J. Nat. Hist. Mus. Inst., Chiba, Vol.2 No.1 : 47-52. March 1992.

A Landscape Ecological Approach to Urban Systems as Part of the Total Human Ecosystem

Zev Naveh

Faculty of Agricultural Engineering Technion
Israel Institute of Technology Haifa 32000, Israel

The science of ecology evolved in the 20 century as a branch of classical biology for the study of the interrelations between plants and animals and their natural environment. Contemporary ecology has continued this trend and also ecosystem ecologists try, as far as possible, to study natural and close to natural ecosystems and their plant and animal populations and communities. In these, man is regarded chiefly as an external disturbance factor. Even in the young science of urban ecology the major focus is on plants and animals living in urban environments.

The study of urban systems involve very complex and closely interwoven biological, ecological, physical, psychological, sociological, economical and cultural functions and relations which transcend the artifical borders errected by the different natural and humanistic disciplines with either bio- or anthropocentric approaches. In order not to get lost in the maze of these perplexing problems and numerous variables, there is need for more comprehensive transdisciplinary approaches and methods based on a unifying overarching conceptual framework.

The object of my lecture is to show that landscape ecology as a transdisciplinary and holistic science can provide such a conceptual framework. However, in the short time available, I can point out only to some of the major premises, which have been published in much more detail in our book on landscape ecology (Naveh & Lieberman (1984, 1989).

Some major premises of holistic landscape ecology

We have based this holistic approach to landscape ecology on General Systems Theory and Hierarchy Theory and Biocybernetics. Their basic paradigm is the view of the hierarchical organization of nature as ordered wholes of multilevelled stratified open systems, each higher level with additional emerging qualities.

Such a hierarchical systems approach to ecology, has been adopted by Odum and many others, for the natural ecological hierarchy of increasing complexity from the organism to the population of organisms, their agglomeration into communities and their integration with the physical environment into ecosystems. We have introduced the concept of the Total Human Ecosystem as the highest and most complex level of the ecological hierarchy, above that of the ecosystem level. In this man is integrated with his total, natural and artificial, urban environment. This term was coined first by Egler (1970) in an important article on pesticides in our ecosystems. In this he suggested that "man-and-his-total environment forms"a single whole in nature that can be, should be and will be studied in its totality".

An important development in the hierarchical system theory was the recognition of the dichotomic, dual-faced nature of each open system in the hierarchy. According to this concept called by Koestler (1969) holon concept (Holon from the greek word Hol(os) + (Prot)on namely whole and part, each open system is at the same time both part and whole: It is a dependent part of its higher integrative level, and therefore a sub-system in the terminology of General Systems, but also a independent, self-contained whole toward the lower, subordinate level within the systems hierarchy. It is therefore also a super-system. In other words each hierarchical level is an intermediary structure, neither "parts" nor "wholes". He used the human organism as an example and showed the great value of this concept for bridging the missing link between atomism and holism. The structure and behaviour of an organism, as well as any other hierarchically ordered whole, cannot be explained or reduced to its elementary

parts, but it can be dissected into its constituent branches of holons.

Guided by such a holistic system approach, we concieve landscapes not like Forman and Godron (1986) and others, as repeated patterns of ecosystems, but as ecological systems on their own rights, as "site-specific boxes of air/soil/water encapsulating organisms with man as an integral part" (Rowe, 1988)

We have also adopted the holon concept for the landscape hierarchy in order to emphasize the complementary character of these landscape units. They are at the same time parts of a spatio-temporal and perceptional hierarchy and as wholes toward their lower levels and can be approached both from a reductionistic and holistic point of view. Therefore, within the above-described hierachical, ecological order or "holarchy" landscapes can be regarded as the concrete space time defined sites and holons of the Total Human Ecosystem with increasing complexity from the ecotope, or landscape cell, as smallest mappable landscape holon to the ecosphere, as the largest and most complex global landscape of the Total human Ecosystem.

