Modeling Child-Nature Interaction in a Forest Preschool: A Behavioral Analysis Aligned with Landscape Affordances

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Abstract

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Interaction with nature has been positively linked to the psychological, physiological, and social development of children. In turn, nature preschools offer children the means for such interaction on a daily basis. However, little is known about child-nature interactions in such educational settings. In this observational study, I sought to model the child-nature interaction of 49 three-to-five year olds at Fiddleheads Forest Preschool located in the University of Washington Arboretum. Through a randomized time-sampling methodology, children's interactions were video-recorded over a period of 35 weeks. Based on a second-by-second coding of the video data, a model was developed that is comprised of 26 child-nature interaction patterns, which refer to functional units of human interaction that are aligned with the affordances of the landscape. I also predicted that relatively more wild areas of the nature classroom would be positively associated with child-nature behaviors that were more relational – more in balance and in harmony with nature. Results confirmed this hypothesis. Discussion focuses on the ontogenetic and phylogenetic significance of the modeled child-nature interactions, and of the importance of more wild forms of nature for human development and flourishing.

Introduction

In the United States, there is an alarming trend concerning the psychological and physiological well-being of children and adolescents. 13.7 million youths are classified as obese, with 13.9% aged two to five years (CDC, 2018). Additionally, 9.4% of young people between the ages of 2 and 17 have been diagnosed with ADHD, with approximately 400,000 of them being preschoolers (CDC, 2018). While clinical intervention represents a common and oftentimes effective source of intervention to address these issues, mounting empirical evidence indicates that spending time in nature affords relevant psychological and physiological benefits that can also address these issues, particularly for children. In a review of over 60 empirical studies on the topic of childhood health and nature, far-reaching benefits of interacting with nature included improved motor development as well as improved mental health and emotional regulation, especially for children diagnosed with ADHD (Gill, 2014). The same review also found specific benefits of forest programs, with children experiencing better self-control and developing better social skills in these more nature-oriented programs. Given the rise in childhood health issues occurring in tandem with widespread destruction of the environment, ascertaining the benefits of children's contact with nature may ultimately allow for the preservation of the natural environment and the wellbeing of future generations.

Alongside research indicating the mental and physical benefits available to people through contact with nature, mounting evidence also indicates the developmental significance of interaction with the natural environment from a young age. Much of this past research has focused on different forms of play that occur in nature, particularly the degree to which nature affords opportunities for imaginative and symbolic play (Dennis et al., 2014). In addition to forms of play in nature, research has examined the degree of physical movement that can occur in more

naturalistic settings in comparison to traditional hardscape playgrounds. One such study found a significant increase in moderate-to-vigorous physical activity in a play area that was renovated to include more elements of nature (Coe et al., 2014). While an understanding of the socio-cognitive benefits of play as well as degree of physical movement in nature certainly represent an important aspect of children interacting with the environment, an evidence-based framework superseding and uniting these two disparate research aims does not currently exist in the literature.

In conducting the current study, I had two major goals: a) to begin to develop a model of child-nature interaction based on interaction pattern theory, and b) to examine behavior as aligned with landscape affordances. With respect to the second goal, I sought specifically to test my hypothesis that relatively more wild or unmediated areas of the outdoor classroom sites would afford more child-nature interaction that can be defined as "relational": that is, behavior within a natural environment that reflects awareness, respect, or balance on behalf of the individual in relation to their surroundings. Ultimately, this study represents the first of its kind, and uses a finite dataset from one particular nature preschool location in order to both develop a proof of concept that may then be applied to other natural settings available for children and to seek to provide evidence for the importance of relatively wild nature in the development of positive human-nature relationships.

The data for this study was collected at Fiddleheads Forest Preschool located in the University of Washington Arboretum. Nature and forest preschools are becoming increasingly common across the U.S. These outdoor early childhood educational programs take place with all or a significant majority of class time spent outside in all weather conditions, unless temporarily prohibited due to extreme cold, heat, or wind. Thus, a significant difference between a nature preschool and a typical preschool exists both in the amount of time spent outdoors as well as the

degree of natural environment available with which the children may interact. Collecting data from a single nature preschool allowed for the analysis of children's interactions with the natural environment given a controlled set of variables including the following factors: participant age, available landscape affordances, time of day for data collection, and degree of teacher and adult supervision. This choice of data selection site as a forest preschool also allowed for child-nature interaction to be considered in a broader educational context.

Interaction Patterns. In order to systematically understand the ways children interacted with the natural environment at Fiddleheads Forest Preschool, I used an interaction pattern analysis approach. *Interaction patterns* refer to the functional units of human interaction with the relevant characteristics that nature affords (Kahn et al., 2012). An interaction pattern analysis allows for the characterization of human-nature interaction with enough specificity to capture ontogenetic and phylogenetic significance, but with enough generality so that many different instantiations of the interaction can be enacted. As an illustration of an interaction pattern, it is useful to consider the physical act of "balancing" that has been identified in the literature as developmentally important for children in nature (Hanscom, 2016). In natural environments, there are often different shapes and sizes of natural objects available for children to balance on, such as fallen trees or rocks. In an interaction pattern analysis, this overarching child-nature interaction is characterized as *balancing on natural features*. The first part of the interaction pattern specifies the action undertaken by the child and is represented in our analysis by the gerund form of the verb "balance". In this example, the latter portion of the interaction pattern indicates the aspect of the natural environment involved and here is abstracted to a broader hierarchical category that involves logs and stumps in the category "natural features".

Interaction patterns can occur in many different forms and instantiations. For example, if the context of use deemed it appropriate, the aforementioned child-nature interaction of *balancing on natural features* could be instantiated in a more specific or a more broad manner with respect to both the action as well as the environmental elements. In the case of the former possibility, perhaps in a specific nature setting where icy conditions are typical then the physical action of *walking carefully across natural features* represents an important or frequent child-nature interaction. Thus, an interaction pattern analysis of this data would require a more specific form of "balancing" to be used. Or perhaps in another landscape characterized by boulders and rocky terrain, *balancing on large rocks* is a marked occurrence for children. In this case, the nature feature included in the interaction pattern would need to be described as the more particular element involved. In this way, an interaction pattern analysis of child-nature interaction allows for the distinction of the relevant ways individuals interact with the environment and also affords greater specificity or increased breadth depending on the particular environmental context of use.

