A HISTORIC PERSPECTIVE FOR ENVIRONMENTAL SUSTAINABILITY PRINCIPLES IN AMERICAN ARCHITECTURE

Sharon D. Gamble
HISP 700
University of Maryland
School of Architecture, Planning, and Preservation
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ABSTRACT

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Directed By:	Professor Donald W. Linebaugh, PhD Director, Graduate Program in Historic Preservation University of Maryland, School of Architecture, Planning and Preservation

Environmental sustainability has become one of the most visible considerations for today's built environment. Over the past thirty years, there has been an increasing focus on developing and implementing sustainability principles as a means to promote environmental stewardship and the protection of life and natural resources. While we tend to think of sustainability design as a fairly recent phenomenon, is it really? It is doubtful that the architects of historic American buildings ever heard the terms "sustainable design" or "going green," however, many of their designs reflect inherent sustainability principles. The premise of this paper is that sustainability principles have been used throughout American architecture and an important role of historic preservation is to identify and communicate these principles. The goal of this paper is to document and provide a catalogue of some of the more innovative historic approaches to achieving environmental sustainability in American architecture.

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By

Sharon D. Gamble

Final Project submitted to the Faculty of the Graduate Program in Historic Preservation
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Advisory Committee:
Professor Donald W. Linebaugh, PhD, Chair
Professor Carl Bovill, PhD, UMD Architecture Program

Dedication

To Mom and Dad,
who have provided me with their love and enduring support,
and
to my daughters Katie and Emma,
who have inspired my passion in historic preservation,
you who have my love and enduring support.

Acknowledgements

I am very indebted to everyone who has supported me on this final project.

I am extremely grateful to Professors Dr. David Overholt and Dr. Don Linebaugh. Dr. Overholt provided me with the incredible opportunity of interning at the Lincoln Cottage, as well as introducing me to the The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ and spending many hours educating me on sustainable design. Dr. Linebaugh has provided exceptional insight and guidance to help me to define a focus for my degree and has been a tremendous help in shaping this project to a topic which I find fascinating. To Dr. Overholt and Dr. Linebaugh, thank you for your guidance, encouragement, and patience.

It was a privilege to work with Dr. Carl Bovill, my project reader, who has such a vast background on sustainability and building systems. Dr. Bovill's insight into the technologies, thermal metrics, and guidance on additional resource materials was a tremendous help and his ability to net out the technical aspects to layman's terms was most appreciated.

I would also like to thank Carl Elefante and Patrice Frey for their time spent in helping me shape my final project. Having the opportunity to meet with Mr. Elefante and hear his perspective on historic preservation was one of the highlights of my experience in this program – and his observation that your final project topic follows you around for the rest of your career was well heeded. Ms. Frey, now the Director of Sustainability Research for the National Trust, provided her time in giving me an overview of the sustainability research at the National Trust. I also found her thesis, "The Performance of Historic Buildings Under the Leed-NC Green Building Rating System," to be a very valuable reference source in researching this project.

The Librarians at University of Maryland Hornbake Library and Architecture Library provided invaluable support, both directly and indirectly, through their research knowledge and the incredible repository of resources they have built. Douglas P. McElrath, Patricia Kosco Cossard, and Joanne Archer provided a wealth of information and the results of this project could not have been possible without them.

Jackie Letizia has provided many hours of babysitting, enabling me to attend class and research my topic, while knowing that my children were well taken care of. I greatly appreciate her dedication in making sure that they were picked up from school, shuttled to choir and banquet dinners, and everything else that she had to coordinate (including getting them to go to bed!) My Mom and Dad also provided many hours of babysitting and their *behind-the-scenes* support and encouragement to keep me going – I couldn't have done this without them. My inspiration for pursuing an education in historic preservation came from my children, Katie and Emma, who were just three years and eighteen months old when I began this adventure. Now they are in school and beginning to appreciate the importance of historic preservation. My hope is that they and future generations will benefit from the efforts put forth now for historic preservation and environmental sustainability.

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Chapter 1: Introduction

> *Concept of Sustainability: The concept of sustainable design has come to the forefront in the last 20 years. It is a concept that recognizes that human civilization is an integral part of the natural world and that nature must be preserved and perpetuated if the human community itself is to survive. Sustainable design articulates this idea through developments that exemplify the principles of conservation and encourage the application of those principles in our daily lives.*
>
> National Park Service[1]

The importance of environmental sustainability continues to grow and evolve from a concept into a way of life. Environmental sustainability is becoming a commitment by humans to understand and change the way they use the earth's resources.[2] Concerns about topics such as global warming, oil prices, and deforestation have resulted in many changes in the way people conduct their lives. Evidence of this heightened awareness includes increased sales of local, organic produce; improved opportunities for recycling waste and using recycled material; receptiveness to using new approaches for renewable energy, such as solar and wind-power energy sources; and increased awareness and sensitivity of individual and industry carbon footprints.

Perhaps no where is the importance of environmental sustainability more visible than the built environment, given the huge impact that construction and building operations have on the earth's natural resources. For example, approximately 39% of the United States energy consumption is attributed to buildings, as compared to

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[1] U.S. National Park Service. "Guiding Principles of Sustainable Design." http://www.nps.gov/dsc/dsgncnstr/gpsd/ch1.html (last accessed on January 12, 2008).
[2] Parker, Jeanette. "Sustainability: Biomimicry and Waste = Food." http://www.nps.gov/archive/npnh/dec05_npnh_newsletter/p5.htm (last accessed on May 17, 2008).

approximately 32% for transportation and 29% for industry energy consumption.[3] Furthermore, in the United States alone, buildings account for approximately 30% of greenhouse emissions, 65% of electricity usage, 30% of raw materials, and 30% of waste output.[4] It should come as no surprise that the environmental sustainability of buildings has come to the forefront as an important national concern, emphasizing the importance of incorporating sustainability principles in their design, construction, operations, and maintenance.

