# CHILDREN AND NATURE

## What We Know and What We Do Not

Dr. Robert Gifford
Dr. Angel Chen

University of Victoria

Prepared for the Lawson Foundation

March 31, 2016

## EXECUTIVE SUMMARY

This literature review summarizes empirical research on the links between nature and benefits for child development, focusing on the most compelling scientific findings. The goal was to survey current knowledge, so as to identify where research needs to proceed.

In his ground-breaking work, *Last Child in the Woods*, Richard Louv coined the term "nature deficit disorder," not as a medical diagnostic term, but to describe cumulative effect of alienation from nature, including the loss of open space and increasingly sedentary lifestyle of children that can lead to adverse psychological and health consequences. Is the belief in nature's salutary value empirically supported? Concern about diminished contact with nature has stimulated research from diverse disciplines to answer this question.

The general pattern of findings is that access to nature, whether in the form of wilderness immersion or merely window views of trees, supports healthy development. Engagement with high-quality green space is associated with several positive health outcomes, including lower body mass index, decreased blood pressure, healthier immune functioning, reduced myopia, morbidity, and cardiovascular-related diseases. Natural playgrounds contain diverse features that offer opportunities for control and mastery, support more imaginative and constructive play than constructed grounds, and indirectly promote social affiliation. Greater access to nature also yields improved moods, resilience in response to stress, greater self-discipline and impulse control, improved concentration, better academic achievement, and reduction of attention deficit and hyperactivity disorder symptoms. In addition, consistent exposure to nature and interactions with nonhuman species are important ingredients for fostering ecological knowledge, identity, and ethics.

Many studies have one or more methodological weaknesses that should be addressed in future research. Among these is a reliance on self-reports, the uncontrolled presence of potentially confounding variables, and selection effects (e.g., active children choose to play outdoors more often). These limitations can partly be addressed through the use of large-scale epidemiological studies and complementary mixed methodologies. However, more rigorously controlled experiments are necessary to establish evidence of a causal relation.

Research in environmental psychology, ecology, health, and planning varies in its approach to the question. However, this interdisciplinary work is necessary to develop a more complete and nuanced understanding of nature's benefits for children. Theoretical knowledge, research principles, and successful practices should be well-integrated. Collaboration between planning agencies, community organizations, and school districts should consider and incorporate natural features in children's facilities while considering a range of psychological and socio-economic barriers.

The imposition of territorial boundaries and preferences for manicured green spaces by some adults conflict with children's desire for creativity and free-range exploration. When adults support children's gravitation to nature, and their assistance in designing managed natural spaces, children benefit more and can help provide an important contribution to society. This will come with well-chosen new research initiatives.

We conclude that more or better research is needed in these nine areas:

1. *Establishing causality.* Most research in this area is correlational, which leaves the question of what truly causes what unclear. Some examples include: Does green space cause increased physical activity, or do more active children seek green space? Do empathetic, socially oriented children form bonds with their pets, or do pre-existing family contexts or preferences lead to the choice to have pets?
2. *Establishing effectiveness.* For example, can the benefits of wilderness be differentiated from or found superior to traditional non-nature therapies? The same may be asked about animal-assisted therapy (AAT). Does AAT offer only a short-term affective fix rather than long-term behavioural change?
3. *The role of parents.* To what extent do parents restrict their children's use of nature? How are children's experiences of nature influenced by their parents? Can children's behaviour in nature influence their parents? What are the gaps between parents' perception of, and children's experiences of, outdoor play?
4. *The role of animals.* Does animal companionship promote a greater capacity for emotional regulation over the lifespan, as children become more independent or when a pet is not available?
5. *The design of managed nature.* Are urban green spaces designed with the needs of local children in mind? Future work should investigate the role of children as decision-makers in the research and design process.
6. *Inequality.* To what extent is access to nature for low-income and minority children, especially in urban parks, less about proximity to green spaces and more about perceived safety, poverty, and related social factors? What are some potential solutions for inequality of access to nature or ways to remove existing social barriers to safe urban parks?
7. *Health and stress.* What is the mechanism and the extent to which biodiversity affects immune functioning and diseases? To what extent does nature experience ameliorate the impact of stressful life events, such as family relocation or bullying?
8. *Cognition and beliefs.* How does children's folkbiology, that is, their everyday untutored understanding of nature, affect their behaviour during their childhood, but also their later environment-related choices as adults? How impactful is environmental generational amnesia (EGA), the phenomenon that as environmental degradation increases across historical time, each generation's standard for environmental quality is weakened?
9. *Virtual nature and technology.* Is simulated nature as beneficial as real nature? Will children accept it as an adequate substitute for enriching their experiences of real nature, or will it have no benefits or, worse, negative impacts on children? Might real and virtual versions of nature be combined to maximize benefits to children? Might such technologies as global positioning system (GPS) tracking and mobile phones generate valuable real-time data about children's behaviour while they in natural settings?

# TABLE OF CONTENTS

*"Natural environments represent dynamic and rough playscapes…The topography, like slopes and rocks, afford natural obstacles that children have to cope with. The vegetation provides shelters and trees for climbing. The meadows are for running and tumbling." Fjørtoft (2001), p. 111*

# INTRODUCTION: THE SHRINKING NATURE EXPERIENCE OF CHILDREN

Although nature obviously can be detrimental to children (and others) through natural disasters, disease vectors, accidents, and some predatory animals, this report focuses on the benefits of nature. Its goal is to set out what science already knows about nature's benefits for children, thereby helping to clarify what is not yet known.

Concerns about increasing disconnection from nature were expressed over a century ago by the influential American philosopher William James. In his essay entitled "On a Certain Blindness in Human Beings," which appeared radical at the time, James (1899/2008) asserted that humans are desensitized by materialistic concerns in their contrived settings, and that the antidote is to reawaken sensibility by returning to "a more profound and primitive level" (p. 135).

How does this unprecedented separation from the natural world impact children's development? Until recently, James' assertion had not undergone scientific scrutiny. This report reviews evidence about the role of access to nature in children's well-being. It begins with problems associated with children's increasingly sedentary lifestyle, which is characterized by controlled, interior spaces, electronic distractions, and substitution of virtual knowledge for direct-contact knowledge. Theoretical perspectives are presented to explain our innate affinity with nature and why living in disconnection of our ecological context may be psychologically damaging. The main methodological approaches on the study of children and nature are described. Next, the report reviews the benefits of time and activities derived from spending time in nature, including enhanced creativity, social affiliation, physical health, mental health, concentration, cognitive development, and moral development, as well as therapies based on nature. The report dedicates a section to discussing whether companion animals and virtual (simulated) nature are beneficial to child development. Finally, we suggest a number of methodological directions and gaps in knowledge that should serve as fruitful starting points for future research.

## Diminishing Access to Nature

Over the last five decades, children's recreational activities have radically changed, given that they spend considerably less time outdoors than their predecessors (e.g., Bodrova & Leong, 2003; Evans, 1995; Hofferth & Curtin, 2005; White, 2004). Evidence for this trend has been collected through online surveys, children's time-use diaries, and data on visits to

specific nature destinations. For example, in a survey of 830 mothers in the United States, 87% reported playing outdoors every day as children, but only 31% of their 3- to 12- year-old children did so (Clement, 2004). A survey of 1,150 English adults found similar generational differences (England Marketing, 2009). The National Kids Survey, which collected data between 2007 and 2009 on 3,000 households, found that nearly two-thirds of children were spending at least two hours a day outside (Cordell, Betz, & Green, 2009), but nature-based recreation activities (e.g., hiking and camping) were less commonly reported than other outdoor alternatives (e.g., sports, hanging out with friends, and using electronic devices outdoors). However, that study is relatively recent. In a much longer (30-year) longitudinal study of a representative US sample, researcher-administered time diaries revealed that time spent in outdoor activities among children under the age of 13 declined by 16% between 1981 to 1997, followed by further decline of 10% among children ages 6 to 12 between 1997 to 2003 (Hofferth, 2009; Hofferth & Sandberg, 2001). Pergams and Zaradic (2008) provided further evidence for a fundamental shift away from nature-based activities: from 1939, the number of visits to U.S. National Parks ceased trending upward and has fallen steadily at about 1.2% annually since the mid-1980s, despite increased numbers of protected lands.

## Barriers to Children's Access to Nature

### Parents as gatekeepers

Several constraints on children's use of outdoors should be noted. Research has shown that parents are the "gatekeepers" (Beets, Vogel, Chapman, Pitettie, & Cardinal, 2007) whose perception and fear are the major factor on restricting children's use of outdoor nature (Carver, Timperio, & Crawford, 2008; Gaster, 1991; Rasmussen, 2004; Weir, Etelson, & Brand, 2006), not objective indicators of neighbourhood safety (Beets & Foley, 2008). Increased media coverage of criminal activities (Pyle, 2002), fear for potential play injuries (Groves & McNish, 2008), strangers and gangs (Veitch, Salmon, & Ball, 2008), liability lawsuits (Clements, 2004), and anxieties about insect-borne illness, ultraviolet rays, and pollution (White, 2004) may all contribute to the recent culture of "paranoid parenting" (Furedi, 2008).

### Media and technology

The proliferation of digital media and technology is another major obstacle to children spending time in nature (Clements, 2004; Rideout, Vandewater, & Wartella, 2003). Data vary on the amount of time preschool children spend in "screen time," from 4.6 hours (The Nielsen Company, 2009) to 2.2 hours per day (Rideout, Foehr, & Roberts, 2010). The American Academy of Pediatrics (AAP, 2011) advises no screen time for children under the age of two, and less than two hours a day for older children. Digital screening has been associated with reduced social interaction, less time spent doing homework, less outdoor and creative play (Vandewater, Bickham, & Lee, 2006), attentional problems (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004), poor academic achievement (Comstock, 1995; Hofferty & Curtin, 2005), loss of self-confidence (Henderson, Zimbardo, & Graham, 2001),

loneliness and depression (Kraut et al., 1998), snacking on unhealthy food (Christakis, 2006), childhood aggression and diminished prosocial behaviour (e.g., Anderson & Bushman, 2001), as well as more materialistic values and less environmental concern (Good, 2007).

### Socio-structural constraints

Socio-structural constraints on access to nature include increased residential density, disappearing open space, poor urban planning, and neighbourhood design (Churchman, 2003; Handy, Cao, & Mokhtarian, 2008; Varney and van Vliet, 2005), household size (Baum, Hayes, van Gellecum, & Hoon, 2006), and poverty (Sutton, 2008; Thomas & Thompson, 2004). For example, in Melbourne, 8- to 12-year old children with lower-SES must travel more than twice as far as higher-SES children to reach their nearest parks (Veitch, Salmon, & Ball, 2008). In the UK, racial and economic inequality of access to nature has also been documented: neighbourhoods with over 40% of black or ethnic minority residents have 11 times less local green space in their neighbourhoods than relatively affluent, predominantly white communities (CABE, 2010). This highlights the importance of considering all subgroups of children and different socio-spatial contexts. The development of green spaces should be tailored at least in part to local demographic needs. Evidence that this is routinely done is lacking.

### Breaking the barriers

In 2005, Richard Louv published his influential book, "Last Child in the Woods: Saving Our Children from Nature Deficit Disorder." It alarmingly highlights the health, social, and environmental costs of the increasingly sedentary lifestyle led by American children. A rapidly growing literature documents that children in contemporary societies are deprived of experiences in nature that offer sensory stimulation, physical challenges, exploration and creative play in support of optimal development (e.g., Faber Taylor & Kuo, 2006). Since the publication of Louv's book, public interest has grown in tandem with scientific journals such as *Children, Youth, and Environments* and non-profit organizations such as the Children and Nature Network, to support grassroots movements to re-connect children with nature.

## INNATE BONDS WITH NATURE: THEORETICAL PERSPECTIVES

### Ecopsychology and the "Ecological Unconscious"

One theoretical perspective that proposes we have an innate bond with nature, ecopsychology, adopts a therapeutic orientation, emphasizing the potential for mutual healing between planetary and personal well-being. According to Theodore Roszak (1992), the core of the human mind is the ecological unconscious, defined as a primal bond between humans and the natural world in which we evolved. A fundamental premise of ecopsychology is that modern living suppresses the conscious recognition of this innate interconnectedness with nature, as we exploit and dominate nature and mistakenly pursue

extrinsic goals to fulfill our intrinsic needs (Kanner & Gomes, 1995). To simultaneously awaken the ecological unconscious and help restore the ecology, ecopsychologists utilize techniques such as ecotherapy (the practice of psychotherapy in nature settings), outdoor meditation, wilderness retreats, environmental restoration, and contact with animals (Roszak, Gomes, & Kanner, 1995). Because ecopsychology is more speculative than empirical, its work is largely overlooked in mainstream scientific, evidence-based psychology (Reser, 1995).

## Evolutionary Perspective: The Biophilia Hypothesis

According to the evolutionary perspective, because we humans evolved in wild habitats for 2 million years, we are better adapted in natural environments than cities, which are only about 10,000 years old. Because of our ancestral roots in nature, the biophilia hypothesis proposes that humans have universal, unlearned affiliation with nature and an "innate tendency to focus on life and lifelike processes" (Wilson, 1984, p. 1).

Empirical evidence for the biophilia hypothesis focuses primarily on positive affective responses to natural settings and many other species. People from diverse cultures generally prefer natural over built settings (e.g., Korpela, Hartig, Kaiser, & Fuhrer, 2001; Newell, 1997; Thomashow, 1995) and report intense spiritual awakening while in nature (e.g., Frumkin, 2001; Hartig & Staats, 2007; Maller, Townsend, Pryor, Brown, & St. Leger, 2006). Children also value play settings that are relatively free of restrictions and human intervention (Chawla, 1990; Hart, 1979; Kellert, 2002; Pyle, 1993). Certain landscape features that are aesthetically appealing, such as bodies of water, vegetation, and expansive views, are both therapeutic and evolutionarily beneficial for survival (Gullone, 2000; Ulrich, 1993; Kahn, 1999; Wilson, 1984).

Further evidence for biophilia concerns children's instinctive nurturing tendencies towards animals (Beck & Katcher, 2003; Myers & Saunders, 2002). Young animals elicit tender reactions and caretaking not only because they share many neotenic (baby-like) features (e.g., proportionally large eyes and high forehead) that are commonly perceived as cute (Gaulin & McBurney, 2003), but because primitive humans were more attached to and dependent on their pets for survival, for example as watchkeepers for predators (Inglod, 1994; Katcher & Wilkins, 1993).

The feeling of kinship with nature also encompasses the automatic aversion to some aspects of nature (Kahn, 1997; Wilson, 1984). Biophobia, or repulsiveness to certain dangerous natural stimuli, such as snakes and spiders, evokes fight-or-flight responses that are evolutionarily adaptive, given that humans are vulnerable to predators and other poisonous species (Bixler & Floyd, 1997; Orr, 1993; Ulrich, 1993) Biophobic responses are readily acquired in children and are more resistant to extinction than culturally conditioned dangerous objects, such as guns (Öhman, Dimberg, & Öst, 1985).

However, children can simultaneously exhibit fearful orientations and moral affiliation toward potentially threatening natural objects. In one interview with 6- to 12-year-old children who were leaving a bat exhibit in Brookfield Zoo, although some feared bats, they

still cared about them, attributed feelings to them, accorded their right to live free, and "kind of liked" the thrilling visit (Kahn, Saunders, Severson, Myers, & Gill, 2008). However, along the biophobia-to-biophilia continuum is a large range of degrees, qualities, and complexities of emotions that have not yet been mapped for children.

Some researchers argue that without additional learning about, cultural connections to, and experience of nature, genetic factors alone are insufficient to optimize biophilic tendencies (Kahn, 1999; Kellert, 2002). The nature *versus* nurture debate has subsided; the prevailing paradigm is that human development is shaped by intricate interplay between inherited (nature) and environmental (nurture) influences (e.g., Keating, 2011). Genetic biophilic predispositions, which trigger instant reactions conducive to ancestral survival are suppressed by contemporary lifestyles unless they are awakened by active engagement in nature (Dubos, 1980; Ulrich, 1993). The wild landscapes may be considered an "environment of evolutionary adaptedness" (EEA), a term used by evolutionary scientists to define the contexts in which our ancestors evolved. EEA describes a set of selection pressures that shape adaptations (Gangestad & Simpson, 2007). To re-establish our connection with nature, more frequent unsupervised play in natural environments is not only necessary to foster biophilia but also for providing an optimal avenue for child development (e.g., Orr, 1993)

Prospect-refuge theory (Appleton, 1975), another evolution-based idea, predicts that people prefer places which allow them to see without being seen, as the result of our primitive desire for safety (refuge) while keeping close watch on our surroundings (prospect). Characteristics of children's favorite places also tend to be associated with autonomy and escape from adult supervision (Mergen, 2003), opportunities for exploration and adventure (Derr, 2006), as well as refuge and a corresponding sense of privacy and security (Kirkby, 1989).

Importantly, however, empirical data on these theoretical bases of the child-nature relation primarily focus on how children understand and evaluate nature, rather than on how nature influences their growth. In order to better examine whether children need nature can be empirically established, several methodological approaches typically used in empirical studies are described next.

## STUDYING CHILDREN AND NATURE

### Defining Nature

Most "natural environments" are in some measure affected by human artifice and control (Tuan, 1978). Others that are relatively uninfluenced by human inhabitants are known as "wildness." Clayton and Myers (2009) classified nature into four categories: Domestic nature (e.g., indoor plants, companion animals), nearby nature (parks, gardens, urban greenery), managed nature (e.g., forests, zoos, fisheries), and wild nature, including remote areas (e.g., the open ocean). Louv (2008) construed nature as being beyond restrictive terms, while emphasizing biodiversity and abundance: "For children, nature comes in many

forms. A newborn calf; a pet that lives and dies; a worn path through the woods; a fort nested in stinging nettles; a damp mysterious edge of a vacant lot-whatever shape nature takes, it offers each child an older, larger world separate from parents" (p. 7). This review considers nature to be a domestic-managed-wild continuum, with the presence of some natural process as the common denominator (Carver, Evans, & Fritz, 2002; Nash, 1982).

In different studies, definitions of nature vary, depending on the context within which nature is operationalized and measured. In an urban context, for example, nature can be defined as any natural element accessible to children, such as their green schoolyard. What constitutes "contact" also varies across studies. Contact might be slides of savannah-like landscapes in a child development laboratory, "boot camp" activities for young clients in a juvenile justice system, or children holding companion puppies on their laps. These various conceptualizations of nature reinforce the notion that nature can be experienced in many ways (Clayton & Opotow, 2003). In general, an encouraging pattern of results has emerged from the use of various measures, designs, and populations in the literature; it demonstrates that children's experience in nature settings, across various forms of contact, is beneficial to their development (Clayton & Opotow, 2003; Kahn, 1999; Kahn & Kellert, 2002; Kellert, 2002).

## Research Methods

### Qualitative approaches

In general, research studies may be classified as qualitative or quantitative. Qualitative (or, sometimes "ethnographic") methods include observation, interviewing, autobiography, document analysis, reports of parents and teachers, or giving children cameras and asking for their interpretation of "nature." Observational methods, which describe children's typical behaviour patterns in natural settings are often credited for their ecological validity. Classic studies by Hart (1979) and Moore (1986) utilized participant-observation methods: the researcher strolled along with children and asked them to show, map, and talk about familiar places. These studies described children's preferences for wilderness and unstructured landscapes for play. In other "walk-along" studies, the researchers accompanied children in their neighbourhood, walking through familiar routes while interviewing them about their activities and place engagements (Lim & Calabrese Barton, 2010). These child-participatory methods empower young people to express their concerns and to contribute ameliorating suggestions for their communities (Hart, 1997).

Although observational methods are interwoven with contextual description and provide a rich "written photograph" for the situation under study (Erlandson, Harris, Skipper, & Allen, 1993), the data nevertheless lack information about children's specified feelings and experiences. One approach is to use psychometric instruments to measure constructs such as ecological knowledge or relatedness to nature. Another method is to ask adults to reflectively re-construct their childhood experiences and meaning. One series of studies on "significant life experiences" among dedicated environmentalists employed autobiographical reminiscences of their childhood experiences and found that emotional affinity formed early in life with nature shaped a life-course trajectory of ecological concern

and actions (e.g., Corcoran, 1999; Sward, 1999, Tanner, 1980). Because these studies focus exclusively on environmental activists, further research is necessary to examine long-term effect of nature experience among the general population. Such work could offer important insights about the construction of ecological values (Wells & Lekis, 2005).

## Quantitative approaches

The putative healing power of nature has drawn diverse disciplinary interests and practitioners, ranging from ecologists, landscape architects, and nature kindergarten protagonists to horticultural therapists. The rich diversity of work addressing this topic is heartening, but the plethora of often-weak findings are sometimes accompanied by extravagant claims. What is the substantiated evidence for the value of nature in promoting child development?