Interaction patterns fundamentally rely on the characterization of the natural environment along a wild to domestic continuum. This continuum allows for an understanding of human-nature interaction based upon a categorical distinction of the relative degree of human mediation within a natural environment. Interaction patterns denoting humanity's biological legacy accrued through hundreds of thousands of years of evolution in tandem with nature often involve natural environments located on the more wild end of the continuum. On the other hand, interaction patterns characterizing the shift from hunting and gathering to agriculture that occurred in human societies during the Neolithic era and continuing into modernity are more often afforded by landscapes that are more domestic. Drawing again from the previous interaction pattern example, *balancing on river rocks* represents a more wild example of the overarching pattern mentioned in

the paragraph above, while *balancing on cement blocks* exists as a more domestic instantiation of the same basic interaction pattern. Note that in this case, "cement blocks" are included as the environmental affordance involved in this human-nature interaction. While cement blocks represent an artefact of human construction made from natural materials, they still can be considered when assessing human interaction with the physical world – indeed, this is why the wild-domestic continuum is useful to understand the broad range of human interaction with the features that a natural and urban environment affords. In sum, both of these interaction pattern examples represent important aspects of child-nature interactions, and the distinction between a more wild form and a more domestic form allows for our categorization of the different aspects of natural and artefactual features that are present given a particular context.

The concept of interaction patterns draws inspiration from the ideas of architect and design theorist Christopher Alexander. In his 1977 work *Pattern Language*, Alexander and his colleagues provide extensive characterizations of 253 design patterns that represent essential solutions to structural problems that help to maximize the quality of architectural space (Alexander et al., 1977). An example of a design pattern that should be included in an effective space for human inhabitance includes Alexander's description of an *entrance transition* between the outside and inside of a building. In his explanation for designing a space to represent both the end of one and the beginning of another, Alexander notes that this may be effectively accomplished by using various combinations of archways, textures, and tiles – all different changes in the physical space that ultimately lead to the same psychological effect. Another example of a design pattern involves constructing special places for children within the home. Alexander specifies that within the adult space that characterizes much of the home, *child caves* provide a space for play and imaginative interaction among children. It is mentioned that in such a space, each child would take up about 5

feet. Alexander further specifies that children typically enjoy engaging in these spaces in groups of three to five, so an allocation of "15 to 25 square feet, plus about 15 to 25 square feet for games and circulation" denotes a rough maximum size for this design pattern to be instantiated in many different homes for the benefit of children residing there (p.928). Essentially, Alexander's design patterns for successful human-architectural space interaction can be extended and reinterpreted in an interaction pattern framework for the analysis of effective human-nature interaction.

Environmental affordances. Different forms of interaction with physical space or the physical environment may exist within a single theoretical framework but be instantiated in a multiplicity of forms. In this study's interaction pattern analysis framework, another important aspect of the modeling approach relies upon the concept of environmental affordances. Gibson (1979) described the way in which the environment of an organism furnishes certain properties that represent a means of specific interaction. In his view, the world is not only perceived by the observer in terms of shapes and spatial relationships, but also by the possibilities for action. In Gibson's view, it is this comprehension of the potential means for interaction that essentially guides and constricts the behavior of any organism. As an example of an environmental affordance, he considers that the physical properties of a surface as horizontal, flat, extended, and rigid creates an affordance of *support*. However, this affordance of support is limited to the particular dimensions of the being interacting with it. For instance, due to its small size and the physical properties determining water tension, a water bug will find a lake to appropriately offer the affordance of support. But when we consider the same lake from the perspective of a young child, the relevant affordance supports the interaction of *buoyancy* or *swimming*.

While one can see how a lake may offer an affordance for the child to swim, in order for the child to engage in the interaction pattern of *swimming in lake,* it is first required that the child

intuit the fact of the environment providing this capacity. A student of Gibson's, Thomas Reed, built upon the notion of affordances in his work titled *The Necessity of Experience* (1996) and indicated that people will only perceive the available opportunities for interaction within a physical space when they have had direct experience with the world. Primary experience that is gained through our physical senses, according to Reed, is our most basic way of understanding reality and learning for ourselves. In his view, the rise of technology in recent decades and the shift from primary to secondhand experience of reality represents a cultural shift from perceptual discernment by an individual to a reliance on selected and packaged information provided by a source external to the self. Reed contends that although we have entered an age of unprecedented information processing and transmission capabilities, we simultaneously are experiencing in our lives a diminished role of ecological information - that which we can gain only through our own personal interaction with the world.

Constructivist psychology. This explanation takes us to the heart of the increasing prevalence of both childhood mental and physical illness and widespread environmental destruction that is occurring on a worldwide scale. It has been postulated that as a species we are suffering from *environmental generational amnesia,* whereby each successive generation of people accepts the degraded state of the environment they are born into as normal (Kahn et al., 2012). Within the context of this shifting baseline, a child then constructs their understanding of the world and its properties in a way that does not account for the diminishment that has taken place – which thereby allows for the continued destruction of the environment. This exists as an insidious and recursive process, whereby the acceptance of a nature degraded by our own hands as normal then perpetuates its increasing destruction. And with a degraded environment comes less interaction with nature, and with less interaction with nature comes the inability to even

recognize the possibilities for interaction as represented by environmental affordances that are becoming increasingly eradicated.

With this in mind, opportunities for extended and frequent interaction with nature may provide a solution space for helping to reverse the negative psychological and physiological effects of environmental generational amnesia within the purview of constructivist psychology. Jean Piaget's (1954) theoretical framework by which children construct knowledge of the physical and logical world by means of repeated interactions with the physical and social constituents of their environment provides a conceptual base for understanding the utility of child-nature interaction for the sake of improved human health and well-being. Through the mechanisms of assimilation and accommodation, children process new information and seek to either fit this input into their existing conceptual schemata or reconstruct their existing understanding of the world in a manner most amenable to this added experiential information. If children have the opportunity to experience nature and interact with their environment frequently, a constructivist theoretical perspective then predicts that children will be able to develop into adults who both have a greater understanding of themselves in relation to the physical world and also have a deeper appreciation for the natural environment.

In the current study, I sought to systematically characterize the ways in which children interact with the landscape affordances of a natural environment to begin to develop a model of child-nature interaction. Since this study represents the first of its kind, the research concerns were guided by an exploratory design, with one specific and testable hypothesis generated from the following research questions:

1. What child-nature interaction patterns occur in a forest preschool?

2. Do different parts of the outdoor classrooms lead to different interaction patterns?

With respect to the second research concern, I hypothesized that more wild parts of the outdoor classroom sites would give rise to more relational interaction patterns, and more domestic parts of would allow for the instantiation of interaction patterns that are directly harmful to the environment. I define relational interaction patterns as those that require a dimension of balance with and responsiveness to the natural environment, while those directly harmful to the environment involve behavior with a clear destructive intent and effect on the environment. I expected to find that areas of the outdoor classroom sites that were less mediated by human interference and had more natural elements, thus being more wild, would afford a greater degree of behavior indicating a child's responsiveness to or being in balance with the surrounding natural environment. I also expected areas of the outdoor classroom sites with less unmediated nature and more artefactual components would be associated with more behavior that is directly harmful to the environment. With these predictions of landscape affordances driving behavior either in relation to nature or directly harmful to the environment, I ultimately seek to consider not only the kinds of child-nature interactions that may exist but also how to perpetuate and foster children's positive relationships with the environment.