While the focus on sustainability has come to the forefront in the past twenty to thirty years, it is important to realize that sustainable design is not really new – it has been around for centuries. Ancient Greeks were faced an energy crisis with a shortage of fuel. Ancient Romans had to deal with indoor air pollution. The ability to use forces of natural to provide safe, healthy, and comfortable living has been the focus of many architects. For example, Vitruvius, the first century Roman architect, is credited with having written one of the earliest documents on building ventilation in his *Ten Books of Architecture.*[5] Vitruvius wrote that "Wind is a flowing wave of air, moving hither and thither indefinitely. It is produced when heat meets moisture, the rush of heat generating a mighty current of air."[6] He described how winds coming from different directions could create ventilation and went on to write about its potential impact on human disease and health.

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[3] U.S. Green Building Council. "Building Impacts." p. 3.
[4] U.S. Green Building Council. "Research." http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1718 (last accessed on January 12, 2008).
[5] West, Aaron. An Exploration of the Natural Ventilation Strategies. p. 3.
[6] Vitruvius. *Ten Books of Architecture*. p. 25.

In American history, energy efficient buildings have been problematic since the first fireplaces were used to heat homes. In approximately 1742, Benjamin Franklin invented the Franklin stove to provide a safer and more efficient means of indoor heating. The evolution to continue to improve building heating and cooling efficiency and safety has continued to evolve and includes the first major steam heating system installed in Paris in 1828 and electric centralized heating and air conditioning systems of the 20th century.

In the 1950's, architect Richard Neutra sounded the environmental alarm that "today's man-made environment has become an irritating, increasing threat to the vitality and soundness of mind and body."[7] Well before the 1962 publication of Rachel Carson's *The Silent Spring* and the first Earth Day on April 22, 1970, Neutra and others before him have expressed the importance of balancing nature and technology. These architects and designers of the built environment sought to develop new approaches to provide a healthy environment for building occupants while leveraging the natural resources the earth has provided.

The purpose of this project is to identify environmental sustainability principles incorporated into historic American architecture. While it is doubtful that these architects and designers ever heard the terms "sustainable design" or "building green," many of their designs reflect inherent sustainability designs. The goal is to develop a catalogue of historic designs that can be used by others 1) to become more knowledgeable about historic approaches to sustainability, 2) to be able to recognize

[7] Neutra Institute for Survival Through Design. http://www.neutra.org/Aims_Purposes.html.

examples of sustainable approaches in other historic buildings, and 3) to consider using or renewing these approaches in their preservation and rehabilitation projects.

Approach

The research approach for building this catalogue consisted of four phases:

1. Phase 1: Determine which sustainability principles to consider.
2. Phase 2: Review the writings of architects and designers of historic American architecture to identify which ones appeared to employ sustainability principles.
3. Phase 3: Select entries for the catalogue based on architects, buildings, and building systems that demonstrate the selected sustainability principles.
4. Phase 4: Document the catalogue, providing the designer's background and the specific sustainability principle addressed.

Sustainability Principles to Consider

When identifying sustainability considerations in American architecture, it's helpful to establish a framework for the building "elements" that will be assessed. The U.S. Green Building Council (USGBC) has taken responsibility for many aspects of sustainable design. The USGBC is a non-profit organization with the stated goal of expanding "green" building practices.[8] With the support of over 12,000 organizations, the USGBC has established the Leadership in Energy and Environmental Design (LEED®) Green Building Rating System™ to be a measure of

[8] US Green Building Council. http://www.usgbc.org (last accessed on January 12, 2008).

sustainability performance. The LEED rating system is based on five environmental categories and a sixth category for innovation: 1) Sustainable Sites, 2) Water Efficiency, 3) Energy and Atmosphere, 4) Materials and Resources, 5) Indoor Environmental Quality, and 6) Innovation. One approach would be to base this analysis on these Leadership in Energy and Environmental Design (LEED) sustainability performance criteria.

However, since some aspects of LEED performance assessments may not be as relevant over a hundred years ago as they are today, it may be more productive to look at historical approaches within a more general framework. James Marston Fitch, in his *American Building: The Environmental Forces that Shape It*, provides an alternate framework for assessing similar attributes. After careful review, the following factors were selected to evaluate:[9]

- Thermal Environment: The thermal environment affects the temperature comfort of the occupants in a building and is a function of the air temperature, radiant temperature, humidity, and velocity of air flow. It is affected by the building's heating and cooling system and the structural thermal envelope. Thermal control systems generally fall into two categories – convective and radiation.[10] Convection occurs when warm air rises and cooler air sinks, such as when hot air is blown into a room and it transfers heat as it rises toward the ceiling. Radiation is the transfer of heat through electromagnetic waves, such as the heat from the fire in a fireplace or sunlight coming through a window.
- Atmospheric Environment: The atmospheric environment impacts the air quality in a building and affects the ability of the lungs, heart, and blood to