In recent decades, the literature on the benefits of "contact with nature" has undergone rigorous scientific scrutiny and assessments. Studies that rely on what relatively small, biased, or self-selected samples (e.g., parks advocates or nature lovers) report (or believe) have been increasingly replaced by quantitative studies that use objective measures with samples that have no particular pre-relationship with nature (e.g., children from urban low-income families). In these studies, "nature" has been better quantified, such as objective distance to the nearest park. Benefits are measured objectively, in terms of such measures as youth crime statistics, blood pressure, physiological measures of immune system functioning, performance on standardized tests, and with behavioural tracking methods such as pedometers and accelerometer.

A major strength of a well-controlled experiment is its ability to establish definitive causal inferences, the essence of scientifically valid research. However, randomly assigning children to different experimental conditions is often not ethical or feasible. One solution is the naturalistic experiment, which came into prominence in environmental psychology in the 1960s and 1970s, advocated by pioneers such as William Ittelson, Harold Proshansky, and Roger Barker (see Proshansky, Ittelson, & Rivlin, 1975). Some recent naturalistic experiments on the effects of natural landscapes on human functioning have been conducted by Frances Kuo and her colleagues (see Kuo, 2002, for example). Much of their research was conducted in Chicago public housing neighbourhoods, where demographically similar residents reside in architecturally identical buildings. Quasi-random assignment in this work came in the form of applicants on a waiting list taking units as soon as they became available (i.e., chance mainly ruled the assignment to live in any one of the building units). This automatically varied the presence or views of trees, bushes, grass, or other natural elements around or from a unit or building. This series of naturalistic experiments demonstrated that residents, including children, who had a view of vegetation performed better on several social, psychological, and physical health measures (for a list of studies, see Kuo, 2002). Chicago public housing research has stimulated many other studies that compared children's mental and health outcomes among different levels of vegetation or distance to green spaces (for reviews, see Chawla, 2015; Lester & Maudsley, 2007; McCurdy, Winterbottom, Mehta, & Roberts, 2010; Muñoz, 2009; Pretty et al., 2009; Ward Thompson, Travlou, & Roe, 2006; Woolley, Pattacini, & Ward, 2009).

## BENEFITS OF NATURAL PLAYGROUNDS

The right of children to play is ordained in Article 31 of the United Nations Convention on the Rights of the Child (Office of the United Nations High Commissioner for Human Rights, 2008). Play is spontaneous, personally directed, intrinsically motivated, and free from externally imposed rules or social demands (Rubin, Fein, & Vandenberg, 1983). It is said to be the mechanism through which maturation occurs (Moore, Goltsman, & Iacofano, 1992), and the means by which children learn without being taught through doing, exploring, and discovering. The American Association of Pediatricians emphasizes the need for frequent unstructured, free play time for children's optimal development (Ginsburg, 2007).

Children have a unique attraction to natural environments. Many studies have demonstrated that children generally prefer to play in natural areas over playing on turf or asphalt (e.g., Department of the Environment, 1973; Korpela, 2002; Lucas & Dyment, 2010; Sebba, 1991; Sobel, 1993). For example, in a classic ethnographic study by Moore (1986), when children who live in urban areas were asked to draw or map their favorite places, 96% of the illustrations were of outdoor places depicting lawns, schoolyards, local parks, and single trees.

Natural playgrounds differ from artificial environments in several ways. The terrain is more varied and uneven and has a wide range of irregular obstacles that offer unique physical challenges for cultivating fitness and motor skills (Fjørtoft, 2001; Pellegrini, 2005). Natural landscapes are also inherently complex, dynamic, and often disordered (Bixler, Floyd, & Hammitt, 2002; Heft, 1988). A large supply of diverse objects, changing natural phenomena, and close encounters with other creatures provide mental and sensory stimulation while offering multiple avenues for diverse activities, exploration, divergent thinking, imagination, and creativity (Cobb, 1977; Faber Taylor, Kuo, & Sullivan, 2001).

## CREATIVITY AND PLAY

Green space has often been linked to more imaginative, constructive, and creative play and longer sessions of play than on built equipment or constructed playgrounds. This has been empirically supported by several studies on school grounds, residential courtyards, and childcare centres where children's behaviour was observed in different settings (with less or more vegetation), or before and after a site was green-designed (Blizard & Schuster, 2004; Cloward Drown & Christensen, 2014; Cosco, 2007; Fjørtoft & Sagaie, 2000; Grahn, Martensson, Lindblad, Nilsson, & Ekman, 1997; Herrington & Studtmann, 1998; Kuh, Ponte, & Chau, 2013; Luchs & Fikus, 2013; Moore & Wong, 1997; Samborski, 2010; Stanley, 2011).

In one of the Chicago urban public housing studies (Faber Taylor, Wiley, Kuo, & Sullivan, 1998), the level of vegetation in 64 outdoor spaces in a relatively poor neighbourhood of predominantly African-American families was measured from aerial imagery. Three- to 12-year-old children more creative play, and had more access to adults (who indirectly foster social development)

than children in less-vegetated spaces. The authors suggested that physical environment might ameliorate risks associated with poverty by supporting creative activities that are crucial to development.

Similarly, Nedovic and Morrissey (2013) conducted an action research project that involved re-development of a daycare centre in Melbourne. During the planning phase, when 3- and 4-year-old children were consulted on what they would like to see in their outdoor play area, their responses overwhelmingly showed a preference for natural elements. After the implementation of the new features, teachers described positive changes in the children's behaviour, particularly richer and more imaginative play. As one staff member observed, "The children have become dinosaurs and the pebbles are their food. The children have become babies and the pine cones are their bottles. The children have become lizards and they must find water to survive" (Nedovic & Morrissey, 2013, p. 288– 289).

Nature landscapes not only offer developmentally significant play behaviours that are functional (running, climbing) or symbolic (dramatic and role-playing), but also constructive (e.g., building huts and objects; Frost, 1992) As prospect-refuge theory (Appleton, 1975) predicted, children tend to seek out naturally occurring shelter or actively shape or construct shelters that afford safety and protection (Hart, 1979; Matthews, 1992). In a Seattle preschool yard, children engaged in more dramatic play in green spaces compared to built areas, particularly in places that afforded a greater sense of enclosure (Kirkby, 1989). The most popular play area was a cluster of shrubs at a corner of the playground, where children created hideouts and transformed the shrubbery into imaginary spaces such as forts, a house, or a spaceship. Over the years, children had built rooms, pathways, and tunnels throughout the vegetation. Kirkby argued that children in private spaces were less distracted and more engrossed, which enhanced their ability to engage in play.

A school's philosophy about the use of outdoor environment is also important, not only the actual physical design of the environment. In a study by Malone and Tranter (2003), eight- to ten-year-old children's play behaviour was observed in several Australian primary schools. Children exhibited more exploration, imaginative playing (role-play, drama, fantasy), and construction of huts and objects when the schoolyard had natural spaces *and* when the school valued the outdoor school environment.

## SOCIAL AFFILIATION

Children's play can enhance their social competence and emotional maturity (Piaget, 1962; Rubin, Fein, & Vandenberg, 1983). Through pretend or dramatic forms of play, children develop peer relationships as they learn important skills, such as cooperation, altruistic behaviour, self-control, social roles, conflict management, language, problem-solving, and emotional regulation (Howes, 1988; Howes & Matheson, 1992).

Nature playscapes are associated with more dramatic social play (Dyment & Bell, 2008; Herrington & Studtmann,1998). For example, Fjørtoft (2004) reported that among five- to seven-year-old children, a widely branched juniper bush was highly favored because it

offered possibilities to hide, with access to the outside. A group of 12 children performed several forms of social play there, including games of house, Indians and cowboys, pirates, and Star Wars.

Nature playscapes differ from traditional playgrounds in several ways that support social development. Play in green settings appears to be more socially inclusive; boys and girls tend to play more together and are less age-segregated (Fjørtoft, 2004). Traditional playgrounds primarily address children's physical development, whereas the introduction of natural materials promotes additional cognitive, social, and emotional skills. In one "landscape-based" study, Herrington and Studtmann (1998) examined the relations between landscape type and children's social play. In an equipment-based playground, physical prowess was the means for establishing the social hierarchy among 2- to 6-year-old children. Leaders in the social strata were usually children who were stronger, faster, and able to climb higher. After the installation of plant material, the use of play equipment decreased, and the vegetated space became a prime place for socialization and fantasy play. The basis of social hierarchy changed to "a child's command of language and their creativity and inventiveness in imagining what the space might be" (Herrington & Studtmann, p. 203).

## PHYSICAL HEALTH

Despite the expansion of pediatric health care and advances in biomedical science in the past few decades, childhood chronic health conditions, including obesity, asthma, are still increasing (Mithal et al., 2009; Perrin, Bloom, & Gortmaker, 2007). Children with these health conditions are at risk of developing pulmonary and cardiovascular disease in adulthood. One of the major culprits is increasingly sedentary indoor lifestyle. If this trend is not abated, the current generation of children may be the first to have shorter life expectancy than those of their parents (Olshansky et al., 2005). Thus, more work is urgently required to promote long-term prevention methods such as promotion of outdoor activities in nature.

In the neuroscience literature, outdoor elements have been found to provide benefits that can serve as important preventive ingredients in children's health. For example, Vitamin D is essential for healthy development of bones, muscles, and neurons, as well as lessening depressive symptoms and increasing feelings of vitality (Knippenberg et al., 2014). Vitamin D deficiency from a lack of sun exposure can lead to rickets in children (Ginde, Liu, & Camargo, 2009). Another example comes from a strain of healthy bacterium, Mycobaterium vaccae, that are found in healthy soil. Through gardening, playing, or ingestion (e.g., eating unwashed organic foods), contact with soil can actually help children avoid asthma and atopy (Ege et al., 2011), alleviate symptoms of depression and chronic fatigue (Dinan, Stanton, & Cryan, 2013; Messaoudi et al., 2011), and improve cognitive functioning (Montiel-Castro, González-Cervantes, Bravo-Ruiseco, & Pacheco-López, 2013). Thus, contact with natural elements operates as important preventive "ingredients" or natural interventions for children's health.

## Stress Buffer and General Health Enhancer

Many studies with adults have shown nature to buffer stress, using blood pressure reductions and cortisol levels as biomarkers for assessing stress (see review, Hartig, Mitchell, de Vries, & Frumkin, 2014). Other physiological measures, along with subjective sense of health and well-being, have recently been incorporated in studies focusing on children. For example, Soderstrom et al. (2013) examined how the quality of the outdoor environments of nine Swedish child day care centres affected the health of children aged 3 to 5. Health outcomes were measured by body mass index, waist circumference, saliva cortisol, length of night sleep, and parental report. The quality of environment was assessed by the total outdoor area and the amount of trees, shrubbery, and hilly terrain. Children in higher-quality environments retained healthier body shapes, slept longer at night, and maintained better wellbeing. In another study, urban German ten-year-olds who lived in areas with more residential greenness, assessed by vegetation cover from satellite images, had lower blood pressure, independent from potential confounding environmental stressors, such as temperature, air pollution, and noise (Markevych et al., 2014b). In a pre-post quasi-experimental study, the re-design (greening) of a rural Austrian schoolyard decreased blood pressure and enhanced self-reported psychological well-being among middle school (13-15 years of age) pupils, whereas students in the control school (no intervention) displayed slightly increased physiological stress over the same time period (Kelz, Evans, & Röderer, 2015).

Similar findings were revealed in other large-scale studies using parental reports or children's self-assessments of general subjective wellbeing. In a nationally representative Scottish sample of 3586 children (averaged 5.9 years of age), mother's perceived walking distance from home to the nearest green space was associated with children's general health. Specifically, children living more than 20 minutes walking distance from a green space spent more than two hours of weekly TV time, had worse general health ratings, but were more likely to live in lower socioeconomic households (Aggio, Smith, Fisher, & Hamer, 2015). However, after controlling for the socioeconomic status of 1837 10- to 15-years old Finnish children, perceived health and reported well-being were associated with larger amount of green structure around their homes (Kyttä, Broberg, & Kahila, 2012).

## Physical Activity

Driven by the epidemic prevalence of pediatric obesity in the United States and other developed nations, level of physical activity is the most frequently studied topic in the literature of children's engagement with nature. The principle is that regular physical activity helps build and maintain healthy bones and muscle, which in turns helps energy expenditures and reduces the risks of osteoporosis and obesity (Andersen, Hasselstrom, Gronfeldt, Hansen, & Karsten, 2004; US Department of Health and Human Service, 2008).

The positive relation between neighbourhood green space and levels of physical activity is most strongly supported by empirical evidence (Gill, 2014). Christian and colleagues (2015) conducted an extensive review of 22 studies on the relation between neighbourhood green

space and early health development from birth though age of seven. In most of these studies, physical activity was positively associated with neighbourhood density of vegetation (Grigsby-Toussaint, Chi, & Fiese, 2011; Lovasi et al., 2011), access to parks (Roemmich et al., 2006), community playground (Quigg, Reeder, Gray, Holt, & Waters, 2011; Sallis et al., 1993), and urban housing outdoor green space (Aarts, Wendel-Vos, van Oers, van de Goor, & Schuit, 2010; Faber Taylor, Wiley, Kuo, & Sullivan, 1998). Moreover, studies by De Vries, Baker, van Mechelen and Hopman-Rock (2007) in the Netherlands and by Janssen and Rosu (2015) in Canada also found that the proportion of neighbourhood green space is associated with greater physical activity. Although most of these studies are correlational in nature, longitudinal and interventional studies are necessary to examine whether a causal relation exists.

Proximity to green space is an important prerequisite for physical activity. Although definitions of "proximity" vary across studies, they generally refers to distances within 500 to 800 meters. In one review of 32 studies that examined characteristics and components of parks that motivate young people (8-21 years old) to be active, the ease of access to green space, measured either as the distance from one's home to public parks or the percentage of green coverage in their neighbourhood, was the most frequent predictor of physical activity (Gardsjord, Tveit, & Nordh, 2014).

Schoolgrounds with greater diversity of environmental features encourage children to get moving. For example, a study of 11 Swedish pre-schools revealed that 4- to 6-year-old children took more steps in environments that contained richer vegetation of trees, shrubs, and uneven ground than preschool outdoor sites with limited vegetation (Boldemann et al., 2006). Greening schoolgrounds can diversify the play repertoire by providing a wider array of physical activities, such as jumping, climbing, digging, lifting, raking, building, and role playing, that nurture all aspects of their development. In a study of 59 schools across Canada that underwent greening projects, reports from teachers, parents, and administrators indicated that through greening, schoolgrounds provide various opportunities for boys and girls of all ages, interests, and abilities to be more active (Dyment & Bell, 2008). Thus, green schoolgrounds increase the range of enjoyable, non-competitive, open-ended forms of light to vigorous play, in contrast to more structured, competitive, rule-bound sports and games on asphalt and turf grounds.

## Obesity and Weight Control

The association between proximity to green spaces and healthy weight among children has been empirically supported by many studies (e.g., Alexander, Huber, Piper, & Tanner, 2013; Bell, Wilson, & Liu 2008; Dadvand et al., 2014; Fan & Jin, 2014; Kim, Lee, Olvera, & Ellis, 2014; Liu, Wilson, & Ying, 2007; Lovasi et al., 2013; Ohri-Vachaspati, Lloyd, DeLia, Tulloch, & Yedidia, 2013; Veugelers, Sithole, Zhang, & Muhajarine, 2008; Wall et al., 2012; Wolch et al., 2011). Proximity to green space can also assist weight control among children who are in long-term treatment for pediatric obesity. In a study of 8- to 12-year-old overweight children who underwent two-year family-based behavioural weight management program, neighbourhood environment moderated the relation between obesity treatment and weight

loss. In particular, across all interventions, access to parkland (within a 5-minute walk) and fewer convenience stores were associated with greater BMI reduction (Epstein, Daniel, Wilfley, & Roemmich, 2012).

Environments with more diverse landscape features may be more conducive to weight loss than outdoor barren space. In one study, children who played in environments with more trees, shrubbery, and hilly terrain spent longer time outdoors, took significantly more steps per minutes, and more often had normal BMI and slimmer waists (Soderstrom et al., 2003). Interestingly, children's body shape was affected by everyday outdoor play in high-quality environments, but not necessarily by physical activity itself. The authors suggest that fitness interventions, a common approach to prevent childhood obesity, is complicated, time-consuming, expensive, and often results in an impact of negligible clinical significance (Puder et al., 2011). A more economically sound solution may be introducing environments with lusher vegetation where physical activity increases naturally because children play longer.

Notably, Potwarka, Kaczynski, and Flack (2008) argued that the availability of certain park facilities, such as unpaved trails, play equipment, bike paths, and athletic fields that directly support physical activity may play a more important role in maintaining healthy weight in children. In their study, Canadian children who lived near a park facility that contained playground equipment within 1 km of their homes were almost five times more likely to be at a healthier weight than children without a park facility nearby. However, proximity to park space alone or the number of parks nearby a children's residence was not associated with healthy weight status in this study (Potwarka, Kaczynski, & Flack, 2008). That is, park facilities matter more than mere green space. Other studies also report that parks with recreational facilities increase physical activity of young children (e.g., Epstein, Raja, Gold, Palch, Pak, Roemmich, 2006; Roemmich, Epstein, Raja, Yin, Robinson, & Winiewicz, 2006).

However, some studies find no association between the distance to a park and weight status (Burdette & Whitaker, 2004; Davison & Lawson, 2006; Liu, Wilson, Qi, Ying, 2007; Potestio et al., 2009). Perhaps this is partly because the association between nearby green spaces and physical activity often varies with gender, race, ethnicity, income, perception of neighbourhood safety, and other factors (Pont, Ziviani, Wadley, Bennett, & Abbott, 2009). To target chronic disease prevention and increase physical activity in general, Ding, Sallis, Kerr, Lee, and Rosenberg (2011) suggest that policy should address a cluster of environmental variables, including walkability, traffic speed and volume, residential density, access to recreational facilities, in addition to proximity to green space itself.

Pediatric obesity is a complex, dynamic problem that results from a combination of multiple causes and contributing factors. It should be examined in an ecological, political, socio-economic context. A robust body of research demonstrates that, in many nations, residence in low-income neighbourhoods and ethnic minority status result in children having less access to green space or well-maintained parks, in particular parks with amenities, relative to more advantaged households (Bolivar, Daponte, Rodriguez, & Sanchez, 2010, Estabrooks, Lee, & Gyurcsik, 2003; Gordon-Larsen, Nelson, Page, & Popkin, 2006; National Recreation and Parks Association, 2011; Powell, Slater, & Chaloupka, 2004; Wen, Zhang, Harris, Holt,

& Croft, 2013). For example, in eight European cities, higher levels of obesity among low-income children were linked, in part, to less access to green spaces and diminished physical activity (Evans, Jones-Rounds, Belojevic, & Vermeylen, 2012). This is an environmental justice issue, because access to parks is not equitably distributed in most cities, but is highly stratified based on income and ethno-racial characteristics (Jennings, Johnson-Gaither, & Gragg, 2012). Children, who comprise a vulnerable part of the population in terms of health (Flaskerud & Winslow, 1998), are particularly at risk from unequal access to these resources (Strife & Downey, 2009). Surprisingly, with the increasingly recognized need for high-quality green spaces, relatively little research has focused on potential solutions for inequality of access to nature or the active removal of existing social barriers to equal opportunity for safe and well-maintained parks.

## Fitness Skills

A few studies have demonstrated that experiences in natural environments might stimulate greater motor ability, as children move around in rugged terrain and cope with physical challenges (Fjørtoft, 2004; Frost, 2006; Grahn, Martensson, Lindblad, Nilsson, & Ekman, 1997). In a natural experiment, Fjørtoft (2001) measured the fitness skills of two groups of Norwegian children: those who played freely in the forest next to their kindergarten (experimental group) and children who used traditional playgrounds. Both groups were tested with EUROFIT (Adam, Klissouras, Ravazollo, Renson, & Tuxworth, 1988), a set of nine physical fitness tests covering flexibility, speed, endurance, and strength. For example, the flamingo balance test (standing on one foot) measures general balance, plate tapping (rapid tapping of two plates) assesses speed and coordination of limb moment, and the sit and reach test measures the flexibility of the lower back and hamstring muscles. At the pre-test (beginning of school year), the experimental group scored lower than the reference group. At the post-test, nine months later, however, the children who played in the natural forest scored significantly better on all test items. These results lead to the reasonable conclusion that versatile play in a stimulating natural playscape has causal effect on motor fitness. Similarly, a case study by Grahn and colleagues (1997) showed that kindergarten children who had access to natural environmental elements within their playground area performed better on the EUROFIT tests than children in a kindergarten with more traditional urban playground. In another study, free-form play in a complex natural play setting (higher diversity of topography and vegetation, as indicated by landscape ecology analysis) resulted in greater physical motor development in comparison to a less-varied, manicured play setting (Fjørtoft, 2004).