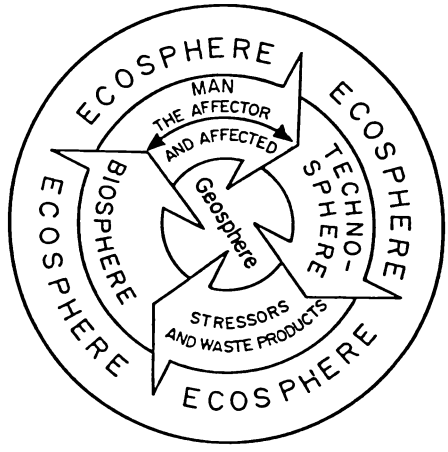

Fig. 1. Mutual causality among industrial man, the biosphere, and the geosphere. Waste products and stressors from the technosphere are causing adverse changes in man's health, well-being and behavior. This conflict can be resolved only by a new balance between man's self-transcending and self-asserting holon properties toward the biosphere and geosphere as part of the total human ecosystem-ecosphere. (Naveh and Lieberman, 1984).

Bio-ecosystems, techno-ecosystems and the total human ecosystem

Following the ecosystem classification of Ellenberg (1973), we have to distinguish between two major classes of ecosystems: Natural and close-to natural ones, namely terrestrial, maritime and limnic bio-ecosystems of the open landscapes and artifical, man-made urban-industrial techno-ecosystems of the built-up landscapes. Bio-ecosystems have evolved during many thousands of years as part of the biosphere, which can be regarded as the greatest, global bio-ecosystem. They are driven by the biological conversion of solar energy and by natural resources material and maintain and regulate themselves by bio-physical information as so-called "adaptive biological systems" (Jantsch, 1975). Techno-ecosystems, on the other hand, are constructed and maintained by the technological conversion of fossil or nuclear energy and natural, as well as synthetic materials. They are controlled and regulated by cultural, scientific, technological, political and spiritual information of "inventive human (or human action) systems (Jantsch, 1975). All these techno-ecosystems of villages, cities industrial plants, power stations, mines, highways and all other constructed engineering devices form together the global technosphere.

Although created and controlled by man, traditional low-input agricultural ecosystems can still be regarded as bio-ecosystems. But modern agro-industrial ecosystems with high inputs of chemicals and gasoline driven machineries, occupy an intermediate position between both classes.

In reality, on the greatest, inhabitated part of the earth all bio-and technosystems are forming together closely interwoven networks and mosaics of global geo-bio-techno-systems. These are the-above described concrete entities of the Total Human Ecosystem. In these, both man and all other organisms of the lower hierarchical levels of populations, communities and ecosystems and their living space are integrated in concrete, space/time defined, three dimensional patches of land, water and air. The spatial scales of these landscape units range from the smallest, mappable landscape cell or ecotope of forests, grasslands, fields, rivers and lakes of the open landscapes and from the house, street and city of the built-up landscapes to the largest global land-

scape of the ecosphere.

Biosphere and technosphere landscapes and the fate of man

The biosphere has undergone for many million years a steady growth in complexity and negentropic order and until very recently, it has proved its stability and efficiency in biological productivity and in bio-geo-chemical circulation. But the technosphere after 200 years of unrestrained spatial expansion, energy and material consumption and therefore also of entropy and disorder is presently undergoing a severe ecological crisis by which it endangers its future and that of the biosphere.

Man, like all other organisms, has been an integral part of the biosphere during 99.99 % of his biological and cultural evolution, which lasted almost 3 million years. This includes also our modern *Homo sapiens sapiens* species who evolved in the last 50000 years and most of this time lived, like his ancestors, as food gatherer and hunters in the open natural surroundings or in caves. He was therefore a dependent holon of the biosphere.

The early creation of the technosphere can be traced back to the beginning of the so-called neolithic agricultural revolution, less than 10000 years ago, when man started to build houses and villages and converted greater and greater parts of the natural and semi-natural bio-ecosystems into agro-ecosystems. But at the beginning of the industrial revolution, about 200 years ago, only 2.4% of the human population lived in cities with more than 20000 inhabitants. Today already about 50 % of the world population lives almost exclusively in urban-industrial surroundings of modern cities and in rapidly growing isolation from the open natural and agricultual landscape. Our rapidly expanding modern urban-industrial techno-ecosystems of cities, industrial plants, mines, highways etc. are therefore very recent creations. If this environmental and cultural transformation would not have been so rapid, it could be regarded as a further step in our cultural evolution from *Homo sapiens sapiens* to "*Homo sapiens industrialis.*" But as mentioned already it occured in such a short time span and with such rapidly increasing intensity that it has become now an accelerating neo-technological cultural and environmental revolution.

