The Urban Cliff Hypothesis and its relevance to ekistics

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The Cliff Ecology Research Group (CERG), Department of Integrative Biology, University of Guelph, Guelph, Ontario, Canada, has been in existence since 1985 when its members began working on the ecology of the Niagara Escarpment (fig. 1). In 1988 they discovered a stand of ancient trees growing on the cliffs and in 1989 they discovered that in fact the escarpment cliffs support the oldest and least disturbed forest ecosystem in Canada. Individual living trees older than 1,300 years are still present and the forest appears to be in steady state. CERG's work on the ancient trees led to the idea that cliffs serve as refuges for many species including ancient humans. That observation led to the development of the Urban Cliff Hypothesis that is described in this paper and was presented at the international symposion on "The Natural City," Toronto, 23-25 June, 2004, sponsored by the University of Toronto's Division of the Environment, Institute for Environmental Studies, and the World Society for Ekistics, and also led to the recent book entitled The Urban Cliff Revolution.

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Introduction

Throughout human evolutionary history, there has been a continuous interaction between food supply, population size, and dwelling site characteristics. This interaction is driven by two forces:

- first, the underlying physiology, anatomy, and behavior of the human animal; and,
- second, the nature of the environment providing the resources that the humans were dependent on.

This interaction is *human ecology* in the broadest sense. While Ekistics[1] as a discipline is concerned mainly with the science and problems of modern human settlements, the Urban Cliff Hypothesis argues that these current problems and some of their solutions have ecological roots in the distant past (LARSON et al., 2004).

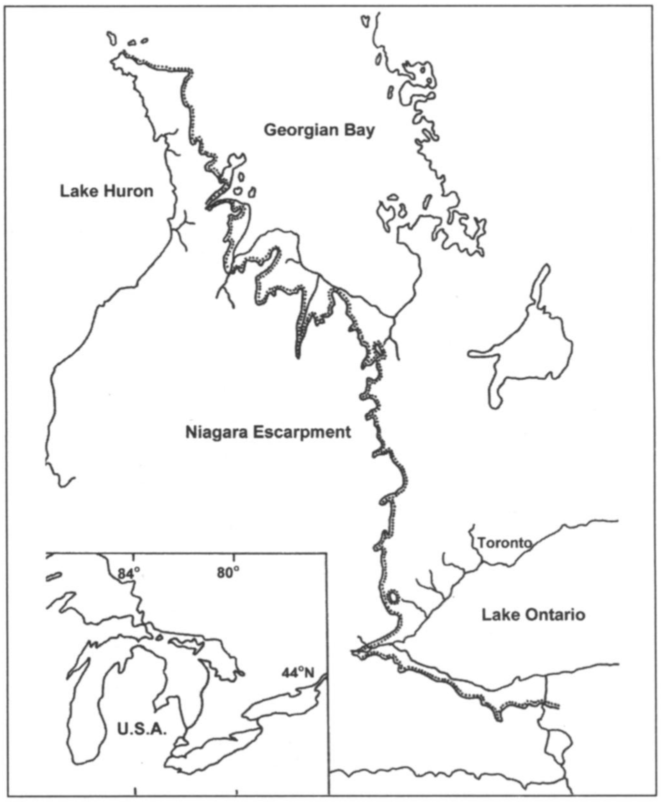

Fig. 1: Sketch map of the Niagara Escarpment in southern Ontario, Canada.

The objective of this paper is to summarize key aspects of the hypothesis and then to show points of relevance to current thinking as it relates to the design, function, location, and restoration of human dwellings. More specifically:

- we argue that the state of basic human ecology has not changed much since the Pleistocene and that many current problems in urban design and management can be solved using ideas generated by the hypothesis;
- we summarize those aspects of human biology that have defined us throughout our evolution;
- we show how these traits meshed with the changing environments in which humans found themselves over the last 1.5 million years;
- we trace the interaction between human animal and dwelling site to the modern era; and,
- we conclude by showing evolutionary connections between the modern condition and the distant past.

