention. Its flexible framework accommodates diverse contexts while maintaining consistent principles, its widespread Scottish implementation provides access to experienced practitioners, and its explicit focus on building nature connectedness aligns directly with my research interests. These considerations led to three progressive research objectives: establishing a systems perspective of nature connectedness development, identifying strategic leverage points within the system, and exploring how the Award's lasting impact under different system conditions. In section 6.3, I review the extent to which these objectives have been met. Answering these questions meant contending with limited longitudinal data on lasting nature connectedness in Scotland. This constraint directed me to engage outdoor learning practitioners as the best available source of knowledge on how nature connectedness develops in children and young people and the role of the John Muir Award.

Chapter 3 detailed my consideration of various complex systems modelling approaches capable of answering my questions. Fuzzy Cognitive Mapping emerged as a pragmatic solution, capable of transforming practitioner knowledge into both visual representation and mathematical model. This semi-quantitative approach, grounded in constructivist principles, recognises that practitioners hold valuable mental models of complex systems that can be systematically elicited and synthesized despite being partial or subjective (Jetter and Kok, 2014; Giabbanelli and Nápoles, 2024). The rest of the chapter detailed the stepwise application of FCM to meet my research context and objectives. Each step involved trade-offs between capturing nuanced practitioner knowledge and achieving a parsimonious model. Key choices included engaging adult practitioners rather than young people directly, combining group workshops with individual interviews, and developing age-differentiated model variants.

The resulting model serves to translate practitioner understanding into an aggregated systems representation, enabling structural, static, and dynamic analyses that reveal how the complex system shapes nature connectedness. Chapter 4 and Chapter 5 were structured to progressively use the model to address each of my three research questions: mapping the complex system, identifying leverage points, and exploring the John Muir Award's impact under different scenarios. Chapter 4 presented the results of these analyses, while Chapter 5 interpreted those results within the broader context of nature connectedness and outdoor learning scholarship, demonstrating how practitioner knowledge captured through FCM complements and extends existing research understanding.

6.3 Research questions answered

This study was designed to address three research questions, progressing from broad system description to strategic insights. Each question exploited distinct analytical capabilities of the FCM methodology to support exploration of practitioners' understanding of how the John Muir Award contributes to lasting nature connectedness from within a complex system. Here I provide a brief assessment of what FCM enabled me to achieve and where its limitations and the practical constraints of doctoral research shaped my findings.

6.3.1 Research Question 1

RQ1: According to outdoor learning practitioners, what is the complex system shaping Scottish children and young people's lasting nature connectedness?

This study answered RQ1 by eliciting practitioners' collective understanding as a parsimonious network of 15 key concepts and 38 weighted relationships. The FCM demonstrates that nature connectedness formation is nonlinear, developing from interconnected factors that influence each other over time. The model, moreover, highlights the potential for system change, capturing differences in relationship strengths between concepts for children (8-11) and young people (12-15).

That said, the model is far from a complete representation of practitioner views and real-world complexity. Given my prioritisation of parsimony as well as the limited rounds of knowledge collection and stakeholder feedback possible within doctoral research, it is unlikely that the final model fully represents the breadth and depth of practitioner knowledge.

6.3.2 Research Question 2

RQ2: What concepts do practitioners consider most important for shaping nature connectedness and may serve as strategic leverage points?

Static analysis of the FCM was conducted to calculate degree centrality scores, presenting a hierarchy of concept importance based on practitioners' estimation of relative influence. Some concepts like *child-led outdoor play* and parental influence emerged as highly central, while others like *vicarious nature experiences* occupied peripheral positions. The analysis also revealed age-related shifts in concept importance, particularly decreasing parental influence and increasing peer/community influence for adolescents.

A notable caveat is that while there is a clear distinction between the importance of low and high centrality concepts, high centrality does not necessarily signify a leverage point. A concept might be central to the system yet impossible to change through an intervention. Thus, concepts with high centrality still need to be contextualised to better appreciate where specific interventions might best focus their efforts for contributing to long-term change.

6.3.3 Research Question 3

RQ3: How can we simulate the system to explore the lasting impact of the John Muir Award under different plausible scenarios?

The semi-quantitative properties of FCM enabled a dynamic analysis that moved beyond static descriptions to explore what-if scenarios. Outcomes of these scenarios would be difficult to predict through mental reasoning alone. By running simulations with and without the Award present, I could consider how its impact varied across these conditions. The Award showed stronger positive effects in already-supportive environments and struggled to overcome multiple negative factors when they dominated the system.

An inherent limitation of FCM of simulations is that they only reveal what practitioners think would happen based on their mental models. Furthermore, because the model examines system patterns at a meso-level, it cannot account for individual-level changes within participants or delayed impacts that might only manifest when individuals encounter nature again in the future.

6.4 Contributions to future research and practice

The shortest and perhaps most obvious sentence of this entire thesis is also its central argument. Context matters. While evaluations of interventions routinely demonstrate short-term improvements, there is often no consideration of whether these gains persist over time. As discussed in Sections 5.3.3 and 5.5.3, younger children and participants with limited prior outdoor learning experience often show disproportionately large gains in nature connectedness following even brief interventions (Liefländer et al., 2013; Barrable et al., 2019; Price et al., 2022; Chawla, 2020). These short-term gains are sometimes interpreted as evidence that outdoor learning interventions initiate a trajectory toward more enduring improvements in participants' relationships with nature (Chawla, 2020. This study presents its critique in the form of a network of interrelationships, showing how system conditions can either amplify or constrain the effects of interventions. Rather than evidence of lasting transformation, immediate improvements may only capture temporary gains that do not address underlying adverse conditions.

Although it began as a critique of linear evaluation methods, the primary aim was to be constructive. This study set out to offer tools for researchers grappling with the challenge of understanding how even brief interventions contribute to lasting connectedness. The FCM demonstrates that useful approximations of system dynamics are achievable, providing a framework to ask better questions, generate hypotheses, and inspire further modelling efforts.

The limitations and constraints of this study have kept me from asserting that system conditions inherently matter more than intervention design or immediate impacts of a single experience. The model was intentionally parameterised and was not meant for capturing the full depth and resilience of what occurs during a John Muir Award experience—the moments of wonder, challenge, and learning that may shift a young person's relationship with nature. However, I have positioned this study to offer a balancing perspective against the literature’s predominant emphasis on the immediate outcomes (Sheffield et al., 2023). The following subsections articulate how this work advances research and practice while acknowledging that capturing complexity requires multiple approaches working in concert.