## Neonatal Weight

Birth weight is a leading cause of neonatal and infant mortality, and an important predictor of childhood adverse outcomes. In the past few years, the effects of urban greenery on foetal development have gained considerable research interest on public health (e.g., Agay-Shay et al., 2014; Hystad et al., 2014; Kihal-Talantike et al., 2013; Laurent, Wu, & Milesi, 2013; Markevych et al., 2014a). A review of eight studies that examined the effects of residential greenness of pregnant women's living environment on the birth weight of their babies

included 214,940 mothers from Europe, North America, and Asia. Seven of the eight studies reported a positive association between neighbourhood greenness and birth weight. The eighth study found this effect only for mothers in the lowest educational group, suggesting that the benefits of residential greenness may be stronger for more disadvantaged groups (Dzhambov, Dimitrova, & Dimitrakova, 2014). A number of possible mechanisms may underlie the relation between green space and positive pregnancy outcomes, including improved air quality, less noise, lower temperatures, psychological restoration, stress reduction, and increased opportunities for social contracts and physical activity (Richardson, 2014). Future studies that take into account of green space functionality and quality, and mothers' emotional connection to nature, may yield a clearer and more precise explanation of this result.

## Asthma and Immunity

Ethnic and socioeconomic disparities in asthma are substantial: children who live in poor urban neighbourhoods have greater asthma morbidity and hospitalization rates (Gupta, Carrión-Carire, & Weiss, 2006). Time spent outdoors may be linked to healthy immunity development. In one study, Lovasi, Quinn, Neckerman, Perzanowski, and Rundle (2008) collected tree density information and the prevalence of asthma incidence on 4- and 5-year-old children living in New York City. After controlling for potential confounds (SES, population density, and proximity to pollution sources), increases in tree density were associated with a lower prevalence of childhood asthma. However, future work is needed to evaluate whether a tree-planting intervention will establish a stronger causal inference to the reduction of pediatric asthma.

A typical method for measuring amount of vegetation in studies of immunity and green space is to use aerial imagery. However, this does not fully capture the biodiversity of nearby nature. According to the biodiversity hypothesis, the rapid increase in the prevalence of allergies, asthma, and other chronic inflammatory disorders in urban populations is caused by the loss of biodiversity, which reduces contact to beneficial environmental microbes which aid in essential immunoregulatory functions (Rook, 2009; von Hertzen, Hanski, & Haahtela, 2011). In support of the biodiversity hypothesis, Finnish adolescents who lived near greater biodiversity, assessed by the number of species of vascular plants, had a higher diversity of healthy skin bacteria and less allergic disposition (Hanski et al., 2012). Additionally, the relative abundance in human skin microbiota of Estonian children and adolescents was explained by the proportion of forest and agricultural land around their homes (Ruokolainen et al., 2015).

Future work is necessary to clarify the underlying mechanism and the extent to which biodiversity affects immune functioning and diseases. Undoubtedly, the processes that link human health and contact with environmental features are complicated, multifaceted, and difficult to examine experimentally, yet the notion that microorganisms play a key role has profound implications. Public health is at risk with rapid urbanization, deforestation and reductions in the diversity of species. At the individual level, pediatric immune disorders

can persist for a long time, and might cause disability and require continuous medical treatment.

## Myopia

Myopia, or nearsightedness, is a common condition in which images of distant objects are out of focus. The prevalence of children diagnosed with myopia varies from 9.2% among 5- to 17-years old American children (Kleinstein et al., 2003) to 49.7% in Swedish children aged 12- to 13- years old (Villarreal et al., 2000). Increased illuminated screen viewing may exacerbate increases in the prevalence of myopia. An Australian study of 12-year-old children revealed that higher levels of time spent outdoors, rather than sports and other activities per se, were associated with less myopia, after controlling for parental myopia and ethnicity (Rose et al., 2008). Consistent with this finding, a study in Singapore with 1249 children found that increased hours of outdoor activity were less likely to be myopic (Dirani et al., 2009). In a natural experiment conducted in Taiwan, Wu, Tsai, Wu, Yang, and Kuo (2013) compared 7- to 12-year-old children in two elementary schools—one with an intervention program, in which children were encouraged to engage in daily 80 minutes outdoor activities during recess time, and the control school did not have this program during recess. After one year, the progression and new cases of myopia were significantly lower in the intervention group than the control group.

## Poverty-related Health Disorders

Finally, access to green space may reduce income-related health inequalities by offering a protective buffer against poverty-related stress. Mitchell and Popham (2008) classified more than 40 million people in England on level of income and access to natural environment, and obtained their mortality records. The association between income deprivation and mortality varied with different amounts of exposure to green space. In particular, the inequality in cardio-respiratory disease mortality related to income deprivation was lower in urban populations with greater exposure to green space than those with poor access (Mitchell & Popham, 2008). Similarly, in a Japanese longitudinal study, living in an urban neighbourhood with relatively plentiful walkable green space was correlated with a lower mortality risk (Takano, Nakamura, & Watanabe, 2002). The relation between green space and health appears to be stronger for people with lower socio-economic status and children (De Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Maas et al., 2009; Maas, Verheij, Groenewegen, De Vries, & Spreeuwenberg, 2006; Mitchell & Popham, 2007). Urban life exposes children to many stressors, including traffic noise, crowding, and pollution, so natural environments that promote good health might play an important role in reducing socioeconomic health inequalities.

# MENTAL HEALTH

## Distress and Psychological Health

Exposure to natural environments appears to have beneficial effects on psychological health. Maas and colleagues (2009) gathered the medical records of 345,143 citizens and investigated the relation between morbidity and the amount of residential green space. After controlling for socioeconomic and demographic variables, they found that living within a 1 km radius of a green space was significantly correlated with reduced risk for 15 out of 24 disease categories, including neurological disease, mental illness, and cardiovascular disease. The association was strongest for anxiety disorder and depression, especially for children.

Several studies using large databases have examined the relation between nearby green space and children's emotional adjustment. For example, among urban English children who live in poverty, those with a higher percentage of green space in their neighbourhood had fewer emotional problems from age 3 to 5, relative to their counterparts in less green neighbourhoods (Flouri, Midouhas, & Joshi, 2014). In Lithuania, among children of mothers with less education group, mental health problems (hyperactivity, peer problems, and total difficulties) were negatively associated with residential distance to city parks, whereas among children of mothers with more education, prosocial behaviour was associated with residential greenness (Balseviciene et al., 2014).

Cumulative childhood stress can affect cognitive development and trigger later mental health issues (Hanson et al., 2015). Contact with nature may contribute to resilience of children, particularly for children who face childhood adversity or tremendous disadvantage (Evans & Kantrowitz, 2002). Wells and Evans (2003) examined the amount of nature in their residential environment and the psychological well-being of 330 children in grades 3 to 5 who lived in rural New York. Nature was defined as the amount of nature in the window view, the number of indoor plants, and the materials in their outdoor yard. Stressful life impacts were assessed by parental report of psychological distress and the children's ratings of self-worth. The impact of stressful life events, such as family relocation or bullying, was lower among children with higher levels of nearby nature. The authors speculate that social relationships and the attention restoration afforded by nature could account for some of this outcome; longitudinal research could establish a more rigorous causal conclusion.

Apart from stressful life events, the value of green refuges and rehabilitation has also been demonstrated in other studies of children facing numerous types of challenges, including children with a background of poverty (Hung, 2004; Wells 2000), children with temporary disabilities caused by accidents, operations, or psychological trauma (Moore, 1999), children with learning disabilities (Faber Taylor & Kuo, 2009; Kuo & Faber Taylor, 2004), behaviour disorders (Katcher & Teumer, 2006), new immigrants (Cutter-Mackenzie, 2009), juvenile offenders (Cammack & Waliczek, 2002; Cammack, Waliczek, & Zajicek, 2002), and those in war zones (Chawla, 2014).

What are the ingredients of nature's protective forces? The ethnographic work of Moore (1986) and Kreutz (2015) demonstrated that natural areas provide opportunities for positive adaptations, including creative play, bonding with animals, self-tests of developing strength and skill, and quiet retreat. Masten and Reed (2002) highlighted three strategies that foster resilience in children across all protective factors: reducing risks (e.g., inhibiting impulsiveness and delaying of gratification), building assets (e.g., improving concentration, problem-solving, or interpersonal skills), and mobilizing adaptive systems (e.g., connecting children to friends).

## Psychological Restoration and Improved Mood

The first empirical investigation of psychological restoration in nature took place in relatively wild areas. Kaplan and Talbot (1983) incidentally found that participants who took part in the Outdoor Survival Program experienced positive emotions after being in the woods for more than a week. Inspired by the idea of the environment as restorative, many subsequent studies have demonstrated positive effects on mood with relatively shorter durations (a few hours or less) even in managed settings, such as parks or garden. For example, Cooper Marcus (2006) found that 95% of patients in a children's hospital reported a positive change in mood after spending time outdoors, from feeling depressed and anxious, to a more calm and balanced outlook. The specific qualities that were influential for inducing mood change were natural elements (flowers, fragrance, water features) because they represent a contrast to the experience of being inside a hospital (e.g., fresh versus controlled air; rich sensory experience versus predominant straight lines; continuity and cycle of life versus evoking thoughts of illness and death). Many other studies corroborate the general pattern of improved mood. For example, young adults who completed a demanding task displayed less anger after walking in a nature preserve than an urban setting (Hartig, Evans, Jamner, Davis, & Gärling, 2003). Gardeners who performed a stressful task rebounded better, in terms of mood and cortisol levels, after spending 30 minutes of gardening work rather than passive indoor reading of the same duration (van den Berg & Custers, 2011).

Simply viewing vegetation through a window can also derive somewhat similar restorative benefits as venturing out into natural environment. In a classic study by Roger Ulrich (1984), surgery patients who were assigned to rooms with windows looking on a natural scene had shorter hospital stays, received fewer negative comments from nurses, and required less pain medication than patients with similar rooms with windows facing brick walls. Even images of nature may promote psychological restoration (Berto, 2005; Hartig, Böök, Garvill, Olsson, & Gärling, 1996; Laumann, Gärling, & Stormark, 2003). Participants who ran on a treadmill while viewing rural photographs demonstrated significant reductions in blood pressure, increases in self-esteem, and more positive effects on mood than participants exposed to urban scenes (Pretty, Peacock, Sellens, & Griffin, 2005). Office workers experienced less anger when art posters with natural content were present in their offices (Kweon, Ulrich, Walker, & Tassinary, 2008).

Why is nature restorative? Two predominant theories are attention restoration theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995) and the psycho-evolutionary theory (Ulrich, 1983; Ulrich et al., 1991). Both are drawn from the biophilia hypothesis and the evolutionary theory (Staats, 2012), but they differ in how they conceptualize restoration. The psycho-evolutionary theory of stress reduction is concerned with recovery from psychophysiological stress and negative affect. After a stressful experience, visually appealing natural scenes are restorative because they elicit positive affective responses such as interest, pleasantness, and calmness. In contrast, ART focuses on cognitive processes; it explains the restorative effects of green space on overused or prolonged directed attention (mental fatigue). Restorative environments, which are characterized by the qualities of being away, fascination, coherence, and compatibility, help capture involuntary attention, ameliorate attention fatigue, and recover the ability to concentrate.

## Concentration and Self-Control

*Reduction of attention deficits*. Mental fatigue from prolonged concentration is characterized by feelings of distracted, impulsiveness, and irritability. As noted above, ART predicts that nature effortlessly engages the mind away from stressors and enables restoration and reflection (Kaplan, 1995). The theory is supported by experiments in which participants' attentional capacity is replenished by nature after having been depleted by cognitively demanding tasks (e.g., Berman, Jonides, & Kaplan, 2008). In children, ART is supported by studies that have examined nature's capacity to help relieve symptoms of Attention Deficit Disorder (ADD) and Attention Deficit-Hyperactivity Disorder (ADHD). Mental fatigue and ADHD appear to involve disruption of the same underlying brain mechanism (Glosser & Goodglass, 1990; Mole, Marshall, Pietrowsky, & Lutzenberger, 1995). ADHD is a neurobehavioural disorder primarily characterized by a deficit in directed attention. Its symptoms include an inability to focus on unappealing tasks, inability to complete tasks, inability to listen and follow instructions, and being easily distracted. These symptoms can cause significant functional impairments in learning and socialization (Loe & Feldman, 2007; Nijmeijer et al., 2008). ADD and ADHD are typically treated with stimulants such as Ritalin and Strattera. However, reduction of symptoms is often temporary and these medications come with side effects such as sleep disruption and appetite suppression.

Using a multimethod approach, a research team led by Frances Kuo has demonstrated that nature can potentially offer a safer alternative medication or complementary therapy for ADD and ADHD. In two correlational studies, parents of children with ADD were surveyed in a Midwestern (Faber Taylor, Kuo, & Sullivan, 2001) and nation-wide samples (Kuo & Faber Taylor, 2004). Parents were presented with a list of after-school activities in three settings: indoor (e.g., windowless room), built outdoor (e.g., downtown), and green outdoor (e.g., farms) to indicate the severity of postactivity attentional functioning of their child. Parents reported better functioning in their children after they engaged in activities in green outdoor settings than in either indoor or built outdoor settings, even after controlling for the social setting and the activity itself, such as passive reading. Furthermore, the more tree cover in a child's play area, the less severe his or her attention deficit symptoms.

To address the causal role of green settings on the reduction of attentional deficit symptoms, Faber Taylor and Kuo (2009) conducted a field experiment in which children who were diagnosed with ADHD received a sequence of different treatments. Upon completing a series of puzzles designed to induce attention fatigue, 17 children completed 20 minutes of guided walks in three settings (an urban park, a downtown area, and a residential area) that differed in the extent to which natural or urban elements dominated. Walking through the greenest setting (the urban park) significantly improved concentration in a subsequent cognitive demanding task to a degree comparable to the effects of a widely used medication for ADHD. Thus, the link between green space and the reduction of ADHD symptoms has been empirically supported by the use of controlled comparison across settings in the field experiment, which establishes causality, and the use of national sample in the large survey-based work, which addresses generalizability.

Other researchers have also demonstrated the role of natural environments in improving attentional functioning. Using a longitudinal design, Wells (2000) tracked the effect of a pre- and post-move from substandard housing to better-quality housing in 17 low-income children in the United States. Children who experienced the greatest increase in natural elements (the amount of nature in the window view and grass yards) had highest levels of attentional functioning following the move. In the Netherlands, two groups of children diagnosed with ADHD built a cabin in a woodland in one day and made an expedition to a small town the following day. Children in both groups performed better on a concentration task and demonstrated cooperative social behaviour in the woods, but displayed more aggressive, inattentive, impulsive and hyperactive behaviour in the town (Van den Berg & van den Berg, 2011). The beneficial association between green space and reduction of hyperactivity and inattention are also supported by other studies conducted in 36 Barcelona schools (Amoly et al., 2014), 11 Swedish preschool playgrounds (Martensson et al., 2009), metropolitan residences in Munich (Markevych et al., 2014c), and in urban English neighbourhoods (Flouri, Midouhas, & Joshi, 2014).

*Self-discipline and academic achievement*. Self-discipline draws on limited quantities of directed attention (Muraven & Baumeister, 2000). The failure of self-discipline in children can lead to academic underachievement, juvenile delinquency, teenage pregnancy, and other negative social and personal outcomes (Baumeister, Heatherton, & Tice, 1994). Directed attention may be renewed through contact with nature (Wells, 2000; Faber Taylor, Kuo, & Sullivan, 2002). In a study that investigated the effects of vegetation around Chicago public housing, the more natural a girl's view from home, the better her performance on three forms of self-discipline: tests of concentration, impulse inhibition, and delay of gratification (Faber Taylor, Kuo, & Sullivan, 2002). For boys, however, no significant associations was found between self-discipline and near-home nature. Perhaps they typically spend more time playing further from home than girls (Wohlwill & Heft, 1987).

Students often experience academic stress. Nature exposure may reduce mental fatigue and enhance overall student academic achievement and behaviour. For example, after controlling for SES and school characteristics for 101 public high schools in Michigan, greater views of trees and shrubs from cafeteria and classroom windows were positively associated with standardized test scores, graduation rates, likelihood of planning to attend a

four-year college, and (fewer) occurrences of criminal behaviour, while featureless landscapes (e.g., athletic fields, parking lots, and large empty lawns) were negatively associated with these outcomes (Matsuoka, 2008). In Massachusetts, grade three students scored higher on standardized tests of English and mathematics when more trees and vegetation were in the vicinity of their schools (Wu et al., 2014). In Barcelona, the cognitive development of grade two to grade four students in 36 primary schools was assessed periodically over a 12-month period in relation to the amount of surrounding vegetation around their home, school, and during commuting. Greater improvement in working memory and reduced inattentiveness were associated with surrounding greenness, particularly with vegetation in and around schools (Dadvand et al., 2015).

## NATURE THERAPIES

Contact with nature in a variety of forms has been utilized in the treatment and prevention of diseases and other mental health concerns. Nature-assisted therapy (NAT) is defined as an intervention that involves plants, natural materials, and outdoor environments to treat, hasten recovery, or rehabilitate patients (Annerstedt & Währborg, 2011). NATs also serve as catalyst for the synthesis of sustainability, mental health, and education. NAT has been used with a variety of client groups, in the field of mental health and ecotherapy, environmental social work, environmental education, and include wilderness and adventure therapy, horticultural therapy, and animal-assisted therapies. For example, horticultural therapy utilizes gardening to aid people with depression, who are often suffering from distortion of attention and rumination (Gonzalez, Hartig, Patil, Martinsen, & Kirkevold, 2010; Messer Diehl, 2009). Relational therapy uses structured psychotherapy in an outdoor setting where shy, withdrawn child clients can feel safe and relaxed in a reciprocal mutual relationship with their therapist, while memories of traumatic experiences are believed to be “transcended” or relieved through outdoor activities (Santostefano, 2004; 2008).

This section focuses on NATs that have important developmental outcomes—wilderness program and animal-assisted therapy.

### Wilderness Therapy

The wilderness and adventure therapy (WT/AT), also known as outdoor behavioural healthcare (OBH), is the oldest form of NAT (Gass, Gillis & Russell, 2012; White, 2012). The popularity of WT/AT may be due to increasing mental health problems among young people (Werhan & Groff, 2005). The primary client group is children and adolescents who have substance abuse, anxiety, depression, avoidant personality disorder, and other antisocial behavioural problems such as defiance, impulsivity, and anger-management issues (e.g., Banderoff & Scherer, 1994; Romi & Kohan, 2004). Most clients are under 18 and over 60% are male (Russell, 2012).

Although no standard protocol for WT/AT exists (Friese, Hendee, & Kinziger, 1998), the general approach is to integrate counselling techniques with intense wilderness experiences

lasting a month or longer, while learning relevant technical skills and teamwork, such as rafting and preparing food (Wilson & Lipsey, 2000).

Experimental outcome research on the effectiveness of WT/AT programs is limited, primarily because conducting experiments in which young, at-risk clients are assigned to a wilderness therapy condition while a control group receives alternate or no treatment is difficult and ethically questionable (Russell, 2012). However, a few empirically sound quantitative and qualitative studies have demonstrated positive outcomes of some programs (e.g., Harper, Russell, Cooley, & Cupples, 2007; Russell, 2003; 2005). For example, in one outcome-assessment study on OBH, adolescents (aged 16-18) who were primarily diagnosed with Oppositional Defiant Disorders, substance disorder, and depression attended seven wilderness therapy programs that averaged 45 days that included group living and activities. At admission, the clients exhibited symptoms at levels similar to those of hospital inpatients. Treatment outcomes, evaluated by parents and clients' self-assessments, included significant reductions of behavioural and emotional symptoms at discharge (Russell, 2003). To check whether some transfer of learning occurred, two-year follow-up post-treatment interviews were conducted, which indicated that the program was perceived as beneficial, that the majority of youths reported good academic performance and improved family communication, and that aftercare services, which facilitate the transition from an intensive wilderness immersion to family, peer, and school environment, were utilized by most of the clients (Russell, 2005). Thus, skills and lessons learned during wilderness immersion seem to have been applied to everyday lives. Other studies also report associations between participation in wilderness therapy and children's physical health, personal autonomy, self-esteem, self-awareness, interpersonal skills, and (decreased) antisocial behaviours (e.g., Behar & Stephen, 1978; Kellert & Derr, 1998; Kaplan, 1977; Kaplan & Talbot, 1983).

Although wilderness therapy has been recognized as a promising intervention for behavioural and cognitive developmental changes (Werhan & Groff, 2005), several limitations must be addressed. One methodological limitation is the exclusive reliance on self-report measures. Participant reports may be biased by their own perceptions, rather than objective treatment outcomes. Positive comments may be biased by the desire to please researchers or to support the programmes.

Second, wilderness experience itself may be confounded by the program's activities. In other words, the need for self-reliance in unfamiliar and changing environments, regardless of setting, may promote positive effects. Further, it is not clear which specific aspects of WT and how much wilderness immersion is necessary to accrue those benefits. Some WT programs are based on the outdoor adventure challenge model (i.e., the "boot camp" approach), whereas others employ standard psychotherapeutic techniques, such as cognitive-behavioural therapy, in wilderness settings. To date, no researchers have yet systematically isolated the wilderness effect (Greenway, 1995) from traditional psychotherapy or other potential confounds.

Third, others have criticized potential injuries that might results from outdoor activities, particularly water-based or high-altitude sports. Some programs are not licensed or

accredited, and a few programs have been condemned for alleged physical and emotional abuse (Krakauer, 1995; Kutz & O'Connell, 2007). Also, certain activities may not be suitable or ethical for patients with physical disabilities or severe mental health issues.