The human animal

Humans have not changed much in the past half million years, and even the forms of humans that lived one million years ago were much more like "us" than they were like any other animal living at the time. Body size, brain capacity, bone density, and dentition have all been subject to a long history of close scrutiny by palaeoanthropologists (GAMBLE, 1994; TATTERSALL, 1998). Debates over the names of human species, their evolutionary lineages, and their paths of colonization out of Africa all depend on exploring the smallest details of the differences in skeletons and tools that have been found (JOHANSON and EDGAR, 1996). While we value the huge literature that focuses on these small differences and their importance in reconstructing the pattern of human evolution, when we view humans coarsely we see an African bipedal primate that is a large-brained social omnivore weighing about 50 kg. For a long time humans have been nearly hairless, skin-sweating animals that were not very powerful for their size. These points are exceptionally important because fur is required for effective thermoregulation of mammals, and either strength or agility are needed in the harvesting of resources or in self-defense (SCHMIDT-NIELSON, 1975). Mammals that lack fur must display other mechanisms of thermoregulation if they are to survive climates that are outside of the zone of thermal neutrality (the range of ambient temperatures that produce minimum resting metabolic rates). Sweating through the skin achieves excellent thermoregulation and is more effective when the animal lacks a body covering of fur (MONTEITH and UNSWORTH, 1990). Mammals that lack physical strength or agility must depend on social structures or intelligence to deal with competitors, predators or other aspects of a changing environment.

Real human needs (as opposed to wants) are easily characterized. Food containing energy and nutrients is essential and the amounts needed to sustain basic metabolism are roughly 1,500 Kcal per day. Intense physical activity can increase this need by a factor of two or three. Water is also needed in amounts varying between 2 and 4 liters depending on physical activity. Shelter is needed because the better the shelter, the less food and water is required. Most other primates are social organisms of forested landscapes. Forest habitats provide not only food, but shelter from the sun, from wind, and from nighttime energy losses to the atmosphere. Open ground provides no such shelter.

When the cooling and drying of the planet took place at the end of the Pliocene between four and two million years ago, there was in Africa a pattern of forest contraction and savanna expansion. This ecological trend placed selection pressures on many species to change their habitat interactions, to change their interactions with each other and also to change their food supply. There is still an active debate about the precise timing of the evolution of bipedalism: none of which is ecologically relevant to understanding the opportunities it provided and the costs it imposed.

Bipedalism results in a vast reduction in the amount of direct beam solar radiation to which an organism is exposed. Plant biologists have studied the morphology of desert cacti and have found that erect leafless stems provide a mechanism that reduces heat loading during the day (GIBSON and NOBEL, 1986). Exactly the same kind of benefit accrues to an animal that emerges from the protection of forest cover and forages in open savanna with little protection from the sun. In addition to reducing solar radiation loads, an erect stature also allows for a more effective evaporation of sweat from the skin and therefore better thermoregulation (provided that water is available to drink). Bipedalism also increases the ability of an animal to gain greater distance views across habitats and thereby the trait provides some protection against competition and predation. In forested environments, escape into the canopy provides protection from competitors and predators. Lastly, bipedalism frees up one complete set of limbs for non-locomotory functions.

Despite the benefits of bipedalism, there are costs associated with it as well. Principal among these is that an erect stature causes rapid body cooling when the sun is not shining. Therefore energy balances made positive during daytime periods quickly become negative in the dark unless shelter of some form is sought.

The expansion of savanna environments in east Africa not only increased the opportunities to early humans, but to large numbers of other granivores and their predators as well. Gamble (1994) has argued, and we have shown (LARSON et al., 2004) quantitatively that savanna environments are vastly more productive for humans than any other kind of terrestrial habitat that we could exploit. The huge advantage of savanna is offset by the risks imposed by the high density of predators that live there as well and hence the problem of seeking appropriate shelter arises again.

The changing opportunities for shelter

For arboreal primates, shelter is virtually available everywhere. Despite the low productivity of arboreal environments for primates, protective cover existed everywhere and therefore environmentally, competitively, or predator mediated mortality was probably low. Exactly the opposite was likely true following the transition to savanna living 1.5 to 1.0 million years ago. Productivity for human ancestors increased by more than one order of magnitude, but so did the risks of mortality directly from heat, cold and drought, as well as mortality from competitors and/or predators. Shelter was therefore absolutely essential (PFEIFFER, 1972).