[9] Fitch, James Marston. *American Building 2: The Environmental Forces That Shape It.* p. 6.
[10] Fitch, James Marston. *American Building 2: The Environmental Forces That Shape It.* p. 51-53.

receive and circulate oxygen. The atmospheric environment is a function of the air pressure and composition of the air within a building. Air composition includes the gaseous composition (including oxygen, nitrogen, carbon dioxide, and water vapor), nongaseous aerosols, and suspended impurities (including pollen, smoke, microorganisms, and molds.)[11]

- Luminous Environment: The luminous environment is the overall lighting within a building. Depending on the type of lighting used, the Luminous Environment also may impact the thermal environment. As new lighting technologies have been developed, the luminous environment can be comprised of a surprisingly complex set of elements, which includes natural light (which may use light filtration techniques such as polarization, photochromic filtering, light reflection, and heat-rejection glass filtering), and artificial light sources that can vary by source (incandescent, fluorescent, high-intensity), type of fixture (recessed, downlight, spot, flood), optical accessories (louver, baffle, diffuser, color filter), source (point, linear, planar), and type of distribution (direct, indirect, focused, diffused.)[12]

Review the Writings of the Architects and Designers

The approach for identifying architect or designer candidates began with looking for those who had published writings related to their views on the natural environment and appeared to have an affinity for using the natural environment in their designs. For example, Thomas Jefferson, Catherine Beecher, O.S. Fowler, Montgomery

[11] Fitch, James Marston. *American Building 2: The Environmental Forces That Shape It.* p. 63-67.
[12] Fitch, James Marston. *American Building 2: The Environmental Forces That Shape It.* p. 117-131.

Meigs, A. J. Downing, and Frank Lloyd Wright wrote treatises, books, diaries, and/or letters expressing their views and experience in integrating their buildings with the environment. This research was then linked with the three sustainability principles to determine which sustainability principles were the best match for these architects.

Selecting the Entries for the Catalogue

The overriding consideration in selecting entries for this catalogue was to select designers who considered ecology in their approach. In addition, the architects and designers included in this paper are meant to be a representative of a cross-section of American Architecture, some who have had formal architecture education and others who have not; some are American born and others are not; and they have designed a variety of building types, including homes, offices, and public government buildings.

Documenting the Catalogue

This paper is organized chronologically and covers the 18th, 19th, and 20th centuries. In general, the format was to provide a brief background on the architects to highlight any predisposition they may have to environmentally conscious design principles. A summary of some of the catalogue entries and associated sustainable design principles is provided in Table 1. A more detailed description of each of these structures is provided in the following chapters.

Table 1: Catalogue Entries and Associated Sustainability Principles

Architect/ Designer/ Engineer	Structure	Thermal Environment	Atmospheric Environment	Luminous Environment
The Cupola	Canterbury Village Shaker Dwelling House	Cooling system via drawing warm moist air up out of the building	Enables replenishment of fresh air	Provides natural light
Thomas Jefferson (1743-1826)	Monticello	Rumford Fireplace; Radiant heat, window angles, Deciduous trees placed to provide shade in summer, allow sun in winter	Three-sash windows can be used as doors; Cross ventilation floor plans; Staircases located to increase air flow	Portal windows; Three-sash windows; Skylights; Octagonal walls reflects light; Palladian windows; Mirror positioned across from windows to reflect light
Catherine Beecher (Architecture Plans) (1800-1878)	American Homes	Centralized Heating	Approach to home ventilation	Outdoor porches
O.S. Fowler (1809-1887)	Octagon House	Centralized Heating in lieu of fireplaces	Cupola draws air up from center of house; perimeter verandas	Cupola lighting over central stairway; light reflection of angled walls
AJ Downing (1815-1852)	Cottage Houses	Arnott Chimney valve to increase heat flow to room	Registers, vents	Ribbed ceilings reflect light
General Montgomery Meigs (1816-1892)	Pension Building (Building Museum)		Designed new ventilation system	Great hall for natural light for employees
Charles (1868-1957) and Henry Green (1870-	Gamble House		Sleeping porches; Extended roof eaves;	

Architect/ Designer/ Engineer	Structure	Thermal Environment	Atmospheric Environment	Luminous Environment
1954)			Open rafters	
Frank Lloyd Wright (1867-1959)	Usonian - Pope-Leighey House	Floor-based Radiant heat Walls were thin – paper between No A/C – no space for air conditioning ducts[13]	Large windows, glass doors "blurred the distinction between the inside and outside"[14]	Indirect lighting; Clerestory window patterns
Richard Neutra (1892-1970)	Lovell House		Maximize ventilation by location on hillside; Porches and patios for sleeping and sunbathing	Creative use of natural light through green foliage; Wall to ceiling windows; Integration of indoors with outdoors

[13] Jandl, H. p. 120.
[14] Jandl, H. p. 121.

Chapter 2: Eighteenth Century

The Cupola

The term "cupola" is Latin for "little cup" or "little dome." It has been used for centuries to provide buildings with ventilation and natural light. The cupola has become an icon of American architecture, often found on eighteenth and nineteenth century barns, residences, and public government buildings.

The function of the cupola is to act as a type of chimney to release the warm, moist air within the house up and out through the roof. As the warm air is pulled up, the air flow pulls in fresh air through the windows and doors on the lower floors. The ventilation of a building had come to be recognized as a contributor to good health. Some cupolas, such as the one on the Shaker Canterbury Village Dwelling House were open, to allow the maximum amount of air flow at any time.

