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Plant Biodiversity of Urban Roadside Trees in Antalya, Turkey

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Abstract: Planting trees in urban areas has a number of environmental, social and ecological benefits, and roadside trees are an integral part of urban green space. Having a broad diversity of trees in urban roadsides can guard against the possibility of large-scale devastation by both native and introduced insect and disease pests. Urban foresters and municipal arborists are advised to follow guidelines for tree diversity within their areas of jurisdiction: (1) plant no more than 10% of any species, (2) no more than 20 % of any genus, and (3) no more than 30 % of any family. The aim of the study was to assess biological diversity on the five major urban roadsides (Atatürk Boulevard, Yüzüncüyıl Boulevard, Hürriyet Street, Serik Street, Palmiye Street). The species are identified and counted. Face to face interviews were carried out with landscape architects/municipal arborists to understand decision making process on selecting and deciding the species to be planted. Results showed that three species and one genus do not fit to the expected ratio. Municipals lacked an inventory list and a biodiversity scale for planning and planting in ratios necessary to keep a diverse biological environment. Based on the shortcomings, we would recommend to establish an inventory to do more informed decision first, and plan new plantings in a way that would increase biodiversity in species and genus level.
Keywords: Urban green space, Roadside trees, Biodiversity, Urban landscape.

Kentsel Yol Ağaçlandırmalarında Biyoçeşitlilik, Antalya-Türkiye Örneği

Özet: Kentsel yeşil alan sisteminin ayrılmaz bir parçasını oluşturan kentsel alan ağaçlandırmaları birçok çevresel, sosyal ve ekolojik faydayı da beraberinde getirmektedir. Kentsel yol ağaçlandırmaları için seçilecek ağaç türlerinde çeşitliliğin sağlanması yerli ve egzotik zararlılardan ve hastalık etmenlerinden kaynaklanan büyük ölçekli hasarların önlenmesine olanak sağlar. Kent ormancıları ve belediye bünyesinde çalışan ağaçlandırma ile ilgilenen uzmanlar kendi yetki alanları içerisinde çeşitliliğin sağlanması için tavsiyelerde bulunmaktadır: Bir alanda dikim yaparken (1) aynı türe ait bireylerin oranı toplam bireylerin %10'unu, (2) aynı cinse ait bireyler tüm bireylerin %20'sini ve (3) aynı familyaya ait bireylerin tüm bireylere oranının %30'u geçmemesi gerektiği şeklindedir. Bu çalışmanın amacı Antalya ilinin 5 ana yol güzergahındaki (Atatürk Bulvarı, Yüzüncüyıl Bulvarı, Hürriyet Caddesi, Serik Caddesi, Palmiye Caddesi) yol boyu ağaçlandırmalarındaki biyolojik çeşitliliğin belirlenmesidir. Çalışma kapsamında belirlenen caddelerdeki türler tek tek belirlenerek sayılmıştır. Kullanılan türlerin belirlenmesi ve türlerin dikiminde karar sürecini anlayabilmek ve bilgi edinmek için ilgili belediyelerde görev yapan peyzaj mimarları ile yüz yüze görüşmeler yapılmıştır. Elde edilen sonuçlara göre 3 türün ve 1 cinsin beklenen oranla uyuşmadığı belirlenmiştir. Belediyelerin kullanılan türlerle ilgili herhangi bir envanter listesine sahip olmadıkları, dikimlerde biyoçeşitliliği temel alan bir planlama yapmadıkları da elde edilen sonuçlar arasındadır. Tavsiye edilen oranlara göre dikimlerin yapılması çeşitliliğin sağlandığı bir biyolojik çevrenin sürdürülebilmesi için önemli bir koşuldur. Belirlenmiş bu eksiklikler göz önüne alındığında öncelikle daha bilinçli kararların verilebilmesi için envanterlerin yapılması önerilmektedir. Ayrıca yeni yapılacak olan dikimlerle de tür ve cins seviyesinde biyoçeşitliliğin arttırılmasını sağlayacak bir planlama yapılmalıdır.
Anahtar kelimeler: Kentsel yeşil alanlar, Yol ağaçlandırması, Biyoçeşitlilik, Kentsel peyzaj

