RICE UNIVERSITY

AN URBAN SUITABILITY SELECTION PROCESS

by

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The environmental problems of our urban settlements, and the resultant ecological crisis, gives rise to the need for an Urban Suitability Selection Process based on the ecological approach. In order to understand how we generated our present problems, an historical survey is used to document man's changing attitudes towards his environment, and to indicate the importance of natural systems.

It is proposed that the ecological input is the primary factor in environmental quality and that the human, natural, and economic costs of urbanization can be reduced when viewed as a holistic process, based on ecology.

The basic principles of the ecological approach are defined and related to their input on urban form. A dual system of man and nature is proposed as the essence of urban suitability, and the use of this concept is documented by a study of three practitioners in the field of environmental planning, Phillip H. Lewis, Ian L. McHarg, and Donald L. Williams. Their processes are summarized for the most relevant indicators of urban suitability, and condensed into an Urban Suitability Selection Process.
The final section applies the basic elements of the process to the Houston urban area. The use and limitations of the environmental inventory is discussed with respect to the availability of data and its use in understanding natural patterns. Finally, performance requirements for urban suitability are recommended with a discussion of their effect on the man/environment relationship.
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AN HISTORICAL SURVEY

1. Man's Early Awareness of Natural Systems:

The earth is old, at least four or five billion years old by scientific measurement (and there are at least forty methods for measuring). Man is barely one million years old. Expressed proportionately, man has been in existence for only $1/4,000$ of the earth's history.

If the history of the earth were documented using time-lapse photography, and condensed to a film of one year duration, man would not appear until the last quarter hour of the film. During the last five minutes of the film, we would see the world some 7,200 years ago, or about 5,200 B.C.. This period saw the recession of the glacial age, the most recent example of world-wide geological change. Its causes are obscured in pre-history, but its effects had dramatic influences on the evolution of man.

This period left the earth in a series of spasms or oscillations. The rapid retreat, followed by a stand-still, or even an advance of the ice, occurred simultaneously with an elevation of the land. "This seems to have had two interesting consequences. For one thing, the increased snowfall round the Mesopotamian basin gave rise to such violent spring floods, year after year, that some early towns were abandoned, and the memory of the disastrous time has been preserved, it seems, in the story of Noah's flood..."¹ In Egypt its effects were equally important. The Nile Valley seems to have been marshy and mostly uninhabitable, but the resulting elevation drained it. The result was a long
ribbon of extremely fertile land that tempted the early agriculturists of the neighboring lands (the biblical "promised land"). Thus, largely as the result of geologic change and a fluctuating climate, hunting gave way to agriculture and the beginnings of civilization were established.

Most of our knowledge of man, his works, and his culture, only goes back to about 3,000 B.C., the beginning of recorded history. Our records tell us that when man became an implement maker he gained the power to transform landscapes, and to manage soil and water resources for his benefit. In doing so, man has become a major force of geological change.

It was during this period that the basis for metaphysics was developed so that man could describe and ascribe values to the natural processes that he observed, but little understood. In this manner his conventional wisdom was developed. The earliest forms of this practice recognized man's dependency upon the natural life support system, but a developing anthropocentric view altered this recognition, so that only those elements directly related to man's survival were considered. This form of existence was successful in relating man to his environment, and enabled the proliferation of our species and its resulting culture.

When man learned to domesticate plants and animals, he realized that he required a readily available supply of food and water. This meant that unless the grazing range of his stock contained particularly good soil and abundant rain, the land would be overgrazed. Man's earliest solution
to this problem was to move to another pasture, in some ways similar to the present exodus from city to suburb. The repercussions of this action can be seen in the Middle East and along the shores of the Mediterranean. This land originally supported thin, open forests with a good growth of grass on the mountain slopes. Overgrazing resulted in the elimination of these forests by destroying the seedlings that could replace the old trees. "Because the trees were not replaced, a park like forest developed with widely spaced trees and grass covering the ground (the origin, perhaps, of the western concept of park?). Finally there were no trees left at all. Without trees or grass to keep the soil in place on steep slopes, extensive erosion occurred. ...Many of the seaports of the ancient Mediterranean world are now miles from the sea because of this greatly accelerated silting process."²

As man increased his knowledge of the origins, methods and limits of his milieu, his ability to structure his environment also increased. At the same time, his ability to compensate for or postpone the consequences of his intervention in the natural processes enabled him to increase the scale of his domination. The fact that he was decreasing his natural "buffer" and increasing the pathology of his settlements was not understood. Even when this situation resulted in famine or plague, his reaction was to address his energies to the effect, not the cause. The questions of right and wrong were asked with man as the sole instrument of right, in an environment that was the source of the wrong.
Moving to the far-east, we find that soil and water conservation was practiced and understood in parts of China over forty-six centuries ago. The land use policies announced by Emperor Shen-nung in 2,700 B.C. stated, "Mountains exhausted of forests are washed bare by torrents...To rule the mountain is to rule the river." But knowledge alone was not enough, for the people were prevented from managing their soil and water resources in an continuous way. Invasions, the breakdown of social controls, and the fall of the Dynasties all contributed to the degradation of the environment. As a result, according to Walter Lowdermilk, whose world-wide explorations of soil and water sources began as an American research professor at the University of Nanking, the desert of North China was probably man-made. While the rainfall is about the same today, the desolate condition of the country prevents its utilization.

Throughout the beginnings of history many natural adversities served to plant the desire in man to rise above the natural limitations. Therefore, with few exceptions, instead of attempting to understand the natural processes, man developed a philosophy that placed him above nature. The anthropocentric view had come of age. As long as man still lacked the power to effect large scale alterations, this new philosophy meant little to the natural process. But when the combination of scale and time of intervention resulted in adverse change in man's environment, the lesson only served to strengthen man's desire to eliminate those "evil" aspects of his environment.
In the Middle East we find the dichotomy of man's use and abuse of his natural resources. On the one hand we see the creation of vast expanses of desert that was described earlier as the result of overgrazing. Paul Sears agrees with this conclusion and compares the situation with that of the American dust bowls. Walter Lowdermilk concurs, for his findings show that the level of ground water in these areas are unchanged since Roman times. On the other hand, in the Nile Valley, the land has remained suitable for cropping for over 6,000 years. This resource was managed by the irrigation systems of man, and the natural system of yearly flooding. But today we find some diminution of crop yields, probably due to oversoaking of the soils and the elimination of organic material by the Aswan Dam. In fact, the reduction of delta forming material by the dam could cause a major change in the land form and productivity of the Valley and the processes it controls.

We can now begin to see the effects of natural systems upon man. Our early culture, laws, and survival were based on a suitable usage of the land, water, and to a lesser extent, air. There are many examples that could be brought to light and cross-referenced, but the scope of this work is addressed at our current needs, which are immediate, and not just in the laying of a sound historical foundation. Let it suffice to say that within recorded history, man's use and abuse of his land and water resources has been the largest enabling factor in the relative success of his settlements. Today's rapid technological changes cause us to lose sight of this factor, and look towards technology for answers that only address the effects.
2. The Industrial Revolution.

"Each advance in man's cultural evolution seems to have had a greater impact on his environment than the previous one. As hunting and gathering gave way to herding, agriculture, industrialization, and increased technological complexity, man seemed to lose touch with the magnitude of his effect on his surroundings."\(^5\)

As we move to the present time, it becomes obvious that man's energetic relation to his environment has gone through a rapid process of change. The industrial system now derives its power from concentrated fossil fuels. Much of this new power source is put back into the environment to enable greater yields of food and critical raw materials. This situation has created our present prosperity, but our sense of opulence is short sighted.

Many of the old landmarks on the path of man and energy are now being re-evaluated. The natural systems can no longer recycle the by-products of civilization without an intelligent form of management. Land use is currently dependent on an economic rationale, installed by a philosophy of growth that sees the highest and best use of this resource as a monetary return. But this view is not holistic, for it sees only the front-end costs of its input on the environment. As ecologist Howard Odum states, "...When man's simple role in the environmental system was based on sunlight energy, plant production was very important. Since plant production depended on area, land use was a principal concern of the social system. But only a small part of the earth's surface
and the energy flows of the environment was really controlled by man, and the checks and ballances of the natural system prevailed. Man did survive with these regimes, however, and his social processes for decisions were developed and brought to the present on the basis of suffered protection by the natural system."

At this point, it becomes obvious that man's mores, ethics, customs, and religious patterns have not had enough time to adapt to these changes. Most people think that the progress man has created in the industrial era was a result of his knowledge and ingenuity - a dangerous partial truth. The current progress we have achieved is due to special power subsidies. Our form of progress can evaporate whenever and wherever the subsidies are removed (ie. the recent coal strike in England). Knowledge and ingenuity are the means for adapting power subsidies to man's needs, as well as the means for planning for Urban Suitability.

As the sciences of Geology, Pedology, Chemistry, Physics, and Medicine advanced in their understanding of the effects of natural causes, man has continued to operate within his philosophy of domination. But the development of these sciences also initiated a search for the cause that resulted in the degradation of the environment and the life processes. This new knowledge, with few exceptions, was suppressed by the domination philosophy of the conventional wisdom. Hence, the use of inanimate power sources and the resulting growth syndrome, continued unchecked, generating our urban society.
In order to perpetuate the conventional wisdom and its temporary success, laws and institutions were developed to encourage the growth of industrialization and to protect its values. The dynamic changes that the industrial revolution initiated in our natural systems were not heeded. This fact was a result of the suppression of the natural science data, as well as the changes in the social and economic values that the new laws and institutions encouraged. If man had applied the knowledge available to him at the time, and provided for the changes in his value system, the location and form of our urban settlements would have been drastically different from what we have today.

3. The Need for an Ecological Context in Planning:

"Our first obligation is to other people, but we cannot ignore the plants, animals and soil of the world as we scheme and dream, earthmovers and nuclear explosives ready. Our continued existence depends on the continued well-being of all plants and animals, not just corn and cows. Our disregard for the other organisms on earth is not just a manifestation of myopia; it is based on our abysmal ignorance of the interrelatedness of plants, animals, and their environments."7

Today we are faced with the above heritage, and the growing knowledge in the fields of Ecology, Planning, and the Physical Design Sciences. The laws and institutions that man has developed over the course of history are now being viewed on broader terms. The traditional metaphysics, that enabled man to achieve his present status, is being viewed as archaic and, in fact, a threat to his continued existence. City form and process, which has increased man's culture, diversity,
and choice, is now being viewed as a machine that threatens the natural processes upon which man is dependent.

In response to the ever growing magnitude of these views, a new metaphysics is being formed which views man and nature as partners in the process of survival. This view is being projected on a holistic basis that will profoundly affect the man/environment relationship and the developing concept of environmental quality.

If we are to respond to the problems of survival, environmental quality, and Urban Suitability, we are forced to look at our relationship to the natural systems that support our land, air and water resources, which are the basis for our urban society. Much has been written as to the social, economic, and physical ramifications of urbanization, but it has been only recently that the ecological implications have been considered. This growing body of knowledge is creating many new insights into the urbanization process and its effects upon the environment. What was once a conservation science is now becoming a basic tool in the urban design process. In a way, the complex systems and environmental degradation that resulted from the industrial revolution sponsored the growth of this body of knowledge.

This developing view of "spaceship earth" requires a new set of inputs in the planning process. The conventional enabling elements of Health, Safety, and Welfare are still valid, but are evolving towards the more holistic concept of environmental quality. The physical form of the environment, both rural and urban,
is currently being documented. The theoretical groundwork, which has existed in the sciences, is being brought together. As a result of this "coming together" and the increasing body of knowledge being developed, the urban form of the future will be subject to much more exacting performance criteria.

What is necessary today is a method for coordinating this knowledge so that the beneficial aspects of our environment can be defined and preserved, and the detrimental aspects can be studied so that alternate systems can be proposed.

It is towards this end that this Thesis is addressed. In realizing that projections for the year 2000 call for a doubling of our existing physical facilities, we can see the necessity for a firm grasp on the concept of environmental quality. It is proposed that the ecological input is the primary ingredient of environmental quality of cities; that a knowledge of the ecological approach is necessary to the planning profession; and that the long term human, natural, and economic costs of urbanization can be drastically reduced when viewed as a holistic process.

"Earth is the mother of all, and when we forget her life weakens. Here is a myth that withstands scientific examination. The more we manage to discover about soil, light, air, water, and all that grows out of them, ourselves included, the more we must incline to acknowledge the reality of eternal relationships that the authors of Genesis and the pagan Greeks...felt in their bones."
THE ECOLOGICAL APPROACH:

1. A Definition of the Ecological Approach.

Following a billion years of evolution, our biosphere is populated with many kinds of ecological systems, each adapted to a different set of environmental conditions and capable of maintaining a continuing pattern. Many of these systems have the same kind of occupational complexity as can be found in our industrialized system. Unlike our urban situation of environmental chaos, the ancient ecological systems continue on quietly, efficiently, cleanly self-controlled year after year, even with some man-made stress.

"Once we understand the purposeful mechanisms built by natural selection into the program's control within the ecosystem, we can recognize the splendid miniaturization and complexity, which many misinterpreted earlier as a symptom of accident, disorder, and randomness. Guiding the self-managing systems of nature now seems far more sensible than the destruction of our life-support bases or dangerous, clumsy attempts to substitute our untried and expensive human anthropomechanic devices."9

Ecology derives its meaning from the Greek word "oikos", meaning household. The term was first used in 1873 by Ernest Heinrich Haechel (1834 - 1919) to describe a natural process,"...the compatible association and orderly succession of plants and animals in response to the conditions imposed by a given soil and climate."10 But ecology is not a new science. It is a move, in some part intuitive, to draw all the branches of science
together and restore them to wholeness.

