VIEWS FROM ABOVE: COMBINING GREEN ROOF TECHNOLOGY WITH RESTORATIVE VIEWS OF NATURE

by

JESSICA MAE BUESCHING

(Under the Direction of Marguerite Koepke)

ABSTRACT

Green roofs are one of the many design solutions created to balance the growth of society with environmental concerns. These surfaces provide a range of environmental and economic benefits to both individuals and large-scale systems. The proximity of many of these vegetated rooftops to nearby buildings, particularly in urban settings, creates opportunities for views from windows onto the green roof surfaces. Multiple studies indicate that views of nature offer psychological and physiological benefits to humans in various settings. This study looks at the potential of applying concepts from psychologically restorative natural settings to green roof surfaces, creating green roof designs which provide not only environmental benefits, but opportunities for mental restoration and stress relief to those individuals viewing the green roof.

INDEX WORDS: Green Roofs, Restorative Landscapes, Environmental Psychology

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JESSICA MAE BUESCHING

B.A., Denison University, 2001

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF LANDSCAPE ARCHITECTURE

ATHENS, GEORGIA

2004

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by

JESSICA MAE BUESCHING

Major Professor: Marguerite Koepke

Committee: Marianne Cramer
Jack Crowley
Linda Velazquez

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
May 2004

DEDICATION

Thank you to my parents, who have always supported my artistic ambitions, and who helped me to see that there truly is a way to combine art with science.

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CHAPTER 1: INTRODUCTION

We live in a society of growth and expansion. Each new discovery pushes us to explore one step further, to find answers to our lingering questions, and to set higher goals. Despite the many positive outcomes gained from this progress, the desire for new information and new discoveries comes with a price on both environmental and individual levels. Buildings and roadways replace many natural landscapes, disrupting environmental processes and systems. On an individual level, pressure from society and both job and self-imposed deadlines cause many individuals to suffer from stress and mental fatigue.

This thesis will explore the separate ideas of green roof technology and the impact of views of nature on humans, and illustrate the possibility of combing the topics together in the design process. Vegetated rooftop surfaces go far back in history, and are slowly making a re-appearance in the built environment. Chapter two explores the history of green roofs and looks at the wide range of benefits created from a single green roof installation.

Views of nature and the natural landscape have had a noted impact on humans throughout history. Chapter three discusses many of the theoretical approaches to explain our association with the natural landscape, as well as the healing qualities associated with nature. Examples from the evolution of the medical profession, movements in art history, and ideas of spirituality and the landscape illustrate a few of the many ways humans find positive connections with nature.

Recent studies indicate that views of nature have a restorative quality that positively impacts an individual's perceived sense of stress. Psychological studies presented in chapter four offer observations and surveys which illustrate the beneficial impacts of nature on perceived stress levels. These studies include individuals in educational, medical, urban, and employment settings. In addition to an individual's perceived sense of stress, study data presented in chapter five indicates that views of nature have a positive impact on an individual's physical responses to stress and information overload in the same four types of settings.

Green roofs offer one solution to help solve not only the environmental problems caused by population expansion, but also an opportunity to provide individuals with moments of relief from stress and information overload. Chapter six explores the relationship between views of nature and green roof settings, and the possibility of creating restorative moments through green roof design. A conceptual design for The University of Georgia law school library annex, described in chapter seven, demonstrates the design possibilities created by merging the two ideas of green roof technology with restorative views of nature. These views from above onto green roof systems have great potential to positively impact a wide range of individuals and systems. The design possibilities are endless, and each green roof project is a small step in increasing the knowledge, awareness, and potential benefits of the system on a variety of levels.

CHAPTER 2: GREEN ROOFS

In a society hungry for technological advances and progress, much of the unaltered countryside transforms from greenspace into buildings and roadways. This growth comes with a price; air quality, water quality, and useable wildlife habitat are just three environmental systems which show signs of distress. In the search for solutions to our environmental problems, rooftops provide designers with a blank canvas for new possibilities. "Rooftops are a city's greatest untapped resource—acres and acres of empty space just waiting to be used!" (Kuhn, 1996). While many developers see rooftops as an avenue for expansion, these flat or slanted surfaces provide a location to solve problems caused by overdevelopment. A single green roof simultaneously offers multiple benefits, including the reduction of stormwater runoff, lower air temperatures, and the reintroduction of vegetation in dense urban environments.

Green Roofs: Extensive and Intensive Systems

In casual conversation, the terms "green roof" and "rooftop garden" are often used interchangeably, yet there is a distinct difference between the two concepts. Rooftop gardens are generally container gardens located on building rooftops. The plants which make up these gardens are primarily grown within individual pots or containered planters. Green roofs are much more involved systems (Figure 2.1). A traditional green roof is a compact layered

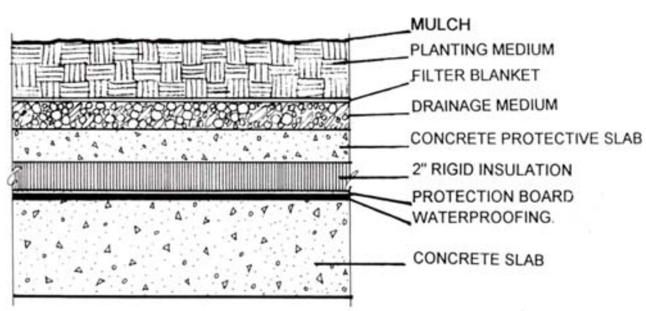

Figure 2.1 Typical American green roof section; these components are found in both extensive and intensive systems (Osmundson, 1999, p153).

system, including plants, the growing medium, a root barrier, drainage layer, waterproofing layer with root repellant, and the roof structure itself (Peck & Kuhn, n.d.). These contained green spaces, located atop man-made structures, can be found at, above, or below grade. Once established, the networks of plants located on these rooftop surfaces resemble colorful meadows.

There are two major types of green roofs: extensive and intensive systems. Extensive green roofs are very thin, light-weight systems that require minimal amounts of maintenance and water once established (Figure 2.2). The growing medium for this green roof system is typically not made of traditional soil, but is composed of a mineral mixture including gravel, sand, crushed brick, peat, leca, and organic matter (Peck & Kuhn,

Figure 2.2 Extensive green roof; Assembly Plant, Ford Motor Company, Dearborn, MI (Michigan State University, Department of Horticulture),

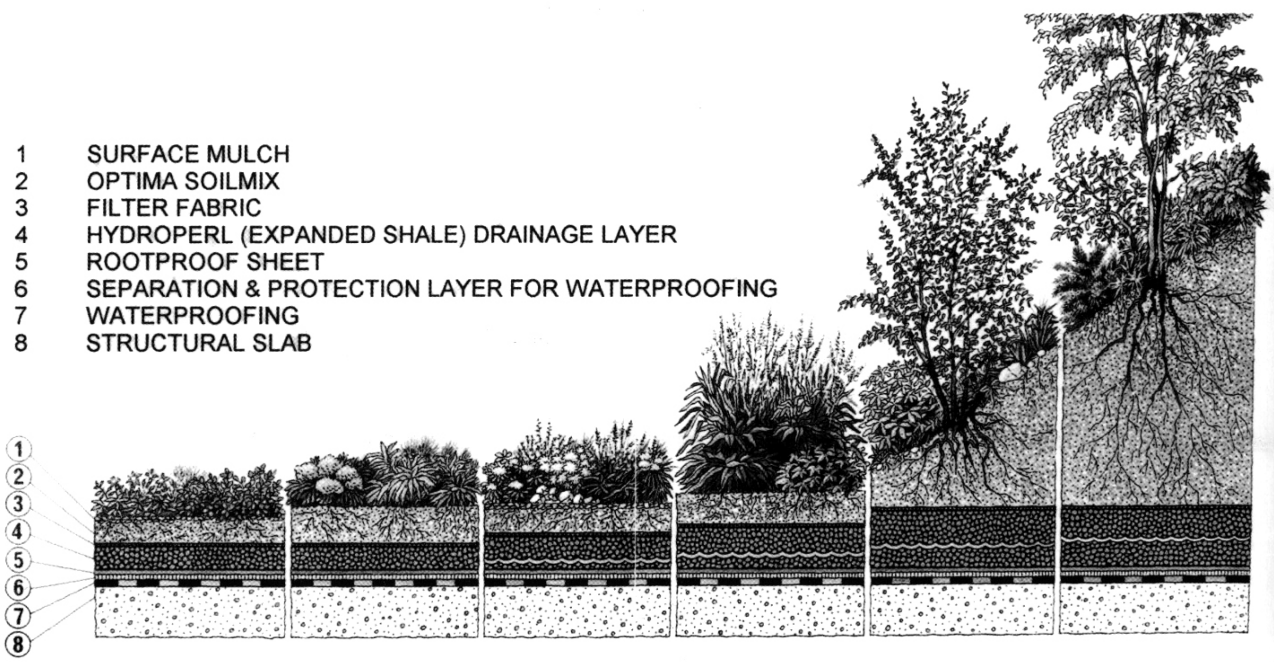

Figure 2.3 Extensive (left) and intensive (right) green roof sections (Osmundson, 1999, p182)

n.d.). The growing medium of a standard extensive system ranges from 2-6” in depth, and when wet, weighs approximately 10-40 pounds per square foot. This system has the potential to reduce stormwater runoff by 75% (Conservation Design Forum, 2003). The shallow growing medium creates dry, harsh conditions that many plants cannot tolerate. As a result, extensive green roof plantings typically include native species or plants tolerant of harsh alpine conditions (Peck & Kuhn, n.d.). Typically, an extensive green roof system is not accessible to the public. This type of green roof is primarily designed to improve environmental conditions and to lessen the impacts of a built structure on the environment.

The main differences between extensive and intensive green roofs are cost, the depth of the growing medium, and the choice of plants on the rooftop (Figure 2.3). Intensive green roof systems require a much higher level of care and maintenance after construction is complete. This system of green roofs is characterized by a deeper growing medium, a heavier overall weight, higher costs, and a more diverse plant palette. Unlike the extensive green roof, intensive green roof systems use soil as the growing medium (Peck & Kuhn, n.d.). The soil layer is usually greater than 8” deep, and the saturated weight may exceed 60 lbs/sf. Depending on the thickness of the soil layer and the structural components of the building, a rooftop may require additional support features to bear the weight of the green roof. A saturated 12” intensive system, for example, weighs approximately 75-100 lbs/sf, while a 24” system can weigh up to 150-190 lbs/sf at saturation. Intensive systems have the ability to reduce the average annual rooftop water runoff by over 85% (Conservation Design Forum, 2003). The increased thickness of the growing medium allows for diverse plantings, including shrubs and some trees. Whereas many extensive roofs do not include an irrigation system, intensive green roofs often incorporate some form of irrigation into the design (Peck & Kuhn, n.d.). Unlike extensive systems, intensive green roofs are often accessible to the public. These surfaces are designed not only to improve environmental conditions, but can have recreational functions, including garden space, patios or rooftop restaurants, and even small golf courses.

History

Green roofs are not a new concept in the design field. Green roofs, rooftop gardens, and raised vegetated surfaces date back to prehistoric times. The ancient ziggurats of Mesopotamia are the first mention of man-made gardens constructed above grade. Many of the flat landings of these stepped pyramids of stone were planted with trees and shrubs. These vegetated terraces offered resting places and relief from the heat during the climb to the top of the structure (Osmundson, 1999). The Hanging Gardens of Babylon provide another legendary example of rooftop gardens (Figure 2.4). Built by Nebuchadnezzar II during the rebuilding of Babylon, historical accounts describe the terraced structures as supported by a series of vaults to hold the soil and plant material. The highest of these vaults raised the uppermost garden to the same level as the neighboring city walls (Osmundson, 1999). In order to protect against wind and rain, the Vikings built structures with turf roofs and walls (Peck, Callaghan, Kuhn & Bass, 1999). Several examples of 300-400 year old homes with rooftops of wood, bark, and layers of sod still exist today in Iceland and Skandinavia (Kuhn, 1996).

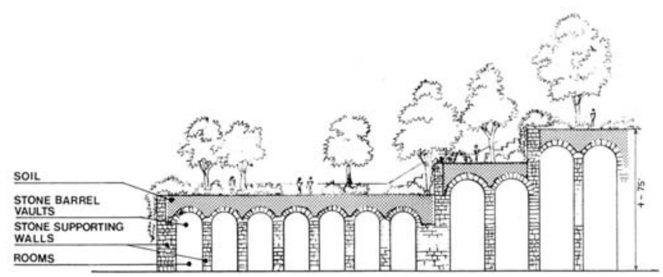

Figure 2.4 Hanging gardens of Babylon (Osmundson, 1999, p113)

For a short time during the early 1900's, rooftops offered a place of escape from the crowded city life. While traveling through Europe, Rudolph Aronson, an American conductor and musician, was inspired by the relaxation people sought in the country. During the summer months until the mid 19th century, Europeans wishing to experience the theater traveled to the countryside to enjoy pleasant, leisurely evenings of music in pleasure gardens. Aronson brought this idea home to New York City and the theater district (Figure 2.5):

> To the realization of financial obstruction I believe may have been due my greater thought, for at once came to me the question: why not utilize for garden purposes the roof of the buildings I hope to erect, and thus escape the enormous cost of valuable ground space? In other words, I mentally transported the Ambassadeurs from the ground floor of the Champs Elysée in Paris to the roof of a building on Broadway in New York. Already I christened it in my mind the Roof Garden, and I could mentally see an adornment of plants, shrubbery, and fountains. (Johnson, 1985, p5).

The popularity of these summer retreats above winter theaters was short-lived. By the mid 1920's, technological advances led to the decline and extinction of these open-air summer venues. Public auditoriums in theaters soon were all equipped with air conditioning units, eliminating the need to go outdoors to stay cool. Newer buildings were too tall and windy for outdoor rooftop entertainment, and the constant noise of the city made outdoor entertainment on lower buildings difficult to enjoy (Johnson, 1985; Osmundson, 1999).

Figure 2.5 Rooftop theater garden; American Theater, New York City (Osmundson, 1999, p123).

Modernist architects Le Corbusier and Frank Lloyd Wright incorporated the idea of rooftop gardens into their designs and philosophies. Swiss architect and designer Le Corbusier looked at roofs as additional living space and urban green space (Osmunson, 1999; Peck & Kuhn, n.d.). In his writing, "The Five Points of A New Architecture," which later became an important document defining modern architecture, Le Corbusier included rooftop gardens as one of the five points. He noted that with the establishment of central heating, traditional (convex) rooftops were no longer necessary. His vision for the future of building rooftops consisted of concave, reinforced concrete surfaces with terraced garden spaces. To prevent extreme temperature differences from cracking the concrete, Le Corbusier proposed maintaining a constant humidity level by filtering rainwater downwards towards the center of the roof. Sand and grass across the terraced surfaces allowed slow water infiltration into the system, thereby maintaining constant moisture levels along the rooftop surface. According to one author's summary of Le Corbusier's five concepts, "The garden terraces become rich with flowers, shrubs, trees, and grass. Thus we are led to build roof-terraces for technical reasons, for economic reasons, as well as for comfort and beauty" (Jordan, 1972, p37).

Frank Lloyd Wright saw vegetated rooftop spaces as a way to further incorporate the building into the landscape, and to extend the interior function of the building into the outdoor arena (Osmundson, 1999). This extension of architecture into nature and the interrelationship between constructed features and the landscape is evident in many of his residential designs (Aguar & Aguar, 2002). While Frank Lloyd Wright differed from Le Corbusier in his vision for urban development, he also saw rooftops as an important component in the urbanization of our growing cities. In the Skyscraper Regulation Project (1926), involving nine blocks of the downtown Chicago Loop area, Wright described alternative urbanization concepts for the city. Of these, one recommendation included establishing roof gardens to "create inner-city green spaces for outdoor living" (Aguar & Aguar, 2002, p221).

Though green roofs and rooftop gardens were once considered vernacular building practices, they are making a strong reappearance in contemporary design. With increasing concern for the loss of greenspace and the decline of urban environment health in the 1960's, Europeans turned to green roofs as a potential solution (Peck & Kuhn, n.d.). The 1980's saw a large growth in the European green roof market, partly driven by state legislation, municipal grants, and monetary incentives offered per square meter of installed green roof material. These incentives were effective, and in 2001, Germany retrofitted 13.5 million square meters of its rooftop surfaces with green roofs (Grant, Engleback, &Nicholson, 2003). Today, green roofs are a frequent sight in most European countries. The United States is still ten years behind the European designers in terms of green roof technology and knowledge (Peck & Kuhn, n.d.), yet the documented benefits of green roof technology are prompting designers and developers alike to rethink traditional roofing methods.

