

Review Article

The Role of Interaction with Nature in Childhood Development: An Under-Appreciated Ecosystem Service

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Abstract: Humans depend on the vital services provided by natural ecosystems. Regrettably, some individuals believe these ecosystem services are free; and therefore, have no value. An under-appreciated service provided by ecosystems is strengthening childhood development through interaction with nature to enhance childhood cognitive and physical development. The development of a child's physical and cognitive abilities is complex with studies indicating multiple determinants and varied time scales. Childhood development is the product of many natural, social and built environmental attributes. While the impacts of social and built environments on childhood development are clearly described in the scientific literature, the role of natural environment is less clear. Even though people do not pay for this ecosystem service in a conventional sense, the loss of this service can result in a significant cost to humans through slower cognitive and physical development in children. Deprivation of these exposures to natural ecosystems can diminish a child's development and eventually their underlying quality of life. While the impact of nature on childhood development is understood by most child developmental psychologists, this impact is under-appreciated by non-social scientists studying the contributions of ecosystem services in society. The complicated and symbiotic interactions of natural ecosystems, their services and childhood development are poorly acknowledged in the ecological literature. In this article, the important role of natural ecosystems and their services in childhood cognitive and physical development are examined through an examination of studies assessing this childhood development-ecosystem service connection.

Keywords: Child Development, Ecosystem Services, Cognition, Nature

1. Introduction

Childhood cognitive development is a series of progressive of stages involving multiple interactions among stages that is the result of continuing experiences with the natural environment [1]. However, because of the ever-changing nature of human development, no individual factor or exposure window determines a child's probable development. Regardless, there is a significant period, spanning the ages of 3 to 6 years old and to a lesser degree 7 to 12 years old, when a

child is most likely to develop specific cognitive and developmental skills that are essential for learning at a later age [2]. Environmental psychological theory suggests that contact with nature is important because it promotes a child's creativity and imagination, intellectual and cognitive development and boosts social relationships [3-5]. Similarly, basic theories of education suggest interaction with nature enhances a child's knowledge of nature, establishes their emotional, cognitive and spiritual connection to the world, and promotes their understanding of their place in the world [6-9].

Natural ecosystems produce basic services (i.e., ecosystem services) upon which people depend [10]. Ecosystem services that are provided by Nature (e.g., simply the existence of Nature and natural ecosystems providing developmental or therapeutic services) [11], without explicit cost, are an underappreciated ecosystem services in the present ecological literature describing intermediate and final ecosystem goods and services. Regrettably, many researchers and individuals throughout society believe because these types of ecosystem services have no direct cost to them; they therefore, have no value [10]. These ecosystem services, while unlikely to have a specific economic value measured in currency, can impact day-to-day decisions made by communities. Similarly, community decisions can impact the magnitude and quality of ecosystem services provided by nature. While humans do not pay directly for these services, society bears significant costs for their loss. These losses can be realized as decreased health, increased destruction of soil fertility, enhanced greenhouse gases, increased needs for contaminant treatment, and simple disappearances of those visions of nature that upgrade our basic quality of life.

The purpose of this review is to examine the positive aspects (and negative aspects) that exposure to the natural environment provides a child in his/her formative years for psychological and cognitive development, physical development, and development of independence, team building, creativity and self-concept. Nature, whether in a city park, walking in the woods, or strolling down a tree-lined street, has the capacity to help develop and restore children and that simply playing in nature can develop cognition, independence and team-building attributes [12-20]. Even just seeing photographs of greenery for short periods of time can enhance and improve one's mood. Spending time in natural environments invigorates people and reduces stress [21]. Using mobile EEG devices, recent studies could monitor a subject's emotional state during a stroll in a natural environment. Researchers found that people experienced less frustration and produced meditative-like brain waves if they were walking in a natural or created green spaces, compared to a busy business area or a bustling shopping street [22].

