

Making Children's Environments "R.E.D.": Restorative Environmental Design and Its Relationship to Sustainable Design

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Abstract

Children have the most to gain or lose from restorative environmental design. They may receive many positive developmental benefits, such as increased attention capacities, cognitive function, increased social and creative play, and improved motor skills. At the same time, they are most vulnerable to the risks associated with a degraded planet. While green building and sustainability have gained great momentum in the past decade, criteria that promote a connection to or understanding of nature are frequently absent from many "green" designs. Restorative environmental design brings together the ideas of sustainable design, such as reducing carbon footprints and sourcing local, sustainably produced materials, with biophilic design, which fosters the human connection to nature through the built environment. Through case examples of children's environments, we hope to show that restorative environmental design (RED) is an important and new model for what has heretofore been deemed "green" design.

Keywords

children, nature, learning environments, play environments, biophilic design, restorative environmental design, sustainable design

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Introduction

Our planet is changing rapidly, largely from human-driven causes: climate change, large scale extinctions, and toxic environments stem from a human disconnection from nature. The built sector alone is thought to be responsible for nearly half the emissions that result in global warming (Architecture-2030 2011). Yet architecture and planning can make a significant contribution to more sustainable societies. They can also help create restorative environments, which not only minimize environmental impacts but also help to rebuild human connections to the natural world. These impacts are particularly significant in the design of children's environments: children receive many positive developmental benefits from contact with nature (e.g., Chawla 1998, Kellert 2005, Kirkby 1989, Fjørtoft 2001, Faber Taylor and Kuo 2006, Pretty et al. 2009) and at the same time are one of the most vulnerable sectors of the population to both current risks from unhealthy buildings (Wargo 2010) and future health risks from a degraded planet (Steingraber 2011).

In recent years, many green building rating systems and certification criteria have been developed for sustainable design. In the United States, the Leadership in Energy and Environmental Design (LEED) Green Building Rating Systems has become the most common rubric for evaluating sustainable design features. Similarly, BREEAM (Building Research Establishment Environmental Assessment Method) based in the UK is widely used internationally. And while these frameworks are a useful starting point for designing more sustainable buildings, they are not all inclusive. Missing from these frameworks are assessments of building toxicity and health impacts, particularly with children (Chambers 2011, Wargo 2010), comprehensive use of life cycle assessments in energy, water and materials accounting (Chambers 2011, Trusty and Horst 2002), some social and economic indicators (Day 2003) as well as criteria that promote the connection to and understanding of nature in the built environment (Chambers 2011, Kellert 2005, Kellert et al. 2008, Moore and Cooper Marcus 2008).

This latter absence is the focus of this paper. In recent history, much of the built environment has failed to provide a positive and satisfying connection to nature (Kellert 2005). The theory of biophilia suggests that humans have an inherent need to affiliate with nature and that these affiliations are important in facilitating people's physical and mental health and well-being (Heerwagen 2009, Kellert 2005, Wilson 1994). When nature and natural processes are incorporated into the built environment, this is called biophilic design. Natural building (e.g., Day 2004, Pearson 1994), ecological design (e.g., Van der Ryn and Cowen 1995, Todd 2005) and biomimicry (Benyus 1997) are also approaches to design that build on the principles and processes of nature. Biophilic design shares much in common with these other approaches to design in that it learns from and celebrates the beauty, wonder, and intelligence offered from the natural world.

Restorative environmental design brings together the ideas of sustainable design, such as reducing carbon footprints and sourcing local, sustainably produced materials, with biophilic design, which fosters the human connection to nature through the built environment. Through case examples of children's environments, we hope to show that restorative environmental design (RED) is an important and new model for what has heretofore been deemed "green" design.

The Need for Biophilic Design

Throughout history, cities and towns have often relied on the conversion of wild and diverse ecosystems to more homogenous places. The natural habitat that remains or is built into parks tends to be less diverse and exists on a smaller scale, fragmented and frequently diminished in quality. While parks and open spaces remain within some urban environments, cities today are the world's greatest consumers and polluters, both. They are charged with consuming 40% of the energy resources, 30% of natural resources, and 25% of freshwater resources. At the same time, they emit 33% of air and water pollutants and produce 25% of solid wastes (Architecture-2030 2011, Kellert 2005). This model of development and resource use has led many people to believe that exploitation, pollution, and unsustainable living are inevitable outcomes of the urban lifestyle (Kellert 2005).

Yet at the same time, people also intuitively make the connection between ecological and human health and well-being. People bring nature into their homes and work environments, choose nature for many recreation and vacation destinations, and are extremely positive toward such urban restorations as the High Line Park in New York City or the Cheonggyecheon River restoration in Seoul, South Korea. While people sense this relationship, it runs counter to the prevailing notion that urban nature is dispensable. In fact, a growing body of research supports the importance between the health of the environment and the health of people (Kellert 2005). Direct experience with nature in city parks and green spaces has been shown to provide many social and health benefits for people of all ages; these benefits include reduced stress, greater immunity, reduced incidence of disease, improved mood, and ability to perform tasks that require focused attention (Coley et al. 1997; Cooper Marcus and Barnes 1999; Hartig 1991; Faber Taylor et al. 1998; Kaplan and Kaplan 1989; Maller et al. 2002; Malone 2009; Mitchell and Popham 2008; Pretty et al. 2009; Ulrich and Parsons 1993; Warner 1994). In work environments, exposure to nature through natural lighting; natural ventilation; incorporation of natural materials into design; photographs or artwork of nature; and direct exposure to nature through views of green spaces, green roofs, or indoor installments of water or plant features all can result in increased mental and physical well-being, increased worker satisfaction, performance and retention (Bringslimark et al. 2009, Browning and Romm 1998, Fisk and Rosenfeld 1997, Frumkin 2008, Heerwagen 2000, Heerwagen and Hase 2001, Kaplan 1993, Kaplan 1995a, Kaplan 1995b, Lohr 1996, Raanaas et al. 2011, Wise 1997). City greening projects and green spaces in neighborhood design also help revitalize an overall sense of community (e.g., Bennaton 2009, Corbett and Corbett 2000, Faber Taylor et al. 1998, Gottlieb and Misako Azuma 2007, Kuo et al. 1998, Murphy Dunning 2009).

