

## **Patterns in Nature: Why We Need Them in the Built Environment**

<https://www.terramai.com/blog/patterns-in-nature-and-built-environment/>

Patterns are everywhere in nature. The natural patterns found in nature deeply affect and nurture us. They are imprinted in our physiological-cognitive system and when we spend time in environments devoid of natural patterns, it leads to anxiety and stress which in the short-term hampers productivity but in the long term can lead to illness.

## **The Impact of Biophilic Learning Spaces on Student Success**

[https://www.hcm2.com/wp-content/uploads/AIA-Biophilic-Design-Research\\_The-Impact-of-Biophilic-Learning-Spaces-on-Student-Success.pdf](https://www.hcm2.com/wp-content/uploads/AIA-Biophilic-Design-Research_The-Impact-of-Biophilic-Learning-Spaces-on-Student-Success.pdf)

Study examines to what extent the design of the physical learning space, enhanced with biophilic design, contributes to student stress reduction and improved learning outcomes for a middle school Math class at a public charter school in West Baltimore.

## **Greening for academic achievement: Prioritizing what to plant and where**

<https://www.sciencedirect.com/science/article/pii/S0169204620314456>

Converging evidence from hundreds of studies suggests that contact with nature enhances learning in elementary and high school students -- could greening in and around schoolyards improve academic achievement in sixth grade students, many of whom are negotiating the transition from elementary to middle school? This study examines the greenness-academic achievement relationship in 450 public schools in Washington State using two different measures of greenness (tree canopy cover and total green cover as assessed via NDVI), at two different scales (250m and 1000m radial buffers around a school), with two different measures of school achievement (the percentage of students meeting or exceeding state standards in reading and math). Six of eight spatial error models showed statistically significant, positive relationships between school greenness and achievement in sixth-graders – tree canopy within 250m of a school predicted better performance in both reading and math, as did total greenness within 250m, and tree canopy within 1000m – even after controlling for 17 potential confounders, including student characteristics, school resources, size, and location. Further analyses suggest that the greenness-achievement ties are primarily driven by the tree cover within 250m, planting trees within 250m might maximize any effect on achievement.

### **Autonomic Nervous System Responses to Viewing Green and Built Settings: Differentiating Between Sympathetic and Parasympathetic Activity**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4690962/pdf/ijerph-12-15026.pdf>

This study compares the benefits of looking at nature through windows and looking at photos of nature. The benefits are comparable.

### **The Restorative Benefits of Nature: Toward an Integrative Framework**

[http://willsull.net/la270/LA\\_270\\_Readings/LA\\_270\\_Readings\\_files/Kaplan%201995.pdf](http://willsull.net/la270/LA_270_Readings/LA_270_Readings_files/Kaplan%201995.pdf)

Directed attention plays an important role in human information processing; its fatigue, in turn, has far reaching consequences. Attention Restoration Theory provides an analysis of the kinds of experiences that lead to recovery from such fatigue. Natural environments turn out to be particularly rich in the characteristics necessary for restorative experiences. An integrative framework is proposed that places both directed attention and stress in the larger context of human-environment relationships.

### **Kids and Classrooms: Why Environment Matters**

<https://www.psychologytoday.com/us/blog/the-athletes-way/201601/kids-and-classrooms-why-environment-matters>

In his seminal 1958 book, *The Poetics of Space*, Gaston Bachelard identifies the importance of architectural design—as well as the surrounding landscapes and infrastructure of buildings—on the human psyche. Bachelard contends that our minds thrive in spaces that allow us to daydream and stagnate in spaces that are depressing or oppressive.

### **The Cognitive Benefits of Interacting With Nature**

[https://www.researchgate.net/publication/23718837\\_The\\_Cognitive\\_Benefits\\_of\\_Interacting\\_With\\_Nature](https://www.researchgate.net/publication/23718837_The_Cognitive_Benefits_of_Interacting_With_Nature)

We compare the restorative effects on cognitive functioning of interactions with natural versus urban environments. Attention restoration theory (ART) provides an analysis of the kinds of environments that lead to improvements in directed-attention abilities. Nature, which is filled with intriguing stimuli, modestly grabs attention in a bottom-up fashion, allowing top-down directed-attention abilities a chance to replenish. Unlike natural environments, urban environments are filled with stimulation that captures attention dramatically and additionally requires directed attention (e.g.,

to avoid being hit by a car), making them less restorative. We present two experiments that show that walking in nature or viewing pictures of nature can improve directed-attention abilities as measured with a backwards digit-span task and the Attention Network Task, thus validating attention restoration theory.