Green Roof Benefits

Green roof technology benefits a range of users and systems. Initially, the cost of a green roof installation is almost twice that of traditional premium rooftops and three times that of the more common low-cost rooftop projects (Roofscapes, Inc., 2002). While the initial cost of green roof installation is high, many designers and developers believe that the benefits of green roof systems and potential long-range outcomes outweigh these initial costs.

Public Benefits

Stormwater benefits. One of the most discussed public benefits gained from green roof technology is the reduction of stormwater runoff. Increased impervious surfaces in urban and suburban landscapes impede the natural process of rainwater infiltration back into the groundwater system. A forested or open, undisturbed landscape has almost no surface runoff. Approximately 30% of the rainwater from a storm event reaches the shallow aquifers, and another 30% recharges deeper aquifers. The remaining 40% immediately returns to the atmosphere through plant evaporation and transpiration. However, urban areas with 75-100%

impervious cover see only 5% groundwater recharge from a single storm event and 15% water evaporation (Scholz-Barth, 2001). The remaining water runs off paved and impervious surfaces and has a detrimental affect on urban stream ecology. Traditional stormwater management systems focus on conveying this excessive stormwater runoff through high-velocity concrete pipes. These pipes frequently funnel stormwater into urban streams. As a result, urban streams face unnatural fluctuations in water levels and water quality, leading to stream bank erosion and habitat degradation. This stormwater runoff is often warmed as it flows off of pavement or built structures, leading to the unnatural heating of the stream environment.

Green roofs offer a potential solution to the stormwater runoff concerns of urban and suburban settings. A study conducted in the city of Portland, Oregon estimates that retrofitting half of the downtown rooftops with green roofs could retain approximately 66 million gallons of water each year (Peck & Kuhn, n.d.). Green roofs cleanse stormwater as the water percolates through the soil, filtering out sediment, leaves, and particulates. Any water not absorbed by the rooftop system exits the system cleaner than when it entered (Scholz-Barth, 2001). By lessening the quantity of water runoff and improving the quality of water that is not absorbed, green roofs have a positive impact on urban hydrology.

Urban Heat Island Effect. Another concern facing growing cities across the country is elevated atmospheric temperatures. Paved and constructed surfaces absorb and retain daytime heat. In areas with high percentages of paved surfaces, this extra heat leads to the overheating of entire areas, a process known as the urban heat island effect. Atlanta, for example, has summer temperatures approximately 10° F higher than the surrounding landscape (greenroofs.com, 2003). This ten degree temperature difference nearly doubles the amount of ozone produced in the Metro Atlanta area (greenroofs.com, 2003). In addition to increased pollutants in the atmosphere, higher urban temperatures lead to a greater demand on energy supplies and more heat-related illnesses.

Green roofs have the potential to reduce the rooftop heat absorption and decrease the urban heat island effect. Plant material on the rooftops absorbs or deflects solar radiation before it comes into contact with the roof surface, preventing excess heat production (Peck & Kuhn, n.d.) (Figure 2.6). In a study conducted on the Chicago City Hall green roof, temperatures were measured on both the city hall (green roof) and county (black roof) sides of the building. August afternoon temperatures on the planted portion of the city hall green roof ranged from 91-119°F. The paved portion of the city hall green roof gave readings between 126-130°F, while the black tarred county side of the building was 169°F (City of Chicago, 2001). Test green roof systems, such as the Chicago City Hall green roof, clearly demonstrate the positive impact of vegetation on urban atmospheric temperature reduction.

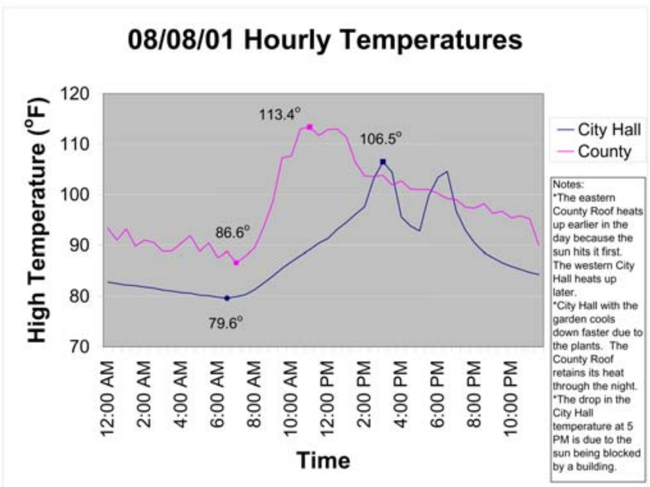

Figure 2.6 Chicago City Hall temperature data comparison between green roof (city hall) and tarred roof (county side) (City of Chicago, 2001).

Air quality benefits and habitat creation. Additional public benefits gained from green roof projects include improved air quality and habitat creation for urban wildlife. Plants help to remove airborne particulates from the atmosphere. A one square meter of grass roof can remove up to 0.2 kg of dirt from the air each year (Earth Pledge Foundation, 2002). This greened rooftop oasis provides a stepping stone for birds, connecting isolated habitat pockets within an area, or establishing an elevated island habitat among the urban environment (Peck & Kuhn, n.d.).

Private Benefits

Roof protection and energy savings. Private benefits of green roofs affect building owners and individual users. One of the most significant benefits building owners experience from a green roof installation is the extended lifespan of the rooftop itself. Typical roofs require costly repairs or replacement after 15 to 20 years due to extreme temperature fluctuations and exposure to damaging UV radiation (Earth Pledge Foundation, 2002). Green roofs act as a buffer to these harsh environmental conditions, preserving the integrity of the roof. In many cases, a green roof can extend the life of a rooftop up to three times that of a traditional roof (Scholz-Barth, 2001).

Vegetative coverings over buildings create significant energy savings for the building itself. In general, buildings with green roofs consume less energy than those without vegetative coverings. In a study comparing energy savings for buildings with and without green roofs, a non-insulated building with a green roof can expect a 44-48% annual energy savings, a moderately insulated building with a green roof 5-7% annual energy savings, and a well-insulated building with a green roof a 2% savings in energy costs (Niachou et al., 2001). In a simulated study of the Chicago city hall green roof, a 1° F drop in the rooftop ambient air temperature resulted in approximately a 1.2% drop in the building cooling energy costs. Based on this approximation, if all buildings in the downtown Chicago area were retrofitted with green roofs (approximately 30% of the total land area) the city could save $100 million dollars in annual cooling costs (Peck & Kuhn, n.d.).

Incentive Programs

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program identifies green roofs as one of many ways to "green" new or existing buildings. LEED standards are significant in the design field, establishing a common set of standards for measuring efforts of green technology, promoting environmentally-sound building practices, recognizing environmental leadership in the building industry, raising awareness of the benefits of environmental building practices, and establishing competition among designers and developers of green technology (U.S. Green Building Council, 2003). This voluntary program, targeting new or existing commercial, institutional, and high-rise residential structures, evaluates the environmental performance of a building over the life of the structure. Green roofs can earn a building up to three credits towards LEED certification based on the stormwater control properties, energy efficiency, and natural views provided by the vegetative surfaces (greenroofs.ca, n.d.). Additional credits may be possible as the building generates data based on the performance of the green roof and energy consumption.

Cities worldwide offer incentives to improve the impacts of urban development on the environment, including the use of green roof technology. Over 80 cities in Germany alone provide incentives for incorporating green roof technology (greenroofs.com, 2003). Stuttgart, Germany, for example, requires that all new flat-roofed industrial buildings install green roofs (Peck & Kuhn, n.d.). While green roof incentives are not readily available in the United States, several cities are beginning to see the importance and potential of these vegetated features. In June of 2002, Chicago passed the Chicago Energy Conservation Ordinance, requiring all new or refurbished roofs to incorporate green roofs or reflective roofing materials (Earth Pledge Foundation, 2002). The Earth Pledge Foundation recently launched the Green Roof Initiative in

New York City, a program promoting the installation of green roofs across the city to lower temperatures, improve the overall air quality, and reduce stormwater runoff (2002). This pilot program emphasizes both the environmental and the economic impacts green roofs have on the community.

Atlanta is one of many cities searching for new ways to manage environmental problems. The Atlanta Regional Commission notes that currently, more than 800 stream miles in the ten county Metro Atlanta area violate water quality standards (n.d.). Approximately 80% of this affected area is from non-point sources and urban runoff. Water quality is not the only environmental concern facing the city. In terms of air pollution, Atlanta is one of the largest metropolitan areas which does not meet the Clean Air Act's requirements for ozone levels (Atlanta Regional Commission, n.d.). As one means of addressing these concerns, Atlanta is in the process of revising many of its environmental policies, including those addressing stormwater. The new policies will include the use of green roofs as a means of stormwater management (greenroofs.com, 2003). The extensive green roof system on Atlanta's city hall, completed in January of 2004, is one of the first green roof demonstration projects in the southeast (Figure 2.7). In a telephone interview with Benjamin Taube, Environmental Manager for the city of Atlanta, Taube said that while data from the rooftop will be monitored and collected, the primary purpose of the green roof project is public exposure, demonstrating to the general public the advantages of green roof systems (personal communication, January 13, 2004).

Figure 2.7 Atlanta City Hall green roof; December 2003 (courtesy of Benjamin Taube, Environmental Manager, City of Atlanta).

The benefits of green roofs in our urban and suburban communities extend beyond the documented environmental and economic impacts. According to landscape architect Bruce Dvorak of Conservation Design Forum, "For every design 'action,' there are environmental, social, and psychological reactions to be observed" (2003). Green roofs mimic many of the processes of natural, undisturbed environmental conditions. Numerous studies illustrate the stormwater and temperature-reducing properties of green roofs. These environmental results translate into economic incentives for installing green roof systems. Socially, green roofs offer places for community gardening, bringing neighbors together through the gardening process. Individuals living in urban settings in buildings with green roofs have the opportunity to escape city life to a raised vegetated vista. It is the psychological impacts of viewing or experiencing green roofs which are just now being acknowledged and explored. Landscape architect Theodore Osmundson states, "A roof garden, particularly a roof garden located above ground level, is like a peaceful island within the urban jungle" (1999, p28). Simply viewing a green roof allows city-dwellers and urban employees to maintain a connection with nature. Accessible green roofs offer a place of isolation away from the distracting noises of an urban environment. Views from neighboring buildings overlooking green roofs offer moments of rest and visual escape from stress. It is this visual connection with nature in urban and suburban environments that creates another level of benefits gained from green roof installation. Not only do green roofs relieve some of the stress on environmental conditions caused by excessive development, but they provide a source of mental restoration for the people who see or experience them on a daily basis.

CHAPTER 3: THE RESTORATIVE VALUE OF NATURE

Elements of nature have the ability to restore equilibrium to distressed systems. Whether these systems are natural processes disrupted by urban development, or are humans under stress and compromised from work or school, nature plays a role in the restoration process. A single landscape system in an urban setting, for example, simultaneously provides positive ecological *and* psychological outcomes:

> In addition to its ability to remove pollutants and cool the air through shade and transpiration, urban greenery is important psychologically. It provides a safety value, giving respite from the constant tension imposed by the built environment. Vegetation allows the human spirit to release itself from the inherent stress of the technosphere and helps it regain stasis and ease (Lewis, 1996, p31).

Researchers have developed multiple theories to illustrate the logical connection between humans and the natural environment, each in a slightly different context. History paints a picture of man's conscious decision to incorporate the natural environment into the human lifestyle. Plans for the design of an ideal monastery, originating from the monastery of St. Gall, Switzerland during the ninth century, mentioned including 49 different plant species (Squire, 2002). Art and religion tie spirituality and spiritual healing to the landscape (Figure 3.1). Thomas Cole's painting, *The Subsiding of the Waters of the Deluge* (1829), shows not only God's destructive capabilities but also the possibility of hope and reward for the future

Figure 3.1 Thomas Cole. *The Subsiding of the Waters of the Deluge* (Veith, 2001, p71).

(Veith, 2001). Together, these theories and studies illustrate a strong connection between the human lifestyle, restorative experiences, and the landscape.

Theoretical Concepts

The attraction of man to vegetation and the environment is not a random event. It is a pattern evident far back in our history. Several theoretical arguments help to explain our attraction to nature and the restorative experiences we perceive from the environment.

Many researchers identify this connection with nature as a learned habit over time. Through interactions with other people and precedents set in past designs, individuals learn to positively respond to certain types of plants and natural experiences, and to prefer certain forms of nature over others. American society, for example, teaches individuals to identify positive associations with nature through vacations, and stress or negative feelings with city life void of vegetation (Ulrich & Parsons, 1992). Many of our specific preferences in landscape design are a learned habit. Diane Relf illustrates this idea with the concept of foundation plantings in America (1998). Though no longer necessary to hide unattractive portions of buildings, previous generations promoted this style as attractive. Contemporary society learned this preference from past generations and continues to prefer and endorse this type of design today (Relf, 1998).

These associations and learned preferences establish a general trend, and it is important to remember that a single image in nature does not necessarily evoke a universal response. In his research, Charles Lewis notes that "the interpretation [of nature] will depend on what life experiences we bring to the seeing. A given landscape setting or even individual tree may evoke different responses in different people" (1990b, p33). Learned preferences differ regionally. An individual growing up in Texas may have a more positive attitude towards flat, open landscapes with sparse vegetation than someone who grew up in the mountains of Virginia (Relf, 1998).

Studying the human-nature connection from a cultural standpoint expands on the learned habit of human responses to the environment, and helps to explain differences in preference across social boundaries. Multiple societies around the world teach positive associations with nature, but the specific features valued by each culture differ. Ulrich and Parsons give the example of the French preference for topiary and the American fascination with foundation plantings (1992). Even the same plant species has different connotations in different cultures. The Tree of Heaven (*Ailanthus altissima*) is considered a weed tree in American designed landscapes. However, in other countries such as Korea or Holland, the Tree of Heaven is considered a valuable species in street tree plantings (Lewis, 1990b).

Correlations between technological advances, stress levels, and nature form the basis for the arousal-overload theory. This theory links a person's attraction for nature with the stress-reducing effects perceived from viewing the natural experience. The world of technology and progress bombards individuals with overwhelming levels of sound, movement, and visual complexity. This high level of stimuli leads to "damaging levels of psychological and physiological excitement" (Relf, 1998, p22). According to Relf, plants and visions of nature help to lower these arousal levels and reduce our perceived sense of stress (1998). Ulrich makes a similar argument for this arousal-overload theory, noting that it is the presence of nature, not necessarily the quantity of the natural stimuli, which results in lower levels of stress responses (Ulrich et al, 1991; Ulrich, 1991).

Some researchers argue that the human affinity for nature has an evolutionary basis. Jay Appleton argues that current landscape preferences come from our biological history and the importance of habitat selection for survival (Gerlach-Spriggs, Kaufman, & Warner, 1998). In his analysis, the savanna-type of landscape provided the optimal setting. Elements of the savanna met the survival needs of early humans, offering prospect and refuge, safety and sustenance. Heerwagen and Orians support this argument, noting that when cost is not a factor, individuals today choose to live in or near landscapes that mimic the characteristics of a savanna (1993).

> Most evolutionary explanations have in common the argument that, as a remnant of two or three million years of evolution, modern humans may have a partly genetic readiness to respond positively to types of nature content (such as vegetation or water) and environments that were favorable to well-being and survival for premodern people (Ulrich, 1999, p51).

Ulrich notes that while differences exist among researchers on the details of this theory, the common link among evolutionary arguments is the connection between humans and certain combinations of content and arrangement of forms within the environment (Ulrich & Parsons, 1992).

Researchers Judith Heerwagen and Gordon Orians tested the hypothesis of the human evolutionary preference towards a savanna-type landscape by looking at drawings by two notable designers (1993). Humphrey Repton, an 18^{th} century British landscape architect, often gave his clients "before" and "after" drawings of their estates. These drawings, accompanied by text and bound in red-covered books, were known as Repton's Redbooks. Heerwagen and Orians note that Repton is an interesting case study, as he often altered his designs to make the overall product more appealing to the potential client. Their analysis of 18 different "before" and "after" images shows that Repton frequently added or removed elements from the landscape to create a vision similar to that of the historic savanna. In a separate study of nine pairs of sketches and paintings by 19^{th} century English painter John Constable, Heerwagen and Orians found similar results (1993). Landscape painters such as Constable frequently altered the scenes they painted to increase the interest and drama of the scene. Constable typically composed quick sketches of the existing landscape before rendering the final product. These "before" sketches gave researchers a base with which to compare the final product and draw conclusions. As in the study of Repton's Redbooks, Heerwagen and Orians noted that Constable often altered the existing landscape to create a savanna-like appearance.