6.4.1 Contribution to future research

This study demonstrates that practitioners possess extensive knowledge about the formation of nature connectedness within a complex system which can be captured without the resource-intensive requirements of traditional longitudinal studies. While I make no claims that the model captures an objective reality, practitioners' shared knowledge and firsthand experiences, despite inherent biases, represent the closest approximation available for understanding how lasting nature connectedness develops in Scottish children (Giusti et al., 2018). By making this tacit knowledge explicit through FCM, the study serves as pioneering gateway research that bridges theoretical understanding with empirical investigation (Barbrook-Johnson and Penn, 2022).

The model may provide a framework to guide future empirical studies. Instead of measuring isolated variables or simple pre-post changes, researchers can use the map to identify which relationships require investigation and which causal pathways might explain why some interventions produce lasting change while others fade. The FCM essentially provides a map of the territory, highlighting which variables need controlling and which interactions deserve closer examination (Eisenbroich and Badham, 2022). For instance, the model presents child-led outdoor play as having the strongest direct impact on nature connectedness, but this activity is still highly adult-mediated. Researchers could test whether interventions that promote free play in isolation show limited lasting impact compared to those which engage parents and the wider community.

Perhaps a more immediate use for the model is that it continues to be refined for further learning. While the FCM's current iteration captures one group's perspective within specific boundaries, it has been designed to invite expansion and refinement. Youth voices could reveal dynamics that adult practitioners overlook or misinterpret. Comparative analysis across cultural contexts would distinguish universal patterns from local variations. Hybrid approaches could combine the FCM's participatory foundation with quantitative validation as longitudinal datasets accumulate. Each iteration would add nuance while maintaining the core insight that lasting impact derives from system dynamics rather than intervention design alone.

In short, the FCM is not as a fixed conclusion but a flexible tool for collaborative learning. It represents an open invitation to researchers to challenge, refine, and even replace the model as understanding deepens (Jucker and von Aue, 2022). Indeed, if this FCM is eventually dismissed in favour of better approaches, it will have fulfilled its purpose. Wilensky and Rand (2015, p. 20) refer to a complex systems modelling as a "test bed for alternate assumptions". To meaningfully dispute the model, critics must demonstrate how an assumption is faulty or missing, thereby extending the model's usefulness for ongoing discussion and learning (Wilensky and Rand, 2015). Whether future researchers build upon this specific model or develop entirely different approaches, the model's lasting contribution lies in demonstrating that the inherent complexity and uncertainty characterising the formation of nature connectedness need not paralyse research efforts.

6.4.2 Implications for Outdoor Learning Practice

The FCM reflects practitioners' collective perspectives rather than objective reality. Yet this study's focus on eliciting mental models is not merely a limitation but comes with valuable insight for the practice of outdoor learning. This is because practitioners are the designers and deliverers of outdoor learning interventions. Their beliefs about the system fundamentally shape how they approach their work, allocate resources, and assess effectiveness.

For practitioners involved in this study, the FCM enables critical examination of their own causal logic, a tool for professional reflection. By making tacit knowledge explicit, practitioners can trace the causal pathways underlying their decisions, potentially revealing assumptions that limit impact. As one practitioner (Pract5) observed, "I think a lot of the time we're just flying by our intuition." The model transforms intuitive understanding into something that can be systematically examined, questioned, and refined (Saúl et al., 2022). Practitioners may ask: Am I targeting long-term causes over short-term symptoms? Are my assumptions about lasting impact logically consistent?

For the John Muir Award, the model provides a window into how practitioners conceptualise the scheme's role within a wider system. This collective understanding has notable implications for programme development and evaluation. Most strikingly, practitioners identified the Award's primary lasting influence not through transformational participant experiences but through leader empowerment. The Award's flexible framework enables leaders to become agents of sustained change, applying its principles repeatedly across different contexts long after initial programme delivery ends. This reframes success metrics from participant numbers and immediate satisfaction scores toward growing practitioner confidence and capability.

The simulations also provide further opportunity to explore practitioner beliefs, identifying intervention opportunities and limitations. While the Award can strengthen specific system components, it cannot independently overcome all adverse conditions. However, enhanced scenarios explored in Section 4.4.4 demonstrate how the Award might amplify impact through strategic additions such as family engagement components for children or peer advocacy elements for young people. These represent not radical redesigns but recognition that interventions must work with, rather than against, existing system dynamics.

This systems perspective thus suggests that lasting impact depends on building capacity within existing networks rather than optimising isolated experiences. Follow-up support, institutional partnerships, and alumni networks become as important as initial programme quality. The model thus enables more sophisticated articulation of what the Award can realistically achieve. Rather than promising transformation through one-off experiences that assume lasting impact will follow, practitioners can demonstrate how the programme builds system capacity over time through multiple reinforcing pathways.

Given the Award's recent ‘update’ with the new Wild Places Guardian level, this systems perspective offers timely tool for the John Muir Award (JMT, 2025b). The model suggests evaluation frameworks should track indicators of system strengthening including enhanced leader confidence, improved institutional support, and shifted family attitudes alongside traditional participant outcomes. Success becomes not just immediate nature connectedness gains but the establishment of conditions that enable ongoing engagement. This reframing provides a more complete and ultimately more compelling articulation of the Award's value within complex social-ecological systems, acknowledging both the programme's contributions and its embeddedness within broader contexts.

6.5 Concluding thoughts

This thesis set out to investigate how outdoor learning interventions contribute to the lasting formation of nature connectedness, with the John Muir Award as a focal case. By applying complex systems mapping for the first time in this field, it demonstrates that such modelling approaches can generate new insights into dynamics that have long eluded traditional methods. While inevitably bounded by constraints and limitations that accompany any attempt to bottle complexity, the study nonetheless delivers a novel, rigorous, and valuable contribution to knowledge.

Its novelty lies in being the first application of complex systems mapping to the lasting formation of nature connectedness in children and young people, directly addressing a research gap that has persisted despite repeated calls for systems approaches in both outdoor learning and nature connectedness scholarship. Its rigour rests on a transparent, stepwise process that prioritised accurate representation of practitioner perspectives.