In the past, scientific data was gathered by specific professions working in isolation. The discovery of the microscope ushered in centuries of enlightenment that further separated and isolated the various "categories" of knowledge. Much of this work verified the structure and function of the natural world as being composed of parts within parts within parts. Yet today, our microscopic view has not provided us with the solutions to our most pressing environmental problems. The missing information is not wholly in the microscopic view, or in the identification of parts. The ecological approach is now beginning to bridge this gap by enabling man to see the systems of which he is one of the parts, this also includes man's systems of urbanization. Bit by bit, a macroscopic view is evolving in the various sciences and in the philosophic attitudes of their practitioners. This is exemplified by international geophysical collaborations, the daily maps of world wide weather and the environmental research of ecologists into the elements of environmental quality. Many professionals who have a clear view of the complex of parts associated with their fields are using the macroscope concept to step back, group parts, simplify concepts, and view larger systems of interaction.

From this discussion we can now see that the biosphere is the largest ecosystem, and that the intelligent utilization of its resources is the goal of the ecological approach. Land, air, and water are the major sub-systems
of the biosphere. Other sub-systems are organized by
their physical processes and organisms into functional
units. To study any phenomenon, the ecological approach
requires both the knowledge of the parts and an under-
standing of its role in the larger system. We now come
to the heart of the ecological approach - the questions.
How are the large and small systems structured, how do
they function, and how are they organized within the bio-
sphere? What principles are recognizable in the macro-
scopic view, in the sub-systems, and in the systems of
man? What is the common functional order of the macro-
scopic world?

The complexity of these questions precludes a sim-
plistic answer. However, the work done by ecologists
in their studies of the evolution of the chemical, bio-
logical, and physical processes allows us to define some
of the principles found in the ecological approach.
These principles can be used to design a flexible response
to our environmental problems. What we need is the
framework for a functional urban design process.

The following principles outline the basis of the
ecological approach:

1. Evolution (change - stability)
2. Scale (macrocosm - microcosm)
3. Density (centralization - decentralization)
4. Energy (conservation - expenditure)
5. Intrinsic Suitability (man - nature)
1. **Evolution** is inevitable, it is dynamic, and a process of change. While the biosphere remains in a relatively stable state, the sub-systems are changing more rapidly over time, evolving towards a more efficient usage of their potential energies. Large scale evolutionary change requires long periods of time, while small scale systems can change more rapidly. There is a power cost for the evolutionary process that is required by the laws of thermodynamics. These laws state that energy can never be created or destroyed, but the conversion of energy from one "state" to another can never be 100% efficient. Therefore, since evolution requires more choices or available paths of development than are required to hold the order stable, energy degradation occurs, removing energy from one system to enable the evolution of the other. "Thus a system can evolve new patterns more rapidly when there are more power flows, providing excess quantities of choice in the form of extra offspring, more specialized mechanisms for selecting, and more reward cycling." Evolution requires the change of the parts for the stability of the whole. The more rapid the change, the higher the cost. This explains the long periods of stability during pre-history, and the rapid change occurring in the urbanized world. Evolution does have its limits which are defined by the amount of power available. Since rapid change in one system must draw it's power from other systems, eventually the whole will be effected, resulting in a breakdown of our milieu.
2. **Scale** is the relative dimension factor between change and stability. At the smaller scale of natural processes (microcosm) the making of new organisms is more efficient than repairing the old ones (natural selection). The larger systems that are composed of parts (macrocsm) are ordinarily repaired rather than replaced. In this respect the pattern is similar for trees and forests, or people and civilizations. "As long as the environment is stable, the diverse type gradually displaces the simplified version because the diverse one has the staying powers and self-developing mechanisms that the simplified version lacks."¹² Thus, if we wish to maintain order in a small structure, we must repair it more often, or allow evolution to effect a change by replacing it with a more diverse type. On the other hand, the larger structural forms are more stable because they are maintained almost exclusively by repair, and therefore they are most difficult to change. We can now see that the majority of the natural energetic costs occur at the smaller scales. Stable structural forms can be created and maintained more inexpensively (energetically) by fashioning them of large scale.
components. The development of man's ability to use fossil fuel has caused a misuse of this natural system. The large scale systems (macrocosms) were the dominant elements in the stability of the biosphere, but now the relatively small scale systems of man (microcosms) have the power to effect large scale alternations of the environment. Man is not only using this power to repair the components he values, but he is also a major input into the change of the large scale systems which threatens the stability of the biosphere.

**THE EFFECT OF SCALE ON ECOLOGICAL SYSTEMS**

Organisms-Populations-Communities-Ecosystems-Biosphere

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3. **Density** of natural processes varies inversely with the scale of the processes. Hence, the density of small scale processes tends to be high, very centralized, and concentrated in a limited area. These processes are extremely vulnerable to outside influences since their continuation is dependent upon a close-knit organization of parts and a direct path for energy flows. On the other hand, the larger scale processes display great diversity, much decentralization, and low density. Since the large scale processes contain the smaller scale processes, the
dominant pattern is one of decentralization in which small scale concentrations occur. The "open" areas in this pattern are necessary to the evolution of the small scale systems since they provide a buffer that limits sudden and abrupt interreactions that can cause adverse change.

4. **Energy** controls the amount of physical structure that can exist, as well as the speed at which energy cycles can function. These cycles are present in all natural systems. The small scale systems, the larger systems that include civilized man, and the whole biosphere, receive only a certain amount of energy, that must be cycled. The expenditure of energy is necessary for the development and maintenance of the evolutionary process. The most efficient usage of our limited energy sources is called the conservation of energy. Darwin was responsible for popularizing the concept of natural selection, but it was not until early in this century (1922) that Lotka indicated that the maximization of power for useful purposes was the basis for natural selection. While the natural systems make use of solar energy, man's systems make use of fossil fuels. These fuels are immensely powerful, but of limited supply. Because man still lacks sufficient power to control the whole biosphere, he is protected in his ignorance of the use of this power source. The accelerating growth of energy flux in man's system must be accompanied by the growth of his knowledge of the use of this resource.

5. **Intrinsic Suitability** refers to the fact that the natural processes serve many functions that have evolved over
time to their current state. As such, these processes represent the most advanced solutions to the management of our life support systems. They came into being through the process of evolutionary change and are working towards stability. They contain elements of varying scales that enable both the centralization of vital processes and the conservation of energy through the economies of scale. These processes do work for man, and represent the highest and best use in the natural value system. If man attempts to alter these systems, he must have knowledge of their full implications, so that in solving one problem, he does not create many more "side effects" that only increase environmental deterioration.

There are many similarities between the principles of the ecological approach and the principles of urban form. The principals of evolution, scale, energy flow, density, and intrinsic suitability have all been used in the creation of urban form. But our negligence towards the implications of these inputs has resulted in the misuse of the environment which is the cause of a large portion of our urban problems.

We therefore must unite the success of our urban settlements with the success of the natural systems. By documenting the process of accomplishing this task we can design an Urban Suitability Selection Process.

In the previous discussion we outlined some of the basic principles of the ecological approach. It was stated that Urban Suitability was dependent upon these principles. One could then ask: how do these principles apply to the works of man; how do the existing man-made processes fit into this system? One is tempted to answer, "carefully, very carefully," but that is not a satisfactory answer, even though it may be the essence of our problems.

We need to consider the juxtaposition of the systems of nature and the systems of man. The ecological approach would place emphasis on the natural systems and the principles derived from them, while the anthropocentric approach concentrates on the domination and substitution of natural systems when conflicts arise. All of nature's systems are not in man's best interest, but the same thing can be said of man's own systems. Our task is then one of developing a process of evaluation for both systems. The result of this process should enable man to develop continuing patterns with nature which:

(1) allow for change by providing for choice in location, structure, and activity;

(2) encourage stability through a consistent process of relating man's systems to their counterparts in the natural system;

(3) provide for varying scales of urban form, activity, and processes that reflect the existing scale of the natural processes;
include centralized activities that are free to respond to the parameters of decentralized organization;

(5) acknowledge the limited power sources available in both systems; and

(6) have a thorough understanding of natural systems, their intrinsic suitabilities, and the work they do for man.

To begin with, it is interesting to note that the number of occupations in our urban society has been found to be similar to the number of species in a natural system. "As man receives auxiliary energies from fossil fuels, he uses less and less of the natural network of species but replaces them with work functions in his own society... By this theory the number of occupations of people and the number of species in the system are complimentary; cutting down on one requires an increase in the other." Each species is composed of specialists that perform a specific set of functions. If man replaces one of those functions by an occupation in his society, he must be prepared to compensate for the other functions. It is more economical to make use of the natural system to work for man and reduce the costs of urbanization, while upgrading environmental quality.

This is the first step in developing a holistic view of the urban environment. "Above all, we must be wary of man's tendency to reduce the variety of components in his ecosystem, for this increases susceptibility to adverse change." As stated earlier, change
Involves costs which are energetic and monetary. Adverse change has it's enabling energetic cost, as well as the cost of correction. It is more economical to do it right the first time, or to correct our past mistakes before the costs of correction are beyond our capability.

An interesting example of this situation is the problem of storm water runoff. The natural system removes excess water through surface and sub-surface channels that are stabilized by vegetative cover and directed by the slope of the land. This system evolved through climatic and geologic action to create our rivers, lakes, and aquifers. These systems have their limits which are expressed by our flood plains, marsh lands, and other ramifications. When man urbanizes he covers the land with impermeable surfaces that prevents the variety of natural responses to this hydrological system. The knowledge of where to build, at what densities, and for what activities is the basis of the ecological approach to the urban environment. But a holistic approach does not stop at this point. It requires a complete response to the problem. Recently a paving material has been developed that equals the permeability of most soils and allows storm water to seek its natural course. This not only reduces the costs of storm water systems, but allows the water to recharge the aquifer for subsequent use by man. Many of our environmental problems can be solved by applying the ecological approach to a holistic view of the urban environment.
When we talk about the use of the ecological approach to know where to build, we are talking about developing a locational theory based on natural and man-made processes. The existing urban environment demonstrates the man-made locational process based on economies, transportation, power availability, exposure, and amenity. These indicators make no direct reference to natural processes, except where adverse cost is encountered in overcoming a natural limitation, or where there is a desire to create prestige with natural amenity. It is proposed that an understanding of natural processes can indicate the most suitable areas to build upon, to support our infrastructure, and recycle the by-products of urbanization, as well as supplying amenities for the urban environment.

A holistic locational process should be based on a firm understanding of our needs, goals, and values. It can be stated that the broad topic of societal goals must be considered in a complete study of environmental quality, since knowledge of the consequences of environmental manipulation implies choice among those consequences. The choice of means and the choice of ends are inseparable, in both theory and practice. In planning for Urban Suitability, hard and sometimes irreversible choices must be made as to our direction, as well as how we will get there. "And as environmental science results in a concomitant technology, the goals society sets for itself will themselves be one of the many products of technology, as well as the basis for selection among technol-
ogies. Therefore, to make optimum use of this process, we need to explore our needs, goals, and values. This task is an evolutionary process in itself. By understanding the values of the natural processes, we can generate a more complete view of man's needs.

One of the primary indicators in this process is the recognition of natural structural patterns, or areas where the natural processes are highly delineated. A direct comparison can be made to the structural patterns of the man-made infrastructure. These areas are the paths of action for the natural systems, and the links between interacting sub-systems. If these areas are drastically disturbed, and the links broken, adverse change can result in both the natural and man-made processes.

As more and more of these indicators are being developed, our understanding of the holistic process of man and nature is increasing. The following section makes a comparison of the work done by three practitioners of the ecological approach. The processes they have developed are based on both natural and man-made inputs, and represent the state of the art in environmental planning. These processes use functional urban design methods that can be used to define Urban Suitability.
ENVIRONMENTAL PLANNING - THE STATE OF THE ART

The development of the ecological approach to planning was originally initiated as environmental resource analysis. This move was an attempt to locate and quantify "single factor" resources. Within the last decade, in response to our growing knowledge of the dynamic world, the "systems" approach to this problem has replaced the more simplistic methods. This development resulted in a new thrust to include the quality of environmental resources as well as the quantity; to include spatial patterns and groupings, as well as location; and the development of a philosophy that looks at the environment as an intrinsic resource in itself.

Recently, several professionals in the environmental design field have been developing processes that begin to define environmental quality by using various methods of resource analysis. These methods were structured to serve the requirements of their respective needs, but there also exists a "common ground" which is drawing these inputs into a complete process of environmental design.

The following professional environmental designers exemplify the "coming together" of the various approaches to environmental quality. These representatives come from different educational and geographic backgrounds, therefore a comparison of their work will serve to document the evolution and future implications of environmental design in an Urban Suitability Selection Processes.

Phillip H. Lewis is the chairman of the Department of Landscape Architecture at the University of Wisconsin.
He is working on the problems of establishing environmental qualities and values, and the implications of the natural and man-made environments on the broad patterns that influence development.

Ian L. McHarg is the chairman of the Department of Landscape Architecture at the University of Pennsylvania. He is both a landscape architect and planner, who is concerned with the planning and design implications of natural processes in regional and urban design.

Donald L Williams is the Assistant Director of the Urban Studies Center at the University of Louisville. He is an architect who has become involved with the regional planning process. He is working on the methodology for locating suitable areas for new urban development, and the contributing factors in a physically responsive design process for new communities development in the areas surrounding established urban centers.
Professor Lewis has structured his process to respond to the need for "...public awareness of the patterns, both natural and cultural, within the landscape." His objective is to "...identify, preserve, protect, and enhance the most outstanding intrinsic values and see that introduced man-made values are developed in harmony with these quality resources."