Methods

Participants

Forty-nine (27 female) children between the ages of three five (M=4.5, SD=0.65) participated in this study. Of the 48 children whose parents identified their race/ethnicity, 36 indicated White/Caucasian, three indicated Asian, and nine indicated other or mixed race/ethnicity. They were recruited from the Fiddleheads Forest Preschool parent contact list furnished by the program director.

The Nature Preschool Site

There were two outdoor classrooms of Fiddleheads Forest preschool located across from one another in the University of Washington Arboretum. The school names the sites Magnolia and Trillium. I divided both sites into five distinct zones for complete and equal video coverage (M1-M5; T1-T5). A randomized time-sampling methodology was used to collect 35 weeks of data from February 2016 to May 2017. Filming took place Monday through Friday for 1 hour each day, with each zone being filmed for a total of ten minutes. All zones of the outdoor classroom sites were filmed the same number of times. The layout of the two classrooms can be seen in the figure below.

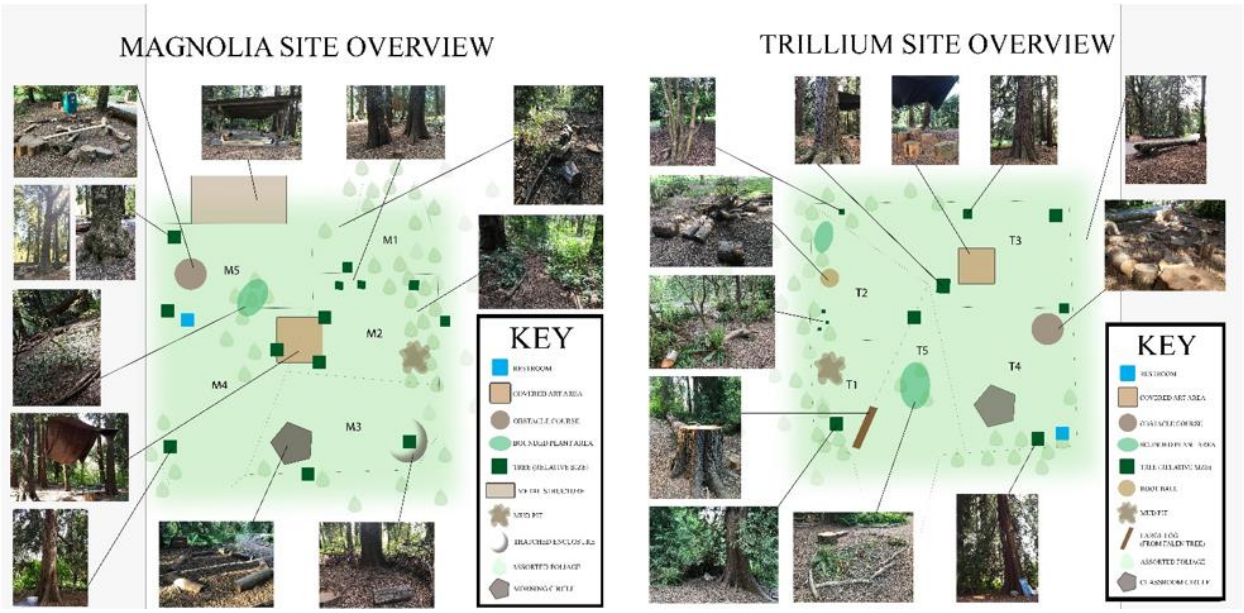

Figure 1. Maps of Fiddleheads Forest Preschool outdoor classroom sites

Coding and Reliability

The 35 weeks of child-nature interactions were recorded on a single digital camera. These video recordings were then reviewed for behavioral coding. As this study represented the first of its kind, we developed a new coding system to characterize all pertinent interaction patterns as well as the relevant environmental affordances available in the outdoor nature classroom sites.

The children's behavior was coded as it occurred with the environmental affordances of the outdoor classroom sites. In total, 1851 child-nature interactions were observed over the entire data collection process. These observed child-nature interactions were coded as 26 interaction patterns organized within the six following over-arching categories: Elemental, Physical, Mental, Social, Animal, and Impactful. These conceptual categories represent the different dimensions of child-nature interaction observed at Fiddleheads Forest Preschool and allow for the relevant distinction among the 26 enacted interaction patterns.

In the analysis of the landscape affordances enabling the enactment of interaction patterns at Fiddleheads Forest Preschool, 18 nature features were coded and categorized into the following over-arching categories: Stable, Components of Relatively Stable, and Transient. These three conceptual categories indicate the relevance of parts of the outdoor classroom that remain year-round, as well as those that exist in a more ephemeral manner. This coding classification allowed us to analyze child-nature interaction as it occurs in a dynamic natural system.

A second coder trained in the use of the coding system recoded the first 17 weeks of video data. For all of the interaction patterns, the overall value of Cohen's kappa was .6. For all of these identified interaction patterns, the overall value for the Cohen's kappa of the total wild to domestic rating was .57. Two commonly referenced benchmarks for interpreting the values of Cohen's kappa are Fleiss, Levin, and Paik (2003), who rate any value of kappa over 0.75 as "excellent" agreement, between 0.40 and 0.75 as "intermediate to good", and below 0.40 as "poor," and Landis and Koch (1977), who rate a kappa of 0.81 to 1.00 as "almost perfect" and between 0.61 and 0.80 as "substantial" agreement." The entire coding manual will be made available online for inspection and as a resource.

Results

The results from this study of child-nature interaction at Fiddleheads Forest Preschool is divided into the following two sections: 1) interaction patterns and 2) landscape affordances. For each section, I include a table that provides a prototypical photo of the interaction pattern or landscape affordance, the percentage of occurrence in the dataset, and additional information relevant to the observed child-nature interactions and associated nature features.

