

Living Walls



Communicating the aesthetic, environmental, productivity and health benefits of plants in the built environment.

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Living Walls

Living walls have been around for thousands of years. Ferns, vines, shrubs and trees naturally take hold and grow in the crevices and pockets of cliffs and waterfalls. They are frequently found growing between the mortar of brick and stone walls. The ancient Gardens of Babylon featured green walls. And more recently living walls have become popular design elements in the built environment, bringing live plants to urban areas, both inside and out. The benefits abound, not only for the people who live and work in and around these buildings, but for the environment as well.

This white paper presents a summary of the following:

- The research being done on living walls
- The requirements and design features for successful plantings
- The best practices for designing, building and maintaining these systems
- The health, well-being and biophilic benefits
- General costs of the systems
- And the positive effects of living walls on the environment.

This paper will also present the differences present in various green walls systems and how those systems are appropriate for differing needs.

Biophilia

When we talk about plants and their relationship to people, it is helpful to first talk about biophilia. Biophilia refers to an innate instinctive bond between humans and other living things, “the evolutionary tie between people and nature.”¹ We as living creatures share a deeply rooted affiliation towards life. In a nutshell, life is attracted to other life.

While we may not be actively aware of it, biophilia is present in our everyday lives. For example, studies by Steelcase, Inc., a popular manufacturer of office furnishings, found that 42% of office employees bring in their own plants to personalize their workplace.² People feel a connection with the plants in their work area and often take a personal interest in their well-being, even if the plants are owned or leased by their employer! They ask the horticulturist taking care of “their” plants about their plants’ health and care. They may even talk to their plants and give them names!

This biophilia, this ingrained affinity for life, creates opportunities for architects, designers, building owners and managers, horticulturists and lovers of life to create a more well-adjusted environment for people who inhabit and visit these workspaces.

Research suggests that “buildings that contain the essential features of preferred natural settings in nature will be more supportive of human well-being and performance”³ than those that do not contain these elements.



¹ Heerwagen Judith H., Ph.D., “Design, Productivity and Well Being: What are the Links?”, presented at The American Institute of Architects Conference on Highly Effective Facilities, Cincinnati, OH March 12-14, 1998.

² Steelcase Workplace Index, 2006.

³ Heerwagen, Judith H., Ph.D., 1998.

Scientist, G. H. Orians theorizes that our preferences to the interior environment correspond to the features of the savanna where *Homo sapiens* theoretically first evolved.⁴ The savanna landscape includes clustered trees, semi-open spaces, refuge from excessive sunlight and rain from spreading tree canopies and high visibility with views that reach to the horizontal horizon. Many scientists extrapolate that the presence of indoor plants and views of outdoor landscapes are appealing to people due to biophilia and this evolutionary tie to the savanna-styled environment provided by interior plants and urban landscapes.

Dr. Heerwagen also states:

“We know from the growing body of literature that contact with nature is beneficial to people, even when the contact is second hand through window views. The results of this research suggest that it is not only what is seen out the windows that is important, but what comes in – e.g., daylight, fresh air, nature sounds, and a sense of relatedness to the outdoors.”⁵

Interior Spaces, Art and Architecture

In addition to plants, people are attracted to art and architecture. The design style of an interior can be enhanced through the choice of containers and plants. Whether the room is designed to have a more elegant ambience or the designer is creating a modern, edgy space, the correct plants and containers can help create a stylized, finished look to the room. There are plants and planters to enhance and accommodate all interior styles. In some cases plants and living walls can be featured as living art.

Green walls can also provide other benefits which we'll explore in further detail. And the building itself can be a statement of a company's commitment to “going green.”

LIVING WALLS

Living walls, also known as green walls, vertical planting systems, vertical gardens, plant walls or vegetated walls have been successfully adding value and beauty to interiors around the world for many years. Some date back to the 1970's and are still beautifying their interior spaces today, a profound testimonial to excellent design, plant selection, engineering and horticultural plant care.