### **Do Experiences With Nature Promote Learning? Converging Evidence of a Cause-and- Effect Relationship**

<https://www.frontiersin.org/articles/10.3389/fpsyg.2019.00305/full>

Nature may promote learning by improving learners' attention, levels of stress, self-discipline, interest and enjoyment in learning, and physical activity and fitness. Nature also appears to provide a calmer, quieter, safer context for learning; a warmer, more cooperative context for learning; and a combination of "loose parts" and autonomy that fosters developmentally beneficial forms of play. It is time to take nature seriously as a resource for learning - particularly for students not effectively reached by traditional instruction.

### **Might School Performance Grow on Trees? Examining the Link Between "Greenness" and Academic Achievement in Urban, High-Poverty Schools**

<https://www.frontiersin.org/articles/10.3389/fpsyg.2018.01669/full>

School greenness predicted math achievement when neighborhood greenness was controlled for, but neighborhood greenness did not significantly predict either reading or math achievement when school greenness was taken into account. Future research should assess whether greening schoolyards boost school performance

### **Classrooms With Nature Views: Evidence of Differing Student Perceptions and Behaviors**

<https://journals.sagepub.com/doi/abs/10.1177/0013916513499583?journalCode=eba&>

The current study examines differences across multiple sections of a college writing course in two types of identically designed classrooms—those with a view of a natural setting and those with a view of a concrete retaining wall. Results showed that students in the natural view classrooms were generally more positive when rating the course. Students in the natural view condition also had higher end of semester grades, but no differences in attendance were observed between conditions. Such findings suggest that classrooms with natural views offer advantages and also

suggest that the inclusion of natural elements in courses could facilitate positive perceptions and better grades.

### **School Green Space and Its Impact on Academic Performance:**

A Systematic Literature Review

<https://pubmed.ncbi.nlm.nih.gov/30717301/>

Scholars and policymakers have criticized public education in developed countries for perpetuating health and income disparities. Several studies have examined the ties between green space and academic performance, hypothesizing that green space can foster performance, and, over time, help reduce such disparities.

### **Green urban landscapes and school-level academic performance**

<https://www.childrenandnature.org/research/higher-levels-of-tree-canopy-are-linked-to-higher-school-level-reading-test-scores/>

This study explored relationships between environmental variables (tree cover, vegetated land covers, water) on and around school grounds in an urban area and school-level academic performance. Schools with higher levels of tree canopy tended to have higher reading test scores, lending support for increasing tree cover around schools as a way to improve academic success.

### **Do Lessons in Nature Boost Subsequent Classroom Engagement? Refueling Students in Flight**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5758746/>

Teachers wishing to offer lessons in nature may hold back for fear of leaving students keyed up and unable to concentrate in subsequent, indoor lessons. This study tested the hypothesis that lessons in nature have positive—not negative—aftereffects on subsequent classroom engagement.

### **Impact of Particulate Matter Exposure and Surrounding “Greenness” on Chronic Absenteeism in Massachusetts Public Schools**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5334761/>

Chronic absenteeism is associated with poorer academic performance and higher attrition in kindergarten to 12th grade (K-12) schools. In prior research, students who were chronically absent generally had fewer employment opportunities and worse

health after graduation. We examined the impact that environmental factors surrounding schools have on chronic absenteeism.

### **Are young children's utterances affected by characteristics of their learning environments? A multiple case study**

<https://www.tandfonline.com/doi/abs/10.1080/03004430.2016.1211116>

Do experiences with nature – from wilderness backpacking to plants in a preschool, to a wetland lesson on frogs—promote learning? Until recently, claims outstripped evidence on this question. But the field has matured, not only substantiating previously unwarranted claims but deepening our understanding of the cause-and-effect relationship between nature and learning. Hundreds of studies now bear on this question, and converging evidence strongly suggests that experiences of nature boost academic learning, personal development, and environmental stewardship.

### **Tree cover and species composition effects on academic performance of primary school students**

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0193254>

Academic performance data from over 300 schools was examined in relation to tree cover, tree diversity, and tree species around the schools. Findings support previously- documented associations between academic performance and “greenness,” but also found tree cover to be a more pronounced predictor of academic performance than other vegetation types, especially for schools with the highest level of external challenges.