Interaction Patterns

As can be seen in Table 1, by far the most frequently enacted interaction pattern was *using one's body vigorously in nature* from the Physical category and represented 25% of total observed child-nature interactions. This result is somewhat expected, as much of the children's behavior in the nature preschool classrooms involves short bursts of activity and is aligned with previous research indicated the importance of moderate-to-vigorous physical activity in children's time in the outdoors. Perhaps the most interesting component of this result was the diversity of vigorous movements children so frequently enacted: sprinting, jogging, crawling, rolling, kicking, jumping, and throwing. The affordances of the outdoor nature classroom sites and the setting of a forest preschool as occurring entirely outdoors allowed for these patterns to not only be enacted frequently, but also in a pervasive manner. While a typical preschool may offer junctions of outdoor play time in a relatively urban environment, Fiddleheads enables continuous and variable physical movement throughout the school day. This is important as one considers not bursts of activity intermixed with long periods of sedentary behavior, but rather continued and sustained physical movement for optimal human health and well-being.

Table 1. Interaction Patterns at Fiddlehead Forest Preschool: Illustrative Photo, Percentage of Use, and Ontogenetic and Phylogenetic Significance.

Category	Interaction Pattern	Percentage of Total Observed Child-Nature Interactions	Ontogenetic and Phylogenetic Significance
Physical	 *Using one's body vigorously in nature*	25%	While humanity came of age using our bodies vigorously in natural environment, modern urban environments often do not allow for the daily and consistent exercise our bodies need for optimal psychological and physiological health. Nature preschools allow for the enactment of this interaction pattern in many different forms.
Elementa l	 *Being outside in inclement weather*	11%	Weather potentially exists as the most wild form of nature that children in a nature preschool may encounter. In this way, it requires children to act in accordance with its demands and is entirely outside the control of mankind. At Fiddleheads Forest Preschool, conditions of rain, snow, ice, and cold are not uncommon.
Physical	 *Gathering nature items*	8%	Hunting and gathering represent fundamental components of the human ancestral interaction with nature. The outdoor nature classroom sites at Fiddleheads Forest Preschool allow for children to engage in the latter constituent of this phylogenetically significant human-nature interaction pattern. As observed anecdotally in this data set, this interaction pattern also furnished opportunities for children to work on social skills such as sharing and re-distribution of a finite resource.
Physical	 *Balancing on natural features*	7%	The ability to achieve physical equilibrium often underlies the ability psychologically and emotionally equilibrate. This interaction pattern is uniquely afforded by the varying shapes and sizes of natural features in the Fiddleheads Forest preschool outdoor classroom sites and allows children to develop an understanding of proprioception and their physical relationship to the surrounding physical environment.

Physical	 *Manipulating nature items*	7%	This interaction pattern captures the broad recognition by children of their ability to not only interact with the affordances of the natural landscape, but to also achieve desired endpoints through their physical exertion and subsequent transformation of some component of their surroundings. The development of a sense of agency and self-efficacy underlies much of adult competency, and opportunities for practice and ascertaining the capacity of oneself to manipulate their physical environment at a young age provides a useful scaffold to help structure the eventual attainment of aptitude and proficiency in one's dealing with the requirements of life.
Physical	 *Digging in ground*	6%	This interaction pattern combines two important phylogenetic and developmental achievements: 1) the recognition of the parameters for interaction with landscape affordances, and 2) the ability to use tools to achieve desired ends. Nature preschools uniquely offer the optimal environment for children to engage in artefactual manipulation of the physical environment.
Social	 *Pushing to the edges of social boundaries*	5%	Testing boundaries socially and physically underlie healthy childhood development. One must assess the limits that exist in order to know the potential success that one will attain. Children in Fiddleheads Forest Preschool more than not respected the boundaries in place (typically for their own protection, or that of delicate flora in the nature classrooms) – but we did observe instances of children pushing a bit beyond the edge and subsequently ascertaining the affordances of the landscape engendered by their transgression of socially designated boundaries.
Physical	 *Grappling with nature items*	5%	Sometimes there are things we encounter in life that are beyond our ability to control. For children in Fiddleheads Forest Preschool, this idea manifested in the inaccurate assessment of a child's ability to successfully exert their will or intentions upon their surrounding physical environment. Ultimately, there exists grace even in the failed attempt to exert one's influence on their environment, as it necessarily develops dexterity in recalibrating and poise in reconfiguring how to achieve one's objectives.

Physical	 *Clambering on natural features*	4%	The varying shapes, sizes, and forms of landscape affordances at Fiddleheads Forest Preschool allowed children to engage physically with the environment in many different ways. This interaction pattern represents a means of physical exertion at once both vigorous and exploratory, allowing children to navigate the affordances of the physical environment as well as the capabilities provided by their own physique.
Mental	 *Imagining nature to be something other than it is*	4%	The ability to mentally transform objects of the physical world underlies fundamental cognitive development of the human mind. Nature provides ample affordances for children to engage in pretend play scenarios and practice this cognitive skill that evolved over tens of thousands of years of the human mind and body interacting with the natural environment.
Physical	 *Leaning against tree*	3%	The physical support of a big tree often offered children in Fiddleheads Forest Preschool emotional support after instances of conflict with classmates. Self-regulation is an essential skill children must develop, and the ability to recognize the affordances of nature to scaffold one's psychological recalibration after a social altercation makes nature preschools an ideal early childhood learning environment.
Animal	 *Looking at wild animals*	3%	E.O. Wilson posited that humans have an innate tendency to affiliate with life and life-like processes (1975). A nature classroom allows for children to engage with insects and animals in many ways- with voyeurism being one of them. Observing the behavior of other life forms *in situ* affords children at forest preschools such as Fiddleheads deep and engaging experiences with animals in the wild.
Physical	 *Striking wood on wood*	2%	The ability to intuit the affordances of natural and artefactual materials likely underlies the human achievement of tool use. Developmentally, this interaction pattern represents the capacity of a child to ascertain the utility of different objects and to manipulate their environment.