The growth of, and the need for public outdoor recreation directs the main thrust of Professor Lewis's work. To accomplish this task, his method seeks to preserve outstanding patterns of preceptual quality. As a result, he has divided recreational resource patterns into those possessing intrinsic and extrinsic values. Intrinsic values are created by the natural environment, while extrinsic values are a result of man-made changes. From his study of the State of Wisconsin, Lewis concluded that surface water, wetlands, and significant topography were the major elements in this pattern. These areas contain the most delicate and most beautiful examples of natural processes, and are the most important areas of man's historical development. The pattern of these major resources combined to produce a linear configuration based on the configuration of major water courses, which Lewis termed an Environmental Corridor.

The analysis used to determine these corridors depended on two major inputs: an inventory of recreational resources, and later, a soil survey to determine which forms of recreation or associated uses, were best suited
for each soil pattern. As a result, Lewis has defined over 200 resources that can be associated with his Environmental Corridor in Wisconsin. In fact, over 90% of the recreational resources of Wisconsin are found within the corridors, with many concentrated in nodal form at various points. Areas outside the corridors that show a heavier man-made impact, or less natural amenity, were indicated as being suitable to human alterations such as farming, residential development, or other forms of urbanization.

In order to refine this process, Lewis devised a system to assign relative values to the resources defined above. When totaled, the numerical value of the concentrations of natural and cultural features can be used in a decision making process that can be understood by the public, as well as the government officials. As a result, priorities were established within the corridor that could be quantified. This fact enables quantitative interpretation of qualitative data for the purposes of total environmental planning.

Associated implications of this process include the following usages of the Environmental Corridor:

1. they act as natural buffers to separate incompatible land uses and unify residential development;
2. they enhance and stabilize property values;
3. they act as natural "air conditioners" by controlling temperature, humidity, noise, and pollution;
4. they can protect aquifer recharge areas; and
5. they protect flood plains from development.
Professor Lewis recommends that his process first be entered into by completing a basic regional inventory, and then integrating a scientific and preceptual understanding of the landscape patterns with the recognized functional aspects of the planning process. The resulting design will be a functional expression of the intrinsic and extrinsic suitability of the landscape—the dual pattern of man and nature.

Since the main elements of the corridor are based on visual contrast and diversity, i.e. steep topography, wetlands, and surface water, the application of this process must be varied for different types of landscapes. The corridor pattern is a response to the need to organize information for large areas into a comprehensible pattern which shows that natural and man-made features can be grouped into a supportive pattern that has more significance in the visualization of the environment than any individual pattern. The main elements of the corridor are found to a greater or lesser degree in most landscapes, even if the original pattern was derived from the Wisconsin landscape.

Where time is limited, Lewis uses a case study area of limited size to demonstrate the corridor concept, and the elements involved in the specific region. The case study area could be a county or other political subdivision, but is chosen on the basis of the representativeness of the major landscape features. The major resources and additional resources are then compiled for the study area, and projected over the region for similar elements and
their resulting patterns.

This methodology generates a unique implementation device. Since necessary data on intrinsic and extrinsic resources is not readily available, or non-existent, Lewis employs regional staff members of state and local agencies, as well local citizens and special interest groups, to assist in the inventory. The involvement of local people for local information not only increased the detail and subjective value of the study, but also increased the opportunities for implementation by creating a knowledgeable constituency when laws or funding become a public issue. The use of governmental personnel has a similar effect on the orientation and direction of governmental policy. This methodology may be one of the best ways to coordinate public and private efforts for the mutual education and cooperation that is necessary for the implementation of any complex process.

Another input that can enable implementation is the highly symbolic value of the corridor. This broad locational structure is a framework to orient and concentrate the efforts of special interest groups. By demonstrating that all special interests of a conservation, preservation, or environmental nature were contained in a single pattern, attention was concentrated on the corridor in a unified effort. The result was an understanding of the interrelatedness of the combined natural and cultural patterns which can serve the temper staunch conservationists, and persuade economic determinists to respect the value of the corridor system.
The corridor concept can be used to compare the patterns of existing growth, accessibility, and areas of potential urbanization to discover any conflicts in the natural and man-made patterns. In this manner the corridor concept can be used to guide future urban growth.

THE ENVIRONMENTAL CORRIDOR - Phillip H. Lewis

The Corridor in Areas of Diverse Topography

The Corridor in Areas of Flat Topography
A. Given - a total study area.
B. Identify uses to the planned for, establish use criteria.
C. Select case study area for which:
   1. resources meeting use criteria are identified;
   2. inventory major resources and locate on transparent overlays;
   3. combine patterns of major resources into one pattern;
   4. inventory additional resources and locate on transparent overlays;
   5. identify diverse patterns for special purposes;
   6. combine additional resources into a single pattern;
   7. compare and correlate patterns of major and additional resources.
D. Inventory major resources for the total study area.
E. Inventory additional resources for the total study area.
F. Assign points (value) to major and additional resources.
G. Identify relative priority areas by totaling points in each area.
H. Establish demand for planned uses, define final priority areas.
I. Identify limitations of each priority area to specific uses, and assign specific uses.
2. Ian L. McHarg - Process, Value, and Form.

McHarg's educational background includes graduate degrees in both Landscape Architecture and City and Regional Planning. His early years were spent in Scotland, were he developed an intense interest in natural processes by witnessing the dichotomy between the industrialized city and the pastoral countryside. This background has structured his interest in the life process and its implication as a limiting or liberating factor for land-use planning.

The first enabling element in McHarg's approach is the recognition of the natural processes. "We need, today, an understanding of natural process and its expression and, even more, an understanding of man-nature, which, less deterministic, still has its own morphology, the expression of man-nature as process."20 "Clearly the problem of man and nature is not one of providing a decorative background for human play, or even ameliorating the grim city; it is the necessity of sustaining nature as a source of life, milieu, teacher, sanctum, challenge and most of all, of rediscovering nature's corollary of the unknown in the self, the source of meaning."21

In response to this philosophy, McHarg states that we must develop a new set of principles for the structure of human adaptations. Economic determinism, which has been recognized as the major concept in locating urban development, should be replaced by a more holistic process, which McHarg feels is based in the ecological approach.
The second element in this approach is the installation of values with their associated natural processes. "Land, air and water resources are indispensable to life and thus constitute social values... A recognition of these social values, inherent in natural processes, must precede prescription for the utilization of natural resources." There are problems when one works with values, such as change over time, the varying scale of the processes, and the case of unmeasurable values, but McHarg thinks that this only indicates the areas that need immediate work. The value of the natural processes can be determined by research into which processes do work for man, and which are potentially destructive to the present form of man's settlements.

The final element in McHarg's process is the interpretation of the above elements for the purpose of generating opportunities and constraints for the form of urban development. "The basic proposition employed is that any place is the sum of historical, physical, and biological processes, that these are dynamic, that they constitute social values, that each area has an intrinsic suitability for certain land uses and finally, that certain areas lend themselves to multiple coexisting land uses." McHarg has been particularly successful in implementing his process, for his office, Wallace, McHarg, Roberts, and Todd, Architects, Landscape Architects, and City and Regional Planners, have been involved in projects ranging from highway route selection to new town planning. His
work has been based on the dramatization of the alternative consequences of proper or improper use of natural processes, thereby directing attention to the ecological approach for land-use planning. The use of value criteria in his process has enabled the client, whether individual or public body, to react and respond to the alternatives that McHarg presents. "In addition to being rational, the method is explicit. Any other person, accepting the method and the evidence, is likely to reach the same conclusions as those demonstrated in the study. This is in direct contrast to the bulk of planning, where the criteria are often obscure and covert. Moreover, this method permits a more important improvement in the planning method - that is, that the community can employ its own value system."24

McHarg begins his process by delineating the study area and its sub-areas. He indicates that physiography is the most effective way to isolate internally homogeneous areas. Next, an inventory is taken of natural and cultural features, in the following order:

(1) Climate,
(2) Historical Geology,
(3) Physiography,
(4) Hydrology,
(5) Pedology,
(6) Plant Ecology,
(7) Animal Ecology, and
(8) Land-Use.
The above sequence is stressed by McHarg due to the concept of causality. Once climate and geology are understood, physiography can be interpreted, which, in turn, allows an understanding of the river and stream patterns, aquifers and their recharge areas, and the subsequent soil formations and the life processes that depend upon them. This analysis develops historical reasons for an area's identity and is the basis for a natural value system.

The next input requires that the above categories be rated for their positive, negative or neutral effects on the prospective land uses. Further refinement of the above categories is necessary for this phase. From the basic inventory such data as economic minerals, unique or scarce features, and slope and accessibility, is used as the indicators for land use suitability (see land use suitability chart).

As a result of the above process, intrinsic suitability maps are produced that identify a single dominant land use for every area of the total study area. Areas that are acceptable to multiple use can then be noted and displayed in a separate set of maps. At this point, McHarg's process has defined an idealized land use pattern, based on the intrinsic suitability of the natural processes acting on the study area.

The remaining parts of McHarg's process respond to his view of demand, as opposed to supply, of natural resources. McHarg is primarily concerned with the problem of supply, but recognizes the need for information on the spatial requirements of the demand. The source of this
information is to be found in Architectural, Planning, and Psychological research, and is being constantly updated as more is known about these basic inputs.

Visibility is also an important consideration to McHarg. His work in this field is concerned with the impact of man's structural forms on the natural landscape. In his study of the Hudson River Valley, he included some visual principles for guiding future development. These principles consider the path of the viewer, the physiography of the region, the degree to which forest can absorb development and still preserve their forest aspect. This work is not complete, but it is a necessary step in coordinating the fields of ecology, planning, and architecture, which until recently have been in professional isolation.

Once the above information and values have been documented, McHarg then establishes the criteria for form and design. This final step requires the balancing of supply and demand, which is in effect, another value judgment that varies with each study area. McHarg states that the conflicts that arise are a result of our economic and population growth syndrome. As a solution, he suggests that "Optimally, one would wish for two systems within the metropolitan region - one the pattern of natural processes preserved in open space, the other the pattern of urban development."25

The following is an outline of land use suitability that McHarg developed in his Staten Island Study.26 It serves as a course summary of McHarg's process for relating ecological factors to land use planning.
**LAND USE SUITABILITY CHART**

x - undesirable land use  
o - desirable land use  
- - neutral  
* C - conservation, P - passive recreation, A - active recreation, R - residential, I - commercial and industrial.

<table>
<thead>
<tr>
<th>Ecological Factor</th>
<th>Ranking criteria</th>
<th>*Land Use Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Climate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-air pollution</td>
<td>incidence</td>
<td>- x x x x -</td>
</tr>
<tr>
<td></td>
<td>max - min</td>
<td></td>
</tr>
<tr>
<td>-tidal inundation</td>
<td>incidence</td>
<td>- - x x x</td>
</tr>
<tr>
<td></td>
<td>max - min</td>
<td></td>
</tr>
<tr>
<td><strong>2. Geology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Features of unique scientific and educational value.</td>
<td>scarcity</td>
<td>o o - x -</td>
</tr>
<tr>
<td></td>
<td>max - min</td>
<td></td>
</tr>
<tr>
<td>-foundation condition.</td>
<td>compressive strength</td>
<td>- - o o o</td>
</tr>
<tr>
<td></td>
<td>max - min</td>
<td></td>
</tr>
<tr>
<td><strong>3. Physiography</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-unique features.</td>
<td>scarcity</td>
<td>o o - - -</td>
</tr>
<tr>
<td></td>
<td>max - min</td>
<td></td>
</tr>
<tr>
<td>-scenic value. (land)</td>
<td>distinctive</td>
<td>o o o o -</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>-scenic value. (water)</td>
<td>distinctive</td>
<td>o o o -</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>-riparian lands of water features.</td>
<td>vulnerability</td>
<td>o - x x x</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>-beaches along the bay.</td>
<td>vulnerability</td>
<td>o o x x -</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>-surface drainage</td>
<td>proportion of surface water to land area</td>
<td>o o x x x</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>-slope.</td>
<td>gradient</td>
<td>- - x x x</td>
</tr>
<tr>
<td></td>
<td>high - low</td>
<td></td>
</tr>
<tr>
<td><strong>4. Hydrology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-marine (commercial)</td>
<td>navigable channels</td>
<td>- o - - - o</td>
</tr>
<tr>
<td></td>
<td>deepest - shallow</td>
<td></td>
</tr>
<tr>
<td>-marine (pleasure)</td>
<td>open water</td>
<td>o o o - -</td>
</tr>
<tr>
<td></td>
<td>large - small</td>
<td></td>
</tr>
<tr>
<td>-fresh water (active rec.)</td>
<td>expanse of water</td>
<td>o o o -</td>
</tr>
<tr>
<td></td>
<td>large - small</td>
<td></td>
</tr>
<tr>
<td>-fresh water (stream side rec.)</td>
<td>scenic</td>
<td>o o - - -</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>-watersheds (protect stream quality)</td>
<td>scenic streams</td>
<td>o o o x -</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>-aquifers</td>
<td>yield</td>
<td>o - - - o</td>
</tr>
<tr>
<td></td>
<td>high - low</td>
<td></td>
</tr>
<tr>
<td>-aquifer recharge area (zones)</td>
<td>important aquifers</td>
<td>o - - -</td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td></td>
</tr>
<tr>
<td>Ecological Factor</td>
<td>Ranking Criteria</td>
<td>Land Use Value</td>
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<tr>
<td>-----------------------------------</td>
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</tr>
<tr>
<td>5. Pedology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- soil drainage</td>
<td>permeability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(height of water table) most-least</td>
<td>x - o o o</td>
</tr>
<tr>
<td>- foundation conditions</td>
<td>compressive strength and stability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td>- - o o o</td>
</tr>
<tr>
<td>- erosion</td>
<td>susceptibility</td>
<td></td>
</tr>
<tr>
<td></td>
<td>most - least</td>
<td>o - x x x</td>
</tr>
<tr>
<td>6. Vegetation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- existing forest</td>
<td>quality(best-poor)</td>
<td>o o x o x</td>
</tr>
<tr>
<td>- forest type</td>
<td>scarcity(most-least)</td>
<td>o - x -</td>
</tr>
<tr>
<td>- existing marshes</td>
<td>quality(best-poor)</td>
<td>o o x x x</td>
</tr>
<tr>
<td>7. Wildlife</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- existing habitats</td>
<td>scarcity(most-least)</td>
<td>o o x -</td>
</tr>
<tr>
<td>- intertidal species</td>
<td>intensity of shore activity(least-most)</td>
<td>o o -</td>
</tr>
<tr>
<td>- water-associated species</td>
<td>degree of urbanization (non - fully)</td>
<td>o o x o</td>
</tr>
<tr>
<td>- field and forest species</td>
<td>forest quality</td>
<td></td>
</tr>
<tr>
<td>- urban related species</td>
<td>presence of trees</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(abundant-absent)</td>
<td>- o - -</td>
</tr>
<tr>
<td>8. Land Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- features of unique importance</td>
<td>educational and historic value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(most - least)</td>
<td>o o - o -</td>
</tr>
<tr>
<td>- features of scenic distinctive</td>
<td>value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(most - least)</td>
<td>o o o o o</td>
</tr>
<tr>
<td>- existing and potential availability</td>
<td>recreation (most - least)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>resources</td>
<td></td>
</tr>
<tr>
<td>Urban Suitability Exclusion Process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Exclusion of flood plains, woodlands for erosion control, steep slopes, row cropland and cropland.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Exclusion of aquifer outcrops, noise zones, existing forest cover.</td>
<td></td>
<td></td>
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<tr>
<td>3. Exclusion of scenic and historic corridors. Ranking of urban suitability based on soil bearing capacities and suitability for septic tanks.</td>
<td></td>
<td></td>
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<tr>
<td>4. Identification of aggregations of urban suitable land.</td>
<td></td>
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</tr>
</tbody>
</table>
A. Given total study area.