Introduction

The total urban area is expected to triple until 2030. The expansion is occurring faster in low-elevation, biodiversity-rich coastal zones than in other areas (Secretariat of the Convention on Biological Diversity, 2012). In urban areas, biodiversity offers social and biological functions to residents, including ecological balance, ecosystem services, environmental protection, outdoor recreation, aesthetic enjoyment, nature education, and nurturing grounds, shelters, refuges and dispersal centers for wildlife species (Box and Harrison, 1994; Cilliers et al., 2004; Reduron, 1996; Tsai, 2001). Roads are man-made urban corridors, an essential part of urban green infrastructure (Ranta et al., 2015). Roadside trees, as integral part of urban green spaces, are of value to biodiversity, recreation and esthetic (Bernath and Roschewitz, 2008; Ode and Fry, 2002; Rowntree, 1984, 1986; Tyrväinen et al., 2005). They provide home and sustenance for many floral and faunal species.

Roadside trees in urban areas have many environmental benefits including removing air pollutants (Kiran et al., 2011; McPherson et al., 1997), improving urban aesthetics (McPherson et al., 1999) and supporting wildlife habitat (Clark et al., 1997; Schwaab et al. 1995), mitigating the "heat island" effect through evapotranspiration and shading (United States Department of Energy 1992), sequestering carbon (McPherson et al. 1994), and reducing building energy use for cooling and heating (Akbari et al. 1992).

Roadside trees share similar management concerns and challenges to other urban trees (Parks and Street Lights Office, 2005). The specific physical and physiological constraints restrict species selection and affect their management. Usually, the relatively narrow roadside corridor and underground utilities severely confine tree growth in compact city environment (Jim, 1992). The heavy shading, heat irradiation, pollution, poor soil quality, limited rooting volume and soil compaction would exclude many species from roadside use (Bassuk and Whitlow, 1987; Bühler et al., 2007; Jim, 1999). The need for headroom and lateral clearance for vehicular and pedestrian traffic and adjacent buildings would preclude more species (Galvin, 1999). The high mortality rate of street trees implies that the species with low adaptation to the harsh roadside environment would be eliminated (McPherson, 1994). This in turn would require tree removal and replacement. With increased management cost and reduced funding available, public agency tree managers need tools that will allow them to prolong the service life of public roadside tree populations. The fact that the urban environment is a series of heterogeneous microclimates as Bassuk (1990) stated, the perfect urban tree' that are aesthetically pleasant and can withstand the multitude of environmental stresses encountered by roadside trees does not exist. The differences in environmental variables (e.i. drainage, soil fertility, pH, salt and the amount of rooting space) can create so widely differing site conditions that even identical cultivars of street trees possess non-uniform growth. Besides, the lessons of the extensive plantings of a few species in USA proved that this approach is shortsighted (Bassuk, 1990; Nannini et al. 1998). Planting monocultures, or extensive plantings relying on only a very few species can create genetic vulnerability by encouraging the build-up of pests and diseases (Bassuk, 1990). The cases showed that as most serious pests or problems are specific to certain families, genera, or species of plants, a key to sustainability in urban settings lies not in the selection of any single cultivar with a particular set of characteristics but in biological diversity within populations. Having a broad diversity of trees in urban roadsides can guard against the possibility of large-scale devastation by both native and introduced insect and disease pests.

However, for many cities, the danger of monoculture plantings remains real with a very few species making up the greatest percentage of the population (Bassuk, 1990). To avoid catastrophic losses and pest outbreaks associated with virtual monocultures, we should maintain a broad diversity of trees. Thus, biodiversity in existing street tree population needed to be assessed. The objectives of this study are; to evaluate the current status of species composition in the major urban roadsides, representing important, economic, cultural and transport roads of Antalya, and to understand decision making process on the species to be planted. Implications are discussed on urban roadsides management to achieve and maintain broad biodiversity.

Materials and Methods

This study focused on landscape trees in the five major urban roadsides (Atatürk Boulevard, Yüzüncüyıl Boulevard, Hürriyet Street, Serik Street, Palmiye Street) of Antalya city (Table 1). They are managed by the Parks and Gardens Office of the city Municipal.

Antalya, located on Anatolia's flourishing southwest coast bordered by the Taurus Mountains, is the largest Turkish city on the Mediterranean coast with over one million people in its metropolitan area (Turkish Statistical Institute, 2011). It is located between 37°10’54’’N, 30°56’00’’E and occupies 20.723 km^2. Antalya, famous as a historical city and a tourism destination, was first settled around the 200 BC. The climate is Mediterranean with warm, dry summers and cooler but mild winters where mean monthly temperatures range from 6 to 34 °C, annual precipitation of 1075 kg/m^2 with 90% falling during October-March season.