Available shelter sites for 50 kg bipedal mammals, however, were few on savannas. Trees were short, isolated and unsuitable for significant protection from anything. Soils on level terrain were derived from volcanism and subsequent weathering. Natural cavities that opened to the surface could easily be exploited by burrowing mammals such as hyena, jackal, and large rodents. Humans were too large and ill equipped for the digging of dens in soil. There is no evidence in the literature of den digging by human ancestors in the time period. The rapid weathering of large savanna landscapes exposed to volcanism did, however, lead to the development of erosion pathways, wadis, and river canyons. This erosion also formed the development of rocky shelves along the margins of the watercourses and these rocky shelves included large caves and

Fig. 2: Early human occupation sites along the upper reaches of the Danube River and its tributaries in southern Germany allowed people to have the protection provided by caves (a, above) while also providing them with a commanding prospect view of the landscape (b, on the opposite page). Fertile riparian zones supplied water and food in abundance. (*Source:* Photographs by D. Larson).

overhanging rock shelters (LARSON et al., 2000).

While rock shelters were certainly not perfect refuges from climatic and biological stressors, they were nonetheless relatively permanent and abundant relative to the numbers of humans who lived at the time. In addition, water and grazing animals (some of the other *needs*) were usually close by.

Human use of rock shelters

The evidence of the human exploitation of rock shelters as either permanent or temporary dwelling sites is overwhelming. There is evidence that all species and subspecies of humans used rock shelters during the time period from 1.4 million to roughly 40,000 years B.P. No evidence of tailored clothing exists before this time period either. In fact, no reliable evidence exists *anywhere* in the anthropological literature to suggest that humans had the capacity to create a "built" environment (either huts or clothing) until 40,000 years ago. An early claim by De Lumley (1969) that *Homo erectus* had built shelters out of rocks, poles and tree branches has largely been dismissed. From all the available evidence then, we can conclude that humans were forced to use naturally occurring shelter sites for most of their evolutionary history.

Rock shelters provided escape from solar radiation, high air temperatures, wind, rain, snow, dust/volcanic ash, competitors, and most predators. They usually existed on elevated parts of the landscape where they could be easily seen and readily accessed. They were easily defended against competitors and predators since gravity benefited the occupants of the cave when they were threatened. Rock shelters also provided raw materials for tools and simple niches for the storage of foodstuffs. We also know from an exhaustive review of the literature, that most of the plants and animals that are currently commensal with humans, or that have been exploited in agriculture, were organisms that were once endemic to rock outcrops, talus slopes, and cliffs. Lastly, the rock shelters that sat high above river courses would provide the occupants with both a sense of refuge and commanding views of the landscape at the same time.

We will return to the idea of refuge and prospect view below. For now, the important thing to realize is that rock shelters at the bases of cliffs allowed the occupants to look out onto a riparian landscape where food and water were both essentially "flowing" by the dwelling site (figs. 2a and 2b). This is the opposite of the current theme of drive-in fast food restaurants. It is also important to realize that this model of the human dwelling site persisted for what amounts to 97 percent of the time that "humans" have been on the earth. The importance of this

Fig. 2 (cont'd).

is huge within the context of Wilson's Biophilia Hypothesis (WILSON, 1984). In essence, Biophilia proposes that the many human psychological reactions to other species, as well as to landscape, beauty, odor, sound etc. have an evolutionary foundation. There is considerable remaining debate over the Biophilia Hypothesis because it presumes that a certain proportion of the human mind is driven by nature (i.e. by genetics) rather than by nurture (i.e. by learning and culture). We have recruited Wilson's idea to the Urban Cliff Hypothesis by arguing that human existence was cast within a rock outcrop environment for at least 97 percent of the time we have been evolving on the earth. Given this vast evolutionary experience, we think it at least *possible* that our current concept of the appropriate form of rooms, houses, villages, towns, and cities in the modern world has been sculpted by this evolutionary experience.

