Creating Satellite Photos from the Ground-Up
and Other Ecological Aspects of Raster Imaging for Architects

ROB FLEMING
Philadelphia University

Introduction

It wasn't until the late 1980's with the development of powerful PC computers and effective computer aided design software that architects finally began to exploit the possibilities of emerging digital technologies. The result has been nothing short of a revolution in the way architects produce documentation in the form of CAD drawings and present images in the form of rendered 3-D models. While AutoCAD and other vector-based programs continue to improve, other new forms of digital media are finding their way into the architect's cadre of tools. Embedded within each new tool, are an entirely new set of issues involving the relationship between how information is represented and the quality of architectural design. While that topic has been thoroughly debated through the comparison of the hand versus the computer, the potential of raster-based software primarily through the vehicle of Adobe Photoshop and other paint programs has not received the attention it warrants. This paper will explore the difference between vector and raster depictions of reality with the goal of uncovering techniques to employ digital technology in the pursuit of good design and even better design education.

Embedded within that goal is the idea that good design should involve an intimate understanding of a given site and its prevailing eco-system. While this is not the sole ingredient, it certainly warrants attention. Due to its prominence as an important issue by a large portion of the profession and the schools, ecological design must be considered as part of the equation of success. Secondly, as I will discuss later, raster-based modes of representation lend themselves to ecological interpretations because of their ability to represent nature in its underlying systematic organization. In addition, these images can also portray nature in a highly textured, visually accurate and temporal manner, thus allowing increased sensitivity to natural sites by design students.

The paper will be broken down into several parts: A comparison between vector and raster imaging; a case study of how raster-based thinking can lead to an increased sensitivity to nature and ecology; a second case study illustrating how students can generate satellite inspired images from the ground up and lastly, some key ecological aspects of raster imaging created widely available raster-based software. The ultimate goal of the paper will be to expand the reader's understanding of the potential of emerging digital media with the hopes that a new and more ecologically evolved architecture will emerge.

Vector-Based Depictions of Reality

Vector images are formed by a compilation of lines and points as defined by a pencil or by computer software. In the case of the pencil, lines possess a distinct beginning and end and are therefore capable of accurately representing a building. In the case of a computer, lines inherently possess information including length, beginning point and end point and absolute/relative position in space. In that sense, vector representation could be said to be Cartesian in that the dynamic design process is played out in a three-dimensional system of coordinates defined by x, y and z designations in space. In the typical design process this Cartesian system is overlaid onto pre-existing natural sites leading to a disharmonious relationship between linear coordinate systems of representation (vector) and the non-linear aspects of the natural world including slope, texture, changes over time, color variation and light. A tree, for example, has no easily defined edges within the vector system, so it is abstractly or symbolically represented with a circle and a dot or by a soft quasi-circle with rough edges. Even the soft vector tree is merely a symbol with the edges of the trees showing what the tree might be like if measured very carefully. Ultimately vector/Cartesian-based representations work very well for defining the edges of buildings, roads, streets or those things built by humans. However its ability to portray nature is limited because the method of representation relies on *symbols* rather than *exact representations* to depict a given natural site and its characteristics.

Raster-Based Depictions of Reality

Raster images are formed by a compilation of units called pixels. Each pixel is defined by a color defined by a RGB ratio: a percentage of pure red, pure green and pure blue mixed together. The pixels are then manipulated in two-dimensional space to form an image. A raster-based portrayal of reality has no defined edges or points and no perceivable solidity, leading the viewer to see the world in an ambiguous way, where the end of one object and the beginning of another is represented by a gradation of different colored pixels. The result is a "textured" view of the world comprised of fields of various combinations of colored pixels that ultimately form recognizable or abstract images.

