Applying Green Architecture Principles to Generate Forest Architecture

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Abstract: *Scientist invent Technologies, engineer put them at work, marketers sell them, but only designers combine all those elements and change them into something desirable (KEHL, 2004)*[1]*. Design has been one of the most promising fields of professional expertise within the last years, bringing together form and use, resulting in products that inspire not only consumers, but society as a whole to search for the best within their own working aesthetic. Forest engineering has exhaustively looked for improving production rates by breeding and improving tree species, adjusting nutritional levels at plant and soil, and recently with genetic engineer of better trees. Forest architecture appears as an option for going over those limits and help to increase forest yields by improving site quality. Forest architecture models proposition are strongly based on forest biology and its elements (trees, animals, birds, insects etc), as well as on local physical conditions (winds, terrain, rain etc). There are seven major principles defended as keystones for having a forest architecture project: Better design of forest interiors; Territorial Planning – considering natural features; Energy production from alternative sources; Managing growth/ development; Using plants as indicators and cleaners; Recycling; Specification of materials. Combined, they can bring nature and people to the same level and by that provide a better room for forest within society. As useful tool within forest management, those principles are to be used for generating a "certification" scheme, which can answer to consumers regarding their concerns about quality of life within rural scenarios.*

Index terms: Design – Forest architecture - Certification

[1] KEHL, J. R. (2004) Internet Interview. Design professor and coordinator of Architecture course of Armando Alvares Penteado Foundation (Faap).

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Forestry has always been practiced with the objective of production and maintenance of timber, and more recently non-timber, forest products. These procedures include highly technical and mathematical (especially statistical) knowledge.

When improving conditions for multiple uses of the forests, such as maintaining soil fertility, exchanging CO2 with the atmospheric air, and providing room for wildlife or human recreation, the approach forestry has taken is to avoid harvesting operations during certain lapses of time and/or setting-apart some areas for conservation.

Every single attempt to define forest architecture, has always regarded it as being a "natural" consequence of these engineering objectives. Some refer to forest architecture as being "the spatial organization of a forest as a system in terms of its subsystems (VESTER et al, 1998)[2]; others would affirm that it is the form and shape of the forest according to its dynamic in a determined time-period. There are also people that describe forest architecture as a result of tree species composition and forest age.

Forestry has always been determined by the calculated model derived from the application of prescribed formulas based on biological behavior of tree species, their growth rates, site qualities, climate conditions and market demands. Forest architecture has been no more than the result of processing all that data.

None of the authors who have addressed the subject so far has even imagined that forest architecture could be the result of a sensible analysis of its components with creative intervention by a forest engineer with an artistic soul.

To simply act by inspiration has never been accepted by the forest science. Forestry has approached nature as an object to be influenced by man to increase production or to avoid human presence in the name of preservation. The imbalance resulting from neglect of this creative aspect is perhaps the reason why so much controversy has aroused from using natural resources in general. People are not satisfied that forests are regarded as machines to be operated by of officially by designated personnel.

This is also the main reason why people attracted by the possibility of becoming a forest professional becomes disappointed with the career, realizing that forestry is unable to fulfill their desire to create a better environment through incorporation of their creative ideas. Forest science has created a gap between people and forests as much as science has created between people and religion. Nonetheless. religion is still there for the ones who believe in it, as much as the forests are there waiting for foresters to creatively interacting with them.

The human soul is not part of the consideration of science. Creativity, the engine behind all achievements of society, has a secondary role within science, which seems to depend only on its own research and theories to make progress.

Time is running out within forestry. The human spirit can not be regarded as secondary when forests are daily becoming a greater part in the life of society. The success of forests will soon depend on style as much as production rates.

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[2] VESTER, H.F.M. (1998) *Characterization of mature and secondary Forest formations in the Southern Yucatan Peninsular region.* www.earth.clarku.edu/luluc/r_vester.htm mail: hvester@ecosur-qroo.mx

Elements of style are what can translate the personality of a forest to captivate an individual, as well as define the approach of the forest professional.. The challenge of being creative obviously won't be well accepted by scientists who do not factor in the human spirit and human values, but there are vast examples of what society can give in return to people who make efforts to integrate style in the construction of a better world. The enhancement of the human dimension within the forests can assist in bringing the so-called "services" of the forest to economic reality. In other words, applying the human dimension and translating it into a useful, practical, and functional environment is what we might refer to as forest architecture. The biological, physical, and social aspects of the forest combined with the mathematical analysis are liberally sprinkled with the human touch of pleasing design components.

