Designing Future Landscapes from Principles of Form and Function[1]

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Abstract: Future landscapes will consist of a gradient of types ranging from wilderness areas to totally "humanized" environments. The man-dominated landscapes will be required to fulfill multiple functions only one of which is aesthetic enjoyment. It is suggested that basic principles of form and function may contribute to design criteria. Applications to the southeastern forest landscape are being pursued.

INTRODUCTION

Volumes have been written about man's detrimental impact upon his surroundings. However there are still a variety of aesthetically appealing landscapes existing today. These landscapes range from relatively natural scapes coveted by wilderness users to the various "humanized" environments, created to fit the physiological and emotional needs of more "modern" man (Dubois 1976). Yet there is little doubt that man is creating new and perhaps less desirable, environments and landscapes. Florida and other "sunbelt" states are especially impacted by human population growth and development issues. As fossil fuels dwindle and the residential utility bills skyrocket in the Northern states there seems little reason to expect a change in trend.

Approximately 8000 new immigrants settle in Florida each week ($\simeq$ 400,000 per year). Assuming a per capita land development of 5 acres for residence and public and private support facilities (e.g., transportation, shopping and service centers), approximately 40,000 acres per week or 2 million acres per year must be developed. In 1973 one of every seven new houses built in the United States was built in Florida. Other land uses are equally compelling. Along with North Carolina, Florida produces approximately 80% of all domestic phosphate consumption. Florida alone produces approximately 80% of the North American phosphate exports and ranks second only to Morrocco as an International producer. In spite of the above, Florida remains a rural state. With over 16 million acres of commercial, short rotation forest land, Florida is an annual leader in acres reforested. In total, these factors create the prospect of leaving future generations with an unplanned environment by default. They also create the opportunity for planning and perhaps designing a more livable future environment. It is the purpose of regional planners to design future spatial and temporal patterns that optimize the mix of functional ecosystems as elements. Aesthetics and visual appeal must occupy a critical position in these designs. On the other hand there will be little opportunity for designing aesthetics into the landscape unless functional utility is considered first. We believe that basic notions of ecological and general systems theory are highly apropos.

THE CONCEPT OF REGIONAL SYSTEMS

Central to ecological and general systems theory is the principle of emergent properties. This principle asserts that certain properties only emerge or become identifiable with a level of organization when viewed from a higher level. In other words, the whole is greater than the sum of the parts. For example, even though life can be reduced to a series of physical-chemical processes it is known to possess attributes which cannot he explained or predicted

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by physics and chemistry. Similarly, populations can he reduced to collections of individuals and yet many population phenomena can not be explained as organism responses. Although we often treat lichens as organisms and even assign them scientific names as though they were simple species, we know full well that their properties result from a unique interaction of algae and fungi.

The principle of emergent properties is based on the premise that constituent elements add together functionally and synergistically. Individual elements play specific functional roles and by so doing, the whole takes on characteristics beyond to the properties of the parts. A forest is more than a stand of trees and landscape is more than a collection of scenes. Future landscapes designed with regional purpose and balance in mind must consist of integrated functional elements. When they do, the regional system will exhibit emergent properties such as beauty and ecological stability.

Waddington (1951) has observed that any reasonably astute adult walking along a beach and encountering objects of debris would have little difficulty distinguishing man-made from natural artifacts. He goes further to suggest that the principal reason is that man-made products have been designed with a single purpose in mind. To the contrary, natural selection operates on a multitude of criteria simultaneously and therefore blends and integrates form with multiple function. The form of designed landscapes must emanate from a multitude of simultaneous functions.

FUNDAMENTAL BIOLOGICAL FORMS

The descriptive relations between form and function are well established in the basic biological science such as botany and zoology (Portman 1967, Thompson 1961). For example, given relatively similar ecological niches or roles in geographically isolated ecosystems, organisms of greatly different evoluntionary background frequently develop similar forms. Although no useable synthesis or application above the organisms level has been made, the approach seems clear and rewarding. Given that we can articulate the ecological functions required of the regional landscape we believe we can draw upon certain universal forms for their achievement. We cite three simple examples.

The dendritic pattern (Fig. 1) is common to both plant and animal kingdoms. Root systems, nervous and circulatory systems and many taxi of lower organisms are organized on the basis of this pattern. To the extent that correlative analysis is valid, the function associated with this form is almost universally collection, concentration and/or distribution of elements or resources. The logical extension of this basic biological principle to the landscape is illustrated by regional drainage patterns. This is not only obvious in the concentrating reaches of the headwaters but also in the dissipating network of many river deltas. We conclude that many of man's more recent large-scale development schemes could profit from obeyance of such a simple natural landscape pattern.