Other cupolas had louvered sides and could be mechanically controlled to allow the air to flow out and to screen the sunlight out as appropriate. Other features that may be found on historic cupolas include weathervanes, metal ventilator hoods, and lightening rods.[15]

Unfortunately, the cupola is sometimes mistaken for a decorative feature and is not recognized for the important building function that it provides. The National Park Service has noted concern that cupolas may be stripped from historic buildings

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[15] Auer, Michael J. "Preservation Brief Number 20: The Preservation of Historic Barns." p. 1.

without realizing the important function they can provide to enhance the energy performance of the building.[16]

Thomas Jefferson and Monticello

And our own dear Monticello, where has nature spread so rich a mantel under the eye? mountains, forests, rocks, rivers. With what majesty do we there ride above the storms! How sublime to look down into the workhouse of nature, to see her clouds, hail, snow, rain, thunder, all fabricated at our feet! And the glorious Sun, when rising as if out of a distant water, just gilding the tops of the mountains, and giving life to all nature!

Thomas Jefferson, 1786

Thomas Jefferson (1743-1826) was a man who not only loved nature, but possessed many talents which he used to better appreciate nature. He was a President of the Untied States, a historian, an educator and founder of the University of Virginia, a philosopher, and an inventor. He was a revered naturalist whose love of nature is revealed in his book *Notes on the State of Virginia.*[17] Thomas Jefferson was also a self-taught and accomplished architect who combined his love of nature in his building designs. He designed Monticello, the University of Virginia, and Poplar Forest all with the intent of blending these buildings into their natural settings. Equipped with his architecture knowledge, love of nature, and innovative mind, Thomas Jefferson's Monticello includes an impressive array of design considerations to harness the power of natural resources to provide a healthy, comfortable environment for its inhabitants.

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[16] National Park Service."Sustainability and Historic Preservation – Lessons Learned" p. 24.
[17] Duncan, T.R. "Enlivening Democracy." p.23.

Thermal Environment

It is interesting to note that energy efficiency was important in Jefferson's era just as it is today. The fireplaces of the 18th century were inefficient and poorly designed, essentially a "rectangular masonry box with a chimney coming straight out at the top."[18] The hot air generated by the fire went straight up the chimney and the resulting draft pulled the cold air in through poorly insulated walls, windows, and doors. One contemporary invention to address this problem was the Franklin Stove. Developed by Benjamin Franklin in approximately 1742, a cast iron insert took the air from the room, heated it, and released it back into the room. The smoke went down a flue in the back of the stove and then was released up the chimney. By reducing the firebox and chimney throat, the combustion could be better controlled and it would give off radiant heat – thus improving its efficiency.[19] Also in the late 18th century, Count Rumford developed the Rumford Fireplace. While the Franklin Stove was sometimes too large to fit into a residential fireplace, the Rumford fireplace was designed to be smaller and the sides ("cheeks") were angled to help radiate heat into the room. The rear of the fireplace was moved forward "to reduce the volume of the burning chamber" and the throat was reduced to four inches high.[20] Jefferson reportedly converted two of his fireplaces to the Rumford fireplace before changing strategies and going with the Rittenhouse stove, developed by David Rittenhouse.

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[18] McLaughline, Jack. *Jefferson and Monticello.* p. 305
[19] McLaughlin. p. 305.
[20] McLaughlin. p. 306.

The Rittenhouse stove was a variation of the Franklin stove, without the double back and flue and made of brick rather than iron.[21] Jefferson reportedly made the change to the Rittenhouse stove because he did not think that Rumford had given appropriate credit to the original work done by Franklin and Rittenhouse.[22]

In addition to more efficient fireplaces located throughout the house, Jefferson also used large windows (triple-sash windows) to provide radiant heat. Deciduous trees were planted at the appropriate locations near the house so that the lower sun angles of the winter would be positioned to heat the home. In the summer, these trees would provide shade to screen the hot sun.[23]

Atmospheric Environment

Thomas Jefferson was very much aware of the importance of natural ventilation to provide fresh air throughout the house. The house was designed with main floor cross-ventilation that enabled the cooling during the summer months.

The circulation space was also designed on each floor so that the air would easily flow to the staircases and then flow up to the top of the staircases. The two staircases located at either side of the house act as cooling towers to carry the air up and through the house. At the top of the staircases are overlapping glass panes with ventilation gaps to release the warm air.[24]

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[21] McLaughlin. p. 307.
[22] McLaughlin. p. 307.
[23] Duncan, T.R. p. 43.
[24] Duncan, R.T. p. 43.

Luminous Environment

Thomas Jefferson designed Monticello to be open to nature and bring the beauty of nature into the living space. The home has numerous porticoes, porches, and terraces to provide open-air living spaces.[25] Jefferson also was creative in his use of windows to bring more natural light into the home. Monticello has thirteen skylights, one of which was in his bedroom, which brightened the inside of the house with natural light. Jefferson also used tall triple-sash windows which not only brought in natural light, but could also be used as doors and to provide natural fresh air. He also used shutters, Venetian blinds, and interior screens to reduce the impact of the heat of the direct sun, while still enabling some natural light to enter for enjoyment.[26] Jefferson used mirrors to reflect the daylight by placing them opposite the walls with windows, providing the rooms with more natural light and an air of cheerfulness. These mirrors were also fitted with candles to reflect the evening candlelight, providing a reflection of light for spaces that would otherwise be too dark to use in the evening.[27]