Design and architecture of the forest sound pretty much the same, but I'm going to draw a tiny line separating the first from the second. Although it seems that architecture is somehow designing and engineering structures, I find it more accurate to bring to light what a design would necessarily mean and what architecture of forests are to realize.

It has been said that scientists invent technologies, engineers make them work and marketers sell them, but only designers can combine all those elements and transform them into something desirable (KEHL, 2004)[3]. It has also been stated that the starting point of architecture is dynamic, the movement of bodies within space; concurring for their constant redefinition, it is the materialization of a concept, associated with the materials to be used.

1. Observations on the Behavior of Living Things:

Before describing design and architecture subjects, it is necessary to point out some particularities about the nature of living things according to mathematical principles, since we already established a link between science, engineering, and architecture.

For living organisms, the rate at which cell burn energy, the speed at which its muscles twitch, its gestation time, and the age at which it reaches maturity – are sped up by the same factor as its life span is. It's as if in designing a mouse, someone had simply pressed the fast-forward button on an elephant's life (KLARREICH, 2005)[4].

Biological rates appear to bear a simple mathematical relationship; they are proportional to the animal's mass raised to a power that is multiple of ¼. An animal's metabolic rate appears to be proportional to mass to the ¾ power, and its heart rate is proportional to mass to the power -¼. This is true for every biological scale, from sub-cellular molecules to global ecosystems, from the mutation rate in cellular DNA to Earth's carbon cycle.

Max Rubner proposed, back in 1883, that an animal's metabolic rate is proportional to its mass raised to the 2/3 power. If one animal is, say, twice as big as another animal in each linear dimension, then its total volume, or mass, is 2^3 times as

[3] KEHL, J. R. (2004) Internet Interview. Design professor and coordinator of Architecture course of Armando Alvares Penteado Foundation (Faap).

[4] KLARREICH, E (2005) *Life on the Scales: Simple Mathematical Relationships Underpin Much of Biology and Ecology.* Science News. Vol 167. February, 2005 (106-108).

large, and its metabolic rate should be proportional to its surface, which works out to mass to the 2/3 power.

In 1932 this was recalculated, by Max Kleiber, the correct exponent being ¾, not 2/3. The first assumption held that the metabolic rate was based on the lost of heat by the skin, while the second takes in consideration the efficiency of delivering fuel to its cells. Thus, consider animals as three and not two dimensionally structured.

This has been subject of some controversy and must be further examined, but the point is that this drives us to look for scaling relationships in plant communities where some unnoticed patterns have been evidenced.

In a mature forest, the average distance between trees of the same mass follows a quarter-power scaling law, as does trunk diameter. The distance between trees of the same mass is simply proportional to the diameter of the trunk (NIKLAS and WEST, 2005)[5]. Based on past experience, I concur.

The number of trees of a given mass in a forest follows the same scaling law governing the number of branches of a given size on an individual tree. The forest as a whole behaves as if it is a very large tree (NIKLAS and WEST, 2005).

Science has spoken. As a forest engineer I should say that I figured that out long ago and proposed an engineering system for dealing with those findings, which will be presented here.

2. Forest Design:

Being aware of specific knowledge that involve expertise about living things, we start stepping into the field of ecological design, which should drive us to the point of defining forest design concepts as something that can be useful when trying to identify the style of different professionals and their approach to a living forest.

It is not enough to arrange trees in rows to maximize future harvests; it is not enough to preserve small areas of old-growth without natural disturbances; it is not enough to create edged forests to satisfy human eyes; it is not enough to leave beauty strips to real forest to fool travelers (NOTES FROM UIDAHO)[6]. It is not enough to make roads that assure access to trucks and loggers; it is not enough to invest in major conservation units for biodiversity conservation; it is not enough to build facilities within the forest for harvesting operations. In short, none of the actions regarding the forests can be taken without considering it outside of the context of the entire landscape, including human images and institutions. The landscape itself is a unique individual, a community, a dynamic system of interacting patterns.

Design is needed to create natural spatial patterns and temporal phases across the entire landscape, which is a heterogeneous area composed of a mosaic of interacting ecosystems. Forest design must consider the facts of the living forests assets with the production needs of society, and reach further, creating a style that defines the life of society and the professional perception of it.