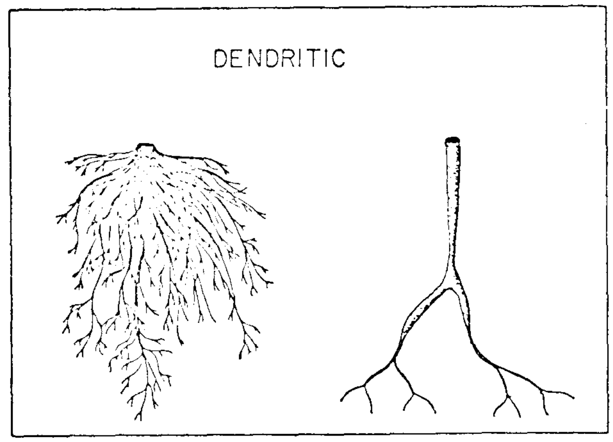

Figure 1--The Dendritic pattern so common throughout the plant and animal kingdom is also known to apply to the upper reaches of river systems as well as the lower reaches wherever delta formation is prominent. Its primary function is that of collecting and/ or dissipating water and nutrients.

A second form that pervades much of biology is the convoluted form (Fig. 2). This form dominates gastro-intestinal tracts, lungs, gills, baleens and compound leaf structures. The almost universally associated function is interchange of substances, either nutrients, gasses or heat. We perceive a landscape extension of this fundamental notion as the use of graded curves in high relief highway engineering (e.g., dissipating high amounts of potential energy from an auto on a steep incline) and meanders in fluvial geomophology. There is currently considerable interest in applying this principle in agronomic landscape design for pest control (Plank 1960).

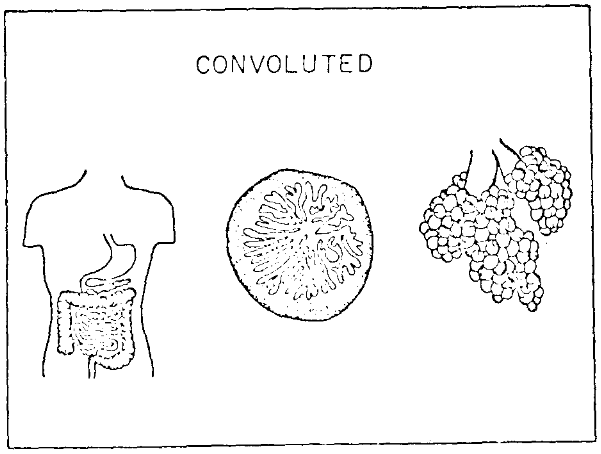

Figure 2--The convoluted form is common at the organ and organ-system level of hierarchy and is also known to apply to certain phyla of organisms. Margalef (1968) suggests that ecosystem boundaries follow this pattern to greater or lesser degrees depending on the amount of exploitation occurring.

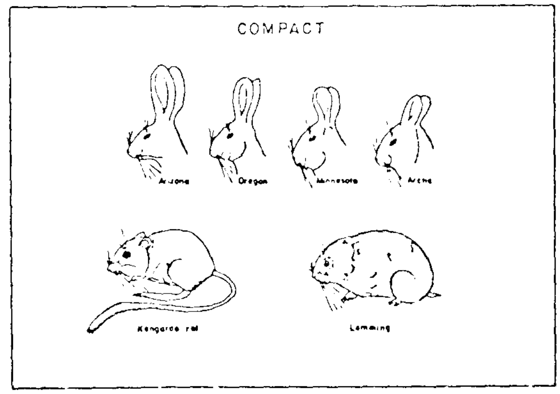

Figure 3--The compact form referred to in animal ecology as Allen's Rule is associated with conservation of resources such as energy and the defense of boundaries. This form would be appropriate for field plot designs and related landscape units where a minimum edge to area ratio is desirable.

The convoluted ecosystem form has been identified as a correlate of spatial ecosystem interaction. Margalef (1968) asserts that: "A more mature system always exploits a less mature system" and that this exploitation occurs at the boundary or interface between the two adjoining systems. Therefore, it is to the advantage of the mature system to maximize the amount of boundary convolution and thus inter-change capacity.