### **Impact of views to school landscapes on recovery from stress and mental fatigue**

<https://aslathedirt.files.wordpress.com/2016/01/li-sullivan.pdf>

Results demonstrate that classroom views to green landscapes cause significantly better performance on tests of attention and increase student's recovery from stressful experiences. A lack of mediation effect demonstrates that attention restoration and stress recovery are two distinct processes

## **Using functional Magnetic Resonance Imaging (fMRI) to analyze brain region activity when viewing landscapes**

<https://www.sciencedirect.com/science/article/pii/S0169204617300300>

Over the years, the restorative benefits of the natural environment have been taken seriously. These restorative effects continue to be verified in research from both the psychological and physiological perspectives. The latest functional magnetic resonance imaging (fMRI) technology provides an opportunity to further explore the psychophysiological aspects of these benefits from the natural environment.

## **Human brain activation in response to visual stimulation with rural and urban scenery pictures: a functional magnetic resonance imaging study.**

<https://www.semanticscholar.org/paper/Human-brain-activation-in-response-to-visual-with-a-Kim-Jeong/10de84b6c4d3ef6b011510dc87e1e955c19d0bba>

Human brain activation was assessed in terms of eco-friendliness while viewing still photographs depicting rural and urban surrounding environments with the use of a functional magnetic resonance imaging technique

## **Neural Bases on Cognitive Aspect of Landscape Evaluation: A Study Using Functional Magnetic Resonance Imaging**

<http://www.jneuro.com/neurology-neuroscience/neural-bases-on-cognitive-aspect-of-landscape-evaluation-a-study-using-functional-magnetic-resonance-imaging.php?aid=23244>

Using functional magnetic resonance imaging (fMRI), we show that two kinds of landscape pictures, Japanese traditional architecture/ nature images (JTANs) and modern cityscapes (MCs), have distinct effects on human brain activation. While participants viewed pictures of the above-mentioned landscapes, their brain activity was more prominent in the dorsal than the ventral visual pathway, and activation in the right precuneus was evident during the viewing of the JTAN pictures. Moreover, the cerebellum and hippocampus were activated during the viewing of unpleasant MC pictures. Conclusion: Our results suggest that the dorsal pathway and the right precuneus play important roles in scenery evaluation, while the ventral pathway and the left lingual gyrus are involved in unpleasant emotion generation.

## **Nature's Relationships: Fractals and Forests**

<http://www.freshvista.com/2018/natures-relationships-fractals-and-forests/>

Fractals are Nature's geometric images. They are described as "self-similar" because they are endless inclusions of similar patterns within similar patterns, systems within systems.

## **Benefits of Nature Contact for Children**

<https://journals.sagepub.com/doi/abs/10.1177/0885412215595441?journalCode=jplb>

This review examines different ways that contact with nature can contribute to the health and well-being of children. Applying the capabilities approach to human development for a broad definition of well-being, it traces research from the 1970s to the present, following shifting research approaches that investigate different dimensions of health. A compelling body of evidence exists that trees and natural areas are essential elements of healthy communities for children. They need to be integrated at multiple scales, from landscaping around homes, schools, and childcare centers, to linked systems of urban trails, greenways, parks, and "rough ground" for children's creative play.

## **A green view through a classroom window can improve students' performance**

<https://www.sciencedaily.com/releases/2016/01/160122170932.htm>

High school students perform better on tests if they are in a classroom with a view of a green landscape, rather than a windowless room or a room with a view of built space, according to new research.

## **Being raised in greener neighborhoods may have beneficial effects on brain development**

<https://www.sciencedaily.com/releases/2018/02/180223100626.htm>

A new study shows for the first time that exposure to green space during childhood is associated with beneficial structural changes in the developing brain.

## **Inclusion With Nature: The Psychology of Human-Nature Relations**

[https://cdn.naaee.org/system/files/harmony/files/schultz\\_nature\\_connectedness.pdf](https://cdn.naaee.org/system/files/harmony/files/schultz_nature_connectedness.pdf)

Human survival is directly tied to our relationship with the natural environment. Achieving a sustainable lifestyle depends on establishing a balance between the consumption of individuals, and the capacity of the natural environment for renewal.

Yet, we often act as if we are separate from nature - as if we can get along without nature. Indeed, built environments serve as barriers between individuals and the natural environments in which they live.

### **Research Shows a Walk in the Park Improves Attention in Children with ADHD**

<https://aces.illinois.edu/news/research-shows-walk-park-improves-attention-children-adhd-0>

A study conducted at the University of Illinois shows that children with ADHD demonstrate greater attention after a 20-minute walk in a park than after a similar walk in a downtown area or a residential neighborhood.