During this most recent revolution "*Homo industrialis*" has acquired almost unlimited technological powers to change his environment. But, unfortunately, this power has not been restrained sufficiently by ecological knowledge and wisdom to avoid the far-reaching undesirable impacts of these environmental changes. Contrary to our so-called primitive ancestors we did not realize that we cannot cheat nature with our technochological achievements. Even when we can reach the moon and the mars we are still bound to live within the limited resources of mother earth, its air, water and soil of the geosphere and the living organisms of the biosphere. Their uninterrupted interplay ensures the physical and biological basis of our existence.

This rapid conversion of the human living space from a natural habitat into an urban-industrial one, is causing the alarming, large-scale disturbance, disruption and destruction of natural terrestrial and aquatic ecosystems and the biological ecological and visual impoverishment of the remaining natural, semi-natural and rural landscapes. These endanger the future of the biosphere on which these cities depend. It has also created the severe problems of soil, water and air pollution in his new man-created urban environment.

If this process of unrestrained growth will continue than the earth surface will develop within 100 years into one global urban megalopolis technosphere landscape. This will turn into an almost complete biological desert and the few remaining degraded, polluted and overcrowded bio-ecosystems will become "open-door recreation slums" (Naveh, 1973).

There is an alarming tendency with increasing human impact of accelerated, exponential urban-industrial expansion and increasing dominance of man-made artifacts, leading to more and more monotonous urban industrial landscapes. Its rapidly expanding urban-industrial complexes are driven by destabilizing run-away feedback loops between energy/material, consumption, scientific and technological information and exponentially rising demands and expectations. These increasing inputs of fossil energy, waste material, stressors and cultural information are accompanied also by increasing losses of natural ecotopes and spontanously occuring organisms, and of nega-

tive, regulative natural feedback loops ensuring environmental stability and resilience.

There is also severe doubt if *Homo industrialis* - in spite of his great adaptation capacity to new environments - could have in such a short time span relative to his whole evolutionary history, adjusted himself so fast to this new environment, so that he could have developed sufficient resistance to these entirely new and overwhelming combined and mutual-increasing urban stresses which are so very different from those, to which he has been exposed for millions of years.

One of the major sources of our environmental crisis is the dual position of *Homo sapiens industrialis* by being - still, like all other biological creatures - a depending biological part of the biosphere. But at the same time he has become also an independent cultural whole who has created and is ruling a new sphere on earth - the technosphere, existing now besides the biosphere. As explained above, these endanger the viability and stability of the biosphere and its life-supporting bio-ecosystems and thereby also his existence and that of the technosphere.

As biological creatures we are an integral part of the biosphere, depending on its undisrupted function. But at the same time, as creators and rulers of the technosphere and its urban-industrial and agro-industrial systems, we are modifying it and even endangering its future viability and therefore also that of these man-made systems of the technosphere and ourselves. We are, therefore at the same time the effectors and the affected and this dichotomy of dependence and independence is one of the main causes for the confusion and conflict in our present ecological status Fig.1.

The need for a new symbiosis between man and nature

We have to realize that these crucial problems cannot be resolved only by technological means and even not by advanced urban planning and traffic regulations. Effective pollution control, recycling of waste, replacement of gasoline-driven cars by electric cars in city centers - all these are of great importance and value and your country is taking a leading role in their development and application. But as long as these remain isolated efforts for the improvement of the quality of life in the city, they will be costly and short-lived. They must become an integral part of an all-embracing effort for innovative environmental planning and management of our total living space in the city and in the country side. From the point of view of the landscape ecologist, its goal must be much more far reaching than pollution control, waste disposal and traffic regulation and city renewal.

This deep ecological crisis can be resolved only through a further step in our cultural revolution from "*Homo industrialis*" to "*Homo integralis*", This should lead towards a new symbiosis between modern man and nature at a higher organizational level of the Total Human Ecosystem. Such a symbiosis requires not only scientific knowledge and technological power, but also ecological wisdom to recognize our true place in nature and its vulnerability and limited resources on earth. It can be resolved only by the realization that both our urban and natural ecosystems have to become parts of a higher level of a global bio-geo-social system. With other words: We have to recognize our holon status as dependent parts of a higher controlling whole, namely the Total Human Ecosystems.