The first green wall system of contemporary times were called “botanical bricks” and were invented by Professor Stanley Hart White of the University of Illinois in 1938.⁶ However, they did not become popular until Patrick Blanc, often considered the “father of the green wall” designed his first vertical garden in 1988 for the Museum of Science and Industry. Blanc's designs were so innovative that he quickly became world-renowned for his green walls and they have been increasing in popularity ever since.

Green walls can be on the interior or exterior wall of a building. Lighting and directional orientation are key to the longevity of a green wall and the overall health, growth and appearance of the plant material. These walls can create a living space that is private and aesthetically pleasing while reducing noise from the surrounding area.

⁴ Orians, G.H. 1980. Habitat Selection: General Theory and Applications to Human Behavior. In J.S. Lockard (Ed.) *the Evolution of Human Social Behavior*. Chicago: Elsevier.

⁵ Heerwagen, Judith H., Ph.D., 1998.

⁶ Encyclo Online Encyclopedia; and “Going Vertical” by Marie-Laure Seguin, 2012.

Living Walls as Art



Living Walls are a perfect example of how plants can be featured as works of art unto themselves. These walls can be used as a focal point and larger walls are often found in building lobbies and atrium areas. Plants with different colors and textures of foliage can be woven into clever designs, such as a corporation's logo or an aerial view of the surrounding area. Blooming plants can be included in certain systems to add seasonal interest and color. As the plants grow and change, a green wall takes on a life of its own, become a living, changing piece of art.

Health Benefits, Well Being and Increased Productivity Benefits

Studies show that plants naturally reduce our stress and make us feel more at ease in our surroundings. In addition, they appeal to our basic need to be around life (biophilia). For patients in a healthcare facility a green view is important. Patients with a green view may recover faster with less complaints and medication.⁷

Living walls contribute to our overall wellbeing, which affects our mood, health and productivity.

Wellbeing has been defined by biologist Stephen Boyd as including:

- The opportunity to engage in spontaneous social encounters.
- Freedom to move between solitary work and group interaction.
- An environment with noise levels similar to those found in nature.
- An interesting visual environment.⁸

Studies by Alice Isen show that positive moods, a part of wellbeing, are associated with:

- Enhanced learning and more efficient decision-making on complex tasks.
- Greater use of logical reasoning techniques in problem solving.
- Higher benefits for all parties, and more innovative approaches, in negotiating.⁹

Wellbeing and “feeling good” promotes focused attention and leads people to see things differently, to notice more details and search more broadly for solutions and alternative interpretations.¹⁰ V.I. Lohr found that people working in a windowless room with indoor plants worked more efficiently, were more attentive and had lower blood pressure than those working in the same room with the plants removed.¹¹ Dr. Roger S. Ulrich, Ph.D. has done extensive research on the benefits of indoor plants for health care patients and staff. He found that simply looking at environments dominated by green plants, flowers and/or water significantly promoted recovery and reduced stress in patients, and only a

⁷Ulrich, Roger S., Ph.D., “Healthy Benefits of Gardens in Hospitals,” presented at the Plants for People conference, International Exhibition Floriade 2002.

⁸Boyden, S. 1971. Biological Determinants of Optimal Health. In D.J.M. Vorster (Ed.) *The Human Biology of Environmental Change*. Proceedings of a conference held in Blantyre Malawi, April 5-12, 1971. London: International Biology Program.

⁹Isen, A. 1990. The Influence of Positive and Negative Affect on Cognitive Organization: Some Implications for Development. In N.L. Stein, B. Leventhal, T. Trabasso (Eds.) *Psychological and Biological Approaches to Emotion*. Hillsdale, NJ: Erlbaum.

¹⁰LeDoux, J. 1996. *The Emotional Brain*. New York: Simon and Schuster.