### **Being around trees and other greenery may help teens stave off depression**

[https://www.washingtonpost.com/national/health-science/study-being-around-trees-and-other-greenery-may-help-teens-stave-off-depression/2018/01/19/252df102-fc92-11e7-ad8c-ecbb62019393\\_story.html](https://www.washingtonpost.com/national/health-science/study-being-around-trees-and-other-greenery-may-help-teens-stave-off-depression/2018/01/19/252df102-fc92-11e7-ad8c-ecbb62019393_story.html)

Exposure to trees and other greenery has been shown to stave off depression in adults, and a new study finds the same may be true for teenagers.

### **Using Smartphone Technologies to Investigate the Impact of Nature on Mental Well-Being in Real Time**

<https://academic.oup.com/bioscience/article/68/2/134/4791430>

Existing evidence on the beneficial effects of nature on mental health comes from studies using cross-sectional designs. We developed a smartphone-based tool (Urban Mind; [www.urbanmind.info](http://www.urbanmind.info)) to examine how exposure to natural features within the built environment affects mental well-being in real time.

### **The Key to Better Students Is Getting Them Outside**

<https://www.outsideonline.com/2150116/best-schools-teach-more-science-and-math>

The best schools know that kids learn when their noses aren't shoved in textbooks all the time



## **What are the Benefits of Interacting with Nature?**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3709294/>

There is mounting empirical evidence that interacting with nature delivers measurable benefits to people. Reviews of this topic have generally focused on a specific type of benefit, been limited to a single discipline, or covered the benefits delivered from a particular type of interaction. Here we construct novel typologies of the settings, interactions and potential benefits of people-nature experiences, and use these to organize an assessment of the benefits of interacting with nature.

## **The Nature of Americans**

<https://natureofamericans.org>

Foundations to these recommendations is the core premise that connection to nature is not a dispensable amenity but, rather, is essential to the quality of life, health, social well-being, prosperity, and productivity of all Americans.

## **Forest Bathing: A Retreat To Nature Can Boost Immunity And Mood**

<https://www.npr.org/sections/health-shots/2017/07/17/536676954/forest-bathing-a-retreat-to-nature-can-boost-immunity-and-mood?sc=tw?sc=tw>

The aim of forest bathing, Choukas-Bradley explained, is to slow down and become immersed in the natural environment.

## **A Dose-Response Curve Describing the Relationship Between Urban Tree Cover Density and Self-Reported Stress Recovery**

<https://journals.sagepub.com/doi/abs/10.1177/0013916514552321>

These findings suggest that viewing tree canopy in communities can significantly aid stress recovery and that every tree matters.

## **What are the merits of a tree canopy?**

<https://theapopkavoice.com/merits-tree-canopy/>

An urban tree canopy is not just the area that contains the tree but also includes the area that the tree overhangs to provide shade and protection. Trees provide many benefits to the community from environmental to economic to aesthetic.

## **Green Mind Theory: How Brain-Body-Behavior Links into Natural and Social Environments for Healthy Habits**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5551144/>

We propose a Green Mind Theory (GMT) to link the human mind with the brain and body and connect the body into natural and social environments.

## **Wild and free: Unpredictability and spaciousness as predictors of creative performance**

[https://www.childrenandnature.org/research/certain-features-of-nature-imagery-can-promote-creativity-in-](https://www.childrenandnature.org/research/certain-features-of-nature-imagery-can-promote-creativity-in-individuals/?utm_source=Research+Digest+January+2017&utm_campaign=Jan2017+Research+Digest&utm_medium=email)

[individuals/?utm\\_source=Research+Digest+January+2017&utm\\_campaign=Jan2017+Research+Digest&utm\\_medium=email](https://www.childrenandnature.org/research/certain-features-of-nature-imagery-can-promote-creativity-in-individuals/?utm_source=Research+Digest+January+2017&utm_campaign=Jan2017+Research+Digest&utm_medium=email)

Certain features of nature imagery can promote creativity in individuals

## **How to Protect Kids from Nature-Deficit Disorder**

[https://greatergood.berkeley.edu/article/item/how\\_to\\_protect\\_kids\\_from\\_nature\\_deficit\\_disorder?utm\\_source=GG+Newsletter+Sept+21%25252C+2016&utm\\_campaign=GG+Newsletter+Sept+21+2016+&utm\\_medium=email](https://greatergood.berkeley.edu/article/item/how_to_protect_kids_from_nature_deficit_disorder?utm_source=GG+Newsletter+Sept+21%25252C+2016&utm_campaign=GG+Newsletter+Sept+21+2016+&utm_medium=email)

Today's kids spend less and less time outdoors, and it's taking a toll on their health and well-being. Research has shown that children do better physically and emotionally when they are in green spaces, benefiting from the positive feelings, stress reduction, and attention restoration nature engenders.