Edward Wilson brings together these evolutionary ideas of nature and the complex interactions of people with the environment in the concept he calls "the biophilia hypothesis." Biophilia, the emotional and physical attraction of humans to nature and other living organisms, implies a hereditary relationship between humans and nature (Wilson, 1993). It is not a single instinct, but a combination of responses and rules learned over time that influence an individual's emotional, cognitive, aesthetic, and spiritual development (Kellert, 1993). Wilson uses the human response to snakes as a demonstration of the evolution of a biophilic response (1993). General biophilic responses, such as modern human responses to snakes, are a result of evolutionary processes induced by constant exposure to snakes over time. Through natural selection, the aversion for and fascination of snakes is passed on to future generations. This process dates back to interactions of the Old World monkeys, who developed vocalizations to warn other members of the community of the presence of snakes in the area. As in all theories, the notion of biophilia does not necessarily elicit uniform responses across every gender, ethnic, and cultural group (Soulé, 1993).

Healing Aspects of Nature

Despite differing arguments to rationalize our affinity for the natural environment, both past and present civilizations have realized the restorative potential of the landscape and incorporate nature and natural views into designs and lifestyles.

> The garden or landscape is connected to people in a way that is uniquely healing in its essence. The restorative qualities of gardens span the human spectrum and have no social, cultural, or ethnic boundaries. Gardens may contain elements that are specific to culture, climate, or time, however, the simple truth of their

> existence reflects the universal desire for human interaction with nature, with humans as the stewards of the land" (Tyson, 1998, p3).

Similar to green roofs, human desire for contact with nature dates back to prehistoric times. Evidence of gardens built in early civilizations exists in designs constructed before the birth of Christ. In ancient Egypt, Egyptian court physicians encouraged mentally disturbed members of the royal family to walk in palace gardens (Davis, 1998). Many early Persian settlements in Mesopotamia established wall gardens within their living spaces (Ulrich & Parsons, 1992). The stepped surfaces of the ziggurats of ancient Mesopotamia, already discussed as an example of early rooftop gardens, were covered with trees and shrubs to provide places of rest and relief from the heat (Osmundson, 1999). Cloister gardens in the Middle Ages offered places for meditation, rest, and recovery from illnesses (Tyson, 1998).

The history of the medical profession establishes a strong link between humans, nature, and health. Clare Cooper Marcus and Marni Barnes outline a detailed history of healing gardens and the use of nature in the medical profession, dating back to the arcaded courtyards of hospitals and monasteries of the Middle Ages (1999). The 17th and 18th centuries saw a growth in the ideas of science and medicine. Society's new belief in the spread of disease through airborne vapors led to the desire for fresh air and cross-ventilation. Hospitals constructed during this time period had a "teeth of a comb" appearance, with wards linked at one end by a long service corridor and useable outdoor space in between each ward. The treatment of hospital patients during the 19th and early 20th centuries frequently included wheeling patients onto rooftops or sun porches for fresh air. In addition, the treatment of psychiatric patients changed during the 19th century from assigning punishment to prescribing nurturing activities (Cooper Marcus & Barnes, 1999). In sanitariums, therapy regimens for such patients often included views of nature. The Friends Asylum for the Insane, opened in Philadelphia in 1817, included programs to involve patients with the care of vegetable gardens and fruit trees (Lewis, 1994). The institution was designed with a park-like setting, including walkways, paths, shade, and grassy meadows. In 1879, the hospital installed the first greenhouse that had the sole purpose of providing therapeutic benefits to patients (Davis, 1998).

The patient-nature relationship changed drastically in the 20th century. The general trend switched from long-term patient care and relaxation in nature to a focus on progress. Administrations achieved these goals of profits and efficiency by maximizing the use of time and space and minimizing the length of stays in hospitals. Late 20th century hospitals abandoned the early, park-like surroundings for more urban, centralized environments (Cooper Marcus & Barnes, 1999).

While hospitals temporarily abandoned the inclusion of nature in their design, the professions of occupational and horticultural therapy kept the ideas of nature and gardens as therapeutic elements. After World War II, doctors began to use horticultural therapy as a method of treatment for veterans, the elderly, and the mentally ill (Cooper Marcus & Barnes, 1999). Veterans Administration Hospitals recruited garden club volunteers to help organize activities to take war patients' minds off of their pain and stress (Lewis, 1994). The use of nature in the medical field is slowly becoming more accepted in today's society.

While spirituality is a complex topic with extreme variations between religions, it is important to note that strong historical connections exist between humans, their spiritual health, and the landscape. The history of Christianity has a strong spiritual connection with nature. Tyson offers several examples of religious figures, including Saint John of the Cross and Saint Therèse of Lisieux, who used the garden and individual elements of nature to express their union with God (1998). Native American cultures also have strong ties to the landscape, noting that humans are just one part of the natural world and that we are connected to all forms of nature in some manner (Lewis, 1994).

In various periods of art history, landscape painters saw the landscape as a means of expressing religious qualities. Romantic painters, such as John Martin, used the landscape to express man's spiritual relationship with nature (Hawksley, Cunningham, Payne, & Bradbury, 2002). The Hudson River School of art, often considered to be America's first major artistic movement, played a large role in relaying religious and spiritual meanings through art. Paintings from this era are characterized by landscape scenes with a sublime view of the wilderness. Vanishing points disappear into the light, giving an illusion of infinite space (Veith, 2001). "In their day, however, years before art for art's sake, modernist formalism, and postmodern interpretations, Hudson River School paintings were seen as spiritually exhaulting and morally beneficial for the entire nation" (Veith, 2001, p14). Many artists, including Thomas Cole, Asher Durand, and Frederic Church created large, panoramic imagery of nature that had a dramatic effect on those who viewed the works (Figure 3.2). In a description Church's painting, *The Heart of the Andes* (1859), Veith expresses the impact of not only Church's work, but the overall effect of Hudson River School paintings on viewers:

Figure 3.2 Frederic Church. *The Heart of the Andes*. (Veith, 2001, p16)

> The result is a visual representation of transcendence. Nature is rendered concretely and in detail, but the focus of the paintings is not on physical objects as such. The eye does not linger on nature for its own sake; rather the eye is made to go through and beyond nature toward something ineffable. This transcendence does not negate nature but rather gives it a particular significance (Veith, 2001, p17).

American landscape painters of the 18th and 19th century continued portraying this spiritual connection with nature through sublime, awe-inspiring imagery. “By the time Emerson was writing, the sublime had been largely transformed from an esthetic to a Christianized mark of the Deity resident in nature” (Novak, 1995).

Frederick Law Olmsted, often considered the founder of the field of landscape architecture in the United States, promoted the healing potential of nature in his designs and philosophies. He recognized and promoted the connection between health and the environment.

> It is a scientific fact that the occasional contemplation of natural sense of impressive character, particularly if this contemplation occurs in connection with relief from ordinary cares, change of air and change of habits, is favorable to the health and favor of men and especially to the health and vigor of their intellect beyond any other conditions which can be offered them; that it not only gives pleasure for the time being but increases the subsequent capacity for happiness and the means of securing happiness (Olmsted, 1865, p46).

He noted that people who are stressed from work or household chores suffer from a variety of “disorders” (Olmsted, 1865). The natural landscape served as a place of relief from these stresses and the “rigidity and confinement” of city life; such landscapes offered refreshing views for both the mind and spirit (Beveridge & Rocheleau, 1995). “It therefore results that the enjoyment of scenery employs the mind without fatigue and yet exercises it; tranquilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system” (Olmsted, 1865, p48). This connection between natural scenery and the restoration of both physical and mental health served as one of Olmsted’s arguments for establishing and maintaining a park system (Olmsted, 1865; Ulrich & Parsons, 1992). Olmsted used the analogy of parks as lungs for the city, offering green space for residents to relax and breathe clean air (Lewis, 1996).

Economic valuation studies offer an alternative method to illustrate contemporary society's desire to view and experience the natural landscape. While these studies do not establish a connection between human health and the environment, they do offer evidence of our desire to incorporate the natural landscape into our daily lives. The travel-cost method of economic valuation assesses the value of a resource based on the amount of money spent to reach its destination. It is not a perfect method, as many individuals place value on resources without ever visiting the site or have multiple reasons for making a single trip. Yet the general travel costs, entry fees paid, and time spent traveling help to establish a monetary value for the resource. The results of a travel cost study in the Chicago region indicate that urban dwellers place significant value on the presence of urban forests (Dwyer, Peterson, & Daragh, 1983). Housing prices also indicate society's value of urban greenspace. In a cost-benefit analysis of four urban parks in Worcester, Massachusetts, researchers found that homes next to the parks sold for higher prices than homes only 2000 feet away (More & Stevens, 1983). This study indicates that the presence of a park or urban greenspace has a positive effect on property values.

Experiencing Nature

Historical accounts illustrate a long relationship between humans and the natural environment, and recent studies indicate that humans value nature in design. How we choose to experience these elements of nature affects the level or type of benefit we perceive.

> …The conveyance from the three dimensional world—that which designers mold and shape—to the internal perceived world is not as simple or straightforward as just taking in lines, forms, colors, and shapes that comprise our environment. What the individual experiences is enhanced or added to at two stages of incorporation into the human psyche. The first level of distortion is contained in what the individual observes, and the second in how it is interpreted. (Barnes & Cooper Marcus, 1999, p88).

Observational experiences of nature provide opportunities for rest and mental relaxation (Lewis, 1990a). These experiences take the form of short walks in the park or long-term wilderness programs where participants spend lengthy periods of time in outdoor settings. Unlike constant sounds and distractions in urban settings that require effort to ignore, views of nature offer an alternative to busy every-day environments and give "an opportunity for rest from the constant mental alertness" (Lewis, 1990a, p246). Roger Ulrich identifies this concept as a positive distraction; views of elements of nature provide stress relief to both the sick and the healthy (Ulrich, 1999). Views from windows offer another opportunity to view nature, giving direct visual access to environmental information, access to sensory change, a feeling of connection with the outside world, and an opportunity for restoration and recovery (Heerwagen, 1990).

Participatory experiences establish a more intense restorative experience. While both observation and participation in nature have restorative properties, direct participation creates a connection between the individual and the environment (Lewis, 1990a). An individual working in a garden, for example, invests a certain amount of time and energy into the process, and as a result, feels a sense of responsibility for the plants in the garden (Lewis, 1990a).

Whether it is a simple, short-term observation of nature or a personal investment of time and energy into a natural system, experiences of nature have positive psychological and physiological effects on humans. The human population has a strong association with the natural environment, through survival decisions, environmental design options, spirituality, and healthcare opportunities. This historical link between human health and the environment is well-documented and establishes a basis for many recent studies on the psychological and physiological impacts of viewing nature. The results of many of these studies provide supporting evidence to the existing argument of the benefits perceived from viewing the natural landscape.

CHAPTER 4: PSYCHOLOGICAL IMPACTS OF STRESS

History describes a strong connection between man and nature. Art, religion, historical documents, and legend all describe this conscious decision of humans to include elements of nature into our daily lives. And this connection continues today. Many individuals place value in patio plants, backyard vegetable gardens, and urban greenspace. While aesthetics play a notable role in our decision to incorporate nature into our lives, some researchers believe that the benefits perceived from viewing nature extend beyond enjoying appearances. Recent studies on both the psychological and physiological impacts of viewing nature offer new evidence of stress reduction and mental restoration. Psychologically, environments with window views have positive impacts on job satisfaction and help reduce the perceived stresses of employment (Leather, Pyrgas, Beale, & Lawrence, 1998; Finnegan & Solomon, 1981). Views of nature have a calming effect on students after exams (Honeyman, 1992). Physiologically, views of nature have a positive impact on recovery from surgery (Ulrich, 1984) and prompt the brain to mimic a relaxed state of mind (Ulrich & Parsons, 1992). Together, these recent studies of psychological and physiological benefits of viewing nature strengthen the argument of the human-nature connection.

Psychological Effects of Stress and Information Overload

Contemporary society is growing at an astounding rate, leaving many individuals struggling to keep up with changes and to manage the abundance of new technology and information. Stephen Kaplan identifies one source of this increased pressure on society as an overabundance of information (1992). The quantity of information available to the public, which was once scarce and highly selected, now reaches overwhelming levels. Kaplan notes that today it is our attention, not information, which is scarce. Attempts to take in too many forms of information at once lead to stress and fatigue (S. Kaplan, 1992). Job demands, family needs, and personal goals and ambitions prevent us from eliminating these sources of stress completely. However, recent studies show that viewing elements of nature offer one solution to reduce the psychological and physiological effects of these daily stressors.

Stress is an ever-present concept which everyone experiences at some point in their lives. Gary Evans and Sheldon Cohen identify stress as a "person-based concept" that affects each individual differently (1987, p572). Overall, there are no stimuli which evoke universal responses. Personal history, methods of assessing a threat, and coping styles differ from person to person. Stress is "a relational concept signifying an imbalance between environmental opportunities and individuals' goals and capabilities to cope with that imbalance" (Evans & Cohen, 1987, p573).

Evans and Cohen identify four major types of environmental stressors. Cataclysmic events, such as floods and earthquakes, require significant changes by many individuals. Stressful life events, including marriage, divorce, or the loss of a job, require major lifestyle changes on a personal level. Daily hassles, such as noisy crowded rooms or work deadlines, are typical events that cause irritation or frustration. Ambient stressors are constant, continuous forms of stress, such as air pollution (1987). Psychological stress responses to these environmental stressors focus on how a person interprets a situation and decides to cope. These responses are individual processes; there is no universal system to explain a person's psychological reactions to a stressful situation (Evans & Cohen, 1987).

Rachel and Stephen Kaplan hypothesize that the manner in which a person absorbs information affects his or her perceived sense of stress. Involuntary attention is an effortless process and does not fatigue the mind. Interesting or exciting elements in the environment, such as the change of leaves in autumn or clouds passing in the sky, capture an individual's attention, making it very easy for the individual to focus on the subject (S. Kaplan, 1992). Direct attention, however, requires effort by the individual to focus, leaving the person subject to fatigue (S. Kaplan, 1992). Screening out background noise while trying to concentrate on an exam is one example of directed attention. The distinguishing feature between indirect and direct attention is the concept of inhibition (Kaplan & Kaplan, 1989). An individual maintains direct attention on a subject by inhibiting and blocking his or her perception of other activities. The Kaplans identify this continuing effort to avoid external distractions as a key cause of mental fatigue (Kaplan, Kaplan, & Ryan, 1998).

Mental fatigue leaves a person emotionally, not physically, tired and worn out (Kaplan, Kaplan & Ryan, 1998). Under pressure and suffering from mental fatigue, individuals are more likely to take risks, become irritable, make additional mistakes, and often lose patience with other people. Absorbing additional information becomes much more difficult. While stress often comes from the preparation for an event a person perceives as threatening or harmful, mental fatigue can come from either these threatening experiences or from activities we enjoy and look forward to (Kaplan & Kaplan, 1989).

While mental fatigue, stress, and information overload affect nearly everyone at some point in their lives, the effects do not need to be permanent. Charles Lewis summarizes several qualities of vegetation that provide psychological relief from stress and tension (1990a). He writes that plants have a soft appearance to contrast the hard lines of architecture and the built environment. Their steady, constant growth and slow, predictable change offers a welcomed contrast to the erratic changes and unpredictable interruptions of contemporary society. And in a world of constant judgment and scrutiny, Lewis notes that plants offer a non-threatening, non-judgmental element to our lives, paying no attention to race, intellect, or physical abilities (1990a).