Perhaps the clearest example of the power of raster imaging can be found in digital photography, where reality is depicted by a compilation of pixels organized to form a pictorial understanding of a given object. This pictorial view of the world al-

lows insight into the specific nuances of a given site. Trees can be understood as real, tangible objects, rather than the symbolically depicted trees of vector imaging. By gathering a series of photographs taken over time, the dynamic aspects of a given natural site will be understood by the change in density and foliage of trees, or by the changing quality of light depending on season, weather and time of day. Through this process, the natural world becomes more perceptually accessible and may be seen as a place of dynamically changing and growing objects. In this scenario, raster imaging could be said to be more non-linear or potentially cyclical in its depiction of reality in comparison to symbolically oriented vector images of nature. At the same time, however, raster imaging offers little or no accuracy in the traditional Cartesian sense because buildings, for example, are impossible to accurately measure from aerial photographs. Non-physical delineation of space like property lines and building setbacks are impossible to illustrate through raster imaging alone.

Unlike photographic raster imaging where nature is represented pictorially, Satellite imaging offers the opportunity to see nature as layers of interconnected information. For example, the Land SAT system takes aerial photographs of a given region by making three passes each pertaining to red, blue or green values. The passes are then recombined to generate an image of the ground. Those RGB values can also be reassigned to any color, which allows that same site or region to be presented in an abstract way that can highlight different aspects of the site (Figure 1). That same satellite can also generate images by capturing varying levels of thermal activity on the ground. In this mode, areas of shade would be considered cool, while other areas exposed to the sun would be hot. The images generated from these satellite photos offer a glimpse of nature at a level of detail not visible to the human eye. Information about an ecosystem can then be presented in an abstract, diagrammatic way. The result is a "pattern" based view of reality where trees, water, crops and human settlements can be seen in broad strokes, thus helping to understand the ecology of a given site.

Fig. 1. Satellite image reveals patterns of nature. Location unknown.

Many have argued that the environmental movement gained momentum when the first space photos came from the Apollo project. This makes sense because people saw, for the first time, that the world was a blue and green and brown orb always changing and highly unique. It was a natural place filled with intrinsic value. In some respects, raster satellite images offer us the same opportunity. Designers can begin to see sites and regions in ways that are difficult to perceive from even a tall tower thus giving us insight into the organization of nature, as well as destructive human settlement patterns. In contrast to the earlier discussion regarding vector imaging, raster-based satellite images possess the potential to convey a systems-based understanding of the world. Here, environmental patterns such as slope, bodies of water, vegetation, agriculture can be seen in juxtaposition with human made patterns of development and destruction. This distinction is important with respect to the types of buildings design students eventually create. The theory presented here attempts to counter attack the tendency of design students and practicing architects, for that matter, who rely on vector imaging, to propose object buildings floating in a natural landscape that are typically disconnected form their natural context, or worse, destructive to the local ecosystem. Raster imaging possesses the potential to connect students more intimately to their given natural sites and hopefully will lead to more ecologically sensitive design proposals.

Case Study One: Raster-Based Thinking as a Means to Increase Sensitivity to the Natural World and Ecology

As part of a third year studio focused on environmental issues we began to use the ideas of raster imaging with the notion that the development of satellite-inspired images would assist the students in seeing their given site more ecologically. The students and faculty discussed the differences between vector and raster images with the idea that the students would devise a

Fig. 2. Detail of site analysis image from the environment group.

means of representing their site analysis in a raster format. Each group of students was assigned a specific site analysis issue to map on a given site. The groups were divided along issues of environment, diversity and energy. The environment group mapped vegetation, water features, breezes and other naturally occurring elements by walking the site and marking the extents and location of these elements. At this point, Photoshop was not used due to limitations with the University's hardware availability and the student's lack of computer skills. For the diversity group, circulation paths of humans, autos, deer, birds, etc. where all combined on a single hand colored map. Where circulation was more intense, the students used a brighter version of the designated color. Lastly, the energy group was asked to develop a "thermal" model of the campus by depicting various intensities of color depending on the energy efficiency of each building.