Eighteenth Century: Summary

Eighteenth century American architecture clearly reflects sustainability principles to address basic environmental needs for heating and cooling efficiency, indoor air quality, and providing indoor lighting. Architects and building designers tended to use more "common sense" approaches for managing the environment.[28] Buildings were situated to take advantage of natural breezes for cooling in the summer and to

[25] Duncan, T.R. p. 55.
[26] Dunsan, T.R. p. 55.
[27] Duncan, T.R. p. 55
[28] Park, Sharon C. NPS Technical Brief No. 24. p. 1.

use the sun for heat in the winter. Deciduous trees were used to provide shade in the summer and allow the sun through in the winter. Doors and windows were used to facilitate cross breezes for ventilation. Lighting was enhanced with strategically placed mirrors and Palladian windows. Additional features such as the cupola, enhanced fireplace designs, skylights, and triple-sash windows were not necessarily reflective of innovative technology, but demonstrated progress in attempting to use natural resources to provide a healthier, more comfortable living environment.

Chapter 3: Nineteenth Century

Catherine Beecher and the American Woman's Home

There is no point of domestic economy, which more seriously involves the health and daily comfort of American women, than the proper construction of houses.

Catherine Beecher
A Treatise on Domestic Economy[29]

Catherine Beecher (1800-1878) was a well-known teacher who advocated the education of women. She founded several schools for women and wrote books such as *A Treatise on Domestic Economy for Use of Young Ladies at Home and at School* (1841) and *The American Woman's Home* (1869). While she was not a trained architect, Beecher's books contained house plans, descriptions of the science of ventilation, and detailed explanations of the properties of heating (conduction, convection, radiation, and reflection.)[30] Referred to as the Christian House, her goal was to provide guidance on how a house could be designed to enable "every member of a family to labor with the hands for the common good, and by modes at once healthful, economical, and tasteful."[31] She had many innovative principals of domestic economy and used them to introduce architectural innovations to encourage the "health and well being of the American family.[32] Many of these principles were focused on organization of the home and approaches to conserve time, labor, and

[29] Jandl, H. p. 29.
[30] Beecher, Catherine. *The American Woman's Home.* pgs. 23-83.
[31] Ibid. p. 24.
[32] Ibid. p. 29.

money. Beecher also went to great lengths to explain the importance of building systems, including heating and ventilation, to providing a healthy home.

Thermal Environment

Beecher's plans for a Christian house published in *The American Woman's Home* includes a rudimentary form of central heating. Two Franklin Stoves are located in the two largest rooms against the central interior walls. In the center of the house is a "stoveroom" containing a large iron stove. The stoveroom opens into the kitchen to provide easy access for cooking. The flues are stacked behind the stairs so that they can carry the heated air up to the second level of the house to the bedrooms. A duct was used, connecting the stoves together, to pull in fresh air from outside.

O.S. Fowler and the Octagon House

Orson Squire (O.S.) Fowler (1809-1887) began his career as a phrenologist, a precursor to modern day psychology. He was a nationally recognized authority on mental well-being prior to his venture into architecture.[33] In his book *A Home for All*, Fowler advocated the octagon house as being functional, stylistic, and efficient. As Fowler was well read and traveled extensively, it is thought that the inspiration of his octagon house may have come from accounts of ancient Greek and Roman structures. He understood that his designs were substantially different from more traditional homes and made frequent comparisons to the "square, winged and cottage styles."[34]

[33] Jandl, H. p. 42.
[34] Jandl, H. pgs. 43-45.

Thermal Environment and Atmospheric Environments

Like Beecher, Fowler was an advocate for centralized heating. His book recommended a centralized furnace instead of warming the home with separate fireplaces. He provided calculations that showed the cost to warm an octagonal shape house was lower on a per square foot basis then the cost to heat a rectangular shaped home.

Fowler also noted that one of the advantages of his octagonal design was improved ventilation. He wrote “for every human being requires a copious and constant supply of this commodity, so indispensable, not merely to human comfort, but to existence. His houses typically featured a cupola over a central staircase to provide ventilation. Fowler also recommended ventilators be used “in every room, both at the ceiling and at the floor, to control the intake of air.”[35] As with A.J. Downing, Fowler also recommended that registers be used. His plans frequently included exterior verandas around the house to provide residents with an option to spend time outside, enjoying the fresh air and natural sunlight.

[35] Jandl, H. p. 45.

Luminous Environment

The cupola provided a great deal of natural light shining onto the central staircase. Fowler wrote that "the appearance of [the central] stairway is really magnificent – lighted from the glass dome, 70 feet straight up, cupola included, octagonal in form."[36] Many occupants of octagonal houses have concurred with Fowler's premise that there is more light in the polygon shaped rooms than in rectangular ones, most likely because the angles walls were better positioned to reflect light.

Andrew Jackson (A.J.) Downing and the Country House

There is no subject directly connected with domestic life on which there is so large a amount of popular ignorance as ventilation. When a man is hungry, nature compels him to cry out for food…men have been known to live without food and drink for five weeks, though any person wholly deprived of air will die in three minutes.