Physical	 *Lying on earth*	2%	Meaningful contact with nature does not always occur in a visual or auditory manner, despite the relative hyper-focus of most scientific literature on these two sensory modalities within the purview of nature and human health. Children at Fiddleheads Forest Preschool would sometimes engage with nature by lying down on the ground and disengaging with the social world around them, likely providing a degree of restoration through their repose on the surface of the earth.
Physical	 *Leaning and hanging from supple tree limbs*	2%	Ecological psychology posits that interactions with the affordances of nature allow for the successive intuition of further affordances that allow for even more extensive interactions. As children explored the counterbalancing of their weight with respect to the low-hanging tree limbs of the nature classrooms they simultaneously developed a physical understanding of their bodies in relation to nature as well as exploring the properties of the available landscape affordances.
Physical	 *Falling on ground*	1%	The ability to fall- and to get back up – is a skill requiring opportunity and practice. Natural environments uniquely provide an ideal physical context for children to learn this fact of life. However, as children more often consider themselves "inside children" and less often engage in physical activity outdoors, they are less likely to engage in this interaction pattern.
Physical	 *Recovering from a potential fall on ground*	1%	Following from the above interaction pattern, it is likely that engaging in available opportunities for falling will lead to the integration of appropriate action schemas that will ultimately keep one on their feet. A nature preschool environment allows children to have myriad opportunities to fall – and recover- as they develop their sense of physical and mental being within the world.
Physical	 *Constructing shelter*	1%	Recognizing the affordances of natural environments and using them to engage in place-making represents a human-interaction with nature rooted deep in our evolutionary history. The nature features available in Fiddleheads Forest Preschool allowed for children to engage with the natural environment in a way that draws upon our Paleolithic past.

Social	 *Being in solitude in nature, passively*	1%	Part of being a social being requires the acknowledgement of the space that exists for being alone. At Fiddleheads Forest Preschool, children would often take advantage of the seclusion offered by the landscape affordances – particularly in situations requiring regulation, restoration, or rest.
Animal	 *Cohabiting with a wild animal*	1%	Dominionistic behavior often involves human beings not only exerting their will over the natural environment, but also believing that this is the way that things should be. This interaction pattern exists as a prototypical relational child-nature behavior observed at Fiddleheads Forest Preschool. The acknowledgement of another life form and the actions taken by children to respect an insect or animal's right to continued existence make natural educational environments ideal for the development of a positive human-nature relationship.
Social	 *Being in solitude in nature, actively*	1%	In contemporary urban society, being "active" often involves the directed focus of our attention. Attention Restoration Theory posits that this leads to directed attention fatigue, whereby our cognitive resources are temporarily depleted (Kaplan & Kaplan, 1989). This interaction patterns represents a potential means of attention restoration through children engaging with nature not through directed attention, but through a less effortful kind termed *soft fascination*. The availability of relatively secluded natural areas at Fiddleheads Forest Preschool uniquely afford this child-nature interaction.
Animal	 *Imitating animals*	1%	In addition to allowing for the practice and elaboration of children's pretend play skills, this interaction pattern also involves the internalization of the importance of the fauna of the natural world. Children mimicking animals within their play scenarios ultimately indicates their respect for other living creatures as a form of being worthy of imitation.
Social	 *Making social boundaries on earth*	1%	The "loose parts" available in the outdoor nature classroom sites allow for children to engage in a developmental recapitulation of the phylogenetic shift from nomadic to agricultural life that characterizes the Neolithic period of the human species. Children would use branches, sticks, and logs and stumps to create boundaries and designate different spaces within the nature classrooms.

Physical	 *Climbing high in small tree*	<1%	The exertion of our physical bodies can manifest in many forms that are often linked to potential adaptive advantages rooted in our evolutionary history. This particular interaction pattern could be phylogenetically linked to the ability of an individual to gain access to a valuable vantage point.
Animal	 *Calling birds*	<1%	Birds represent a form wild form of nature that are often accessible even to people in urban environments. In this particular enactment of this interaction pattern, the child attempted to communicate with the birds in the outdoor nature classroom all the while recognizing that they were not at her behest to respond or in any way react to her wishes. This fundamental recognition of the freedom of the other underlies the development of any healthy relationship one may form in life.

The second most frequently occurring child-nature interaction comes from the Elemental category and was designated as *being outside in inclement weather* (11%). For this study, "inclement weather" required at least one of the following relatively extreme weather conditions: heavy or torrential rainfall, the presence of snow or ice, or temperatures near 32°F (0°C). This pattern represents a fundamental characteristic of the affordances of a nature preschool, in that especially in a city such as Seattle, children must learn to regulate their minds and bodies to deal with difficult weather conditions. This pervasive pattern also likely helps engender many of the other child-nature interactions occurring in Fiddleheads Forest Preschool. *Being outside in inclement weather* also potentially represents the most wild aspect of nature that these children have access to, as it is entirely outside the control of humankind and requires people to continually assess their physical state in accordance with the external conditions. In this way, inclement weather as coded in this data set as exceptionally heavy rain, snow, or icy conditions provided a means for these children to each day exercise self-regulatory skills in a physical and psychological sense and to develop an appropriate sense of homeostatic equilibration.

A majority of the remaining interaction patterns enacted came from the Physical category (65%). This category allowed for the analysis of the manifold ways that children used their bodies to interact with the affordances of the outdoor classrooms and reveals that a large majority of their interactions involve a physical component. *Gathering nature items* (8%) represented the most frequent of the remaining Physical interaction patterns, and along with *constructing shelter* (1%) exists as a developmental recapitulation of a phylogenetically engrained pattern of human-nature interaction. Physical equilibration also proved to be especially relevant, as children often engaged in *balancing on natural features* (7%) as well as developing body-environment awareness through *falling on ground* (1%) and also *recovering from a potential fall on ground* (1%). Children often explored their ability to alter or affect the surrounding environment, manifested in the representative interaction patterns of *manipulating nature items* (7%), *digging in ground* (6%), and *grappling with nature items* (5%).

While vigorous exertion of one's body was captured in the most frequently occurring interaction pattern noted earlier, different forms of physical engagement and exploration of the outdoor environment proved to be important. Children pushed their physical limits by *clambering on natural features* (4%) and *climbing high in small trees* (<1%). They also learned the properties and affordances of natural features by using loose parts to *strike wood on wood* (2%) and gaining proprioceptive knowledge of one's relation to a dynamic natural environment by *leaning and hanging from supple tree limbs* (2%). Physical contact with the environment of the outdoor classroom sites also entailed more restorative behaviors through *leaning against trees* (3%) and *lying on earth* (2%). These interaction patterns were often preceded by an instance of discord between children, followed by a child seeking the physical support of a big tree or the surface of

the earth. It appears that this physical support of landscape affordance often provided a means by which the children could self-regulate emotionally.

