ISOLATION TRENDS OF URBAN OPEN SPACES

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ABSTRACT:

Urban open spaces are invaluable assets in maintaining ecological health in a highly developed urban matrix. Unfortunately, habitat values and ecological quality of these areas are often challenged by consecutive urbanization. The assessment of changing structure and function of an urban open space system is crucial in maintaining livable cities. General characteristics and types of open spaces are investigated in two case studies - one from a developed and another from a developing country. Also, the possible impacts of urban landscape change on the ecological qualities of natural open space patches are explored by using a landscape structure indicator. Even though various conceptual and analytical approaches exist in measuring the ecological integrity of natural systems, this paper specifically deals with isolation issues. Because an isolated open space system loses its ecological integrity, isolation index yields meaningful results for anticipating the possible threats generated by urban structure. Isolation trends of urban open spaces are displayed. Also, numbers yielded by the isolation index are presented. GIS seems to be an appropriate tool to evaluate the intricate attributes involved in the phenomenon. Black and white aerial photographs of the City of Phoenix, Arizona from 1978, 1988 and 1998 are utilized. Also, black and white aerials of the City of Aydin, Turkey from 1977 and 1993 and an Ikonos 2002 image are used for the analysis in ArcGIS 8.3 environment. Comparison of two cases yields some eye-opening facts with regards to the planning and management of urban open spaces, and possible threats to the ecological viability of these precious areas in the future.

1. INTRODUCTION

1.1 Urban Open Spaces

Urban open spaces are vital part of urban landscape with its own specific set of function. Open spaces (natural or man made) contribute to the quality of life in many ways (Burke and Ewan, 1999). Besides important environmental benefits, these areas provide social psychological services, which are critical for the livability of the city and well being of urbanites (Chiesura, 2004). Thompson (2002) sees open spaces in cities as places to celebrate cultural diversity, to engage with natural processes and to conserve memories.

The definition of open spaces evolved in time embracing all types of opportunities to suit the varying outdoor needs of human beings and needs of plant and animal species. Nowadays, the concept of "open space" in complex urban matrix is not limited only to the urban parks and preserves but also non park-non natural- places. Public spaces such as streets, school yards, outdoor sport complexes, cemeteries, and public squares are important open spaces (Hall, 1998). These areas are open to full spectrum of the society and their sound planning and design make them more attractive. Baines (1999) recognizes the value in waste lots, the derelict, gap sites awaiting redevelopment but not currently managed. Non natural places such as railways, highway right of ways, canals have functional values. According to Thompson (2002) these areas are indeterminate areas of open space and these function specific spaces are as much necessary as decorative parks. Ecologically sound planning and design of such spaces aids in establishing ecological networks (Cook,2000, Cook 2002) in the urban matrix. Chiesura (2004) suggests taking into account the variability in the open space types to fulfill the needs and expectation of all the segments of the population. Accordingly the understanding of the characteristics of different types of open spaces in an urban matrix may guide local authorities in the long term planning process. The assessment of change in open space system is equally important to take measures in maintaining livable cities.

This study aims to investigate the characteristics and the types of open spaces in two cases from a developed and a developing country. It also aims to measure the possible impacts of land use change on the ecological quality of natural open space patches. Even though various conceptual and analytical approaches exist in measuring the ecological quality (Forman,

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1997, Forman and Godron, 1986), this paper specifically deals with the isolation issues.

1.2 Isolation of Natural Habitats

Isolation is the typical outcome of habitat fragmentation. The more isolated the system, the lower the ecological value due to increasing constraint in materials and energy flow. This means an isolated system loses its structure and function. Moving from patch to patch, species are inhibited by large distances between patches in a highly developed urban matrix. Subsequently, biodiversity diminishes in small and isolated patches, hence diminishing ecological integrity.