Table 1. The abundance, distribution and species diversity of landscape trees in the 5 roadsides of Antalya.

District	Road lenght (km)	Width of median strip (m)	Tree count (no.)	Number of Species	Number of Genus	Number of Family
Atatürk Boulevard	5	6	1014	19	18	14
Yüzüncü Yıl Boulevard	2	6	366	18	17	12
Hurriyet street	3	7	543	18	18	14
Serik street	6,4	10	2469	22	20	15
Palmiye street	2	6	200	7	7	6
Total	18,4		4592	40	36	23

The study was conducted between April 15 and June 15, 2014. The tree species grown on the median strip and sidewalks were identified, and counted. The division into native and alien species follows the Flora of Turkey (Davis et al., 1988). The data on length of each roadsides and width of median strip was recorded. Face to face interviews were carried out with landscape architects /municipal arborists to understand decision making process on selecting and deciding the species to be planted, and to determine whether tree inventories are updated for the roadsides.

Assessment of species composition was made according to the method for managing diversity in urban plantings developed by Santamour (1990). The method referred as "the 10-20-30 formula" states that the urban forest should not contain more than 10% of any single tree species, 20% of any tree genus, and 30% of any tree family for maximum protection against pest outbreaks. The data collected in the study was broken down and tallied by species, genus, and family. The recommendations were then developed to enhance biodiversity in roadside tree plantings.

Results and Discussion

Total length of the studied roads was 18.4 km. The width of the median strips ranged from 6 to10 m (Table 1). The five main roadsides of Antalya are composed of 4592 trees representing 40 species, 36 genus and 23 family. Roadside trees can importantly contribute to urban biodiversity but overplanting a few species should be avoided. The species composition is dominated by *Washingtonia robusta* (20%), *Citrus aurantium* (17.6), and *Ficus retusa-nitida* (17.8%), encompassing over 55% of species.

By species count, alien tree species are over represented to native ones with 78% and

22%, respectively (Table 1). The 45% of the species is deciduous. Of the 55% evergreen species, 23% each of conifers and palm trees and 54% are of broadleaved evergreen species. The conifers and palms are minor components with each 12.5% presence. The broadleaf growth form and species are dominant (75%). The 40% of the broadleaves trees are evergreen. The preponderance of broadleaved species is diluted by the presence of palm trees and conifers. Conifers are minor elements represented with only 5 species (*Pinus pinea*, *Pinus brutia*, *Cupressus arizonica and Cupressus sempervirens*, *Taxus baccata*).

Table 2. The abundance, distribution by family, genus and species, provenance and growth form of landscape trees in the 5 urban roadsides of Antalya.

Family	**% of total**	**Genus**	**% of total**	**Species**	**no. of trees**	**% of total**	**Provenance**	**Growth form***
Platanaceae	4,85	*Platanus*	4,85	*orientalis*	223	4,85	native	D
Rutaceae	17,55	*Citrus*	17,55	*aurantium*	806	17,55	alien	BLE
Fabaceae		*Acacia*	0,54	*saligna*	25	0,54	alien	BLE
Fabaceae		*Robinia*	5,37	*pseudoacacia*	247	5,37	alien	D
Fabaceae		*Bauhinia*	1,61	*variegata*	74	1,61	alien	D
Fabaceae	8,53	*Leucaena*	1	*leucacephala*	46	1	alien	BLE
Myrtaceae	1,78	*Eucalyptus*	1,78	*camaldulensis*	82	1,78	native	BLE
Meliaceae	1,69	*Melia*	1,69	*azedarach*	78	1,69	alien	D
Moraceae		*Ficus*		*carica*	3	0,06	native	D
Moraceae		*Ficus*	17,9	*retusa-nitida*	819	17,83	alien	BLE
Moraceae	18,29	*Morus*	0,39	*alba*	18	0,39	alien	D
Arecaceae		*Washingtonia*		*robusta*	920	20	alien	P
Arecaceae		*Washingtonia*	21,45	*filifera*	67	1,45	native	P
Arecaceae		*Phoenix*	3,54	*dactylifera*	163	3,54	native	P
Arecaceae		*Chamaerops*	0,71	*humulis*	33	0,71	alien	P
Arecaceae	26,48	*Syagrus*	0,71	*romanzoffiana*	33	0,71	alien	P
Sapindaceae	2,96	*Acer*	2,96	*negundo*	136	2,96	alien	D
Pinaceae		*Pinus*		*pinea*	83	1,8	native	C
Pinaceae	4,31	*Pinus*	4,31	*brutia*	115	2,5	native	C
Lythraceae	1,61	*Lagerstromia*	1,61	*indica*	74	1,61	alien	D
Proteceae	0,45	*Grevillea*	0,45	*robusta*	21	0,45	alien	BLE
Casuarinaceae	2,91	*Casuirina*	2,91	*equisetifolia*	134	2,91	alien	BLE
Bignoniaceae		*Catalpa*	0,28	*bignonioides*	13	0,28	alien	D
Bignoniaceae	0,67	*Jacaranda*	0,39	*mimosifolia*	18	0,39	alien	D
Bombacaceae	0,43	*Chorisia*	0,43	*spesiosa*	20	0,43	alien	D
Cupressaceae		*Cupressus*		*arizonica*	1	0,02	alien	C
Cupressaceae	2,7	*Cupressus*	2,7	*sempervirens*	123	2,67	native	C
Ulmaceae	0,02	*Celtis*	0,02	*australis*	1	0,02	native	D