In addition, much evidence supports the important role nature plays in childhood development in particular. Research has demonstrated that play in nature can improve children's motor skills (Fjortoft 2001), increase cognitive functioning and attention capacities (Faber Taylor and Kuo 2006, Kuo and Faber Taylor 2004, Pretty et al. 2009, Wells 2000), alleviate childhood stresses (Kuo 2010, Wells and Evans 2003), and result in more social and creative play (Änggård 2010, Kirkby 1989, Faber Taylor et al. 1998a). A growing body of research also suggests that frequent, direct experience with nature, coupled with an adult who teaches respect for nature, significantly influence the development of environmental care and stewardship later in life (Chawla 1998, Hsu 2009, Muller et al. 2009, Tanner 1980, Thompson et al. 2008, Wells and Lekies 2006).

Despite the many positive benefits to be gained from nature, much urban development continues to reduce or erase nature from cities and leave pollution and waste behind. Beatley (2011) suggests that while many architects and designers have begun to incorporate nature into urban design, planning lags behind. The result is that many people still do not have access to the positive benefits

nature provides. Even for those cities that do have natural areas, this is not always accessible to children or equitably distributed across the landscape (Hart 1982, Heerwagen 2009, Mitchell and Popham 2008). Frequently, minority and lower income families live within urban areas that are degraded and natural experiences are diminished or non-existent. More recently, some of these families have also been pushed to the outskirts of cities where big box stores and strip development dominate and little attention is given to the maintenance or design of places, let alone those that provide access to nature (Alegría 2006, Beatley 2011, Friedmann 2007, Pavel 2009, Spencer 2010). Human populations across the globe are increasingly urban in their demographics. In 2008, more than half of the world's population lived in cities (UNFPA 2007). Yet the principles of biophilic design are important in conferring many positive benefits in built environments for residents in rural, suburban, and urban settings alike.

We assert that these two issues – degraded built environments and lack of access to nature – are issues of design rather than a necessary part of society. In fact, biophilic design can increase environmental and social equity by improving human habitats through increased access to the benefits of nature, natural forms and processes, natural ornamentation, and suitable habitat for plant and animal species in built environments (Baldwin et al. 2011).

Biophilic Design: Harmonizing the Natural and Built Environments

Restorative environmental design brings together two complementary goals: (i) minimizing or mitigating adverse environmental impacts, and (ii) promoting positive interactions between people and nature in built environments. Biophilic design refers to this latter, often neglected, aspect of restorative environmental design. Nature in built environments is commonly associated with landscape design, such as through gardens, parks, or more recently green roofs or vertical gardens, yet biophilic design can also be found in a building's façade and interior environments as well as the exterior landscape (Kellert 2005). Biophilic design is characterized by six basic elements: (i) environmental features; (ii) natural shapes and forms; (iii) natural patterns and processes; (iv) light and space; (v) place-based relationships; and (vi) evolved human-nature relationships (Heerwagen and Hase 2001, Kellert 2008). Each of these elements, articulated in detail by Kellert (2008) is briefly described below:

- (i) *Inclusion of environmental features* is one of the simplest means of biophilic design. A diversity and abundance of plants, water features, natural sunlight, views that provide vistas or animal sightings, and green roofing and vertical gardens are all examples of direct nature that allow people to derive benefits from nature in the built environment. In addition, buildings that pay attention to and incorporate local materials, local geological or landscape features, and aspects of local habitats successfully link the natural and built environments. The use of natural materials is common in the traditions of ecological design and natural architecture, and is increasingly used in sustainable design as well. Materials that evoke nature or natural processes, such as blue-stained wood from insect-introduced fungus or weathered flagstone, allude to ecological processes that sustain life.
- (ii) *Natural shapes and forms* include representations of the natural world. For example, botanical motifs; tree or wooden columns; shells, spirals, eggs, ovals, and animal forms; and curved or domed shapes that resemble forms in nature such as beehives, nests or cliffs all are means of simulating nature through biophilic design. Curved or flowing shapes also more closely mimic nature than straight lines and right angles common to built environments.
- (iii) *Natural patterns and processes* emphasize the incorporation of natural properties into the built environment. Patterns and processes can include design elements such as sensory

variability, by providing diverse experiences of light, sound, touch, or smell; the integration of patterned wholes or fractals; the provision of *refuge* through lowered ceilings or enclosed spaces to promote a sense of security and shelter; and use of a central focal point, which facilitates way-finding. *Sensory richness* provides many of the odors, colors, smells, and visual sensations that are important in childhood development. Nature inherently provides opportunities for rich sensory experience and development. (Heerwagen 2009). It also can connect children with the daily and seasonal rhythms of life. It is this richness that encourages exploration, an essential component of children's play (Änggård 2011, Heerwagen and Hase 2001).