Finally, exposure to nature in years 3-12 for children through free play is important for several normal developmental aspects [23]. As a result, four childhood developmental aspects are discussed in greater detail in this review, particularly in their relationship to free play:

1. Self-Esteem and Creativity.
2. Cognition.
3. Independence.
4. Well-being and Life Satisfaction.

2. Methods

The review was conducted using a variety and search engines (e.g., Google Scholar) and multiple key words and phrases. The primary key words and phrases are listed in Table 1. These searches yielded 247 manuscripts published in the twenty years. The manuscripts were reviewed for content,

applicability to the purpose of the review, ease of accessibility and importance for addressing the stated review hypotheses. The criteria application resulted in 113 appropriate publications that lead to additional foundational papers on selected subjects.

Table 1. Key Words and phrases used in this literature review and resultant number of citations found.

Key Words and Phrases	Number of Citations
Nature and Child Development	51
Ecosystem Services/Childhood Development	21
Interaction with Nature/Childhood Development	34
Free Play	17
Self Esteem/Interaction with Nature	11
Creativity/Interaction with Nature	9
Cognitive Development/Interaction with Nature	20
Development of Independence	48
Well-Being/Interaction with Nature	17
Life Satisfaction/Nature	7
Outdoor Play/Nature	12
Total	247

3. Results: Interaction with Nature and Development

Children, today, encounter an assortment of indoor play venues to choose from, including television, indoor play gardens, videogames, and even indoor playground equipment [24]. Opportunities for natural safe outdoor play have been increasingly reduced by urbanization; often extending into surrounding suburban areas. Many parents actively discourage their children from going outdoors in order to protect them from harm [25]. This abatement results in more children maturing disconnected from nature and the outdoors. This disconnection from nature is having important consequences for children's overall well-being and development directly impacting cognitive development, independence, and creativity [26].

3.1. Free Play

Play with peers and in nature in is one of the first non-mother-directed activities to appear in early life of non-human species [27-28]. Similarly, human play indicates a very deliberate and real form of behavior for the infant and child [29], and free play, particularly in natural settings, can be an important determinant of socialization and cognition [30].

Research on children's preferences has reported that spaces in the outdoors that might be designed by children would not be asphalt or dirt playgrounds with scattered pieces of playground equipment but rather areas that are full of trees, flowers, plants, dirt, water, mud, dirt, sand, insects and animals [31]. Most educators and parents agree that outdoor play is an important and natural part of a child's healthy development [32-34]. This natural development through free play fosters many skills that are necessary for adults (e.g., problem solving social competence, safety skills and creative thinking) [35].

Natural ecosystems represent rugged and dynamic landscapes that challenge cognitive and motor activity in children. Intuitively, children use their environments for physical challenges and play, creative problems to be solved and opportunities to expand their mental capacities and understanding of the structure and function of their natural environment [36]. Recent research findings indicate that people, particularly children, benefit from contact with nature for their well-being [11, 37-38]. Unfortunately, at the present time, access to the outdoors seems to be diminishing for young children making them increasingly separated from the natural environments [39]. According to a study of 2400 children from sixteen nations, aged 1-12 years, free play has been declining over the past two decades with the lack of free play and experiential learning opportunities significantly hampering children's development [40]. Free play activities in nature have been replaced by watching television and playing video and computer games [40]. Children's best learning occurs through interactive play that is hands-on and personally directed self-discovery [41]. Younger children (i.e., aged 3-6 years) have a natural curiosity that demands direct sensory engagement rather than conceptualization [42]. This curiosity and sensory engagement coupled with fantasy creation may be one reason children are being driven to computer gaming as adults limit access to natural environments through fear of injury or perceived protection [43].

3.2. Self-Esteem, and Creativity

Research over the past three decades has established important and significant connections between strengthened development in children and direct contact with nature [43-47]. Direct contact with natural environments positively and significantly improves children's cognitive, affective, and moral development [4]. Test scores for behavioral conduct disorders, anxiety, and depression have been shown to be lower for rural children living near nature [48]. Children living near natural environments ranked themselves higher on self-worth measures than their peers who resided in less natural settings [48]. Similarly, children with a greener view from their apartment scored higher on several measures of impulse control and delay of gratification [49].

Children's general access to nature appears to be diminishing [4, 50]. Not only has the quantity of natural environments for children to utilize been reduced, but some parents seem to be limiting their children's access to natural environments for fear of accident or violence [43, 51]. Programmed activities increasingly fill children's lives leaving them with smaller portions of their days for nature exploration. A broad literature has examined the potential effects of increased exposure to green spaces and natural environments on healthy child development. Some of the most exhilarating findings of a connection between developmental outcomes in children and contact with nature come from studies examining the relationships among children's sense of self and self-esteem and outdoor challenge programs. These findings suggest significant benefits for children's development result from contact with nature [45, 52-54].