According to Koestler (1969) this dichotomy of opposing tendencies of each holon in any biological, ecological and social hierarchy for integration in order to function as part of the larger whole and of self assertion to preserve its autonomy is causing a basic polarity. Each holon must assert its individuality but at the same time it must submit also to the demands of the whole through self-transcendence in order to ensure the systems viability. It is of interest to note that such a basic polarity inliving systems has been also recognized in the ancient Chinese philosphy as "yang" the aggressive, compatetive and self-assertive human behaviour and "yin", the cooperative, integrative and self-transcendent behaviour.

We cannot return to the original symbiotic status of primitive man with nature. But at the same time, we cannot continue to expand our urban-industrial landscapes and their waste and stressor products with the arrogance, and ignorance of an exploitative I-It relation which has replaced man's close contact and his respectful I-Thou relation towards his natural ecosystems. This means that we need not only much more

ecological knowledge and wisdome, but also ecological ethics to change our environmental behaviour and relation with nature. Such a change is, in my opinion, the greatest challenge for the future of mankind and its further evolution or extinction.

In this respect the Japanese people may have a great advantage because of their traditional cultural attitude to nature and its relations to technology. As Murota (1985) explained, until the Meiji Restoration in 1868, when Westerns modern technology and with it Western distorted views of nature were introduced to Japan, originally the Japanse language had no special word for nature. It had to be translated, using the Chinese term. This was not because the tradional Japanese culture ignored or denied nature. On the contrary, the Japanese people considered themselves so intimately integrated with nature that they could not identify it as a special, objective identity. To them it was manifested in the trees, the birds, the rivers, the rocks, and in any other natural object. They had therefore a deeply ingrained cultural wisdom of this I-Thou relation with nature. They regarded it as a close friend and blessing, in contrast to the Western I-It relation in which nature serves as an object that has to be conquered with the help of science and technology for the materialistic needs of man. The traditional Japanese technology and engineering was not rooted in Western mechanistic natural sciences. It stems from this deep ecological wisdom, considering technology as a tool which should be evaluated in terms of its artisitc merit by YUTSU NO SHIREN, the test of artistic value.

For your nation, therefore, this new symbiosis could mean a re-enforcement and modernization of your traditional ecological and technological wisdom and Japanese ethos and its application in the development of an alternative biosphere-technosphere relation, and in the creation of new urban landscapes.

But also among Western scientists, ecologists, and even economists and technologists there is a growing recognition for the need for such a revolutionary change in our attitudes towards nature. One of the most original thinkers and practioners who has very much influenced my own work, is Frederic Vester from Germany whose writings, films, exhibions and practical planning and development projects point out into similar directions of such a new symbiosis between *Homo integralis* and nature. Vester (1980) showed convincingly that nature, through the long evolution of the biosphere, has developed by trial and error the most sophisticated technologies which have proved their efficiency throughout hundred thousands of years. These are far superior int their efficiency and durability to any of our modern and most advanced and promising technological advances, such as, f. i. microchips. In contrast to these, our brain cells and its chromosomes are already containing the masterplan of the total organism. Their enfoldment is not aimed towards indefinite and unlimited quantitative growth but at increasing qualitative growth in complexity. Nature technologies are not, like our engineering devices and engines built as closed systems according to a fixed construction plan, based on physical and mechanistic forces alone. They have evolved in a long-lasting and ongoing process of mutual cybernetic relations between life and environment at all levels of the above-mentioned biological and ecological hierarchy. Therefore these biosphere technologies are automatically completely integrated with the environment and also with human nature.

These biocybernetic forces should be utilized also in our new symbiosis with nature, which could be called, therefore a biocybernetic symbiosis, and because of its closely interwoven global aspects, a bio-geo-cybernetic symbiosis.

In this symbiosis human progress in life quality but not in unlimited growth-should be reconciled with the conservation and restoration of the biological, ecological, and cultural diversity of our open landscapes. For this purpose we have to replace the presently antagonistic relations between the technosphere and the biosphere by the spatial and functional integration of all our human-made urban and rural landscapes of the technosphere, which are driven by fossil and nuclear energy with all still remaining natural, semi-natural and agricultural landscapes of the biosphere, driven only by the photosynthetic conversion of solar energy.