Fortunately, these concerns have prompted the formation of the Outdoor Behavioural Healthcare Council in 1997, and it promotes program standards, ethics, and risk management. Nevertheless, due to relative high cost of these programs and the variability in therapeutic methodology across programs, more scientific evidence is needed to establish program effectiveness, and more research is required on which components of AT are appropriate for specific populations.

## Children and Animals

According to Gibson (1986), animals are an inseparable part of nature, and no organism can exist without a natural environment. Until recently, developmental research had largely overlooked children's perception, relationship, and interaction with animals, even though animals, represented in a variety of forms (live, stuffed, imaginary), play a significant role in children's lives. A few developmental psychologists argue that, in order to understand children's play patterns, sense of self, empathy, and ecological concerns, researchers should focus on biocentric approach (informed by the concept of biophilia), rather than traditional anthropocentric (human only) framework on children's development (e.g., Melson, 2001, 2003; Myers, 2007; Myers & Saunders, 2002). Children's affiliations with and abiding attraction to animals are based on several underlying emotional mechanisms (Vining, 2003), including companionship and social support, reinforcement of self-worth via unconditional love, provision of self-concept, psychological and physiological healing, connection with nature, and a sense of awe and wonder. Although empirical research on the beneficial effects (if any) of undomesticated wildlife is nonexistent, research on the developmental benefits of contact with animals falls into two categories: pet ownership and companionship and animals in therapeutic context.

### Pet ownership and companionship

Self-worth and empathy. Pet ownership may have positive impacts on sense of self. Youths who owned pets reported having more responsibility and scored higher on a self-esteem measure than those who did not own a pet (Covert, Whiren, Keith, & Nelson, 1985). Adults had more positive self-concept if they had their first pets when they were less than 6 years old or during their teenage years (Poresky, Hendrix, Mosier, & Samuelsson, 1988). Four studies demonstrated that children with stronger relationships with their pets scored higher on measures of empathy (Melson, Peet, & Sparks, 1991; Poresky, 1990, 1996; Vidovic, Stetic, & Bratko, 1999). To date, these findings were mostly derived from correlational studies and therefore causality is unclear: Do empathetic, socially oriented children form bonds with their pets, or do pre-existing family contexts or preferences lead to the choice to have pets, or does having pets cause these benefits?

Emotional self-regulation. Companion animals may support emotional self-regulation, an important recipe for children's socio-emotional well-being. Interviews with children show

that during stressful situations, many seek out their pets for reassurance, emotional support, and unconditional love (Covert, Whirren, Keith, & Nelson, 1985; McNicholas & Collis, 2006; Rost & Hartmann, 1994; Triebenbacher, 1998). Pre-schoolers with pets were less likely to feel anxious and withdrawn during transition to public schools (Melson & Schwartz, 1994). The rationale for pets as an important resource in social support system may be that animals are perceived to offer unconditional love and non-judgmental acceptance. In fact, greater alleviation of cardiovascular stress responses and lower cortisol levels were associated with interaction with a companion animal than with people (e.g., Friedmann et al., 1983; Allen, Blascovich, & Mendes, 2002; Odendaal & Meintjes, 2003). However, whether animal companionship and attachment promote a greater capacity for emotional regulation over the lifespan, as children become more independent or when a pet is not available, remains to be learned.

## Animals in therapeutic context

In animal-assisted therapy (AAT), animals play a vital role in assisting children with behavioural problems or emotional disturbance by improving their cognitive, physical, social, and emotional well-being. Katcher and Wilkins (1993, 1998, 2000) have used animal-assisted interventions for children diagnosed with autism, attention-deficit disorder, conduct disorder, and oppositional–defiant disorder. Animals are capable of stimulating a high level of interest, and because of their slightly unpredictable reactions, they evoke curiosity and sustained attention, and provide opportunities for affection and nurture play (Katcher & Wilkins, 1998).

Furthermore, mastery of fear of animals and learning to care for them give children a sense of competence and self-esteem. In one longitudinal study, children were assigned to either five hours per week of an Outward Bound course, which consisted of supervised activities such as rock climbing, canoeing, and swimming, or five hours per week of a nature and companionable zoo (CZ) program. When the school term was over, children who had the animal contact demonstrated significantly fewer aggressive episodes and pathological behaviours. After zoo visits, autistic children demonstrated improved attention, social interactions, and positive emotions, and children with ADHD were able to sustain attention and showed better impulse control. Beneficial effects of CZ were carried over to regular school program. Compared to an outdoor challenge program, children underwent AAT showed accelerated learning, improved school attendance, and reduced teacher-rated severity and frequency of behavioural symptoms (Katcher & Wilkins, 1993; 2000).

Other studies demonstrated enhancement of social behaviour with animals in therapeutic setting. Children with Down's syndrome displayed greater sustained focus towards, and more cooperative interaction with, their therapist when a live dog was present than when an imitation dog of similar in size and color was present (Limond, Bradshaw, & Cormack, 1997). Martin and Farnum (2002) undertook similar analyses of children with pervasive developmental disorders, a class of disorders characterized by delays in the development of socialization, including autism and Asperger's syndrome. The children's social behaviour varied with the study's conditions. Compared to a non-social toy (ball) and a stuffed dog, the presence of a dog facilitated more playful moods (indicated by laughing and giving

treats), increased awareness of social surroundings, and more meaningful discussion with therapist. In another study, children with mental disabilities engaged in more verbal responding with therapist when a dolphin was present than when their favorite toy was present (Nathanson & de Faria, 1993).

AAT may also favorably influence the development of communication skills (Beck & Katcher, 2003). During talking, singing, or talking to companion animals or inanimate objects, stuttering is almost absent (American Psychological Association, 1994). Pet owners were also more skilled at decoding human nonverbal facial expression, particularly among boys (Guttmann, Predovic, & Zemanek, 1985). In a more controlled study, Dismuke (1984) examined the influence of a 12-week structured horseback riding program for children suffering language-speech pathology. Pre-, mid-, and post-test of speech and language skills, sensorimotor integration, and self-esteem revealed significant improvement in all areas, including complexity of language structure, appropriateness, and efficient use of speech in children who participated in the rehabilitative horseback riding program in conjunction with communication therapy, compared to non-riding control group with the same language curriculum in their classroom setting. The strengths of this study were the use of random assignment to the conditions and that the raters were blind to the condition in which the children received treatment. However, the use of different therapists and teachers in each condition may have confounded the results.

Although limited preliminary research is suggestive of AAT's positive effects, several limitations and methodological weakness must be addressed, because they may provide insights to future research directions. First, many studies that have been published in support of AAT were practice–based (Marino & Lilienfeld, 1998). They use small sample sizes, rely on potentially biased raters, and may be flawed by a host of potentially confounding factors (e.g., socializing, placebo effect, subjective evaluations). From a scientific perspective, more randomized and rigorously controlled studies are necessary to establish more valid evidence for therapeutic outcomes of AAT. Second, a lack of published longitudinal research for evidence of long-term improvement of clinical population suggests that AAT may only offer a temporal affective fix, that is, short-term relief, rather than long-term behavioural change (Lilienfeld & Arkowitz, 2008). Third, some children may become attached to therapeutic animals that are not their pets. It may be ethically questionable to subject a child to disappointment and possible relapse once AAT discontinues.

## COGNITIVE DEVELOPMENT AND UNDERSTANDING NATURE

An important aspect of intellectual development is the ability to discriminate, identify, and classify objects based on prototypes. Nature provides extensive opportunities for children to acquire these abilities through a wide range of observable objects, features, and behaviours (Kellert, 1997; 2002). The complexity and diversity inherent in natural environments creates stimulating and memorable learning contexts, and ever-changing natural phenomena afford children to perceive nature as dynamic and timeless (Prescott, 1987). For example, weather patterns (ice forming as the temperature drops) and animal habitats

(caterpillar becomes butterfly) advances understanding of relation among natural stimuli. Dull and static environments can delay or block cognitive development (Moore, 1986).

## Folkbiology: Children's Naïve Understanding about Nature

Folkbiology is a term used to describe intuitive understanding and reasoning capacity about the natural world (Coley, 2000). It is developed in each culture, even without formal schooling (Medin & Atran, 1999). Research has identified several implicit principles or biological fundamentals that children use when they think about nature. One is essentialism, the idea that certain categories have an underlying reality or property that one cannot observe. For example, 10-year old children believe that a raccoon painted black with a white stripe with a pouch of "smelly stuff" does not change its identity despite its similar outward appearance to a skunk (Keil, 1989). Preschoolers also assume that the identity of an animal will not change across different environments and upbringing. For example, they believe that a baby cow, raised by pigs, would come to "moo" and not "oink" because its essence is that of a cow (Gelman & Wellman, 1991). Another principle is "vitalistic causality," a form of construal in which the primary causal concept is "life force." For example, 4-year-olds readily understand that biological causal mechanisms, not human intervention, underlie the growth of plants and animals (Hickling & Gelman, 1993). They also recognize that animals and plants draw vital power from food and water to provide energy, make them grow, and help them recover (Inagaki & Hatano, 2004).

The amount and quality of children's intuitive understanding about nature is shaped both by cultural construction and their experience in nature (Medin & Atran, 2004; Ross, Medin, Coley, & Atran, 2003), suggesting an interplay between genetic and experiential factors. With formal instruction, native biological concepts are often replaced by more sophisticated, scientific understanding (e.g., evolution replacing essentialism). The influence of cultural experience on folkbiology was analyzed Ross, Medin, Coley, and Atran (2003). Rural Native American, urban European American, and rural European American children were told that an imaginary substance called *andro* resides in all living things. One group of children was told that the substance is inside humans, and then were asked if other animals also possess it ("Do wolves have andro, like humans do?). In another condition, children were told that the substance is inside other animals and were then asked if humans also contain the substance. Some children demonstrated *anthropocentric* thinking, making projections of similarity from humans (the central exemplary of living things) to other animals (e.g., "if humans have it, wolves must have it too"). Others demonstrated *biocentric* (nature-centred) thinking, or bidirectional projections of similarity (from humans to animals, and vice versa). The three cultural groups showed distinct developmental trajectories of folkbiological induction. Relative to non-native children, Native American children made more biocentric projections. Although both groups of non-native children share anthropocentric beliefs, the typically richer experience of rural children led them to make more biocentric projections than the urban children did. Thus, cultural beliefs about ecological affinity, as well as personal experience with nature, facilitate the acquisition of biocentrism. If they lack sufficient exposure to nature, children cannot fully develop nuanced understanding of living things and natural systems (Coley, Solomon, & Shafto, 2002). For example, 6-year-old

urban children were able to assign living things to appropriate taxonomic categories (e.g., mammals, plants. and insects), but they had less-developed understanding of organisms' ecological and habitats than those from rural backgrounds.

Research appears to indicate that people's general knowledge about their local nature is decreasing. Local ecological knowledge (LEK), or indigenous knowledge, is a vital part of our capacity to manage and conserve ecosystems. LEK is negatively correlated with income levels in local communities in India, Indonesia, and the United Kingdom, and across countries that vary in per capita GDP (Pilgrim, Cullen, smith, & Pretty, 2007). In particular, where a community has become more industrialized and independent of local environmental goods and services, knowledge of species' names and function is lower. LEK acquisition is rapid at young ages in resource-dependent countries, but not in the UK, where it is slow and delayed. In the UK, high school youth demonstrated limited ability to identify common flowers, and they viewed such identification skills as relatively unimportant (Bebbington, 2005).

Despite this, children do have a strong capacity for recognizing natural and man-made creatures. Sadly, children's ability to identify cartoon characters increased from ages 4 to 11 years of age, more than their capability to identify common natural wildlife types. By age 8, children were able to recognise nearly 80% of 150 Pokémon characters (Balmford, Clegg, Coulson, & Taylor, 2002). Another poignant illustration is depicted in the documentary film *Play Again* (2010). During one scene, when children were asked to identify a variety of pictures presented to them, they readily identify corporate logos, but were struggling to name common plants, as several children refer to the dandelion as "wish flower" or "some kind of weed." To conclude, research on children's folkbiology will not only broaden understanding of cognitive development in general, but should also help us to better understand why and how adults' nonsustainable behaviours may be influenced by anthropocentric thinking and ignorance about ecology (Medin & Atran, 1999).

## Moral Development and Environmental Values

Children's understanding of nature may also influence their moral reasoning and development of environmental values. Peter Kahn and colleagues (Kahn, 1997, 2002; Kahn & Friedman, 1995) have conducted extensive cross-cultural interviews with children, asking them about their views about environmental degradation. They found the two primary forms of environmental moral reasoning that resemble those described earlier. Anthropocentric moral reasoning reflects concerns for human wellbeing, including aesthetics, personal interests (e.g., no animals to play with), and human health and welfare (e.g., pesticide contamination). Biocentric moral reasoning, on the other hand, focuses on the intrinsic value and rights of natural systems, which are thought to deserve respect comparable to that for humans. This perspective involves seeing similarities among all living things and evokes feelings of empathy for natural species (Gebhard, Nevers, & Billmann-Mahecha, 2003). For example, one child commented "if nature made birds, nature does not want to see birds die…[the birds] need the same respect we need" (Kahn, 2003, pp. 116-117).

In general, Kahn and others find that children tend to be more morally concerned about people than other species (e.g., Hussar & Horvath, 2011). Interviews with children from three diverse cultures (inner-city Houston in Texas, the Brazilian Amazon, and Lisbon) revealed that most children conceive of environmental disaster as a violation of a moral obligation, and offer anthropocentric justifications (Kahn, 1999; Kahn & Lourenço, 2002). For example, Kahn (1997) interviewed children's ethical reasoning concerning the 1989 Exxon Valdez oil spill in Alaska which dumped nearly 11 million gallons of oil into Prince William Sound, destroying beaches and killing thousands of marine species. Although children did cite the harm to wild animals, fish, and recreational users, anthropocentric reasoning was used with higher frequency than biocentric reasoning (58% vs 20% of reasons given).

Children also show a developmental progression of biocentric reasoning: Older children are more likely to exhibit biocentric reasoning, perhaps because of their more sophisticated grasp of ecological systems. For example, one interview study revealed age differences in mental construction of animals' need. Younger children were able to grasp animal's basic physiological needs for food and water, but older children (after age 10) recognized their ecological habitat and conservation needs, such as outlawing hunting or reducing pollution (Myers, Saunders, & Garrett, 2004). When children do exhibit biocentric reasoning, they emphasize animal welfare more than that of plants, possibly because their awareness of plants as "alive" occurs later in their development (Melson, 2013). As noted earlier, innate affiliation with animals encourages caring and concerns for non-human species and serves as a foundation for broader environmental concern (Myers, 2007; Myers & Saunders, 2002). In sum, children are more likely to adopt biocentric values with more fully developed understanding of ecology as well as positive childhood experience in nature.

## Environmental generational amnesia

Children in industrialized societies with limited interaction with wild places may experience an **extinction of experience** (Pyle, 1978; 1993), which describes a cycle of impoverishment that is initiated by reduced diversity of natural elements, followed by a sense of apathy, alienation, and disaffection, which in turn, begets more depauperated environments and deeper isolation from nature. Similarly, Kahn (2002) argued that lack of environmental concern is not merely a result of giving the environment secondary priority relative to the immediacy of material needs, but the gradual perception of one's slowly ecologically deteriorating condition as a normal experience. Kahn suggests the term **environmental generational amnesia** (EGA) for describing the phenomenon that the natural environment that people encounter during their childhood serves as a benchmark against which they evaluate future degradation. As environmental degradation increases across historical time, each generation's standard become more denuded, which results in decreased sensitivity to the magnitude and scope of the ecological crisis, and numbing awareness for proactive responses. This normality of degradation is illustrated in interviews with African American children growing up in Houston, one of the most polluted cities in the United States. Despite their general knowledge about water pollution, about most children believed that their local waterway was not polluted (Kahn, 2007).

Although the notion of EGA is intuitively compelling, empirical data in support of environmental generational amnesia is relatively scarce. One related study examined responses to pollution in Los Angeles from long-term residents (lived there five years or more) versus new arrivals (within three weeks) with comparable levels of socioeconomic status. Compared to the recent immigrants to the city, long-term residents were less likely to mention smog as a community problem and felt themselves less vulnerable to it. When presented with slides of California scenes depicting differing levels of smog, long-term residents were less sensitive in detecting the presence of smog in the photographs (Evans, Jacobs, & Frager, 1982). Although this finding supports the notion that people may adapt to air pollution, whether the pollution was viewed as part of the ambient environment, or that the negation of pollution served as a justification mechanism for a problem that is perceived to be outside of residents' control is unclear. Nevertheless, evidence supporting EGA will require cross-generational data and documented changes to biological systems to determine whether baseline perceptions collectively shift over time (e.g., Papwroth, Rist, Coad, & Milner-Gulland, 2009).

That being said, **EGA** has the potential to affect children's perceptions by obliterating the true extent of the ecological crisis. Children from the industrialized world may not realize what they are missing, and they lack the perspective of previous generations who lived before the era of pollution and denuded landscape. Direct experience in wild nature is critical for targeting generational amnesia. As children begin to better understand that human and environmental welfare are intimately linked, they will recognize a sense of **ecological self**, which gives rise to biospheric values.

The ecological self is developed through a process of self-actualisation, as one transcends from an isolated, primarily autonomous egoistic self that parallels industrialization (Baumeister, 1987) to a self that identifies oneself as part of the larger ecological whole (Naess, 1985). People frequently experience this ecological self in wilderness settings (Coburn, 2006; William & Harey, 2001). Research on the significant life experiences of active environmentalists revealed several key factors that contribute to exemplary commitment to environment, including positive childhood experience in nature, bonding with local environments, and supportive role models (e.g., Chawla, 1998; Monroe, 2003; Tanner, 1980). Importantly, nature experiences must be repeated and recurrent; rarely does a singular event breed familiarity or emotional affinity. According to Naess (1985), the development of ecological self leads to environmentally responsible behaviours, on the basis of genuine love and common identity rather than self-sacrifice.

### Technically-simulated nature

Modern children's declining access to nature has been increasingly replaced by virtual experiences of it (Kahn, 2011). Vicarious nature refers to non-firsthand experience, through acquaria, zoos, and electronic media or simulated nature (Kellert, 2002). In general, vicarious nature can provide excellent information and narrative creativity, and therefore can serve an important role in education and conservation campaigns. Newer technologies allow interaction with nature, such as a bird identification portable device, geocoaching

(finding hidden objects using GPS), remote-controlled vehicles for underwater exploration, and online communities for sharing nature videos and photos (i.e., iNaturalist.org).

As with novel aspect of any new technology, children and youth typically respond to technically-mediated nature activities with enthusiasm (Chavez 2009; Harmon & Gleason, 2009). Harrington (2009) conducted an observational study to compare guided-real and virtual reality field trips among 4th graders. The virtual field trip allowed child-initiated exploration and navigation by mouse or keyboard, while offering simulated events in sound, video, as well as facts about different species. Responses after both trips revealed increased student initiative. Although most students found the virtual trip exciting because it allowed them to "fly" around or pretend to be another creature, more overall positive emotions were reported from the real trip. Multisensory experience and unplanned, out-of-curriculum learning are more memorable and occurred more in the real environment. Future research should explore how the real and virtual learning environments might be combined as a complementary fashion to maximize intrinsic motivation and discovery-based learning.

Kahn (2011) conducted a series of studies that compared the experience of a natural entity, its absence, and a technological simulated version of it (e.g., views from natural windows, technological windows, and no windows in offices). Some studies of children compared responses to a highly responsive robotic dog (Sony's AIBO) with those to a live dog. Although children said they could be friends with AIBO, more children conceptualized the live dog, compared to AIBO, as having physical essence, mental states, sociality, and moral standing (Kahn, Friedman, Pérez-Granados, & Freier, 2006). Age differences in children's interaction with the robotic dog were found: preschoolers treated AIBO and the real dog similarly (e.g., petting and talking), but older children were nearly five times more likely to give more affection to a live dog than to AIBO (Melson, Kahn, Beck, & Friedman, 2009). Thus, a pattern emerges from these studies which suggests that simulated life forms are not complete substitutes for real ones, and that built spaces, even those with biophilic designs, do not function identically to natural landscapes. Kahn (2011) concluded that "technological nature is better than no nature, but not as good as actual nature" (p. xvi).

However, technological representations may be useful to some degree where it is not suitable or difficult to incorporate "real" nature, as in extreme environments or for children who suffer from pet allergies. Given the fast pace of technological changes, research on its effect on child development might be difficult, but future studies should consider broader questions such as whether children accept even better-simulated nature as an adequate substitute for enriching their experiences of real nature, or whether dangers exist, such as a loss of basic humanity, if we rely on technology to replace nature.