Table 2. *(continued)*

Hamamelidaceae	3,13	*Liquidambar*	3,13	*orientalis*	144	3,13	native	D
Malvaceae	0,06	*Hibiscus*	0,06	*Mutabilis*	3	0,06	alien	BLE
Salicaseae	0,06	*Populus*	0,06	*alba*	3	0,06	alien	D
Rosaceae		*Malus*	0,15	*floribundo*	7	0,15	alien	D
Rosaceae		*Prunus*		*laurocerasus*	3	0,06	alien	D
Rosaceae		*Prunus*	0,63	*cerasifera-nigra*	26	0,56	alien	D
Rosaceae	0,98	*Eriobotrya*	0,19	*japonica*	9	0,19	alien	BLE
Simaroubaceae	0,08	*Ailanthus*	0,08	*altissima*	4	0,08	alien	D
Taxaceae	0,06	*Taxus*	0,06	*baccata*	3	0,06	alien	C
Apocynacea	0,02	*Thevetia*	0,02	*peruviana*	1	0,02	alien	BLE
Oleaceae		*Ligustrum*	0,21	*japonicum*	10	0,21	alien	BLE
Oleaceae	0,28	*Olea*	0,06	*europea*	3	0,06	alien	BLE
Total 23 family		**36 genus**		**40 species**	**4592 trees**			

*D, BLE, C and P denotes deciduous, broad leaf evergreen, conifers and palm trees respectively.

The composition analysis according to 10-20-30 formula showed that there is no well-balanced population. Three species and one genus do not fit to the expected ratio. The species are *Washingtonia robusta*, *Citrus aurantium*, and *Ficus retusa-nitida*, and the genus is *Washingtonia. Washingtonia robusta* should be suspended until population levels account for a maximum of 50 % of all *Washingtonia* (currently 93%) and 10% of total roadside trees (currently 20%). The genus *Washingtonia* should account for no more than 20% of the total roadside trees population (currently 21.4%). When the *Washingtonia* population dips below 20%, replacement might be undertaken with native *W. filifera* rather than continuing with over-used alien *W. robusta.* In addition, planting of palm tree belonging to family of *Arecaceae* is not recommended anymore because current level (26.5%) is close to the maximum recommended level (30%).

Extensive plantings relying on only a very few species are increasingly vulnerable by encouraging the build-up of pests and diseases (Bassuk, 1990). The recent devastation caused by red palm weevil *(Rhynchophorus ferrugineus*) on *Phoenix dactylifera* (date palm) and *Phoenix canariensis* has also proved the dangers of extensive plantings of only a few species. The native *W. filifera* and alien *Chamaerops humilis* palm species were resistant to the red palm weevil (Dembilio et al., 2009). Having pest resistance further supports use of *W. filifera* in Antalya, especially at a time during and directly after the loss of *P. dactylifera*, a replacement has been sought to fill in the gaps left by dead trees.

Citrus aurantium (citrus tree or bitter orange) should not be used until population levels account for a maximum of 10% of total roadside trees (currently 17.6%). It is native to southeastern Asia, extremely popular in coastal mediterranean region of Turkey and is used as one of the symbols of Antalya. The fragrance of blooming flowers and colorful fruits create desired contrast with green color of other trees, common elements of roadside trees in the region. However, as with many of other fruit trees, citrus trees are subject to most of the pests including many fungal and viral diseases and can be prone to nutritional deficiencies (Morton, 1987). The pest problems, removal and cleaning of dropped fruits increase their maintenance needs and losses.