- (iv) *Light and space* provide diversity and variability in people's experience of the built environment. The full color spectrum provided by natural light can increase productivity and well-being (Frumppkin 2008, Loftness and Snyder 2008); filtered and diffuse light, shadow and contrasting forms of light, pools of light, warm and reflected light all provide diverse experiences, including a sense of mystery, protection, security and comfort within a built environment. Similarly, diverse shapes and forms, a sense of spaciousness, variability of spaces, and spaces that connect the interior and exterior help to satisfy people's simultaneous needs for a sense of openness and protection.
- (v) *Place-based relationships* combine culture and ecology in a specific geographical context. This geographic place connection provide a sense of territorial control as well as an emotional connection to home. These connections can be facilitated in the built environment through design that connects to historic, ecological, and cultural place. Use of indigenous materials, design that works with natural landscape features and orientation, and that considers resource flows and ecological connectivity help foster a place-based relationship. Evoking this spirit of place is critical to fostering human connections and the desire to protect and maintain a place over time
- (vi) *Evolved Human-Nature Relationships* emphasize the "fundamental aspects of the inherent human relationship to nature" (Kellert 2008:13). These include design features that foster a sense of prospect and refuge, order and complexity, curiosity and enticement, mastery and control, exploration and discovery, affection and attachment and fear and awe. *Prospect and refuge* provide a sense of enclosure and shelter. For children, they frequently provide opportunities for seeing without being seen. Derr and Lance (in process) and Kirkby (1989) have observed how children seek shelter in bushes or tall grasses at the edge of playgrounds for hiding (refuge) as well as viewing others (prospect). *A sense of freedom* is also important in childhood development. Structural barriers to the outdoors inhibit a sense of freedom while direct exposure to sensory variability and rhythms and cycles of life are critical to childhood development (Day 2007). Day (2007) describes ways to incorporate spaces both indoors and out where children feel both free to explore and test boundaries but also feel protected and safe. This freedom to safely explore is important in childhood development for its ability to provide opportunities to test boundaries and to model adult behaviors as well as to develop a connection to the larger world (Derr 2006).

For children it is also important that biophilic spaces be *transformable*, providing "loose parts" and the freedom to manipulate these parts (Hart 1982). Transformable nature might be found in a sandbox with sticks from nearby trees, a water feature that children can touch, or loose pieces of nature in a classroom. Natural places lend themselves to transformation (Änggård 2011, Berg and Medrich 1980, Derr 2006, Hart 1979, Kirkby 1989, Maxey 1999, Moore 1986, Sobel 1993). Jones (2002:42) describes children's use of places as "remarkably responsive with a fantastical mixing of the material and the imaginary." It is the transformability that allows for imaginative encounters with places. While most emphasize the importance of outdoor spaces in facilitating nature experiences (Moore and Cooper Marcus 2008), little attention has been given to the indoor

environments, where children spend a growing percentage of their time. Ideally, indoor spaces support learning, free play, and a sense of community and connection to place (Moore 1986). The case studies explored herein will thus give greater attention to this aspect of design for young children.

Restorative Environmental Design

There are many ways that biophilic design overlaps with sustainable design. Some of the most common examples of this overlap include the use of daylighting, passive solar design, and use of natural materials in increasing thermal mass. Kibert (2007) describes a framework for sustainable construction that assesses the building impact on materials, water, energy, and land and ecosystems. When considering these features, the overlap between sustainable and biophilic becomes more apparent (Table 1).

Table 1: Comparison of sustainable design and biophilic design features		
Type of Resource	Sustainable design feature	Biophilic design counterpart
Materials	Retrofitting or using recycled materials (e.g., recycled wood flooring)	Natural materials Natural shapes, forms or features
	High thermal mass	Transformability
	Low embodied energy	
	Natural building materials (e.g., cob, straw bale, sustainably harvested wood)	
Water	Water treatment and recycling	Direct nature (e.g., constructed wetlands or ponds)
	Rainwater collection	
Energy	Renewable energy	Natural light
	Passive solar	Varied light patterns
	Daylighting	
	Local labor	Connection to place
Land & Ecosystems	Minimizing land disturbance, working with natural land forms and processes	Ecological connection to place Direct exposure to plants and animals
	Green roofs and vertical gardens	Evoking nature through natural shapes, forms, and features
		Transformability

There are other aspects of sustainable design that are important but do not have a direct correlate with biophilic design. These include use of photovoltaics or wind energy, toxin free buildings, and use of other materials such as recycled steel. However, since restorative environmental design

focuses on minimizing environmental impacts as well as maximizing the human experience of nature, these elements should be considered part of restorative environmental design. The four cases presented herein illustrate how restorative environmental design incorporates both low-impact as well as biophilic design.

Restorative environmental design has the potential to impact the ways children learn, heal, play, and connect to a broader community. While all of these benefits are important, we focus herein on learning environments because they broadly illustrate features of sustainable and biophilic design in the built environment.

Case Studies

Case studies were selected based on a review of many types of children's environments, including schools, museums, nature centers, parks and playgrounds. Cases were evaluated based on the presence of sustainable design features as well as biophilic design features. While there are many excellent children's environments that exemplify sustainable design or biophilic design, the four cases were chosen because they help to further our understanding of restorative environmental design in the way they incorporate both sustainable and natural features (Table 2). Children's learning environments were also chosen because they help to demonstrate the relationship between sustainable and biophilic design. Though there are many excellent restorative design examples internationally (*cf* examples in Beatley 2011, Kellert et al. 2008, and Sassi 2006), cases were selected from the United States because of the authors' proximity to and experiences with them.