Fragmentation occurs when a large habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of different habitat (Young and Jarvis, 2001). The unfavorable outcomes of fragmentation have been well documented for plant (Jacquemyn, Butaye and Hermy, 2003) and animal species (Rickman and Connor, 2003). Great volume of literature is dealing with species composition in fragmented forest (Hill, and Curran 2001), or rural landscapes (Merriam, 1984). Research on urban areas are relatively less, this is, may be, because in many urban landscapes the land is transformed so much that the open spaces no longer possess natural attributes. Connectivity of isolated patches is suggested as a remedy to the adverse effects of fragmentation (Noss and Harris, 1986, Soule, 1991, Cook, 2000). Ecological networks are offered as a suitable approach to improve the ecological value of urban open spaces (Cook, 2002, Cook and Van Lier, 1994). Variety of landscape structure indices exists for measuring a landscape's state (i.e. perimeter/area ratios, matrix utility, degree of naturalness, connectivity etc.).

The relationship between each individual patch and its surrounding land uses is analyzed through isolation index. Isolation index concerns the spatial arrangements of open patches, and, specifically, the distance between the adjacent open spaces. The location of patches relative to one another and the distances between nearest neighboring patches are not only important expressions of arrangement in a land use pattern, but also a good indicators of ecological quality in habitat patches.

2. METHOD

2.1 Study Area

The methodology in this work involved a multiple case study of the City of Phoenix, Arizona and the City of Aydin, Turkey. The study area of the first case extends from the Bell road (north) to Chandler Road (South). Scottsdale Road and the 35th Avenue define the eastern and western boundaries of the area of analysis. The total study area is approximately 897370 ha. The population of the town increased 54% in 30 years (1970-2000). The City of Phoenix is centrally located in the Phoenix metropolitan area that receives migration from colder areas of the US. In addition to mild winter climate, interesting desert landscape attracts people to this region.

The study area of the second case, the City of Aydin is located in the Aegean region of Turkey. The study area here is limited to the extension of the urban area (2195 ha.) in the 2002 city plans. The population rise was 67% between 1970 and 2000. The main contributor of this increase is the transformation from agricultural community to industrialized one and the improvements in the service sector. Mild climate of the area is pleasant but not a factor in the development. In both cases, the municipalities put a great deal of effort in promoting quality of life. However, in terms of the urban open spaces, their effort is undermined by the historic land use development. For instance, the species loss was documented in the South Mountain Preserve, the largest urban park in the US (Daniel and Butterwick, 1992). A research by Esbah (2001) showed that the ecological values of the mountain preserves changed due to historic land use pattern in Phoenix.

2.2 Materials

Black and white aerial photographs of the City of Phoenix were obtained for 1978, 1988, and 1998. The aerials were on a 1"=200' scale. Similarly, in the case of Aydin, a set of aerial photographs from 1977, 1993, and Ikonos image from 2002 were utilized. Some ancillary data such as city plans and pictures, historic documents and information from previous researches also assisted the analyses. Aerials of Phoenix were georeferenced by using the Maricopa County Association of Governments street cover, and Aydin's were georeferenced by using already rectified Ikonos image. Land use polygons were created for different types of open spaces, and attributes of each polygon were entered manually. Subsequent spatial analyses were conducted in the ArcGIS 8.3 environment.

2.3 Analyses

The analyses involved two phases: First, general characteristics and types of open spaces in both cases were defined. Main categories of open lands investigated in this study is listen in Table 1 and Table 2. Also in this phase, the magnitude of change in the urban matrix with regards to open spaces was investigated by using aerial photographs and GIS technology. Second, isolation trends of urban open spaces were studied. In this step, the employment of a landscape structure index, an isolation index, was crucial. (Forman, 1997, Cook, 2002).

The formula for the isolation index is:

$$R = \frac{1}{N} \sum d_{ij} \qquad (1)$$

where R= isolation ratio
N= number of natural pat ches
d_{ij} = distance (patch i and neighboring patch j)

Higher the isolation ratio the more isolated the system, hence diminishing ecological quality. Isolation index concerns only the natural patches of certain size. For instance, in Phoenix' case, the mountain preserves and desert parks and those areas that are not disturbed were used in the analysis. The rest of the non-natural open space types were excluded. In Aydin's case no suitable patch, fitting this description, exists. Therefore the isolation analysis was conducted only in the Phoenix's case.

3. RESULTS

3.1 Open Space Characteristics

Case of the City of Phoenix: The overall open space system, including natural and non-natural patches, experienced substantial structural and functional change in the City of Phoenix. Table 1 displays the amount of change in different types of open spaces. 55% of the study area was covered by open spaces in 1978. The percentage of these patches in the urban matrix dropped to 44% in 1988 and to almost 37% in 1998.