The Kaplans build upon this positive association of plants with mental restoration, identifying four main characteristics of a restorative setting. According to their hypothesis, a restorative setting gives a person the sense of *being away*, either physically away or conceptually, allowing the mind a chance to wander. They note that this sense of being away must be separated from the source of mental fatigue—a business trip may be away from the office, but is not necessarily away from the cause of stress (Kaplan, Kaplan & Ryan, 1998). The idea of *extent*, the Kaplans' second concept of a restorative setting, creates a place that does not feel confining. The third concept, *fascination*, ensures that the restorative setting holds the individual's attention. This fascination can be something interesting, intriguing, or a feature to visually "figure out." The final concept, *compatibility*, indicates that the setting fits the needs of the individual. The Kaplans use the example of viewing a sunset. Watching a sunset provides an opportunity for escape from stress. However, if the setting includes an overwhelming presence of mosquitoes or irritating insects, the situation meant to provide a moment of relief actually introduces another form of stress. "Restorative benefits are more likely to occur when one can feel secure enough to let down one's guard, when one can become absorbed in the environment without feeling vulnerable" (Kaplan, Kaplan & Ryan, 1998, p68). These moments of rest can occur in various settings, including gardens, parks, or even from views of nature through a window.

Psychological stress responses and potential solutions are still a source of research and question. Judith Heerwagen offers several critiques of the Kaplans' definition of a restorative setting. She acknowledges that fascination may be a key component to mental restoration, yet questions how often or for how long we need to look out a window to perceive benefits. She questions whether several mini-breaks are better than one ten-minute rest, and asks whether there are options other than windows that are more effective in producing the "time way" needed for mental restoration (1990).

Comparative Surveys, Preference Surveys, and Observations

Unlike many physiological studies of stress and mental fatigue, psychological studies do not provide quantifiable data as evidence. Rather, detailed observations of actions and responses, comparative surveys between groups of individuals, and preference surveys indicate general attitudes and methods of coping with stress. Based upon these forms of study, researchers are beginning to find and document connections between experiencing various forms of nature and perceived stress reduction.

General stress. Memories and recollections of stressful times indicate that nature has significant benefits on mental well-being. Often, these studies indicate that individuals seek out nature as a place of refuge. In a survey study, a group of university students were asked to remember a time when they were upset, stressed, depressed, angry, confused, or grief-stricken and where they went to feel better. Of those surveyed, 71% reported a preference for outdoor settings (Cooper Marcus & Barnes, 1999).

Merely the knowledge that there are usable parks and areas of nature among urban environments can have a positive impact on human stress levels. Ulrich and Addoms surveyed frequent, minimal, and non-users of a park, and found that all three groups received some form of benefit from the park (Ulrich, 1999). While noted benefits by frequent and minimal users of a park are expected, it was the non-users' responses that are interesting. Ulrich and Addoms summarized comments by non-users in the study, who noted importance in simply knowing the park was there and that they could use it at any time. Based on these comments by non-users of the park, the study suggested that simple knowledge of a park's existence provides a place of escape and retreat for potential users (Ulrich, 1999).

Job-related stress. In the workforce, the benefits of nature and natural settings have strong positive correlations with job satisfaction. Simply the presence of a window in an office setting improves employees' attitudes and sense of job satisfaction (Finnegan & Solomon, 1981). Leather, Pyrgas, Beale, & Lawrence note that the presence of sunlight in an office setting has a positive impact on job satisfaction (1998).

Studies by Rachel Kaplan expand on the nature-employment stress reduction connection. In a study survey conducted by Rachel Kaplan, 168 employees from corporate or public agencies received surveys which asked about job stresses, the work environment, employee satisfaction, and physical health (1993). Participants included people with and without views of natural settings, plus some individuals who worked primarily in outdoor settings. The employees responded to the questions using a five-point system to rank their responses. The results of the survey showed that workers with outdoor jobs experienced less stress, felt less pressure, and had fewer sources of frustrations than employees with indoor employment environments. Of the employees who worked mostly in an indoor setting, those with window views reported fewer ailments and complaints, and in general reported a higher overall job satisfaction than employees without window views.

In a second study asking employees about the hassles of daily life and the role plants and nature play in the recovery process, Rachel Kaplan found that the type of view seen through a window affects the perceived sense of restoration (1993). Participants with views of multiple natural components reported a much higher restorative value from the experience than workers with window views of other buildings, streets, or parking lots. Kaplan reported that "those [participants] with a view of nature felt less frustrated and more patient, found their jobs more challenging, expressed greater enthusiasm for it, and reported higher life satisfaction as well as overall health" (R. Kaplan, 1993, p199).

School-related stress. Nature and the natural landscape have similar positive impacts on students and their recovery from stress and mental fatigue. In a study by Roger Ulrich, two groups of college students stressed from a final exam were shown a slide show (Ulrich & Parsons, 1992). The first group saw images of unvegetated urban scenes, and the second group watched slides of rural scenes dominated by vegetation. After watching the slides, the participants who saw the vegetated scenes reported a greater level of recovery from stress, including more positive feelings, a significant reduction in fear, and lower levels of anger and aggression, than the students who saw urban imagery. A similar study by Mary Krehbiel Honeyman found that students shown slides with vegetation, in either urban or rural contexts, experienced decreased stressed levels whereas students shown urban scenes lacking vegetation perceived increased levels of stress (1992).

Urban stress. Vegetation in urban settings greatly impacts a person's attitude and preference. Honeyman's study on the influences of vegetation on stress levels of students also concluded that the presence or absence of vegetation impacts the psychological response to urban environments (1992). Roger Ulrich notes that "…there is a strong tendency for North

American and European adult groups to prefer natural landscape scenes over urban views, especially when the latter lack vegetation or water features" (1986, p35).

Stress in medical settings. Medical settings themselves present a source of stress and anxiety for patients, family members, and employees. Designers have already realized the potential for healing through nature with the creation of healing gardens in hospitals. Patients may go outdoors and experience a few minutes away from sterile hospital environments filled with memories of sickness. Families have an alternative place to sit with sick relatives or to find a place to contemplate tough decisions. These gardens also provide employees with a place to go for lunch or breaks, allowing them a few minutes away from the stress of caring for patients. There are multiple studies which indicate that patients perceive a positive benefit from going out-of-doors. Cooper Marcus and Barnes interviewed hospital patients about their ability to use outdoor spaces at a hospital (1999). Of those interviewed, 95% indicated that the outdoor experience had a positive effect on their moods. Two thirds of the participants mentioned some form of natural element, such as trees, flowers, or seasonal changes, as contributing to their perceived positive change. Non-visual stimuli, such as the sound of birds, water bubbling in a fountain, or fragrances in the air, affected over half of the participants in a positive manner.

Imagery of natural landscapes has positive impacts on human anxiety levels in healthcare settings. Heerwagen and Orians compared heart rate data (physiological evidence) with patient reports of their anxiety levels in a dental clinic (Ulrich, 2002). On certain days, a large nature mural was hung on the wall of the clinic, and other days the wall was left bare. Results from the patient surveys indicate that patients who visited the office on days when the mural was on display experienced lower levels of stress and anxiety.

Multiple studies by different researchers indicate that there is a positive correlation between viewing nature and perceived levels of mental restoration and stress reduction. Whether in school, on the job, in medical institutions, or in urban settings, views of nature have a notable impact on the human psyche. In most cases, studies of the psychological impacts of nature provide documented observations of the positive correlation between viewing nature and mental restoration. A person's feelings, memories, and preferred settings establish a trend between perceived stress relief and views of nature. However, when combined with physiological data studying an individual's physical responses to natural versus urban settings, the link between nature and mental restoration becomes even stronger.

CHAPTER 5: PHYSIOLOGICAL IMPACTS OF STRESS

Stress has a wide range of impacts on an individual, including mental fatigue, psychological impacts, and physiological changes. History tells of a long-term association with nature. Art and religion continue to tell stories of man's conscious decision to include nature in daily activities. Recent studies document the positive psychological impacts we perceive from viewing nature. Physiological studies add one more layer of evidence, providing a quantifiable set of statistics which illustrate the connection between views of nature and stress reduction.

Physiological Effects of Stress and Information Overload

Physiological measurements of stress, unlike psychological impacts, are quantifiable and show the direct impacts of events on an individual. Physiological stress responses focus on how the body reacts to stimuli and attempts to return itself to equilibrium. Stressful events send signals to the brain, which trigger the release of hormones throughout the body. These hormones have a direct impact on bodily functions, including increased heart rate, muscle tension, and blood pressure (Evans & Cohen, 1987). By using these physiological measurements as a base for comparison, researchers are able to study the effects of viewing various types of scenery, including natural and urban settings, on human stress responses.

Physiological Data

General stress. Whether in an office setting, in school, or in unfamiliar settings, stress has a perceivable impact on physiological responses. Multiple studies indicate that the natural landscape or individual elements of nature have a positive impact on these responses. In a study by Ulrich, Simons, Losito, Fiorito, Miles, and Zelson, researchers showed that views of nature have a stronger impact on stress recovery than views of urban environments (1991). A group of volunteer students were shown a ten-minute film of job-related accident prevention to elicit stress responses and to create a stressful situation. Following the stressor film, the students were shown one of six different 10-minute films: nature-vegetation, nature-water, urban-heavy traffic, urban-light traffic, urban-many pedestrians, and urban-few pedestrians. The videos included both sound and color. Researchers monitored cardiovascular activity, skin conductance responses, and muscle tension. Results of the study showed that students viewing the natural scenery recovered more quickly and completely than those who viewed the urban films. Self-reported ratings by the participants (psychological results) confirmed these findings (Ulrich et al., 1991). In a discussion of this study, Ulrich notes that "examples of common types of tree contacts for urbanites include viewing trees through a window in a home or workplace, lunching in a park, or driving through an area having street trees. The physiological findings raise the possibility that these and other brief contacts with trees might be important for many urbanites in fostering recovery from mild stress such as daily hassles or annoyances" (Ulrich, 1990, p28).

A study by Wise and Rosenberg compares physiological stress responses with preference. In a simulated space station environment, researchers looked at the impacts of scenery on stress caused by work-productivity demands. The bulkhead region of the work area was painted with one of four scenes: a savanna-like landscape, a mountain waterscape, a hi-tech abstract scene, or a blank (control) background. While participants reported the mountain waterscape as the most aesthetically pleasing, the savanna scene had the greatest impact on the measured skin conductance physiological responses. The physiological responses were the same for both those who liked and disliked the scene (Relf, 1998).

Job-related stress. Research monitoring the physiological responses of viewing nature demonstrates a positive correlation with nature and stress in the workforce. While many studies of stress in the office focus on psychological and perceived forms of stress, there are a growing number of studies looking at physical responses. Many of these studies do not specifically take place in an office environment, yet the effects of stress on performance-based activities, such as proofreading, typing, or concentration, are applicable to employment settings. In a study by Hartig, Mang, and Evans, people who just returned from a wilderness trip performed better on a proofreading study than a control group (Kaplan, Kaplan, & Ryan, 1998). This study did not specifically take place in an office setting, yet the notion of proofreading or performing simple, intensive tasks is common in most employment situations.

School-related stress. Elements of nature positively impact the stress responses of students in school. Tennessen and Cimprich conducted a study of college students and found that those individuals whose dorm rooms overlooked natural settings had better performances on attention-demanding tasks (Kaplan, Kaplan, & Ryan, 1998). Similar to physiological responses in employment settings, the number of studies directly correlating the restorative value of nature with physiological responses in educational settings is limited. Yet many of the performance-based activities studied in other settings to determine the general physiological benefits of viewing nature also apply to students, faculty, staff, and educational administrators.

Urban stress. Views of nature before we even arrive at an office setting affect an individual's performance on simple, every-day tasks. In a simulated "drive to work" set up by Parsons, Tassinary, Ulrich, Hebl, and Grossman-Alexander, a group of participants were shown either a vegetation-dominated or building-dominated series of roadside images (Ulrich, 1999). Once the individuals "arrived at work," they were each given a set of stressful tasks involving mental math. By measuring physiological responses to stress, such as increased blood pressure and skin conductance, the researchers concluded that individuals with drives in predominantly built environments were more stressed during the mental arithmetic tasks than participants who viewed natural roadside scenery (Ulrich, 1999).

Stress in medical settings. One of the most famous studies which demonstrates a connection between viewing nature and stress reduction in medical settings is Roger Ulrich's research on the impacts of window views on hospital patients (1984). Comparing two sets of patients recovering from gall bladder surgery, Ulrich looked at the length of stay in the hospital, the amount of prescribed medication, and the overall comments made by nurses about the patients' health and attitudes. One set of patients had hospital beds with views overlooking deciduous trees, and the other set had window views of a brick wall. The patients who had views overlooking trees and vegetation spent less time in the hospital, took fewer amounts of medication and at weaker doses, and received fewer negative comments by the nursing staff (Ulrich, 1984). This quantifiable data of human responses indicates a definite value of nature in the healing process for sick individuals.

Vegetation and non-stressed individuals. Individual elements within nature and the natural landscape as a whole appear to have a positive impact on non-stressed individuals as well as those suffering from mental fatigue. Simple elements such as flowers in a pot have a notable impact on our physiological responses. In a study by Nakamura and Fuji, researchers monitored and compared brainwave activity for non-stressed individuals outside of a hospital setting who looked at either pots with flowers, pots without flowers, pots without plants, and cylinders with the same shape as the flowerpots (Ulrich, 2002). Based on results of the alpha wave brain activity, participants were most relaxed when viewing the pots with flowers, and were least relaxed when watching pots without plants. In a second study, the same researchers monitored the EEG (electroencephalogram) levels of healthy individuals sitting in a real-life outdoor setting. Study views included a hedge, a concrete fence with similar dimensions as the hedge, and a mixed setting of greenery and concrete. The results of the study showed that the greenery had the most relaxing effects and the concrete setting had the most stressful effects (Ulrich, 2002).

Similar to Nakamura and Fuji's second study, Roger Ulrich's study of brainwave activity of unstressed individuals compares views of natural environments with views of urban environments (Ulrich & Parsons, 1992). Participants watched lengthy slide presentations of either natural scenes dominated by vegetation or urban scenes lacking vegetation. Analyses of the study showed that natural and urban scenes had different effects on brainwave activity. The data collected from individuals observing natural scenes showed a stronger tendency to imitate a relaxed, wakeful state of mind. Participants' self-ratings (psychological results) confirmed these results; individuals who viewed the natural, vegetated scenes reported a more positive attitude afterwards and indicated that these scenes held their attention and interest at a higher level than those who viewed the urban scenes.

Benefits of viewing nature have a positive impact on human physiological responses in a range of settings and environments. Ulrich's research documents positive results in hospitals (Ulrich, 1984). Nakamura and Fuji's work illustrates positive results among non-stressed individuals (Ulrich & Parsons, 1992). Tennessen and Cimprich show positive physiological results among college students viewing nature (Kaplan, Kaplan, & Ryan, 1998). Together with psychological studies concerning perceived senses of stress and mental restoration, there is a strong argument for the benefits of natural landscapes and landscape elements in the reduction of human stress and mental fatigue. Not only do individuals report feeling better after short breaks of watching outdoor scenery, they perform better on daily tasks, have an increased ability to concentrate on required activities, and have physiological responses that mimic a relaxed state of mind. These results imply that the simple activity of taking a few moments to view the natural landscape has a powerful impact on an individual's daily life, both in the perceived sense of well-being and the ability to perform required daily activities. While many hospital administrators are beginning to realize and take advantage of the benefits of natural scenery through the use of healing gardens, the benefits of viewing nature can be applied to a wide variety of settings.

School officials, students and faculty members of college campuses, employees in urban or suburban environments, medical personnel and patients, and even home owners are just some of the groups of people who perceive benefits from viewing vegetation. Yet in many instances, these people who would benefit greatly from views of nature live or work in highly developed settings where views of parks or open green space are unavailable. The lack of available green space on the ground level or long-term funding for installing new parks should not stop designers from attempting to re-introduce greenery in such locations. Green roof technology provides an up-and-coming solution to many ecological problems and environmental concerns, and can be designed in a way which maximizes the ecological benefits while providing opportunities for mental restoration for those who look onto these greened rooftop surfaces.