The study's value extends beyond theoretical critique to practical application. For researchers, the model offers a framework for generating testable hypotheses about system dynamics and inspiration for alternative modelling approaches. For practitioners, it makes tacit knowledge explicit in the form of causal logic that can be examined, questioned, and refined—enabling more strategic decision-making about intervention design and resource allocation. For the John Muir Award, it provides insight into how practitioners conceptualise the programme's contributions to lasting outcomes, informing both strategic planning and evaluation frameworks that focus on system-level impacts rather than short-term participant change.

This study is valuable because it is incomplete. It offers an interactive framework rather than a definitive account, and in doing so invites refinement, critique, and extension as research in this field develops. Its enduring contribution is to encourage new ways of thinking as part of a shared effort to strengthen human–nature relationships for the benefit of both people and planet.

Appendices

Appendix 1 – Photo of concepts influencing nature connectedness as listed by outdoor learning practitioners in group workshop

Appendix 2 – Ethics approval letter

21st February 2023

MVLS College Ethics Committee

Project Title: How do children and young people connect with nature? Refining a complex systems map.
Project No: 200220156

Dear Dr Dunkley,

The College Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the proposed study. It is happy therefore to approve the project.

- Project end date: As stated in application
- The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research:
- https://www.gla.ac.uk/media/media_490311_en.pdf
- The research should be carried out only on the sites, and/or with the groups defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment, except when it is necessary to change the protocol to eliminate hazard to the subjects or where the change involves only the administrative aspects of the project. The Ethics Committee should be informed of any such changes.
- You should submit a short end of study report to the Ethics Committee within 3 months of completion.
- For projects requiring the use of an online questionnaire, the University has an Online Surveys account for research. To request access, see the University's application procedure at https://www.gla.ac.uk/research/strategy/ourpolicies/useofonlinesurveystoolforresearch/.

Yours sincerely,

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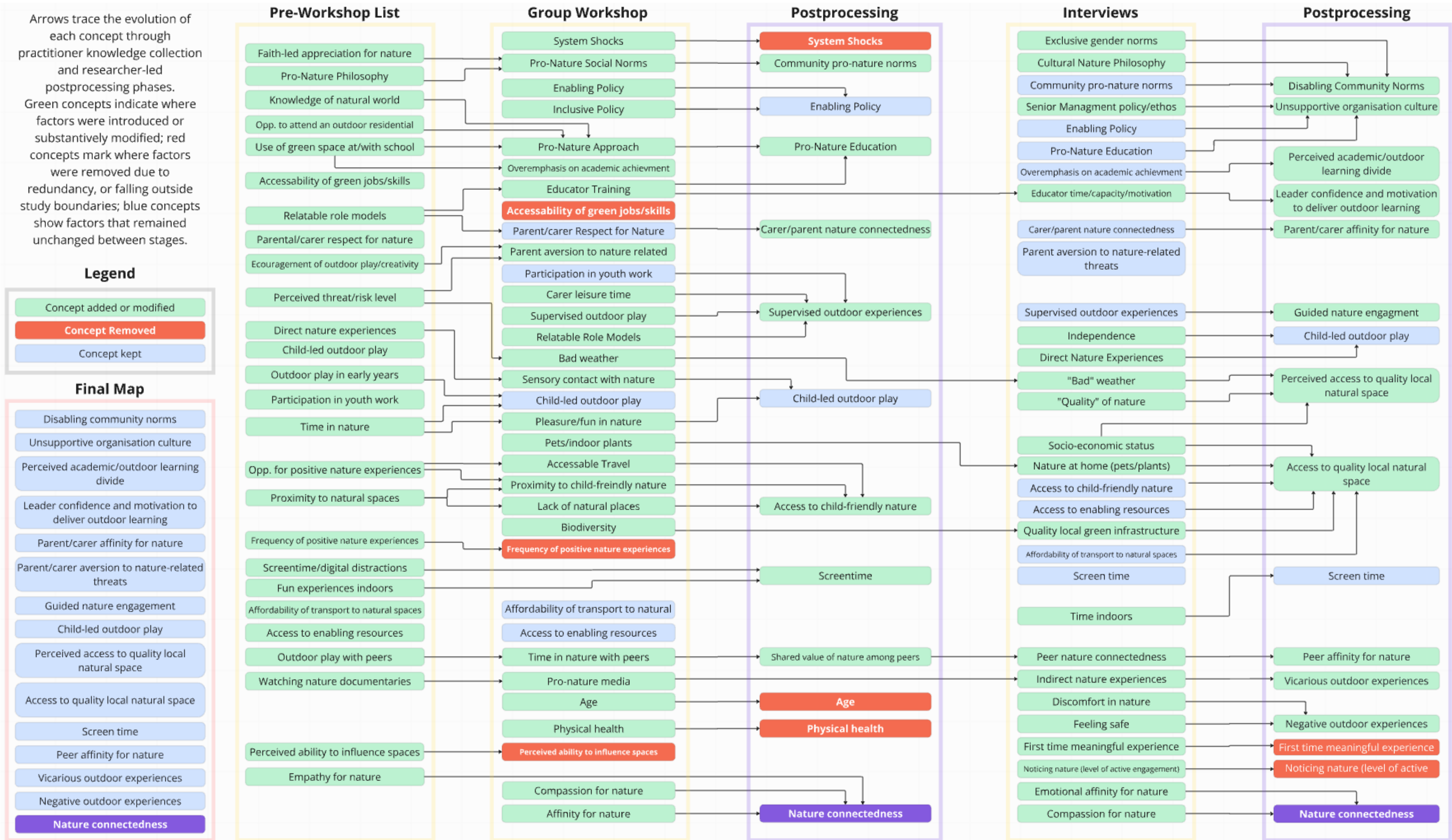
Appendix 3 - Concept evolution workbench: Tracking concept aggregation through FCM stages



Appendix 4 - Summarised causal descriptions for each relationship in the final aggregated FCM