# RECOMMENDATIONS FOR FUTURE RESEARCH

## Methodological Directions

### The need for more controlled studies

Studies about the effects of nature on children are more often qualitative than experimental. Experimental studies are needed to scientifically bolster the general notion in causal terms that contact with nature benefits child development. These studies would use random assignment of participants to condition or different interventions, objective evaluations of outcomes, control of extraneous variables (such as the activities themselves), and raters who are blind to experimental conditions. Quantitative methods also help answer the question such as how much, in terms of quantity, richness, and type of interaction (e.g., passive vs. active, or real vs. simulated) is the amount of nature exposure necessary to produce beneficial effects. Thinking in parallel with medicine, how much of a "dose" of nature as a "medication" is required for each deficit (e.g., obesity, depression, or inattention) in development.

More rigorously controlled designs are particularly important for health and psychological claims to be considered and utilized. Policymakers are much more likely to be persuaded about a treatment's utility by data from quantitative, experimental methods. As Kuo (2002) argued, research is likely to be applicable to planners and policy makers if it is conducted within realistic and well-controlled experimental context (to demonstrate causal relations) with dependent (outcome) variables that are important to decision-makers (e.g., burglary rates as opposed to self-reports of territorial defensibility) and independent variables that can be feasibly controlled (e.g., the number of trees in a play setting as opposed to than individual preferences for nature).

### The need for balanced methodology

Of course, each method has its own advantages and limitations. Experimental studies are often limited by small sample sizes and are hampered by ethical and financial barriers. These limitations can be addressed by the use of large, epidemiological studies based on objective health data. Furthermore, ethnographic work offers unique advantages over experiments, such as in-depth theoretical and descriptive materials on how children experience and make sense of the outdoors (Greene & Hill, 2005). Qualitative research is valuable in understanding the subjective and even spiritual features of our relationship with nature. It is useful for developing new ideas about what *might* be happening, which should then be tested with experimental designs. It can also provide an assessment of children's overall wellbeing, beyond narrow-scope results typically delivered by experiments.

Longitudinal research on children and nature is lacking. Longitudinal work is particularly useful in the examination of trends, preferences, and developmental benefit of different experiences overtime (see Handy, Cao, & Mokhtarian, 2008 for an example of using such technique). However, as with other non-experimental studies, it is subject to other confounds (social background, personal characteristics, rater bias, etc.). Cross-sectional

studies, which examine different groups at one point in time, can demonstrate a link between experiences and benefits, but they cannot make causal inferences. Thus, future research could aim for a balance among qualitative, experimental designs, longitudinal, and cross sectional methods.

### The need for interdisciplinary work

In addition to comprehensive knowledge, it is also important to develop and test theory and practical intervention strategies. Researcher-practitioner partnerships in educational and design-oriented work can create positive, realistic outcomes for children. In the health domain, collaboration between social scientists and medical or biological scientists can create a stronger knowledge base by integrating behavioural and social understanding of child development with measured health benefits. Children's health status and their health-related behaviours are determined by a multifaceted process involving a myriad of, and potentially interacting, sociocultural, psychological, and environmental factors (Karpati, Galea, Awerbuch, & Levins, 2002). To understand short- and long-term benefits of contact with nature, interdisciplinary research presents both opportunities and challenges. Interdisciplinary reserachers are required to generate shared understandings of "nature" and "wellbeing." An extensive effort must be made to learn and integrate different analytical and methodological approaches. Neverthless, successful interdisciplinary findings will provide a strong evidence base for policy makers to implement new ways of encouraging children's active partipation in the outdoors and facilitating more nature access.

### The need for methodological innovation

Along with attention to the basics of sound research design and selecting practically useful research objectives, flexibility and innovation are other important factors in crafting future, potentially high-impact research (Kuo, 2002). Findings from innovative methodology or measurements can help to refine or elaborate theories as well as to discover other underlying mechanisms or benefits associated with nature that are otherwise unknown to now.

Looking back a bit for example, a few studies utilized new-at-the-time methods in their investigation of children and nature. Social geographers Tucker and Matthews (2001) uncovered the "everyday" world of children, including their existing friendship and social conflicts over the use of rural spaces by analyzing child-taken photographs, child-led video tours, and in-depth discussion groups. In Iran, Gharahbeiglu (2007) demonstrated the power of children's conceptualization and imagination of spaces from their paintings of their ideal playground in comparison to photographs of existing open spaces. Mikkelsen and Christensen (2009) integrated ethnography, global positioning system (GPS) tracking, and mobile phone surveys to generate data about activities and social relationships in real time, enabling researchers to virtually follow the movements of the participants. What might the new wave of technology or imagination provide as innovative tools?

### Children as part of participatory research

Aries (1962) noted that "childhood is a modern invention." Modern children became increasingly regulated and subject to surveillance and they engage in spaces specifically designated for their use, while spontaneous play and interaction are diminishing. In a similar vein, Elsely (2004) argue that children generally occupy space within a world constructed by adults. Natural elements are missing from most adult-designed playgrounds (Frost, 2006), even though children prefer natural features (Burke, 2005; Groves & McNish, 2008; O'Brien, 2005).

Most research has examined adults' perspectives on the suitability of play spaces, given that parental influence is a primary determinant of geographical and social boundaries for children's outdoor behaviour choice of play (Herrington, 2008; Valentine, 2004). Children have little influence over the development of public space, because they usually rarely have the opportunity to contribute their views as to what kinds of spaces that work for them (Elsley, 2004). Research is needed that tackles not only the physical design and accessibility of spaces in general, but also the gaps between parents' perception of, and children's experiences of, outdoor play. Future work should also investigate the role of children as decision-makers and focus on greater involvement of children as key actors in the research and design process (Lolichen, 2007; Murayama, 2007). This would give children a sense of agency and greater engagement with spaces that, after all, are meant for them and their best interests. In one rare study, primary school children took the role as "community expert" by taking photos of their environment over a one-week period and then reflected on their preferred spaces for play (Burke, 2005). The author argued that this photo-diary technique helps children to generate data that can be useful for influencing planning and policy for play.

## Gaps in Research

### Nature and benefits to adults

The number of studies of nature and children's well-being is small compared to that aimed at adult benefits. Although some benefits of nature are particularly important to children, such as reduction of attention deficits and levels of physical activity associated with outdoor play, the question of whether children share many of other benefits from nature that adults do is largely missing in the literature. For example, studies of adults have demonstrated that patients with a view of trees frequently received weaker pain medications, such as aspirin or acetaminophen, while patients with brick wall-view required stronger pain medications such as narcotics (Ulrich, 1984). Another study examined adult patients who underwent flexible bronchoscopy. Patients with nature scene murals placed at their bedside while listening to nature sounds before, during, and after the procedure were more likely to report better pain control than patients with no nature scenes and sounds (Diette, Lechtzin, Haponik, Devrotes, & Rubin, 2003). Thus, future research should consider this nonintrusive strategy for children who undergo painful, invasive procedures.

## Family systems

Currently, research that examines the influence of nature contact on family systems seems to be absent. Presumably, children indirectly benefit from adults around them who enjoy some of the positive outcomes associated with nature. For example, green neighbourhoods are associated with stronger neighbourhood social ties, greater sense of community, and willingness to help. Highly cohesive neighbourhoods appear to compensate for family problems (e.g., parental stress, family instability, poor parenting behaviours) by providing the child with access to service and social support (Furstenberg, 1993; Silk, Sessa, Morris, Steinberg, & Avenevoli, 2004). Parents and other adults in neighbourhoods may act as role models for children (Jencks & Mayers, 1990), such as demonstrating altruism. What are the spinoff benefits for children?

In contrast, less green environments are associated with higher rates of aggression, violence, crimes, loneliness, joblessness, and inadequate social support (for review, see Kuo, 2010). These social and economic stressors can affect children's emotions and family dynamic (Caughy, Nettles, & O'Campo, 2008). Research is needed to address potential influences of nature on both children and their caretakers, and whether nature experience from either side may influence the other. For example, how are children's experiences of nature influenced by their caretakers? Can children's behaviour in nature influence their caretakers?

## Targeted, magnitude-effect oriented reviews

Research on the benefits of nature is abundant, but so far it has not been particularly well-organized or comprehensive, so general conclusions have been difficult. A few review articles on children and nature have been published in recent years (e.g., McCurdy, Winterbottom, Metha, & Roberts, 2010; Muñoz, 2009), but they mainly focus on physical health. The goal of this review has been to identify, appraise, and synthesize all relevant studies on nature's benefits for children. It is uniquely comprehensive because it addresses research on a wide range of affordances of nature and it considers a variety of methodologies and research designs, theoretical viewpoints, and studies that examine nature's level, scale, and setting (from wilderness to window views), children's demographics and characteristics (different countries, age ranges, socio-economic backgrounds), and degree of engagement (from free play to highly structured activities).

An important lesson for this is that the reader should be cautious about drawing the conclusion that a particular benefit from one style of engagement in one type of setting for one group of children will translate to other styles of engagement, settings, or groups of children. More narrowly focused reviews, or meta-analytic reviews, tend to screen studies based on limiting criteria (e.g., only children before the age of 12 within urbanized settings) and utilize statistical summary techniques, such as effect size, to describe the weight of evidence (Roberts & Petticrew, 2006). However, they often omit some theoretical and descriptive or qualitative material, thus under-emphasizing children's holistic wellbeing and their subjective relationship with nature. Nevertheless, we and others (e.g., Gill, 2014) offer several suggestions that may warrant exploration in targeted reviews that focus on estimating the magnitude of an effect (rather than its statistical significance):

- A particular quality of environment (e.g., landscape quality, biodiversity, ambience, amount of tree cover) on a particular benefit. For example, certain natural elements in air quality are required for respiratory-related health.
- A particular engagement with nature for a particular outcome. Although no reviews have been dedicated to comparing the degree of engagement, more playful styles are generally associated with physical health benefits and less playful styles are generally associated with educational benefits.
- The effect of time spent in natural settings for a particular outcome. Although green environments must be experienced repetitively or for a long period of time to yield maximal benefits, other studies have suggested that brief exposure can produce similar beneficial outcomes. For example, simply viewing green pictures can generate the same cognitive effects as a long hike (Kuo, 2010).
- A particular benefit for a particular group of children, including older children and those in developing countries. We could not find a quantitative review dedicated to differences in children's relationship with nature and benefits by children's gender, ethnicity, socioeconomic position, or age.

## Environmental equity

Quantitative studies of children's access to nature and positive outcomes have been largely restricted to high-income nations. However, their opportunities for contact with nature, ways of encountering nature, and experiences of nature are strongly patterned by social, economic, racial, cultural characteristics (Richardson et al., 2012). As the earlier discussion of childhood obesity makes clear, children in minority and low-socioeconomic communities disproportionately suffer health conditions and other long-term developmental consequences of overexposure to environmental toxins and limited experiences in nature (Kellert, 2005). Ethnic and race-based environmental inequalities among adults are well-documented in literature. However, the need to further explore inequalities among children is urgent for several reasons. First, children are more vulnerable than adults to the negative effects of pollution because children's physiology and metabolism are fundamentally different from adults (Crom, 1994; Pastor, Sadd, & Morello-Frosch, 2002).

Second, in addition to examining children's unequal access to nature, investigating cultural barriers and perception to green access is important. For example, poor urban Hispanic children have limited opportunities to experience pristine natural settings because of economic constraints and limited transportation options. Even if they have access to urban community green spaces, a majority of them express fear of gang violence, crime, and stranger danger in these spaces (Strife, 2008). Fear of neighbourhood violence not only restricts physical activities outdoors, it also erodes community trust and increases stress that, when sustained over time, further exacerbates poor health. Thus, for low-income and minority children, access to nature may be less about proximity to and availability of local green spaces, as measured by most quantitative studies in more affluent communities, but more about social-environmental issues, including safety perception, racial segregation, poverty, and ability to travel (Lopez & Hynes, 2006). Future research that focuses on these

interlinked factors may necessitate more holistic and multi-sector public health policy responses and interventions.

Third, studies of children and nature should not be limited to those in developed countries because a large portion of the world's children are growing up in the developing world. According to UNIC (2015), of the 2.2 billion of children in the world, 1.9 billion of them live in developing countries and 1 billion live in poverty. Population growth and rapid urbanization are projected to increase for more than two-thirds of all people by 2050, with nearly 90 percent of the increase occurring in Asia and Africa (United Nation, 2014a). Given the growing number of children who live in high-density urban slums with increasingly limited resources, asking how access to nature can be provided for them is imperative. For example, in their book, *Greening in the Red Zone*, Kransey and Tidball (2014) described several historical cases in which people assisted the renewal of ecosystems in "red zones" of extreme poverty, war, and natural disaster. These included the creation of community gardens, development of horticultural practices, and turning degraded open space into parks.

## CONCLUSIONS

An impressive array of research, drawing from multiple disciplines, has attempted to investigate basic questions about the putative beneficial effects of nature on child development. Despite some methodological concerns, substantial evidence speaks positively about the potential benefits of contact with nature, particularly on short-term effects of stress relief and the reduction of attention fatigue. Obviously, anyone who believes in evidence-based policy will not assume that nature is always and automatically good for children. Much remains to be understood about for whom, when, how, and in which contexts it offers benefits. This review details what we know, and offers suggestions for exciting future research directions.

Children should be prime stakeholders in community-driven initiatives. They should be empowered to describe their thoughts and experiences in efforts to enhance nature and human advances. Interdisciplinary research, collaboration between different fields, and cross-cultural research and national comparisons should be initiated as we move toward fuller understanding of children-nature relations. More controlled, evidence-based research is needed to inform environmental design, urban planning, and policy changes. Part of this investigation should include demonstrating how nature's benefits may complement or promote, other benefits, such as species preservation and the reduction of carbon emissions, in ways that justify public investments in research and interventions. In closing, we recognize that contact with nature is not merely a remedy to children's "nature deficit disorder" but also a bridge to social equality, ecosystem integrity, and long-term viability of environmentally sustainable cultures.

# APPENDIX: METHODOLOGY

We reviewed the literature on children and nature with an emphasis on this question: Does contact with nature promote healthy child development? The goal was to summarize the state of current knowledge, in terms of what is already known, the quality of research, and identifying areas where opportunities to increase knowledge exist. The review encompasses two other realms---animals and technologically vicarious nature---as part of this assessment. We began our search for relevant referred articles and academic book chapters in recent literature reviews, focusing on children and youth as well as adults. We scanned work from non-governmental organizations, including the Research Resources database of the Children and Nature Network (https://www.childrenandnature.org/research/) as well as the scientific databases Web of Science, PsychInfo, Academic Search Complete, ERIC, and Google Scholar, using the key words "child*," "youth," and "adolescents" in combination with "well-being," "health," "development," "benefits," and "green*," "green space," "natural environment," "schoolyards," "green space," and "parks." We also searched the non-indexed, non-peer-reviewed (grey) literature and online reviews via Internet searches. A spreadsheet table available by request presents a non-exhaustive list of methodologically sound studies, with a particular focus on nature's contribution to developmental benefits.

## REFERENCES

References with asterisks are cited in the text. All references were examined as part of the review process.


*Aarts, M. J., Wendel-Vos, W., van Oers, H., van de Goor, I., & Schuit, A. J. (2010). Environmental determinants of outdoor play in children: a large-scale cross-sectional study. *American Journal of Preventive Medicine, 39,* 212–219.

Adam, C. V., Klissouras, M., Ravazollo, R., Renson, W., & Tuxworth, W. (1988). EUROFIT: *European Test of Physical Fitness*. Rome, Italy: Council of Europe, Committee for the Development of Sport.

Agay-Shay, K., Peled, A., Crespo, A.V., Peretz, C., Amitai, Y., Linn, S., Friger, M., & Nieuwenhuijsen, M.J., 2014. Green spaces and adverse pregnancy outcomes. *Occupational and Environmental Medicine*, 71, 562–569.

*Aggio, D., Smith, L., Fisher, A., & Hamer, M. (2015). Mother's perceived proximity to green space is associated with TV viewing time in children: The Growing UP in Scotland study. *Preventive Medicine*, 70, 46–49.

Alexander, D. S., Huber, L. R., Piper, C. R., & Tanner, A. E. (2013). The association between recreational parks, facilities, and childhood obesity. *Journal of Epidemiology and Community Health, 67,* 427–31.

Allen, K., Blascovich J., & Mendes, W. B. (2002). Cardiovascular reactivity and the presence of pets, friends, and spouses: The truth about cats and dogs. *Psychosomatic Medicine*, 64, 727–739.

American Psychological Association. (1994). *The diagnostic and statistical manual of mental disorders IV (DSM-IV)*. Washington, DC: Author.

*Amoly, E., Dadvand, P., Forns, J., López-Vicente, M., Basagaña, X., Julvez, J., …Sunyer, J. (2014). Green and blue spaces and behavioral development in Barcelona school children. *Environmental Health Perspectives*, 122, 1351–1358.

Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: A meta-analytic review of the scientific literature. *Psychological Science, 12,* 353–359.

Andersen, L., B., Hasselstrom, H., Gronfeldt, V., Hansen, S., E., & Karsten, F. (2004). The relationship between physical fitness and clustered risk, and tracking of clustered risk from adolescence to young adulthood: Eight years follow-up in the Danish Youth and Sport Study, *International Journal of Behavioural and Natural Physics, 1,* 6.

Annerstedt, M., & Währborg, P. (2011). Nature-assisted therapy: Systematic review of controlled and observational studies. *Scandinavian Journal of Public Health, 39,* 371–388.

Appleton, J. (1975). *The experience of landscape*. New York, NY: Wiley.

Aries, P. (1962). *Centuries of childhood: A social history of family life* (B. Robert, Trans.). New York,\NY: Vintage.

Balmford, A., Clegg, L., Coulson, T., & Taylor, J. (2002). Why conservationists should heed Pokémon. *Science, 295*, 2367.

*Balseviciene, B. Sinkariova, L., Grazuleviciene, R., Andrusaityte, S., Uzdanaviciute, I., Dedele, A., Nieuwenhuijsen, M. J. (2014). Impact of residential greenness on preschool children's emotional and behavioral problems. *International Journal of Environmental Research and Public Health, 11,* 6757–6770.

Banderoff, S., & Scherer. D. (1994). Wilderness family therapy: An innovative treatment approach for problem youth. *Journal of Child & Family Studies, 3,* 175-191.

Baum, S., Hayes, M., van Gellecum, Y., & Hoon, H., Y. (2006). Advantage and disadvantage across Australia's extended metropolitan regions: A typology of socio-economic outcomes, *Urban Studies, 43,* 1549–1579

Baumeister, R. F. (1987). How the self became a problem: A psychological review of historical research. *Journal of Personality and Social Psychology, 52,* 163–176.

Baumeister, R. F., Heatherton, T. F. & Tice, D. M. (1994). *Losing control: How and why people fail at self-regulation*. San Diego: Academic Press.

Bebbington, A. (2005). The ability of A-level students to name plants. J*ournal of Biological Education, 39*, 62–67.

Beck, A. M., & Katcher, A. H. (2003). Future directions in human-animal bond research. *American Behavioral Scientist, 47,* 79–93.

Beets, M., W., & Foley, J., T. (2008). Association of father involvement and neighbourhood quality with kindergarteners' physical activity: A multilevel structural equation model. *American Journal of Health Promotion, 22,* 195–203.

Beets, M., W., Vogel, R., Chapman, S., Pitettie, K., H., & Cardinal, B. J. (2007). Parent's social support for children's outdoor physical activity: do weekdays and weekends matter? *Sex Roles, 56,* 125–131.

Behar, L., & Stephens, D. (1978). Wilderness camping: an evaluation of a residential treatment program for emotionally disturbed children. *American Journal of Orthopsychiatry, 48,* 644–653.

*Bell J. F., Wilson, J. S., & Liu, G. C. (2008). Neighborhood greenness and 2-year changes in body mass index of children and youth. *American Journal of Preventive Medicine, 35,* 547–553.

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science, 19,* 1207–1212.

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology, 25,* 249–259.

Bixler, R. D., Floyd, M. F. (1997). Nature is scary, disgusting, and uncomfortable. *Environment and Behavior, 29,* 443–467.

Bixler, R. D., Floyd, M. F., & Hammitt, W. E. (2002). Environmental socialization: Quantitative tests of the childhood play hypothesis, *Environment and Behavior, 34,* 795–818.

Blizard, C., & Schuster, R. (2004). They all cared about the forest: elementary school children's experiences of the loss of a wooded play space at a private school in update New York. *Proceedings of the Northeastern Recreation Research Symposium, GTR-NE-326,* Newtown Square, PA, 57–63.

Bodrova, E., & Leong, D. (2003).Chopsticks and counting chips: do play and foundational skills need to compete for the teacher's attention in an early childhood classroom? *Young Children, 58,* 10–17.

*Boldemann, C., Blennow, M., Dal, H., Mårtensson, F., Raustorp, A., Yuen, K., & Wester, U. (2006). Impact of preschool environment upon children's physical activity and sun exposure. *Preventive Medicine, 42,* 301–308.

Bolivar, J., Daponte, A., Rodriguez, M., & Sanchez, J. J. (2010). The influence of individual, social, and physical environment factors on physical activity in the adult population in Andalusia, Spain. *International Journal of Environmental Research and Public Health, 7,* 60–77.

Burdette, H. L., & Whitaker R. C. (2004). Neighbourhood playgrounds, fast food restaurants, and crime: relationships to overweight in low-income pre-school children. *Preventive Medicine, 38,* 57–63.