The information from each group was then colored onto a 10' square grid @ 1' = 100' scale map of the site. The students felt limited in their ability overlay all the information simultaneously, but within the first two groups, environment and diversity a deep understanding of the complexity of the given site emerged (figure 2). They began to speak of the "fabric" of the site as if the human-made and natural elements existed in a three-dimensional woven organization. The third group, energy, struggled because they choose to represent their information symbolically rather than by using gradations of color to communicate energy efficiency. The group used various sizes of colored rings. Each larger ring represented increasing amounts of energy used to heat and cool the building (figure 3). The studio felt that this was unsuccessful because the imaging technique was symbolic relying on the size of the rings rather using a gradated pixel grid. The studio had hoped to see an image inspired by a thermal satellite image. The students assigned different colors to each 10' square on the map. Notice the arrow on the lower right of the image. This was not the point of the exercise because the students used a symbol rather than a gradation of color to imply movement. This image can be seen in color @ *http://faculty.philau.edu/flemingr/acsa.*

By the end of the site analysis, the trees and water loomed large in the minds of the designer students. They saw an interconnected system of site from the wild areas to the defined outdoor spaces of the campus. They could see how the paths of deer regularly intersected with people and cars. They began to see the site as a complex weave of built and natural objects all existing in various levels of harmony or disharmony.

For the subsequent master planning phase of the project, the students continued the idea of designing within a raster framework by developing a set of overlay drawings that represented new buildings as areas of color rather than as discrete objects (figure 4). This was a radical departure from the typically compositional, design approach where students place buildings to either form new spaces or exist as objects. During the process, the students became so excited about the idea of "weaving" their master plan that they actually built a loom and wove their major master-plan ideas into an expressive conceptual piece (figure 5).

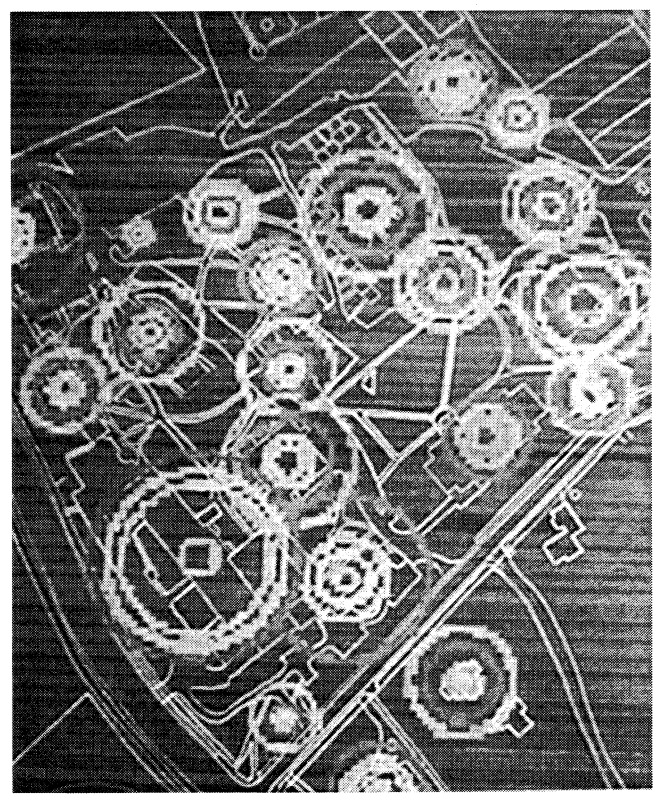

Fig. 3. Incorrect interpretation of raster exercise is seen here as the energy group used symbolic rings rather than gradation of colors to define intensity of energy use.

Fig. 4. Raster inspired overlay drawing for proposed campus master plan.

Red areas represent location and shape of buildings. This image can be seen in color @ *http://faculty.philau.edu/flemingr/acsa.* Students constructed a loom where each woven material represented a different system of organization, natural or human-made, of their campus master plan.