The built environment

For the bulk of this time, the habitable rock shelters and river canyons in which they occurred were more abundant than the humans that occupied them. Estimates of human population sizes in prehistory are very unreliable but some have estimated the total human population in France before the dawn of the last ice age was in the range of 30-50,000 people (GAMBLE et al., 2004). Only several hundreds of people are thought to have inhabited Great Britain at this time (SMITH, 1992). No one knows the events that resulted in the final exodus of modern humans from Africa between 100,000 and perhaps 60,000 years ago but, at some point in time, human population size was large enough to make it difficult to find unexploited rock shelters even in the south of France, Spain, Italy and other Mediterranean countries. Even if modern humans did not *invent* "architecture" to solve this problem about 40,000 years ago, when this capacity to *build* actually showed up on the scene, there was no longer any population size limitation imposed by the number of dwelling sites. Dwelling sites could be made anywhere, could be made quickly, and could even be transported. What is more, the capacity to *build* solved the real problems associated with cave living – the accumulation of waste and the distance between the resources and the dwellings. Buildings with good design allow all of these problems to be solved at once.

The earliest built dwellings such as those at Dolní Věstonice (40,000 years B.P., GLADKIHM et al.,1984) (fig. 3) all involved multiple dwelling units with functions that were partitioned between the units. Such built structures appear in increasing numbers from 40,000 to 9,000 years B.P. when the first cities were formed. Cooking, food storage, animal containment, and sleeping areas were all separated. This separation of activities is also observed in the grass huts found at Ohalo II (fig. 4) along the shores of the Sea of Galilee (23,000 years B.P., NADEL, 2003; BELMAKER, et al., 2001) and at Tabun Cave, Israel (fig. 4). All of these structures appear to have been built to allow the humans to position their dwellings as close to their essential resources as possible without giving up the advantages of prospect view and refuge provided by real rock shelters. These earliest dwellings may also have provided the vast array of commensal and mutualistic plants and animals with sites for their own proliferation. House mice, black rats, pigeons, hedgehogs, barn owls, and wildcats all proliferated in this environment. In addition, a large array of grasses and forbs flourished in the disturbed land around the first encampments. Many of these (as it was discovered by hunter-gatherers) were edible whether they grew wild in the hills or grew in the refuse and nutrient rich patches around the camps.

In the time period from 20,000 to 10,000 years B.P., agriculture as we know it did not exist, but many of the species that were eventually recruited into agriculture were present and exploited by people. The central importance of some of these species is only being realized now. A recent study by Vigne et al. (2004) has pushed back the association of the *Felis domesticus* (=*Felis silvestris*, the European wildcat) with humans from 3,500 years B.P. to 9,500 years B.P. Vigne argues that the housecat was revered by humans at this time since wild grains that were harvested but then stored in primitive dwellings would have been easy prey for the growing populations of rock doves, mice and rats that had already taken advantage of human encampments.

The full development of modern agriculture that started about 10,000 years B.P. in the old world and about 7,000 years B.P. in the new world provided enormous opportunities for human population growth. After this time, there was little increase in the use of natural rock shelters. The capacity to create artificial structures that had all of the benefits of natural rock shelters but none of the detriments made it possible for people to manufacture (using stone, mud bricks or wood) perfect sites that provided refuge and prospect views at the same time. Such structures are now universal in human societies.

Architecture

The goal of architecture at the small and large scale is to manufacture refuges for humans at a number of scales – the individual, family, and extended society (RUDOFSKY, 1977). Human existence has two basic phases – the collection of resources needed for living, followed by the consumption of those resources. Since we are omnivorous animals, the collection phase is governed by the behavior of plants and animals that live outside. If the foodstuffs are fully wild, architecture is not needed. If the foodstuffs are cultured or domesticated, some form of refuge is provided to them as well (a field, net, enclosure, barn, etc.). In the consumption phase, refuge is needed to keep competitors and predators at bay and to increase the comfort while the resources are being consumed. But neither the refuge nor the comfort can be absolute – "individuals" need their "family" groups, and "families" need their "societies." Hence, refuge for one can deny comfort for another. This brief summary suggests two quite independent components to architecture:

- The first is *efficiency* (usually defined in economic terms); and,
- the second is *comfort.*

- **Efficiency** in the form of massive high-rise apartment buildings might be measured as the persons/sq.km, or persons/tonne of concrete and steel. But the experience of architects and town planners in the world's largest cities has shown that maximum efficiency of construction does not produce maximum benefit to the residents (SAMUELS and PRASAD, 1994).
- In particular, **comfort** (especially psychological comfort) within one's own dwelling might include massive electronic security systems that *increase* the sense of peace within the dwelling while simultaneously *decreasing* the sense of peace outside of the dwelling space.