A. J. Downing,
The Architecture of Country Houses

A.J. Downing (1815 – 1852) was a prominent landscape designer, architect, and overall naturalist in his time. His approach to architecture emphasized convenience, function, and harmony with nature and his books, *A Treatise on the Theory and Practice of Landscape Gardening, The Architecture of Country Houses,* and *Victorian Cottage Residences,* promoted his picturesque style. Pattern books such as Downing's were popular in the early 19th century. However, Downing's publications addressed the house in the context of its setting and surrounding landscape. His

[36] Ibid. p. 50.

books also included essays on the how well planned homes could be affordable, suited to social positions, and presented as "smiling lawns and tasteful cottages."[37]

Thermal and Atmospheric Environment

Downing also included a great deal of information about heating and ventilating systems in his pattern books. He promoted the use of the chimney-valve (register) in the flue near the chimney to provide more efficient heating and to facilitate the ventilation of a room. For example, Figure 15 shows the air flow of a room without appropriate ventilation and the resulting bad air that stagnates in the room.
By placing a chimney-valve in the flue near the chimney. When there is no fire, the bad air will have a tendency to rise can rise to the top of the room and flow out through the flue.

When there is a fire, a *strong upward current is created* and a supply of fresh air will come in to fill the created vacuum. However, Downing also realized that the rapid supply of fresh air would not necessarily provide a comfortable environment in the room by bringing in cold air from the outside. So, he proposed the use of a chimney register to be inserted into the flue to moderate the supply of fresh air as necessary.

Downing was an advocate of the Arnott chimney-valve, developed by Dr. Neil Arnott to moderate the supply of fresh air. The valve had a thumb-screw which could be used to adjust the draught to be more or less open. A hole could be made in the chimney by removing two or three bricks and the resulting hole, with mortar, would

[37] Jandl, H. p. 7.

provide a tight fit for the chimney-valve. Typically the valve would be inserted on the side of the chimney and could be painted to blend in with the color of the walls.[38]

Luminous Environment

Downing also used creative ways to increase lighting within the house. For example, some of his house plans included a ribbed ceiling in lieu of the traditional flat ceiling. Similar to the way a polygon shaped room would better reflect the light off the walls, the angled ceiling creates an environment where the light can be reflected back into the room and create an atmosphere of *gaiety.*

Montgomery C. Meigs and the Pension Building

Montgomery Cunningham Meigs (May 3, 1816 - Jan. 2, 1892) was an engineer by training, graduating from the United States Military Academy. He spent the next quarter century with the engineer corps of the Army where he worked on numerous engineering projects.[39] Meigs was known for being innovative in his engineering designs. He engineered the Washington Aqueduct, which carried water from the Great Falls of the Potomac River to the city of Washington, with an "ingenious" method of controlling the flow and distribution of the water.[40] He also designed a bridge to cross the Cabin John Branch of the river which was unsurpassed as the longest masonry arch in the world for approximately fifty years.[41]

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[38] Downing, A.J. *The Architecture of Country Houses.* pgs. 464-471.
[39] Arlington Cemetery Web-portal. Historical Information, General Montgomery Meigs. http://www.arlingtoncemetery.net/meigs.htm.
[40] Ibid.
[41] Ibid.

From 1853-1859 Meigs was assigned to the building of the wings and dome of the United States Capitol, where he had learned many lessons about building systems. Ventilation was one area that appears to have caused him great consternation. On December 9, 1854, Meigs noted in his journal a conversation that he had with Mr. Peters (a co-editor of the *Union* paper):

> *He says we are to have a hard fight this winter, that the ventilation of the House is being discussed all through the country. By the way, he told me that my notes on ventilation had been published in some of the English political papers as well as in The Civil Engineer and Architects Journal and that they were flatteringly spoken of.*[42]

However, ten days later on December 19, 1854, he experienced the wrath of one of the members of congress as noted in his following notes:

> *When I went back to the office, Mr. Walter told me that he had had one of the most troublesome men in Congress to see him, Mr. Lyon of New York. That he was very rough in his manners and his conversation. That he said we were going to smother them in the House of Representatives and to shut them out from the light of heaven. The air heated by hot water is enough to kill an ox. He allowed after some time that the windows had some beauty, but he told Mr. Walter that his dome was a botch. He had been rambling all over St. Peter's of Rome, and his own house is heated with hot water, so he considers himself a judge of all matters relating to heat, ventilation, and to art!*[43]

With the onset of the Civil War, Meigs rejoined the Army, was promoted to Brigadier General, and was named Quartermaster General of the Army. He served as the Quartermaster until 1882, supervised the plans for building the War Department Building, the National Museum, and others.[44]

Upon his retirement in 1882, Meigs became the architect for the new Pension Building. After the Civil War, the U.S. Pension Bureau was created to provide

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[42] Meigs, Montgomery. *Capitol Builder.* p. 162.
[43] Meigs, Montgomery. *Capitol Builder.* p. 172.
[44] Arlington Cemetery. Historical Information, General Montgomery Meigs. http://www.arlingtoncemetery.net/meigs.htm.

pensions to the Union veterans. Meigs' technical expertise and creativity certainly made him a great candidate to design a building which could be accessible by veterans and would be befitting those who were wounded, maimed, widowed, and orphaned from the Civil War.

Atmospheric and Luminous Environments

One of his primary goals in designing the building was to provide natural air conditioning and lighting for the Federal employees. The windows extended up to the roof to let in light. From the exterior of the building, one can see the clerestory windows around the top of the roof and the tall, arched windows around the top floor. At the center of the interior is a great hall, which measures 116' by 316' and rises approximately 120'. The building is well known for its innovative ventilation system that Meigs engineered. He put vents in the exterior walls so that the warm air would be drawn up and escape through the skylights in the roof. The fresh air would be drawn up through the center of the building, providing fresh air for the employees inside. The tall atrium in the center of the building acted as a flue to draw the air up. The clerestory windows were mechanically controlled and used as a chimney to release the warm air from the building. All of the air in the building was reportedly replaced in approximately two minutes.