B. Prepare and interpret an Ecological Inventory:
   1. Map natural and cultural resources on transparent overlays,
   2. Interpret data to reveal dominant prospective land uses of each discrete part of the total study area.
      a. interpret data relevant to prospective land use,
      b. produce intrinsic suitability maps.
   3. Ascribe a value to every land area for all prospective land uses.
      a. establish a rating system for intrinsic resources,
      b. group compatible and incompatible land uses,
      c. synthesize data into a combined suitability map.

C. Prepare and interpret an economic inventory.

D. Establish criteria for visibility.

E. Establish criteria for form and design.

F. Acquire the necessary powers to realize the plan.*

* Effectuation may require both negative and positive powers, but positive powers such as revenue producing activities, infrastructure development, and other capital improvements, work best and offset public opposition to regulations.
Early in 1968, The Urban Studies Center at the University of Louisville proposed to develop a New Communities Family Mobility System. This system was basically a response to the problems of poverty, but it has evolved over a period of four years into a system that confronts the broader problems of the environment as a whole. Donald L. Williams is the Assistant Director of the Center, and group leader for the Physical Environment section of the System.

The most outstanding characteristic of the System is that it is holistic. NEWCOM's basic premise is that a socially suitable environment can be designed, that this environment will minimize poverty, alienation, and environmental degradation, and that it can be made operational by utilizing the normal workings of the free enterprise system. This requires the blending of a complex array of ingredients.

The process that the System develops is virtually a step-by-step procedure for analyzing and synthesizing the required inputs at the proper time. The reader is referred to the Urban Studies Center\textsuperscript{27} for further information on the complete system, since it is the ecological input to urban suitability that is the primary concern of this work.

There is one fact that the System makes crystal clear—the need for the ecological approach is present throughout the entire process, but it is in the first,
large scale inputs that it plays the major role. This should be the basic premise for any planning process. The quality of urbanization is dependent on the environmental opportunities and constraints that the designers have to work with at the scale of land use planning and physical design.

The first phase of the process uses a regional inventory to delineate the areas least suited for urbanization and identify the areas for further study in the sub-regional phase. The first input in the process is a definition of the region. This is an important step, as the previous processes we have considered assumed an area, or stated that it was "given". However, this is not the case in most situations where one must consider social, political, economic, and ecological areas. Williams defines the region by comparing a set of urban indicators (see Appendix I) and their relative importance to the urban region under study. He broadly defines the region as, "An area and its people in which benefits and losses are directly or indirectly experienced by all. Boundaries of each individual factor will vary, but it is possible to delineate the region by recognizing a factor of primary importance." 28

As part of the regional analysis, an ecological inventory is performed. "To adequately consider any region for urbanization, all attributes of the natural processes must be documented in such a way as to facilitate analysis. The basic understanding of what the natural attributes are, how they came to be and how they
are working together is the essential key to the successful selection of the appropriate site or sites for the proposed NEWCOM (new community)."29 "The objective at this point is the elimination of those areas which are least acceptable to development from an ecological point of view."30 This process permits a detailed examination to be made for those sub-regions having relative positive attributes for urbanization.

The regional selection (or elimination) process is summarized by the basic criteria for urbanization suitability: "The negative values were: areas for extraction, areas vulnerable to pollution plus aquifer recharge areas, and areas with poor foundation conditions. The positive values were: areas least vulnerable to pollution of ground water, areas with recreation potential, and areas with good foundation conditions."31 These criteria were generated from Williams' study of the Louisville region. Other areas may differ, but the process provides for the difference, so that the dominant characteristics of any urban region can be generated (see Appendix I).

The second phase in the process is a sub-regional analysis that further studies the areas selected in the regional analysis. "The analysis at the Regional Phase ...was carried out under two basic premises. The first premise stated that the environment offers natural processes which reveal a working value system. This working system can be analyzed to find those areas which are crucial to sustaining the natural ecosystems. These are the areas found to do work for man and are extremely
vulnerable to intensive development. The second premise stated that within the natural environment there exists areas which are amenable to man's development. That with a thorough search of natural processes, areas can be located that would be quite compatible with the location of a large urbanized area.  

The most important inputs to the sub-regional ecological analysis are considered to be: (1) Geology, (2) Soils, and (3) Slope. These criteria are seen as being the primary indicators of the natural system's tolerance to urbanization in the areas that were not excluded during the regional elimination process. In order to expedite the lengthy analysis procedure, a computer program was written. This program uses a grid system of 1.25 kilometers (385 acres) to display the results of the sub-regional analysis. As a result of this program, the final areas to be considered for the location of NEWCOM were selected, including a set of use considerations that generalized the ecological and urbanization considerations to be applied to these areas.

The final phase of the NEWCOM locational procedure is the area analysis. The purpose of this phase of analysis is "...to continue the examination of land areas for the best possible locational alternatives for NEWCOM urbanization...selected in further detail regarding their size, location, access, climate, vegetation, wildlife, hydrologic system, physiographic position and amenity." The real impact of this three-phase process comes to light in the area analysis. The process has
enabled the selection of areas for potential urbanization that, if handled properly by performance requirements, allow the natural processes to continue undisturbed, and permits a pattern of urbanization to occur that is not in danger of environmental degradation.

Williams feels that performance requirements are the best devices to insure environmental quality at the local level. General performance requirements can be written for objectives that are of a universal nature, but specific applications are needed for specific problems. A set of general requirements are to be found in Appendix I, and can be used as the basis for specific recommendations.

This process has shown that it is possible to begin a search for urban suitability in a definable region, and generate areas that are responsive to our needs. The result of this process is a dual pattern of man and nature. If the natural patterns are protected from intense use, then only the patterns of man require additional performance requirements.

"The most favorable attribute of this three step process is that it allows the analysis to begin generally and end very specifically. The degree of specificity reached in the final requirements and descriptions would have been impossible at the regional level; also the degree of generality at the regional level would have been superfluous at the area level."\(^{34}\)

The remaining sections of the System are a response to the requirements of form generation in the selected
areas. Since the process for selecting site suitability has defined the opportunities and constraints that the natural environment presents, the process of form generation (activity requirements, land use, and design requirements) has been made responsive to the ecological approach.

SUMMARY OF THE LOCATIONAL PROCESS

I Regional:
1. Regional Objectives;
   a. Delineate areas least suited for urbanization,
   b. Identify areas for Sub-regional study.
2. Regional Inputs;
   a. Definition of the region,
   b. Functional assumptions,
   c. Natural environment data,
   d. Socio-economic data,
   e. Linkage data.
3. Document and Report Results;
   a. Input analysis,
   b. Synthesis,
   c. Recommendations.

II Sub-regional:
1. Sub-regional Objectives;
   a. Find areas acceptable for NEWCOM location,
   b. Write general performance requirements for areas.
2. Sub-regional Inputs;
   a. Detailed natural science data,
   b. Computer digitation and print-outs,
   c. Rank ordering process,
   d. Linkages data,
   e. Urbanization data,
   f. Location of historical and cultural sites.
3. Document and Report Results;
   a. Assumptions,
   b. Inventory,
   c. Data analysis and digitation,
   d. Data ordering (rank ordering),
   e. Results of natural process analysis,
   f. Final cells.

III Area:
1. Area Objectives;
   a. Select preference areas,
   b. Describe, analyze, and rate them in order,
   c. Write performance requirements for areas.
2. Area Inputs;
   a. The areas selected in the sub-regional phase,
   b. Computer print-outs from the sub-regional phase,
3. Document and Report Results;
   a. Area analysis,
   b. Performance requirements,
   c. Identify preferable areas.

Williams does not see this process as a closed system. He designed this approach to respond to the need for an interdisciplinary approach to our changing environmental needs. "In community performance planning THE WHOLE DOES NOT EQUAL THE SUM OF THE PARTS. This necessitates the formulation of a consistent procedure for altering the parts in the future. This will allow the psychosocial, physical and economic designers to deal with problems and opportunities simultaneously."
OUTLINE OF THE ANALYSIS PROCESS - Donald L. Williams

1. Define the region to be studied.
2. Analyze socio/economic inputs.
3. Analyze linkage inputs.
4. Analyze natural science inputs:
   a. bedrock geology,
   b. surficial geology,
   c. physiography,
   d. hydrology,
   e. pedology,
   f. conservation,
   g. intrinsic suitabilities.
5. Eliminate the least suitable areas from further consideration.
6. Delineate the suitable areas for further study.
7. Analyze natural science data for positive attributes for urbanization.
   a. basic data of major importance:
      1. geology,
      2. soils,
      3. slope.
   b. supportive data:
      1. hydrology,
      2. climate,
      3. vegetation and wildlife,
      4. elevation.
8. Delineate final areas and write general performance requirements.
9. Select preference areas.
10. Write performance requirements for specific areas.

The processes analyzed in the previous section can be used to create an Urban Suitability Selection Process. The enabling elements of each process are based on the ecological approach, but since each process is responding to a separate need, we need to define the specific elements in each process that can be used to create an Urban Suitability Selection Process.

All three processes are response to the problems of urbanization and it's effects upon the natural systems. Lewis is involved with the recognition of the pattern of natural processes so that we may conserve and protect our fast disappearing recreational amenities. McHarg's work is based upon the recognition of the natural processes that do work for man, hence, constitute social values. Willliam's uses a systems approach for the location of new communities in developing urban regions, based on an understanding of both man and nature.

The following basic elements are found to a greater or lesser degree in all three processes:

1. Basic Premises (philosophy); Man and nature must be partners in the use of our limited resources. Emphasis is placed on the ability of the natural processes to support the activities of man, with the first consideration being the locational constraints demonstrated by the natural systems (supply). Next, the man-made locational inputs are applied (demand). The final step requires that these two inputs be balanced into a dual pattern of man and nature.
2. **Data Collection** (inventory); Since an understanding of the formation of the natural environment is necessary to the development of locational constraints, an inventory is made to determine the most limiting factors. This data will also be used for the prescription of values during the next step and therefore should be as complete as possible. For the most part, the information that currently exists is limited in scope and dispersed by scientific isolation. For this reason, an interdisciplinary approach is necessary. Both McHarg and Williams use a team of ecologists and planners to gather environmental data, while Lewis uses both public employees and private citizens for his subjective approach. The development of central environmental data sources would simplify and expedite this input.

3. **Rating System** (value); To interpret the data collected above, a consistent method of evaluation is necessary. Since a knowledge of which systems are doing work for man, as well as their degree of vulnerability, is indispensable to the prescription of value, a system of both opportunity and constraint should be used. Lewis and Williams both use a numerical system which could be used in a universal rating system, and is superior to McHarg's system of positive, negative, and neutral values. McHarg's system is adequate for large scale pattern recognition, but lacks the detail for accurate prescription of value. The use of a numerical system offers a method to quantify environmental quality, and also allows for computerization of the growing body of
environmental information. This rating system should be used to set limits on man's use of the natural systems, since indicators can be developed to show the tolerance of the environment to the intensity of urbanization. This fact reinforces the need for environmental research into the development of these indicators. Informational detail will direct the prescriptive powers of this input.

4. **Pattern Recognition** (form generation); From the use of the preceding inputs we can define the areas that are vulnerable to intensive use, as well as the areas that are suitable for urbanization. The remaining areas will display a mixture of both opportunity and constraint. Thus nature exhibits a pattern that can be used to define the form of future urbanization. This pattern can also be used to define the areas of existing urbanization that need limits placed upon the use of the environment. Both Lewis and Williams are concerned with only one of the patterns. Lewis wants to conserve the negative, vulnerable pattern, while Williams is only looking for the positive, unconstrained pattern. McHarg uses this system as the final, form generation phase in his process, but his indicators are based on a varying value system that changes with the area studied. The development of a consistent evaluation method can unify the existing diverse interpretations.