¹¹Lohr, V.I., C.H. Pearson-Mims, and G.K. Goodwin. 1996. Interior plants may improve worker productivity and reduce stress in a windowless environment. *Journal of Environmental Horticulture*. 14(2): 97-100.

few minutes were needed to produce this effect and promote restoration.¹² He found that views of plants elevated positive feelings such as pleasantness and calmness and reduced negative feelings such as fear, anger, and sadness. Blood pressure, heart activity, muscle tension and brain activity could all be improved by viewing plants for as little as 3 to 5 minutes. In addition, recovery from stress was much faster or more complete when individuals were exposed to natural settings.

In another study T. Hartig found that blood pressure was significantly improved if the people being studied looked at a nature setting dominated by plants rather than by built elements.¹³

Other studies have shown that indoor and outdoor gardens, plants and windows with a view of nature increase patient and family satisfaction at healthcare facilities.¹⁴ Cooper-Marcus and Barnes also showed



that many hospital staff members used gardens as a means of achieving a restorative escape from the stress of their jobs which also brought about a sense of control of their situations.

In addition, Dr. Ulrich found that hospital patients with a view of nature had shorter hospital stays and fewer complaints of minor post-operative complications such as headache and nausea.¹⁵ This has strong implications in the role that plants can play in controlling health care costs, particularly those associated with hospital stays and pain medications, as well as the benefits to patients themselves.

A sense of wellbeing may also contribute to lower absenteeism. In a study of 210 salespeople, those who experienced positive moods at work were less likely to be absent.¹⁶

So, indoor plants and living walls have many benefits besides simply looking beautiful.

Indoor Air Quality and Pollution Control

A living wall naturally filters the air through the absorption of carbon dioxides and volatile organic compounds. There have been many studies which prove that plants and the microbes found in soil media absorb harmful VOC's and convert them into compound which plants use for food. This leads to fewer health complaints such as headaches and respiratory irritations, as well as increases in focus and attention.¹⁷ This process is significantly enhanced with bio-filtration living walls that integrate the wall into the HVAC system.

¹² Ulrich, Roger S., Ph.D., "Healthy Benefits of Gardens in Hospitals", presented at the Plants for People conference, International Exhibition Floriade 2002.

¹³ Hartig, T. (1991). *Testing restorative environments theory*. Unpublished doctoral dissertation, Program in Social Ecology, University of California, Irvine.

¹⁴ Cooper-Marcus and Barnes, 1995; Whitehouse et al., 2001; Picker Institute and Center for Health Design, 1999.

¹⁵ Ulrich, R. S. (1984) View through a window may influence recovery from surgery, *Science*, 224:42-421.

¹⁶ George, J.M. 1989. Mood and Absence. *Journal of Applied Psychology*, 74(2): 317-324.

¹⁷ Burchett MD, 2005, *Improving Indoor Environmental Quality Through the Use of Indoor Potted Plants*, Final Report to Horticulture Australia Ltd, Sydney.

Increased Productivity through Collaboration Spaces

Common areas utilizing plants, such as green walls, create spaces for employees to work together in collaborative groups. As shown, the presence of interior plants can increase productivity and inspire creativity amongst employees.

Sound Control

Plants naturally absorb sound and soften noise pollution¹⁸. A green wall can add an aesthetic and be used as a noise barrier in an acoustically loud space. This can be very important in both indoor and outdoor spaces, particularly in noisy urban areas.

Temperature Control and Reduced Heat Island Effect

One of the benefits of interior plants is that they help cool the air around them through the process of evapotranspiration (the movement of water from the soil, through the plant and into the atmosphere.) Large interior plants are also very good at reducing temperature through shading. This is especially effective in tall buildings where atrium plantings, including tall specimen trees and plants, are often included to help with temperature regulation. In urban outdoor spaces, living walls work to reduce the heat island effect by cooling outdoor temperatures.