From	To	Type	Description	Strength
Negative Outdoor Experiences	*Nature Connectedness*	Negative	Negative Outdoor Experiences decrease a child's Nature Connectedness Negative outdoor experiences may overshadow the perceived positive aspects of nature, leading to a lower likelihood of developing a deep, enduring connection to the natural world. Such experiences challenge the development of nature connectedness by instilling apprehension instead of curiosity and admiration.	6
Unsupportive Organisation Culture	*Perceived Academic/Outdoor Learning Divide*	Positive	Unsupportive Organisation Culture increases the Perceived Academic/Outdoor Learning Divide A lack of endorsement or outright opposition from senior management towards outdoor learning could exacerbate (increase) the Perceived Academic/Outdoor Learning Divide. This could manifest in policies, resource allocation, and the daily rhetoric within educational and youth work institutions that further entrench the belief that outdoor learning is a low priority and separate from academic attainment or other child development goals.	6
Disabling Community Norms	*Parent/Carer Aversion to Nature-Related Threats*	Positive	Disabling Community Norms increase Parent/Carer Aversion to Nature-Related Threats Though a carer's relationship with nature is largely based on their own prior experience with the outdoors, community norms continually influence a carer's perception of nature. Carers look to others to inform when and how their children should interact with local nature. Carers want to be seen as responsible by the wider community and not come across as "bad parents" or "hippie weirdos" (Pract12).	7
Disabling Community Norms	*Leader Confidence and Motivation to Deliver Outdoor Learning*	Negative	Disabling Community Norms decrease Leader Confidence and Motivation to Deliver Outdoor Learning A lack of communal support and the perceived challenges of overcoming societal barriers can diminish leaders' enthusiasm and self-assurance in the value and feasibility of outdoor learning initiatives, impacting their willingness and ability to offer meaningful nature-based experiences to children.	5

Parent/Carer Affinity for Nature	*Guided Nature Engagement*	Positive	Parent/Carer Affinity for Nature increases Guided Nature Engagement When parents or caregivers possess a strong connection to nature, they are more likely to value, seek out, and facilitate structured outdoor learning opportunities for their children. This affinity for nature motivates them to engage children in educational activities that are designed to foster a deeper understanding and appreciation of the environment. Older kids can seek out opportunities on their own, but younger children rely on parental support (money/transport/permission).	7
Disabling Community Norms	*Child-Led Outdoor Play*	Negative	Disabling Community Norms decrease Child-Led Outdoor Play Disabling community norms, by casting suspicion on unsupervised outdoor activities, create an environment where children may feel discouraged from engaging in child-led play in natural settings due to fears of judgment or reprimand. A child's age likely influences the community's perception of their outdoor activities. An unsupervised group of teenagers in a public park, for example, are typically assumed to be up to trouble.	
Perceived Access to Quality Local Natural Space	*Leader Confidence and Motivation to Deliver Outdoor Learning*	Positive	An increase in the Perceived Accessibility of Quality Local Nature increases Leaders Confidence and Motivation to Deliver Outdoor Learning An increase in the perceived accessibility of quality local nature will help to counter leaders' lack of confidence and motivation to deliver outdoor learning. If local green spaces are perceived by leaders to be nearby, well-maintained, safe, and inviting, they will have fewer barriers to making use of these spaces for outdoor learning.	5
Disabling Community Norms	*Peer Affinity for Nature*	Negative	Disabling Community Norms decrease Peer Affinity for Nature Disabling norms contribute to a reduced inclination among peers to value and enjoy natural spaces. This, in turn, leads to a cycle where the social environment stifles the development of a collective appreciation for nature among children and their peers, further alienating them from outdoor experiences and the benefits of nature connectedness.	4

Leader Confidence and Motivation to Deliver Outdoor Learning	*Guided Nature Engagement*	Positive	Leader Confidence and Motivation to Deliver Outdoor Learning leads to an increase in Guided Nature Engagement The extent to which a leader feels prepared and driven to offer outdoor learning opportunities positively impacts the degree and frequency with which children participate in and benefit from guided interactions with nature. “Having the right teacher is crucial.” Pract3 recalls speaking with a teacher who had little interest in taking students outdoors and referred to themself as an “indoor geography” teacher. At the other end of the spectrum, some teachers/leaders are always looking for opportunities to incorporate outdoor learning; they "keep wellies under their desk."	8
Vicarious Outdoor Experiences	*Child-Led Outdoor Play*	Positive	Vicarious Outdoor Experiences may increase Child-Led Outdoor Play Vicarious experiences, while more passive, can serve as a gateway to real-world engagement with nature, encouraging children to seek out direct experiences and interactions with the natural environment. Pract1 says that certain phone apps can provide "a-ha moments" that foster interest in nature. However, some practitioners recognised that these vicarious experiences may also lead to a skewed perception of nature when emphasising only exotic or non-local species or idealised views of natural environments. Pract5 argued that nature content should be linked to local, accessible nature experiences, not just exotic or far-off examples. “It's about linking that nature content ... with what you might discover on your doorstep."	2
Guided Nature Engagement	*Perceived Access to Quality Local Natural Space*	Positive	Guided Nature Engagement increases a child's Perceived Access to Quality Local Natural Spaces Participating in guided activities helps children become more familiar with local natural environments, thereby increasing their sense of accessibility and encouraging further exploration. Leaders share knowledge about the value and use of local natural space with children and their families.	3

Peer Affinity for Nature	*Child-Led Outdoor Play*	Positive	Peer Affinity for Nature increases Child-Led Outdoor Play Children, especially as they grow older, often mirror the behaviours and interests of their peers. Children who value and enjoy nature encourage one another to explore, discover, and play in natural settings, fostering an environment where child-led outdoor play is not only more appealing but also socially supported. As children age, the opinions of their friends typically become more influential than those of parents or teachers.	4
Parent/Carer Aversion to Nature-Related Threats	*Screen Time*	Positive	Parents' Aversion to Nature-Related Threats may lead to an increase in indoor activities and Screen Time. Concerns about safety, wildlife, or the weather can lead parents to prefer the controlled environment of indoor activities, including increased screen time, as safer alternatives to outdoor play. “I've heard the television referred to as the electronic babysitter.” (Pract3) Pract10 talks about how their perspective as a parent has been shaped by fear of their local environment, impacting their children's access to outdoor experiences. "I worry much more about my kids in the city than I do when we're away...And that's just the urban fear."	5
Disabling Community Norms	*Perceived Access to Quality Local Natural Space*	Negative	Disabling Community Norms decrease a child's Perceived Access to Quality Local Natural Spaces Community attitudes that foster apathy, fear or exclusion regarding who can utilise local natural spaces directly reduce children's perception of their ability to access and benefit from these spaces. These norms, by promoting a sense of insecurity or by suggesting that certain individuals do not belong in such spaces, hinder children from feeling welcomed or safe in accessing green infrastructure. Despite the physical availability of green spaces in Scotland, social and cultural barriers may discourage their use among children. "You could be relatively poor or relatively wealthy, but if you're not in the social or cultural environment that values spending time in nature, then you could have a park right outside your flat but not use it" (Pract4).	8