5. **Recommendations** (performance requirements); Once the basic pattern of man and nature has been established, a complete system of use recommendations can be developed.
This step is necessary to insure the proper location and operation of those urban elements that are the worst offenders of environmental quality. If taken further, these recommendations can be used to establish performance requirements for all three patterns defined above. Since the negative pattern, or pattern of natural constraints, will probably be used for some of man's essential activities, this action will insure the continuation of these vital processes. On the other hand, the use of performance requirements in the positive and neutral patterns can respond to the conventional enabling elements of health, safety, and welfare, which can place limits on the use of the environment. This methodology, however, only makes use of legally enforceable constraints and does not satisfy the need to encourage growth in the patterns of opportunity. It is therefore recommended that the use of development incentives be promoted through the planning agencies of the public selector. McHarg makes an attempt at using this approach with his presentation of alternatives, but it is only Williams who uses it in the last locational phase of his process.

6. Action (implementation); This process is seen as being implemented in three phases involving citizen participation, Federal incentives, and response from the private and public sectors. The first phase is currently in progress as evidenced by the increasing number of conservation issues and the environmental concern being voiced by individuals and groups that
traditionally have had only limited involvement in environmental issues. This public concern has initiated a growing response in the political body that is struggling to understand the necessary inputs for a holistic approach to the urban environment. This situation can be summarized by the stated purpose of the National Environmental Protection Act of 1969:

"The purposes of this Act are: To declare a national policy which will encourage the productive and enjoyable harmony between man and his environment; to promote efforts that will prevent or eliminate damage to the environment and biosphere, and stimulate the health and welfare of man; to enrich the understanding of ecological systems and natural resources important to the Nation; and establish a Council on Environmental Quality."

The Federal input to this process should be one of creating positive incentives in the form of funds for the necessary research, and direction for the application of the findings. Its negative powers of regulation should only be used to limit the use of our environmental resources beyond their tolerance to support man and the natural processes. Finally, Regional Planning Agencies should take the Federal incentives and develop an environmental data system that can be used for the prescription of performance requirements. This source of information can be used by both the private and public sectors to stimulate the growth of an implementable Urban Suitability Selection Process.

We have analyzed the functional aspects of the three processes in the previous section so that we can combine
their basic elements into one complete process. To fur-
ther this goal, we must now define which inputs respond
most directly to the principles of the ecological approach.
This combined approach will allow us to create an Urban
Suitability Selection Process based on the present state
of environmental planning and its response to the eco-
logical approach to environmental quality.

The following charts compare each process with the
ecological principles defined in section II (1). This
summary indicates that Williams' three phase process is
best suited for our needs, but also indicates the valu-
able elements in the other process that can be used to
simplify the time and effort that is required. These
combined inputs form the basis for an Urban Suitability
Selection Process.
## A SUMMARY OF THE PROCESSES

<table>
<thead>
<tr>
<th>Ecological Principle</th>
<th>Limiting Factor</th>
<th>Lewis</th>
<th>McHarg</th>
<th>Williams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolution</td>
<td>Change</td>
<td>No provision for choice or change, but recognizes the evolutionary process within the Environmental Corridor. Concentrates on the enforcement of the stability of the pattern.</td>
<td>Uses alternatives to demonstrate change and the interaction between man and nature. Causality shown by order of data collection.</td>
<td>Eliminates areas subject to natural change and provides location-al choice with sub-regional selection. Gives equal weight to man and nature for the stability of the whole.</td>
</tr>
<tr>
<td>Scale</td>
<td>Macrocosm</td>
<td>Only defines large scale natural patterns, but uses small scale concentrations as priority areas. Major &amp; additional resources are ill defined.</td>
<td>Concentrates on large scale inputs to define opportunities &amp; constraints. Attempts to use small scale indicators for land use selection, but system is not complete.</td>
<td>Uses a three phase process of regional elimination, sub-regional selection, and area performance. Relates the effects of man and nature upon each other.</td>
</tr>
<tr>
<td></td>
<td>Microcosm</td>
<td>Identities concentrations of natural and man-made resources for indication of the Corridor pattern. Priorities established by relative density.</td>
<td>Uses values implied by natural processes to define density of land use, but rating system is subjective and vague.</td>
<td>Locates areas for urban decentralization and places communities of limited size within the natural pattern. Uses performance requirements to limit land use density.</td>
</tr>
<tr>
<td>Density</td>
<td>Decentralization</td>
<td>Attempts to conserve the pattern of natural energy flow, but does not formally recognize this fact.</td>
<td>Uses a dual pattern of man and nature to conserve natural processes and reduce the social and economic expenditures of urbanization.</td>
<td>Proposes a reduction in monetary expenditures by using ecological site selection. Conserves natural energy sources as well as processes.</td>
</tr>
<tr>
<td>Energy</td>
<td>Centralization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecological Principle</td>
<td>Limiting Factor</td>
<td>Lewis</td>
<td>McHarg</td>
<td>Williams</td>
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<tr>
<td>----------------------</td>
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</tr>
<tr>
<td>Intrinsic Suitability</td>
<td>Man</td>
<td>Uses intrinsic and extrinsic values in a preceptual system that defines the patterns of man and nature for the preservation of recreational resources.</td>
<td>Presents alternatives to demonstrate the natural value system and man's opportunities for form creation. The basic premise of his philosophy.</td>
<td>Eliminates the most vulnerable areas to man's impact, selects areas with the least limitations, and prescribes performance criteria to insure suitable usage.</td>
</tr>
<tr>
<td></td>
<td>Nature</td>
<td></td>
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</tbody>
</table>

| Implementation        | Private Sector | Uses citizen groups to gather data of subjective nature which is incorporated into the symbolic pattern of the Corridor. | Uses alternative plans based on development with or without environmental planning. Contracts for full service planning and design services. | Demonstrates the decrease in the costs of development. Uses public sector controls in the enforcement of performance requirements. |
|                      | Public Sector  | | | |

**Summary**

The Environmental Corridor pattern serves as a symbolic regional demonstration of natural and cultural processes that can help the implementation of the ecological approach. However, it is too simplistic for comprehensive planning, but can be used as the basis for further study.

McHarg's work is of high emotional appeal and is more of a philosophy than a process. The use of the order of causality in the environmental inventory, and the presentation of alternative consequences are the most significant contributions to the process.

The three phase process of regional elimination, sub-regional selection, and area performance requirements is the best framework for an Urban Suitability Selection Process. The amount of time and talent required is prohibitive for most applications, but regional data sources could minimize this limitation.
SUMMARIZED OUTLINE OF THE PROCESSES

Lewis
1. Select case study area.
2. Inventory major & additional resources.
3. Assign values for total area.
4. Establish Demand.
5. Identify priority areas.
6. Identify Environmental Corridor pattern.
7. Implement.

McHarg
1. Inventory study area.
2. Map natural & cultural resources.
3. Assign value of individual land use potential.
4. Develop individual suitability maps.
5. Establish combined values.
6. Develop combined suitability maps.
7. Implement.

Williams
1. Define region to be studied.
2. Analyze natural, socio-economic & linkage data.
3. Eliminate least suitable areas.
4. Analyze ecological data for sub-regional study.
5. Select final areas.
6. Write performance requirements for areas.
7. Implement.
### The Elements of an Urban Suitability Selection Process

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Lewis</th>
<th>McHarg</th>
<th>Williams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philosophy, Basic Premises</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Regional Definition</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Regional Analysis (Inventory)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Natural science data</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Man-made data (socio-economic)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Public sector data sources</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-house professional staff</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Case study area</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Value System (evaluation)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Subjective</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Pragmatic</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Regional Pattern</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Opportunities and constraints</td>
<td></td>
<td></td>
<td>x</td>
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<tr>
<td>Environmental corridor</td>
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<tr>
<td>Regional Selection</td>
<td>x</td>
<td></td>
<td>x</td>
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<tr>
<td>Regional Elimination</td>
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<tr>
<td>Sub-regional Analysis</td>
<td>x</td>
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<td>x</td>
</tr>
<tr>
<td>Natural science data</td>
<td>x</td>
<td></td>
<td>x</td>
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<tr>
<td>Man-made data</td>
<td>x</td>
<td></td>
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<tr>
<td>Major and additional resources</td>
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<td></td>
<td>x</td>
</tr>
<tr>
<td>Refined Value System (detailed)</td>
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<td>x</td>
<td></td>
</tr>
<tr>
<td>Subjective</td>
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<td></td>
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<tr>
<td>Pragmatic</td>
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<tr>
<td>Sub-regional pattern</td>
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<td>x</td>
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<tr>
<td>Sub-regional selection</td>
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<td></td>
<td>x</td>
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<tr>
<td>General performance requirements</td>
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</tr>
<tr>
<td>Area Analysis</td>
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<td>Natural science data</td>
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<tr>
<td>Man-made data</td>
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<tr>
<td>Value System (prescriptive power)</td>
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<td>Performance requirements</td>
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<td>Public sector</td>
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<td>x</td>
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<tr>
<td>Legislation</td>
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</tbody>
</table>

The use of a three phase system of analysis, and the structure provided by the basic elements and process elements, allows us to combine these inputs into an Urban Suitability Selection Process.
A. Define the region to be studied, state basic premises and expected results.

B. Inventory of basic locational inputs for regional evaluation:
   1. Natural science data (order of causality, intrinsic value)
      a. Climate,
      b. Historical geology,
      c. Physiography,
      d. Hydrology,
      e. Pedology,
      f. Plant ecology, and
      g. Animal ecology.
   2. Man-made data (extrinsic value)
      a. Socio-economics,
      b. Linkages, and
      c. Existing urbanization.

C. Develop a rating system to identify areas of opportunity and constraint for urbanization:
   1. Identify valuable resources for conservation and/or limited use,
   2. Identify neutral areas,
   3. Identify areas that are suitable for urbanization.

D. Establish a basic regional pattern for man and nature (dual system).

E. Sub-regional inventory of specific natural science data for the categories defined above:
   1. Geology (depth to bedrock, mineral resources, and unique features),
   2. Pedology (general soil data, shrink-swell, erodibility, and permeability),
   3. Slope (range and consequences)

F. Refine value criteria and correlate with man-made data above.

G. Identify sub-regional pattern as above for all three areas.

H. Write general performance criteria.

I. Inventory specific sites for further opportunities and constraints.

J. Write specific performance requirements for specific areas.

K. Implement (could occur at each phase).

* A sample study area may be used.
THE HOUSTON URBAN AREA - URBAN SUITABILITY

The Urban Suitability Selection Process generated in the previous section is a valuable tool for Urban Design. The process as outlined is a generalization that requires specific interpretation in specific areas. However, the process responds to the need for a definite approach to environmental planning. Each step in the process is intended to increase the informational content of the previous step, and enable more accurate prescriptive powers. The process uses a three phase system that can be terminated and used at the end of each phase, but the use of the entire system is required for a holistic approach to environmental quality. The level of information useful to designers increases from the regional pattern, which identifies broad areas suitable for urbanization, to sub-regional and specific areas, which require more specific knowledge, and the use of performance requirements.

To test this process, the Houston urban area has been selected for a demonstration of the basic elements of the process. A complete application of the process is not intended, as the time required, as well as the personnel for an interdisciplinary study, is not available.

The City of Houston is the center for a fast growing pattern of urbanization, that by conventional indicators, has no limit to its directions of growth. The intent of this study is to show that the Houston area displays a regional pattern that offers opportunities and constraints to the urbanization process; that this
pattern can be used advantageously to decrease the costs of urbanization and increase environmental quality; and that the use of performance requirements is necessary to insure the proper use of our environmental resources.
1. The Environmental Inventory:

The basic premise of this study was stated in the introduction to this section. In order to understand the regional forces at work in Houston's ecological systems, a regional inventory is necessary. Since the data collected during this phase will serve as the basis for the work of the other phases, we must first define the region and our area of concern.

Houston is located in Harris County, Texas, which lies on the Gulf Coast Prairie. The county measures approximately 35 by 50 miles, with an area of 1,765 sq. miles, or 1,129,600 acres. The major part of the County is a broad, nearly level plain, with a minor part (16%) heavily forested, especially along the bayous and streams. The area was once a very important agricultural county, but it is now recognized as a major urban area which is dependent on an economic base consisting of petro-chemical industries and diverse manufacturing. Approximately 90% of the 1,722,533 people in the county live on about 40% of the land. With the continuation of Houston's rapid growth, the population is expected to double within the next 30 years. It is within this context that we must define the region and it's area of environmental impact.

For the purposes of this study, we will simplify the regional definition section by using the boundaries of the Houston-Galveston Area Council, (HGAC), since their Regional Atlas covers a major portion of the data needed for the inventory (See Appendix II). The HGAC has recently expanded to include the Counties in the Gulf Coast State
Planning Region, but we will use the previous eight County Region for which data has been assembled. In order to expedite our inventory, Harris County will be used as a case study area, and the findings from this study will be projected for the HGAC boundaries. Since Harris County is located in the geographic center of the HGAC region and displays a representative landscape pattern, this simplification will not adversely dilute the input data. The only exception to this statement occurs on the Gulf Coast, where a distinct set of environmental conditions are encountered. We must use a different data source for this area, the Bureau of Economic Geology of the University of Texas at Austin.

The Bureau of Economic Geology\textsuperscript{37} will probably become the central data source for ecological data in the State of Texas. It recently completed an Atlas of the Texas Coastal Zone which took 15 man-years to compile. Their future plans call for similar inventories of the entire State. This information will enable the application of the ecological approach to the planning processes of the State's urbanized areas. The information and maps they have produced are the most complete sources of ecological data for this region, but their area of coverage focuses on the coastal zone and only penetrates 50 miles inland. Therefore the data sources previously described are necessary for complete coverage.

The following is a list of environmental data sources.
Environmental Inventory Data Sources:

Harris County - City planning Dept., Demographic and Urbanization data; U.S. Dept. of Agriculture, Soil and Water Conservation District; U.S. Geological Survey, Geology and Hydrology; Chamber of Commerce, Economics.

Houston SMSA - Census Data, population, housing, Economics, etc.