The creation of biosphere oases in the biological desert of the cities

Time does not allow me to go into more details.

But I would like to point out that one of the first steps in this direction is the creation of green and watered biosphere oases in the biological deserts of our cities and the dedication of at least 10 % of the open landscapes in the countryside to nature reserves, recreation park and to low-intensity and non-chemical agricultural uses. This was proposed by Haber (1989), as an important part of the planning program towards greater differenciated land use in combination with the reduction in the intensivity of agricultural practices.

Such low input biosphere landscapes fulfill not only important socio-economic, cultural, aesthetic and scientific functions but also closely related biological, chemical and physical functions of purification, of climatic moderation, filtering and absorption of dust, gases and particles, removal of smells,reduction of noise, prevention of erosion and flooding ect. They act as powerful biological sponges which even not the most sophisticated and expensive engineering device could fulfill with similar effficiency.

We should realize that these are all free services which nature supplies us without payment as a by-product of photosynthesis, evapo-transpiration, mineral, gas and water circulation during the growth of green plants and their root systems. If modern society would have to pay for these services, it would have taken, probably much better care to save these live-supporting natural and semi-natural ecosystems and think twice before cutting even a single tree in the city. But we will need more efficient and convincing tools for public and decison makers education.

A very fine example for such a tool is a unique, illustrated "Window book" by Vester (1985). in this he showed that "A tree is more than a tree", namely a tree is worth more than the annual wood value of 2-3 DM.

If we combine all its multiple benefits, functioning as as a sun energy engine, biological filter, wildlife shelter, breeding, nesting habitat and, food supplier,water pump, bioindicator, soil builder and improver, moisture storer, climate engine, erosion and flood protector ect., then the annual value of a tree rises more than thousand times - up to 5600 DM according to Vesters calculation.

Conclusions

Ecological knowledge, wisdom, and ethics will lead to the conclusion that the creation of green and watered biosphere oases in the biological deserts of our cities is by far the cheapest and most efficient way for over-all urban environmental improvement. It does not require fossil energy like all man-made engineering devices and therefore does not add any further burdens of entropy and stressors on the urban landscapes. But it has much more far-reaching effects: it reduces the soal and body crippling threats of urban stresses and draws the enstranged city dwellers closer to a new I-Thou dialgoue with nature. It brings thereby a richer dimension to his life which cannot be measured by dollar or Yen values and material goods, but it will pay high interest in non-economic richnesses and urban life-quality.

References

Egler, F. E. 1970. The Way of Science: A Philosophy of Ecology for the Layman. Hafner, New York.

Forman, R. T. and M. Godron, 1986. Landscape Ecology. Wiley and Sons, New York.

Haber, W. 1989. Differenzierte Bodennutzung im Siedlungsraum. DISP (Dokumente u. Informationen zur Schweitz. Orts-, Regional, u. Landesplanung) 99 : 18-21.

Jantsch, E. 1975. Design for Evolution: Self-Organization and Planning in the Life of Human Systems. Geogre Braziller, New York.

Koestler, A. 1969. Beyond atomism and holism-the concept of the holon. In: A. Koestler and J. R. Smithies (Eds.) Beyond Reductionism: New Perspectives in the Life Sciences. Hutchinson of London, pp. 192-216.

Murata, Y. 1985. Culture and the environment in Japan. Environmental Management 9 : 105-112.

Naveh, Z. and A. S. Lieberman 1984; 1989. Landscape Ecology-Theory and Application. Springer- Verlag New York.

Rowe, J. SD. 1988. Landscape ecology: The study of terrain ecosystems. In: M. R. Moss, (Ed). Landscape Ecology and Management. Polyscience Publications Inc., Montreal, Canada.

Vester, F. 1980. Neuland des Denkens. Vom technokratischen Zeitalter zum kybernetischen Zeitalter. Deutsche Velags-Anstalt Stuttgart.

Vester, F. 1985. Ein Baum ist mehr als ein Baum. Koesel-Verlag Muenchen.