Burke, C., (2005). Play in focus: Children researching their own spaces and places for play. *Children, Youth and Environments, 15,* 27–53.

CABE, (2005) Start with the park: Creating sustainable urban green spaces in areas of housing growth and renewal. Retrieved March 1, 2016, from http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/publications/start-with-the-park

Cammack, C., & Waliczek, T. M. (2002). The Green Brigade: The educational effects of a community based horticultural program on the horticultural knowledge and environmental attitude of juvenile offenders. *HortTechnology, 12*, 77–81.

Cammack, C., Waliczek, T. M., & Zajicek, J. M. (2002). The Green Brigade: The psychological effects of a community-based horticultural program on the self-development characteristics of juvenile offenders. *HortTechnology, 12,* 82–86.

Carver, S., Evans, A. & Fritz, S. (2002) Wilderness attribute mapping in the United Kingdom. *International Journal of Wilderness, 8,* 24–29.

Carver, A., Timperio, A., & Crawford, D. (2008). Playing it safe: the influence of neighbourhood safety on children's physical activity – a review. *Health and Place, 14,* 217–227.

Caughy, M. O., Nettles, S. M., & O'Campo, P. J. (2008). The effect of residential neighborhood on child behavior problems in first grade. *American Journal of Community Psychology, 42,* 39–50.

Chavez, D. J. (2009). Youth Day in Los Angeles: Evaluating the role of technology in children's nature activities. *Children, Youth, and Environments, 19,* 102–124.

Chawla, L. (1990). Ecstatic places. *Children's Environments Quarterly, 7,* 18–23.

Chawla, L. (1998). Research methods to investigate significant life experiences: Review and recommendations. *Environmental Education Research, 4,* 383–398.

Chawla, L. (2014). Children's engagement with the natural world as a ground for healing. In M. E. Krasny & K. g. Tidball (Eds.*), Greening in the red zone: Disaster, resilience and community greening* (pp. 111–124). Heidelberg, Germany: Springer.

Chawla, L. (2015). Benefits of nature contact for children. *Journal of Planning Literature, 30,* 433–452.

Christakis, D. A. (2006). The hidden and potent effects of television advertising. *Journal of the American Medical Association, 295,* 1698–1699.

Christakis, D. A., Zimmerman, F. J., Digiuseppe, D. L., & McCarty, C. A. (2004). Early television exposure and subsequent attentional problems in children. *Pediatrics, 113,* 708–713.

*Christian, H., Zubrick, S. R., Foster, S., Giles-Corti, B., Bull, F., Wood, L., … Boruff, B. (2015). The influence of the neighborhood physical environment on early child health and development. *Health and Place, 33,* 25–36.

Churchman, A. (2003). Is there a place for children in the city? *Journal of Urban Design, 8,* 99–111.

Clayton, S., & Myers, G. (2009) *Conservation psychology: Understanding and promoting human care for nature.* West Sussex, UK: Wiley Blackwell.

Clayton, S., & Opotow, S. (2003). *Identity and natural environment*. Cambridge, MA: MIT Press.

Clements, R. (2004). An investigation of the status of outdoor play. *Contemporary Issues in Early Childhood, 5,* 68–80.

Cloward Drown, K. K., & Christensen, K. M. (2014). Dramatic play affordances of natural and manufactured outdoor settings for preschool-aged children. *Children, Youth and Environments, 24,* 53–77.

Cobb, E. (1977). *The ecology of imagination in childhood.* New York, NY: Columbia University Press.

Coburn, M. (2006). Walking home: Women's' transformative experiences in the wilderness of the Appalachian Trail. *Dissertation Abstracts International: Section B, 67,* 2857.

Coley, J. D. (2000). On the importance of comparative research: The case of folkbiology. *Child Development, 71,* 82–90.

Coley, J. D., Solomon, G. E. A., & Shafto, P. (2002). The development of folkbiology: A cognitive science perspective on children's understanding of the biological world. In P. H. Khan & S. R. Kellert (Eds.), *Children and nature: Psychological, socio-cultural and evolutionary investigations* (pp. 65–91). Cambridge, MA: MIT Press.

Coley R. L., Sullivan W. C., Kuo, F. E. (1997). Where does community grow? The social context created by nature in urban public housing. *Environment & Behavior, 29,* 468–494.

Comstock, G. (1995). Television and the American child. In C. N. Hedley, P. Antonacci, & M. Rabinowitz (Eds.), *Thinking and literacy: The mind at work* (pp. 101–123). Hillsdale, NJ: Erlbaum.

Cooper Marcus, C. (2006) Healing gardens in hospitals. In C. Wagenaar (Ed.), *The architecture of hospitals* (pp. 314–329). Rotterdam, The Netherlands: NAi Publishers.

Corcoran, P. B. (1999). Formative influences in the lives of environmental educators in the United States. *Environmental Education Research, 5,* 207–220.

Cordell, K. H., Betz, C. J., & Green, G. T. (2009). *National kids survey. Internet Research Information Series*. Retrieved from February 19, 2016, from http://warnell.forestry.uga.edu/nrrt/nsre/IrisReports.html

Cosco, N. (2007). Developing evidence-based design: Environmental interventions for healthy development of young children in the outdoors. In C. Ward Thompson & P. Travlou (Eds.), *Open space: People space* (pp. 125–35). London, UK: Taylor and Francis.

Covert, A. M., Whiren, A. P., Keith, J., & Nelson, C. (1985). Pets, early adolescents, and families. In M. B. Sussman (Ed.), *Pets and the family* (pp. 95–108). New York, NY: Haworth.

Crom, W. (1994). Pharmacokinetics in the child. *Environmental Health Perspectives, 102,* 111–117.

Cutter-MacKenzie, A. (2009). Multicultural school gardens. *Canadian Journal of Environmental Education, 14,* 122–135.

*Dadvand, P., Nieuwenhuijsen, M. J., Esnaola, M., Forns, J., Basagaña, X., Alvarez-Pedrerol, M., …Sunyer, J. (2015). Green spaces and cognitive development in primary schoolchildren. *Proceedings of the National Academy of Sciences of the USA, 112,* 7937–7942.

Dadvand, P., Villanueva, C. M., Font-Ribera, L., Martinez, D., Basagaña, X., Belmonte, J., …Nieuwenhuijsen, M. (2014). Risks and benefits of green spaces for children. *Environmental Health Perspectives, 122,* 1329–1335.

Davison K. K., & Lawson C. T. (2006). Do attributes of the physical environment influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity, 3,* 19.

*De Vries, S. I., Bakker, I., van Mechelen, W., & Hopman-Rock, M. (2007). Determinants of activity friendly neighborhoods for children. *American Journal of Health Promotion, 21,* 312–316.

De Vries, S., Verheij, R. A., Groenewegen, P. P., & Spreeuwenberg, P. (2003). Natural environments– healthy environments? An exploratory analysis of the relationship between green space and health. *Environment and Planning A, 35,* 1717–1731.

Department of the Environment. (1973). *Children at play*. London, UK: Her Majesty's Stationery Office.

Derr, T. (2006). Sometimes birds sound like fish: Perspectives on children's place experience. In C. Spencer & M. Blades (Eds.), *Children and their environments: Learning, using and designing spaces* (pp. 108–123). New York, NY: Cambridge University Press.

Diette, G. B., Lechtzin, N., Haponik, E., Devrotes, A., & Rubin, H. R. (2003). Distraction therapy with nature sights and sounds reduces pain during flexible bronchoscopy. *Chest, 123,* 941–948.

Dinan, T. G., Stanton, C., & Cryan, J. F. (2013). Psychobiotics: A novel class of psycho-tropic. *Biological Psychiatry, 74,* 720–726.

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood environment and physical activity among youth. *American Journal of Preventive Medicine, 41,* 442–55.

Dirani, M., Tong, L., Zhang, X., Chia, A., Young, T. L., Rose, K. A., … Saw, S. M. (2009). Outdoor activity and myopia in Singapore teenage children. *The British Journal of Ophthalmology, 93,* 997–1000.

Dismuke, R. P. (1984). Rehabilitative horseback riding for children with language disorders. In R. K. Anderson, B. L. Hart, & L. A. Hart (Eds.), *The pet connect ion: Its influence on our health and quality of life* (pp. 131–140). Minneapolis: Censhare, University of Minnesota.

Dubos R. (1980). *The wooing of earth*. London, UK: The Athlone Press.

*Dyment, J. E., & Bell, A. C. (2008). Grounds for movement: Green school grounds as sites for promoting physical activity. *Health Education Research, 23,* 952–962.

*Dzhambov, A. M., Dimitrova, D. D., & Dimitrakova, E. D. (2014). Association between residential greenness and birth weight. *Urban Forestry and Urban Greening, 13*, 621–629.

Ege, M. J. E., Mayer, M., Normand, A., Genueit, J., Cookson, W., Braun-Fahrlander, C., … the GABRRIELA Transregio 22 Study Group. (2011). Exposure to environmental microorganisms and childhood asthma. *New England Journal of Medicine, 364,* 701–709.

Elsley, S. (2004). Children's experience of public space. *Childhood and Society, 18,* 155–164.

England marketing. (2009). Report to natural England on childhood and nature: A survey on changing relationships with nature across generations. Retrieved January 3, 2016, from

http://www.naturalengland.org.uk/Images/Childhood%20and%20Nature%20Survey_tcm6-10515.pdf

*Epstein, L. H., Daniel, T. O., Wilfley, D. E., & Roemmich, J. N. (2012). The built environment moderates effects of family-based childhood obesity treatment over 2 years. *Annals of Behavioral Medicine, 44,* 248–258.

Epstein, L. H., Raja, S., Gold, S. S., Paluch, R. A., Pak, Y., Roemmich, J. N. (2006). Reducing sedentary behavior: The relationship between park area and the physical activity of youth. *Psychological Science, 17,* 654–659.

Erlandson, D. A., Harris, E. L., Skipper, B. L., & Allen, S. D. (1993). *Doing naturalistic inquiry: a guide to methods*. Newbury Park, CA: Sage.

Estabrooks, P. A., Lee, R. E., & Gyurcsik, N. C. (2003). Resources for physical activity participation: does availability and accessibility differ by neighborhood socioeconomic status? *Annuals of Behavioral Medicine, 25,* 100–104.

Evans, J. (1995). Where have all the players gone? *International Play Journal, 3,* 3–18.

Evans, G., Jacobs, S., & Frager, N. (1982). Behavioral responses to air pollution. In A. Baum & J. Singer (Eds.), *Advances in environmental psychology* (Vol. 4) (pp. 237–270). Hillsdale, NJ: Erlbaum.

*Evans, G. W., Jones-Rounds, M. L. Belojevic, G., & Vermeylen, R. (2012). Family income and childhood obesity in eight European cities. *Social Science and Medicine, 75,* 477–81.

Evans, G. W., & Kantrowitz, E. (2002). Socioeconomic status and health: The potential role of environmental risk exposure. *Annual Review of Public Health, 23,* 202–231.

Faber Taylor, A., & Kuo, F. E. (2006). Is contact with nature important for healthy child development? State of the evidence. In C. Spencer, & M. Blades (Eds.), *Children and their environments: Learning, using and designing spaces* (pp. 124–140). New York, NY: Cambridge University Press.

*Faber Taylor, A., & Kuo, F. E. (2009). Children with attention deficits concentrate better after walk in the park. *Journal of Attention Disorders, 12,* 402–409.

*Faber Taylor, A., Kuo, F.E. & Sullivan, W.C. (2001). Coping with ADD: The surprising connection to green play settings. *Environment & Behavior, 33,* 54–77

*Faber Taylor, A., Kuo, F. E., & Sullivan, W. C. (2002). Views of nature and self-discipline: Evidence from inner-city children. *Journal of Environmental Psychology, Special Issue: Environment and Children, 22,* 49–63.

*Faber Taylor, A., Wiley, A., Kuo, F., & Sullivan, W. (1998). Growing up in the inner city: Green spaces as places to grow. *Environment and Behavior, 30,* 3–27.

Fan, M., & Jin, Y. (2014). Do neighborhood parks and playgrounds reduce childhood obesity? *American Journal of Agricultural Economics, 96,* 26–42.

*Fjørtoft, I. (2001). The natural environment as a playground for children: The impact of outdoor play activities in pre-primary school children. *Early Childhood Education Journal, 29,* 111–117.

Fjørtoft, I. (2004). Landscape as playscape: The effects of natural environments on children's play and motor development. *Children, Youth and Environments, 14*, 21–44.

Fjørtoft, I., & Sagaie, J. (2000). The natural environment as a playground for children. *Landscape and Urban Planning 48*, 83–97.

Flaskerud, J. H., & Winslow, B. J. (1998). Conceptualizing vulnerable populations health-related research. *Nursing Research, 47,* 69–78.

*Flouri, E., Midouhas, E., & Joshi, H. (2014). The role of urban neighborhood green space in children's emotional and behavioural resilience. *Journal of Environmental Psychology, 40,* 179–186.

Friedmann, E., Katcher, A. H., Thomas, S. A., Lynch, J. J., & Messent, P. R. (1983). Social interaction and blood pressure: influence of companion animals. *The Journal of Nervous and Mental Disease, 171,* 461–465.

Friese, G., Hendee, J., & Kinziger, M. (1998). The wilderness experience program industry in the United States: Characteristics and dynamics. *Journal of Experiential Education, 21,* 40–45.

Frost, J. (1992). *Play and playscapes*. New York, NY: Delmar Publishers.

Frost, J. (2006). The dissolution of children's outdoor play: causes and consequences, presented to The value of play: A forum on risk, recreation and children's health. Retrieved January 24, 2016, from http://www.ipema.org/Documents/Common%20Good%20PDF.pdf

Frumkin, H. (2001). Beyond toxicity: Human health and the natural environment. *American Journal of Preventive Medicine, 20*, 234–240.

Furedi, F. (2008). *Paranoid parenting: Why ignoring the experts may be best for your child.* Chicago, IL: Chicago Review Press.

Furstenberg, F. F. (1993). How families manage risk and opportunity in dangerous neighborhoods. In W. J. Wilson (Ed.), *Sociology and the public agenda* (pp. 231–258). Newbury Park, CA: Sage Publications.

Gangestad, S., & Simpson, J. A. (2007). *The evolution of the mind*. New York, NY: Guilford.

*Gardsjord, H. S., Tveit, M. S., & Nordh, H. (2014). Promoting youth's physical activity through park design. *Landscape Research, 39,* 70–81.

Gass, M. A., Gillis, H. L., & Russell, K. C. (2012). *Adventure therapy: Theory, research, and practice.* New York, NY: Routledge.

Gaster, S. (1991). Urban children's access to the neighbourhood: changes over three generations. *Environment and Behavior, 23,* 70–85.

Gaulin, S. J. C., & McBurney, D. (2003). *Psychology: An evolutionary approach* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Gebhard, U., Nevers, P., & Billmann-Mahecha, E. (2003). Moralizing trees: Anthropomorphism and identity in children's relationship to nature. In S. Clayton & S. Opotow (Eds.), *Identity and the natural environment* (pp. 91–111). Cambridge, MA: MIT Press.

Gelman, S. A., & Wellman, H. M. (1991). Insides and essence: Early understandings of the non-obvious. *Cognition, 38,* 213–244.

Gharahbeiglu, M. (2007). Children's interaction with urban play spaces in Tabriz, Iran. *Visual Studies, 22,* 48–52.

Gibson, J. (1986). *The ecological approach to visual perception*. Hillsdale, NJ: Erlbaum.

Gill, T. (2014). The benefits of children's engagement with nature. *Children, Youth and Environments, 24,* 10–24.

Ginde, A. A., Liu, M. C., & Camargo, C. A. (2009). Demographic differences and trends of vitamin D insufficiency in the US population, 1988–2004. *Archives of Internal Medicine, 169,* 626–632.

Ginsburg, K. R. (2007). The importance of play in promoting healthy child development and maintaining strong parent-child bonds. *Pediatrics, 119,* 182–191.

Glosser, G., Goodglass, H. (1990). Disorders in executive control functions among aphasic and other brain damaged patients. *Journal of Clinical and Experimental Neuropsychology, 12,* 485–501.

Gonzalez, M. T., Hartig, T., Patil, G. G., Martinsen, E. W., & Kirkevold, M. (2010). Therapeutic horticulture in clinical depression: A prospective study of active components. *Journal of Advanced Nursing, 66,* 2002–2013.

Good, J. (2007). Shop 'til we drop? Television, materialism and attitudes about the natural environment. *Mass Communication and Society, 10,* 365–383.

Gordon-Larsen, P., Nelson, M. C., Page, P., & Popkin, B. M. (2006). Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics, 117,* 417–424.

Grahn, P., Martensson, F., Lindblad, B., Nilsson, P., & Ekman, A. (1997). Ute på dagis (Outdoors at daycare) in *Stad and Land (City and Country), 145*. Alnarp, Sweden: Swedish University of Agricultural Sciences.

Greene, S., & Hill, M. (2005). Researching children's experience: Methods and methodological issues. In S. Green & D. Hogan (Eds.), R*esearching children's experience: Approaches and methods* (pp. 1–21). London, UK: Sage.

Greenway, R. (1995). The wilderness effect and ecopsychology. In T. Roszak, M. E. Gomes, & A. D. Kanner (Eds.), *Ecopsychology: Restoring the earth, healing the mind* (pp. 122–135). San Francisco, CA: Sierra Club Books.

*Grigsby-Toussaint, D. S., Chi, S. H., & Fiese, B. H. (2011). Where they live, how they play: neighborhood greenness and outdoor physical activity among preschoolers. *International Journal of Health Geographics, 10,* 66.

Groves, L., & McNish, H., (2008*). Baseline study of play at Merrylee primary school.* Glasgow, Scotland: Forestry Commission Scotland.

Gullone, E. (2000). The biophilia hypothesis and life in the 21st Century: Increasing mental health or increasing pathology? *Journal of Happiness Studies, 1,* 293–322.

Gupta, R. S., Carrion-Carire, V., & Weiss, K. B. (2006). The widening black/white gap in asthma hospitalizations and mortality. *The Journal of Allergy and Clinical Immunology, 117,* 351–358.

Guttmann, G., Predovic, M., & Zemanek, M. (1985). The influence of pet ownership in non-verbal communication and social competence in children. In Proceedings of the international symposium on the occasion of the 80th birthday of Nobel prizewinner professor Dr. Konrad Lorenz (pp. 58–63). Vienna, Austria: Institute for Interdisciplinary Research on Human-Pet Relationships.

Handy, S., Cao, X., & Mokhtarian, P. (2008). Neighbourhood design and children's outdoor play: Evidence from northern California. *Children, Youth and Environments, 18,* 160–179.

*Hanski, I., von Hertzen L., Fyhrquist, N., Koskinen, K., Torppa, K., Laatikainen, T., … Haahtela, T. (2012). Environmental biodiversity, human microbiota, and allergy are interrelated. *Proceedings of the American Academy of Sciences USA, 109,* 8334–39.

Hanson, J. L., Albert, D., Iselin, A. R., Carre, J. M., Dodge, K. A., & Hariri, A. R. (2015). Cumulative Stress in childhood is associated with blunted reward-related brain activity in adulthood. *Social Cognitive and Affective Neuroscience, 11,* 405–412.

Harmon, L. K., & Gleason, M. (2009). Underwater explorers: Using remotely operated vehicles (ROVs) to engage youth with underwater environments. *Children, Youth, and Environments, 19,* 126–144.

Harper, N., Russell, K., Cooley, R., & Cupples, J. (2007). Catherine Freer wilderness therapy expeditions: An exploratory case study of adolescent wilderness therapy, family functioning, and the maintenance of change. *Child & Youth Care Forum, 36,* 111–129.

*Harrington, M. C. R. (2009). An ethnographic comparison of real and virtual reality field trips to Trillium Trail: The salamander find as a salient event. *Children, Youth, and Environments, 19,* 74–101.

Hart, R. (1979). *Children's experience of place*. New York, NY: Knopf.

Hart, R. (1997). *Children's participation: The theory and practice of involving young citizens in community development and environmental care*. London, UK: Earthscan/UNICEF.

Hartig, T., Böök, A., Garvill, J., Olsson, T., & Gärling, T. (1996). Environmental influences on psychological restoration. *Scandinavian Journal of Psychology, 37,* 378–393.

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology, 23,* 109–123.

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health, 35,* 207–228.

Hartig, T., Staats, H. (2006). The need for psychological restoration as a determinant of environmental preferences. *Journal of Environmental Psychology, 26,* 215–226.

Heft, H. (1988). Affordances of children's environments: A functional approach to environmental description. *Children's Environments Quarterly, 5,* 29–37.

Henderson, L., Zimbardo, P., & Graham, J. (2001). *Social fitness and technology use: Adolescent interview study*. Stanford, CA: Stanford Institute and the Shyness Institute.

*Herrington, S., & Studtmann, K. (1998). Landscape interventions: New directions for the design of children's outdoor play environments. *Landscape and Urban Planning, 42,* 191–205.