The idea of seeing buildings as part of a larger ecological system continued with the final version of the master plan design where the proposed building's location and geometry seemed to emerge from the ground up, rather than inscribed from above as in past design approaches of third year students (figure 6). In the end, the master plan appeared to be *systems-based* in its origins because new buildings, paths and roads where woven into the existing built and natural fabric of the site. The typical approach of defining exterior space and placing objects was discarded in favor of a process of superpositioning. Because of this, the site was viewed as a series of intersecting human-made and natural systems, which led to a master plan that was not "building centric" in its character but rather, more ecologically based. Buildings emerge as a response to existing natural and human-made patterns as opposed to being compositionally placed.

Case Study Two: Satellite Images From the Ground UP

Last spring semester, a group of third year students attempted to create a fully digital/raster site analysis. Although the hand drawn pixels discussed in the first case study were a great vehicle to learn about the benefits of raster thinking, this group of students wanted to explore how the computer could accentuate the power of these images. The process was grueling because the given site was very large (about 20 acres). Each student was assigned an issue such as biodiversity that includes animal patterns; hydrology or temperature range and was asked to map these on actual site visits. They then generated an overlay grid on an AutoCAD vector drawing of the site. Various colors were chosen to represent each issue and various levels of gradation would represent intensity. Each student created a separate image for his or her issue, thus revealing a pattern (figure 7). The next step was to overlay each map in Photoshop in order to discover corollary information. The students exported AutoCAD bitmaps into Adobe Photoshop at identical scales. They then used various levels of opacity and layer positioning to create an infinite number of interpretations of the site. This was very powerful for them because they could see the role of trees and water in providing cooling, shade and refuge for biodiversity (figure 8). This image can be seen in color @ *http://faculty.philau.edu/flemingr/acsa.*

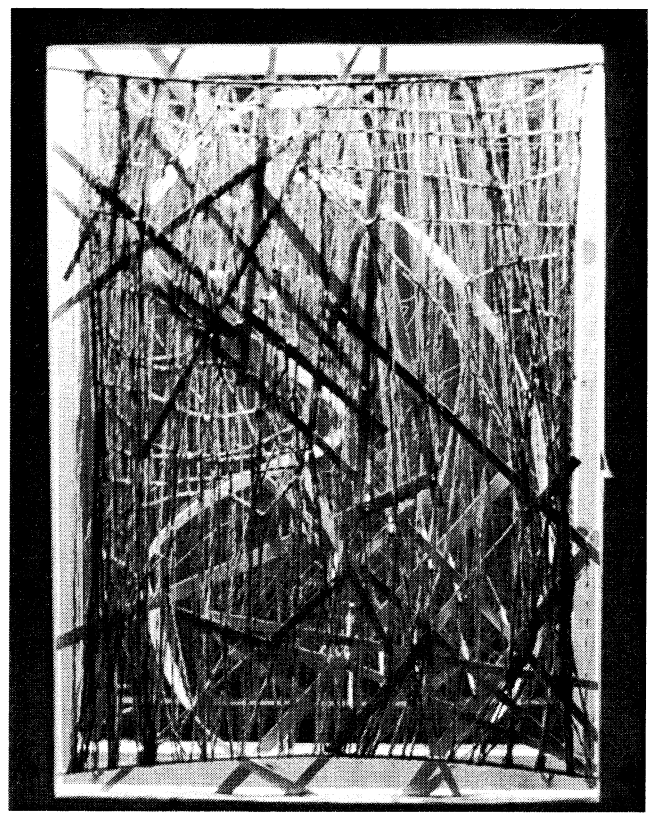

Fig. 5. Interpretive "weave."