The Social category of interaction patterns accounted for 7% of remaining enacted child-nature behaviors. These behaviors involved both *pushing to the edges of social boundaries* (5%) and *making social boundaries on earth* (1%). These two patterns echo the evolutionary shift from nomadic to agricultural life whereby territorial distinctions began to exist at the forefront of the human understanding of space. The latter pattern also indicates the children's responsiveness to the available "loose parts" in the outdoor classroom and their subsequent enactment of a phylogenetically engrained nature interaction in a developmentally appropriate manner. Also embedded with the Social category *being in solitude in nature* (1%) in both an active and passive manner. An important component of the human social existence is the ability to acknowledge the need at times for one's privacy. As such, the landscape at Fiddleheads Forest Preschool affords features to offer secluded areas for children to be alone. Children often sought solitude in these areas after an altercation or dispute with fellow classmates, leading me to consider that the ability to find solitude in nature may provide an effective mechanism for regulation, regrouping, and restoration.

The child-nature interactions afforded by the fauna of the outdoor nature classroom is captured by the Animal category (4%). In modern life, the ability for children to engage with animals more often occurs through interactions with domesticated pets or animals in zoos. Fiddleheads Forest Preschool allowed children to engage with insects and animals in situ by providing a periodically changing environment for *looking at wild animals* (4%), engaging in diverse play situations by *imitating animals* (1%), and also opportunities for calibrating their actions with respect to the well-being of other lifeforms by providing an environment allowing for

the *cohabiting with a wild animal* (1%). While representing only a single occurrence within the data set, a marked child-animal interaction was captured of a child attempting to communicate with the frequent avian visitors of the outdoor classroom. This instance of *calling birds* (<1%) represents the engagement of the child to the surrounding nature and her responsiveness to the animals with which we share the environment.

The development of cognitive transformation and pretend play skills proved to be afforded by the outdoor nature preschool environment and is represented by the pattern *imagining nature to be something other than it is* in the Mental category (4%). This behavior often involved loose parts of the nature classroom and is indicative of an essential phylogenetic transformation of human cognitive ability that underlies much of the modern human mind. The ability to mentally re-present objects and engage in pretend play with these transformed items provides a foundation for much of human social and cognitive development. The degrees of freedom afforded by the possibilities for human interaction with a natural environment uniquely offers an ideal context for children to exercise this fundamental mental skill and to engage in social play scenarios.

Landscape Affordances.

As can be seen from Table 2, a total of 18 landscape affordances were determined to be relevant in driving the enactment of interaction patterns at Fiddleheads Forest preschool. Wood-chip ground and mulch proved to be involved in the highest number of interaction patterns, representing 25% of total child-nature interactions. Since this particular nature feature comprises a majority of the surface of both outdoor classroom sites, this result is not entirely unexpected. However, the data did reveal a consistent trend that I did not anticipate: that is, the pervasive tendency of interaction patterns to often involve more than one landscape affordance. For instance,

wood-chip ground and mulch was used in conjunction with three different nature features in the enactment of some interaction patterns.

Table 2. Landscape Affordances at Fiddleheads Forest Preschool: Illustrative Photo, Percentage of Use, Nature Features used in Combination, and Associated Interaction Pattern

Category	Landscape Affordance and Example	Percentage of Total Observed Child-Nature Interactions	Nature Features Used in Combination	Associated Interaction Patterns
Transient	 Wood-chip ground and mulch	25%	Logs and stumps Tree roots Tree bark	*Digging in ground* *Falling on ground* *Gathering nature items* *Imagining nature to be something other than it is* *Lying on earth* *Manipulating nature items* *Recovering from a potential fall on the ground* *Being in solitude in nature, actively* *Being in solitude in nature, passively* *Using one's body vigorously in nature*
Relatively Stable	 Logs and stumps	17%	Wood-chip ground and mulch Sticks Branches	*Balancing on natural features* *Clambering on natural features* *Constructing shelter* *Falling on ground* *Gathering nature items* *Grappling with nature items*
Transient	 Water	11%	Tree roots Earth, dirt, and mud pits	*Being outside in inclement weather* *Gathering nature items* *Manipulating nature items*

Relatively Stable	 Earth, dirt, and mud pits	8%	Tree roots Big trees Water Sticks Root ball	*Digging in ground* *Falling on ground* *Gathering nature items* *Imagining nature to be something other than it is* *Lying on earth* *Manipulating nature items* *Being in solitude in nature, passively* *Using one's body vigorously in nature*
Relatively Stable	 Socially bounded plant areas and boundaries	6%	N/A	*Falling on ground* *Making social boundaries on earth* *Pushing to the edges of social boundaries*
Transient	 Moss, leaves, and disassembled plant materials	5%	N/A	*Gathering nature items* *Imagining nature to be something other than it is* *Grappling with nature items* *Lying on earth* *Manipulating nature items* *Recovering from a potential fall on the ground* *Being in solitude in nature, actively* *Being in solitude in nature, passively* *Using one's body vigorously in nature*
Transient	 Sticks	5%	Big trees Branches Logs and stumps Tree bark Earth, dirt, and mud pits	*Gathering nature items* *Imagining nature to be something other than it is* *Manipulating nature items* *Striking wood on wood* *Using one's body vigorously in nature*

Transient	 Insects and animals	4%	Low-hanging branches	*Calling birds* *Cohabiting with a wild animal* *Imitating animals* *Looking at wild animals* *Directly harming nature*
Relatively Stable	 Big trees	4%	Sticks Branches Tree roots Low-hanging branches Earth, dirt, and mud pits	*Balancing on natural features* *Clambering on natural features* *Directly harming nature* *Leaning against tree* *Being in solitude in nature, passively* *Using one's body vigorously in nature*
Transient	 Branches	4%	Sticks Big trees Logs and stumps	*Balancing on natural features* *Constructing shelter* *Gathering nature items* *Grappling with nature items* *Imagining nature to be something other than it is* *Manipulating nature items* *Recovering from a potential fall on the ground*
Relatively Stable	 Paths	3%	N/A	*Using one's body vigorously in nature*
Relatively Stable	 Small trees	2%	Tree roots	*Being in solitude in nature, actively* *Being in solitude in nature, passively* *Clambering on natural features* *Climbing high in small tree* *Leaning against tree* *Leaning and hanging from supple tree limbs*

Relatively Stable	 Plants and foliage	2%	N/A	*Being in solitude in nature, actively* *Being in solitude in nature, passively* *Directly harming nature* *Gathering nature items* *Imagining nature to be something other than it is* *Manipulating nature items* *Recovering from a potential fall on the ground* *Using one's body vigorously in nature*
Components of Stable Features	 Tree bark	1%	Wood-chip ground and mulch Sticks	*Balancing on natural features* *Directly harming nature* *Gathering nature items* *Imagining nature to be something other than it is* *Manipulating nature items* *Recovering from a potential fall on the ground* *Using one's body vigorously in nature*
Relatively Stable	 Root ball	1%	Earth, dirt, and mud pits	*Clambering on natural features* *Imagining nature to be something other than it is* *Using one's body vigorously in nature*
Transient	 Rocks, stones, and pebbles	1%	N/A	*Gathering nature items* *Grappling with nature items* *Manipulating nature items* *Striking wood on wood* *Using one's body vigorously in nature*
Components of Stable Features	 Tree roots	1%	Earth, dirt, and mud pits Small trees Big trees Wood-chip ground and mulch Water	*Balancing on natural features* *Directly harming nature* *Gathering nature items* *Imagining nature to be something other than it is* *Manipulating nature items* *Recovering from a potential fall on the ground*