Parent/Carer Aversion to Nature-Related Threats	*Guided Nature Engagement*	Negative	Parent/Carer Aversion to Nature-Related Threats may lead to a decrease in Guided Nature Engagement When parents or caregivers perceive nature as posing significant risks (e.g. wildlife, injury, and 'bad' weather) they are more hesitant to provide, allow or encourage their children's participation in guided outdoor learning experiences. Fear or apprehension in nature can be transferred from caregivers to children. As a result, children will be more apprehensive and less engaged even when participate in structured outdoor experiences.	3
Parent/Carer Affinity for Nature	*Child-Led Outdoor Play*	Positive	Parent/Carer Affinity for Nature increases Child-Led Outdoor Play Young children typically need the consent of their carers to play outdoors. Thus, carers' perceptions of nature and outdoor play will determine the amount of opportunity and degree of autonomy a child is given to explore and engage with nature. If carers view nature as dirty or dangerous, this perspective discourages and often prevents children--who rely on their parents' permission/supervision--from engaging in child-led outdoor play. A parent/carer with a high affinity for nature is more likely to encourage frequent outdoor play. If children observe their caregivers having fun or seeking experiences outdoors, they are more likely to mirror this behaviour.	8
Nature Connectedness	*Parent/Carer Affinity for Nature*	Positive	A child's Nature Connectedness may lead to an increase in their Parent/Carer's Affinity for Nature. Children may have a positive influence on their parents/carers. Observing their child's enthusiasm for nature and the positive effects of nature on their child's well-being, development, and environmental awareness often inspires and motivates parents/caregivers to participate more actively in outdoor activities, fostering shared family experiences that further reinforce their affinity for the natural environment. “Quite often we get reports back from the children and the families that they have gone back [to natural spaces] ... and that is the parent perhaps visiting that space	2

			for the first time and then exploring" (Pract1). Pract11 noted that children's outdoor experiences appear to influence their desire for more nature at home; they are "bringing it home".	
Access to Quality Local Natural Space	*Perceived Access to Quality Local Natural Space*	Positive	Access to Quality Local Natural Spaces increases children's Perceived Access to Quality Local Natural Spaces The objective access to quality natural spaces likely increases children's perception of its accessibility and value. More access generally implies more opportunities for children to interact with these spaces. However, practitioners were careful to note that actual access doesn't always translate to perceived accessibility, indicating a complex relationship between physical availability and personal perception (see the relationship between Disabling Community Norms and Perceived Access to Quality Local Natural Spaces).	4
Parent/Carer Affinity for Nature	*Screen Time*	Negative	An increase in the Parent/Carer's Affinity for Nature may decrease the Child's Screen Time. Parents typically manage children's screen time, normalising its duration and content. Carers who value outdoor experiences are more likely to limit screen time while carers who place little value in nature experiences and/or view nature as a threat will likely encourage more time spent indoors. As children get older and have their own phones, carers have decreasing supervision over screen time.	3
Leader Confidence and Motivation to Deliver Outdoor Learning	*Perceived Academic/Outdoor Learning Divide*	Negative	Leader Confidence and Motivation to Deliver Outdoor Learning decreases the Perceived Academic/Outdoor Learning Divide An increase in educator confidence/motivation means that outdoor learning is being reconceptualised as a complementary aspect of academic achievement. A leader's approach to achieving academic goals becomes broader. A motivated leader/educator, especially at the primary level, can serve as a crucial gatekeeper, effectively integrating outdoor learning despite organisational barriers.	3
Disabling Community Norms	*Negative Outdoor Experiences*	Positive	Disabling Community Norms increases the likelihood of the child having Negative Outdoor Experiences Disabling community norms--by fostering fearful or exclusionary beliefs about who belongs in natural spaces--shape a context in which outdoor encounters are uncomfortable or anxiety-inducing.	5

Nature Connectedness	*Child-Led Outdoor Play*	Positive	An increase in a child's Nature Connectedness increases the cumulative frequency and depth of Child-Led Outdoor Play As children develop a closer relationship with nature (an increase in connectedness), they are more likely to seek out further opportunities for child-led play. This is part of a powerful reinforcing loop; the more children take ownership of their outdoor learning, the stronger their relationship with nature will be, fostering a continuity of outdoor experiences.	5
Parent/Carer Affinity for Nature	*Vicarious Outdoor Experiences*	Positive	Parent/Carer Affinity for Nature increase Vicarious Outdoor Experiences Parents or caregivers with a strong affinity for nature are more likely to introduce their children to mediated forms of nature engagement, fostering an early appreciation and curiosity about the environment.	5
The John Muir Award	*Leader Confidence and Motivation to Deliver Outdoor Learning*	Positive	The John Muir Award increases Leader Confidence and Motivation to Deliver Outdoor Learning Practitioners observe that the Award may demystify the concept of 'outdoor learning' for leaders by providing a flexible framework that supports outdoor experiences tailored to their group's needs. This empowerment helps overcome common barriers like safety concerns or perceived lack of local wild spaces, enhancing leaders' readiness to incorporate nature into their teaching. "The simplicity of the framework embraces whatever people bring to it." (Pract7)	8
Perceived Access to Quality Local Natural Space	*Parent/Carer Aversion to Nature-Related Threats*	Negative	An increase in the Perceived Accessibility of Quality Local Natural Spaces will decrease Parent/Carer Aversion to Nature-Related Risks When parents or caregivers perceive natural spaces as easily accessible and of high quality, they may view these areas as safer and more inviting for their children, thus reducing their concerns about potential dangers and encouraging more outdoor exploration and play.	5