Optimum dwelling architecture must clearly deal with a tradeoff between these conflicting values.

Application of the Urban Cliff Hypothesis

The Urban Cliff Hypothesis argues that, in our evolutionary past, there was a configuration of dwelling spaces that provided this optimal tradeoff between efficient and comfortable use of space to small clusters of people. This configuration

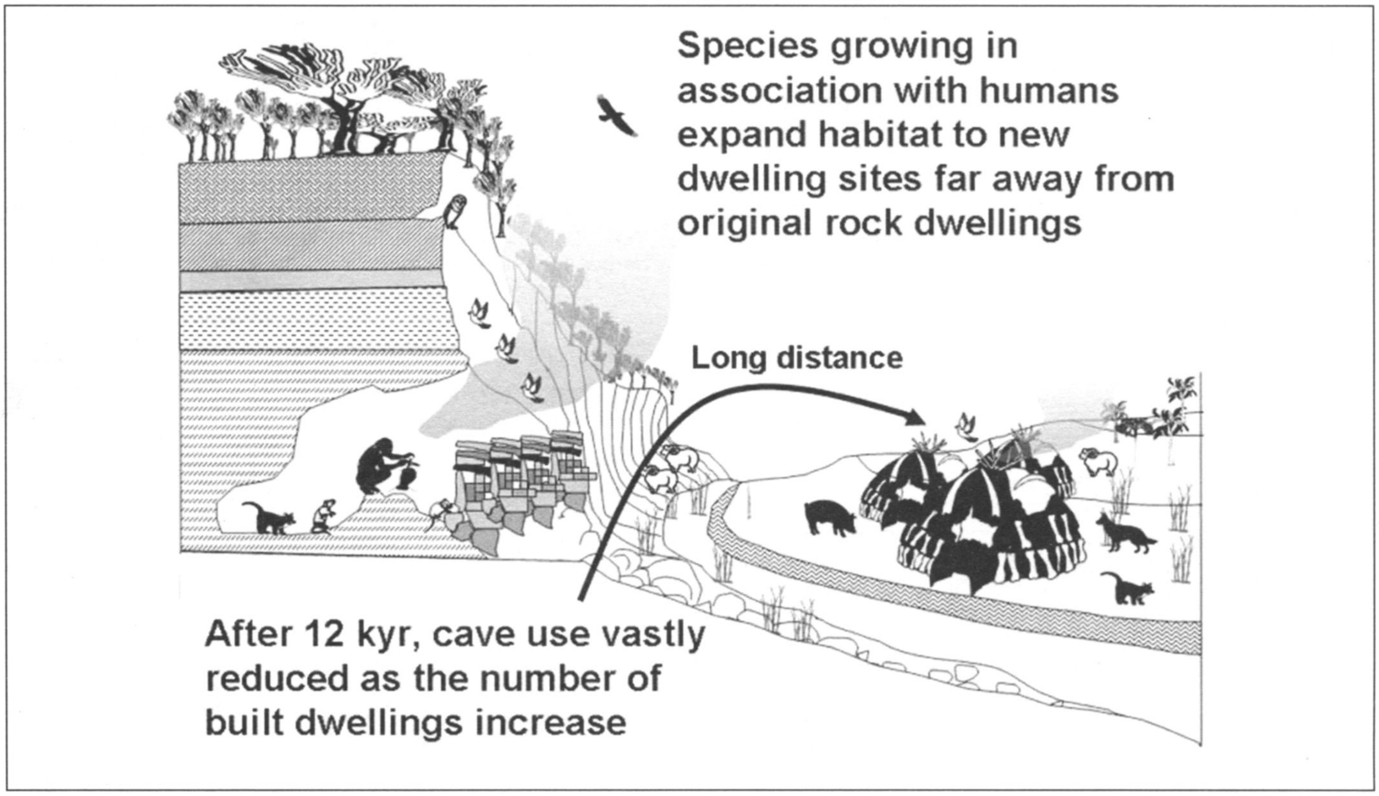

Fig. 3: Sketch of natural rock shelter with associated inhabitants, along with a sketch of the mammoth bone structures that represent some of the first built dwellings.