Houston-Galveston Area Council: HGAC Regional Atlas, Geology, Hydrology, Climate, Transportation, Population density and distribution, Pedology, and urbanization data. Recently expanded to cover the Gulf Coast State Planning Region (1971).

Gulf Coast State Planning Region: Open Space; Water, Sewer and Waste treatment facilities, Transportation; Housing; Flood Control; Agriculture; and Environmental Deficiencies.

Bureau of Economic Geology - Texas Coastal Zones: Environmental Geology; Physical Properties; Environments and Biologic Assemblages; Current Land Use; Mineral and Energy Resources; Active Processes; Man-Made features & Water Systems, Topography & Bathymetry; Rainfall, Discharge, & Surface Salinity.
A survey of the basic locational inputs to Urban Suitability was performed for both the intrinsic and extrinsic data sources. The following is a summary of those inputs, with special emphasis given to Hydrology and Pedology which are graphic indicators of Houston's Geologic formation and the enabling elements in the ecological systems of plants and animals. As a result of this historical activity, the Pedology of the area is seen as being the primary indicator in the process, necessitating performance requirements for a suitable use of this resource.

CLIMATE: Temperature ranges from a January or winter-average minimum low of 43°F. to a July or summer-average maximum of 94°F. Between 1931 and 1960, the average annual mean free-air temperature in the Houston-Galveston area was about 70°F. The average annual rainfall varies between 51.5 and 41.8 inches per year, with a slight increase in precipitation rates since 1931.

These values become significant when compared with the precipitation deficiency rate. Between 1931 and 1960 the Houston-Galveston area had from 5 to 8 inches of excess moisture per year after evaporation and plant transpiration. This excessive effective precipitation maintains a high level of ground water and soil moisture which enables an abundance of fresh water marshes, the existing quantity and quality of coastal vegetation, and successful agricultural production.

The wind direction in this region varies between a persistent southeasterly wind and a northerly wind which
occurs mainly during the months of December, January, and February. The northerly winds are more intense and usually accompany storm fronts.

**GEOLOGY:** The formations from which the Houston area obtains its water supply constitute the major implication of the Geology of the area. These formations consist of sand, gravel, silt, and clay, which were built up by rivers as coalescing fans on or near the continent, and as marine and lagoonal deposits along the coast.

A general summary of the geology of the Houston area indicates that the similarity of sediments and the lack of continuity of the beds make differentiation of geological formations for urban suitability virtually impossible. However, geologists have delineated the aquifer into zones which indicate their relative productivity. Of the seven zones identified, zones 5 and 7 are the most productive. Zone 5 can be reached at a depth of a few hundred feet near the Harris-Montgomery County line to a depth of over 3,800 feet at Galveston Island. Zone 7 starts just north of Buffalo Bayou, at a depth of a few hundred feet, and continues to the Gulf at a depth of over 2,600 feet. These formations crop out in belts that are approximately parallel to the coast, with the older beds dipping about 50'-60' per mile, and the younger beds dipping 15'-20' per mile.

**HYDROLOGY:** Of the approximately 45 inches of precipitation, only about 11 inches runs off in streams, the
remainder is evaporated, transpired, or retained as soil moisture for later evapotranspiration. Some of this moisture percolates through the soil and sub-soil to the ground water body or zones of saturation. Where ground water in the outcrop of an aquifer is unconfined and under atmospheric pressure, water-table conditions are said to exist. Where the ground water is overlain by less permeable material and confined under pressure, artesian conditions are said to exist. This confining layer also restricts percolation rates causing a rise in the ground water levels within a few hours after major storms occur. The base flow of many of the streams in this area is rejected recharge. This situation causes flooding problems and is a major concern of Urban Suitability.

In a large part of the Houston region, heavy withdrawals of ground water from wells reaching to an excess of 2,000 feet deep have changed the natural conditions of equilibrium. In areas where more water is being withdrawn from the deep beds than the shallow beds the pressure differential has been reversed, causing water to move from the confining clay into the sand. This causes the clay to be compressed, and land subsidence is the result. The ratio of subsidence to the decline of artesian pressure is about 1 to 100 in the Houston area. The contribution of water from compaction and vertical leakage to areas of concentrated withdrawals has prevented a drastic decrease in our water levels, but the resulting subsidence of the land makes the continuation of this practice dangerous and costly. Up until 1954, all of Houston's public water supply came from ground water sources. At that time, the con-
struction of Lake Houston gave the area its first surface water supply.

In 1887, Houston's water demand was about 1 to 2 mgd (million gallons per day). In 1960 the demand had increased to 103 mgd. This was accompanied by a lowering of the ground water level by as much as 310 feet in some districts. This fact supports the need for additional surface water sources which are being developed at Lake Livingston and Lake Conroe. The increase in the costs of water that these new facilities will generate is necessary as long as our pattern of urbanization remains concentrated in the Coastal Plain (see Appendix, pg. 95 for additional information on the cost of water supply and distribution).

**PEDOLOGY** The study of the soils in an urban region is facilitated by the use of soil maps that show soil associations. These associations consist of geographic areas that consist of a certain combination of soils in a characteristic and repeating pattern. The nature, pattern, and proportions of soils give the area a landscape of its own. General soil maps display these associations, and are used for broad based planning. Detailed interpretation maps should be used for specific use recommendations and the application of performance requirements.
Soil Associations of Harris County:

1. Lake Charles-Bernard Association - Occupies about 32% of the County and consists of nearly level, deep, neutral, somewhat poorly drained soils with cracking clay and very slowly permeable subsoils. These soils have severe problems for urbanization, due to their high shrink-swell potential, and corrosivity to uncoated steel (many pipes rust out in 2-4 years). These soils are not suitable for septic tanks.

2. Addicks-Clodine-Gessner Association - Occupies about 24% of the County and consists of nearly level, deep, neutral to alkaline, poorly drained soils with sandy surfaces and slowly permeable clay loam subsoils. These soils also have severe urbanization problems due to their poor drainage characteristics.

3. Wockley-Gessner Association - Occupies about 14% of the County and are similar to the above soils, except that they have slowly to very slowly permeable subsoils. This association is used for agricultural purposes, with about 70% in cultivation, and minor residential development in wooded areas.

4. Katy-Gessner Association - Occupies about 11% of the County and differs from the above by being acid to alkaline, and only somewhat poorly drained. This association is the largest rice producing area in the County.

5. Hockley-Segno Association - Occupies about 9% of the County and consists of nearly level to moderately sloping, deep, acid, moderately well to well drained soils, with moderately to moderately slowly permeable subsoils. This association only has slight to moderate limitation to urbanization, and is the most wooded area of the County.
6. Beaumont-Midland Association - Occupies about 8% of the County and consists of nearly level, deep, acid, poorly drained soils with cracking clay surfaces and very slowly permeable clayey subsoils. This association has severe urbanization problems due to its very high shrink-swell potential, corrosivity of uncoated steel, and poor drainage. The soils are not suitable for septic tanks, and since about 50% of this area consists of heavily built-up rural-urban areas into which the population is expanding, specific performance requirements are necessary.

7. Kaufman Association - Occupies about 2% of the County and are found mostly in flood plains. About 80% of this association is subject to flooding, but areas along the stream channels and bottom lands remain in pines and hardwoods, and are used as a wildlife habitat. Urbanization is severely limited in these areas, but the recreational potential is great.

8. Arcadia-Waller Association - Similar to the Hockley-Segno Association but not as well drained since it occurs in more nearly level areas. This association has slight to moderate limitations for urbanization, and consists mainly of mixed pine and hardwoods near major surface drainage routes.

9. Riverdale-Crevasse Association - Similar to the Kaufman Association but consists mainly of fine to course loamy alluvial soils. This association has severe limitations for urban development, but high recreation potential.
THE RATING SYSTEM

To identify areas of opportunity and constraint, the rating system we will use is intended to separate the limitations on Urban Suitability into three areas of impact, based on positive, neutral, or negative effects. This system will enable the exclusion of the areas with the greatest constraints to urbanization, and facilitate the study of more specific criteria for urban suitability in the areas displaying positive or neutral characteristics.

As stated earlier, the soil limitations found in this region are indicative of the constraints that the natural processes place upon urbanization, since the soil formations are a result of Geologic and Hydrologic action. For this reason, soil limitations will be used as the primary indicator of suitability for this generalized regional study.

The rating system used is defined as follows:

1. Slight: There are few limitations, if any, which are easy to overcome with general performance requirements.
2. Moderate: There are some limitations that are feasible to overcome with performance requirements and normal engineering procedures.
3. Severe: Urban use is questionable due to engineering difficulties and magnitude of specific performance requirements that are necessary.
4. Very Severe; Reserved for areas of frequent flooding.
Soil Limitations for Urban Suitability:

**Sewage disposal** - Soil material is required to be permeable enough to permit moderate to rapid percolation of the effluent. Most of Harris County is severely limited in this capacity and sewage treatment is required.

**Streets and Roads** - Economic and safe construction requires limited cut and fill, as well as limited preparation of the subgrade. Drainage and poor supporting capacity are the dominant adverse features. Most of the soils in Harris County are severely limited in this capacity.

**Foundations (Residential)** - Refers to structures of less than three stories in height. The indicators used are: slope, flood hazard, soil depth, shrink-swell potential, and bearing capacity.

**Light Industry** - Emphasis is placed on foundations, ease of evacuation for utilities, and corrosion potential for uncoated steel pipe. The undisturbed soil is rated for spread footings for buildings less than three stories.

**Corrosivity** - Steel: Dependent on the physical, chemical, electrical, and biological characteristics of the soil. Design and construction also have an influence, but electrical resistivity is the main factor.

Concrete: Dependent on soil texture and acidity. Fine textured, strongly acid soils are severely limited. Most of Harris County is only slightly limited in this respect.

**Note:** Most adverse soil conditions can be overcome if the economic pressure is strong enough.
### Limitations of Soils for Urban Suitability

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Sewage Disposal</th>
<th>Streets &amp; Roads</th>
<th>Foundations Low Bld'gs</th>
<th>Light Industry</th>
<th>Corrosivity Steel</th>
<th>Conc. Rating</th>
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<td>Severe</td>
<td>Very</td>
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<td>Very</td>
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</tbody>
</table>

* Each soil was rated using the following values:
  - Slight: 1
  - Moderate: 2
  - Severe: 3
  - Very Severe: 4

Total ratings were given as follows:
  - Slight: 0 - 9
  - Moderate: 9 - 15
  - Severe: 15 - 21
  - Very Severe: above 21
Soil Limitations for Recreational Development:

In response to our growing recreational needs, a recent input to urban suitability is the provision of recreational opportunities within the urban environment. This factor is included in this phase of the process due to the fact that areas displaying recreational potential are usually the first to be subdivided. Delineation of these areas at this point in the process will allow their inclusion in the regional pattern of urbanization.

Soil limitations for recreation in the Houston area are based on the relative intensity of use, as well as certain unique aspects of the various forms of recreation:

- **Camping & Picnicing** - Trafficability, flood hazard, and slope are the major concerns.
- **Playgrounds** - Requirements include large, nearly level areas that are well drained and can support heavy foot traffic.
- **Paths, Trails, & Golf Carts** - These are used for hiking, bridle paths, and random movements. Surface texture and soil drainage are the main criteria.
- **Cottages & Utility Bld'gs** - On site investigation is necessary, but slope, drainage, shrink-swell potential, flood hazard and erosion are the major indicators.
- **Hunting areas** - Generally, adequate food and suitable cover are the principal requirements for game. Wetness, productivity, slope, and permeability are the major criteria supporting upland and wetland species.
<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Picnic Playgrounds</th>
<th>Paths, Trails &amp; Golf Carts</th>
<th>Cottages &amp; Utility Bld.</th>
<th>Hunting Areas</th>
<th>Uplands</th>
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*Note - see community development limitations for rating method.*
2. **THE PATTERN OF NATURAL PROCESSES**

From the previous discussion of the inputs to the environmental inventory, and the data found in Appendix I and II, we can now begin to understand the pattern of natural processes. The work we have done so far indicates that the Houston urban region is a relatively fragile area that has severe limitations on Urban Suitability. The pattern of these limitations constitutes a graphic document that can be used to direct the thrust of new development. This pattern is also the basis for implementing performance requirements to insure environmental quality.

The Houston-Galveston region contains four very broad landscape patterns:
1. The Texas Claypan Area (northwest),
2. The Southern Coastal Plane (north),
3. The Gulf Coast Prairie (south),
4. The Gulf Coast Marsh (east).

These four areas are the ecological basis for the general regional pattern of the natural processes. Of these four areas, the Gulf Coast Prairie and Gulf Coast Marsh have severe urban limitations, and are best suited for agriculture and wildlife habitats, respectively. The remaining two areas, the Texas Claypan Area and the Southern Coastal Plane offer the greater opportunities for urbanization, with the latter being the best suited in the group.
A GENERAL PATTERN OF NATURAL PROCESSES

TEXAS CLAYPAN AREA

SOUTHERN COASTAL PLAIN

Montgomery

forested uplands

Harris

major river system

Liberty

Chambers

bay-estuary

GULF COAST MARSH

Galveston

laggon

coastal barrier

GULF COAST PRAIRIE

Brazoria

minor river systems

THE HOUSTON-GALVESTON REGION

north

0 2 4 8mi. scale
This general pattern can be verified in more detail by projecting the pattern that was generated from the case study of Harris County for the entire Houston-Galveston urban region. For this purpose we will use the data found in Appendix II, which was supplied by the Houston-Galveston Area Council.

From the study of Harris County we have found that the soil problem is the most limiting factor for Urban Suitability in the Houston area. For our regional study we will add the major agricultural areas, marshland, and hurricane inundation areas to our list of limiting factors. These combined inputs generate the pattern of Urban Suitability constraints that indicate the areas that are least suitable for urbanization. These areas should be eliminated as possible sites for urban expansion, and be protected by performance requirements.