Agricultural areas decreased progressively from 1978 to 1998 in the urban matrix. Total of 44382,12 ha. of agricultural land was lost to urbanization in a 30 year period. However, their ratio in the whole open space system does not follow a linear drop. The results indicate that, after 1988 the speed of agricultural land loss slowed down, and that urbanization pressured natural and open patches more.

Open Space Type	1978 (ha)	1988 (ha)	1998 (ha)
Agriculture	98899,98	63562,78	54517,86
Airport	8385,23	8369,4	8369,4
Commercial	943,61	1285,46	1431,96
Drainage	15391,79	15470,64	14956,99
Golf	8400,25	14973,93	18370,41
Military	719,22	719,22	719,22
Natural	247406,06	180326,86	148927,89
Open patch	86772,71	70642,95	36398,15
Park	6236,59	11874,77	13671,16
Public	2742,79	3045,68	3814,28
School	5415,68	6193,84	6571,38
Sport	850,36	1233,7	1750,77
Transportation	5287,44	13223,96	17189,61
Vacant	11191,38	9925,6	4161,94
Open space (TOTAL)	**498643,09**	**400848,79**	**330851,02**

Table1. Change in the open space system of Phoenix

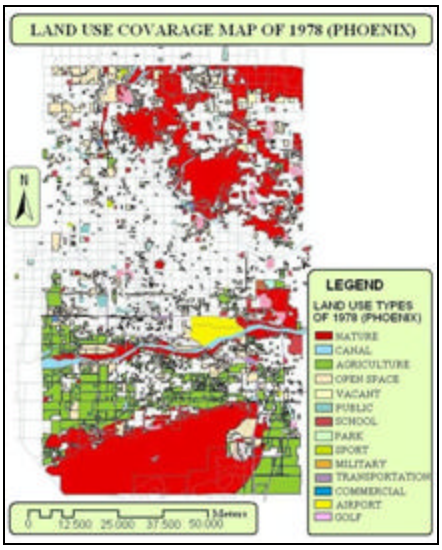

Figure 1. Distribution of urban open spaces, Phoenix, 1978

Overall, the percentage of natural areas in the urban matrix dropped from 27,5% to 16,60% between 1978 and 1998. Mountain preserves and desert parks are the core elements of natural patches. The City of Phoenix established the first mountain park, South Mountain Preserve, in the south of the city limits in 1925 as an urban park. The second preserve, the

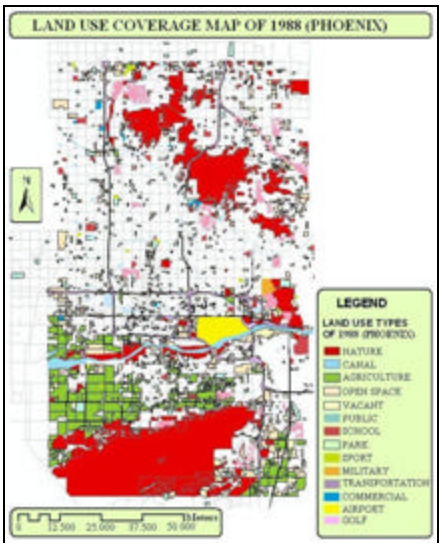

Figure 2. Distribution of urban open spaces, Phoenix, 1988

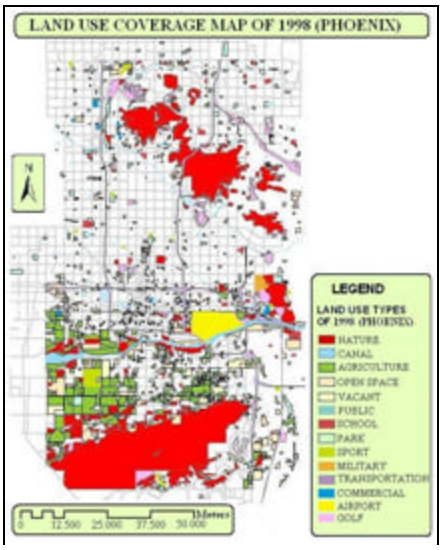

Figure 3. Distribution of urban open spaces, Phoenix, 1998

Phoenix Mountains Preserve, was announced in mid-70s. Towards 2000, the City established a third preserve, the Sonoran Preserve, in the northern portion of Phoenix- near the towns of Carefree and Cavecreek. The study area includes the surrounding areas of first two preserves (Figure 1, 2,3). The establishment of urban preserves and desert parks early in time was a sound approach. These areas are the only places that are not infested by development. The change in their surrounding and the isolation of these ecologically invaluable areas are evident in the figures.