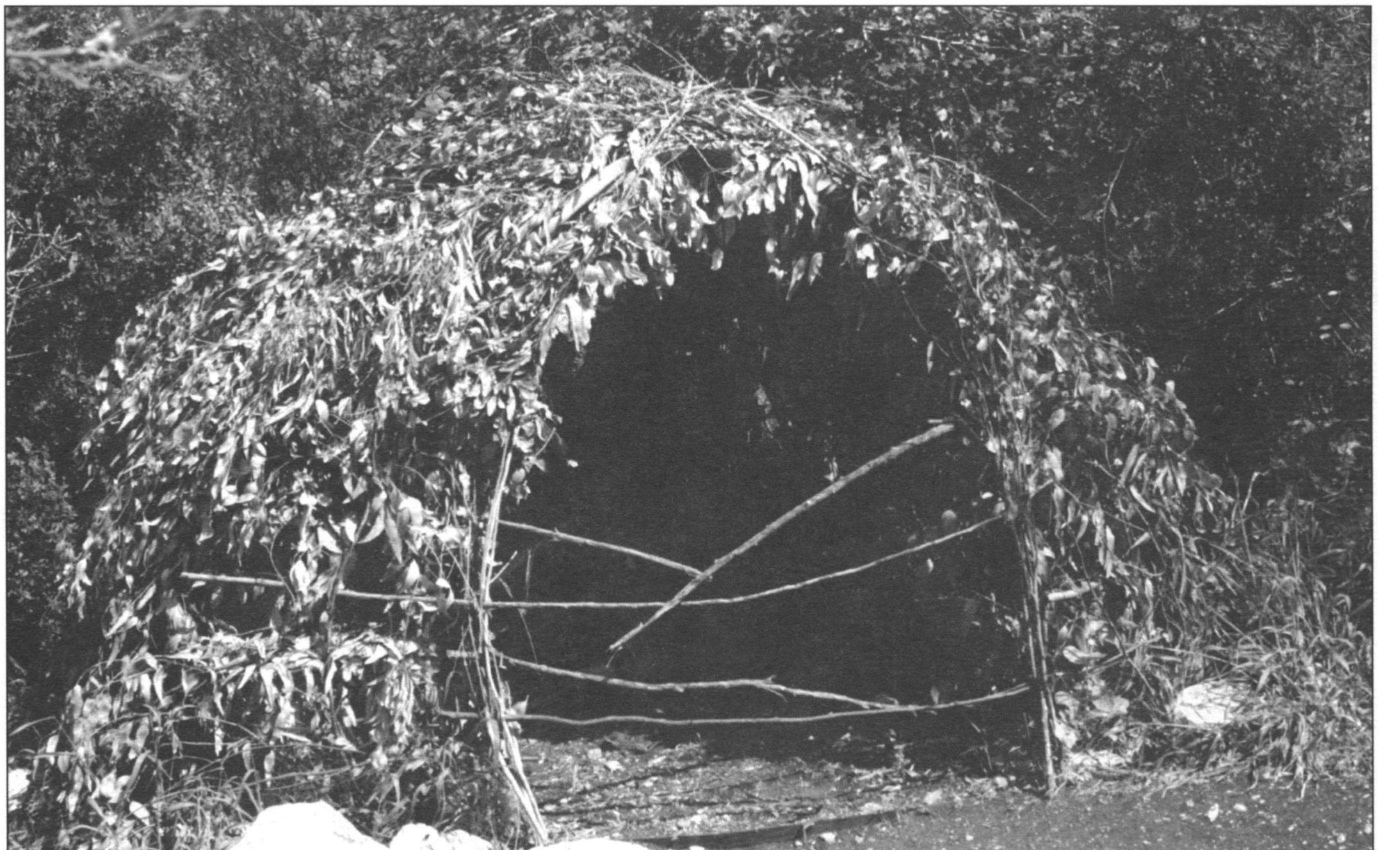

Fig. 4: A reconstruction of a Natufian dome-shaped grass and wooden hut at Tabun Cave, Israel. Such huts were also built at Ohola II on the shores of the Sea of Galilee about 20,000 years B.P. (*Source:* Photograph by D. Larson).

was in place for about a million years before the first wall was ever built or hut constructed (GAMBLE, 1994).

The Hypothesis then argues that, in the first phase of the built environment, this optimization of efficiency and comfort was copied over into many of the structural features of the first buildings. These copies included the following:

- **First,** the use of building materials that offered the greatest sense of "permanence" within the limits of cost and within the limits of the amount of time the occupants intended to reside in the structure. Stone huts were therefore not used by nomadic tribes unless their migration routes were repeated.
- **Second**, the division of the space into subunits that allowed for a division of function: cooking areas, food storage, sleeping, animal containment.
- **Third**, a connection of the individual family unit to other family units was provided in an open communal space that was nonetheless sheltered (at least in part) from the environment. In caves, this was provided by the space around the main hearth behind the dripline of the overhanging cliff, but in the built environment, the same functions were provided by foyers, plazas, cloisters, and courtyards.
- **Fourth**, this small group of family units had access to a flow of resources. In the natural rock shelter, this was represented most often by a riparian zone across which flowed water and associated plants and animals that were used for food. In the built environment, the "resource river" was often an array of merchants or vendors that would move across the communal space making their products available for residents.
- **Fifth**, the natural rock shelters were always rich in vegetation. In the built environment today there is no denying that the incorporation of microhabitat suitable for the growth of trees and other plants (both indoor and outdoor) is an essential feature of comfortable dwelling spaces for individuals, families and societies.