The remaining areas can now be delineated and combined with existing recreational areas and the major water systems to generate the pattern of urban suitability opportunities. This pattern is seen as the primary indicator of the most suitable direction for urban growth.

At this point, a word of caution is necessary. Since only a small portion of the region has displayed a high quality potential for urbanization, some urbanization will probable occur in the limited areas. Even the areas of greatest opportunity should not be construed as being without limitations. To further define the suitability of these areas, it is necessary to continue this study for a higher level of detail. This can be
accomplished in the sub-regional and area phases, as indicated in the outline of the process. This work is beyond the scope of this paper since the time, money, and technical input required, is limited. The technical input situation is currently being improved by the work of the Soil Conservation Service and the Bureau of Economic Geology. The time and money that are necessary can only come from the combined effort of the private and public sectors.

It is interesting to note that the Houston-Galveston Regional Pattern displays some of the patterns that Lewis, Moharg, and Williams have defined, therefore verifying the application of their processes to this region. The combined pattern shows that the natural processes that do work for man are extremely vulnerable to development in this area. Hence, it is recommended that the main thrust of urban growth be directed inland along the corridors that were formed by the alluvial deposits of suitable soils. This task could be implemented through the use of positive incentives such as infrastructure development and educational seminars for developers emphasizing the reduction in the cost of development and maintenance. In this manner, both the private and public sectors can be instrumental in establishing a suitable urban pattern and preserving the pattern of natural processes.
URBAN SUITABILITY
OPPORTUNITIES and CONSTRAINTS

THE HOUSTON - GALVESTON REGION

THE REGIONAL PATTERN

crop and pasture land
severe pedology limitations
urbanization opportunities
hurricane inundation areas
We have seen the impact of the pattern of natural processes on the Houston urban environment. This pattern can be generally applied to the entire Texas Gulf Coast. The major hydrological systems are seen as containing the most fragile environmental elements, and their preservation is necessary for the efficient continuation of natural processes. On the other hand, the areas between these systems offer the highest potential for urbanization, increasing in their breadth as they move inland.

This hydrological pattern is further reinforced by the use of lake development as a water source for industry, as well as a secondary supply for the urbanized areas. Since urban development uses ground water sources, which are adequate for this need, industry can be located either near the surface water source, or in the least vulnerable areas along the coast. This allows for the location of industrial sites within the conservation areas, so that the natural system can recycle the industrial by-products. This precludes the use of the bay-estuary systems, which are very fragile and should be treated as strict conservation areas.

Implementation of this proposed pattern can be effectuated by the development of major circulation routes parallel to the coast, but further inland than the existing routes. Perpendicular to this system, major routes can be created running from the coast, inland along the urbanization corridors.

The following diagram demonstrates this proposed pattern:
PERFORMANCE REQUIREMENTS

The guiding concept throughout this entire Urban Suitability Selection Process was that the ecological approach to urbanization is the prime input in this process. At the regional phase, the most vulnerable areas were eliminated; at the sub-regional and area phases, a more detailed analysis can eliminate more specific areas of vulnerability, and enable the selection of the areas most proprietous to urbanization.

It should be understood that the areas selected will have differing ecological identities, and that these differences create special problems unique to each site. Moreover, the excluded areas will probably feel the impact of urbanization in the form of industrial sites, infrastructure, as well as special usages, and therefore need to be protected.

These problems require solutions on two distinct levels. Since the final areas selected will have many common problems which can be addressed in a similar manner, the first step is to generate a set of overall environmental performance requirements. The second step requires that those areas that have specific problems be singled out, and specific performance requirements be written. This necessitates a more complex implementation process, as we are talking about special or privileged use of vulnerable resources.

A list of general performance requirements is to be found at the end of Appendix I. These requirements are intended to minimize the adverse effects of urban-
ization on air, water, and land. The pollution of any of these natural elements results in the degradation of the environment. These requirements can serve as a basis for writing the specific performance requirements that are necessary for environmental quality.

At this point, it must be noted that the two worst offenders of the environment are industry and the automobile. This situation has resulted from our technical and economic growth patterns. It is not the intent of this paper to address itself to the totality of this problem, but to recommend that problems of this nature require the use of national controls that can only be implemented by incorporating Federal guidelines for environmental quality.

Hence, the use of both general and specific performance requirements, by both the localities and the nation, is required to insure environmental quality in an Urban Suitability Selection Process. These requirements can be applied directly to industrial concentrations, so that their effect on environmental quality can be controlled. But the automobile is a decentralized problem that can only be solved by the development of rapid transit systems. For this reason the use of automobiles should be subject to performance requirements.
CONCLUSION

Our search for Urban Suitability has taken us through thousands of years of evolution. We have learned of man's early philosophy of domination and how this philosophy was brought to the present day. We have also seen that as man's ability to effect large scale alternations increased, the seeds of a new philosophy based on environmental quality were planted. This philosophy has now matured into the ecological approach to the man/environment relationship.

This approach to Urban Suitability is increasing our knowledge of the roles man and nature perform in our biosphere. Urban professionals from all branches of knowledge are interrelating with each other to confront the problems that have become paramount to man's survival. The interdisciplinary nature of these problems has developed the "spaceship earth" concept which is becoming the common bond that can draw the diverse inputs of the urban environment into a holistic process based on the ecological approach.

The work that is currently being done in this field ranges from the staunch preservation preached by activist conservation groups, to the political implications of a Congress struggling to define environmental quality. While these activities are paving the way for man's new role in his environment, the state of the art in environmental planning reflects the useful tools that have been developed to date.
The processes developed by Lewis, McHarg, and Williams have opened the door to the development of a dual system of man and nature. These practitioners of the ecological approach view the environment as possessing a set of opportunities and constraints for man's dominant form of existence - Urbanization. This pattern that is displayed by the natural processes, serves as the basis for an Urban Suitability Selection Processes.

As our knowledge of natural systems increases, we find that the similarities between the ecosystems and the systems of man can aid in the solution of our environmental problems. The first step in this problem solving process is the environmental inventory. A major portion of the work of ecologists and natural scientists is currently being addressed at this need. The growing body of knowledge, and the form it is being compiled in, indicate the successful application of the ecological approach to the future form of the urban environment.

The principles developed by the ecological approach are being applied to man's urban systems, not only to insure our survival, but to take advantage of the intrinsic suitabilities that natural systems possess. This factor will enable a reduction of the human and monetary costs of urbanization, and serve as a basis for a definition of environmental quality.

To insure the most appropriate use of our natural resources, the use of performance requirements is necessary to effect a change in our established value system. The intent of these requirements is not to place negative
controls of restraint on our free enterprise system, but to direct the efforts of our knowledge and ingenuity into those areas that display the greatest opportunities for the continuation of our milieu.

Finally, the implementation of this process requires that we develop a continuing system of evaluation in the relationship of man and nature. This methodology will insure the stability of the biosphere while allowing for change within the sub-systems of man and nature. The enabling element in this approach is seen as the participation of an informed body of practitioners in the political processes necessary to generate the funding and legal tools required for a continuation of this process.
APPENDIX

I
THE NEW COLOMBO LOCAL SITE PROCESS

I. REGIONAL ANALYSIS

A. Input

1. Regional Definition

2. Factors:

   a. Governmental:
      (1) council of governments (COG),
      (2) standard metropolitan statistical area (SMSA),
      (3) development districts,
      (4) state planning regions.
   b. Economics;
      (1) economic base / population,
      (2) U.S. Dept of Commerce economic areas,
      (3) chamber of commerce / labor market,
      (4) retail trading zones.
   c. Cultural;
      (1) newspaper circulation (33%),
      (2) television influence (25%),
      (3) radio coverage,
      (4) commuting field (5%)
   d. Ecological;
      (1) bedrock geology,
      (2) surficial geology,
      (3) physiography
      (4) hydrology (ground & surface water),
      (5) pedology (soils),
      (6) conservation (protection of valued natural processes); knowledge of these types of physical and biological processes allows a selection or elimination system which acknowledges the existence of land for present or potential production. Once identified these areas should be protected from urbanization.
      (7) intrinsic suitabilities (for sustained production and extraction);
      (8) suitability for urbanization
         (a) geology
         (b) soil
         (c) bedrock
   e. Socio-Economic; state those behavioral relationships that are stable; and note the parameters of those that are less clear cut.
      (1) population: density, urban places, growth and direction and age,
      (2) economy: land valuation, vehicle distribution, industry, agriculture and taxation,
      (3) institutions and organizations: education major public/private land holdings.
   f. Linkage Analysis; the physical connections between the region's movement systems and the internal movement systems.
These connections involve the moving of people and goods from place to place—transportation; moving thoughts, messages, and images—communications; distribution of energy sources; collecting and distributing water; recycling of used items—waste.

1. electric power (energy),
2. natural gas (energy),
3. telephone (communication),
4. television and radio (communication),
5. mail (transportation and communication),
6. water,
7. waste,
8. roads (transportation),
9. rail and waterway (transportation).

B. Synthesis—Regional

1. Priorities and Assumptions; This process is one of elimination of areas from further analysis. The synthesis issue is to identify those lands within the region which provide the most promise of being capable of supporting urbanization.

2. Natural Environment Synthesis;
   a. geologic suitability for urbanization,
   b. soil suitability for urbanization (soil suitability for sustained production will be reviewed at the sub-regional phase.),
   c. depth to waterrock

3. Socio-Economic Synthesis;
   a. population; exclude areas where 50% of the population exceeds 60 persons/sq. mi. in density, or population centers of 5,000 or more.
   b. population growth and direction; exclude all areas predicted to receive major low income growth.
   c. land value; exclude all areas valued at more than $1,000,000/sq. mi.

<table>
<thead>
<tr>
<th>price/sq. mi.</th>
<th>price/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,000,000</td>
<td>$1,563</td>
</tr>
<tr>
<td>750,000</td>
<td>1,171</td>
</tr>
<tr>
<td>640,000</td>
<td>1,000</td>
</tr>
<tr>
<td>500,000</td>
<td>781</td>
</tr>
<tr>
<td>400,000</td>
<td>625</td>
</tr>
<tr>
<td>320,000</td>
<td>500</td>
</tr>
<tr>
<td>128,000</td>
<td>200</td>
</tr>
</tbody>
</table>

d. unavailable public land.

4. Linkage Synthesis;
   a. transportation; exclude all areas outside of the 60 minute commuting line (consider the possibility of future transit routes).
   b. linkage costs; exclude areas containing three of the following:
   (1) high water supply costs:
<table>
<thead>
<tr>
<th>population</th>
<th>peak gal./day with sm. indus.</th>
<th>peak gal./day with lg. indus.</th>
</tr>
</thead>
<tbody>
<tr>
<td>40,000</td>
<td>9,600,000</td>
<td>12,000,000</td>
</tr>
<tr>
<td>80,000</td>
<td>19,200,000</td>
<td>24,000,000</td>
</tr>
<tr>
<td>100,000</td>
<td>24,000,000</td>
<td>30,000,000</td>
</tr>
<tr>
<td>150,000</td>
<td>24,000,000</td>
<td>45,000,000</td>
</tr>
<tr>
<td>200,000</td>
<td></td>
<td>60,000,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>plant size</th>
<th>const. cost</th>
<th>maint. cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000,000</td>
<td>$4,000,000</td>
<td>$650,000/yr.</td>
</tr>
<tr>
<td>60,000,000</td>
<td>15,000,000</td>
<td>900,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>population</th>
<th>miles from source</th>
<th>size of pipeline</th>
<th>total acqular investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000</td>
<td>10</td>
<td>16&quot;</td>
<td>$1,095,000</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>18</td>
<td>2,300,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>20</td>
<td>3,710,000</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>24</td>
<td>7,150,000</td>
</tr>
<tr>
<td>25,000</td>
<td>10</td>
<td>24</td>
<td>1,910,000</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>24</td>
<td>3,340,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>30</td>
<td>5,990,000</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>30</td>
<td>9,850,000</td>
</tr>
<tr>
<td>50,000</td>
<td>10</td>
<td>30</td>
<td>2,630,000</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>36</td>
<td>5,020,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>36</td>
<td>7,600,000</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>42</td>
<td>14,100,000</td>
</tr>
<tr>
<td>100,000</td>
<td>10</td>
<td>42</td>
<td>4,840,000</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>46</td>
<td>5,020,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>48</td>
<td>12,700,000</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>54</td>
<td>23,600,000</td>
</tr>
</tbody>
</table>

(2) additional road lanes required,
(3) not adjacent to rail lines,
(4) not adjacent to gas lines.

5. Combination Synthesis: combining all excluded areas leaves those areas which justify further analysis.

II SUB-REGIONAL ANALYSIS
A. Input
1. Natural science data availability and degree of detail:
   a. Topography; U.S. Geologic Survey, state and private sources.
   b. Geology; U.S. Geologic Survey, private sources.
   c. Soils; Soil Conservation Service, field sheets, verbal conferences with soil scientists, conservationists and private sources.
   d. Water; State hydrologic data, private sources.
   e. Vegetation & wildlife; U.S. Geologic Survey ("green" areas only), field investigation is necessary.
   f. Climate; State sources, specific weather stations.
2. Analysis Procedure: three classifications of the data were used;
   a. Basic: of major importance to the locational process;
      (1) geology
      (2) soils
      (3) slope
      By locating these positive attributes for urbanization, negative attributes for the environment, and special productive areas, we can establish a set of explicit priorities and procedures.
   b. Other: existing urbanization, existing large recreational holdings, and areas of cultural attractions.
   c. Supportive: referred to for performance requirements at the area phase;
      (1) hydrologic systems
      (2) climate
      (3) vegetation and wildlife
      (4) elevation

3. Graphic Analysis Procedure: The geology, soils, and slope maps were used ... to select acceptable grids for NewCom urbanization. (see data digitization and rank ordering)

B. Sub-Regional Inventory:

1. Geology;
   a. depth to bedrock, bedrock composition,
   b. surficial material, historical evolution,
   c. mineral resources, potential resources,
   d. gas and oil, commercial quantity,
   e. unique geologic features.