Continuous increase exists with respect to the area of golf courses and urban parks. 9970,16 ha. of land was converted into golf courses between 1978 and 1998. The increase of these areas is an indicator of recreational tendencies as well as local government's policy to attract tourism revenues. Played year around, golf is one of a major attractions of Phoenix metropolitan area. Especially, the utilization of washes and creeks as linear stretches of golf courses is common. Ecological suitability of this approach is questionable.

Because of the quick pace of urban encroachment on natural patches and also hectic urban life style, municipalities try to bring nature into this developed matrix through urban parks. These man made environments could not replace the functions of natural patches. Nevertheless, their social and psychological benefits are well known. Thus, the number and amount of parks increased during time, so did their share in the open space system (from 1,25% to 4,33%) in 30 years.

As elaborated before, potential of any kind of open space patch (natural or non-natural) should be considered in creating livable cities. Therefore, green commercial patches, military areas, school yards, and sport complexes are included in the research. As the demand for these services escalated due to increasing population, the combined ratio of these areas in total open space system went up from 21%in 1978, to 31% in 1988 and to 43% in 1998. Even though their share in open space system was considerably high, the volume of these facilities were constituted only 1,1% in 1978, and 1,59% of the urban matrix in 1998. Additions to existing facilities would offer necessary services to increasing volume of people. But their design should consider Forman's (1997) ecological quality attributes, if these areas were to contribute to the environmental qualities of the urban matrix. Similarly the design of transportation lines and drainage or water ways are important. Such landscape elements possess various corridor functions. Most examples do not exhibit sound design of these structures that is sensitive to habitat requirements of species. The results of this work showed that the amount of such artificial corridors increased in Phoenix. As the urban matrix became more developed and sprawled, the need for these elements esccalated. In Phoenix's case, the integration of such stretches into ecological network requires re-evaluation and innovative design of them to equally include the habitat requirements of species other than humans.

Construction sites and patches carrying the first signs of development are assessed under 'vacant' category. The results indicated that the study area was occupied by development for so long that the vacant lots were becoming scarcer each period. The amount of vacant lots dropped from 1,25% to 0,46 % between 1978 and 1998. It was visible on the aerials that not much space left for building development.

3.1.1 Case of the City of Aydin: Open space pattern of Aydin changed due to historic land use development as well. Open spaces shrank continuously from 73,5% in 1977 to 55,1% in 1993, and to 42,6% in 2002 (Table 2). Agricultural areas are the ones affected by this transformation the most, because the urban area is originally located on an agricultural landscape (Figure 4,5,6). Amount of agricultural land decreased 45,3% between 1977 and 1993; the decline continued with an accelerated rate of 54,3%in the 1993-2002 period.

Open lands of derelict and gap sites diminished too. The percentage of such patches were constituted the 6,8% of the study site in 1977, and 3,6% in 2002. The historic land use pattern is very compact and not sprawling in the town. Because traditional land use development practice tended to utilize these areas before the city extended its planned boundaries, the magnitude of these openings in the landscape dropped. However, the urban expansion style is being influenced by the examples from developed countries, and suburbanization is entering the local planning agenda lately. Understanding of the positive and negative aspects of suburbanization and its implementation in the Turkish context is necessary.