Components of Stable Features	 Low-hanging branches	1%	Big trees Insects and animals Small trees	*Being in solitude in nature, actively* *Being in solitude in nature, passively* *Leaning and hanging from supple tree limbs* *Manipulating nature items*

However, child-nature interaction involving two nature features at once was not the case for all landscape affordances. Interestingly, some nature features involved in the observed child-nature interactions worked in tandem with up to five other landscape affordances while others were only ever interacted with in isolation. While the reason for this is not clear in this data set, it does raise potential implications for the understanding of child-nature interaction in different environmental contexts by shedding light on the relative contribution of some landscape affordances over others to the holistic functioning of a natural system.

Child-Nature Interaction along the Wild to Domestic Continuum

Of the 26 identified interaction patterns, the following eight were coded with a secondary label of "relational": *leaning against tree, looking at wild animals, imitating animals*, *lying on earth, being in solitude in nature-passively, cohabiting with a wild animal, being in solitude in nature-actively,* and *calling* birds. These patterns require a degree of balance and harmony between the child and the natural environment. Child-nature interactions coded as representing the Impactful category were designated as the interaction pattern *directly harming nature.*

In addition to the identification of relevant landscape affordances available at Fiddleheads Forest Preschool, this coding system also allowed for the determination of the relative wildness of

different areas of the nature classrooms. This yielded a code that indicated one of the three following classifications: wild, neutral, or domestic. I termed this the total wild-domestic rating, and it allowed for us to test the hypothesis that more relational behavior would occur in relatively more wild areas of the outdoor classroom sites, while behavior coded as *directly harming nature* would occur in more domestic areas. In the final analysis I compared the relative distribution of total interaction patterns to those coded as relational with consideration to their respective environmental code as wild, neutral, or domestic.

This statistical comparison leaves out the interaction patterns coded as *directly harming* nature. Of the 1851 enacted interaction patterns, only 16 of the Impactful category were coded from the entire data set. This small number made the analysis of the relative environmental occurrence of such patterns difficult to assess as statistically relevant.

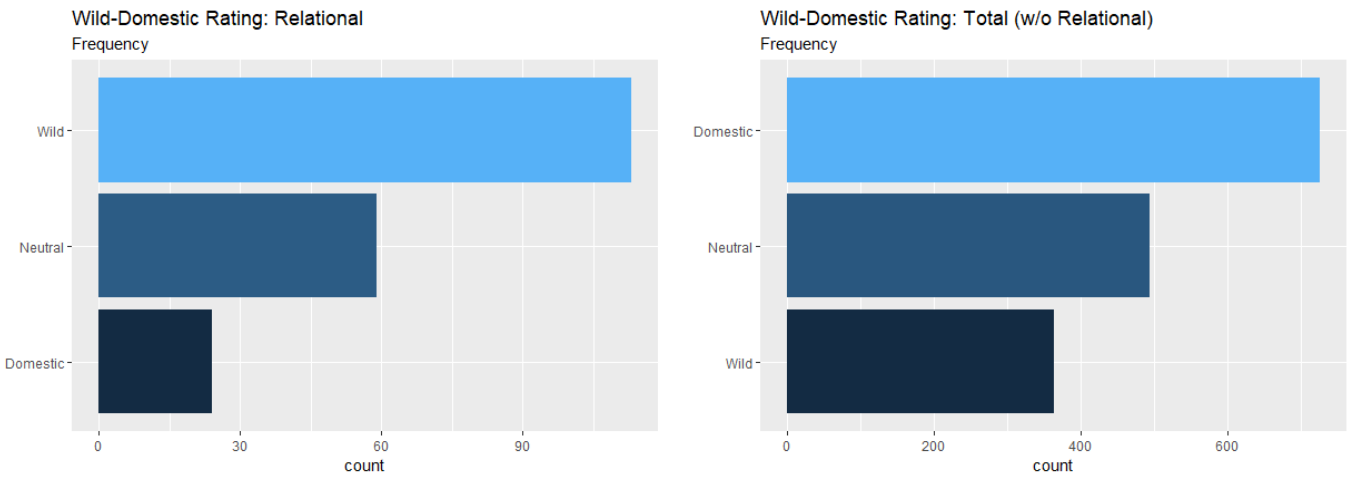

Figure 2. Frequency distributions along the wild to domestic continuum for relational and total remaining interaction patterns at Fiddleheads Forest Preschool.

For the relational category, a total of 196 child-nature interactions meeting this definition were identified. As can be seen in Figure 2, a frequency distribution reveals that a majority of these

relational patterns occurred in relatively more wild areas of the outdoor classrooms, superseding both neutral and finally domestic areas of occurrence. Interestingly, a frequency distribution of the total remaining population of interaction patterns (excluding relational behaviors and those that were coded with no total wild-domestic rating as defined by coding manual requirements) indicates a reverse trend: a majority occurred in relatively more domestic areas, followed by neutral and then wild. While these frequency distributions indicate a potential illustrative trend regarding the relative wildness of interaction pattern occurrence, the large difference in number of interaction patterns for each category requires further steps for statistical analysis.

In order to meaningfully compare the wild-domestic distribution of occurrence for relational and total remaining interaction patterns, a bootstrapping method was implemented. In statistics, bootstrap methods represent a collection of sample re-use techniques used to estimate standard errors and confidence intervals. This technique makes use of many samples drawn from the initial observations (Stine, 1989). Additionally, with the modern increases in computing power, many re-samplings of the original observations in a dataset are possible and leads to a decreased likelihood of sampling error when using the population of data to generate assumptions. I used a bootstrap method of 10,000 re-sampling iterations of our observed relational and non-relational interaction patterns to generate comparative confidence intervals. These confidence intervals were then compared to determine if the proportions of interaction pattern occurrence for these two groups involved the same wild-domestic distribution.

