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Full Length Research Paper

Exploring the Impact of Native Plants on Ecological Integrity in Ku adasi (Turkey) Urban Area and its Surroundings

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Urban sprawl and fragmentation of natural habitats are outstanding threats on biodiversity and ecological integrity of natural areas. Ku adasi (Turkey) is a significant town in terms of nearby National Park of Dilek Peninsula-Great Menderes Delta which has a rich biodiversity and with surrounding areas in their natural conditions. Also Ku adasi is a popular tourism destination and it is one of the most rapidly growing urban areas in the district. Therefore it is important to minimize the disturbance to the surrounding ecological structure while this growth is occurring. The main goals of this study are: (a) To identify natural plant species that can be utilized as ornamental plants in Ku adasi Municipality area; (b) To evaluate existence of the natural plant species that are found in some randomly selected urban areas and (c) To make recommendations for Ku adasi to have a well-planned growth which will protect and contribute to the integrity of the surrounding ecology. Three different analyses were performed with randomly selected land cover types to determine vegetation structure: (a) Pervious surface cover, (b) Native woody plants and (c) Structural diversity. The data collected was used to create a habitat value index. The highest three values were found to be agricultural lands (43.2%), graded vacant land (40.2%) and parks (37.4%). On the other hand, the lowest values were found to be streets (20.3%) and ring roads (26.3%).

Key words: Native plants, ecologic integrity, planning strategies, urban ecology, Ku adasi.

INTRODUCTION

Due to fast urbanization, rural and natural ecosystems are increasingly replaced by urban development. Because of this rapid change in the physical environment, urban open areas and green spaces has become an important component of the complex urban ecosystem. For all professionals running projects located in urban areas, the main goal is to introduce ways to minimize the adverse impact of residential development that has already taken place (Barnes and Adams, 1999).

Besides social, recreational, cultural and economic values, urban open and green spaces provide significant ecosystem services. Urban open and green spaces can sequester carbon dioxide emissions, produce oxygen, purify air and water, regulate micro-climate, reduce noise, protect soil and water and maintain biodiversity.

A broad conservation strategy for urban and urbanizing areas should strive to maintain diversity in native plant species while accommodating human needs. If habitat patches become too small, many species will be lost (Wilcox and Murphy, 1985). An effective planning strategy is needed to create and link these isolated patches. The goal is more than just to connect parcels - it is to develop land in a way that allows for the natural distribution of our urban wildlife species (Barnes and Adams, 1999). Protecting the natural areas that are inclu-ded in the town's growth areas is important in that it enable connectivity of natural areas, to let natural areas penetrate within the urban structure and will also provide areas that can be used for recreational purposes.

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Landscape connectivity is the degree of spatial connectedness among landscape elements (Forman, 1995). Landscape connectivity has ecological effects on flows of energy, materials and biological entities. A network of patches and corridors can provide connection among natural elements and help to preserve linkage between different ecosystems (Wu and Hobbs, 2002).

From a landscape perspective, a critical conservation issue involves the contiguity of habitats. Some animals require large areas. Habitat that might otherwise be satisfactory may be unusable if it is too small or fragmented. Similarly, the detailed information about vegetation will facilitate conservation decisions at the neighborhood level.

In any situation, a critical element for developing a strategy for wildlife conservation is the knowledge about the existing vegetation. The available data on vegetative characteristics is significantly important for understanding the numbers and species of animals that can be supported in a given area. Knowing local vegetation can allow researchers to understand the number and species of animals that can be supported in a given area (Shaw et al., 1998).

Ku adasi is a popular tourism district and attracts many people to visit and live there. The result is the rapid growth of the urban areas which causes fragmentation and isolation in surrounding habitat areas. One of the most effective ways to reduce the adverse effects of this progress is to develop planning strategies aiming to contact isolated habitat areas. This can be achieved by promoting the use native plant species in urban areas.

Study area

Ku adasi is a coastal settlement in Aegean region and located at 37° 50' N - 27 15' E (Figure 1). The city is in Mediterranean climatic zone. The Mediterranean climatic conditions are characterized by dry and hot summers and humid and mild winters. The permanent population of Ku adasi is about 50.000. The number increases to 250.000 people in the summer.

The increase in population of Kusadasi between 1960 and 2000 is shown in Figure 2. This rapid growth of the permanent city population will result in a rapid expansion of the city area. The City grows rapidly since it is one of Turkey's popular tourism destinations. This rapid growth deteriorates the ecological value of the natural areas in the outskirts of the town. This growth also threatens the National Park of Dilek Peninsula which is claimed to have the best protected maquis cover in the whole Europe. Also surrounding areas of Ku adasi is significant with its natural conditions.