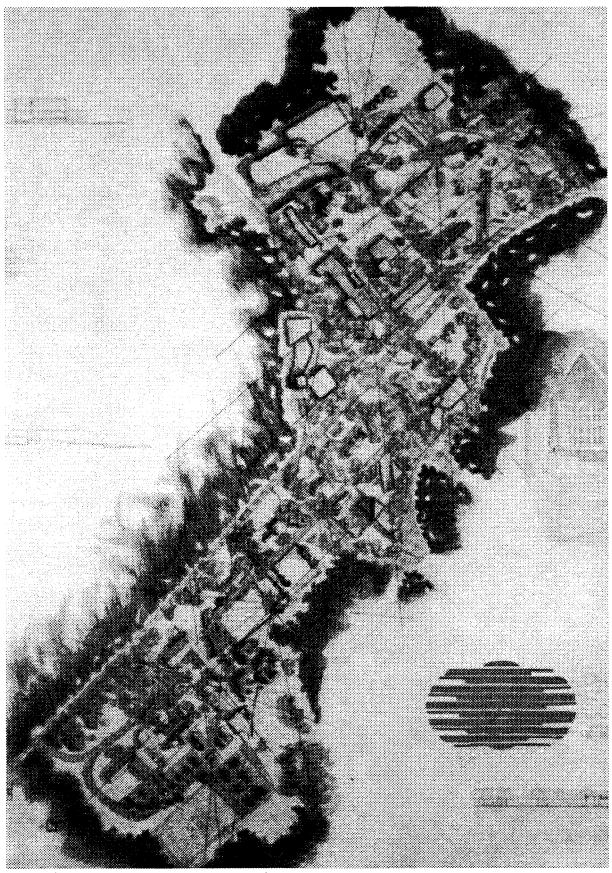

Fig. 6. Final campus master plan project.

In the end, the students also had some great images to look at and study, which got them very excited, thus helping to build momentum for the subsequent building design project. Many came into the building project understanding the site as a system rather than as a blank canvas. This was true for two reasons. First, they were forced to explore the site in great detail in order to input the information into the computer. This, by default, made them extremely intimate with the site. Most of them were reluctant to propose buildings at all so as not to disturb the site. Second, once they had the information in the computer, they could see their site as one would from space as a single picture of great complexity. They seemed to become concerned about the environment because of their newly discovered point of view.

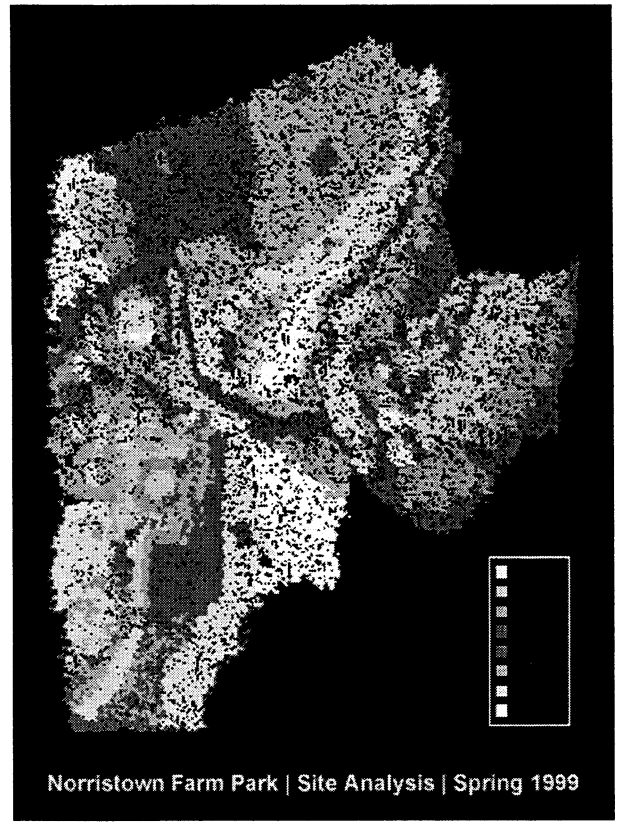

Fig. 7. Satellite image from the ground up: patterns of light.