CHAPTER 6: LINKING THE RESTORATIVE VALUE OF NATURE WITH GREEN ROOF TECHNOLOGY

The healing potential of a green roof design, in terms of stress relief, is a new concept to many designers and to the general public. Separately, the two topics of green roof technology and human restoration from nature are fairly well understood in their respected fields. European countries have been building green roofs for years, even requiring a certain percentage of new rooftops in some cities to include green roof features (Kuhn, 1996). Multiple studies indicate that viewing nature has positive impacts on both psychological and physiological responses. It is the next step, connecting the two concepts, which designers and researchers struggle to comprehend. In many conferences and symposiums, presenters discussing green roof technology only briefly mention the healing potential of green roof design. Based on my research, I've noticed that contemporary green roof designs rarely discuss the human restoration potential of the design concepts. Incorporating design concepts from healing landscapes with green roof technology is a very simple task when a designer takes into account the vast amount of space created by building rooftops and the wide range of windows views looking out onto these elevated surfaces. The new challenge faced by designers and landscape architects is to broaden the focus of design, including not only general aesthetics, program requirements, and ecological components, but also the impacts of the design on human reactions and perceived sense of well-being.

Role of Windows

Windows allow visual access to elements of nature from interior environments. Whether in office settings, hospitals, schools, or everyday situations, windows provide opportunities for brief moments of rest. "…Views out the window readily draw one's attention. These pulls of attention in turn lead to very brief interludes that can provide respite from the immediate tasks and demands, thus providing a micro-restorative experience" (R. Kaplan, 2001, p508). Rachel Kaplan's description of the psychological benefits of viewing nature, discussed in chapter four, includes windows as one of type micro-restorative setting which provides opportunities for relief. Views out windows capture attention effortlessly and provide an opportunity for relief from mental fatigue (R. Kaplan, 2001). In many urban and suburban environments, a large portion of window views look down onto rooftops of asphalt or concrete. Installing green roofs onto such buildings would not only provide ecological benefits to the building and surrounding environmental systems, but would increase the likelihood of restorative experiences for tenants, patients, or employees of surrounding structures.

Windows offer a wide range of benefits to building occupants. In her studies of the effects of window views on psychological responses, Judith Heerwagen summarizes several benefits people gain from window views (1990). She notes that windows provide access to environmental information, including the weather or time of day. They give viewers access to sensory changes. Windows provide a feeling of connection to the outside world, and the views visible from windows offer restoration and recovery from stressful settings (Heerwagen, 1990). Many designers, including Frank Lloyd Wright, place importance on window views in their designs. In a study by Grant Hildebrand, Hildebrand notes that Wright frequently controlled views to create the ideal setting, one in which people could look out yet passers-by could not see in (Heerwagen, 1990). Wright often used elevation changes, setbacks, buffers between public and private spaces, and large overhangs to create shadows that reduced visibility into the space. Building occupants could easily observe changes out-of-doors with a sense of privacy and without fear of being disturbed or interrupted.

It is important to note that not all windows or window views create positive psychological responses. Heerwagen discusses some of the psychological costs of window views in what she terms “the goldfish bowl” effect (1990). This type of setting may have high visual access to the surrounding environment, but also high visual exposure of the interior environment by those individuals outside of the building. These views looking out are subject to monitoring or constant observation by those who pass by. The sense of privacy important in creating a restorative setting is often lost in these situations.

In the field of landscape architecture, windows offer a perfect opportunity to combine the knowledge of green roof technology with opportunities for human stress relief and restoration. Particularly in urban settings, windows in tall buildings offer views onto the roofs of neighboring structures. In many cases, the window views onto rooftops are far enough away from nearby buildings so that it is difficult if not impossible for viewers from one building to see into windows of another, eliminating the sense of privacy invasion discussed by Heerwagen. Green roof designs, which many people initially assume are unnoticeable features that are never seen by the general public, can actually provide

Figure 6.1 Chicago City Hall green roof (Michigan State University, Department of Horticulture, n.d.)

positive experiences to those living or working in taller surrounding buildings. The Chicago City Hall green roof, for example, provides views of its green roof to 33 neighboring structures (Dvorak & de la Fleur, 2003) (Figure 6.1). Cities large and small offer a wide range of rooftops, from flat to slanted surfaces, which are visible from windows of nearby structures. It is this group of rooftop surfaces which offers an opportunity for landscape architects and designers to lead the way in establishing designs that simultaneously benefit environmental systems, provide energy savings for building owners, educate others about the availability and success of green roof technology, and provide a much-needed opportunity to viewers for stress relief and momentary mental restoration.

Aesthetic Preferences

Personal preference plays a large role in the type of landscape which captures attention. In terms of aesthetic preferences for outdoor settings, Roger Ulrich notes that in general, most people have a preference for natural settings (Ulrich, 1986). Typically, these preferable scenes include moderate to high levels of complexity, a definite focal point, moderate to high levels of perceivable depth in the scene, a uniform and smooth ground plane, a curved line-of-site, and little to no perceivable threat. Natural settings typically rated with a low preference, on the other hand, frequently have much lower complexity or very disorderly high complexity, no focal point, a restricted sense of depth, a rough ground texture, and a perceivable threat. Ulrich notes that in both America and Europe, most adult groups have a tendency to "prefer natural landscape scenes over urban views, especially when the latter lack vegetation or water features" (Ulrich, 1986, p35).

There is no concrete, universal trend in aesthetic preference for a specific type of landscape. While the Kaplans discuss the positive appeal of settings with prospect-refuge components or settings with specific combinations of mystery, complexity, coherence, and legibility, these concepts are general trends that do not necessarily apply to all cultures or to all regions in the same country. As discussed in chapter three, there are definite regional preferences for landscape based on a person's life experiences. While there is no current research on the topic of green roof design preference, these types of regional preferences most likely apply to green roofs, including the type of green roof design that is mostly likely to create restorative experiences. No design creates universal responses, yet through careful research into the intended use of the site, the potential user/viewer groups, regional preferences and conditions, and desired outcomes for the space, designers and landscape architects can create green roof designs that have an overall positive impact on mental restoration, stress reduction, and environmental systems.

The process of understanding a person's relationship with the environment is complicated, incorporating various areas of research. There are multiple factors that contribute to a perceived sense of stress relief which merit attention in the design process but are not within the scope of this study. Color theory, for example, establishes one more potential area of consideration for green roof designs. David Squire notes that "colour has a magical quality, strongly influencing moods and markedly contributing to our physical and mental health" (Squire, 2002, p39). Color symbolism and meanings differs from culture to culture and between individuals. The color white, for example, symbolizes purity in western culture and mourning in eastern culture. In ancient Egypt, white symbolized joy (Squire, 2002). Specific colors may have an impact on our physiological responses. Squire comments that the color blue has a tendency to reduce blood pressure and heart rate (2002). Incorporating positive reactions to color combinations into either design concepts or the viewer's immediate surroundings could result in even stronger designs for restorative environments, whether these designs describe ground level environments or green roof surfaces. The topics of color theory and environmental psychology are just two examples of design elements and their impacts on an individual's relationship with the environment.

Designs for Healing Environments

The psychological and physiological studies discussed in this thesis illustrate the notion that elements of nature are beneficial to a wide audience, not just those in hospital settings.

> Restorative gardens are meant for the healthy as well as for the sick. For the healthy, such gardens encourage sociability among companions, promote relaxation and contemplation for the solitary visitor, or create a sense of community among residents who live in quarters around the garden. For the sick of body or troubled in spirit, the same garden relaxes and soothes and thereby encourages the body and the mind to restore themselves (Gerlach-Spriggs, Kaufman, & Bass, 1998, p7).

Psychologically, images of vegetation reduce anxiety levels (Ulrich, 2002), correlate with higher job satisfaction (R. Kaplan, 1993), and provide relief in times of stress or sadness (Cooper Marcus & Barnes, 1999). Elements of nature positively impact physiological responses, including improved performance on attention-demanding tasks (Kaplan, Kaplan, & Ryan, 1998; Ulrich, 1999), faster recovery rates among hospital patients (Ulrich, 1984), and the stimulation of relaxed states of mind among non-stressed individuals (Ulrich, 2002).

While many current studies show a strong relationship between viewing vegetation and beneficial outcomes, not every garden or landscape will produce a positive response or improve mental fatigue. Again, stress responses and personal preferences are not universal. Martha Tyson notes that the type of facility or therapeutic program often dictates certain design elements (1998). She notes that local climates, customs, plant materials, and architectural styles play a role in the final design. What is familiar and soothing to one culture may be threatening to another. How an individual interacts with a garden (active or passive) will influence the type of therapeutic benefit (Tyson, 1998).

The ideas of program and audience become very important in creating a garden which successfully reduces stress and mental fatigue. Different groups have different needs, fears, and sources of stress. What provides temporary relief to one group may not be as beneficial to another. As in any design, it is important to consult all user groups and potential viewers before creating a final design. The Bird Garden sculpture garden is one example of a design where the desired effects did not match the actual outcomes. The Bird Garden sculpture garden, located on a hospital rooftop with views from surrounding buildings, was intended to create a source of visual distraction for hospital patients (Ulrich, 1999). The rooftop contained sculptures of ceramic tile and metal birds in both representational and abstract styles; the garden did not actually contain any greenery, plants, or water features. Artists, hospital design staff, nurses, and hospital administrators put much time into reviewing the final design, yet soon after the installation was completed, nurses noted negative comments about the garden from several patients. A survey of 46 different patients whose rooms overlooked the garden found that 22% perceived an overall negative effect from viewing the space. Many of these patients noted that they couldn't understand what they were looking at. Despite the overall positive response to the garden, the hospital chose to remove the sculpture garden from the rooftop (Ulrich, 1999). This experience is just one example demonstrating the importance of a thorough evaluation of a site and its users.

Roger Ulrich combines the ideas of psychological and physiological stress responses in his theory of supportive garden design (1999). The four ideas of control, social support, physical movement and exercise, and natural distractions lead to an actual and perceived sense of stress reduction. This stress reduction and buffering of negative stimuli in turn produces positive health outcomes.

The four concepts of Ulrich's theory provide a general framework and rationale for design decisions. While he addresses these four concepts in terms of design in medical settings, the overall message is applicable to all types of landscapes. The sense of control important in a restorative garden setting can be actual or perceived, and it is this perceived sense of control that is important in providing a temporary escape from problems or illness (Ulrich, 1999). In order to effectively relay this sense of control, Ulrich writes that individuals must know that the garden exists, be able to get to the garden easily, and access the garden either actively or passively (i.e. through a window). He notes that if someone knows the garden exists but cannon easily find it or access it, the situation leads to a loss of control. For green roof design, this sense of control could be created through signage, telling employees, visitors, or residents about the green roof design, as well as clearly marking ways to access or view the rooftop.

Gardens provide an important place for social and emotional support for patients, visitors, and staff in medical settings. Multiple studies indicate that people who receive social support from others, both in medical and non-medical settings, have better health than those who feel isolated (Ulrich, 1999). Ulrich writes that designs should include space or locations to accommodate and promote social support or group activities, yet not to the point of invading privacy. In a study by Barnhart, Perkins, and Fitzsimons, researchers discovered there was a relationship between preferred behaviors and preferred settings (1998). Patients and staff participating in a study in a large psychiatric center preferred open, natural settings for passive and private activities, such as sitting and watching others, and natural, enclosed areas for active behaviors, including walking and talking with others. These concepts can be applied to green roof designs, taking into consideration the types of activities that will occur on the rooftop and designing settings to promote perceived positive experiences with each type of activity.

In terms of physical movement and exercise, garden designs in medical settings can create a destination that encourages movement for the sick or elderly who may not otherwise be motivated to leave their rooms (Ulrich, 1999). This opportunity for movement and exercise often depends on the interior configuration of the hospital, the location of windows, and publicly accessible spaces. While this may not be as relevant in many green roof settings, trips to accessible green roof systems could provide short breaks for employees from stressful tasks or deadlines.

Ulrich's fourth concept in his theory of supportive garden design, natural distractions, has the greatest impact on restorative green roof design. His research on the effects of nature on humans demonstrates that natural elements have a positive impact on human physiological changes, including lowering blood pressure and heart rate (Ulrich, 1999). Ulrich notes that the type of positive distractions typically used in healthcare settings include comedy and laughter, companion animals, art, music, and nature. Green roof designs offer the perfect opportunity to incorporate elements of nature as forms of distraction for viewers and users of the space. As with the Bird Garden example discussed above, these natural distractions must be appropriate to the setting in order to create positive experiences.

Green Roof Design Analysis

Based upon the previously discussed research into the psychological and physiological benefits of viewing nature, I've reaffirmed my notion that it is the *process* of identifying the users of a site and the needs of those users and the site itself which create the most successful design. My initial intent was to come up with a set of guidelines listing ways to help designers and landscape architects create green roof systems that function both ecologically and on a human restorative level. However, no two sites or user groups are exactly alike, and while a list of possible sources of distractions might be thought-provoking, they are not beneficial unless used in the proper setting or manner.

Similar to any design, a site analysis is extremely important in providing information necessary for creating a successful design. For many standard masterplanning and small-scale projects, plant inventories, slope, hydrology, climate, and soil analyses, historical data, user interviews, and viewshed observations provide important information that establishes the basis for design decisions. While green roofs offer a slightly different situation, the need for a detailed analysis still applies. Haphazard arrangement of vegetation on a properly installed green roof system may indeed function ecologically and provide long-term benefits to the building and surrounding environmental systems, but this method of design does not take full advantage of the restorative benefits green roofs might provide to humans. It is important to inventory the site conditions, explore the constraints and opportunities created by the setting, and identify the targeted audience and desired outcomes of the green roof design. The findings from such an analysis will aid designers in creating the appropriate types of environments necessary to evoke restorative experiences much more effectively than simply providing a general list of green roof design elements and recommendations.

Criteria for Restorative Green Roof Design

Creation of restorative green roof designs can be a complicated task, requiring thought into the perceived experiences not only from the rooftop surface, but also from the views from above. The following concepts for restorative green roof design emerged from the broad range of research presented in this thesis. The concepts and applications of restorative environments merged into five areas which apply to all garden and green roof settings: 1.) audience and program, 2.) length of contact, 3.) nature of access, 4.) type of green roof system, and 5.) the surrounding conditions. These five areas take into consideration the larger picture of the potential green roof design and provide a framework for designers to look critically at the proposed area and focus the design on the specific needs of the users and site.

1. Audience and program. The specific group of individuals who will experience the green roof and the designated program for the space will have a large impact on the type of design that will create a positive restorative experience. As was discussed in chapter three, there are cultural, regional, and intra-regional differences in landscape preferences. Identifying the audience of the green roof will allow the designer to better identify the general preference trends of that region. Is a specific plant generally considered welcomed or a weed? Is there a general preference for openness or a landscape mimicking vegetated rolling hills?

Similarly, the concepts of aesthetic preference discussed in this chapter play a large role in the type of setting that creates positive experiences. Is there a general preference trend towards the natural landscape? Do the viewers prefer the type of settings described by the Kaplans, which include specific combinations of mystery, complexity, coherence, and legibility? Do the general preferences of the users/viewers of the green roof follow Ulrich's description of a highly preferable landscape setting? There is no definite answer to any of these questions, yet for a green roof to create a restorative setting, designers should look into these general trends and identify the situation mostly likely to create a positive response among viewers.

In addition to identifying regional preferences, there can be differences in responses among groups of people. Chapters four and five outline the general trend of restorative experiences perceived from viewing natural landscapes versus urbanized or built settings for individuals in office, educational, urban, and medical settings. Not each group of individuals will respond to the same feature in the same manner. The Bird Garden sculpture garden is one example where elements within the garden had a negative effect on the patients in a hospital setting, yet there was no discussed negative impact on staff members or employees of the hospital.

2. Length of visual experiences. The length of time an individual spends in a location influences the types of elements that can be used to create a restorative setting. The Kaplans in particular stress the importance of being away, extent, fascination, and compatibility within a design (Kaplan, Kaplan, & Ryan, 1998). These concepts, discussed in chapter four, create settings that attract and hold an individual's attention while providing a restorative experience. For a design to effectively capture attention and provide moments of stress relief, designers must determine what is the average length of time a person will be viewing the green roof—is the experience a matter of hours, days, months, or even years? In a situation where individuals only experience short exposure to a site, immediate sources of stimuli are necessary to capture attention and provide momentary relief from sources of stress. For example, the bright pink flowers of an Eastern Redbud tree may be a form of fascination and distraction, but if someone only views the tree during the winter months, this form of distraction has no effect on the viewer. Possible sources of fascination in a short-term viewing situation include birds or other forms of wildlife, movement or plants in the wind, vibrant colors, or the audible sound of wind chimes or leaves rustling in the breeze.