The *Ficus retusa-nitida* is another species its use should be suspended until population levels account for 10% of total roadside trees (currently 17.8%). This species is grown for its attractive, smooth, evergreen foliage. However, like other large Ficus trees, they produce invasive roots that uplift pavements and disturb irrigation systems and the cost of pruning increase maintenance cost. Thus, it is not recommended as a roadside tree.

Platanus orientalis (4.9 %), a native tree, may be increased up to 10% of total population. Platanus trees are especially preferred for the shade and coolness they provide during hot summers in Mediterranean region. The genus Platanus may be planted in locations where space allows in sidewalks or median strips to a maximum of 20% of the total population.

There is also noticeable lack of *Acer* species in the population. *Acer negundo* was the only Acer species with 3% of total population. This, as seen with Platanus species, might be due to limited spaces on sidewalks or utility lines on many locations. The native Acer species, *Acer platanoides*, may be included up to 10% of the total population.

Liquidambar orientalis, commonly known as Turkish sweetgum (Ozdilek et al., 2012), is native to the eastern Mediterranean region and holds an important position in Turkey's endemic species. The current presence of *L. orientalis* is only 3.1% and should be increased up to 10% of total population.

The current level of *Celtis australis* is only 0.02%. This long-living tree is native to region, resistant to air pollution and with its small, dark-purple berry-like fruits hanging in short clusters are extremely popular with birds and other wildlife (More and White, 2003). Thus *C. australis* is one of the should-be-preferred candidate for use in roadsides for the region.

Some trees not found in current species composition would increase biological diversity of roadside tree population of Antalya are listed in Table 3. The recommended species are either native or adapted to the region. The species listed in Table 3 should be incorporated into current population within the constraints of the 10-20-30 diversity method developed by Santomour (1990).

Tree inventories are a common approach for managing urban tree populations. An up-to-date inventory would offer an efficient tool in allocating maintenance operations (pruning, watering, etc.) (Östberg et al., 2013; Tanhuanpäa et al., 2014). The maintenance costs of street trees may be reduced with the efficient utilization of data in inventory. With exception of Palmiye street, the city lacked an inventory list of the roadside trees. Changes in the urban environment are frequent and keeping the inventory list current requires regular updating.

Furthermore, an 'approved tree' list did not exist for use in roadside/street trees for the region to aid decision making process.

Table 3. Recommended species for future roadside tree plantings in Antalya.

Family	Genus	Species	Origin
Sapindaceae	*Acer*	*platanoides*	native
Sapindaceae	*Acer*	*pseudoplatanus*	alien
Oleaceae	*Fraxinus*	*ornus*	native
Oleaceae	*Fraxinus*	*excelsior*	alien
Betulaceae	*Alnus*	*orientalis*	native
Rosaceae	*Crataegus*	*monogyna*	native
Fabaceae	*Gleditsia*	*triacanthos*	alien
Fabaceae	*Sophora*	*japonica*	alien
Malvaceae	*Tilia*	*tomentosa*	alien
Fagaceae	*Quercus*	*robur*	alien

* All species listed must be incorporated into current populations within the constraints of the 10-20-30 formula/filter of Santamour (1990).

Conclusion

Understanding plant diversity in urban roadsides may aid the management make informed decision on urban roadsides and generate practical implications for urban biodiversity conservation in Antalya. Overall, the alien tree species contribute significantly to species diversity in roadside trees of Antalya. The domination by alien species attains 78% by tree count. Therefore, plantings should be undertaken preferably with a variety of native species until a native/alien equilibrum is attained. There are three species and one genus that do not fit to the 10-20-30 formula. The species composition is dominated by *W. robusta* (20%), *C. aurantium* (17.6), and *F. retusa-nitida* (17.8%), encompassing over 55% of species. Use of these species should be suspended until their population levels dips below 10% of total roadside trees population.

Municipal lacked an inventory list, approved species list, and a biodiversity scale for planning and planting in ratios necessary to keep a diverse biological environment. Based on the shortcomings, we would recommend to establish an inventory to make a more informed decision first, and plan new plantings in a way that would increase biodiversity in species and genus level.

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