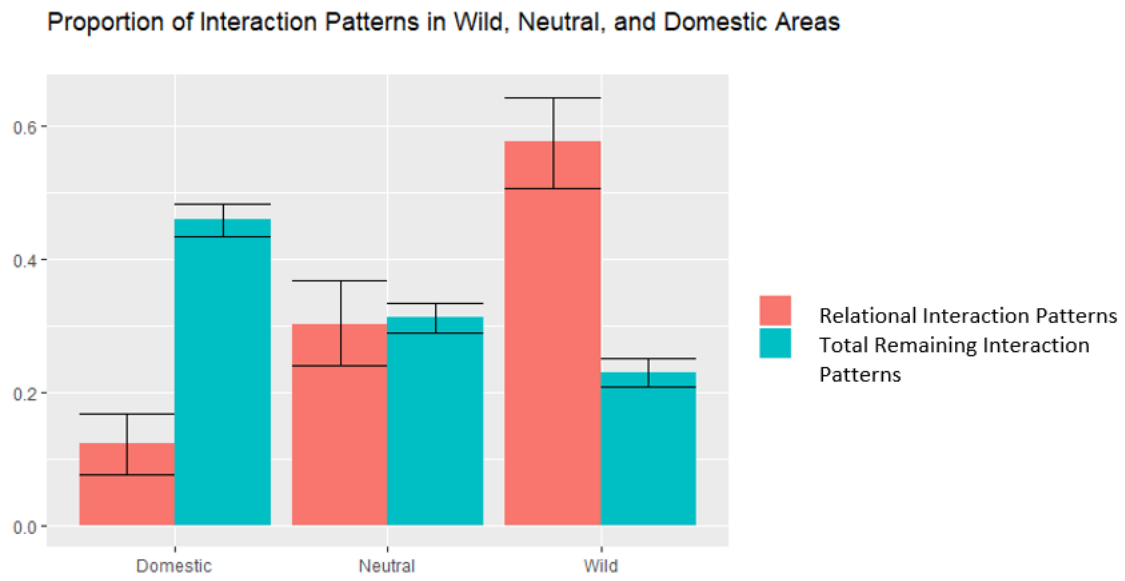

Figure 3. The relative proportion of relational and total remaining interaction patterns along the wild to domestic continuum at Fiddleheads Forest Preschool.

As can be seen in Figure 3, the proportion of relational interaction patterns occurring in a more domestic area of the outdoor nature classroom site is higher (.12 with 95% CI [0.08, 0.17]) than the proportion of the total remaining interaction patterns occurring in a domestic area (.46 with 95% CI [0.43, 0.48]). However, in more neutral areas of the outdoor classroom sites, there are similar proportions of both wild (0.30 with 95% CI [0.24, 0.37]) or total remaining interactions (0.31 with 95% CI [0.29, 0.34]) that were observed. In line with my hypothesis, the proportion of relational interaction patterns occurring in more wild areas of the outdoor nature classroom sites was higher (.58 with 95% CI [0.50, 0.64]) than the proportion of total remaining interaction patterns occurring in a relatively more wild natural areas (.23 with 95% CI [0.21, 0.25]). Thus, this analysis indicates that the relative proportion of relational interaction patterns that occurred in more wild areas was larger than the proportion of total remaining interaction patterns that occurred in wild areas of the nature classroom sites at Fiddleheads Forest Preschool.

Discussion

In the current study, I developed a systematic manner of analyzing child-nature interaction via an interaction pattern analysis and also provided evidence to support the proposition that more wild nature affords opportunities to form more positive child-nature relationships. Of the 26 identified interaction patterns for Fiddleheads Forest Preschool, the most frequently occurring involved physical movement. Aside from *using one's body vigorously in nature*, behaviors involving direct physical exploration of the natural environment were the most commonly observed. Through balancing on, gathering, and manipulating different features of the natural environment children constructed knowledge of themselves in relation to their physical surroundings. Children in this nature preschool developed self-regulatory skills while engaging in outdoor education despite wet, cold, or even icy weather. As well, children engaged in mental transformations of natural objects, explored constructs of social being through finding solitude or refining their understanding of social boundaries. Children also engaged in relationships with insects and animals through cohabiting, imitating, watching, or attempting to communicate with them.

Ultimately, the relative frequency of observed interaction patterns in Fiddleheads Forest Preschool was both enabled and constrained by the landscape affordances available in the two outdoor classrooms. The data made clear that a range of shapes, sizes, and natural materials were necessary for the enactment of the observed child-nature interactions. Relatively large and stable natural features like big and small trees allowed for both physical exploration and emotional regulation. Components of these stable features, including low-hanging branches and tree roots, allowed for further interactions in conjunction with transient features like insects and animals. This last point illustrates perhaps the most interesting finding regarding the landscape affordances at Fiddleheads Forest Preschool, noted anecdotally and also supported empirically in our data set.

For example, often the low-hanging branches of a large tree would allow children to observe spiders, squirrels, and birds from a clear vantage point in the nature classrooms. Our data supports this observation of nature features often operating in conjunction to support child-nature interactions. While 18 nature features were defined as the relevant environmental aspects of the outdoor classroom sites, data yielded many combinations of those original landscape affordances that regularly gave rise to the observed interaction patterns. Further research into child-nature interaction must not only consider the particular environmental features of an outdoor site but also must evaluate the potential for interaction with the natural environment from a more holistic perspective.

The analysis of relational interaction patterns revealed that when compared to the total population of remaining interaction patterns, those more in balance and harmony with the natural environment occurred more often in wild areas of the outdoor classroom sites. In a reverse trend, a comparative proportion of total remaining interaction patterns more often occurred in relatively domestic areas. However, for both relational and the total remaining interaction patterns, a large and similar distribution of occurrence happened in areas deemed to be neutral- that is, areas of the outdoor nature classrooms that were neither completely wild nor domestic. This fact alludes to the relative homogeneity of the outdoor nature classroom sites at this particular nature preschool. While differentiation on the wild-domestic continuum was possible and was found statistically to be a driving factor for the occurrence of relational patterns as aligned with more wild landscape, future work would benefit from analyzing a nature preschool with more heterogenous environmental features as well as more distinct areas that can be coded as either domestic or wild along a broader continuum.

I asked earlier, how can we help move people and the world to a more relational way of living: one that requires a deep awareness of one's surroundings, a fundamental respect for the natural environment, and a desire to live in harmony with those around us. One powerful answer that emerges from this study is that this movement could occur by having young children interact with more wild forms of nature. If so, then we – on a regional, national, and global level – need more wild nature, and more wild forms of nature even in urban areas. We must recognize that the future of human well-being and flourishing requires increased interaction with more wild forms of nature, and that we must act promptly to preserve and protect the natural environment.

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