The Urban Cliff Hypothesis argues that the modern built environment should recognize its roots in its rock shelter past and do this by incorporating a sense of ancient landscape into building design. This does not mean that stone should be used for construction or that concrete should be poured to look like rock. Rather, it means that the division of the built space into functionally separate components should reflect both the need to use the space efficiently and comfortably at the same time. Part of this comfort is based on the need for people to feel protected from nature and from each other while at the same time feeling connected to them both. The automobile and the system of modern roadways that forms a menacing network around the world actually discourages people from making direct human contact at the local scale. Town planners that advocate the proliferation of big-box stores are unwittingly moving the "resource flow" areas outside of the places where people live. Landscape planning, from the point of view of the Urban Cliff Hypothesis, should reemphasize the value of foot traffic and the local provision of "resource flows" so that people are able to maximize their entire standard of living.

Conclusion

In conclusion, the Urban Cliff Hypothesis argues that we are a species that has evolved from rock outcrop exploiting ancestors and that our attitudes and feelings about the built environment have ancient evolutionary roots. In addition, the flora and fauna that form the bulk of the urban and suburban landscapes are themselves largely rock outcrop species that are simply exploiting the rock shelters that we have constructed of wood, brick, stone, glass and steel. If this evolutionary heritage can be accepted, and especially if it can be accepted that the human use and enjoyment of architectural space is something that is under our control, then it becomes possible to construct dwelling sites, workplaces, villages, towns, and cities that create both efficient and comforting environments at the same time. Such architectures may be more important than ever in the 21st century in view of predictions that another two billion persons will need to be accommodated in the next 25 years.

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Editor's Note

1. "We cannot acquire proper knowledge about our villages, towns, and cities unless we manage to see the whole range of the man-made systems within which we live, from the most primitive to the most developed ones – that is, the whole range of human settlements. This is as necessary as an understanding of animals in general is to an understanding of mammals – perhaps even more so." (*Source*: C.A. Doxiadis, "Ekistics: The Science of Human Settlements," *Science*, 23 October, 1970, vol. 170, no. 3956, p. 393).