*Hickling, A. K., & Gelman, S. A. (1995). How does your garden grow?: Early conceptualization of Seeds and their place in the plant growth cycle. *Child Development, 66,* 856–876.

Hofferth, S. (2009). Changes in American children's time–1997 to 2003. *International Journal of Time Use Research, 6*, 26–47.

Hofferth, S., & Sandberg, J. F. (2001). Changes in American children's time, 1981–1997. In S. Hofferth & T. Owens (Eds.), *Children at the millennium: Where have we come from, where are we going?* (pp. 193–229). New York, NY: Elsevier Science.

Hofferth, S., & Curtin, S. C. (2005). Leisure time activities in middle childhood. In K. A. Moore & L. H. Lippman (Eds.), *What do children need to flourish? Conceptualizing and measuring indicators of positive development* (pp.95–110). New York, NY: Springer Publishing.

Howes, C. (1988). Peer interaction of young children. *Monographs of the Society for Research in Child Development, 53*, 1–88.

Howes, C., & Matheson, C. (1992). Sequences in the development of competent play with peers: Social and social pretend play. *Developmental Psychology, 28,* 961–974.

Hung, Y. (2004). East New York farms: Youth participation in community development and urban agriculture. *Children, Youth and Environments, 14,* 56–85.

Hussar, K. M., & Horvath, J. C. (2011). Do children play fair with mother nature? Understanding children's judgments of environmentally harmful actions. *Journal of Environmental Psychology, 31,* 309–313.

Hystad, P., Davies, H.W., Frank, L., Van Loon, J., Gehring, U., Tamburic, et al. (2014). Residential greenness and birth outcomes: evaluating the influence of spatially correlated built-environment factors. *Environmental Health Perspectives, 122,* 1095–1102.

Inagaki, K., & Hatano, G. (2004). Vitalistic causality in young children's naïve biology. *Trends in Cognitive Sciences, 8,* 356–362.

Ingold, T. (1994). From trust to domination: An alternative history of human-animal relations. In A. Manning & J. Serpell (Eds.), *Animals and human society: Changing perspectives* (pp. 1–22). New York, NY: Routledge.

James, W. (1899/2008). *Talks to teachers on psychology and to students on some of life's ideals.* Rockville, MD: Arc Manor.

*Janssen, I., & Rosu, S. (2015). Undeveloped green space and free time physical activity in 11 to 13 year old children. *International Journal of Behavioral Nutrition and Physical Activity, 12,* 26.

Jencks, C., & Mayer, S. (1990). The social consequences of growing up in a poor neighborhood. In L. Lynn & M. McGeary (Eds.), *Inner-City Poverty in the United States* (pp. 111–186). Washington, DC: National Academy Press.

Jennings, V., Johnson-Gaither, C., & Gragg, R. S. (2012). Promoting environmental justice through urban space access: A synopsis. *Environmental Justice, 5,* 1–7.

Kahn, P. H. Jr. (1997). Developmental psychology and the biophilia hypothesis: Children's affiliation with nature. *Developmental Review, 17,* 1–61.

Kahn, P. H. Jr. (1999). *The human relationship with nature: Development and culture.* Cambridge, MA: MIT Press.

Kahn, P. H. Jr. (2002). Children's affiliation with nature: Structure, development, and the problem of environmental generational amnesia. In P. H. Kahn, Jr. & S. R. Kellert (Eds.), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 93–116). Cambridge, MA: MIT Press.

Kahn, P. H. Jr. (2003). The development of environmental moral identity. In S. Clayton & S. Opotow (Eds.), *Identity and natural environment: the psychological significance of nature* (pp. 113–134). Cambridge, MA: Massachusetts Institute of Technology Press.

Kahn, P. H. Jr. (2007). The child's environmental amnesia: It's ours. *Children, Youth and Environments, 17,* 199–207.

Kahn, P. H. Jr. (2011). *Technological nature: Adaptation and the future of human life.* Cambridge, MA:MIT Press.

Kahn, P. H., Jr. & Friedman, B. (1995). Environmental views and values of children in an inner-city Black community. *Child Development, 66,* 1403–1417.

Kahn, P. H., Friedman, B., Pérez-Granados, D. R., & Freier, N. G. (2006). Robotic pets in the lives of preschool children. *Interaction Studies, 7,* 405–436.

Kahn, P. H., Jr. & Kellert, S. R. (2002). *Children and nature: Psychological, sociocultural, and evolutionary investigations.* Cambridge, MA: Massachusetts Institute of Technology Press.

Kahn, P. H., Jr., & Lourenço, O. (2002). Water, air, fire, and earth—A developmental study in Portugal of environmental reasoning. *Environment and Behavior, 34,* 405–430.

*Kahn, P. H, Saunders, C. D., Severson, R. L., Myers, O. E., Jr., & Gill, B. T. (2008). Moral and fearful affiliations with the animal world: Children's conceptions of bats. *Anthrozoös, 21,* 375–386.

Kanner, A. D., & Gomes, M. E. (1995). The all-consuming self. In T. Roszak, M. E. Gomes, & A. D. Kanner (Eds.), *Ecopsychology: Restoring the earth, healing the mind* (pp. 77–91). San Francisco, CA: Sierra Club.

Kaplan, R. (1977). Summer outdoor programs: Their participants and their effects. In *Children, nature, and the urban environment.* USDA Forest General Technical Report, NE-30, 175-179.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15,* 169–182.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature.* Cambridge, MA: Cambridge University Press.

Kaplan, S., & Talbot, J. F. (1983). Psychological benefits of a wilderness experience. In I. Altman, & J. F. Wohlwill (Eds.), *Behavior and the natural environment* (pp. 163–203). New York, NY: Plenum.

Karpati, A., Galea, S., Awerbuch, T., & Levins, R. (2002). Variability and vulnerability at the ecological level: implications for understanding the social determinants of health. *American Journal of Public Health, 92,* 1768–1772.

Katcher, A., & Teumer, S. (2006). A 4-year trial of animal-assisted therapy with public school special education students. In A. Fine (Ed.), *Handbook on animal-assisted therapy* (2nd ed.) (pp. 227–242). London, UK: Academic Press.

*Katcher, A., & Wilkins, G. (1993). Dialogue with animals: Its nature and culture. In E. O. Wilson & S. Kellert (Eds.), *The biophilia hypothesis* (pp. 173–200). Washington, DC: Island Press.

Katcher, A., & Wilkins, G. (1998). Animal-assisted therapy in the treatment of disruptive behavior disorders. In A. Lundberg (Ed.), *The environment and mental health* (pp. 193–204). Mahwah, NJ: Erlbaum.

Katcher, A., & Wilkins, G. (2000). The centaur's lessons: Therapeutic education through care of animals and nature study. In A. H. Fine (Ed.), *Handbook of animal-assisted therapy* (pp. 153–177). New York, NY: Academic.

Keating, D. P. (2011). *Nature and nurture in early child development.* New York: Cambridge University Press.

Keil, F. (1989). *Concepts, kinds, and cognitive development.* Cambridge, MA: MIT Press.

Kellert, S. R. (1997). *Kinship to mastery: Biophilia in human evolution and development.* Washington, DC: Island Press.

Kellert, S. R. (2002). Experiencing nature: Affective, cognitive, and evaluative development in children. In P. H. Kahn & S. R. Kellert (Eds.) *Children and nature: Psychological, sociocultural and evolutionary investigations* (pp. 117–151). Cambridge, MA: The MIT Press

Kellert, S. R. (2005). *Building for life: Designing and understanding the human-nature connection*. Washington, DC: Island Press.

Kellert, S. R., & Derr, V. (1998). *A national study of outdoor wilderness experience*. Washington, DC: Island Press.

*Kelz, C., Evans, G. W., & Röderer, K. (2015). The restorative effects of redesigning the schoolyard. *Environment and Behavior, 47,* 119–139.

Kihal-Talantikite, W., Padilla, C. M., Lalloué, B., Gelormini, M., Zmirou-Navier, D., & Degnen, S. (2013). Green space, social inequalities, and neonatal mortality in France. *BMC Pregnancy and Childbirth, 13,* 191.

Kim, J. H., Lee, C., Olvera, N. E., & Ellis, C. D. (2014). The role of landscape spatial patterns on obesity in Hispanic children residing in inner-city neighborhoods. *Journal of Physical Activity and Health, 11,* 1449–57.

*Kirkby, M. (1989). Nature as refuge in children's environments. *Children's Environments Quarterly, 6,* 7–12.

Kleinstein, R. N., Jones, L. A., Hullet, S., Kwon, S., Lee, R. J., Friedman, N. E., et al. (2003). Refractive error and ethnicity in children. *Archives of Ophthalmology, 121,* 1141–1147.

Knippenberg, S., Damoiseaux, J., Bol, Y., Hupperts, R., Taylor, B. V., Ponsonby, A. L., … van der Mei, I.A.F. (2014). Higher levels of reported sun exposure, and not vitamin D status, are associated with less depressive symptoms and fatigue in multiple sclerosis. *Acta Neurologica Scandinavica, 129,* 123–131.

Korpela, K. (2002). Children's environment. In R. Bechtel & A. Churchman (Eds.), *Handbook of environmental psychology*. New York, NY: Wiley.

Korpela, K. M., Hartig, T., Kaiser, F. G., & Fuhrer, U. (2001). Restorative experience and self-regulation in favourite places. *Environment and Behavior, 33,* 572–589.

Krakauer, J. (1995, October). Loving them to death: The story of one teenager's "wilderness experience." *Outside Magazine, 20,* 72–80.

Krasny, M., & Tidball, K. (2014). *Greening in the red zone: Disaster, resilience, and community greening*. Heidelberg, Germany: Springer.

Kraut, R., Patterson, M., Lundmark, V., Kiesler, S., Mukophhadhyay, T., & Scherlis, W. (1998). Internet paradox: A social technology that reduces social involvement and psychological well-being? *American Psychologist, 53,* 1017–1031.

Kreutz, A. (2015). Children and the environment in an Australian indigenous community. Abingdon, UK: Routledge.

Kuh, L. P., Ponte, I., & Chau, C. (2013). The impact of a natural playscape installation on young children's play behaviors. *Children, Youth and Environments, 23,* 49–77.

Kuo, F. E. (2002). Bridging the gap: How scientists can make a difference. In R. B. Bechtel & A. Churchman (Eds.), *Handbook of Environmental Psychology* (pp. 335–46). Hoboken, NJ: John Wiley.

Kuo, F. E. (2010). Parks and other green environments: Essential components of a healthy human habitat. *National Recreation and Park Association: Research Series*. Retrieved February 12, 2016, from http://www.nrpa.org/uploadedFiles/nrpa.org/Publications_and_Research/Research/Papers/MingKuo-Research-Paper.pdf

*Kuo, F. E., & Faber Taylor, A. (2004). A potential natural treatment for attention deficit/hyperactivity disorder: Evidence from a national study. *American Journal of Public Health, 94,* 1580–1586.

Kutz, G. D., & O'Connell, A. (2007). Residential treatment programs: Concerns regarding abuse and death in certain programs for troubled youth. *United States Government Accountability Office.* Retrieved February 10, 2016, from http://www.gao.gov/new.items/d08146t.pdf

Kweon, B., Ulrich, R. S., Walker, V. D., & Tassinary, L. G. (2008). Anger and stress: The role of landscape posters in an office setting. *Environment and Behavior, 40*, 355–381.

*Kyttä, M., Broberg, A., & Kahila, M. (2012). Urban environment and children's active lifestyle. *American Journal of Health Promotion, 26,* 137–148.

Laumann, K., Gärling, T., & Stormark, K. M. (2003). Selective attention and heart rate responses to natural and urban environments. *Journal of Environmental Psychology, 23,* 125–134.

Laurent, O., Wu, J., Li, L., & Milesi, C. (2013). Green spaces and pregnancy outcomes in Southern California. *Health Place, 24,* 190–195.

Lester, S., & Maudsley, M. (2007). *Play, naturally*. London, UK: National Children's Bureau/Play England.

Lilienfeld, S., & Arkowitz, H. (2008). Is animal assisted therapy really the cat's meow? *Scientific American*. Retrieved March 3, 2016, from http://www.scientificamerican.com/article/is-animal-assisted-therapy/

Lim, M., & Calabrese Barton, A. (2010). Exploring insideness in urban children's sense of place. *Journal of Environmental Psychology, 30,* 328–337.

*Limond, J. A., Bradshaw, J. W. S., & Cormack, K. F. M. (1997). Behavior of children with learning disabilities interacting with a therapy dog. *Anthrozoos, 19,* 84–89.

Liu, G. C., Wilson, J. S., Qi, R., & Ying, J. (2007). Green neighborhoods, food retail and childhood overweight. *American Journal of Health Promotion, 21,* 317–25.

Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. *Journal of Pediatric Psychology, 32,* 643–665.

Lolichen, P. (2007). Children in the drivers' seat: children conducting a study of their transport and mobility problems. *Children, Youth and Environments, 17,* 238–256.

Lopez, R., & Hynes, P. (2006). Obesity, physical activity, and the urban environment: public health research needs. *Environmental Health: A Global Access Science Source, 5,* 5–25.

Louv, R. (2005/2008). *Last child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill, NC: Algonquin Books of Chapel Hill.

*Lovasi, G. S., Jacobson, J. S., Quinn, J. W., Neckerman, K. M., Ashby-Thompson, M. N., & Rundle, A. (2011). Is the environment near home and school associated with physical activity and adiposity of urban preschool children? *Journal of Urban Health, 88,* 1143–1157.

*Lovasi, G. S., Quinn J. W., Neckerman, K. M., Perzanowski, M. S., & Rundle, A. (2008). Children Living in areas with more street trees have lower prevalence of asthma. *Journal of Epidemiology and Community Health, 62,* 647–649.

Lovasi, G. S., Schwartz-Soicher, O, Quinn, J. W., Berger, D. K., Neckerman, K. M., Jaslow, R., Lee, K. K., & Rundle, A. (2013). Neighborhood safety and green space as predictors of obesity among preschool children from low-income families in New York City. *Preventive Medicine, 57,* 189–193.

Lucas, A. J., & Dyment, J. E. (2010). Where do children choose to play on the school ground? The influence of green design. Education 313: *International Journal of Primary, Elementary and Early Years Education, 38,* 177–189.

*Luchs, A., & Fikus, M. (2013). A comparative study of active play on differently designed playgrounds. *Journal of Adventure Education and Outdoor Learning, 13,* 206–222.

*Maas, J., Verheij, R. A., de Vries, S., Spreeuwenberg, P., Schellevis, F. G., & Groenewegen, P. P. (2009). Morbidity is related to a green living environment. *Journal of Epidemiology and Community Health, 63,* 967–973.

Maas, J., Verheij, R. A., Groenewegen, P. P., De Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity and health: How strong is the relation? *Journal of Epidemiology and Community Health, 60,* 587–592.

Maller, C., Townsend, M., Pryor, A., Brown, P., & St. Leger, L. (2006). Healthy nurture healthy people: 'Contact with nature' as an upstream health promotion intervention for populations. *Health Promotion International, 21,* 45–54.

*Malone, K., & Tranter, P. (2003). Children's environmental learning and the use, design and Management of school grounds. *Children, Youth and Environments, 13,* 87–137.

Marino, L., & Lilienfeld, S. (1998). Dolphin-assisted therapy: flawed data, flawed conclusions. *Anthrozoos, 11,* 194–200.

Markevych, I., Fuertes, E., Tiesler, C.M., Birk, M., Bauer, C.P., Koletzko, S., …Heinrich, J. (2014a). Surrounding greenness and birth weight: Results from the GINIplus and LISAplus birth cohorts in Munich. *Health Place, 12,* 39–46.

*Markevych, I., Thiering, E., Fuertes, E., Sugin, D., Berdel, D., Koletzko, S., … Heinrich, J. (2014b). A cross-sectional analysis of the effects of residential greenness on blood pressure in 10-year old children. *BMC Public Health, 14,* 477.

*Markevych, I., Tiesler, C. M., T., Fuertes, E., Romanos, M., Dadvand, P., Nieuwenhuijsen, M. J., …Heinrich, J. (2014c). Access to urban green spaces and behavioural problems in children. *Environment International, 71,* 29–35.

*Martensson, F., Boldemann, C., Soderstrom, M., Blennow, M., Englund, J., & Grahn, P. (2009). Outdoor environmental assessment of attention promoting settings for preschool children. *Health and Place, 15,* 1149–1157.

*Martin, F., & Farnum, J. (2002). Animal-assisted therapy for children with pervasive developmental disorders. *Western Journal of Nursing Research, 24,* 657–670.

Masten, A. S., & Reed, M.G. J. (2002). Resilience in development. In C. Snyder & S. Lopez (Eds.), *Handbook of positive psychology* (pp. 74–88). New York, NY: Oxford University Press.

*Matsuoka, R. (2010). Student performance and high school landscapes: Examining the links. *Landscape and Urban Planning, 97,* 273–282.

Matthews, M. H. (1992). *Making sense of place: Children's understanding of large-scale environments*. Hertfordshire, UK: Simon & Schuster International.

McCurdy, L. E., Winterbottom, K. E., Mehta, S. S., & Roberts, J. R. (2010). Using nature and outdoor activity to improve children's health. *Current Problems in Pediatric and Adolescents Health Care, 40,* 102–17.

McNicholas J., & Collis G. M. (2006). Animals as social supports: Insights for understanding animal assisted therapy. In A. H. Fine (Ed.), *Handbook on animal-assisted therapy: Theoretical foundations and guidelines for practice* (2nd ed.) (pp. 49–71). San Diego: CA: Academic Press.

Medin, D., & Atran, S. (1999). Introduction. *Folkbiology*. Cambridge, MA: MIT Press.

Melson, G. F. (2001). *Why the wild things are: Animals in the lives of children*. Cambridge, MA: Harvard University Press.

Melson, G. F. (2003). Child development and the human-companion animal bond. *American Behavioral Scientist, 47,* 31–39.

Melson, G. F. (2013). Children's ideas about the moral standing and social welfare of non-human species. *Journal of Sociology and Social Welfare, 40,* 81–106.

Melson, G. F., Kahn, J. H., Beck, A., & Friedman, B. (2009). Robotic pets in human lives: Implications for the human–animal bond and for human relationships with personified technologies. *Journal of Social Issues, 65,* 545–567.

Melson, G. F., Peet, S., & Sparks, C. (1991). Children's attachment to their pets: Links to socio-emotional development. *Children's Environments Quarterly, 8,* 55–65.

Melson, G. F., & Schwartz, R. (1994). *Pets as social supports for families with young children.* Paper presented to the annual meeting of the Delta Society, New York City, NY.

Mergen, B. (2003). Review essay: Children and nature in history. *Environmental History, 6,* 643–669.

Messaoudi, M., Violle, N., Bisson, J. F., Desor, D., Javelot, H., & Rougeot, C. (2011). Beneficial psychological effects of a probiotic formulation (Lactobacillus helveticus R0052 and Bifidobacterium longum R0175) in healthy human volunteers. *Gut Microbes, 2,* 256–261.

Messer Diehl, E. R. (2009). Gardens that heal. In L. Buzzell, & C. Chalquist (Eds.) *Ecotherapy: Healing with nature in mind* (pp.166–173). San Francisco, CA: Sierra Club Books.

Mikkelsen, M. R., & Christensen, P. (2009). Is children's independent mobility really independent? A study of children's mobility combining ethnography and GPS/mobile phone technologies. *Mobilities, 4,* 37–58.

Mitchell, R., & Popham, F. (2007). Green space, urbanity and health: Relationships in England. *Journal of Epidemiology and Community Health, 61,* 681–683.

Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: An observational population study. *Lancet, 372*, 655–60.

Mithal, A., Wahl, D. A., Bonjour, J. P., Burckhardt, P., Dawson-Hughes, B., Eisman, J. A., … IOF Committee of Sci Advisors (CSA) Nutrition Working Group. (2009). Global vitamin D status and determinants of hypovitaminosis D. *Osteoporosis International, 20,* 1807–20.

Mole, M., Marshall, L., Pietrowsky, R., Lutzenberger, W. (1995). Dimensional complexity of the EEG indicates a right front cortical locus of attentional control. *Psychophysiology, 9,* 45–55.

Monroe, M. C. (2003). Two avenues for encouraging conservation behaviors. *Human Ecology Review,10,* 113–125.

Montiel-Castro, A. J., González-Cervantes, R. M., Bravo-Ruiseco, G., & Pacheco-López, G. (2013). The microbiota-gut-brain axis: Neurobehavioral correlates, health, and sociality. *Frontiers in Integrative Neuroscience, 7,* Article 70.

Moore, R. C. (1986). *Childhood's domain*. London, UK: Croom-Helm.

Moore, R. C. (1989). Plants as play props. *Children's Environments Quarterly, 6*, 3–6.

Moore, R. C., Goltsman, S. M., & Iacofano, D. S. (1992). *PLAY FOR ALL guidelines: Planning, design and management of outdoor play settings for all children* (2nd ed.). Berkeley, CA: MIG Communications.

Moore, R. C., & Wong, H. H. (1997). *Natural learning*. Berkeley, CA: MIG Communications.