Rapid growth of the urban areas and human activities in Ku adasi seriously threatens the diverse and rich vegetation within the metropolitan area. This threat needs To be elaborately studied and strategic urbanization projections must be developed carefully.

METHODS

The goal of this study was to quantify vegetation characteristics for certain types of land covers found in Ku adasi municipality area, thereby providing a predictive tool for wildlife management and other land management issues.

For this study, an Ikonos 2004 image is analyzed with ArcMAP 8.3. Most general and representative land cover types found in Ku adasi were defined.

A total of 76 random selected land units and 14 transects of variable length were inventoried for vegetation. Within these sampling units 6.683 individual woody plants were counted, representing 124 woody plant species. The values of vegetative variables for each land cover were then averaged, giving an average value of vegetative attributes for each land cover type.

The analyses focused on three main vegetative parameters: (a) Pervious surface cover at landscape level, (b) Native woody plants at flora level, and (c) Structural diversity at vegetation level. Vegetation is a general term for the plant life of a region; it refers to the ground cover provided by plants. Vegetation is a general term, without specific reference to particular taxa, life forms, structure, spatial extent, or any other specific botanical or geographic characteristics. It is broader than the term flora which refers exclusively to species composition. Perhaps the closest synonym to vegetation is plant community, but vegetation refers to a wider range of spatial scales than that term does, including scales as large as the global.

As pervious surface cover refers to any porous land cover that allows water infiltration into sub-surface layers, impervious surfaces are generally understood to be any material, natural or manmade, that prevents the infiltration of surface water to the underlying strata (Arnold and Gibbons, 1996). The degree of pervious/impervious surfaces has been recognized as a significant environmental indicator of ecological cycles and overall ecosystem well being (Smith, 2000).

An agricultural land is a pervious surface cover. On the other hand, urbanization results in a dramatic increase in non-natural impervious surface cover, including rooftops, paved roads, sidewalks, parking lots, and driveways. This attribute is accepted as an important parameter for ecological cycles. Land cover type is a good indicator in terms of predicting how permeable surface is available for natural processes and possible vegetative coverage. Understanding land cover types is also helpful for wildlife management efforts.

Native flora parameter refers to the existence of native plants in a given area. Preserving native plant communities and using native species in planted landscapes are important strategies for providing habitats for the unique animals that are indigenous to the region. For these reasons, it is worthy to examine the existence of native plant species in different types of urban land covers. Vegetation is classified into two groups in this study: Woody plant species and herbaceous plant coverage. Each individual woody plant species were counted separately in sampling land cover type units. Then the native ones are determined and calculated as percentage. Studies of Durmu kahya (2000) and Çelik (1995) are used to identify native plant species in this region. The coverage of native herbaceous species was noted to field observation form as percentage. Eventually a standardized number ranging between 0 and 1 have been assigned to each land cover type.

Structural diversity describes the variation in the forms of existing vegetation in the study area. The structural diversity value is based on the richness of vegetation layers (Morrison et al., 1992). Richness is a variable that is commonly used in defining diversity; it typically represents the number of different species, or as in this example, number of structural layers within a sample (Whittaker, 1975; Barbour et al., 1987). This is a valuable indicator of the diversity of animal species that a plant community is likely to support. Many animals have specific requirements concerning the