In consideration of the lighting for the building employees, Meigs designed the offices to be around the corridor of the large central hall so that there would not be any dark offices or corridors.[45]

[45] GAO Web-portal: U.S. Pension Building

Nineteenth Century: Summary

By the 19th century, sustainable design and building system technology was becoming more sophisticated. Central heating systems were being implemented and gravity hot air systems were becoming standard in many buildings. The science of ventilation had progressed and there was a better understanding of the ways that poor air quality could make people ill, affecting their health and comfort in the home and workplace.[46] The use of operable windows, mechanically controlled cupolas, transoms, and clerestory windows helped to maintain a healthy flow of fresh air, to provide a means of dissipating heat, and to supply additional sources of natural light. This combination of science and technology created not only increased awareness of the importance of sustainable design, but provided the technology to facilitate its implementation.

[46] Park, Sharon C. NPS Technical Brief No. 24. p. 3.

Chapter 4: Twentieth Century

Greene and Greene's Gamble House

Charles (1868-1957) and Henry Greene (1870-1954) were architects in California whose designs reflected their love of nature, often attributed to the time they spent growing up on their mother's family farm in West Virginia.[47] Later, their family also spent time living in a poorly ventilated apartment in St. Louis and it is also thought that their father's concern about the lack of ventilation and fresh air may have also influenced their designs. They designed homes in the Arts and Crafts and were commissioned to design the Gamble House in Pasadena, California in 1908. The house was built as a retirement home for Mary and David Gamble of the Proctor & Gamble family. The house was designed to supply organic harmony and utilize forces of nature to provide a comfortable living environment.

Atmospheric Environment

The Greene's designed a healthy environment of fresh air with the three second floor sleeping porches. The placement of breezeways and windows allowed cross-ventilation breezes. The long roof overhangs provided shade in heat of the summer.

[47] Gamble House Web-portal. http://www.gamblehouse.org/architects/index.html.

Henry Wright and the Solar House

Henry Wright was an architect who was an early practitioner of passive solar research.[48] He was also known for being the editor of *Architectural Forum* magazine in the early 20th century. He designed the Ramirez House in 1944 and it his thought to be one of the earliest passive solar heated homes in the United States. It features 18 ft tall windows on southeast side and an extended roof overhang. In the winter, this would allow sun to shine in and heat room. In summer, when the sun's position was higher in the sky, the long roof overhang would provide shade. Wright also used a new technology for the windows. Thermal pane glass, which had been invented 1935, to prevent heat loss through the windows.

Frank Lloyd Wright and the Usonian House

Study nature, love nature, stay close to nature. It will never fail you.
Frank Lloyd Wright

Frank Lloyd Wright (1867 – 1959) is easily one of the most recognized architects of the 20th century. He created many innovative approaches for sustainable design. Consider, for example, his design for the Usonian home. The term "Usonian" is derived from the acronym USONA for the United States of North America.[49] Wright used this term when referring to his goal of providing practical, well-designed, affordable housing for a democratic America. His focus on the Usonian home came

[48] AIA Web-portal. "Rehabilitation of Henry Wright's Ramirez House."
[49] Note: The term Usonian was actually coined by English author Samuel Butler, Reference: Available on the Worldwide Web at http://www.popeleighey1940.org/background.htm

fairly late in his career, in the mid-1930s. This was a time of great societal and economic change in the U.S. Everyday living was becoming more informal and Wright's design brought a resurgence of styles more compatible with their natural landscape and environment. For example, many homes built in the 1930s and 1940s were placed in the center of the lot and were oriented to make a statement to others -- about the wealth, power, or social position of the owner. They may have had an imposing entrance or an inviting entrance with a front porch or portico. In contrast, the Usonian home was oriented for its residents. It was situated to blend in with the local flora and the entrance was hidden from view of visitors. One such house designed in the Usonian style was the Pope-Leighey House. Examples of some of the sustainable design principles incorporated in the Pope-Leighey house are discussed below.

Thermal Environment

Wright recognized the benefits of radiant instead of convection heat; that by heating objects rather than the air, occupants would feel more comfortable at a lower temperature. He used water heated radiant heat embedded in the concrete floor of the Pope Leighey house to heat the home. Theoretically, this would result in a more energy efficient home with 20-40% less energy required. An added benefit was achieved in that Wright did not need to worry about vents or radiators.

Luminous Environment

Wright used light to make a statement and provide excitement to his homes. For example, he used decorative clerestory windows around the top of the home and in the bedrooms (Figure 30) to provide a dramatic interplay of lighting within the home and from the exterior. Wright also liked to create areas of compression followed by expansion to provide elements of surprise and reflect nature within the home. For example, at the end of the long, narrow hall to the bedrooms, there was a turn that opened into a bright, light filled bedroom. He felt this approach was similar to that found in nature. The analogy was that of a person walking up a hill and turning a bend around a large tree, and then being surprised by an expansive view of a valley.

Richard Neutra and the Lovell House

"Place Man in relationship to Nature; that's where he developed and where he feels most at home!"