Similarly, systematic relationships between enhanced learning and involvement in outdoor curricula in green space have been described [55-56]. Studies comparing creative play in built versus natural spaces are consistent with social, cognitive, and emotional development being supported by nature [57-58].

While arguments concerning methodologies could be brought forward with some of the above referenced studies, all the findings point to a pattern projecting a persistence and the same direction of results regardless of childhood setting or cultural grouping. That persistence and direction points to the general tenet that several domains of children's development – social, cognitive, and emotional – are supported by contact with nature. Just as children require good sleep patterns and nutrition for proper development, they also may require interactions with nature.

3.3. Cognition

Studies into children's outdoor experiences have pinpointed enhanced cognitive functioning to be a primary benefit of ecosystem interaction [59-63]. In a longitudinal study of young children from low-income families where the families were relocated to homes in closer proximity to natural environments, the children were determined to have enhanced levels of cognition as well as an improved ability to direct attention [61]. These changes continued several months after returning to their original homes [61].

Natural and built environments, as well as demographics, inherent factors associated with children and parents, diet, lifestyle and social environments, have been shown to impact the development of cognition [62]. The environmental influences of nature on cognitive development in their review were primarily the result of contaminant exposure with little examination of role of simple exposure to nature and outdoor experiences. Interactions with nature has been shown to improve cognition for adults suffering major depressive disorder [63] and generally improve cognitive benefits (increased working memory) [12] although no similar studies have been conducted with children.

Although interactions with nature can improve adult cognition, experiential interactions with nature during childhood and adolescence provide an important basis for cognitive development [4]. The development of cognition described by Benjamin Bloom and colleagues [66-67] explores the impact potential of experiential contact with natural environments in the development of children's intellect. For most children, the values of nature, both intrinsic and extrinsic, develop at specific stages [68]. The first stage in the development of children's values of nature occurs between three and six years of age and focuses on satisfying material and physical needs while the second developmental period (roughly 6-12 years of age) replaces these utilitarian perspectives with comfort and familiarity of natural setting often relative to proximity to the home. A propensity for exploration replaces the earlier sense of wonder and children use natural environments to develop an identity apart from parents and the immediate home. The establishment of familiarity with nearby environments, often through outdoor

play, is constructive and promotes creativity and the generation of feelings of autonomy, independence and self-sufficiency [68].

In these early years, children are especially preoccupied in making things, in establishing a self and in demonstrating creativity and competence, separate from adults, generally, and their parents, specifically [32-34]. These objectives are often realized by building places in proximity to the home often referred to as forts, dens, and secret hiding places. These constructed and intimate places outside but near the home, nestled in the foliage of trees and bushes of ordinary natural ecosystems, offer the child the chance to create and construct. Finally, in adolescence, children become much more cognizant and appreciative of ecosystems and landscapes and visualize human dependencies on nature (e.g., the role of ecosystems in human interactions). Adolescent children engage in activities testing the physical limits of the natural world nurturing self-confidence, self-esteem, an increased sense of identity and further cognitive development [4].

3.4. Independence

The landscape of childhood contains various stages of development. Childhood needs to encompass playing out of doors and interactions with nature to take an obvious role. This goes beyond the fact that this type of play is fun; it is developmentally adaptive. Just as wild animals play to develop dexterity for survival skills, children play to develop independence through mental dexterity [34]. Outdoor play develops a child's understanding that the world is malleable and that their behavior in the world can make a difference. Playing with simple materials and materials provided by nature (e.g., a simple board is a plank on a pirate's ship, access to the first branch of a tree, a jump for runners, a roof support for a fort) prepares children for playing with ideas as an adult.