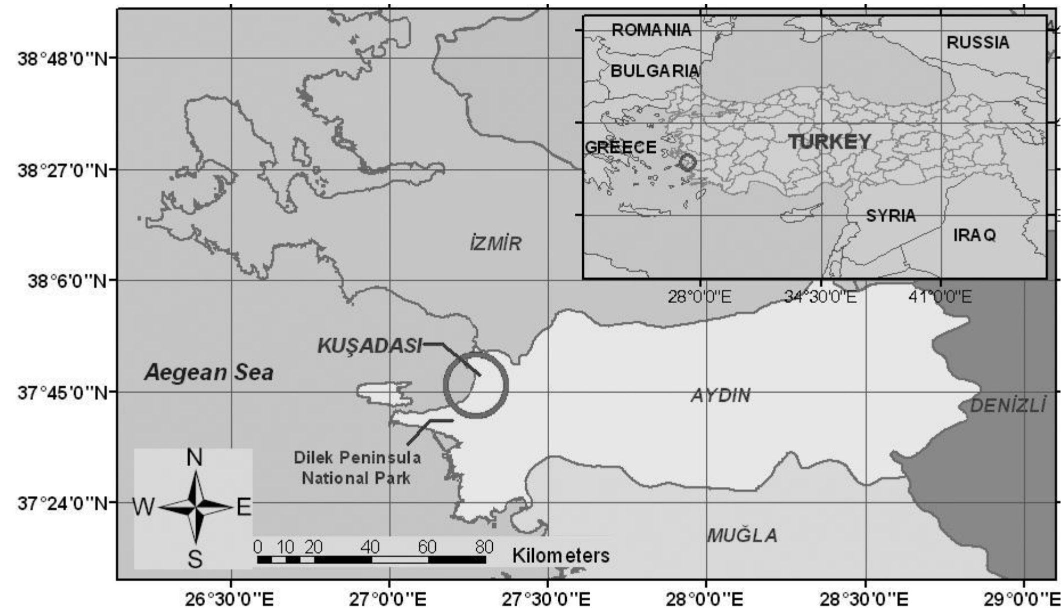

Figure 1. Location of Ku adasi.

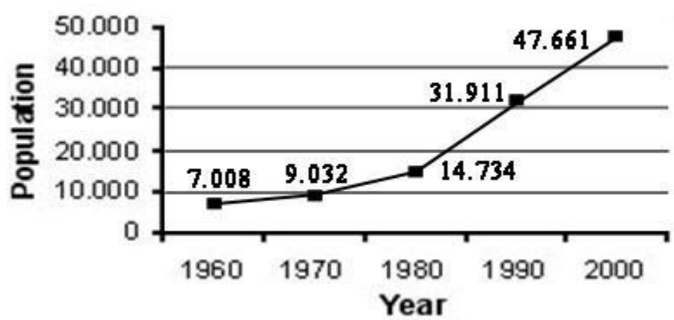

Figure 2. Population increase of Kusadasi between 1960 - 2000.

form or height of plants they can utilize. Four vegetation layers were defined: Groundcover (plants that are less than 0.30 m, such as *Parthenocissus quinquefolia*), shrubs (plants with height up to 2.0 m), small trees (greater than 2.0 m and less than 6.0 m in height), and trees (greater than 6.0 m in height) . The number of layers present was totaled in each sample unit by assigning a number between 0 and 4.

Using these three indicators, a wildlife habitat value index was generated. Emphasis was placed on native species when the index for each land cover was calculated. In addition, twice the weight was given to the value of native vegetation variables. The consequent results ranged between 0 and 1.0 representing wildlife habitat values for any urban land cover types.

RESULTS AND DISCUSSION

Nine (9) main urban land cover types are defined: (1) Suburban residential (single story housing located in the outskirts of the city area. Suburban residential houses are generally used as secondary houses which are one or two story buildings with surrounding yards. Density is generally in low in this category), (2) Cluster settlements (consisting of high rise buildings with substantial amount of open spaces. They are located generally at the perimeter of city), (3) Traditional settlements (located at the city center with scarce green space. The buildings are generally multiple story and very densely arranged with almost no area for vegetation), (4) Graded vacant land, (5) Street, (6) Agricultural land, (7) Industrial, (8) Park and (9) Ring Roads (Figure 3).

The study was carried out in a region which has a rich vegetation cover consisting of abundant plant species. Among them, those which can be used in urban landscape are listed in Table 1.

Land covers in Ku adasi vary greatly. While some areas have hard surfaces with little vegetation, others include relatively wide open spaces with diverse plant species including native vegetation. Plant species examined in this study are shown in Table 2. Highlighted plant species in this figure are natives to the region.

Agricultural lands and graded vacant lands have extremely high values in pervious surface cover ratio which is about 97%. The third outstanding land cover type is park with 43%. Cluster settlement seems to be the most appropriate residential type with holding of 37% pervious surfaces. Traditional settlement is the poorest in having pervious surfaces of 16%. It is not surprising that industrial areas had considerably few pervious surfaces since their structural conditions (Figure 4).

Due to the presence of native plant species in land cover types, agricultural land is a primary category in the list. Agricultural land is followed by graded vacant land. Industrial areas surprisingly have a high value in nativeness. This may be due to the poor conditions of