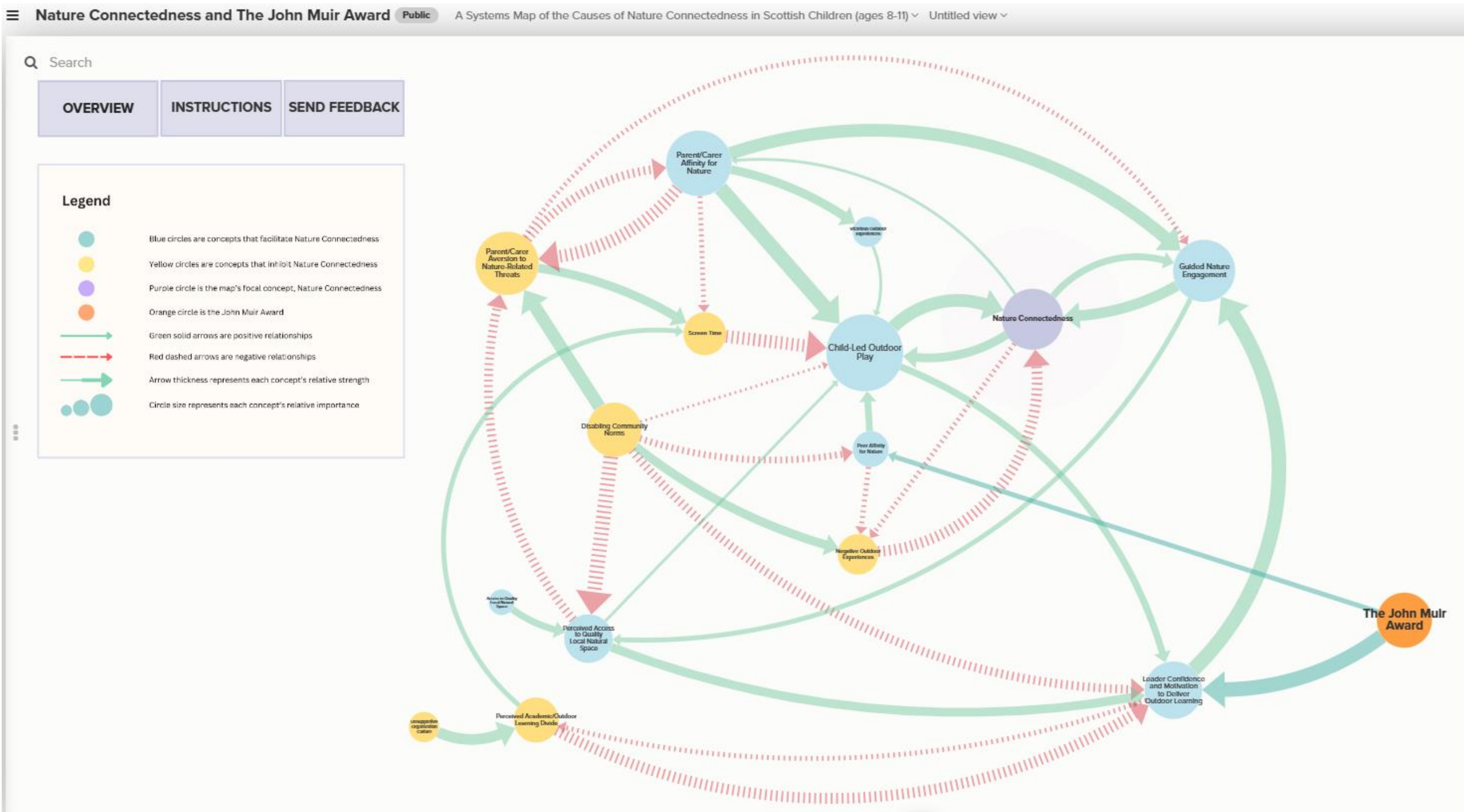
Perceived Access to Quality Local Natural Space	*Child-Led Outdoor Play*	Positive	An increase in the Perceived Accessibility of Quality Local Natural Spaces will increase Child-Led Outdoor Play When children perceive that they have easy access to safe and inviting natural spaces nearby, they are more likely to initiate and participate in outdoor play, both alone and with peers/adults. That said, young children don't tend to care as much about the 'quality' of a space but follow the lead of their parents/carers. Children can have a 'wow moment' even with seemingly trivial aspects of nature, like sticks and earthworms. Older children, with more defined preferences and experiences, are more likely to seek out spaces that align with their personal perception of quality and access, impacting how and where they choose to engage in self-directed outdoor play.	2
Perceived Academic/Outdoor Learning Divide	*Leader Confidence and Motivation to Deliver Outdoor Learning*	Negative	Perceived Academic/Outdoor Learning Divide may lead to a decrease in Leader Confidence and Motivation to Deliver Outdoor Learning Academic attainment and outdoor learning are often perceived to be mutually exclusive. A school may value measurable academic outcomes over the qualitative benefits of outdoor learning, such as enhanced physical health, mental well-being, and connection to nature. This environment reduces leaders' confidence and motivation to integrate outdoor learning due to a lack of support around nature-based activities and competing demands on their time. “These teachers are judged on how many of their kids pass the exam." (Pract12)	6
Child-Led Outdoor Play	*Nature Connectedness*	Positive	Child-Led Outdoor Play increases Nature Connectedness. Children's self-directed play in natural settings fosters a deeper emotional and cognitive bond with the environment. This form of play allows children to form personal connections with the natural world on their own terms, contributing to a lasting appreciation for and understanding of nature's value, which enhances overall nature connectedness.	7
Parent/Carer Aversion to Nature-Related Threats	*Parent/Carer Affinity for Nature*	Negative	Parent/Carer Aversion to Nature-Related Threats decreases Parent/Carer Affinity for Nature When parents or caregivers perceive an increase in significant risks related to outdoor settings their enthusiasm for and engagement with the natural world can be adversely affected. This aversion to perceived threats leads to a cautious or	5