Long-term exposure to a site, ranging from months to even years, creates the possibility for different forms of fascination and distraction. While elements geared towards short-term viewing periods attract immediate attention, long-term forms of fascination can provide ongoing interest, anticipation, and curiosity in the setting. Seasonal changes, including the blooming of flowers, changes in leaf color, and changes in both vegetation height and composition are examples of possible natural distractions for long-term viewing.

3. Accessible versus inaccessible rooftops. Decisions about human access to the green roof surface have a large impact on the forms of distraction which can be used in the final design. Green roof surfaces accessible to the public allow for a wide range of elements which can stimulate relaxing moments away from stress. The green roof atop Atlanta's city hall, discussed in chapter two, has not only environmental benefits, but is situated just outside the building's 5th floor cafeteria and provides an accessible patio space. Vegetation, environmental factors, and hardscape features have the potential to influence all five of the human sensory systems. Cooper Marcus and Barnes' 1999 study of hospital patients' ability to use outdoor space, discussed in chapter four, acknowledges the benefits of non-visual stimuli, including sounds and scents, in the restorative experience.

Accessible green roof designs should be conscious of the views from above as well as those experienced from the roof level. Rachel Kaplan expresses the importance of window views as sources of restorative moments; a green roof designed for actual use by some individuals may be visible through windows of nearby buildings. These views onto greenery in an urban setting can provide moments of stress relief to an additional audience of people.

Judith Heerwagen's discussion of some of the costs of window experiences, explained earlier in this chapter, applies to accessible green roof settings. Whereas her description of the "goldfish bowl effect" applies to individuals sitting inside behind the window, visitors to an accessible green roof setting surrounded by windows could perceive the same sense of privacy invasion. This type of setting places the individual on display to others, and such settings may detract from the positive experiences.

Inaccessible green roof systems must typically rely on visual stimuli to produce moments of positive distraction. Many office buildings in urban environments have windows that are not meant to be opened, making attempts at introducing audible stimuli impossible. Designers creating an accessible green roof system must also consider the design from a visual access only perspective. A green roof designed for human use may also be visible to residents in nearby buildings. These residents may not have access to the green roof surface and can only view the green roof from their windows. Similarly, green roofs in medical settings may be designed for use by patients, but some individuals may be too ill to go outdoors and can only experience the design from windows above. Building on Roger Ulrich's research discussed in chapter four, the simple knowledge of the accessibility of a rooftop or the potential window views available may provide a sense of relief to patients, employees, or visitors to a setting.

4. Extensive or intensive green roof systems. The type of green roof system installed on a rooftop will dictate to a certain extent the manner in which concepts for restorative experiences are implemented. Of the two green roof systems discussed in chapter two, building roofs retrofitted with extensive green roofs require the smallest amount of infrastructure changes to support the weight of the new green roof. While this may help to reduce construction costs, extensive systems have a much more limited plant palette to choose from. Using the same Eastern Redbud tree as an example, this species provides bright spring colors and a definite source of visual distraction, yet it will not survive within an extensive system's thin layer of soil. The loss of the tree will not only detract from the restorative experience by failing to create a source of visual fascination, but it will decrease the overall performance of the green roof.

Whatever the program or targeted audience, the design must be sensitive of the green roof system requirements.

5. Surrounding physical and environmental considerations. It is important to take into consideration the physical elements existing on and around the rooftop. There are several situations in which outdoor sounds can detract from or inhibit the desired restorative experience. The Kaplans notion of directed attention, in which effort to screen out specific sounds or activities actually takes away from restorative experiences and causes mental fatigue, is one example. To create a design which maximizes the restorative potential, these ambient sounds and environmental conditions should be taken into consideration.

The physical environment which creates and frames the viewing experience can have an impact on the visibility of the restorative green roof design. The viewer's distance from the window has the potential to alter the visible portions of the design. Distances close to windows overlooking the green roof create much wider cones of vision. Viewers have the opportunity to see entire forms as well as vegetation growing near the base of the window. Longer distances from the window create much narrower, almost tunnel-like, viewsheds. The frame of the window limits the visible material, cropping out the tops of taller forms and any vegetation or designed elements immediately below the base of the window.

Similarly, the viewing angle affects the viewing experience. Views from windows which are level with the green roof or slightly above the green roof elevation provide eye-level experiences. Background elements appear smaller than their actual size and are partially obscured by elements in the foreground. Differences in plant height, particularly in the foreground, are easily apparent. However, views from higher elevations create birds-eye views of the green roof. Elevation differences of plant material can be difficult to perceive, and the uppermost layer of vegetation blocks the view of all vegetation or designed elements located beneath.

CHAPTER 7: GREEN ROOF DESIGN APPLICATION

Green roof technology and the concepts of restorative views of nature can easily be combined in the design process. This conceptual design takes into account the ideas behind the physical data and theoretical concepts which were discussed in this thesis and applies them to an actual setting. The design illustrates one way that the process of exploration and analysis, rather than a predetermined checklist of possibilities, can create a green roof design that benefits both environmental systems and the viewers of the site.

The University of Georgia law school library annex provides an opportunity to demonstrate the possibilities of green roof technology combined with restorative design concepts (Figures 7.1, 7.2, 7.3, 7.4, and 7.5). This two-story library, located on the University's campus in Athens, Georgia, sits just north of the six-story Caldwell Hall. While not an accessible surface, the approximately 9,100 square foot flat rooftop is visible through a series of windows lining the north side of the fourth, fifth, and sixth floors of Caldwell Hall. These three floors house the University's undergraduate landscape architecture program. Students spend approximately nine months of the year, from mid August through mid May, working in the studio spaces that occupy the northern portion of each floor, next to the windows. As the students advance through the program, they progressively move up to higher floors in Caldwell Hall, giving a slightly different angle and view of the rooftop and surrounding campus. There is a small stairwell on the southeast corner of the library annex which connects a bridge from the law school library annex to the main law school building. The flat roof surface of this stairwell structure, approximately 280 square feet in area, is lower than the rooftop and is also visible from

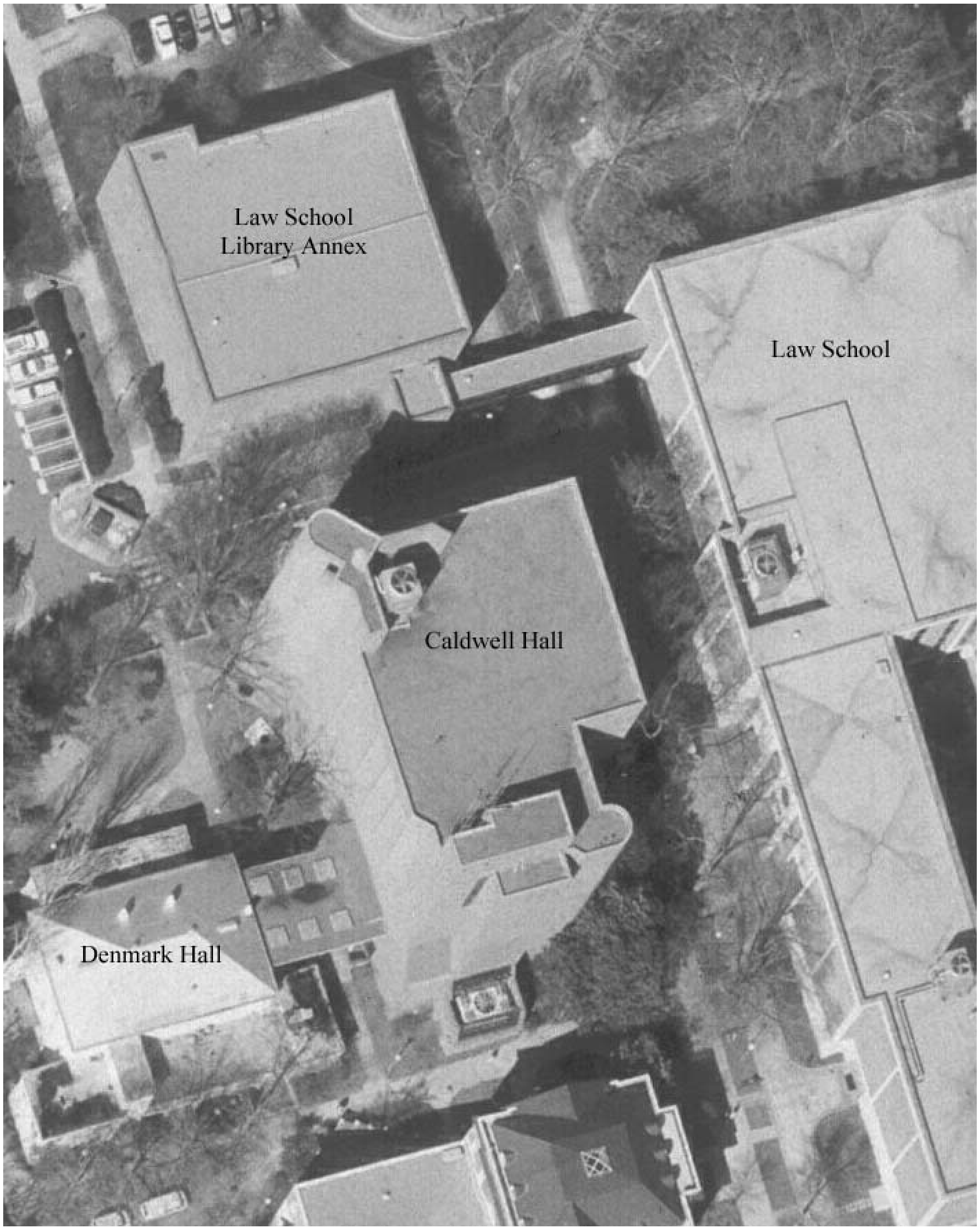

Figure 7.1 Aerial photograph of design site; University of Georgia North Campus

Figure 7.2 View north from the 4th floor, Caldwell Hall, onto the law school library annex rooftop. Moore College is the white building in the background.

Figure 7.3 View north from the 5th floor, Caldwell Hall, onto the law school library annex rooftop

Figure 7.4 View north from the 6th floor, Caldwell Hall, onto the law school library annex rooftop

Figure 7.5 View of the law library annex, looking north, from the sidewalk between Caldwell Hall and the law school

the top three floors of Caldwell Hall. The 77-foot long enclosed pedestrian bridge connecting the law school library annex to the law school is six feet lower than the top of the stairwell tower. The rooftop of this east-west oriented bridge is visible from Caldwell Hall.

Site Analysis

Audience and program. This rooftop offers an opportunity to provide an easily viewable source of temporary relief for a group of stressed individuals in an educational setting. The law school library annex rooftop is visible to landscape architecture undergraduate students as well as faculty members who spend time teaching courses in the studio space. Many students spend long hours in the studio to finish projects and meet deadlines.

Length of visual experiences. The location of this rooftop creates opportunities for both short-term and long-term sources of fascination. Students spend large portions of time each day in the studio space working on class projects or studying for exams. Changes in light direction, intensity, and cast shadows from morning to night create opportunities for different viewing experiences throughout the day and into the evening hours. In addition to these daily opportunities for green roof designs to provide immediate distraction, there are opportunities to include long-term sources of fascination. Students spend nine months of the year in the same studio space, creating occasion for observing seasonal changes on the roof surface. Similarly, the same group of students moves upward to higher floors as they progress through the program. This progression upward creates the opportunity to observe seasonal changes over time, as well as changes in vegetation forms, composition, and differences in viewing angles of the same yearly progression of seasonal changes.

Accessibility. While the library's rooftop is inaccessible to the public, it is easily viewable from the top three floors of Caldwell Hall. Students, faculty, and visitors alike can view the surface through large windows lining the north side of Caldwell Hall. The library is a fairly low profile structure, and individuals approaching the building from any direction would be able to see vegetation growing over the edge of the building's roof.

Green roof systems. For the purposes of this conceptual design, I created two options for the rooftop. An extensive system illustrates the opportunities available for even the thinnest of green roof surfaces. The intensive green roof design concept builds upon the extensive design, adding much more elaborate plantings and possibilities. These designs are conceptual, meant to illustrate elements of restorative environments on a green roof system, and the combined weight of the design components may exceed the current structural carrying capacity of the rooftop.

Surrounding environmental conditions. The views of both the library rooftop and the UGA North Campus from Caldwell Hall provide an interesting juxtaposition of linear and organic forms. (See Figures 7.1 through 7.5 for aerial photographs and images of the roof from Caldwell Hall). There is a strong one-point perspective from all three views, leading the eye north towards Moore College, which appears on-center and aligned with the law school library annex. This building appears to be the focal point of the view out from Caldwell Hall. Lines created by the buildings to the left of Moore College emphasize the strong perspective pull towards the center of the viewing area. Herty field, located between the library and Moore College, has walkways on either side of the green space that visually lead up to Moore College. From Caldwell Hall, the area to the right of Moore College appears mostly vegetated, obscuring most buildings or hard edges that contribute to the one-point perspective.

The rooftop itself is fairly flat with a minimal slope for drainage. A one-foot wide and approximately one foot tall parapet surrounds the edge of the roof. Near the center of the surface, there is a 3'x7' relief hood raised slightly above the surface of the building. A 3'x6' roof hatch sits in the northwest corner of the roof, and there is a small exhaust fan near the southwest corner of the surface. Most views onto the rooftop would take place from an indoor setting, so exterior sounds from exhaust fans, construction, vehicles, or pedestrians would not affect the viewing experience. However, sounds originating from either the rooftop or the top of the stairwell tower could attract the attention of pedestrians walking north, towards downtown Athens, along the east side of the building.

Extensive and Intensive Green Roof Designs

Based on the general analysis of the site, I created a design concept with the goal of establishing a restorative green roof design to provide moments of stress relief for students, faculty members, and visitors to the 4th, 5th, and 6th floors of Caldwell Hall. To achieve this goal, I set up a series of objectives to keep in mind during the design process:

1. Create opportunities for the eye to linger
2. Establish short-term and long-term opportunities for restorative moments
3. Incorporate surrounding landscape elements into the design
4. Attract the attention of occupants of Caldwell Hall and nearby pedestrians
5. Create a functional green roof system
6. Provide opportunities for green roof education

Extensive green roof design. With these objectives in mind, I formed a conceptual design for an extensive green roof system (Figures 7.6, 7.7, and 7.8). A large portion of this design relies on color and blooming times to create opportunities for immediate and long-term mental restoration (See extensive plant list, Table 7.1). The center of the sunburst color pattern, located around the relief hood, is filled with white flowering plants which bloom throughout the growing