Table 2. Restorative Environmental Design Features of Case Studies

Case Study	Type of Children's Environment	Sustainability features		Biophilic features	
Shining Mountain Waldorf School Boulder, Colorado Barrett Studio Architects	Kindergarten and Primary School	✓	Retrofit of previous kindergarten	✓	Natural materials in construction
		✓	Strawbale construction	✓	Natural materials in curriculum
		✓	Sustainable materials	✓	Natural lighting
		✓	Low embodied energy	✓	Transformability of indoor and outdoor spaces
		✓	Daylighting	✓	Direct exposure to plants, animals, water
Sidwell Friends School Washington, DC KieranTimberlake Architects	Middle School	✓	Local labor	✓	Natural forms and motifs
				✓	Colors from a nature-based palette
				✓	Connection to ecological place
		✓	LEED Platinum	✓	Natural lighting
		✓	Photovoltaics	✓	Diffuse and direct sunlight
		✓	Passive solar	✓	Natural materials
		✓	Solar chimneys	✓	Natural ventilation
		✓	Daylighting	✓	Direct exposure to plants, water
		✓	Sustainable and local materials	✓	Connection to ecological place
		✓	Low embodied energy		
Madison Children's Museum Madison, Wisconsin Kubala Washatko Architects	Children's museum	✓	Constructed wetland		
		✓	Rainwater harvesting		
		✓	Rooftop garden		
		✓	Water efficient landscaping		
		✓	Adaptive reuse	✓	Natural materials in construction
		✓	Sustainable, reused, and local materials	✓	Natural materials in exhibits
		✓	Low embodied energy	✓	Natural lighting
		✓	Photovoltaics	✓	Transformability of indoor and outdoor spaces
		✓	Daylighting	✓	Direct exposure to plants, animals, water
		✓	Green roof	✓	Natural forms and motifs
IslandWood Bainbridge Island, Washington Mithun Architects + Designers + Planners	Outdoor Learning Center	✓	Rainwater collection	✓	Colors from a nature-based palette
		✓	Natural linoleum and recycled wood floorings	✓	Connection to ecological and cultural place
		✓	Non toxic materials (e.g., no or low VOC paints)		
		✓	Local labor		
		✓	LEED Gold	✓	Natural materials in construction
		✓	Recycled wood, tiles, carpets, countertops, rugs	✓	Natural materials in curriculum
		✓	Renewable resources, such as wood, cork, bamboo	✓	Natural lighting
		✓	Strawbale construction	✓	Transformability of indoor and outdoor spaces
		✓	Low embodied energy	✓	Direct exposure to plants, animals, water
		✓	Renewable energy	✓	Natural forms and motifs
		✓	Composting toilets	✓	Colors from a nature-based palette
		✓	Living machine for on-site wastewater treatment	✓	Connection to ecological place

Case Study: Shining Mountain Waldorf School, Boulder, Colorado

Shining Mountain Waldorf School Boulder, Colorado Barrett Studio Architects	Kindergarten and Primary School	✓	Retrofit of previous kindergarten	✓	Natural materials in construction
		✓	Strawbale construction	✓	Natural materials in curriculum
		✓	Sustainable materials	✓	Natural lighting
		✓	Low embodied energy	✓	Transformability of indoor and outdoor spaces
		✓	Daylighting	✓	Direct exposure to plants, animals, water
		✓	Local labor	✓	Natural forms and motifs
				✓	Colors from a nature-based palette
				✓	Connection to ecological place

In *WildPlay*, Sobel quotes an early childhood educator: “At an age when children are really good at running and talking, we ask them to stop doing both” (Sobel 2011). Young children, still developing gross motor skills and language proficiency, are asked to sit still and be quiet for hours at a time in many schools today. This is a design problem as well as a pedagogical one. The mixed age (3-6 years) kindergarten at Shining Mountain Waldorf School is designed to solve both problems.



From Left: Shining Mountain Waldorf School kindergarten showing strawbale addition (Krista Lance), retrofitted entryway (Krista Lance), and truth window (author). Note the dappled light frequently present on the kindergarten grounds and the natural colors on the exterior.

The existing kindergarten was a retrofit and addition to a 1970's temporary “double wide.” The K-12 school contracted Barrett Studio architects in Boulder, Colorado, an award-winning environmental design firm that focuses on organic architecture as well as sustainable design, to assist in the expansion of its kindergarten campus. It was decided that rather than demolish the existing structure, they would add two semi-circular strawbale rooms to either side of the rectangular building. The buildings were constructed with help from the school community (Barrett Studios 2011). Retrofit/additions such as this one achieve the goal of reducing the carbon footprint by minimizing new materials, transportation, and energy costs required with a demolition and re-build. The rectangular space is used for storage, a bathroom, and connecting the two classrooms. The new space, with high thermal mass, low embodied energy, and natural daylighting, provides many energy efficient and biophilic features.

Many of the features of the new additions were developed with input from parents and teachers at Shining Mountain. The Waldorf curriculum, based largely on the philosophies of architect Rudolf Steiner, calls for child-scaled spaces, soft colors, natural materials, and organic forms (Bayes 1994). Natural lighting is softened with silk curtains in soft colors. Ceilings in the coatrooms and play area incorporate wooden beams in a sunbeam pattern that lead to natural skylights. Curved forms and shapes are present throughout the interior as well as exterior: wooden fence lines, arched entryways, curving sidewalks, curved countertops in the kitchen, and curved walls of the

extensions all soften the lines and provide the semi-protected secure spaces young children need (Day 2007).