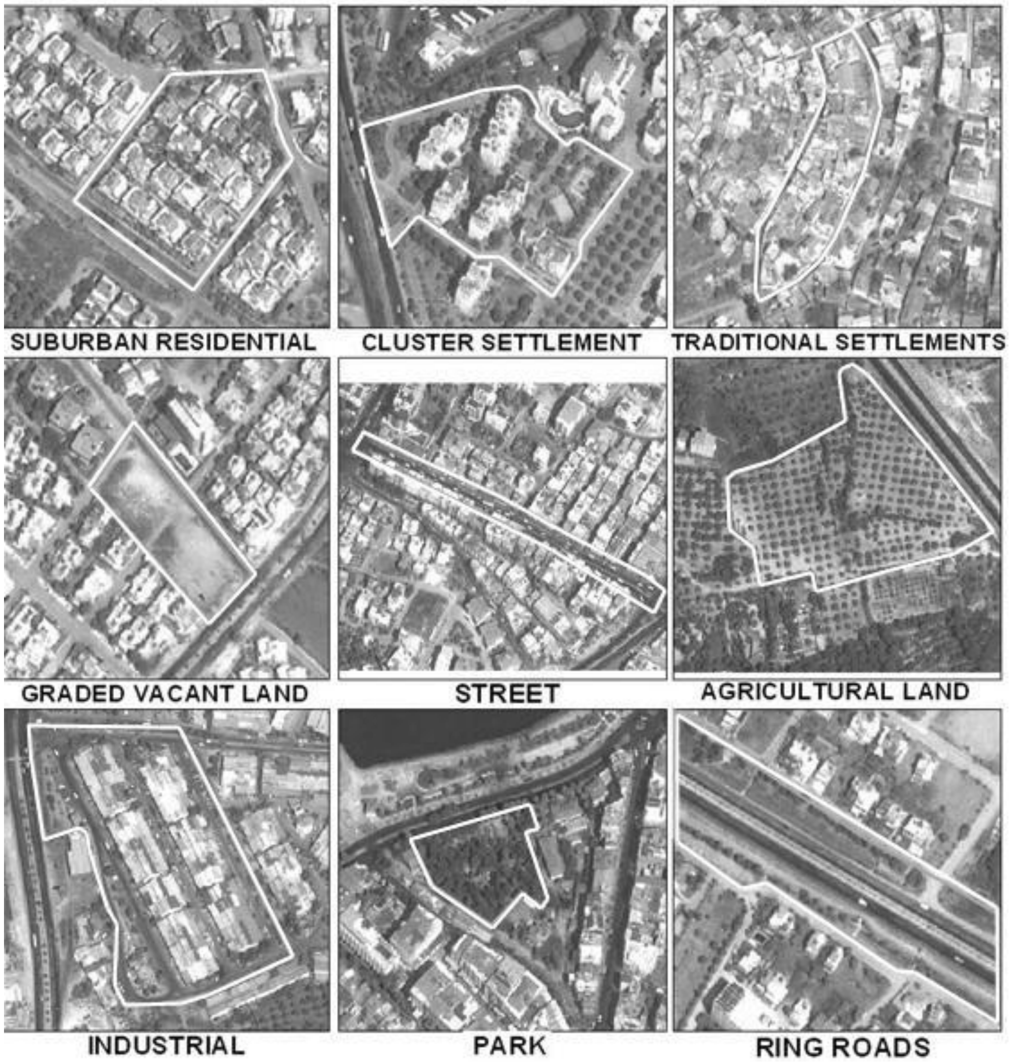

Figure 3. Sample units of land cover types present in Ku adasi urban area.

maintenance of these areas. Another important point to note about this figure is the values of residential land cover types. All of the residential areas represented with rather low percentages (Figure 5).

Structural diversity in human-designed urban landscapes can be substantially higher than native communities. This is due to the increased number of exotic species that reach more than 6.1 m when irrigated (Livingston et al., 2003). The richest plant communities in terms of structural forms are associated with cluster settlements, suburban residential and industrial areas that contain a relatively high number of exotic species. Other landscapes with considerable structural diversity include parks and traditional settlements. Graded vacant lands and agricultural lands are the poorest in terms of structural diversity (Figure 6).

The model for assessing land cover types present in Ku adasi in terms of their floristic and structural attributes in general; incorporated all of the variables described earlier. The results presented in Figure 7 provide a comparison of the overall value of different urban land cover types in Ku adasi. When these three parameters utilized are considered collectively in this multivariate model, agricultural lands are the most valuable environments for wildlife in Ku adasi. The other high rated cover types are graded vacant land, park, cluster settlements and suburban residentials. Industrial, traditional settlements and ring roads have intermediate values. Streets have the lowest value.

Several aspects of this database make it a unique and powerful tool for integrating wildlife conservation into planning action and maintaining ecological integrity. Such a tool can be used for understanding wildlife habitat relationships in an urban context. More specifically, the database could be used to evaluate regional implications of specific development projects and communicate to the public about how urban and suburban development affects the distribution of vegetation and wildlife in this

Table 1. Native plant species of the region.