Edith Cobb in her seminal discourse, "The Ecology of Imagination in Children" [23] touts the importance of the ages between five or six and eleven or twelve as a time when the natural world is experienced in a highly evocative way. This interaction produces "a sense of some profound continuity with natural processes" [23, 34]. This early work suggests that certain types of experience with natural ecosystems occur at this critical time to promote healthy psychological and physiological development. This period in childhood is epitomized by extreme personal originality and the creation of private worlds and rarely persists in the same way into adulthood [23]. It is crucial for children to have opportunities to participate in existence-building activities whether out of doors (e.g., building forts, playing imaginary games) or indoors (e.g., playing with clay or Legos). These activities give a child an opportunity to organize their world and become the person they are meant to be [34].

Darwin's early observations during his voyage on the *Beagle* had a significant impact on his ideas relating to speciation and island biogeography [69]. While visiting more than twenty islands, he discovered, through observation, that although the islands were close together, they were quite dissimilar in terms of soil type and development, rainfall and

other conditions. The variety of islands also had very different types of finches. Darwin speculated that individuals of a single species of finch arrived at of the Galapagos Islands from South America and as the individual island population developed, they spread among the islands from one to the next. Once upon an island, natural selection drove the morphology of the original species in varying and unique directions and unique species developed accordingly. Sobel [33] contends that childhood play follows the same principles as speciation in geographically and culturally isolated communities. While children obviously do not evolve into different species based on cultural isolation, it suggests that children "evolve" different approaches to independence and its role in their development (e.g., enhanced survival and adaptive skills). This is especially true where adults and children interact with nature over longer time periods like during vacations. On vacations, adults can be freed from day-to-day work responsibilities and children have the freedom to be children and not be immersed in programmed sports or electronic recreation [33]. These excursions into play by interacting with each other and nature often promote independence and cultivate imagination [23, 32-34].

3.5. Well-Being and Life Satisfaction

Recently, several researchers have shown an interest in the positive benefits resulting from interactions with natural ecosystems and time spent outdoors regarding an individual's well-being [70-76]. There are several approaches being used to reconnect children to nature. Some of these approaches include simply experiencing nature or participating in physical activity (e.g., exercise). Both play of these approaches can play a significant part in influencing our well-being and physical health in a positive way. Walking for short periods, particularly in natural areas, can enhance and energize personal vitality and well-being [73, 77-81]. Even coupling virtual reality settings that depict natural systems with walking can enhance well-being and provide relaxation although [82-83]. Similarly, an "enhanced" exercise like running in nature enhances mood and physiology as well as increasing overall well-being [84-87]. A strong link between enhanced well-being and contact with nature has been established [88] even extending to length of life. This enhancement can take the form of exposure to nature series on television, movies or simply through books describing nature and its inhabitants. These virtual reality settings can significantly contribute to a child's understanding and appreciation of nature [89-92].

4. Discussion

The main intent of this examination of the literature is to bring attention to an ecosystem service that is often undervalued by researchers examining ecosystem services. Researchers examining cognitive development from a psychological aspect have long valued interactions with nature; however, recent research endeavors into the importance of ecosystem services rarely point out long-valued

aspects of psychological interactions with nature. For example, in recent examination of ecosystem services by the U.S. Environmental Protection Agency, many final ecosystem goods and services (FEGS) are addressed but the role of nature interactions in childhood development is ignored altogether [93]. Ecological researchers primarily address issues associated with the recycling of nutrients, the cleansing of air and water, the support of living natural resources used for food and fiber and the decomposition of waste. However, in other research aspects, the U.S. Environmental Protection Agency has examined the adaption of its Human Well-Being Index (HWBI) to children including development attributes and cognition [94]. The impact of nature and its services on human development, as well as mental and physical health, can rival the importance of the services listed above.

This review targets natural interactions which tend to arise outside of the ecosystem service's identification. For example, how reliable is the data relating the impact of interactions with nature on these conditions describing human health? Strong claims have been made about the importance of children spending time in nature [43]. This interaction with nature is claimed to promote adaptive processes in child development (motor fitness, physical competence, self-confidence) and to support creativity, learning, education and positive attitudes about nature [95-97].

Summarizing the research on children and nature regarding developmental aspects is not easy. The topic has been addressed in many ways by researchers representing different theoretical models and approaches. While the empirical evidence is growing, the picture remains incomplete. Some researchers argue that interaction with nature increases a child's resilience as part of their developmental growth. However, it is very difficult to study these types of benefits empirically.