Corporate Marketing

A vegetated wall adds interest to any space by adding a unique design element. Living walls are an environmentally friendly product providing a quality environment and a strong visual support of corporate green strategies. Studies have shown that a company's building may be viewed as a symbol of its environmental and social performance and may be an attraction for job candidates.¹⁹

In addition, an extensive evaluation of companies in Great Britain and Europe by S. Hodgkinson showed:

Businesses will increasingly want their flagship premises to present a shining example of environmental friendliness in terms of energy efficiency, the use of building materials, and the impact on the wider environment....New aesthetics will undoubtedly be developed to make more visible the fact that green principles have been adopted.²⁰



Edible Walls, Urban Gardening and Education

Edible living walls can be used in schools to educate students on the origin of their food, demonstrating that fruits and vegetables begin their life growing in soil, not wrapped in plastic. Urban gardening helps students connect with fresh foods and encourages them to eat healthier foods and try their hand at growing their own fruits and vegetables. Edible walls can also be used in restaurants to provide a fresh supply of herbs, lettuces and some other vegetables, as well as providing an interesting background for diners.

¹⁸Costa, P. and James, R.W. (1995) Environmental engineering benefits of plants. Proceedings of the Workplace Comfort Forum, London, UK.

¹⁹Turban. D.B. and D.W. Greening, 1996. Corporate Social Performance and Organizational Attractiveness to Prospective Employees. *Academy of Management Journal*. 40(3): 658-672.

²⁰Hodgkinson, S. 1993. Environmental Issues and the Workplace. In F. Duffy, A. Laing, and V. Crisp (Eds.) *The Responsible Workplace*. London: DEGW Ltd.

LIVING WALL SYSTEMS

1. Vertical Displays

Typically vertical displays use grids to support potted plants. Plants are placed in a pot-holding system providing better planting options than a trellis system. Potted plants can be changed out easily and seasonal blooming plants are easy to use with this system.

Generally this is a less expensive option, costing the consumer US \$75-\$125 sq. /ft., installed. This can typically be installed immediately, with no growing period required, and allows for easy plant rotations.



Vertical display

2. Trellised Walls

Trellised walls use grids or cables to support climbing plants. The plants are at the bottom of the grids or cables, on the floor indoors or on the soil grade when planted outdoors. Trellised walls are used most often outdoors. This is a good type of system for curbing heat gain, but takes time for the plants to grow in.

It is generally the least expensive option, costing US \$50-\$75 sq. /ft., installed. Trellised walls also provide the fewest planting options since plants that vine or that can be trained on a trellis must be used.



Trellised wall

3. Modified Trellised Walls

Modified trellised walls use grids to support climbing plants, which are planted in modules within the system instead of on the ground or floor. Modified trellis systems can provide better planting options than a pure trellis system since non-vining plants can also be incorporated, and the systems can most easily be used outdoors. This is generally a less expensive option, costing US \$75-\$100 sq./ ft., installed.



Modified trellised

4. Planting Pockets

With a planting pockets system, fiber plant pockets are mounted on a wall, and soil media and plants are planted directly into the pockets. This type of system is used in outdoor and indoor spaces. A wide range of plants are adaptable to this type of system and maintenance is similar to potted plants.

This is generally another less expensive option, costing US \$65-\$95 sq./ft., installed.



Planting pockets

5. Engineered Modular Systems

With an engineered modular system, modules of plants are used. These have supports to keep in the growth media and weigh around 20-25 lbs. per sq. ft. The growth media support can be complex and expensive. This is an excellent system for highly designed walls, and typically has a 3 month grow-in period. Irrigation is usually built-in and placed on automatic timers. This system may be susceptible to wet and dry areas and needs to be monitored.

This is a more expensive option, with costs ranging from US \$100-\$200 sq./ ft., installed.