			even negative stance towards outdoor activities, potentially reducing the frequency and quality of nature experiences they are willing to share with or endorse for their children.	
Parent/Carer Affinity for Nature	*Parent/Carer Aversion to Nature-Related Threats*	Negative	Parent/Carer Affinity for Nature decreases Parent/Carer Aversion to Nature-Related Risks An increase in a parent/carer's affinity for the natural world can reduce their focus on and concern for potential dangers associated with being outdoors, emphasizing the benefits over the risks. Pract8 recounts a story of a parent from an outdoor nursery who, despite receiving criticism for sending her child to an outdoor school in harsh weather conditions, remained steadfast in her belief that such exposure was beneficial for her child's future resilience.	7
Screen Time	*Child-Led Outdoor Play*	Negative	Screen Time decreases Child-Led Outdoor Play Increased screen time typically means that children spend more time indoors on electronic devices, which naturally leads to less time being spent outdoors in nature. When children do go outside, their habit of frequent screen use might also distract them, making them less engaged and attentive to the natural environment around them. "The more screen time we have, the less time in nature we will have." (Pract9)	7
Nature Connectedness	*Guided Nature Engagement*	Positive	If the child has an increase in nature connectedness, they are more likely to seek out and engage more deeply in Guided Nature Engagement experiences. A child's existing bond with nature can enhance their participation in and benefit from structured, adult-led outdoor activities, finding them meaningful and enriching.	4
Perceived Academic/Outdoor Learning Divide	*Screen Time*	Positive	Perceived Academic/Outdoor Learning Divide may increase a child's Screen Time When educational systems view academic achievements to be more important and at odds with outdoor learning and play, opportunities for outdoor exploration and learning are replaced by more indoor, sedentary, and screen-oriented activities, often perceived as more directly contributing to academic success.	3

The John Muir Award	*Peer Affinity for Nature*	Positive	The John Muir Award may increase Peer Affinity for Nature Participating in the Award as a group may establish a shared identity around an appreciation for nature. Children are required to 'share' their experience as part of completing the Award, which may inspire more children to seek out similar outdoor learning activities.	3
Guided Nature Engagement	*Nature Connectedness*	Positive	Guided Nature Engagement increases a child's Nature Connectedness An increase in the depth and frequency of guided outdoor activities will likely correlate with an increase in children's awareness, empathy, and affinity for nature, ultimately leading to stronger nature connectedness. For children ages 8-11, most outdoor experiences will be in the company of adults. Pract2 stated, "People can only be what they see", emphasising the importance of interacting with nature alongside role models.	6
Peer Affinity for Nature	*Negative Outdoor Experiences*	Negative	Peer affinity for nature decreases negative outdoor experiences When children are surrounded by peers who value nature, they create a supportive social environment that mitigates negative outdoor experiences. Nature-positive peers model respectful engagement with outdoor spaces, provide reassurance during challenging moments, and help reframe difficulties as part of rewarding adventures rather than problems to avoid. Conversely, when peers are openly averse or apathetic to nature, children may observe and adopt these negative attitudes, turning potential connection opportunities into disengaging experiences that reinforce aversion to natural environments. Complaints, fear, or resistance may become contagious within a peer group.	3

Child-Led Outdoor Play	*Leader Confidence and Motivation to Deliver Outdoor Learning*	Positive	An increase in children's Child-Led Play leads to an increase in Leader Confidence and Motivation to Deliver Outdoor Learning An increase in child-led outdoor play may serve to validate that outdoor learning works. Observing children handle natural objects with care, make their own discoveries, and develop their own connections to outdoor spaces builds leaders' confidence that they don't need to control every aspect of the experience. This evidence of children's self-directed outdoor engagement motivates leaders to create more opportunities for outdoor learning.	4
Nature Connectedness	*Negative Outdoor Experiences*	Negative	Nature Connectedness reduces Negative Outdoor Experiences Children who already feel connected to nature are better equipped to handle outdoor challenges. Children's initial fears of "mud, bugs, and briers" may give way to awe and curiosity when they have built a positive relationship with the natural world. Children with higher nature connectedness are more likely to view temporary discomforts or unexpected encounters as normal parts of being outdoors.	3

Appendix 5 – Screenshot and URL of online version of aggregated FCM



https://kumu.io/rchristianmasters/nature-connectedness-and-the-john-muir-award#a-systems-map-of-the-causes-of-nature-connectedness-in-scottish-children-ages-8-11

Appendix 6 - FCM simulation results (1a, 1b, 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b)

Scenario 1a: Mainstream school; children ages 8-11; without the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.28
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.45
Leader confidence and motivation to deliver outdoor learning (C5)	0.2
Nature connectedness (C6)	0.53
Negative outdoor experiences (C7)	0.79
Parent/carer affinity for nature (C8)	0.39
Parent/carer aversion to nature-related threats (C9)	0.67
Peer aversion for nature (C10)	0.87
Perceived access to quality local natural space (C11)	0.24
Perceived academic/outdoor learning divide (C12)	0.79
Screen time (C13)	0.93
Unsupportive organisation culture (C14)	1.0
Vicarious outdoor experiences (C15)	0.64

Scenario 1b: Mainstream school; children ages 8-11; with the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.42
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.74
Leader confidence and motivation to deliver outdoor learning (C5)	0.74
Nature connectedness (C6)	0.72
Negative outdoor experiences (C7)	0.73
Parent/carer affinity for nature (C8)	0.43
Parent/carer aversion to nature-related threats (C9)	0.66
Peer aversion for nature (C10)	0.72
Perceived access to quality local natural space (C11)	0.33
Perceived academic/outdoor learning divide (C12)	0.72
Screen time (C13)	0.91
Unsupportive organisation culture (C14)	1.0
Vicarious outdoor experiences (C15)	0.66

Scenario 2a: Specialist school; children ages 8-11; without the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.31
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.57
Leader confidence and motivation to deliver outdoor learning (C5)	0.28
Nature connectedness (C6)	0.6
Negative outdoor experiences (C7)	0.77
Parent/carer affinity for nature (C8)	0.41
Parent/carer aversion to nature-related threats (C9)	0.67
Peer aversion for nature (C10)	0.87
Perceived access to quality local natural space (C11)	0.27
Perceived academic/outdoor learning divide (C12)	0.72
Screen time (C13)	0.92
Unsupportive organisation culture (C14)	0.3
Vicarious outdoor experiences (C15)	0.65