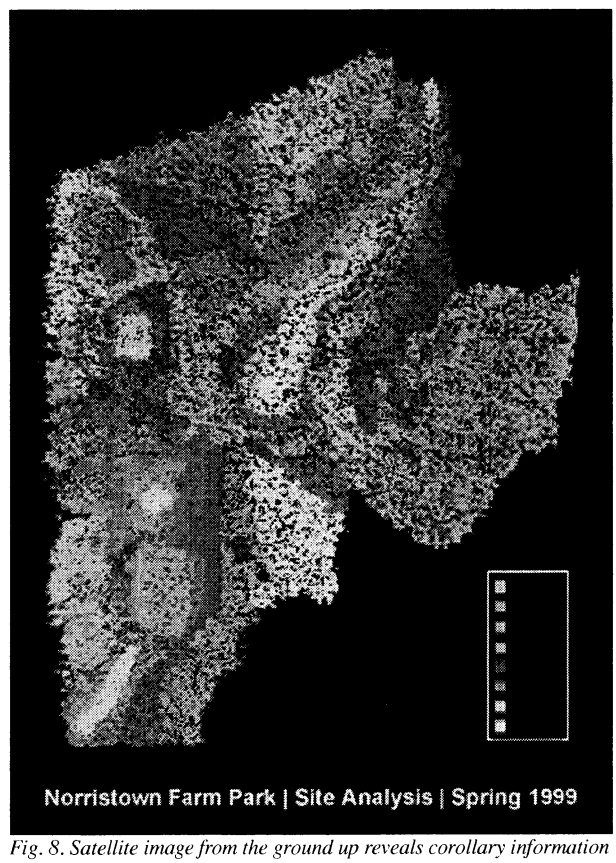

Fig. 8. Satellite image from the ground up reveals corollary information

ASPECTS OF RASTER BASED IMAGING FOR ARCHITECTS

During the process of developing the site analysis listed above, several notions of raster imaging and ecology emerged. They are described in brief below.

Resolution and Scale

Raster imaging offers the ability, to change resolution by increasing or decreasing the number of pixels per inch, which is typically referred to as dpi (dots per inch). In effect, image resolution can be combined with traditional architectural scale. For example, a drawing scale of 1" = 100' can be further defined by designating each pixel to represent 10 square feet, thus the resolution would be 10 pixels per inch or 10 dpi which is a very low resolution. A more detailed image might be 100 dpi, which would mean that each pixel represents 1 square foot of information on a given image. If an image is made at 1" = 50' and a resolution of 100 dpi is set, then each pixel must represent a 6" square. The development of DPI as a scalable entity now allows students to work directly in Adobe Photoshop as opposed to inputting colored squares into AutoCAD, as was the case in the second case study. This will allow the process to move more quickly and open portals to a whole set of digital raster techniques fro defining buildings sites and ecologies.

Gradation as an Expression of Intensity or Temporal Context

Because of the nature of pixels, gradation can be easily achieved allowing architects to represent intensity of information. Obviously the brighter version of the color represents increasing intensity of activity. This idea is similar to architects using stippling, a series of points designed to fabricate a true gradation, to represent intensity of pedestrian movement. With digital technology this gradation can be accomplished in a very evocative fashion. Gradation can also be used to reflect changes over time. For example bodies of water rise and fall depending upon seasons and sometimes flood. The average width of water can be shown in the brightest blue, while light blue colors may "spill over" the banks to reveal the extents of past floods. In the case of a vector drawing, the flood line is represented by a tiny dashed line labeled flood plane. This hardly begins to connect us to the true sense of a flood plane. Literally filling an area in with gradations of blue dots helps us to perceive the site in a richer more temporal way.

Color

Vector based line drawings offer little opportunity for the use of color as a means to express information about a site or building. Color can be a powerful ally simply because the act of choosing a color neatly ties a designer's perception to the site and perhaps even to a given season. For example, not only are the exact outlines of trees defined in an aerial photo, but we can also assign to the otherwise black and white trees, which either exactly mimic, the color of the trees or create symbolic colors that indicate deciduous or coniferous. Since the color of the trees change, a number of the same images in different seasons could be done in order to comprehend the site in a more cyclical fashion. This may lead to more sympathetic solutions because the design student begins to see his/her site as alive and valuable. In opposition is the collection of circles with dots (trees) in the vector format, which is devoid of color, texture, cycles and end up portrayed as devalued objects ready to be torn down to make way for a proposed building.