Over sixty studies were reviewed assessing the benefits of interaction of children with nature. These studies examined cognitive (scientific learning, environmental knowledge and language skills and communication), general health (physical activity, mental and emotional health, healthy eating and motor development), social (social skills), emotional and behavioral, (self-control, self-confidence, self-awareness, independence), ethical/attitudinal (concern of the environment, connectedness to nature and topophilia) and well-being (psychosocial health, quality of play) benefits. Taken as a whole, these studies support the view that just spending time interacting with nature tends to promote a child's well-being and healthy development. Claims about health benefits (e.g., mental health, emotional regulation and motor development) appear robust and based on cause-and-effect studies. Similarly, good evidence of a linkage of interaction with nature as a child and positive views about nature as an adult seem supported. While more modest in number, a significant number of studies appear to support strong interactions with nature at critical stages in childhood development to enhance independence, critical thinking, self-confidence, creativity, and cognitive skills. Particularly, the use of free outdoor play appears to enhance the development of these skills and further to enhance teamwork skills.

While there are no studies to support this conjecture, this review of available studies suggests the possibility that interactions with nature may result in less money spent on anxiety disorders or therapy. Perhaps children exposed to nature and natural free-play tend to develop "problem-solving" skills and enter into "problem-solving" occupations (e.g., sciences, math, engineering or other STEM or STEAM professions).

Abundant and clear evidence has been established that interaction with natural ecosystems can influence not only health but well-being throughout life. The data suggest that individuals, who as children actively interact with nature, are likely to have a better quality of life and tend to live longer. This interaction with nature as young children tends to make them more involved with people and society, more engaged with natural places, and be more active. As a result, adults and children who connect with natural environments and ecosystems tend to participate and volunteer more in groups, display better moods and higher self-esteem, continue to learn, be more resilient to personal stress, and continue their regular engagement with natural environments [98]. Conversely, people, who, particularly as children, gravitated to staying inside, often seem to be more disconnected from their peers, be more sedentary or inactive, have higher levels of c-reactive proteins and cortisol and eat energy-dense and unhealthy foods [99].

5. Conclusions

It is clear that playfulness as an engagement style [100-102] provides a rationale for the view that practitioners and policy makers should focus not only on structures, educational interventions, but also on initiatives that permit for more open-ended, child-directed and playful experiences in natural environments. This examination of the professional literature has displayed the role of nature and the human-ecosystem interaction as a development mechanism for a variety of mental, physical and developmental children's health issues. This is not to suggest that the lack of interaction with nature will always result in inhibited, less healthy children with poorer imaginations and cognitive development. Certainly, there are many adults, who as children minimized their interactions with nature for any number of reasons and developed into healthy adult specimens. However, there is a large set of experimental and observational results that suggest the following developmental aspects are enhanced throughout interactions with nature. These include:

1. Cognitive development,
2. Team-building skills and independence;
3. Relief of anxiety and depression as well as improved memory and ability to concentrate; and
4. Improved familial and social relational skills, self-management and self-esteem.

It seems clear that these types of ecosystem services, provided by Nature without explicit costs (e.g., simply the existence of Nature and natural ecosystems providing developmental or therapeutic services), are underappreciated

as a type of ecosystem service in the present ecological literature describing intermediate and final ecosystem goods and services. While often neglected, the “existence of nature” service provided by nature that directly influences childhood development is a very important and meaningful ecosystem service that should be conserved. The consideration of the costs of and need for preservation and restoration of natural environments, if only for their childhood developmental assets, provides a major example of the enrichment of well-being through broad, inclusive discourse compared to the less than holistic limited and specific conversations concerning non-sustainable development strictly for economic growth that promotes the destruction of natural ecosystems [103]. Similarly, educational curricula that include explicit interactions with nature (both hands on and virtual) must be part of these discussions.

Author Contributions

All authors contributed to this review with J. K. Summers providing the majority of manuscript preparation and writing. D. N. Vivian provided literature searches and manuscript review. J. T. Summers provided consultation and discussion as well as manuscript review.

Conflict of Interest

All work was completed as part of the Sustainable and Healthy Communities Research Program conducted by EPA’s Office of Research and Development and there are no conflicts of interest.

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