A third form well known to biologists is the globular or compact form (Fig. 3). Allen's Rule from animal ecology notes that as average ambient temperature gets colder, appendages of warm blooded animals get smaller. In this case, conservation of heat dictates minimum surface to volume ratios. Several other disciplines have shown that this principle also applied to minimizing the boundary to be defended (e.g., military strategy). Needless to say, this form is the opposite of the convoluted form so essential to heat dissipation or exchange. Indeed Margalef (1968) asserts that in less mature communities the trend must be to reduce to the minimum the potential sites of exploitation. Certain primitive cultures driven by the necessity to defend territorial boundaries yet maximize overall use of the landscape developed their political units in a hexagonal pattern (Woldenherg 1976). The hexagon is the geometric form that minimizes the boundary of individual elements while maximizing their packing at the landscape level.

REGIONAL LANDSCAPE FUNC11ONE

The question quickly becomes whether or not the principles and lessons learned from the basic biological sciences can be extrapolated to higher levels of organization such as the ecosystem or regional landscape. We are confident. they can. As ecologists we believe there are critical ecological functions to be performed within the regional landscape. These are analogous to natural ecosystem functions so well studied in this decade. The support of heterotrophic organisms such as humans requires basic primary production systems. Moreover, since solar energy, the basis for most primary production, is so dilute this primary production function runs the risk of having to be massively extensive. The obvious alternative is to complement and amplify the solar energy with other types of energy such as fertilizers, pesticides and fossil fuels so that the high energy, primary production units of landscape can be reduced in total extent.

Major functions likely to be required of regional landscape systems are:

Production Systems (Fields, forest, animal systems)

Recycling Systems (Sewage, solid waste)

Decomposition Systems (Landfill, cemeteries)

Abatement Systems
- Stress abatement (Recreational areas)
- Pollution abatement (Primary, secondary, tertiary)
- Heat abatement (Thermo-nuclear)

Storage Systems (Housing, etc.)

Water Systems (Retention, storage, conservation, recycling)

Reservation Systems (People, wildlife)

The task at hand is to integrate these and related ecological functions and implement basic planning designs that achieve the desired performance of the regional landscape. We believe that basic biological forms will play vital roles in these designs. We encourage future planners to build upon the ecologically-based precedent set by McHarg and draw from the inventory of form and function relationships well known to biology. Our own efforts are presently directed at the design of the southern coastal plain forested landscape.

THE FUTURE SOUTHERN FOREST

Presently there are slightly over 200 million acres of forested landscape in the American Southeast. Over 700,000 acres are currently being replanted to southern yellow pines (Pinus spp) annually with an expected interval of 25 years to maturity. This southeastern forest yields about 60 percent of the national pulpwood supply. The pulpwood demand projections for the year 2000 anticipate southeastern production of about 100 million tons per year. This value is perhaps 70 percent greater than the current annual growth increment. An additional 30 million acres would be necessary to meet this demand at current production rates. But this is unreasonable since competition for forest acreage is intensive. In Florida, for example, over 200,000 acres of forest land are lost to competing uses each year. The more likely outcome is that future forests will he managed more intensively for pulpwood; and related uses such as recreation, water management and residence will need to be designed into the forest landscape.

The specific functions required of the forested landscape are fiber production (both pulpwood and biofuel), high quality water yield, pest control, wildlife production, aesthetics and related recreational benefits.

Since forest stands interact at their boundaries, the spatial distribution of stand types is critical to the achievement of an integrated synergistic design. The variables of spatial design include size, shape and ratio of ecosystem elements and the emergent pattern created by their boundaries. The amount of edge drama (i.e., the structural difference) between adjacent ecosystems is an additional variable that governs the interaction of the stands as well as dictating the emergent pattern (Harris and Smith 1978). By building upon these concepts we are developing design principles for the future southern forest. When functional interaction of the component ecosystems is achieved the overall landscape will be more productive and stable than simple random combinations.

Specific parameters allowing us to evaluate the relative worth of different time-space mosaics are *i*) heterogeneity and functional diversity, *ii*) the degree of interspersion, *iii*) the linear extent and type of edge, and *iv*) edge drama or juxtaposition.

SUMMARY

The future environment will necessarily serve multiple functions. Although aesthetics is a critical consideration to most of us, it is but one of many functions required of the regional ecological system. We believe the landscape level of hierarchy has been neglected by the disciplines of ecology and planning to date. It remains a vital level of concern. By coupling basic principles of form and function with the demands of future society we may leave behind a planned rather than a de-fault environment.

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