Scenario 2b: Specialist school; children ages 8-11; with the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.47
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.82
Leader confidence and motivation to deliver outdoor learning (C5)	0.82
Nature connectedness (C6)	0.75
Negative outdoor experiences (C7)	0.73
Parent/carer affinity for nature (C8)	0.44
Parent/carer aversion to nature-related threats (C9)	0.65
Peer aversion for nature (C10)	0.72
Perceived access to quality local natural space (C11)	0.34
Perceived academic/outdoor learning divide (C12)	0.46
Screen time (C13)	0.9
Unsupportive organisation culture (C14)	0.3
Vicarious outdoor experiences (C15)	0.66

Scenario 3a: Mainstream school; young people ages 12-15; without the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.05
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.28
Leader confidence and motivation to deliver outdoor learning (C5)	0.1
Nature connectedness (C6)	0.31
Negative outdoor experiences (C7)	0.9
Parent/carer affinity for nature (C8)	0.35
Parent/carer aversion to nature-related threats (C9)	0.69
Peer aversion for nature (C10)	0.93
Perceived access to quality local natural space (C11)	0.27
Perceived academic/outdoor learning divide (C12)	0.87
Screen time (C13)	0.97
Unsupportive organisation culture (C14)	1.0
Vicarious outdoor experiences (C15)	0.63

Scenario 3b: Mainstream school; young people ages 12-15; with the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.07
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.53
Leader confidence and motivation to deliver outdoor learning (C5)	0.5
Nature connectedness (C6)	0.41
Negative outdoor experiences (C7)	0.88
Parent/carer affinity for nature (C8)	0.37
Parent/carer aversion to nature-related threats (C9)	0.68
Peer aversion for nature (C10)	0.85
Perceived access to quality local natural space (C11)	0.35
Perceived academic/outdoor learning divide (C12)	0.83
Screen time (C13)	0.96
Unsupportive organisation culture (C14)	1.0
Vicarious outdoor experiences (C15)	0.63

Scenario 4a: Specialist school; young people ages 12-15; without the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.05
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.37
Leader confidence and motivation to deliver outdoor learning (C5)	0.16
Nature connectedness (C6)	0.34
Negative outdoor experiences (C7)	0.89
Parent/carer affinity for nature (C8)	0.35
Parent/carer aversion to nature-related threats (C9)	0.69
Peer aversion for nature (C10)	0.93
Perceived access to quality local natural space (C11)	0.29
Perceived academic/outdoor learning divide (C12)	0.62
Screen time (C13)	0.95
Unsupportive organisation culture (C14)	0.3
Vicarious outdoor experiences (C15)	0.63

Scenario 4b: Specialist school; young people ages 12-15; with the Award

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.09
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.7
Leader confidence and motivation to deliver outdoor learning (C5)	0.66
Nature connectedness (C6)	0.49
Negative outdoor experiences (C7)	0.87
Parent/carer affinity for nature (C8)	0.38
Parent/carer aversion to nature-related threats (C9)	0.67
Peer aversion for nature (C10)	0.85
Perceived access to quality local natural space (C11)	0.41
Perceived academic/outdoor learning divide (C12)	0.53
Screen time (C13)	0.94
Unsupportive organisation culture (C14)	0.3
Vicarious outdoor experiences (C15)	0.64

Scenario 5a: Mainstream school; children ages 8-11; with the Award; decreased parent aversion

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.6
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.87
Leader confidence and motivation to deliver outdoor learning (C5)	0.79
Nature connectedness (C6)	0.82
Negative outdoor experiences (C7)	0.72
Parent/carer affinity for nature (C8)	0.56
Parent/carer aversion to nature-related threats (C9)	0.3
Peer aversion for nature (C10)	0.72
Perceived access to quality local natural space (C11)	0.55
Perceived academic/outdoor learning divide (C12)	0.71
Screen time (C13)	0.85
Unsupportive organisation culture (C14)	1.0
Vicarious outdoor experiences (C15)	0.7

Scenario 5b: Mainstream school; young people ages 12-15; with the Award; increased child-led outdoor play

Concept	Value
Access to quality local natural space (C1)	0.5
Child-led outdoor play (C2)	0.21
Disabling community norms (C3)	0.8
Guided nature engagement (C4)	0.6
Leader confidence and motivation to deliver outdoor learning (C5)	0.57
Nature connectedness (C6)	0.51
Negative outdoor experiences (C7)	0.87
Parent/carer affinity for nature (C8)	0.39
Parent/carer aversion to nature-related threats (C9)	0.67
Peer aversion for nature (C10)	0.85
Perceived access to quality local natural space (C11)	0.37
Perceived academic/outdoor learning divide (C12)	0.83
Screen time (C13)	0.95
Unsupportive organisation culture (C14)	1.0
Vicarious outdoor experiences (C15)	0.64

Appendix 7 – FCM simulation results when decreasing activation value of disabling community norms (C3)

Concepts	Concept values						
Disabling community norms (C3)	0.80	0.70	0.60	0.50	0.40	0.30	0.20
Access to quality local natural space (C1)	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Child-led outdoor play (C2)	0.42	0.50	0.57	0.64	0.70	0.76	0.80
Guided nature engagement (C4)	0.74	0.78	0.82	0.84	0.86	0.88	0.89
Leader confidence and motivation to deliver outdoor learning (C5)	0.74	0.79	0.83	0.86	0.88	0.90	0.92
Nature connectedness (C6)	0.72	0.77	0.81	0.84	0.87	0.88	0.90
Negative outdoor experiences (C7)	0.73	0.69	0.66	0.61	0.57	0.53	0.49
Parent/carer affinity for nature (C8)	0.43	0.45	0.48	0.50	0.52	0.54	0.56
Parent/carer aversion to nature-related threats (C9)	0.66	0.61	0.55	0.50	0.45	0.40	0.35
Peer aversion for nature (C10)	0.72	0.69	0.66	0.63	0.60	0.60	0.53
Perceived access to quality local natural space (C11)	0.33	0.40	0.47	0.54	0.60	0.66	0.71
Perceived academic/outdoor learning divide (C12)	0.72	0.71	0.71	0.70	0.70	0.69	0.69
Screen time (C13)	0.91	0.90	0.89	0.88	0.87	0.86	0.84
Unsupportive organisation culture (C14)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vicarious outdoor experiences (C15)	0.66	0.66	0.67	0.68	0.69	0.69	0.70

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