Forest ecosystems can be characterized by a number of words: property, productivity, openness, efficiency, maturity, stability, durability, flexibility, diversity,

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[5] NIKLAS, K and WEST, E. (2005) Im: KLARREICH, E (2005) *Life on the Scales: Simple Mathematical Relationships Underpin Much of Biology and Ecology.* Science News. Vol 167. February, 2005 (106-108).
[6] LANDSCAPE DESIGN ARTICLE 1/27/00 – www.uidaho.edu/e-journal/pan_eco/edesign.html

richness, wholeness, dynamics, religiosity, healthy, and with accurate stylish design.

As a dynamic, changing environment inside a changing landscape, forest design must pay attention to the dying, extracting and modifying that occur across time. Good design should be able to resolve conflicts between characteristic qualities of the landscape and the changes from use, it should endure as long as possible with the traces the designer gave to it, which doesn't necessarily establish a rule for non-intervention. This means that the professional working with it could have also previously prescribed dynamic modifications for foreseen changes due to harvest, season, fires or whatever the nature of the influence.

The British Forest Commission gave some figures that might be useful to guide professional forest designers: the six key principles are shape, scale, diversity, visual force, unity, and "spirit of the place". We can certainly add to that, society, as the major "client" for the design appreciation.

The geometric components (volume, plane, line and point) of the design and its variations (number, position, direction, size, shape, interval, texture, color, and temporal) can be organized into groups (nearness, similarity, and diversity), in structures (rhythm, tension, balance and scale), and reflect the society and "spirit of the place." Nevertheless, the artistic side of the profession can create something unexpected and incredible for the situation without compromising any of the naturally existing aspects and still gain enough relevance and recognition to make it new and permanent..

Those arrangements are general rules that every designer follows in order to make his/her work possible to be evaluated by colleagues and the public. Nonetheless, forest design, as we are trying to establish, is a deeper experience between society and environment that depends on a unique relationship between the artist and the creation.

With the objective of describing the meaning of each mentioned component, variations, groups and structures, the intention is to make clear what designers would be looking at when visiting a forest designed by professionals. The effects within the forests will be discussed later.

As for components, anything can be a point – a stone, an old tree, a tower, etc.; a plane is horizontal, or vertical, or diagonal; a line can be a reunion of various points or a connection between two of them, and volume is a three dimension measure, like the size of the other components.

In regard to their variations, number is a quantitative change such as the number of rocks, or trees or towers. Position refers to the placement of components within the forest and the landscape; direction is what gives a sense of movement, and can be used wisely to increase the perception of the uniqueness of the work; size is a comparative measure, which relates some components to the others without obliterating other components within the composition. Shape deals with the general features of the area and how the designed components fit into it. Its perception is influenced by overall proportions. Interval is the relation between all components and to the mosaic of other land uses besides forests. Texture will be the result of this interval. The use of color mixing within forest and landscape will depend on the choice of species and the wisdom about what happens across time: seasons, harvest, population growth and how the professional is able to manage the composition to become a lively place. Finally, time, as a temporal measure is further subdivided in circular fashion(cycle), spiral (a circle under stress, a changing cycle), linear (growing from the floor to the sky, like coming from

pastures to old growth trees across the horizon line), and nonlinear (chaotic, destruction and re-creation).

The next design approach to be analyzed refers to groups, meaning spatial arrangements achieved with the components earlier described, such as: nearness (if they stay close or are distant from each other; obviously, important when addressing architectural innovations for forests); similarity(how those elements mix with each other, not only inside the forest but also in the landscape scenario meaning mixed and different land usage in the mosaic of rural activities; density or connectivity(how many trees or block of trees, or how many blocks of forests exist compared with other land uses and all the other components in the forest architecture); diversity(the different species, and the different environments that combine to compose a dynamic landscape, a dynamic design, the artistic design that creates a dynamic landscape).

The natural Tropical Forest can create confusion and loss of interest by the public, who cannot recognize any overall design. Some species must dominate to create a proper environment for the visitor (not to mention the energy flux within forest and from this to the next element of the landscape scenario). At the other extreme, monoculture plantations present a tedious view for the visitor; these must be mixed somehow with the addition of different species, and others by different ages of the plantation to create a dynamic impression. To create the dynamic impression within the monoculture is a challenge for a forest designer. Furthermore, the use of some of the structures proposed within the discussion of forest architecture might be very useful.