At Shining Mountain, the curricular goals for the kindergarten are focused on providing a broad sensory experience, movement, and opportunity for imitation of the environment (Oppenheimer 2007). Free play and imaginative play are central to the Waldorf kindergarten (Dolder 2007). Interior and exterior spaces are designed to facilitate free play, with many items coming directly from nature: cypress tree knobs and wood slices are used to develop play sets along with pinecones and wooden animals and people. The classroom is also transformative with wooden balance boards and seesaws, several wooden bridges and arches that can be moved, molded and climbed upon. The exterior environment contains wooden play equipment that leaves much to the imagination. Loose parts are common, with sticks of various sizes, pebbles, leaves, fruiting bushes, and sand all available for children's play. The kindergarten yard includes goat and chicken pens, which are tended by the 3rd grade students, whose classrooms are adjacent to the kindergarten in the lower school yard. Kindergarten food scraps are also used to feed the goats. Kindergarten students also share the lower school playground for their morning walks. Access to this area provides sensory experiences, with the trickle of an ephemeral creek, scented pines, and views of Boulder's foothills as a backdrop.



From Left: Loose wooden pieces for play; wooden tea table; Baskets with wooden and felt play pieces and "loose parts" such as pinecones and branch sections (Shining Mountain Waldorf School)

With two or more hours of the day spent outside, the kindergarten yard provides diverse opportunities for free play. Areas of prospect and refuge abound, and children create games hiding behind bushes and then emerging with a burst of energy. As Day (2007) describes, it is important for young children to feel secure in their settings and yet to have the opportunity to venture out from protected spaces into a wider world. The design of the children's kindergarten yard facilitates this. It is completely enclosed with its short, rounded fence lines, and yet from any point children can see outward. The kindergarten design thus provides layers of refuge: the kindergarten yard itself is a refuge looking out onto the wider school campus, and several hiding and viewing points within the schoolyard provide additional refuge from which to view activities, imagined or real, within the kindergarten. For example, for several weeks in the fall of 2010, a group of kindergarteners used the bushes adjacent to the fence as part of a spider hide-and-seek game. One of the friends pretended to be a "big, scary spider" while the others ran and hid among the bushes. It is these types of refuges that Kirkby (1989) described as important to preschool children, with natural refuges being preferred over those that are built and fixed.



From left: Wooden Play Structures with curved fencing in background and small log for hiding (Shining Mountain Waldorf School); Dappled and varied light, with protected spaces from trees (the author)

The Shining Mountain kindergarten does not contain as many apparent sustainable features as some of the other cases presented herein. Yet it is a wonderful example of doing more with less, which is central to sustainability. Many of the materials in the exterior environment naturally occur. The simplicity of the building retrofit met budgetary constraints and used low-embodied, natural materials and local labor. Nature infuses the curriculum and the design, creating a “life-renewing” environment common to many Waldorf kindergartens (Pearson 1994). Shining Mountain as a whole has adopted an environmental stewardship mission and has created “pack-it-in, pack-it-out” and other initiatives to ultimately result in a zero-waste school. In addition, the school installed its first series of solar panels on the high school in January 2012, which will offset 30% of the high school’s electricity use. At the unveiling of the panels, there was a reading of Mary Oliver’s “The Sun” and a discussion of electricity of grandparents past and generations future (Chandler 2012). These are two of the actions that the school has planned to move toward a school that sustains and restores the natural systems on which it relies (Shining Mountain 2011).

Case Study: Sidwell Friends School, Washington D.C. Architect: KieranTimberlake Architects

Sidwell Friends School Washington, DC KieranTimberlake Architects	Middle School	✓	LEED Platinum	✓	Natural lighting
		✓	Photovoltaics	✓	Diffuse and direct sunlight
		✓	Passive solar	✓	Natural materials
		✓	Solar chimneys	✓	Natural ventilation
		✓	Daylighting	✓	Direct exposure to plants, water
		✓	Sustainable and local materials	✓	Connection to ecological place
		✓	Low embodied energy		
		✓	Constructed wetland		
		✓	Rainwater harvesting		
		✓	Rooftop garden		
		✓	Water efficient landscaping		

Sidwell Friends School is a private school based in Washington, D.C. Six of its buildings are constructed with sustainable design features: a lower school addition, a lower school gym, the administrative building, an athletic center, a meeting house and arts facility, and the middle school. The middle school building was completed in 2006, and received a LEED Platinum rating as well as other awards, including the American Institute of Architects Top 10 Green Projects in 2007, and was built with many restorative environmental design features (Table 2).



From Left: Middle School Building showing natural materials and linkages between indoors and out (Ana L. Ka'ahanui); Constructed Wetland (Anne Mandelbaum); Interior Hallway with abundant natural light (Beverly Schaefer); Library with natural materials and light (Beverly Schaefer)

Of particular interest with this school is the use of systems, such as the constructed wetland and a green roof, that also provide local habitat for plants and animals. The constructed wetland is used to treat all wastewater from the middle school, which is then used for toilets. This synergy, when natural systems meet sustainability objectives and also provide opportunities for people to connect with nature, is at the heart of restorative environmental design. The combination of the constructed wetland with appropriate landscaping and green roof provides habitat for numerous plants and animals. Because of the variety of habitats provided, Sidwell developed a wildlife sighting page on its website, with more than 35 postings of at least 16 species of birds, mammals, reptiles, and invertebrates listed by students, teachers, and staff of the school (Sidwell Friends School 2011). These sightings provide an important ecological connection to the school's environment, and help students to understand that the built environment is part of a larger ecological system, both urban and natural.