Relativistic Layering

Perhaps the most powerful aspect of raster imaging for architects is the ability, through Adobe Photoshop and other paint programs, to overlay information. In this scenario, various pieces of information can be highlighted by increasing opacity or by redistributing the order of the actual layers. This was attempted in past semester with mylar and semi transparent colors with limited success. The digital approach allowed a very dynamic and exciting interpretive tool for understanding the site. The idea of relative layering and varying opacity settings was important because no two people will see the site the same, thus the tool allows us to generate a relativistic interpretation of the existing site. Some students for example might place water on the top layer, while other might place sunlight information on top. Each has its merits, but each also reflects a unique understanding of the reality of the site.

Interrelationships and Ecology

Another powerful tool of digital raster imaging is its potential to reveal the ecological interrelationships occupying a given site. For example, Figure 8 reveals that wherever trees and water exist, the micro temperature at that exact location is cooler (figure 8). The design student begins to understand the role of vegetation in balancing a given microclimate. The students can also begin to see how different types of terrain harbor different animals and how the edge of forest becomes very important to existing biodiversity. They begin to see ecological relationships, which is one of the essential building blocks of moving towards a more ecological understanding of a given site.

Conclusion

Ultimately, both raster and vector forms of representation offer valuable insight into the realities of a given site. The vector view tends to be symbolic in its depiction of nature, but highly detailed in describing human built objects. Raster images illuminate ecological patterns at the micro and macro scale as well as provide effective ways of describing natural entities on a given site. Raster and vector can, and often do, combine to create hybrid representations of site and building. These hybrid images

exist as layers of reality represented in one frozen moment of time. In the future, new and effective ways of generating these images will be discovered. Part of that process will include learning about GIS software. While planners have used that software effectively, architects have yet to explore this hybrid medium. Exposure to this will assist in further developing a computer-based pedagogy. Another important aspect of raster-based imaging is its relationship to fractal geometry and self-similarity theories. In future studios and research, plans are underway to fully explore this relationship. In the meantime, it remains an unrealized opportunity.

By exploring raster imaging, there have been several realizations that will be important for the development of curriculum in the design studio in the coming years. First, vector based modes of representation will be de-emphasized in favor of emerging raster methods. The length and scope of the site analysis will be increased. A direct connection between that process and the building design process will be developed. Plans to further explore new technologies that exploit raster based logic, including GIS and hybrid techniques; both in the studio and in our computer aided design electives are in development. In the end, students' awareness of the complex interdependence of a given site's ecosystem and its natural structure will increase. In that respect, sustainable design proposals will automatically follow, not out of a moralistic sense, but rather from a newly developed ecological sensitivity. This new direction represents a departure from the vector/Cartesian mode of thinking to discover new, ecological approaches to building design. Students will become more firmly connected to their given site, understanding both the architectural as well as the natural context and perhaps emerging digital raster technologies will play a vital role in this evolution of design education.

BIBLIOGRAPHY

Doczi, Gyorgy: The Power of Limits. Boston and London: Shambala, 1994.

Fritof, Capra. The Turning Point: Science, Society and Rising Culture. Toronto: Bantam Books, 1982

Gleick, James. *Chaos: Making a New Science.* New York: Penquin Books, 1987.

Jencks, Charles. *The Architecture of the Jumping Universe*: New York: Academy Editions, 1995.

Laszlo, Ervin. *The Systems View of the World: The Natural Philosophy of the New Developments in the Sciences.* New York: George Braziller, 1972.

March, Lionel and Steadman, Philip. *The Geometry of Environment.* London: RIBA Publications Limited, 1971.

McHarg, Ian. *Design with Nature.* Garden City, New Jersey: Natural History Press, 1969.

Rowe, Colin. *The Mathematics of the Ideal Villa and Other Essays.* Cambridge, Massachusetts, and London, England: The M.I.T. Press, 1976.