Acer sempervirens L.	*Ficus carica* L. subsp. *carica*	*Ptilostemon chamaepeuse* (L.) Less.
Acantholimon acerosum Boiss.	*Fraxinus ornus* L. subsp. *cilicica*	*Quercus aucheri* Jaub.&Spach.
Ailanthus altissima (Miller) Swingle	*Genista anatolica* Boiss.	*Quercus cerris* L. var. *cerris*
Alhagi pseudalhagi (Bieb.) Desv.	*Hedera helix* L.	*Quercus coccifera* L.
Anagyris foetida L.	*Juglans regia* L.	*Quercus frainetto* Ten.
Arbutus andrachne L.	*Juniperus excelsa* Bieb.	*Quercus ilex* L.
Arbutus unedo L.	*Juniperus foetidissima* Willd.	*Quercus ilex* X *coccifera*
Arundo donax L.	*Juniperus oxycedrus* L. var. *oxycedrus*	*Quercus ithaburensis* Decne subsp. *macrolepis* (Kotschy.) Hedge. and Yalt.
Calycotome villosa (Poiret) Link	*Juniperus phoenicia* L.	*Quercus pubescens* Willd.
Capparis ovata Desf.var.*herbacea* (Willd.) Zoh.	*Laurus nobilis* L.	*Rhus coriaria* L.
Capparis spinosa L.	*Lavandula stoechas* L. subsp. *stoechas*	*Robinia pseudoacacia* L.
Castanea sativa Mill.	*Liquidambar orientalis* Mill.	*Rosa canina* L.
Cedrus libani A. Rich.	*Lonicera caprifolium* L.	*Salix alba* L.
Celtis australis L.	*Maclura pomifera* (Raf.) C.K. Schneid.	*Salix triandra* L. subsp. Bornmuelleri
Ceratonia siliqua L:	*Morus alba* L.	*Salix viminalis* L.
Cercis siliquastrum L. subsp. *siliquastrum*	*Morus nigra* L.	*Sambucus nigra* L.
Cistus creticus L.	*Myrtus communis* L. subsp. *communis*	*Sarcopoterium spinosum* (L.) Spach.
Cistus laurifolius L.	*Nerium oleander* L.	*Spartium junceum* L.
Cistus parviforus L.	*Olea europaea* L. var. *europaea*	*Styrax officinalis* L.
Cistus salviifolius L.	*Olea europaea* L. var. *sylvestris* (Mill.) Rouy	*Tamarix parviflora* DC.
Coridothymus capitatus (L.)Rchb.f.	*Pinus brutia* Ten.	*Tamarix smyrnensis* Bunge
Coronilla emerus L. subsp. *emeroides* (Boiss. And Spruner) Holmboe	*Pinus nigra* Arnold subsp. *pallasiana*	*Tamarix tetrandra* Palas ex Bieb.
Crateagus monogyna Jacq. subsp.*monogyna*	*Pistacia atlantica* Desf.	*Typha angustifolia* L.
Cupressus sempervirens L.	*Pistacia lentiscus* L.	*Typha domingensis* Pers.
Cytisus laburnum L.	*Pistacia terebinthus* L. subsp. *palaestine* (Boiss.)	*Typha latifolia* L.
Cytisus villosus Pourr.	*Platanus orientalis* L.	*Ulmus minor* Mill. subsp. *canescens* (Melville) Browicz & Ziel.
Erica arborea L.	*Populus tremula* L.	*Viburnum tinus* L.
Erica manipuliflora Salisb.	*Phragmites australis* (Cav.) Trin ex Steudel	*Vitex agnus-castus* L.

community (Livingston et al., 2003).

CONCLUSIONS AND RECOMMENDATIONS

The City of Ku adasi is exposed to a significant urbanization within a short period of time and as a consequence the City and borders expanded continuously to the surrounding natural and agricultural lands. At metropolitan scale, a considerable transformation occurred by alteration of land cover types. Developing planning strategies at this point can prevent the negative effects in the future. Greenspace development has to be promoted not only as a restriction against over development, but as an essential strategy for quality of life and enrichment of natural environment. The study shows that agricultural areas have the highest

Table 2. Plant species counted in transects (underlined plant species are natives or naturalised to the region).