Muñoz, S. A. (2009). *Children in the outdoors: A literature review*. Forres, Scotland: Sustainable Development Research Centre.

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: does self control resemble a muscle? *Psychological Bulletin, 126,* 247–259.

Murayama, F. (2007). A demonstration of the potentials of collaboration between university students and school children in community environmental action. *Children, Youth and Environments, 17,* 322–325.

Myers, O. E. (2007). *The significance of children and animals: Social development and our connections to other species* (2nd ed.). West Lafayette, IN: Purdue University Press.

Myers, O. E., & Saunders, C. D. (2002). Animals as links toward developing caring relationships with the natural world. In P. H. Kahn, Jr. & S. R. Kellert (Eds.), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 153–178). Cambridge, MA: MIT Press.

Myers, O. E., Saunders, C. D., & Garrett, E. (2004). What do children think animals need? Developmental trends. *Environmental Education Research, 10,* 545–562.

Naess, A. (1985). Identification as a source of deep ecological attitudes. In M. Tobias (Ed.), *Deep ecology* (pp. 256–270). San Diego, CA: Avant Books.

Nash, R. (1982). *Wilderness and the American mind*. New Haven, CT: Yale University Press.

Nathanson, D. E., & de Faria, S. (1993). Cognitive improvement of children in water and with and without dolphins. *Anthrozoos, 6,* 17–29.

National Recreation and Park Association. (2011). *Parks and recreation in underserved areas.* Ashburn, VA: National Recreation and Park Association.

*Nedovic, S., & Morrissey, A. (2013). Calm active and focused: Children's response to an organic outdoor learning environment. *Learning Environ Res, 16,* 281–295.

Newell, P. B. (1997). A cross-cultural examination of favorite places. *Environment and Behavior, 29,* 495–514.

Nijmeijer, J. S., Minderaa, R. B., Buitelaar, J K., Mulligan, A., Hartman, C. A., & Hoekstra, P. J. (2008). Attention-deficit/hyperactivity disorder and social dysfunctioning. *Clinical Psychology Review, 28*, 692–708.

Öhman, A., Dimberg, U., & Öst, L.G. (1985). Animal and social phobias: Biological constraints on the learned fear response. In S. Reiss & R. Bootzin (Eds.), *Theoretical issues in behavior therapy* (pp. 123–175). New York, NY: Academic.

O'Brien, L. (2005). *Trees and their impact on the emotional well-being of local residents on two inner London social housing estates.* London, UK: Forest Research.

Odendaal J. S., & Meintjes R. A. (2003). Neurophysiological correlates of affinitive behavior between humans and dogs. *Veterinary Journal, 165,* 296–301.

Office of the United Nations High Commissioner for Human Rights (2008). Convention on the Rights of the Child: General assembly resolution 44/25 of 20 November 1989. Retrieved February 3, 2016 from www.unhchr.ch/html/menu3/b/k2crc.htm

Ohri-Vachaspati, P., Lloyd, K., DeLia, D., Tulloch, D., & Yedidia, M. J. (2013). A closer examination of the relationship between children's weight status and the food and physical environment. *Preventive Medicine, 57,*162–67.

Olshansky, S. J., Passaro, D. J., Hershow, R. C., Layden, J., Carnes, B. A., Broday, J., … Ludwig, D. S. (2005). A potential decline in life expectancy in the United States in the 21st century. *New England Journal of medicine, 352,* 1138–1145.

Orr, D. W. (1993). Love it or lose it: The coming biophilia revolution. In S. R. Kellert, & E. O. Wilson (Eds.), *The biophilia hypothesis* (pp. 415–440). Washington, DC: Island Press

Papworth, S. K., Rist, J., Coad, L., & Milner-Gulland, E. J. (2009). Evidence for shifting baseline syndrome in conservation. *Conservation Letters, 2,* 93–100.

Pastor, M., Sadd, J. L., & Morello-Frosch, R. (2002). Who's minding the kids? Pollution, public schools, and environmental justice in Los Angeles. *Social Science Quarterly,83,* 263–280.

Pellegrini, A. D. (2005). *Recess: Its role in development and education*. Mahwah, NJ: Erlbaum.

Pergams, O., & Zaradic, P. (2008). Evidence for a fundamental and pervasive shift away from nature based recreation. *Proceedings of the National Academy of Sciences, 105,* 2295–2300.

Perrin, J. M., Bloom, S. R., & Gortmaker, S. L. (2007). The increase of childhood chronic conditions in the United States. *The Journal of American Association, 297,* 2755–2759.

Piaget, J. (1962). *Play, dreams, and imitation in childhood*. New York, NY: Norton.

Pilgrim, S. E., Cullen, L. C., Smith, D. J., & Pretty, J. (2007). Ecological knowledge is lost in wealthier communities and countries. *Environmental Science and Technology, 42,* 1004–1009.

Pont, K., Ziviani, J., Wadley, D., Bennett, S., & Abbott, R. (2009). Environmental correlates of children's active transportation: A systematic literature review. *Health and Place, 15,* 849–862.

Poresky, R. H. (1990). The young children's empathy measure: Reliability, validity, and effects of companion animal bonding. *Psychological Reports, 66,* 931–936.

Poresky, R. H. (1996). Companion animals and other factors affecting young children's development. *Anthrozoos, 9,* 159–168.

*Poresky, R. H., Hendrix, C., Mosier, J. E., & Samuelson, M. L. (1988). Children's pets and adults' self concepts. *The Journal of Psychology, 122*, 463–469.

Potesio, M., Patel, A. B., Powell, C. D., McNeil, D. A., Jacobson, R. D., & McLaren, L. (2009). Is there an association between spatial access to parks/green space and childhood

overweight/obesity in Calgary, Canada? *International Journal of Behavioral Nutrition and Physical Activity, 6,* 77.

*Potwarka, L. R., Kaczynski, A. T., & Flack, A. L. (2008). Places to play: Association of park space and facilities with healthy weight status among children. *Journal of Community Health, 33,* 344–50.

Powell, L. M., Slater, S., & Chaloupka, J. F. (2004). The relationship between community physical activity settings and race, ethnicity, and socioeconomic status. *Evidence Based Preventative Medicine, 1,* 135–144.

Prescott, E. (1987). The physical environment and cognitive development in child-care centers. In C. S. Weinstein & T. G. David (Eds.), *Spaces for children* (pp. 73–87). New York, NY: Plenum Press.

Pretty, J., Angus, C., Bain, M., Barton, J., Gladwell, V., Hine, R., …Sellens, M. (2009). *Nature, childhood, health and life pathways*. Colchester, UK: Interdisciplinary Center for Environment and Society, University of Essex.

Pretty, J., Peacock, J., Sellens, M., & Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research, 15,* 319–337.

Proshansky, H., Ittelson, W., & Rivlin, L. (1975). *Environmental psychology* (2nd ed.). New York, NY: Holt, Rinehart & Winston.

Puder, J. J., Marques-Vidal, P., Schindler, C., Zahner, L., Niederer, I., Burgi, F., … Kriemler, S. (2011). Effect of multidimensional lifestyle intervention on fitness and adiposity in predominantly migrant preschool children (Ballabeina): Cluster randomised controlled trial. *BMJ, 343,* d6195.

Pyle, R. M. (1978) The extinction of experience. *Horticulture, 56,* 64–67.

Pyle, R. M. (1993). *The thunder tree: Lessons from an urban wildland.* Boston, MA: Houghton Mifflin.

Pyle, R. M. (2002). Eden in a vacant lot: special places, species and kids in the neighborhood of life. In P. H. Kahn & S. R. Kellert (Eds.), *Children and nature: Psychological, sociological, and evolutionary investigations* (pp. 305–327). Cambridge, MA: Massachusetts Institute of Technology Press.

*Quigg, R., Reeder, A. I., Gray, A., Holt, A., & Waters, D. (2011). The effectiveness of a community playground intervention. *Journal of Urban Health, 89,*171–184.

Rasmussen, K. (2004). Places for children – children's places. *Childhood, 11,* 155–173.

Reser, J. P. (1995). Wither environmental psychology? The transpersonal ecopsychology crossroads. *Journal of Environmental Psychology, 15,* 235–257.

Richardson, E. A. (2014). Do mothers living in greener neighbourhoods have healthier babies? *Occupational and Environmental Medicine, 71,* 527–528.

Richardson, E. A., Mitchell, R., Hartig, T., de Vries, S., Astell-Burt, T., & Frumkin, H. (2012). Green cities and health: a question of scale? *Journal of Epidemiology and Community Health, 66,* 160–165.

Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M2: Media in the lives of 8- to 18-year olds*. Menlo Park, CA: Kaiser Family Foundation.

Rideout, V. J., Vandewater, E. A., & Wartella, E. A. (2003). *Zero to six: Electronic media in the lives of infants, toddlers and preschoolers*. Menlo Park, CA: Kaiser Family Foundation.

Roberts, H. & Petticrew, M. (2006). Policy for children and young people: What is the evidence and can we trust it? *Children's Geographies, 4,* 19–36.

*Roemmich, J. N., Epstein, L. H., Raja, S., Yin, L., Robinson, J., & Winiewicz, D. (2006). Association of access to parks and recreational facilities with the physical activity of young children. *Preventive Medicine, 43,* 437–441.

Romi, S., & Kohan, E. (2004). Wilderness programs: Principles, possibilities and opportunities for intervention with dropout adolescents. *Child and Youth Care Forum, 33,* 115–136.

Rook, G. A. W. (2009). Review series on helminths, immune modulation and the hygiene hypothesis: The broader implications of the hygiene hypothesis. *Immunology, 126,* 3–11.

*Rose, K. A., Morgan, I. G., Ip, J., Kifley, A., Huynh, S., Smith, W., & Mitchell, P. (2008). Outdoor activity reduces the prevalence of myopia in children. *Ophthalmology, 115,* 1279–1285.

*Ross, N., Medin, D., Coley, J. D., & Atran, S. (2003). Cultural and experimental differences in the development of folkbiological induction. *Cognitive Development, 18,* 25–47.

Rost, D. H., & Hartmann, A. (1994). Children and their pets. *Anthrozoos, 7,* 242–254.

Roszak, T. (1992). *The voice of the earth: An exploration of eco-psychology*. New York, NY: Simon & Schuster.

Roszak, T., Gomes, M. E., & Kanner, A. D. (Eds.). (1995). *Ecopsychology: Restoring the earth, healing the mind*. San Francisco, CA: Sierra Club Books.

Rubin, K.H., Fein, G., & Vandenberg, B. (1983). Play. In E.M. Hetherington (Ed.), *Handbook of child psychology: Vol 4. Socialization, personality, and social development*. New York, NY: Wiley.

*Ruokolainen, L., von Hertzen, L., Fyhrquist, N., Laatikainen, T., Lehtomaki, J., Aurinen, P., … Hanski, I. (2015). Green areas around homes reduce atopic sensitization in children. *Allergy, 70,* 195–202.

*Russell, K. C. (2003). An assessment of outcomes in outdoor behavioral healthcare treatment. *Child and Youth Care Forum, 32,* 355–381.

*Russell, K. C. (2005). Two years later: A qualitative assessment of youth well-being in the role of aftercare in Outdoor Behavioral Healthcare Treatment. *Child & Youth Care Forum, 34,* 209–239.

Russell, K. C. (2012). Therapeutic uses of nature. In S. D. Clayton (Ed.), *The Oxford handbook of environmental and conservation psychology* (pp. 428–444). New York, NY: Oxford University Press.

*Sallis, J. F., Nader, P. R., Broyles, S. L., Berry, C. C., Elder, J. P., McKenzie, T. L. (1993). Correlates of physical activity at home in Mexican-American and Anglo-American preschool children. *Health Psychology, 12*, 390–398.

Samborski, S. (2010). Biodiverse or barren school grounds: Their effects on children. *Children, Youth and Environments, 20,* 67–115.

Santostefano, S. (2004). *Child therapy in the great outdoors: A relational view*. Hillsdale, NJ: Analytic Press.

Santostefano, S. (2008). The sense of self inside and environments outside: How the two grow together and become one in healthy psychological development. *Psychoanalytic Dialogues, 18,* 513–535.

Sebba, R. (1991). The landscapes of childhood: The reflection of childhood's environment in adults memories and in children's attitudes. *Environment and Behavior, 23,* 395–422.

Silk, J. S., Sessa, F. M., Morris, A. S., Steinberg, L., & Avenevoli, S. (2004). Neighborhood cohesion as a buffer against hostile maternal parenting. *Journal of Family Psychology, 18,* 135–146.

Sobel, D. (1993). *Children's special places: Exploring the role of forts, dens, and bush houses in middle childhood*. Tucson, AZ: Zephyr.

*Soderstrom, M., Boldemann, C., Sahlin, U., Martensson, F., Raustorp, A., & Blennow, M. (2013). The Quality of the outdoor environment influences children's health—A cross-sectional study of preschools. *Acta Paedriatrica, 102,* 83–91.

Staats, H. (2012). Restorative environments. In S. Clayton (Ed.), *The Oxford handbook of environmental and conservation psychology* (pp. 445–458). New York: Oxford University Press.

Stanley, E. (2011). The place of outdoor play in a school community. *Children, Youth, and Environments 21,* 185–211.

Strife, S., & Downey, L. (2009). Childhood development and access to nature: A new direction for environmental inequality research. *Organization & Environment, 22,* 99–122.

Sutton, L. (2008). The state of play: Disadvantage, play and children's well-being. *Social Policy and Society, 7,* 537–549.

Sward, L. L. (1999). Significant life experiences affecting the environmental sensitivity of EI Salvadoran environmental professionals. *Environmental Education Research, 5,* 201–206.

Takano, T., Nakamura, K., & Watanabe, M. (2002). Urban residential environments and senior citizens' longevity in megacity areas. The importance of walkable green spaces. *Journal of Epidemiology and Community Health, 56,* 913–918.

Tanner, T. (1980). Significant life experiences: A new research area in environmental education. *Journal of Environmental Education, 11,* 20–24.

The Nielsen Company (2009). TV viewing among kids at an eight-year high. Retrieved February 9, 2016, from http://blog.nielsen.com/nielsenwire/media_entertainment/tv-viewing-among-kids-at-an-eight-year-high/

Thomas, G., & Thompson, J. (2004). *A child's place: Why environment matters to children*. London, UK: Green Alliance.

Thomashow, M. (1995). *Ecological identity: Becoming a reflective environmentalist*. Cambridge, MA: Massachusetts Institute of Technology Press.

*Triebenbacher, S. L. (1998). Pets as transitional objects: their roles in children's emotional development. *Psychological Reports, 82,* 191–200.

Tuan, Y. (1978). Children and the natural environment. In I. Altman & J. F. Wohlwill (Eds.), *Children and the environment* (pp. 259–294). New York: Plenum.

Tucker, F., & Matthews, H. (2001). "They don't like girls hanging around there": Conflict over recreational space in rural Northamptonshire, *Area, 33,* 161–168.

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. *Human Behavior & Environment: Advances in Theory & Research, 6,* 85–125.

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science, 224,* 420 421.

Ulrich, R. S. (1993). Biophilia, biophobia, and natural landscapes. In S. R. Kellert and E. O. Wilson (Eds.), *The biophilia hypothesis* (pp. 73–137). Washington, DC: Island Press.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11,* 201–230.

United Nations (2014). *World urbanization prospects: The 2014 revision, highlights (ST/ESA/SER.A/352).* New York NY: United Nation, Department of Economic and Social Affairs, Population Division. Retrieved March 5, 2016, from http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

United Nations Children's Fund (2015). *The state of the world's children 2015: Reimagine the future*. New York, NY: UNICEF.

US Department of Health and Human Services (2008). *Physical activity guidelines advisory committee report*. Washington, DC: US Department of Health and Human Services.

Valentine, G. (2004). *Public space and the culture of childhood*. Aldershot, UK: Ashgate.

van den Berg, A. E., & Custers, M. H. G. (2011). Gardening promotes neuroendocrine and affective restoration from stress. *Journal of Health Psychology, 16,* 3–11.

*van den Berg, A. E., & van den Berg, C. G. (2011). A comparison of children with ADHD in a natural and built setting. *Child: Care, Health, and Development, 37,* 430–39.

Vandewater, E. A., Bickham, D. S., & Lee, J. H. (2006). Time well spent? Relating television use to children's free-time activities. *Pediatrics, 117,*181–191.

Varney, D., & van Vliet, W. (2005). Local environmental initiatives orientated to children and youth: A review of UN Habitat best practices. *Children, Youth and Environments, 15,* 41–52.

Veitch, J., Salmon, J., Ball, K. (2010). Individual, social and physical environmental correlates of children's active free-play: A cross sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 7,* 11.

Veugelers, P., Sithole, F., Zhang, S., & Muhajarine, N. (2008). Neighborhood characteristics in relation to diet, physical activity, and overweight of Canadian children. *International Journal of Pediatric Obesity, 3,* 152–159.

Vidovic, V. V., Stetic, V. V., & Bratko, D. (1999). Pet ownership, type of pet and socio-emotional development of school children. *Anthrozoos, 12,* 211–217.

Villarreal, M. G., Ohlsson, J., Abrahamsson, M., Sjöstrom, A., & Sjöstrand, J. (2000). Myopisation: The refractive tendency in teenagers. Prevalence of myopia among young teenagers in Sweden. *Acta Ophthalmologica Scandinavia, 78,* 177–181.

Vining, J. (2003). The connection to other animals and caring for nature. *Research in Human Ecology, 10,* 87–99.

von Hertzen, L., Hanski, I., & Haahtela, T. (2011). Natural immunity: Biodiversity loss and inflammatory diseases are two global megatrends that might be related. *EMBO Reports, 12,* 1089–1093.

Wall, M. M., Larson, N. I., Forsyth, A., Van Riper, D. C., Graham, D. J., Story, M. T., & Neumark Sztainer, D. (2012). Patterns of obesogenic neighborhood features and adolescent weight. *American Journal of Preventive Medicine, 42,* e65–75.

Ward Thompson, C., Travlou, P., Roe, J. (2006). *Free range teenagers: The role of wild adventure space in young people's lives*. Edinburgh, UK: OPENSpace.

Weir, L., A., Etelson, D., & Brand, D., A. (2006). Parent's perceptions of neighbourhood safety and children's physical activity. *Preventive Medicine, 43,* 212–217.

*Wells, N. (2000). At home with nature: Effects of "greenness" on children's cognitive functioning. *Environment and Behavior, 32,* 775–795.

*Wells, N. M., & Evans, G.W. (2003). Nearby nature: A buffer of life stress among rural children. *Environment and Behavior, 35,* 311–330.

Wells, N. M., & Lekies, K. S. (2006). Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. *Children, Youth and Environments, 16,* 1–24.

Wen, M., Zhang, X., Harris, C. D., Holt, J. B., & Croft, J. B. (2013). Spatial disparities in the distribution of parks and green spaces in the USA. *Annals of Behavioral Medicine, 45,* S18–27.

Werhan, P. O., & Groff, D. G. (2005). Research update: The wilderness therapy trail. *Parks & Recreation, 40,* 24.

White, R. (2004). Young children's relationship with nature: Its importance to children's development and the earth's future. *White Hutchinson Leisure and Learning Group.* Retrieved January 5, 2016, from https://www.whitehutchinson.com/children/articles/childrennature.shtml

White, W. (2012). A history of adventure therapy. In M. A. Gass, H. L. Gillis, & K. C. Russell (Eds.), *Adventure therapy: Theory, research, and practice* (pp. 19–46). New York, NY: Routledge Press.

Williams, K. H., & Harvey, D. (2001). Transcendent experience in forest environments. *Journal of Environmental Psychology, 21,* 249–260.

Wilson, E. O. (1984). *Biophilia: The human bond with other species*. Cambridge, MA: Harvard University Press.

Wilson, S. J., & Lipsey, M. W. (2000). Wilderness challenge programs for delinquent youth: A meta- analysis of outcome evaluations. *Evaluation and Program Planning, 23,* 1–12.

Wohlwill, J. F., & Heft, H. (1987). The physical environment and the development of the child. In D. Stokols & I. Altman (Eds.), *Handbook of Environmental Psychology, Vol. 1* (pp. 281–328). New York, NY: Wiley.

Wolch, J., Jerrett, M., Reynolds, K., McConnell, R., Chang, R., Dahmann, N., Brady, K., …Berhane, K. (2011). Childhood obesity and proximity to urban parks and recreational resources. *Health and Place, 17,* 207–214.

Woolley, H., Pattacini, L., & Somerset Ward, A. (2009). *Children and the natural environment*. London, UK: Natural England.

*Wu, C. D., McNeely, E., Cedeño-Laurent, J. G., Pan, W. C., Adamkiewicz, G., Dominici, F. Lung, S. C., … Spengler, J. D. (2014). Linking student performance in Massachusetts elementary schools with the "greenness" of school surroundings using remote sensing. *PloS One, 9,* e108548.

*Wu, P. C., Tsai, C. L., Wu, H. L., Yang, Y. H., & Kuo, H. K. (2013). Outdoor activity during class Recess reduces myopia onset and progression in school children. *Ophthalmology, 120,* 1080–1085.