Structure is used to define how the whole design "fits" together forming a dynamic section of the landscape. There are four parameters: rhythm (capability of generating interest, as was said about diversity, where the different elements combined in a proper matter can give to the forest design this sense of movement that attracts and directs attention to notable features); tension (elements interacting without resolution, or , pressing them together to create interaction); balance (a balance between species, land uses, seasonal effects, and colors); and finally, scale (the size of the structure the designer is realizing, directly related to the balance within the forest or the total landscape).

Our discussion of forest architecture will promote new ways of developing more productive forests and landscape structures. We must keep in mind the necessity of connections with other land uses that surround it, if any, or connections with the following proposed elements when designing a dynamic structure.

By "spirit of the place" the forest architect should understand that he/she is dealing with a natural environment, a living organism, be it a tree, a forest or the landscape as a whole. This quality of place will be captured when people are visiting or living in the area; thus, whatever doesn't belong should be eliminated. This decision to eliminate an item(s) is the most highly subjective element of design and requires attention to the human factor ("soul") we have noted is part of the artistic sensibility when working within a specific theme.

The forest architect should recognize within the mountains or the planes, the swamps or the dry lands, within the industrial or agricultural pattern of the landscape, the "spirit" it holds. With his/her work, a good forest design reflects this existing link between what is at a place, what enhances those local qualities, and what is unique to each place.

Finally there is the society issue. The dynamic of the environment is changed and adapted by the society that surrounds it. To have the ability to be tuned with the world is the key for any artist's success. The public is the single neglected component of forest design and architecture that has been mostly ignored by engineers so far and is the main cause of their usually controversial approaches to landscape or forest management.

Some of the human characteristics that general designers use to approach their work are: frugality (avoid excess), adaptation (to fit in), plurality (without chaos), Respect(for both, nature and people), playfulness(make it feel good; anticipation (expect the unexpected), responsibility (being an artist doesn't mean ignoring technique),and participation (being part of what he/she is doing).

To address forests as an entity to be managed or abandoned for conservation is a straight and linear approach to forestry; designers know better. Forest design is a tool to improve forest uses by making them adaptable, desirable and friendly for the needs of society..

3. Forest Architecture:

In this last discussion one can realize that marketing the forests is part of both, landscape and society's awareness of it. But we need to go further, combining a well developed design with modern concepts and facilities to make it more productive, healthy and serviceable.

This means designing the forest, combining action, space and movement to create an environment that not only is highly attractive to society, but also integrates the forest within the landscape and with development. Forest architecture is the science and art of building a highly productive, comfortable and safe forest(in terms of both, health and protection against natural phenomena). It is strongly based on biological behavior of forests and its elements (animals, birds, insects, etc.) as well as on physical conditions (wind, topography, rain, etc.).

The forest architect maked a useful connection to the carefully studied designso as to create a suitable or integrated area with the environment that surrounds it; designed structures are also functional, and the architecture should put the whole system together to benefit humans and nature.

The design makes use of biotic and physical features for enhancing and improving conditions at forest sites. After the achievement of an architectural concept of a forest site, the natural forest will be transformed into a man-made forest, without the unnecessary discrimination that this process has received from many environmental groups. The forest architect already knows society's issues are important when defining the design; therefore, his work emphasizes these demands and translates them into a working project.

At the biodiversity level of forest architecture, we must better understand this relation between form and function at the forest management scale to produce a natural environment that can cope with human development. Research in plant and animal behavior and the possibilities of domesticating wild species are keystones for this process.

Recently, we have witnessed an increasing number of reports on human health problems associated with ecosystem destruction. Although these issues have been raised previously, growing populations propel them to daily relevance.

It is necessary to project development and integrate nature realistically. Aesthetic values of forestry can be better understood and modified within an architectural conception, one that can improve conditions for promoting multiple uses of forests.

There is a need for developing better tools that can support a deeper analysis of the impact of sustainability on the environment, society, biodiversity and health for nature and for people. With those tools at hand, forest architecture concepts, decision making can be better supported, social issues can be better addressed, and indicators can be generated to measure precisely the influences our planning can have on the outcomes of development proposals.

Wild landscapes are affected by climate, soils, interactions, and disturbances. Domestic landscapes are affected by land use as well. The forest architect can use the principles described here to create microclimates within the forest itself and the landscape that may shift the forest and landscape into new directions.