Abelia ×grandiflora (Rovelli ex André)	*Fraxinus excelsior* L.	*Pinus nigra* Arn.
Abutilon pictum (Gillies) Walp.	*Grevillea robusta* A. Cunn. ex R. Br.	*Pinus pinea* L.
Acacia retinodes Schltdl.	*Hibiscus rosa sinensis* L.	*Pistacia terebinthus* L.
Acacia cyanophylla L.	*Hibiscus syriacus* L.	*Pittosporum tobira* Thunb. Ait.
Acer negundo L.	*Hydrangea macrophylla* (Thunb.) Ser.	*Pittosporum tobira* Thunb. Ait. cv. Nana
Agave americana L.	*Inula viscosa* (L.) Aiton	*Platanus orientalis* L.
Ailanthus altissima (Mill.) Swingle	*Ipomoea purpurea* (L.) Roth	*Plumbago auriculata* Lam.
Albizia julibrissin Durazz.	*Jacaranda mimosifolia* D.Don	*Populus nigra* L.
Alhagi pseudalhagi (M.Bieb.) Desv.	*Jasminum mesnyi* Hance	*Populus alba* L.
Araucaria heterophylla (Salisb.) Franco	*Jasminum officinale* L.	*Prunus amygdalus* Batsch
Berberis thunbergii DC.	*Juglans regia* L.	*Prunus armeniaca* L.
Bougainvillea sp.	*Juniperus sabina* L.	*Prunus avium* L.
Brachychiton populneus (Schott and Endl.) R. Br.	*Koelreuteria paniculata* Laxm.	*Prunus cerasus* L.
Buxus sempervirens L.	*Lagerstroemia indica* L.	*Prunus domestica* L.
Caesalpinia gilliesii (Wall. ex Hook.) Wall. ex D. Dietr.	*Lantana camara* L.	*Prunus persica* (L.) Batsch
Callistemon viminalis (Gaertn.) G.Don	*Prunus laurocerasus* L.	*Punica granatum* L.
Campsis radicans L.	*Laurus nobilis* L.	*Pyracantha coccinea* M. J. Roemer.
Capparis spinosa L.	*Lavandula angustifolia* Mill.	*Pyrus amygdaliformis* Vilm.
Casuarina equisetifolia L.	*Ligustrum ovalifolium* Hassk.	*Pyrus communis* L.
Cassia floribunda Cav.	*Ligustrum vulgare* L.	*Quercus coccifera* L.
Catalpa bignonioides Walt.	*Lonicera periclymenum* L.	*Ricinus communis* L.
Cedrus atlantica (Endl.) Manetti	*Lonicera tatarica* L.	*Robinia pseudoacacia* L.
Cercis siliquastrum L.	*Magnolia grandiflora* L.	*Rosa* sp.
Chaenomeles japonica (Thunb.) Lindl. ex Spach	*Mahonia aquifolium* (Pursh) Nutt.	*Rosmarinus officinalis* L.
Citrus sp.	*Malus communis* Poir.	*Rubus fruticosus* L.
Cortaderia selloana (Schult. and Schult. f.) Asch. and Graebn.	*Melia azedarach* L.	*Russelia cestrum-elegans* L.
Coryllus avellana L.	*Momordica charantia* L.	*Salix alba* L.
Cotoneaster sp.	*Morus alba* L.	*Salix babylonica* L.
Cupressus arizonica E.L. Greene	*Musa paradisiaca* L.	*Schinus molle* L.
Cupressus macrocarpa Hartw. ex Gord.	*Myrtus communis* L.	*Spartium junceum* L.
Cupressocyparis leylandii (Dallim. and Jacks.) Dallim.	A.B. *Nerium oleander* L.	*Syringa vulgaris* L.
Cupressus sempervirens L.	*Olea europea* L.	*Tamarix gallica* L.
Cydonia oblonga Mill.	*Opuntia ficus indica* (L.) Mill.	*Thuja orientalis* L.
Datura hybrida	*Parthenocissus quinquefolia* Planch.	(L.) *Tilia tomentosa* Moench.
Dracaena sp.	*Pelargonium zonale* (L.) L'Hérit.	*Viburnum tinus* L.
Eriobotrya japonica (Thunb.) Lindl.	*Persea americana* Mill.	*Vitex agnus-castus* L.
Eleagnus angustifolia L.	*Phoenix canariensis* Hort. ex Chabaud	*Vitis vinifera* L.
Eucalyptus camaldulensis Dehnh.	*Phoenix dactylifera* L.	*Washingtonia filifera* (Lindl.) Wendl.
Euonymus japonicus Thunb.	*Phragmites australis* (Cav.) Trin ex Steudel	*Wisteria sinensis* (Sims.) Sweet.
Euphorbia pulcherrima Willd. ex Klotzsch	*Pinus brutia* Ten.	*Yucca filamentosa* L.
Ficus carica L.	*Pinus canariensis* C. Sm.	
Ficus elastica Roxb. ex Hornem.	*Pinus maritima* Mill.	