Richard Neutra

Richard Neutra (1892-1970) was born in Vienna, Austria, and came to the United States as a young man in 1923. His concept of architecture was that it should be about people and "was a means to bringing man back into harmony with nature and himself."[50]

Neutra wanted to use technology to enhance life on earth rather than to destroy it.[51] He coined the term "biorealism" to reflect the inherent relationship between man and

[50] Von Eckart, Wolf. Saturday Review. June 6, 1970. (Back cover of "Richard Neutra: Building with Nature."

[51] Von Eckart, Wolf. Saturday Review. June 6, 1970. (Back cover of "Richard Neutra: Building with Nature."

nature and in 1954 he published *Survival Through Design* to reflect concerns about pollution and environmental protection. In 1927, Neutra designed a home for physician Philip Lovell. Dr. Lovell was a naturopath who advocated healthy living over medicines and surgery.[52] The house came to embody the features Lovell saw as requirements for a healthy lifestyle and it became known as the Lovell Health House. Neutra worked closely with Lovell to meet his objectives for health as well as incorporating an ecological approach to the design. The Lovell house was the first steel skeleton house to be built in the United States, however that honor does not diminish Neutra's ecological sensibilities – he "tried to place his Health House close to nature, like a bird's nest nestling into the landscape; all his other houses are its successors in their efforts to be "nature-near."[53]

Atmospheric and Luminous Environments

Neutra and Lovell shared a common philosophy about the important role of air and light in the domestic space.[54] To maximize ventilation, the house was positioned on the side of a hill to maximize the potential air flow. Neutra also included five patios and six porches to be used for sunbathing and as sleeping porches.

Neutra also believed that the living space should not be separated from "the green world of the organic."55 He viewed the green overhang of the forest as an innate filter for sunlight, creating a natural pattern from the sun's rays. Neutra not only put nature's trees and shrubbery close to the house, but the closeness of the green foliage

[52] Solan, Victoria. "Built for Health." p.137.
[53] Neutra, Richard. *Building with Nature.p. 55.*
[54] Solan, Victoria. *Built for Health.* p. 150.
[55] Neutra, Richard. *Building with Nature.* p. 25.

provided similar light patterns as would be experienced walking under a canopy of trees. Neutra also effectively used floor to ceiling windows to bring in the natural light and provide a scenic perspective of the nature nearby. Furthermore, all of the major rooms opened into an outdoor space and this integration of the outdoors and indoors created an environment full of fresh air and natural light.

Twentieth Century: Summary

Technical innovation made a tremendous impact to building systems in the 20th century. Certainly the heating and cooling systems became more energy efficient and many buildings have become "tighter" in retaining the internal target climate.[56] However, technology advances do not necessarily equate to environmental sustainability. Advanced technology was not required for passive solar heating, such as seen in the Ramirez House, and could be maintained by the situation of the house and exposure to the sun. Nor did Frank Lloyd Wright utilize complex technology for his approach to radiant heating, which was very similar to the principle of the hypocausts used in Roman baths. Furthermore, the 20th century saw a continued implementation of natural ventilation using cross-breezes, porticoes, and sleeping porches as a successful means of providing fresh air and natural lighting.

[56] Park, Sharon C. NPS Technical Brief No. 24. p. 4.

Chapter 5: Summary and Conclusions

The results of this project confirm that there have been many dedicated, innovative architects of American architecture pursuing environmentally sound approaches to sustainable design. In the 18th century, the approaches were fairly basic, such as the placement of deciduous trees to provide shade in the summer and to provide heat from the winter sun. Although primarily common-sense based, the 18th century approaches showed a commitment to improve building thermal, atmospheric, and luminous environments. In the 19th century, new technical approaches such as central heating, gravity based ventilation, and mechanically controlled cupolas became tools to support environmental sustainability. The 20th century brought many new technical innovations and materials, but many of the sustainable design principles implemented continued to use natural resources to improve heating and cooling efficiencies, indoor air quality, and lighting. Radiant heat, passive solar heat, and building settings to take advantage of cross-breezes continued to be proven approaches to environmental sustainability.

There are several benefits to be gained from understanding the historic perspective for sustainable design in American architecture. The more knowledgeable we are about historic approaches to sustainability, the less likely we are to destroy functional building systems. For example, consider the National Park Service’s concern about cupola’s being removed from historic sites. The perception that the cupola is simply an architectural feature can be corrected by communicating that its function is to ventilate, cool, and provide natural light in a building.

Another benefit is to provide a perspective to facilitate the balancing of sustainable design and historic preservation goals. As noted earlier, one of the National Parks Service's "Lessons Learned" is that sometimes preservation and sustainability guidelines can be inconsistent and it's important to understand how the two can complement each other. Consider, for example, operable windows. Well-meaning people seeking LEED performance certification may unknowingly replace operable windows, believing that this will lead to a more energy efficient building. However, there are many other considerations related to the replacement of operable windows, such as the natural ventilation they can provide, that should be considered prior to replacing them.

In conclusion, this project has yielded a sampling of historic sustainable designs in American architecture. These examples can be used by others to 1) become more knowledgeable about historic approaches to sustainability, 2) to be able to recognize examples of sustainable approaches in other historic buildings, and 3) to consider using or renewing these approaches in their preservation and rehabilitation projects. An additional benefit, and perhaps the most important, is that communicating historic sustainability principles may be able to support the convergence of historic preservation guidelines and sustainability performance principles, leading to a united approach for historic preservation and environmental sustainability.

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