2. Soils;
   a. general soil areas, soil groupings,
   b. general soil characteristics:
      (1) depth to bedrock,
      (2) shrink-swell,
      (3) erodability, (most likely range of slope),
      (4) permeability of sub-soil,
      (5) soil drainage.
   c. general productivity and use limitations;
      (1) range of slopes,
      (2) depth to seasonal high water table (ponded or perched),
      (3) agricultural productivity,
      (4) non-agricultural use limitations and water hazards.

3. Slope; (0 - 5%, 5 - 15%, over 15%)

4. Existing Urbanization

5. Existing Large Recreational Land Holdings and historical Sites.
C. Data Digitization and Rank Ordering;
1. Develop a grid system, (NewCom uses a 10 kilometer regional grid of 24,710 acres, and a 1.25 kilometer sub-regional grid of 385 acres.)
2. Data analyzed;
   a. data related to the urbanization process;  
      (1) depth to bedrock,  
      (2) permeability,  
      (3) soil drainage,  
      (4) shrink-swell potential.
   b. data related to urbanization but having a great bearing on the location of possible natural environmental hazards:
      (1) slope,  
      (2) erodability,  
      (3) water hazards.
   c. data related to other land use potential:
      (1) agricultural capability,  
      (2) mineral resources.
3. Category breakdown: Each of the previous categories are broken down into three or four gradations from least limiting to most limiting for high levels of urbanization. Each breakdown is related to both the urbanization process and the natural environmental process.

D. Data Analysis:
1. General. The following output was generated for each data category in the previous section. Only the category breakdown description is included here, as it summarizes the findings.
2. Depth to bedrock:

<table>
<thead>
<tr>
<th>Depth</th>
<th>Natural Environment Considerations</th>
<th>Urbanization Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>10'</td>
<td>minimal blasting necessary, no severe implications.</td>
<td>slight limitations on basements, utility gravity sewers, and roads.</td>
</tr>
<tr>
<td>5-10'</td>
<td>no severe implications</td>
<td>moderate limitations on basements, utility lines, gravity sewers and roads</td>
</tr>
<tr>
<td>3-6'</td>
<td>some implications if large areas are excavated, subject to slippage in shale.</td>
<td>very severe limitations if underground utilities or structures with basements are used. Limitations on cut &amp; fill for roads.*</td>
</tr>
<tr>
<td>3'</td>
<td>severe implications if deep cuts are made into loose shale - subject to rock fall and slippage.</td>
<td>very severe limitations if underground utilities or structures with basements are used. Limitations on cut &amp; fill for roads.*</td>
</tr>
</tbody>
</table>
*The intensity of this problem is related to the character of the geology in terms of site work and "trenching", etc.

3. Slope:

<table>
<thead>
<tr>
<th>Slope</th>
<th>Natural Environment Considerations</th>
<th>Urbanization Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10%</td>
<td>no severe implications</td>
<td>slight limitation for most housing, severe limitation for active recreation, some restrictions for roads &amp; utilities.</td>
</tr>
<tr>
<td>10-15%</td>
<td>moderate implication where cut &amp; fill will cause erosion, potential siltation of streams.</td>
<td>severe limitations for active recreation, large industrial sites, and roads perpendicular to the slope. Specially designed housing possible. (see performance requirements for physical design)</td>
</tr>
<tr>
<td>15%-*</td>
<td>severe implications for removal of vegetation, high erosion potential with great losses of topsoil possible.</td>
<td>severe limitations for active recreation, large industrial sites, and roads perpendicular to the slope. Specially designed housing possible. (see performance requirements for physical design)</td>
</tr>
</tbody>
</table>

*slopes in excess of 15% are unacceptable for urbanization, but serve as conservation and passive recreation areas.

4. Permeability:

<table>
<thead>
<tr>
<th>Permeability</th>
<th>Natural Environment Considerations</th>
<th>Urbanization Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>no severe implications</td>
<td>slight limitations to urbanization if septic tanks are used</td>
</tr>
<tr>
<td>0.20-2.50 inches/hr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate-slow</td>
<td>if fragipan exists, and is disturbed by topsoil removal, very poor revegetation will occur.</td>
<td>severe limitations for septic tanks. slight limitations for active recreation.</td>
</tr>
<tr>
<td>0.20-0.80 inches/hr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow</td>
<td>same as above</td>
<td>no septic tanks allowed. moderate limitations for active recreation on flat slopes.</td>
</tr>
<tr>
<td>0.05-0.20 inches/hr.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
very slow*  
0.05 or less inches/hr.  

*unacceptable for urbanization, but used for conservation.

5. Soil Drainage:

<table>
<thead>
<tr>
<th>Soil Drainage</th>
<th>Natural Environment Considerations</th>
<th>Urbanization Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>moderately-well to well: water is readily removed.</td>
<td>no severe limitations</td>
<td>no great limitations. Recreation fields may need improved drainage.</td>
</tr>
<tr>
<td>well to excessively: water removed very rapidly, porous, steep.</td>
<td>moderate implications if soils disturbed. Vegetation may be difficult to re-establish.</td>
<td>moderate limitations where soil is removed.</td>
</tr>
<tr>
<td>somewhat poorly to poor: soil remains wet for long periods, due to high water table or poor permeability.</td>
<td>severe implications if water table is increased or decreased by construction drainage. Established vegetation severely affected.</td>
<td>severe limitations for urbanization and all other uses due to infiltration of water into the sewers. (Severe in permeable soils)</td>
</tr>
</tbody>
</table>

6. Shrink-Swell:

<table>
<thead>
<tr>
<th>Shrink-Swell</th>
<th>Natural Environment Considerations</th>
<th>Urbanization Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>low &amp; low to moderate</td>
<td>no implications</td>
<td>no limitations that construction technology cannot overcome easily.</td>
</tr>
<tr>
<td>moderate to high</td>
<td>vegetation may have difficulty establishing if this soil is brought to the surface with no topsoil cover.</td>
<td>severe limitations for urbanization, highways fill material and building foundations. Grass areas difficult to establish. Requires strict management.</td>
</tr>
</tbody>
</table>
7. Erodability:

<table>
<thead>
<tr>
<th>Erodability</th>
<th>Natural Environment Considerations</th>
<th>Urbanization Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>no severe implications.</td>
<td>no adverse limitations.</td>
</tr>
<tr>
<td>moderate</td>
<td>moderate implications with slopes.</td>
<td>moderate limitations for cut &amp; fill on slopes.</td>
</tr>
<tr>
<td>high</td>
<td>severe implications, siltation of stream highly possible, loss of topsoil, gulling possible.</td>
<td>severe limitations to prevent stream siltation or top-soil loss.</td>
</tr>
</tbody>
</table>

8. Soil Suitability for Agricultural Capability:
   a. soils of high capability present severe limitations to the pre-emption by urbanization.
   b. moderate capability soils may limit high density development.

9. Water Hazards:

<table>
<thead>
<tr>
<th>Water Hazard</th>
<th>Natural Environment Considerations</th>
<th>Urbanization Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 3'</td>
<td>no implications unless the water table to is greatly increased</td>
<td>moderate limitations to structures with basements, highways fields and large industrial sites, and underground utilities.</td>
</tr>
<tr>
<td>seasonal</td>
<td>no implications unless vegetation and topsoil loss.</td>
<td>severe limitations, location of buildings restricted, also main highways. Some recreation areas can be located here.</td>
</tr>
<tr>
<td>high water table</td>
<td>no implications unless stream flow is greatly diverted, causing great fluctuation of stream flow.</td>
<td></td>
</tr>
<tr>
<td>annual flooding</td>
<td>no implications unless stream flow is greatly diverted, causing great fluctuation of stream flow.</td>
<td></td>
</tr>
</tbody>
</table>

B. Data Ordering:
1. General: The methodology of analysis included the following: category selection, where major inputs were selected; category breakdown, where each input was divided into three or four gradations; data take-off, where the occurrence of each category breakdown is recorded by percentage of the grid in which it is found; assignment of category combination numbers, where the breakdown percentages recorded above are given algorithm assignments for computer use; assigning of rank order numbers, where each category is rank ordered from 1 to 99 by assigning the largest gradation of a category a multiplier of 99, and the smallest gradation a multiplier of 1, etc., so that a value scale of 1 to 99 is created for each category in each grid; and digitization & computer printout. At this point, a value judgement must be made as to the performance
of each grid cell, in each category. HewCom uses the computer printout of the above data to rate the best performing, acceptable and unacceptable grid cells.

2. Categories: major and minor
These eight categories have been divided into major and minor groups based on the ability of the urbanization process, under the strictest performance requirement, to properly ameliorate the adverse condition it would cause.

3. Printout search for best performing to unacceptable grid cells.

4. Selection of final cells for area analysis, based on the above process and it's associated value judgements.

III AREA ANALYSIS
A. Purpose and Inputs
B. Description of Areas
A description of the areas was necessary to develop a further understanding of the factors at work.
1. Climate (macro- and micro-),
2. Vegetation,
3. Wildlife,
4. Hydrologic Systems,
5. Physiography Position and Amenity.
C. Analysis of the Areas
This section uses the description of areas above, with the rank order files generated in the sub-regional analysis, to specify preference areas for HewCom urbanization.
D. Performance requirements
It is understood that the areas selected have differing identities: geology, soils, hydrologic systems, etc. and that these differences create special problem areas unique to each site. However, these areas will have many common problems which must be addressed in similar ways. The purpose of this section on over-all environmental performance requirements is to address those general areas of environmental vulnerability and to make specific statements regarding each.
1. Air:
   a. all burning shall conform to State regulations
   b. all industry shall conform to the performance requirements for industry (ie. Lysander Hew Community, Working Paper #1, Industrial Studies, November 29, 1969),
   c. the use of automobiles shall be discouraged,
   d. any and all steps that can be taken to reduce or avoid the pollution of the air by any means or use shall be closely adhered to.
2. Water - Hydrologic Systems:
The usual effects of urbanization on the hydrologic system are: increased flooding, decreased
water supply, increased erosion and sedimentation, decreased water quality and decreased amenity. These effects are caused by some unavoidable attributes of the urbanization process which include: decrease in natural vegetative cover, increase in impervious surfaces, extensive storm sewerage, and increased use of water and discharge of wastes. Since it is impossible to urbanize without this accompanying change in land and water systems, it is the purpose of these requirements to minimize the adverse impact of urbanization by setting up areas of severe limitations upon development with highly restrictive requirements and to require a system of water management.

a. flood plain:
   no development which requires construction of permanent structures, farming and recreation are accepted uses of the flood plain (defined as the 50 year recurrence level).

b. stream buffer:
   defined as all land lying within 300' of a perennial stream, exclusive of flood plain land; not more than 15% of this buffer may have impervious surfaces, except for private roads or driveways.

c. slopes:
   slopes of 25% or greater are restricted for wildlife, forestry and passive recreation, slopes between 15 and 25% are excluded from subdivision type development but carefully sited structures may be built where soils are deep and well drained (in no case may development cover more than 15%, not disturb more than 25%).

d. woods:
   no structures on less than 4 acre sites in areas of mature woods, with no more than 25% coverage by impervious surface, roofs, compacted soil and/or disturbed vegetation.

e. amenities:
   all amenities shall have high priority for use by the general public; no development shall occur which would increase the daily average flow of the surrounding drainage system, or cause stream erosion; no development shall occur which would increase, decrease or otherwise alter the normal temperature of water in the streams.

f. management:
   all development shall proceed only after plans have been approved as to erosion and sedimentation minimization. all stream channels must be protected as well as vegetation.

3. Land:
   The effects of large amounts of urbanization on land can be of either a positive or negative
value to the quality of the land itself. The following performance requirements are intended to maintain or improve the overall quality and functioning of the land.

a. no development shall occur where excessive amounts of cut and fill, site grading or soil removal is required to accommodate development.
b. roads and all development shall respect the topography of the site such that undue land alteration is minimized.
c. junk and solid and liquid wastes may not be dumped or discharged anywhere in the area, but be handled by the internal facilities.
d. no trees shall be cut except those that are dead or diseased, or are isolated or part of a woods less than 10 acres in size.
e. a permeable type of paving material should be used where feasible.
f. where topography does not permit infiltration areas within the development site, open space should be set aside further down stream to accommodate any increase in runoff.
g. where above ground utilities have been erected, low growing trees should be planted in the right-of-ways.
h. clearing operations should be staged so that only land which will be developed promptly is stripped of protective vegetation.
i. construct catchment basins before clearing to trap debris and silt.
j. all natural features such as lakes, streams, trees and shrubs should be incorporated into the final design layout (internal open space).

E. Specific Performance Requirements for areas selected

IV. CONCLUSION
The final location of land uses, buildings, recreation areas, open spaces must respond to the understanding gained in this search.


3. Ibid 1., pg. 99

4. Ibid 1., pg. 101

5. Ibid 2., pg. 22


7. Ibid 2., pg. 37

8. Ibid 1., pg. 17

9. Ibid 6., pg. 101

10. Ibid 1., pg. 25

11. Ibid 6., pg. 151

12. Ibid 6., pg. 112


19. Ibid 17., pg. 40


22. Ibid 21., pg. 104.

23. Ibid 21., pg. 104.


25. Ibid 21., pg. 57.


27. The Urban Studies Center, University of Louisville, Louisville, Kentucky.


32. Ibid 28., pg. B-139.


37. Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas, 78712; Director: W.L. Fisher.


40. Ibid 39.


42. Ibid 28.
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