Open Space Type	1977 (ha)	1993 (ha)	2002 (ha)
Natural	37,1	27,8	18
Natural Drainage	13	5,7	4,1
Canal	2,4	6,7	7,9
Agricultural	1.241,10	679,1	310,2
Open Space	149,5	158	79,8

Vacant	35,4	109,6	131,4
Public	39	88,3	159,5
School	18,6	35,7	50,3
Park	5,9	10,8	23
Sport	4,7	6,1	12
Military	34,3	35	34,7
Transportation	13,2	23,8	72,6
Industry	17,3	18,9	27,2
Archeological	2,8	2,8	30
Open space (TOTAL)	**1.614,30**	**1.208,50**	**961**

Table2. Change in the open space system of Aydin

Because it was already a cultural landscape of heavy agricultural practices, the study site did not contain ample natural patches. Therefore, from the beginning year of the analysis natural patches' share in the overall open system was very low (2,30% in 1978 and 1988 and 1,87% in 1998). The existing natural patches are the extension of mountainous natural landscape on the north of the town. The city was not able to extend that direction due to the rugged characteristics of the landscape, and the cost of bringing infrastructure. The potential of this natural landscape on the north should be recognized as a source area and the dispersal opportunities of their natural qualities into urban matrix should be searched.

The City of Aydin puts a great deal of effort similar to the City of Phoenix in bringing nature to the urban landscape through parks. Thus, the number of parks increased gradually. However, their contribution in the open space system was, and is, very low: these areas constituted only the 0,37% in 1977, and 2,30% of the system in 2002. Site visits and the park statistics yielded the fact that these parks were very small in area and dominated by extensive impervious surfaces, and many exotic plant species. Sustainable and ecologically sound design of urban parks is very crucial in Aydin, because these very small and peculiar in shape patches are the only elements in urban landscape offering interactions with near natural environments.

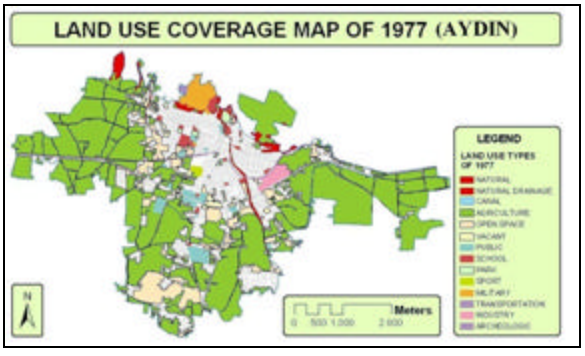

Figure 4. Distribution of urban open spaces, Aydin, 1977.

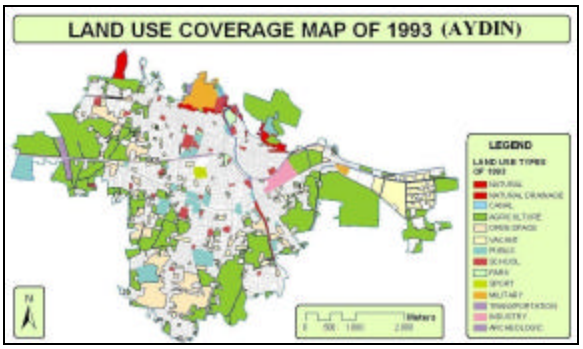

Figure 5. Distribution of urban open spaces, Aydin, 1993

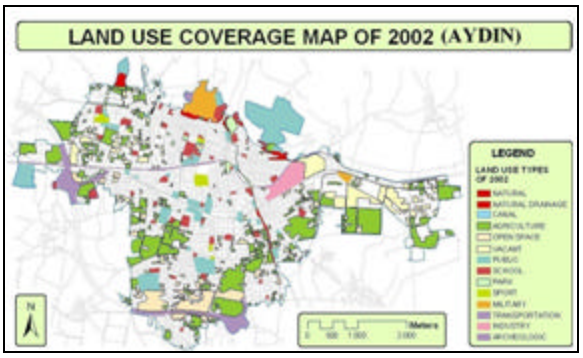

Figure 6. Distribution of urban open spaces, Aydin, 2002

These parks are mostly on a neighborhood park scale. A large urban park and even a preserve in the northern section may be the first steps of improving ecological networks in the city. The opportunity should be seized with other type of open spaces as well. The non-natural patches of public open spaces such as school yards, outdoor sport complexes, cemeteries etc. hold a great potential in environmental and social enrichment of the city. Especially, the gardens and campuses of governmental offices supply an important amount of green space in Aydin. These areas protected from urban development due to their special status. The investigations of aerial photographs showed that, aforementioned spaces make up 5,90% of open space system in 1977 and 70% in 2002.