By consciously creating a meaningful order, we can develop ways of producing widespread community wealth while positioning the community for a long, sustainable future in a healthy environment (NOTES FROM UIDAHO). The healthy environment can be measured by general stress observations, its stability, continuous recycling, and also by direct measures on inside and neighborhood levels of disruptions – such as diseases or incidence of undesirable microorganisms (bacteria, viruses, etc.).

The scale of agriculture, industries, cities, forests and development projects (roads, power plants, etc.) should be related to the scale of the landscape. The forest architect uses design and knowledge of energy flux within and among land uses to evaluate the size of those components and combine them into a good looking and functional place which is integrated and healthy. This addresses the question of patterns, a process applied to components.

By using the patterns society already knows and accepts and the scientific knowledge concerning living forest behavior, forest architecture is able to establish a creative composition that integrate those different land use strategies into a whole unity that translates not only the "spirit of the place," but also the "spirit of the society" around it. All the elements of the landscape are combined in an image that is a cognitive construct of the world, with some aspects (BOULDING, 1956)[7]: spatial, temporal, personal, relational, value orientd, and affective (emotional) in relation to each individual. Cognition is this active relationship that is creatively shaped by the forest architect.

Much of what can be realized by the forest architect will depend on his/her sense of the environment he/she is creating. Smell, sound, touch, taste, happiness, and even religious aspects are part of what the professional should understand or know when working on the project.

Forest architecture must work within the components, structure, and function of the forest, to have long-lasting, satisfactory results. There are four different recognized levels to work with: components (trees, rocks, animals, etc.), products (habitats, houses,

[7] Im: LANDSCAPE DESIGN ARTICLE 1/27/00 – www.uidaho.edu/e-journal/pan_eco/edesign.html

roads, etc.), systems (ecosystems, traffic, industry, etc.), and community (forest, cities, agriculture).

This means that the forest architect should relate a project to its total context without forgetting that the forest is the main object, and must be considered as part of the whole perspective of elements and components. The design should be anticipatory, flexible, pluralistic, polyvalent, polytechnic, and useful in multiple ways. At the same time, the forester must be aware, always, of the genius of the place and of the society, assuming responsibility for the work; having artistic inspiration should not disregard technique.

Forest design and architecture place the human dimension within sustainable development, and promote the well-being of individuals and nature. People wish to live in a healthy environment with aesthetic appeal, which is a requirement for human health. A forest architecture project describes the system in a comprehensive interdisciplinary approach, focusing on dynamics as the keystone for a better management of the forest and its integration within the landscape.

Forestry has exhausted looking for improving forest productivity with breeding of tree species, adjusting levels of plant and soil nutrition and nutrients, and lately by genetically engineering "better" trees. This scientific work derives from the assumption that "sites" have their production limited by climate (weather), soil and sometimes sunlight. Forest architecture can work with those constraints and help to increase productivity by enhancing and improving "site" quality.

We change the focus of forestry with this new challenge of turning forests from being isolated entities to becoming integrated components in the development of society.. This attitude will increase productivity, health and aesthetic aspects of the forest and foster the realization that development and environment are not enemies.

The following principles, derived from modern "Green Architecture", are recognized as fundamentals for guiding the forest architect when developing his/her projects to create a sustainable forest:

- Better design of forest interiors;
- Territorial Planning – considering natural features;
- Energy production from alternative sources;
- Managing growth/development;
- Using plants as indicators and cleaners;
- Recycling;
- Specification of materials.

4. Forest Architecture Certification

Based on the approaches elaborated in this work it is possible to draw a series of principles, criteria and indicator for sustainable development of rural landscape scenarios within the plantation or native forest, such as the Amazon forest, a first step towards having people and nature considerations for growth.

There are many different types of certification in the world today, addressing sustainable architecture (LEED), sustainable agriculture (EU), sustainable forestry (PEFC), industrial process (ISO) and so on. All of them should be consider when

addressing the issue of developing forest architecture and further a landscape architecture certification.

The forest architecture concept wishes to become an integrate part of efforts directed to foster sustainable development, therefore it won't avoid mutual recognition with any other initiatives with the same proposes, as well as it won't deny assuring to assume its responsibility to assure that best practices from other sectors are also part of its own.

The seven principles presented are part of the forest approach regarding site quality improvement, we still must consider specific questions regarding building materials before having enough material do propose a certification system, this is the subject of the following discussion.