## **Nurturing Children's Biophilia: Developmentally Appropriate Environmental Education for Young Children**

<https://www.whitehutchinson.com/children/articles/nurturing.shtml>

Schools, early childhood educators and teachers need to free themselves from the paradigm of giving children indoor play and learning and manufactured outdoor playgrounds and instead allow children to reclaim the magic that is their birthright—the ability to play and learn outdoors in intimate daily contact with wild and varied nature through exploration, discovery and the power of their imaginations. It is only through such positive experiences in outdoor nature that children will develop their love of nature and a desire to protect it for their future and later generations.

### **Benefits of Nature Contact for Children**

<https://journals.sagepub.com/doi/abs/10.1177/0885412215595441>

This review examines different ways that contact with nature can contribute to the health and well-being of children. Applying the capabilities approach to human development for a broad definition of well-being, it traces research from the 1970s to the present, following shifting research approaches that investigate different dimensions of health. A compelling body of evidence exists that trees and natural areas are essential elements of healthy communities for children.

### **At Home with Nature: Effects of "Greenness" on Children's Cognitive Functioning**

<https://journals.sagepub.com/doi/abs/10.1177/00139160021972793>

The nearby natural environment plays a far more significant role in the well-being of children residing in poor urban environments than has previously been recognized. Using a premove/postmove longitudinal design, this research rules out the effects of various extraneous variables that have plagued previous studies and explores the linkage between the naturalness or restorativeness of the home environment and the cognitive functioning of low-income urban children. Both before and after relocation, objective measures of naturalness are employed along with a standardized instrument measuring the children's cognitive functioning. Results indicate that children whose homes improved the most in terms of greenness following relocation also tended to have the highest levels of cognitive functioning following the move.

### **Green spaces and cognitive development in primary schoolchildren**

<https://www.pnas.org/content/112/26/7937>

Exposure to green space has been associated with better physical and mental health. Although this exposure could also influence cognitive development in children, available epidemiological evidence on such an impact is scarce. This study aimed to assess the association between exposure to green space and measures of cognitive development in primary schoolchildren. Our study showed a beneficial association between exposure to green space and cognitive development among schoolchildren that was partly mediated by reduction in exposure to air pollution.

## **How Walking in Nature Changes the Brain**

<https://well.blogs.nytimes.com/2015/07/22/how-nature-changes-the-brain/?smid=li-share&r=1>

A walk in the park may soothe the mind and, in the process, change the workings of our brains in ways that improve our mental health, according to an interesting new study of the physical effects on the brain of visiting nature.

## **Measuring connectedness to nature in preschool children in an urban setting and its relation to psychological functioning**

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0207057>

The urban environment has been criticized for promoting 'nature-deficit' and 'child-nature disconnectedness'. Keeping in mind the importance of nature exposure and its extensive health benefits, many environmental programs around the world hope to (re)connect children with nature. To evaluate the effectiveness of such efforts, valid tools to measure Connectedness to Nature (CN) are needed but do not exist today, especially for use with preschoolers.

## **How Nature Makes Us Healthier and Happier**

<https://www.yesmagazine.org/health-happiness/2017/03/13/what-happens-when-we-reconnect-with-nature/>

Viewing natural beauty (in the form of landscape paintings and video, at least) activates specific reward circuits in the brain associated with dopamine release that give us a sense of purpose, joy, and energy to pursue our goals

## **Additional Research is Available Through the Following Libraries:**

### **Children & Nature Network:**

[https://www.childrenandnature.org/learn/research/?utm\\_source=Research+Digest+December+2017&utm\\_campaign=October2017+Research+Digest&utm\\_medium=email](https://www.childrenandnature.org/learn/research/?utm_source=Research+Digest+December+2017&utm_campaign=October2017+Research+Digest&utm_medium=email)

### **North American Association of Environmental Educators:**

<https://naaee.org/eeepro/research/library>