Engineered Modular System

6. Fixed Hydroponic

Fixed hydroponic vertical walls are lightweight and allow for a large variety of planting options. In this bare-root system plants with little or no soil are placed in pockets attached to a support structure. Hydroponic systems use other growing media instead of tradition soil, such as rock wool. The roots become interwoven with the hydroponic media. The irrigation system is usually built into the wall and plants are irrigated from the top of the wall, with a catch basin to capture the water below. In some systems this captured water can be recirculated back into the irrigation system. They are very dependent on regular timed fertilization and irrigation.



Fixed hydroponic

These walls generally range from US \$90-\$150 sq. /ft., installed.

7. Modular Hydroponic

Modular hydroponic systems are also lightweight and allow for a large variety of planting options. Similar to fixed hydroponic systems, plants are placed in a module with hydroponic growth media and attached to a support structure or incorporated into a modular system. The roots become interwoven with the hydroponic media. Irrigation is also provided at the top of the wall, and is also very dependent upon regular irrigation and fertilization.



Modular hydroponic

Costs can be higher, generally ranging from US \$100-\$175 sq. /ft., installed.

8. Biofiltration Walls

Biofiltration walls are essentially a highly specialized fixed hydroponic wall, which also allows for a large variety of planting options. In these systems the plants placed in hydroponic growth media are attached to a support structure and integrated with the building's HVAC system. This greatly enhances their ability to clean the indoor air of pollutants. This system requires a catch basin and irrigation recirculation system.

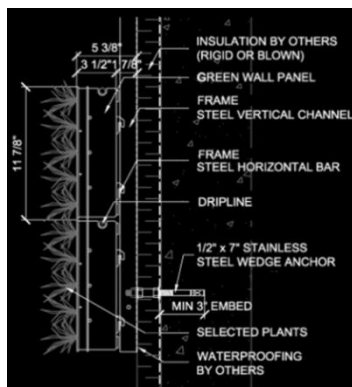


Biofiltration wall

Biowalls are used strictly indoors and are often quite large. Air is pulled through the plants and growth media, into the HVAC system and the freshened air is re-distributed throughout the building. These systems can be several stories high and are usually found in building atriums.

These walls are the most expensive and generally range from US \$250-\$300 sq. / ft., installed.

Installation of Living Walls



It's best to consult with a professional to have any living wall professionally installed and maintained. When installing a green wall, there are many considerations including:

- Weight load capacity
- Waterproofing barrier
- System choice
- Plant selection
- Lighting

- Temperature fluctuations
- Irrigation and other considerations.

Usually your horticulture business will install the system in collaboration with the architect and building engineer for a problem-free installation. Your professional horticulturist will assist in the choosing of a system that will fit your needs and budget. Your horticulturist is also the expert in choosing plants that will survive and maintain the design integrity of your living wall, based on the amount of light available at different levels of the wall and other environmental considerations.

Maintenance

A maintenance plan should be part of the first discussion when planning to install a green wall. Some walls may require a comprehensive, in-depth maintenance plan because of the size of the wall. Other walls may require simpler forms of maintenance. However, every living wall will require a maintenance plan and this should be considered from the beginning. Most green walls will need an irrigation system in place at the time of installation. There are many products on the market that can be utilized, including water sensors to monitor wet and dry areas.



The drainage and irrigation system can be designed as a closed drainage system or an open system. In closed drainage systems, irrigation water is collected and recycled. In an open system excess irrigation water is discharged into the building's drainage system. In both systems the excess irrigation water must be captured at the base of the greenwall.

Many living wall systems, especially the larger systems, include a built-in irrigation system. These are usually drip irrigation systems and are placed on automatic timers. However, they must still be monitored and checked for mineral deposits and "dry spots" in the wall. Fertilizers and some systemic pesticides may be introduced into the irrigation water.

Plants in a living wall system also need to be closely monitored for pest and disease problems, just as conventional potted plants and outdoor trees, shrubs and lawns need to be monitored. Your professional horticultural care company will provide this service as part of their maintenance agreement and will treat for prevention and control of any problems.