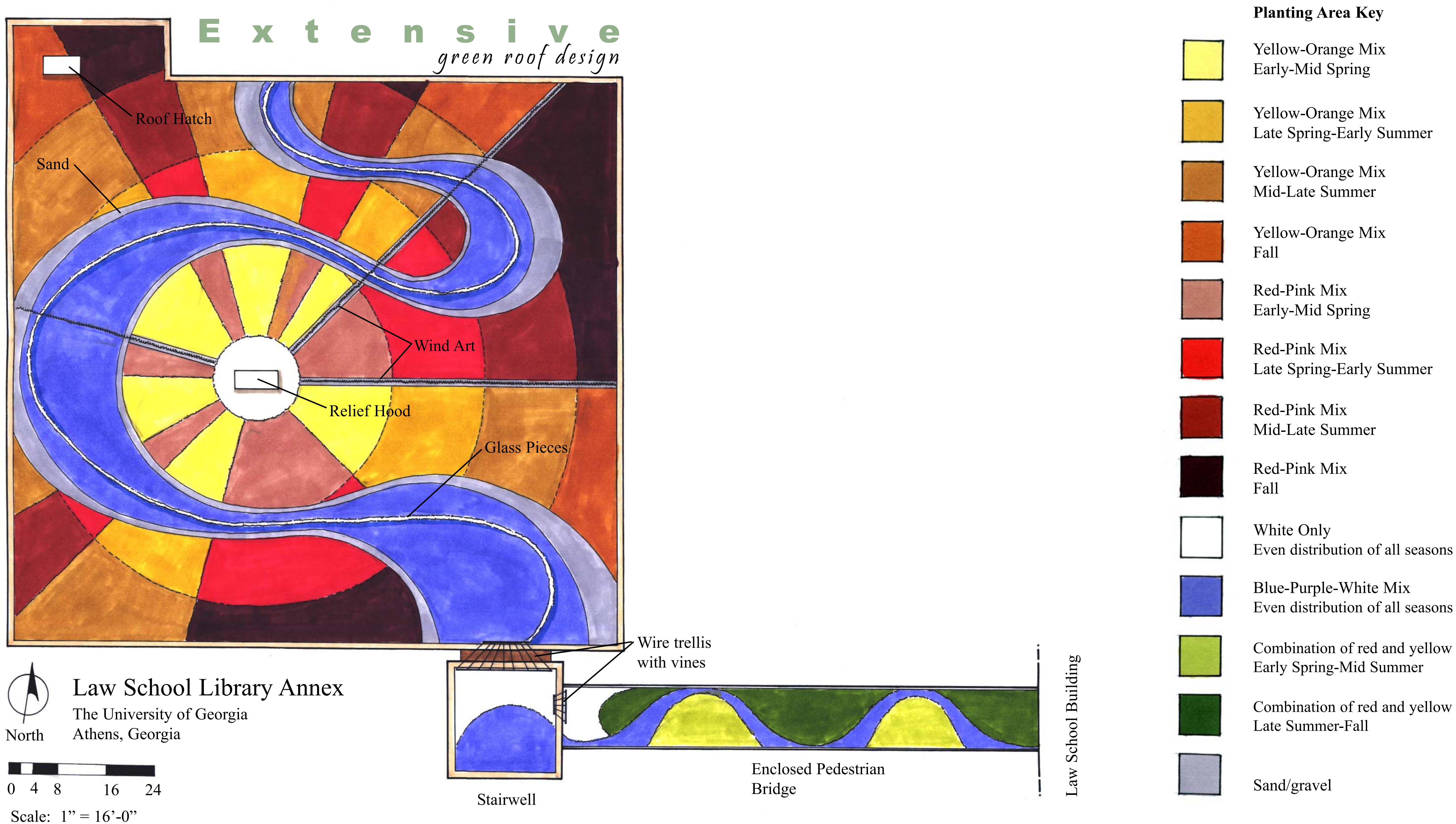

Figure 7.6 Extensive green roof design, plan view

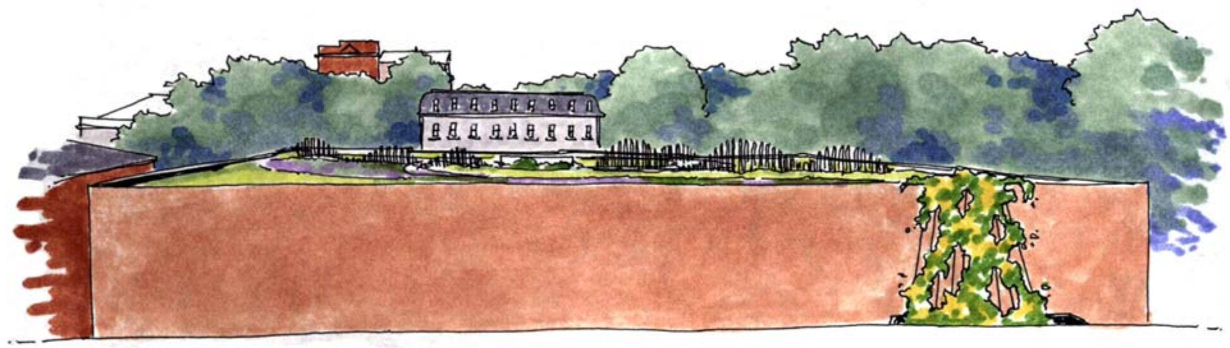

Figure 7.7 Extensive green roof design, 4th floor perspective view (from Caldwell Hall).

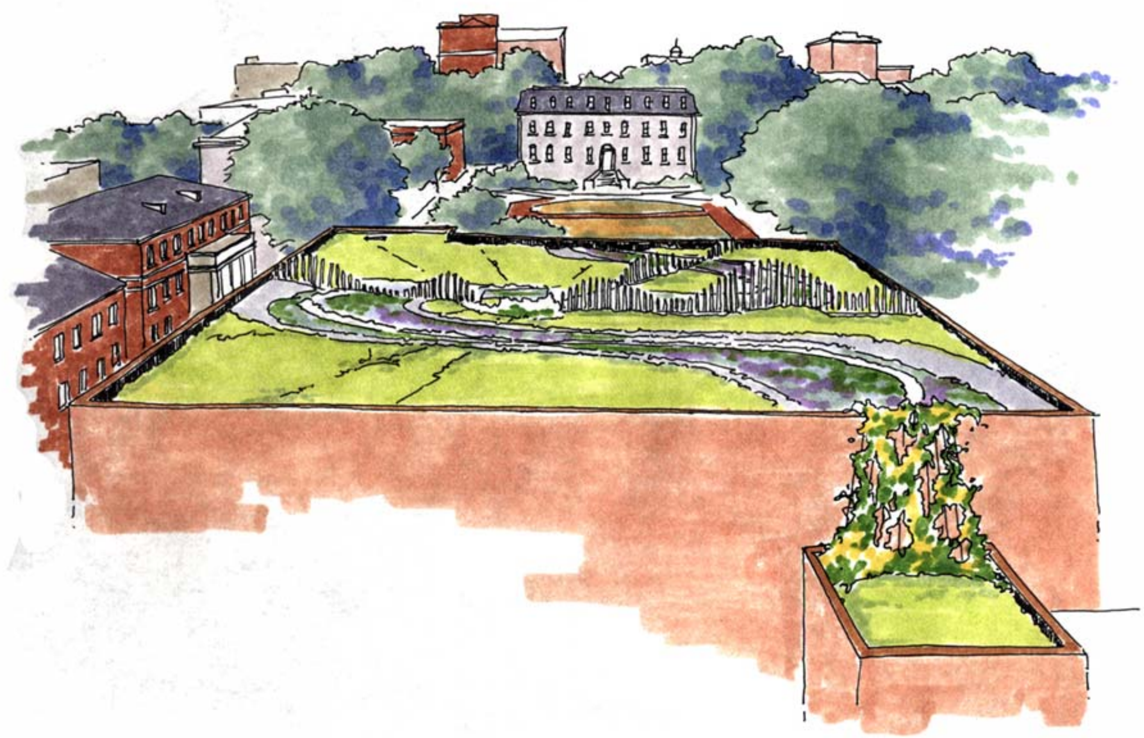

Figure 7.8 Extensive green roof design, 6th floor perspective view (from Caldwell Hall).

E x t e n s i v e

green roof design

plant list

Table 7.1 Extensive Plant List

Blue/Purple/White

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Allium schoenoprasum	Chives	10"	Mauve					■	■				
Delosperma aberdeenense	Miniature Ice Plant	3"	Red-Purple			■	■	■	■	■	■		
Delosperma cooperi	Ice Plant	6"	Purple			■	■	■	■	■	■		
Houstonia pusilla	Small Bluet		Purple	■	■								
Jovibarba allionii	Rollers	3"	White				■	■					
Linaria canadensis	Toadflax		Blue-Purple			■	■	■	■	■			
Rosularia chrysantha		2"	White				■	■					
Sedum album	White Stonecrop	4"	White					■	■				
Sedum album 'Chloroticum'	Mini Jellybean	1"	White				■	■					
Sedum album 'Murale'	Coral Carpet	4"	White; red foliage					■					Red/purple foliage in spring and fall
Sedum boehmeri	Duncecaps	5"	Gray							■	■		
Sedum pusillum	Granite Stonecrop	4-8 cm	White		■	■							
Sedum spurium 'White Form'	White Spurium	6"	White						■				
Talinum okanoganense	Fameflower	2"	White				■	■	■				
Tradescantia hirsuticaulis	Hairy Spiderwort	16"	Purple		■	■							

Pink/Red

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Belamcanda chinensis	Blackberry Lily	24-36"	Red-Orange						■				
Diamorpha smallii	Small's Stonecrop	1-3"	Red foliage							■	■	■	Red color all winter
Polygala curtissii	Rock Outcrop Milkwort	12-24"	Rose-Purple				■	■	■				
Portulaca smallii	Small's Portulaca		Pink										
Sedum cyaneum 'Rose Carpet'		2"	Pink				■	■					
Sedum spurium 'Fuldaglut'	Dragon's Blood Sedum	6"	Red							■	■	■	
Sedum spurium 'Roseum'		6"	Pink						■				
Talinum calycinum	Fameflower	12"	Rose-Pink				■	■					
Talinum parvifolium	Fameflower	6"	Pink				■	■					
Talinum rugospermum	Fameflower	8"	Rose-Pink				■	■					

Yellow/Orange

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Coreopsis grandiflora	Coreopsis	36"	Yellow					■	■	■			
Delosperma nubigenum Basutoland	Yellow Ice Plant	3"	Yellow				■	■					Reddish foliage in fall
Helianthus porteri	Confederate Daisy	24-36"	Yellow										
Jovibarba hirta 'Emerald Spring'	Rollers	3"	Yellow				■	■					
Opuntia compressa	Prickly Pear Cactus	6-12"	Yellow				■	■					
Opuntia drummondii	Prickly Pear Cactus												
Sedum acre 'Aureum'	Golden Stonecrop	3"	Yellow				■	■	■				
Sedum floriferum	Kamschatka Stonecrop	6"	Yellow				■	■	■				
Sedum grisebachii (S. kostovii)		4"	Yellow							■	■		
Sedum kamtschaticum	Russian Stonecrop	6"	Yellow				■	■					
Sedum reflexum	Blue Stonecrop	4"	Yellow				■	■					Blue-green foliage
Sedum sexangulare	Six Sided Sedum	4"	Bright Yellow				■	■					Needle-like foliate
Sedum Weinenstephaner 'Gold'	Bailey's Gold	4"	Yellow					■	■				

Vines

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Gelsemium sempervirens	Carolina Jessamine	10-20'	Bright Yellow		■	■	■						Evergreen

Plant references:
Conversations with Tim Carter, Ph.D. candidate, UGA Institute of Ecology; Duncan & Foote, 1975; Morrison, D., 2002; Murdy, W. H. & Brown Carter, M. E., 2000; NC State University, 2000;

season. Two alternating color groupings of plants, yellows and reds, radiate out from this central ring. Early spring blooming plants are closest to the center of this sunburst, moving progressively outward with plants that bloom in mid spring, summer, and then the fall. There are always forms of color to immediately capture the attention of viewers, and the change in location of the blooming pattern, from the center of the ring outward, creates opportunities for long-term interest and curiosity. All plants included in this design are tolerant of the harsh environmental conditions created by an extensive green roof system. Many of the species are native to granite outcrop habitats in the piedmont. While these plants may not be traditional green roof species, their tolerance of heat, low moisture conditions, and minimal soil make them ideal candidates for extensive green roof plantings.

The curved feature across the roof surface creates a river-like form, which allows the eye to wander across the rooftop plane. This form contrasts the strong one-point perspective pull towards Moore College. Many researchers indicate that water is a common component in restorative landscapes. Savanna settings, often considered the preferable type of landscape, include some form of water feature within the landscape. While a fountain is not a realistic concept for an extensive system, the shape of the form and the blue and white colors of the plants blooming throughout the season create an impression of water. This feature also mimics the curvilinear, meandering form of a healthy stream, and the curving lines are a typical pattern in the Georgia Piedmont. The water form is wider at the curves to create a false perspective impression of depth to the scene. A thin layer of sand outlines the form to give it definition, separate it from the sunburst pattern, and to mimic the idea of a riverbank. To further attract attention to the rooftop and provide a source of intrigue, a thin, heaping pile of rounded glass pieces follows the low-flow pattern of the vegetative stream. The use of small, rounded pieces of

Figure 7.9 Maya Lin. *Groundswell*. Columbus, Ohio, Wexner Center. (Lin, 2000, p6:15)

glass in this design was inspired by Maya Lin's sculpture, *Groundswell*, at the Wexner Center in Columbus, Ohio (Figure 7.9). The blue and white flowering stream then flows into a vegetative "waterfall."

The waterfall feature creates an opportunity to connect the different levels of the rooftop, providing interest not only for individuals within Caldwell Hall, but a means of attracting the attention of pedestrians walking by the building (Figure 7.10). Using thin wires to create a trellis-like form that connects

Figure 7.10 Ground level perspective

the law school library annex to the stairwell, and the stairwell to the pedestrian bridge, vining plants establish the waterfall which connects these three surfaces. The white grouping of plants at the base of the waterfall mimics the idea of splashing, foaming water.

Many of the plant species on the extensive system are low growing and stay close to the ground. To incorporate an additional form of visual interest to attract attention, the wind art feature provides movement and an audio component to the site. Inspired by a sculpture in Chicago by Harry Bertoia (Figure 7.11), three rows of thin, hollow metal poles of varying widths are set approximately 3" apart from each other in a one-foot wide bed of sand (Figures 7.12 and 7.13). The heights of these poles vary to create undulating waves. Three sets of these metal waves radiate out from the center of the sunburst pattern. As the wind blows, these metal poles can gently blow in the breeze, capturing attention of viewers and mimicking the idea of grasses blowing in the wind. Depending on the strength of the

Figure 7.11 Harry Bertoia. Untitled Sounding Sculpture; Aon Building Plaza, Chicago, Illinois (photo by Jessica Buesching)

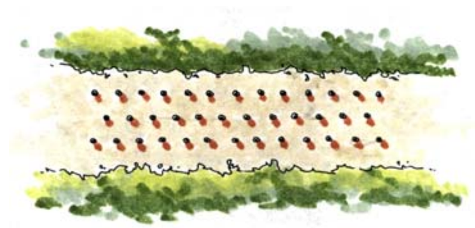

Figure 7.12 Wind art plan view
Scale 1" = 2'-0"

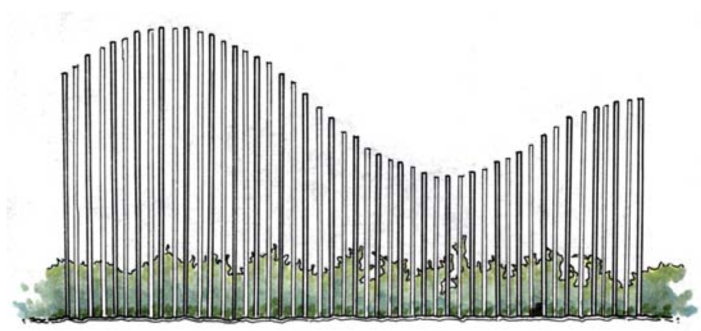

Figure 7.13 Wind art elevation
Scale 1" = 2'-0"

wind, the sound from these metal poles could be heard by pedestrians walking outside the building. Educational signage, located outside Caldwell Hall and the law school library, could explain both the green roof and sound of the wind art features, and hopefully encourage visitors to go into Caldwell and view the surface.

Intensive green roof design. The intensive design builds upon the overall concepts established in the extensive design (Figures 7.14, 7.15, and 7.16). Blooming times and color organization create the same sunburst pattern and river form as in the extensive green roof plan, but the intensive design incorporates a more involved plant palette (See intensive plant list, Table 7.2). The trees in this design are located above structural support columns in the library. Groupings of trees and shrubs create pockets of taller vegetation, introducing a sense of mystery to the space. Lines and curves partially disappear behind the vertical layers of vegetation. Viewers can never see the full form of the “river” from one position, but need to move to different locations in the studio space to see all forms and features. These taller groups of vegetation also frame the view towards Moore College. The delicate, arching forms of the grasses at the base of the waterfall create the sense of splashing and movement, again drawing attention to the differing levels of the rooftop.