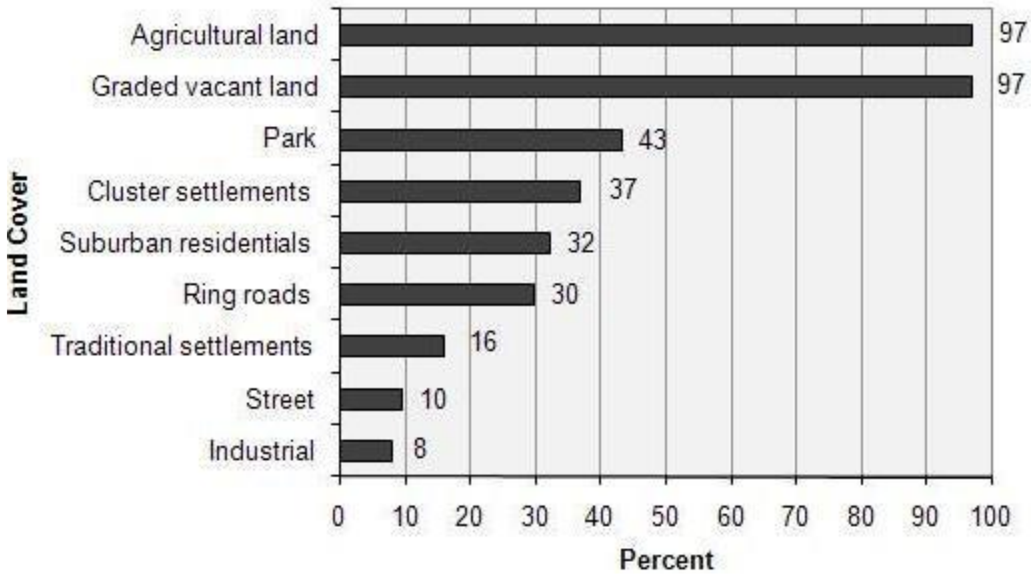

Figure 4. Percent pervious surface cover for land cover types in Ku adasi.

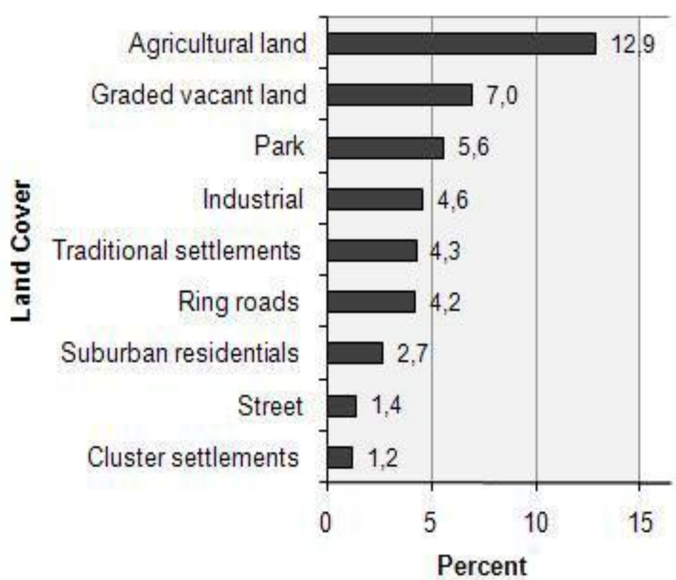

Figure 5. Percent native woody species for land cover types in Ku adasi.

highest value in habitats value index. Therefore, special concern would be given to this land cover type. Growth of Ku adasi is inevitable. Therefore, some strategies must be developed. Highest urbanization pressure is caused by residential areas. Cluster settlement and suburban settlements are nearly at the same level in habitats value index. But it is highly important to point out that while cluster settlements are vertical, suburban settlements are horizontal. It is possible to hold more open space and more population at the same unit area by promoting cluster settlement. On the other hand, the suburban settlement is generally used only in summer times and burdens the municipality ecologically and economically. This type of growth can be restricted by some regulations. A cluster style develop-ment with wide green space would decelerate the agricultural land trans-formation, meet the social and recreational demands of the society, and improve the viability of the urban ecosystem.

Identifying important wildlife habitat areas with com-prehensive study is a must. Once these wildlife habitats are identified, disturbances to these sensitive areas by people can be minimized by creating buffer zones of adjacent cover types. Such zones provide a gradual transition from a protected natural area to a heavily developed one.

While the ring roads and streets in the built-up areas of Ku adasi create many intersections in the urban matrix, they hold the lowest values at habitats value index. A road greenway network can act as an important corridor for people and wildlife. Therefore, they are an important component of the green network in the built-up area. Allocating larger green spaces and using more native plants in these areas can improve the quality of these sites. This will help to integrate fragmented and isolated greenspace patches into an urban ecological network.