While many of the design features of Sidwell Friends focus on systems and building function, a few also affect the interior building: natural daylighting and natural ventilation, as well as connection between the interior and exterior environments through visual, physical and material experiences of place. Recent reviews of school environments support the correlation between daylighting and school performance (Bosch 2004, Uline and Tschannen-Moran 2008, Woolner et al. 2007). The abundance of natural lighting featured in Sidwell Friends School increases energy efficiency while also potentially contributing to academic performance. In contrast, schools with poor air quality and ambient noise negatively impact performance, participation, and satisfaction (Bosch 2004, Uline and Tschannen-Moran 2008, Woolner et al. 2007). The positive attention given to daylighting at Sidwell Friends thus helps to prevent potentially negative influences on learning.

Uline and Tschannen-Moran (2008) also found that aesthetics can foster a sense of connection and generate positive attitudes toward learning. Cosmetic features, such as absence of graffiti or fresh paint, contribute to positive associations with schools. Importantly for biophilic design, pathways and positive outdoor space, also present at Sidwell Friends School, are positively correlated with performance outcomes (Woolner et al. 2007). Pathways that provide a sense of enticement and intrigue are an attribute of biophilic design (Heerwagen and Gregory 2008). The design of these pathways can provide a sense of security important for students overall sense of well-being (Uline and Tschannen-Moran 2008). The connection between interior and exterior environments designed into the school at many levels provides an important aesthetic design feature as well as a connection to the ecological world. One of the wildlife sightings was listed by two students from their classroom. They spotted a pair of crows building a nest in a willow oak near the wetland. These connections between the interior and exterior cultivate connections to the place where

students live and further their understanding of their relation to a larger world. Some also consider the naming of species an important component in developing care toward the environment (*cf* Basso 1996, Nabhan and Trimble 1995).

Beatley (2011) defines a biophilic school as one that connects students to the natural world through the physical environment as well as its pedagogy and curriculum. Sidwell Friends School infuses environmental subjects into its curriculum in a variety of ways. There are middle school advisory projects that provide participatory learning opportunities for students on subjects such as stormwater runoff or recycling. Students also participate in environmental assessments of Washington, D.C. The 8th grade curriculum includes ecology and environmental science, readings of environmental action, and carbon footprint calculations. In the fall of 2011, the 7th and 8th grades also participated in their first BioBlitz. From the trees to the ground below, students searched for a diversity of creatures. The 8th graders have also conducted a pollinator survey for the sixth consecutive year. Working with the US Geological Survey in survey protocols and identification, they have found the greatest concentration and diversity of bees in the constructed wetland and green roof. In the 2011 survey, the team found more than 68 species of bee on campus, of which 12 had never before been recorded within the city (Hardenbergh 2011, Sidwell Friends 2011).

Case Study: Madison Children's Museum, Madison, Wisconsin

Madison Children's Museum Madison, Wisconsin Kubala Washatko Architects	Children's museum	✓	Adaptive reuse	✓	Natural materials in construction
		✓	Sustainable, reused, and local materials	✓	Natural materials in exhibits
		✓	Low embodied energy	✓	Natural lighting
		✓	Photovoltaics	✓	Transformability of indoor and outdoor spaces
		✓	Daylighting	✓	Direct exposure to plants, animals, water
		✓	Green roof	✓	Natural forms and motifs
		✓	Rainwater collection	✓	Colors from a nature-based palette
		✓	Natural linoleum and recycled wood floorings	✓	Connection to ecological and cultural place
		✓	Non toxic materials (e.g., no or low VOC paints)		
		✓	Local labor		

The Madison Children's Museum embraced the philosophy that "the greenest building is one that already exists" (MCM 2010) through its playful and adaptive reuse of the former Montgomery Ward's department building in downtown Madison. Ready access to public transportation was a factor in initially choosing the site, to facilitate access and alternative transportation. While the retrofit was completed in 2010, sustainability and toxin-free exhibitry have been part of the museum's guidelines since 1996. Attention to the potential toxicity of materials is particularly significant for a children's museum. Young children touch more surfaces and have greater hand-to-mouth exchanges than any other sector of the population. This places them at much higher risk for exposure to toxic environments (Steingraber 2011, Wargo 2010). Children's museums by design provide an environment for children to engage with materials, further magnifying the potential exposure to hazardous chemicals if present in the environment.