Urban open spaces are direct expressions of governmental and municipal policies and investments. Turkey encourages industrialization, and sees cities as sources to trigger economy. This approach changed Aydin's overall physical, social, and economic face. Subsequently, urbanization boomed in the town, this brought many government offices and services as well as trade. From a comprehensive open space point of view, this caused very unsustainable structures of ecological barriers in the urban landscape such as addition of highways and roads, new public buildings, and canalization of old riverbed. As it is the case in the City of Phoenix, the design and coordination of these artificial corridors and patches in the ecological network of urban matrix should be considered in timely manner. Otherwise

80,56% increase in the area of these elements generate nothing but a lack of livability in Aydin's urban environment.

3.2 Isolation analysis

The isolation of the Mountain Preserves, Phoenix Mountains Preserve (PMP) and South Mountain Preserve (SMP) were investigated in this part of the study. The results indicated that the mean distance of the preserves increased continually from the surrounding natural patches between 1978 and 1998 (Table 3). In other words, the habitat values of the mountain preserve environment declined gradually due to isolation. Once continuous natural open system was divided into fragmented patches, and isolation of these patches proceeded during the years.

Phoenix Mountains Preserve		**South Mountain Preserve**	
Years	Isolat. Index	Years	Isolat. Index
1978	.40	1978	1.30
1988	.56	1988	1.34
1998	.77	1998	1.58

Tablo3. Isolation values for the Phoenix Mountains Preserve and South Mountain Preserve

PERCENTAGE OF CHANGE IN ISOLATION INDEX		
Periods	PMP (%)	SMP (%)
1978-1988	40.0	3.0
1988-1998	37.5	17.9

Table 4. Magnitude of change in isolation index values

Further analysis of isolation values (Table 4) shows a very dramatic change between 1978 and 1988 for the Phoenix Mountains Preserve. Open spaces of 1978 displayed larger patches with high habitat values. Urban land uses were not dominating the urban matrix, especially, on the northeast of the study site. By 1988, these land uses inflated and became a dominant structure in the matrix. This trend caused 40% isolation. Between 1988 and 1998, the distinctiveness of remaining patches accentuated. PMP, a few other mountain parks such as Camelback Mountain, and washes are examples in hand. The isolation of PMP from its surrounding was 37.5% in this period. The South Mountain Preserve exhibited a similar pattern. The surrounding landscape of the patch was already fragmented in 1978. The isolation index increased 3.0% between 1978 and 1998. This is a very small change, and yet decline in the quality of the SMP habitat progressed. The period between 1988 and 1998 was subjected to higher degradation (17,9%). By this time more small patches detached from the primary patch with greater distances in between.

The investigation of the overall change in the isolation values of each mountain preserve yielded approximately 48.05% change for the PMP and 48.27% change for the SMP within a 30 year period. As far as in which period the decline was the most, 1978-1988 was the period the PMP experienced the most change, and the 1988-1998 was the one for the SMP. As the findings clearly indicate the ecological integrity of the natural open spaces have changed leaving these areas as highly distinct and isolated patches in developed urban matrix. Recommendations include: considering both content and context of the open spaces in management actions; developing effective land acquisition and zoning plans, and improving connectivity with other open space systems in the regional scale with every possible type of connecting patches of natural and non natural open spaces.

4. CONCLUSION

Urban open spaces are key ingredients in the cities' sustainability. The open space systems of both cases of this study include some natural and non-natural elements, which possess great qualities to diminish the negative impacts of isolation in the urban habitats. Opportunities to increase the variability in the open space types should be embraced to enhance the ecological functioning in these highly complex areas. Even though these two examples are different geographically, sociologically and culturally, and economically, they yield the fact that the urban open spaces are the direct expression of what is on the local and national agenda. Their design and perception is affected by socio-economic policies, mostly, leaving no space for ecological thinking. But if the aim is to create livable cities, the recognition of different types of open spaces, and their contribution in the overall system, as well as their design, should be assessed and evaluated. Concepts such as isolation and connectivity are useful in understanding the dynamics in natural open space systems on a broader-city wide scale. The magnitude of such a large scale and complex work requires the utilization of remote sensing and GIS technology. The analyses of aerial photographs and satellite images by using these technologies help planners and managers in the holistic understanding of intricate details involving in the creation of livable cities.

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