A native-species planting scheme for street trees can promote species diversity. Priority should be given to native tree species, supported by systematic identification of suitable candidates by form, texture, growth rate, promote species diversity. Priority should be given to native tree species, supported by systematic identification of suitable candidates by form, texture, growth rate, aesthetic traits, tolerance of urban environmental con-ditions and maintenance requirements (Jim, 2001).

Existence of native plant species in land covers should

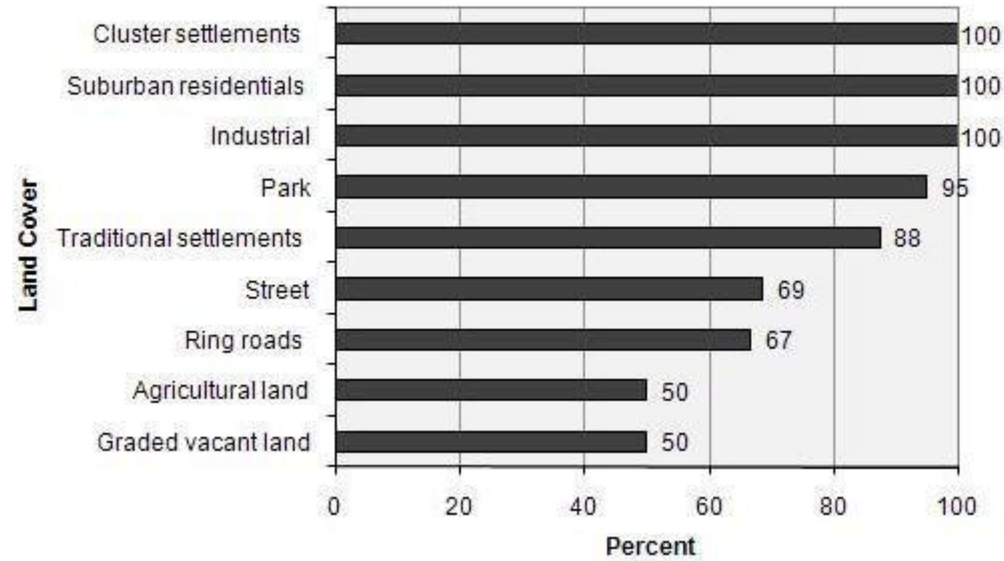

Figure 6. Percent structural diversity for land cover types in Ku adasi.

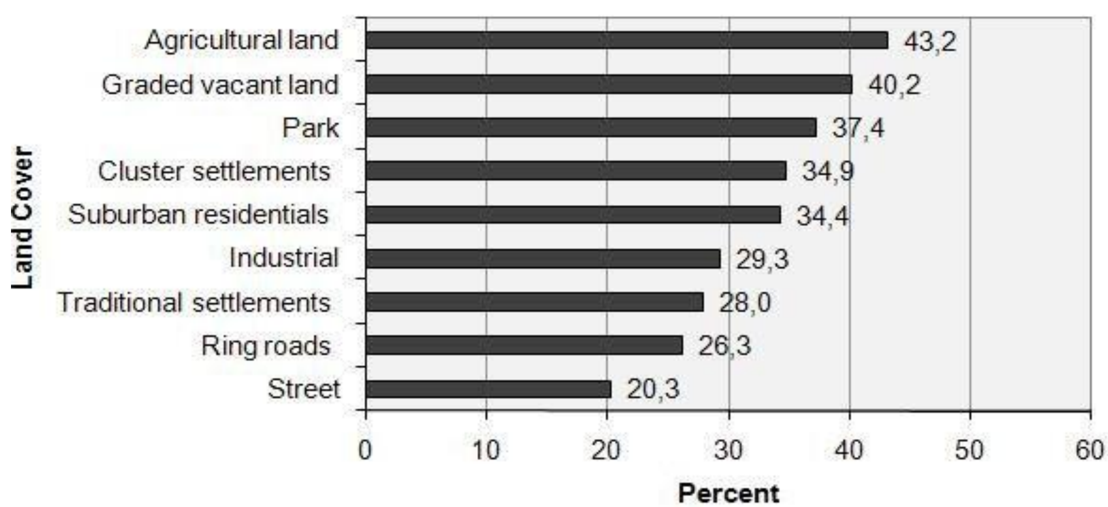

Figure 7. Wildlife habitats value index for land cover types in Ku adasi.

be increased. Planting and transplanting additional native plants in the developed landscape will help to enhance and restore wildlife habitats. Ring roads and streets have a potential for acting as a wildlife corridor. They connect open spaces and providing vegetative diversity at the overall urban matrix. Hence, carefully prepared design criteria will improve effectiveness of corridor function of these areas.

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