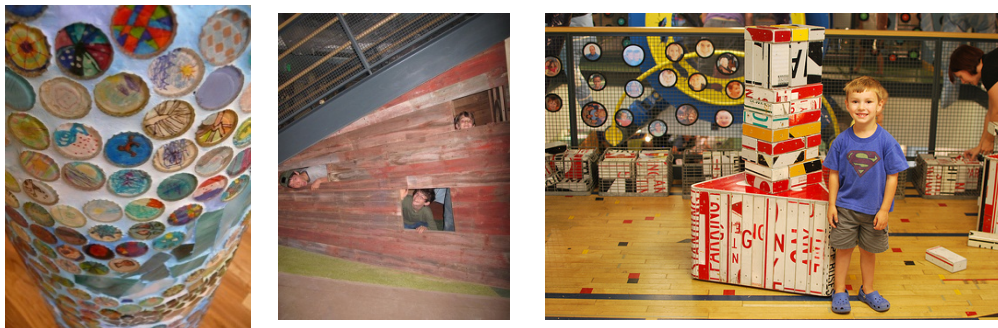
The Madison Children's Museum built on their existing principles of sustainability and toxin-free exhibitry for the department store retrofit by striving to use the least amount of resources and finding creative ways to rebuild and recycle materials. In addition to the adaptive reuse of the department store, they also restored and relocated an 1830's log cabin located to the property. Among the sustainability features are use of wind and photovoltaics for energy production; use of natural, non-toxic, and locally harvested materials, such as a recycled gymnasium flooring from a Milwaukee school; and rainwater harvesting on the rooftop garden. As much as possible, the

museum also sourced materials and labor entirely from Wisconsin and primarily in close proximity or within the city limits. Many of the exhibits also embrace the ideas of reuse and recycling, such as the “Hodgepodge Mahal,” a recycled and repurposed slide and climbing structure made from various “found objects;” a “Refab Lab” containing building blocks and tables made from old street signs; and a mosaic column decorated with bottle caps, broken glass, and found objects by more than 13,000 children. A “solar chicken” on the rooftop garden made from scrap metal uses solar energy to “lay” an egg in order to teach about the sun’s potential for energy production. Similarly, a rooftop wind turbine was constructed from recycled bicycle parts and uses its energy to pump rainwater. These examples all embrace the idea of “architecture as pedagogy” proposed by David Orr (1999). Simple, visible, easily understood exhibits and functional design all help visitors understand the museum’s mission of sustainability. This is further developed through the museum’s “green scavenger hunt:” a self-directed tour of various exhibits with background about the design and function of various “green” exhibits and features (MCM 2010).



From Left: Images from “The Rooftop Ramble:” pond (Tsela Barr), chickens (Erin Moore) and chicken coop (MCM Marketing), dancing on the roof (Ruth Shelly), and acorn climber (Amy Mertz).

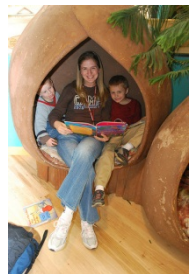
The museum also weaves many biophilic features into its exhibitry and design. Children experience nature directly through the rooftop garden, which features a child-scaled chicken coop, green archway and gardens, pond and rainwater harvesting system, and animal clubhouse with native animals fed from locally harvested foods. The rainwater harvesting system is transparent and easily understood even by young children. The building itself provides many forms of natural lighting as well as natural ventilation. Use of many types of natural materials and colors soften the interior spaces as well: earthen pods for climbing or hiding inside, live plants, chairs and climbing structures from recycled wood, stone and wood flooring and details, colorful hanging butterflies, a tree trunk slide, and a climbing structure modeled after animal rib bones, all provide myriad types of indirect interaction with natural materials and forms. In addition, the museum fosters



From left: Mosaic column detail with patterned wholes (MCM Marketing); Squashed house with reclaimed and natural materials (Tsela Barr); Boy with his sculpture of recycled signs and recycled flooring in the Refab Lab (Dave Martin).

connection to ecological and cultural place through a mural of downtown Madison through the four seasons, educational use of the historic log cabin, views of the downtown from the rooftop garden, “barn boards” constructed from two fallen Wisconsin barns, and local materials such as locally harvested tree cross sections affixed to an entire wall. Benches throughout the museum were hand-crafted by University of Wisconsin-Madison woodworking students (MCM 2010).

The “Wilderness” is an interactive exhibit designed for children under age 5, with abundant day light, colors from a nature-based palette, circular forms, and cubbies filled with loose parts from nature. Willow furniture, tree motifs and natural log supports, and a variety of earthen “homes” are available for children to climb through and nestle into. Similarly the art studio organizes materials in woven baskets, provides natural lighting, curved walls, and wooden seating and flooring. Natural materials are available for child-driven artistic creations. Most children’s museums are designed to be transformable. The Madison Children’s Museum is perhaps unique in its use of natural materials to foster children’s transformations and interactions with space.



From left: Rooftop Ramble: a) A girl listening to the rooftop Aeolian harp (Dave Martin) and b) rooftop mural depicting downtown Madison (MCM Marketing); Wilderness: a) water dome with natural light, natural forms, and indoor plantings (Ruth Shelly), b) wooden slide of natural wood and form (Dave Martin), and c) nesting huts of natural materials and forms (Dave Martin).

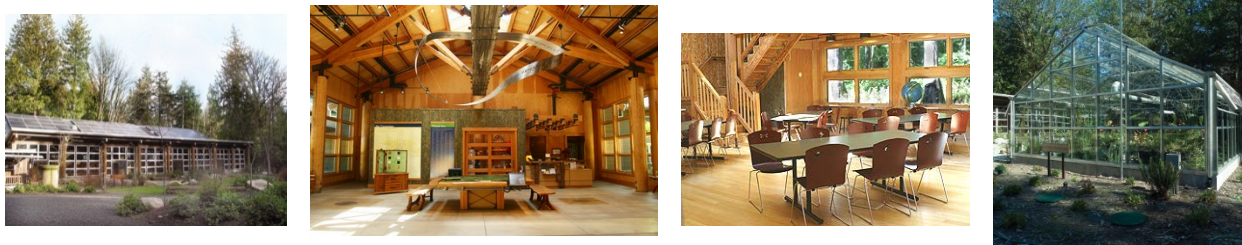
It is not common to find an urban retrofit of a department store that also successfully incorporates many biophilic features. The Madison Children’s Museum was able to do both through its ideas of local sourcing, found materials from nearby nature, and understanding and enhancing their local ecology and history. Because so many of the features are incorporated from Wisconsin materials, the museum also helps foster the idea that people, the urban environment, and nature all fit together through a complex web of design found in the museum.