Design summary. By referring back to the framework for restorative green roof design and focusing the design process on the unique characteristics and qualities created by the site, these designs establish a potential source of relief from stress while functioning as a green roof system. Both the extensive and intensive conceptual designs for the law school library annex rooftop engage viewers with forms of natural distraction. The specific location of the design creates opportunities for relief for a wide range of students and faculty members. The curvilinear

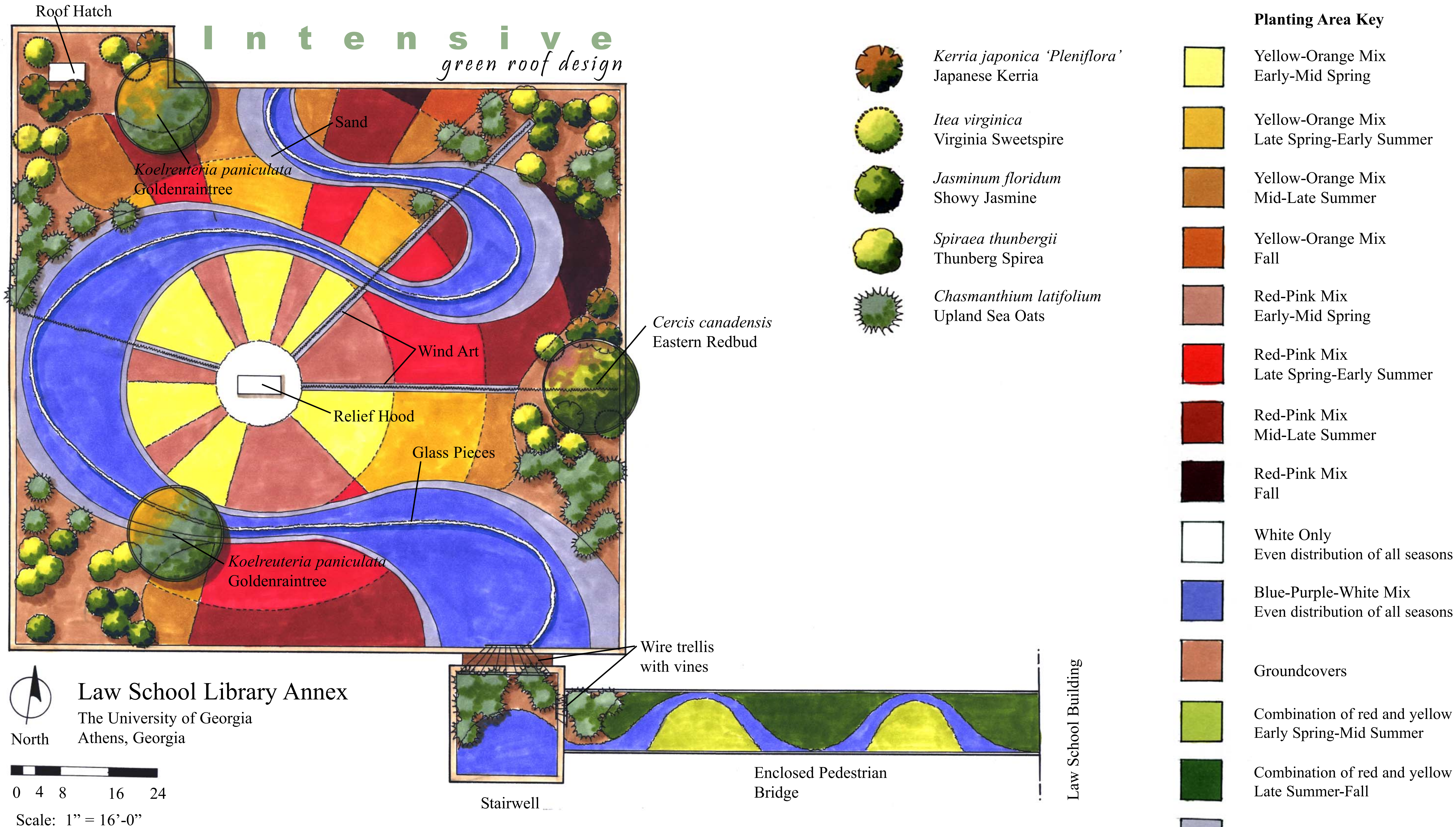

Figure 7.14 Intensive green roof design, plan view

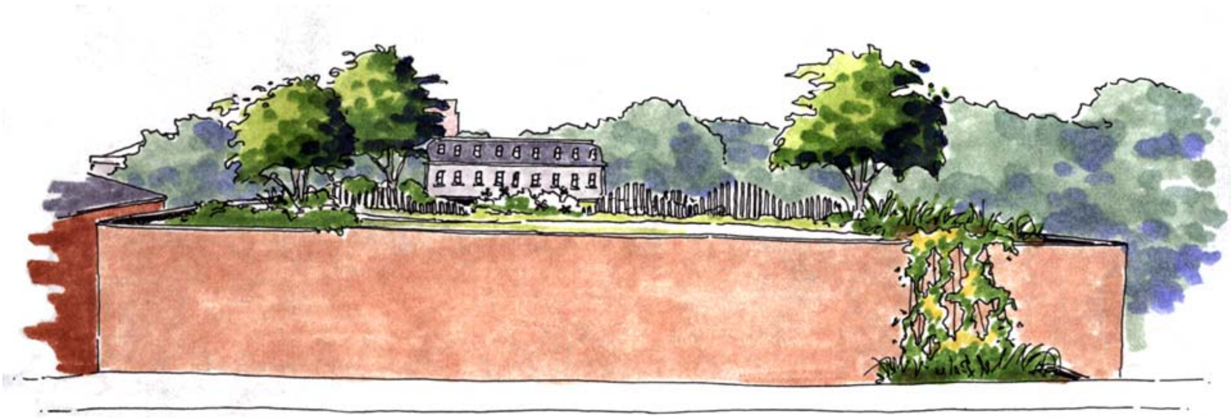

Figure 7.15 Intensive green roof design, 4th floor perspective view (from Caldwell Hall)

Figure 7.16 Intensive green roof design 6th floor perspective view (from Caldwell Hall)

Intensive

green roof design

plant list

Table 7.2 Intensive Plant List

Blue/Purple/White

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Achillea millefolium	Yarrow	24-48"	White			■	■	■					
Aster oblongifolius	Aromatic Aster	24-36"	Blue-Violet								■	■	
Baptisia alba	White Baptisia	24-36"	White				■						Dark blue-gray stems
Echinacea pallida	Pale Coneflower	36"	Purple			■	■						
Erigeron pulchellus	Fleabane	24"	Lavender-White		■	■							
Eupatorium coelestinum	Wild Ageratum	18-24"	Lavender-Blue						■	■	■		
Liatris spicata	Blazing Star	24-48"	Purple					■	■				
Monarda fistulosa	Beebalm	24-48"	Purple				■	■	■				
Penstemon smallii	Small's Penstemon	18-30"	Lavender			■	■						
Phlox caroliniana	Carolina phlox	12-36"	White				■	■	■	■	■		
Phlox maculata	Meadow Phlox	30"	White			■	■	■					
Phlox pilosa	Downy Phlox	8-20"	Pink-Purple	■	■	■	■	■					
Potentilla tridentata	3-Toothed Cinquefoil	9"	White					■	■				
Salvia lyrata	Lyreleaf Sage	4"	Pale Blue-White	■									Evergreen, 12-24" flowers
Sisyrinchium angustifolium	Blue-Eyed Grass	8-10"	Blue				■						Evergreen
Stokesia laevis	Stokes Aster	12-24"	Blue-Lavender			■	■			■			
Tradescantia virginiana	Virginia Spiderwort	24"	Blue-Purple	■	■	■	■						Blooms mornings only
Verbena canadensis	Verbena	8-12"	Purple		■	■							
Verbena canadensis 'Alba'	Verbena	8-12"	White		■	■							

Pink/Red

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Gaillardia pulchella	Indian Blanket	18-24"	Red-Orange			■	■	■	■	■			
Hemerocallis fulva	Day-Lily	12-36"	Red-Orange			■	■	■					
Kniphofia uvaria	Red Hot Poker	24-48"	Red-Orange						■	■	■		
Lobelia cardinalis	Cardinal Flower	24-48"	Red						■	■	■		
Monarda didyma	Beebalm	24-48"	Red				■	■	■				
Phlox paniculata 'Sandra'	Garden Phlox	24"	Cherry Red				■	■	■				
Phlox subulata	Creeping Phlox	6"	Pink		■	■							Evergreen
Verbena canadensis	Verbena	6"	Red-Pink-Purple			■	■	■	■	■			

Yellow/Orange

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Asclepias tuberosa	Butterflyweed	18-30"	Orange			■	■						
Baptisia tinctoria	Yellow False Indigo	30"	Yellow				■	■	■				
Chrysanthemum leucanthemum	Ox-Eye Daisy	12-24"	White, Yellow Eye			■	■	■					
Coreopsis verticillata	Threadleaf Coreopsis	12-24"	Yellow				■						
Oenothera tetragona	Sundrops	12-24"	Yellow		■	■	■						
Pityopsis graminifolia	Silkgrass	12"	Dark Yellow						■	■	■	■	
Ratibida pinnata	Yellow Coneflower	36-48"	Yellow			■							
Rudbeckia fulgida	Orange Rudbeckia	24-36"	Deep Yellow						■	■			
Solidago spp.	Goldenrod	12-36"	Yellow					■	■	■	■	■	

Grasses

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Chasmanthium latifolium	Upland Sea Oats	3-5'											Gold in fall

Plant references:
Duncan & Foote, 1975; Morrison, D., 2002; Murdy, W. H. & Brown Carter, M. E., 2000; NC State University, 2000; University of Georgia, 2003; United States Department of Agriculture, 2004

Intensive
green roof design
plant list

Shrubs/Trees

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Cercis canadensis	Eastern Redbud	20'	Pink										Deciduous, yellow/green in fall
Itea virginica	Virginia Sweetspire	3-5'	White										Deciduous, burgundy in fall
Jasminum floridum	Showy Jasmine	3-4'	Yellow										Evergreen
Kerria japonica 'Pleniflora'	Japanese Kerria	3-5'	Yellow										Evergreen, flowers continue sporadically through summer
Koelreuteria paniculata	Goldenraintree	20-25'	Yellow										Deciduous, summer flowers, butter yellow leaves in fall
Spiraea thunbergii	Thunberg Spirea	3-4'	White										Deciduous, yellow in fall

Vines

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Gelsemium sempervirens	Carolina Jessamine	10-20'	Bright Yellow										Evergreen

Groundcovers

Scientific Name	Common Name	Height	Color	E. Spr	M. Spr	L. Spr	E. Sum	M. Sum	L. Sum	E. Fall	M. Fall	L. Fall	Notes
Hypericum calycinum	St. Johns Wort	8-12"	Yellow										Evergreen, purplish fall color

Plant references:
Duncan & Foote, 1975; Morrison, D., 2002; Murdy, W. H. & Brown Carter, M. E., 2000; NC State University, 2000; University of Georgia, 2003; United States Department of Agriculture, 2004

forms pick up on patterns characteristic of Piedmont landscape. These forms and patterns are most likely familiar to many of the viewers of the rooftop.

The elements within the design create opportunities for both short-term and long-term attraction and fascination. Implied movement through the shape of the river and the varying height of the sculptural elements captures the attention of the viewers and retains the eye on the rooftop. Actual movement created by the wind sculptures and vegetation blowing in the breeze creates an additional form of visual attraction. Constant color throughout the year as well as the reflected light from the glass pieces provide sources of immediate distraction. While not physically accessible, views of the changing patterns of colors and variation in viewpoint from floor to floor in Caldwell Hall create long-term sources of fascination and intrigue.

The location of Moore College across Herty field created a central focus to the window views. Vegetation placement and patterns take advantage of this and other surrounding features, framing the distant buildings. These plants also create a sense of mystery as forms disappear behind the taller vegetation. Vertical elements connecting the three levels of the rooftop and the sounds of the wind sculpture attract the attention of pedestrians on the ground level, creating opportunities for green roof education and awareness.

While not a traditional feature to green roof systems, a series of lights installed at strategic locations on the roof could extend the benefits of the restorative green roof design into the evening and nighttime hours. Students spend many late nights in the design studios finishing projects. Small lights illuminating the curved shape of the vegetative river could create a source of visual interest in an otherwise dark setting. Lights shining onto the base of the wind art features could create an interesting series of shadows. On windy nights, the movement of the metal poles in the light would create movement in the shadow patterns, providing an additional form of attraction and intrigue.

There is no single correct answer to a design problem. The extensive and intensive designs for the law school library annex presented here offer potential solutions to create positive experiences from viewing elements of nature.

CHAPTER 8: CONCLUSION

Although separate fields of study, the concepts of green roof technology and the psychological impacts of nature on humans ultimately affect one another in the design process. If properly installed, the vegetation on green roof surfaces establishes a series of environmental benefits. Some of these benefits include habitat creation, a reduction in stormwater runoff, and a decrease in the energy usage requirements of the building itself. Yet the same plant species found on green roofs can also have a large impact on the individuals who overlook these elevated planted surfaces. There is a growing amount of documentation illustrating the benefits received from viewing nature. "A tree outside the window can be mind filling. It tells about the seasons and the weather; it serves as the setting for diverse animal life; it symbolizes the past and promises a future. Even a single tree can make a difference" (Kaplan, Kaplan, & Ryan, 1998, p76). Applying this research to a green roof setting pushes the restorative ideas of nature to a new level. Whether the rooftop is an extensive or intensive system, the green roof vegetation has the potential to attract an individual's attention and provide moments of stress relief and relaxation.

The conceptual design for The University of Georgia law school library annex green roof offers one example of the union between green roof technology and restorative benefits of landscapes. The combination of the two fields of study takes the traditional design analysis one step further, assuming an interdisciplinary approach to the design process. The ideas of audience and program, the length of the viewing experience, accessibility, the type of the green roof system installed, and any surrounding environmental conditions combine the site analysis concepts from both a green roof and psychological perspective. By taking a step backwards, looking at the larger picture, and considering the impacts of a design on multiple levels, designers can create green roof projects which simultaneously benefit a wider range of systems and users.

The design component of this project taught me a good deal about the process of combining the two ideas of green roof technology and restorative design. Green roofs are slowly becoming a common feature in the American landscape and have amazing potential to benefit a wide range of environmental systems. The background research and data illustrating the beneficial impacts of views of nature on humans shows positive results among many different groups of individuals. I saw green roof settings as a perfect opportunity to combine these concepts. It was during the next step of this project, applying the written ideas and data of restorative views of nature to a visual setting—to a green roof setting—that I realized that my original thought of a predetermined list of green roof design concepts was not a realistic option. There are too many differences in landscape preference from culture to culture, between regions, and among groups of people within the same region. There is no single correct answer to creating a restorative green roof.

The five groupings of criteria concerning the larger picture and the overall framework of a green roof project helped me to focus my design goals on the specifics of a site. Despite this process to narrow my focus, I went through many, many concept sketches and slight design alterations before developing the final design I thought was most appropriate. The thumbnail sketches in Figure 8.1 are just a few of the many concepts I created in the design process for this site. Any of these small sketches could be taken further and developed into a different restorative green roof design. And while the final concept I created took into account many of

Figure 8.1 Concept sketches

the concepts and criteria of a restorative setting, there is no guarantee that this design will evoke the positive responses to nature that I intended. As with many projects and management plans, the idea of a feedback loop is critical in learning and improving. If this design was actually installed, it would be important to interview the students and faculty who view the space and get their feedback and responses to the design. Interviews, surveys, and studies could reveal a great deal about how successful the design is in creating moments of stress relief and relaxation, as well as what components are confusing or inhibit the restoration process. Knowledge of these successes and failures will help immensely in the creation of future green roof designs.

There are still many questions to answer about restorative green roof design. Simply improving our understanding of how green roofs function will play a large role in increasing public acceptance of the structures. Despite their wide-spread usage throughout Europe, many North Americans still turn away from the thought of deliberately planting vegetation on a rooftop. More research is needed to determine which plants are most effective as green roof species, and which forms of vegetation are able to tolerate the harsh conditions of a rooftop environment. Granite outcrops offer model systems of plants which thrive in harsh conditions. These plant species would be ideal candidates to study and monitor on extensive green roof systems.

In terms of environmental psychology, additional studies are needed to document the impacts of views of nature on different groupings of individuals. While there are several studies describing the benefits of natural vegetation in medical, educational, urban, and employment settings, the impacts on hospital patients and staff are by far the most documented and discussed. New studies in all four settings would not only provide a better understanding of our responses to the environment, but offer additional support for the need of vegetation in our immediate surroundings. Similarly, additional research into regional landscape preferences before even beginning the design process will create stronger and more effective restorative designs.

Bringing the two ideas of green roof technology and environmental psychology together into a single design process creates many new questions about green roof design. Color is an obvious source of attraction in a design and can easily be manipulated through plant choices and identifying blooming seasons. Yet to create a stronger restorative green roof design, there needs to be a better understanding of the impacts of colors and color combinations on human emotions. The ideas and concepts presented in this paper concerning restorative green roof design provide a glimpse into the range of possibilities for these greened surfaces. Each new green roof project is a small step towards improving environmental conditions on a variety of levels. By looking more closely at the design of the green roof surfaces, these small steps can have an even greater impact on not only environmental systems, but on the individuals who look out onto and enjoy these views from above.

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