Anytime you have water free-flowing through the plantings there is bound to be some dripping from the plantings themselves that cannot be avoided. Therefore, you must have a large catchment system or an area at the base of a greenwall that can become a wet surface.²¹

Conclusion

Living Walls are truly living, breathing works of art. And they do far more than just look beautiful. They clean the air of harmful toxins; keep us alert and productive; reduce our stress and improve our sense of wellbeing; increase oxygen and humidity levels; help control temperatures; provide urban gardeners with vertical space to grow plants and vegetables; and so much more. With a variety of systems to suit every building and every budget, be sure to contact your local Living Wall specialist for help in designing and caring for the Living Wall that best meets your needs. Enjoy!

²¹ Anderson McRae, ASLA, CLP, : <http://www.greenlodgingnews.com/greenwalls--planting-concept-whose-time-has-come>

Bibliography and Resources:

Anderson McRae, ASLA, CLP: <http://www.greenlodgingnews.com/greenwalls--planting-concept-whose-time-has-come>

Boyden, S. 1971. Biological Determinants of Optimal Health. In D.J.M. Vorster (Ed.) *The Human Biology of Environmental Change*. Proceedings of a conference held in Blantyre Malawi, April 5-12, 1971. London: International Biology Program.

Burchett MD, 2005, *Improving Indoor Environmental Quality Through the Use of Indoor Potted Plants*, Final Report to Horticulture Australia Ltd, Sydney.

Cooper-Marcus and Barnes, 1995; Whitehouse et al., 2001; Picker Institute and Center for Health Design, 1999.

Costa, P. and James, R.W. (1995) Environmental engineering benefits of plants. Proceedings of the Workplace Comfort Forum, London, UK.

Encyclo Online Encyclopedia

George, J.M. 1989. Mood and Absence. *Journal of Applied Psychology*, 74(2): 317-324.

Hartig, T. (1991). *Testing restorative environments theory*. Unpublished doctoral dissertation, Program in Social Ecology, University of California, Irvine.

Heerwagen Judith H., Ph.D., "Design, Productivity and Well Being: What are the Links?" presented at The American Institute of Architects Conference on Highly Effective Facilities, Cincinnati, OH March 12-14, 1998.

Hodgkinson, S. 1993. Environmental Issues and the Workplace. In F. Duffy, A. Laing, and V. Crisp (Eds.) *The Responsible Workplace*. London: DEGW Ltd.

Hyland, G, J. 2002. *How Exposure to GSM & TETRA Base-station Radiation can Adversely Affect Humans*. Department of Physics, University of Warwick, Coventry, UK and International Institute of Biophysics, Neuss-Holzheim, Germany.

Isen, A., 1990. The Influence of Positive and Negative Affect on Cognitive Organization: Some Implications for Development. In N.L. Stein, B. Leventhal, T. Trabasso (Eds.) *Psychological and Biological Approaches to Emotion*. Hillsdale, NJ: Erlbaum.

LeDoux, J. 1996. *The Emotional Brain*. New York: Simon and Schuster.

Lohr, V.I., C.H. Pearson-Mims, and G.K. Goodwin. 1996. Interior plants may improve worker productivity and reduce stress in a windowless environment. *Journal of Environmental Horticulture*. 14(2): 97-100.

Orians, G.H. 1980. Habitat Selection: General Theory and Applications to Human Behavior. In J.S. Lockard (Ed.) *the Evolution of Human Social Behavior*. Chicago: Elsevier.

Seguin, Marie-Laure 2012, "Going Vertical."

Steelcase Workplace Index, 2006.

Turban, D.B. and D.W. Greening, 1996. Corporate Social Performance and Organizational Attractiveness to Prospective Employees. *Academy of Management Journal*. 40(3): 658-672.

Ulrich, R.S. (1984) View through a window may influence recovery from surgery, *Science*, 224:42-421.

Ulrich, Roger S., Ph.D., "Healthy Benefits of Gardens in Hospitals," presented at the Plants for People conference, International Exhibition Floriade 2002.