Case Study: IslandWood, Bainbridge Island, Washington

IslandWood Bainbridge Island, Washington Mithun Architects + Designers + Planners	Outdoor	✓	LEED Gold	✓	Natural materials in
	Learning Center	✓	Recycled materials including	✓	construction
		✓	wood, tiles, carpets, rugs, tires	✓	Natural materials in curriculum
		✓	Renewable resources, such as	✓	Natural lighting
		✓	wood, cork, bamboo	✓	Transformability of indoor and
		✓	Strawbale construction	✓	outdoor spaces
		✓	Low embodied energy	✓	Direct exposure to plants,
		✓	Renewable energy	✓	animals, water
		✓	Rainwater harvesting	✓	Natural forms and motifs
✓	Composting toilets	✓	Colors from a nature-based		
		✓	Living machine for on-site	✓	palette
		✓	wastewater treatment	✓	Connection to ecological place

Located on Bainbridge Island, off the coast of Seattle, Washington, the 255 acre outdoor learning center IslandWood fosters experiential learning and showcases sustainable practices through its building design and creative use of a variety of renewable resources. Because of its location and

organizational mission to “inspire lifelong environmental and community stewardship,” it embodies biophilic design as well.



From Left: Learning Studios with photovoltaics on roof, rainwater cisterns, views of nature and natural lighting (IslandWood), Welcome Center with abundant natural materials and natural light (Kelli Breeton-Fairall), Interior space featuring natural materials and light (IslandWood), and Living Machine for wastewater treatment and water reuse in toilets and irrigation (IslandWood).

The entire campus is devoted to sustainability, with many buildings or even classrooms highlighting a different approach to sustainable design or resource re-use. Buildings are constructed with a variety of materials, including strawbale, salvaged wood, and locally harvested wood from the property. Interiors are built with a variety of recycled materials. In the educational studios, each of the classrooms features a different renewable or recycled resource, such as cork, bamboo or recycled concrete. Natural lighting and ventilation are incorporated into all the buildings. In addition, the campus includes solar meadows, aiding the photovoltaics for energy production; solar panels for pre-heating water; and a Living Machine with constructed wetlands that treats wastewater on-site (IslandWood 2011). While these features contribute to the sustainability of the site, they also largely work with natural materials and processes, thus providing an excellent example of restorative environmental design.



From Left: Tree House (Jim Stewart), Fireplace with geological layering (Bill Finnegan), Fish tile (Jim Stewart), and the outdoor Learning Tree classroom (IslandWood)

Biophilic features include the extensive use of natural materials, natural forms and motifs, and direct exposure to nature. Natural forms and motifs are incorporated throughout building interiors, such as a fireplace that mimics the geological layering of sediments, with a 500 million year old nautilus embedded in it; fish motifs in bathrooms, reminding visitors that all water eventually goes back to nature; and bunk beds and ladders from hand carved wood. Window nooks are included in the bunks of sleeping lodges, allowing natural lighting as well as a direct experience of nature and night sky-watching. A stand-alone tree house overlooks a bog on the campus. Children participated in the design of this playful building. One of the interactive features of the tree house is window portals that allow children to reach out and touch tree branches outside the

house. Because so many features are local and natural, the entire campus evokes the spirit of place that is also an important component of biophilic design (Kellert 2008).

Curricula and programs foster a connection to cultural as well as ecological place, providing a history of land use from Native American to European settlement. In addition to more traditional outdoor learning, students learn to compost their food, weighing it each meal to quantify the waste, and measure and identify sounds on the campus. The construction of the Learning Tree outdoor classroom provides a more accessible tree house for people with disabilities. While much of the experience at IslandWood occurs directly in nature, the building design bridges the indoors and outdoors seamlessly.



From Left: Bird Blind of natural materials, Compost Lesson, and Owl Lesson in the Learning Tree outdoor classroom (All photographs courtesy of IslandWood)

Conclusion

As these case studies show, there are a variety of ways to implement restorative environmental design. Each case responds to its unique site conditions, local history and ecology, and needs and interests of the users, yet each fosters a rich connection to nature through the design of both interior and exterior spaces. These cases also demonstrate how restorative environmental design works best when it bridges low-impact features and technologies with the larger ecological system of which each building is a part. This integrity of design fosters in children a direct connection to place and the larger ecological world. By bringing low-impact technologies together with design that celebrates nature, restorative environmental design has the potential to address the environmental needs for sustainability with the equally important need to reconnect children to nature through their daily lives. Many children who have experienced the restorative environments of these case studies respond positively to them. One kindergarten child at Shining Mountain has told visitors that “my school is the best” because of the freedom of play it affords. Students at Sidwell Friends School have expressed a sense of pride and intrigue in some of the specific design elements, such as using recycled wine barrels, in the construction of their school. Their stories suggest that these environments may indeed foster a more sophisticated understanding of the natural world and its processes, to greater or lesser degrees of consciousness. Future research with children, teachers, and families will help to verify the significance of these impacts.

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