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VEGETATION COMMUNITIES OF URBAN OPEN SPACES: GREEN BELTS AND PARKS IN ISLAMABAD CITY

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Abstract

This study was conducted to assess the vegetation communities of the open urban spaces viz., green belts, gardens and parks of Islamabad city. A total of 162 plant species representing 137 genera and 58 families were recorded. Two way indicator species analysis (TWINSPAN) classified the floristic species composition into four major community types which showed some overlap in an ordination space, reflecting relatively homogenous nature of the vegetation. *Pinus roxburghii* and *Grewia asiatica* were more prevalent in green belts while native vegetation dominated by *Dalbergia sissoo* and *Acacia nilotica* were present in undisturbed green spaces. *Broussonetia papyrifera* and *Populus euphratica* showed distribution along the drains/nullahs in the city. Detrended Correspondence Analysis (DCA) was applied to identify environmental gradients to define vegetation distribution. First ordination axis demonstrated species distribution influenced by presence of invasive species whereas second axis identified urban development as main gradient for separation of plant communities. The results provide information on urban vegetation and can be used to formulate strategies for future park management and conservation and protection of green spaces.

Introduction

Cities are complexes and dynamic entities (Button, 2002) which represent a heterogenous mixture of remnant natural, semi natural, modified or newly created habitats (Jim & Chen, 2008). The components of natural and cultural realms determine the mixture of introduced and indigenous vegetation of urbanized areas (Rowntree, 1988). City parks serve multitude of purposes, collectively provide play fields, teach ecology, offer exercise trails, mitigate flood waters, protect wild life, supply space for gardens and make cities attractive for settlers and tourists (Cranz, 1982). Parks provide growing spaces for plants to expand and have less effect from urbanization (Jim & Chen, 2008).

Urbanization has resulted in the destruction of natural ecosystems, followed by conversion of the land into built up structures and other man made logical habitats such as lawns, gardens, parks etc., (Honu *et al*., 2009). Increase in population and demand of land for infrastructure has resulted in destruction of existing vegetation and inadequate planting sites (Jim, 2000) which has affected the quality of ecological environment and human health (Jackson, 2003). Over the past several decades an urban sprawl has resulted in loss of natural vegetation and fragmentation of open green spaces which facilitates environmental and ecological functions (Benedict & Mc Mahon, 2002). Floristic species composition in cities is closely related with human activities (Hope *et al*., 2003). The cultivation of alien species of trees, shrubs and herbs imported from distant regions of the world has been recognized as important component of urban vegetation (Honu *et al*., 2009). Such practices, however, have affected indigenous vegetation and negative impact on floristic diversity of native plant species.

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Greenway concept in Islamabad has evolved from its roots back in 1960's when it dealt with strategies for beautifying roads of federal capital to improve the landscape quality. The city is amongst the fastest growing urban settlements distinctly characterized by park areas and large green spaces (Anon., 2007). Rapid spread of the city has engulfed chunks of agricultural land and resulted in shrinkage of green spaces. Green spaces are unevenly distributed in the built up area and are not kept primarily for ecological aspect (Feng *et al*., 2005). This study aimed to provide detailed vegetation composition of urban green spaces of Islamabad. The specific objectives are to assess the plant related diversity of open green spaces in the Islamabad city and provide information of vegetation communities of green spaces in the inner city area and identification of the prevailing plant communities using quantitative methods of community ecology. The results will be useful for further management and planning of the area in the era of rapid transformation of unnatural land into an urban land.

Materials and Methods

Islamabad city is located against the backdrop of Margallah Hills at the northern edge of Pothwar plateau situated at 33˚ 49' latitudes and 72˚longitudes, at an altitude of 457 to 610 meters in the semi arid zone with moderate summers and winters (Fig. 1).

To record floristic species composition Islamabad city was divided into 308 grids of 0.25 Km^2. Grids were either partially or completely covered with built up area and grids with green spaces were selected for recording floristic species composition from September 2006 to June 2007. Percent cover of all species was recorded using quadrat size of 10m × 10m from each grid with green spaces (Kent & Coker, 1992). A total of 418 quadrats were sampled in green spaces from 100 square kilometers across the whole city. Herbs, shrubs and trees were identified. Cultivated plants, ornamentals and managed residential lawns were excluded from the study as only the natural green spaces were focused. The geographical coordinates of each of the quadrat was recorded with Garmin (Geko 301) Global Positioning System.

Species abundance and quadrat data (162 x 418) were classified using Two Way Indicator Species Analysis (TWINSPAN; Hill, 1979a) to assess site impact on species assemblages. The vegetation types identified were named after the first and occasionally the second dominant species and the data matrices of species abundance (percent cover) versus site (162 x 418) was subjected to Detrended Correspondence Analysis (DCA; Hill, 1979b) based on gradient length and preliminary correspondence analysis (Jongman *et al.,* 1995). The concept underlying this technique is that of association between samples. As the association measure increases, so does sample similarity. DCA was used to find a linear combination of explanatory variables which could have explained a large part of the variation in the species data. A non-parametric Spearman Rank Correlation coefficient was used which assumes that the relationships are simple. The effectiveness of the analyses was judged by (i) effective spreading out of the points, (ii) avoidance of arch distortion, and (iii) effectively revealing minor community gradients (Hill & Gauch, 1980). DCA ordination offered two significant ordination axes (gradients) for communities and species. All analyses were performed using the software PCORD ver 4.16 (McCune & Mefford, 1999).

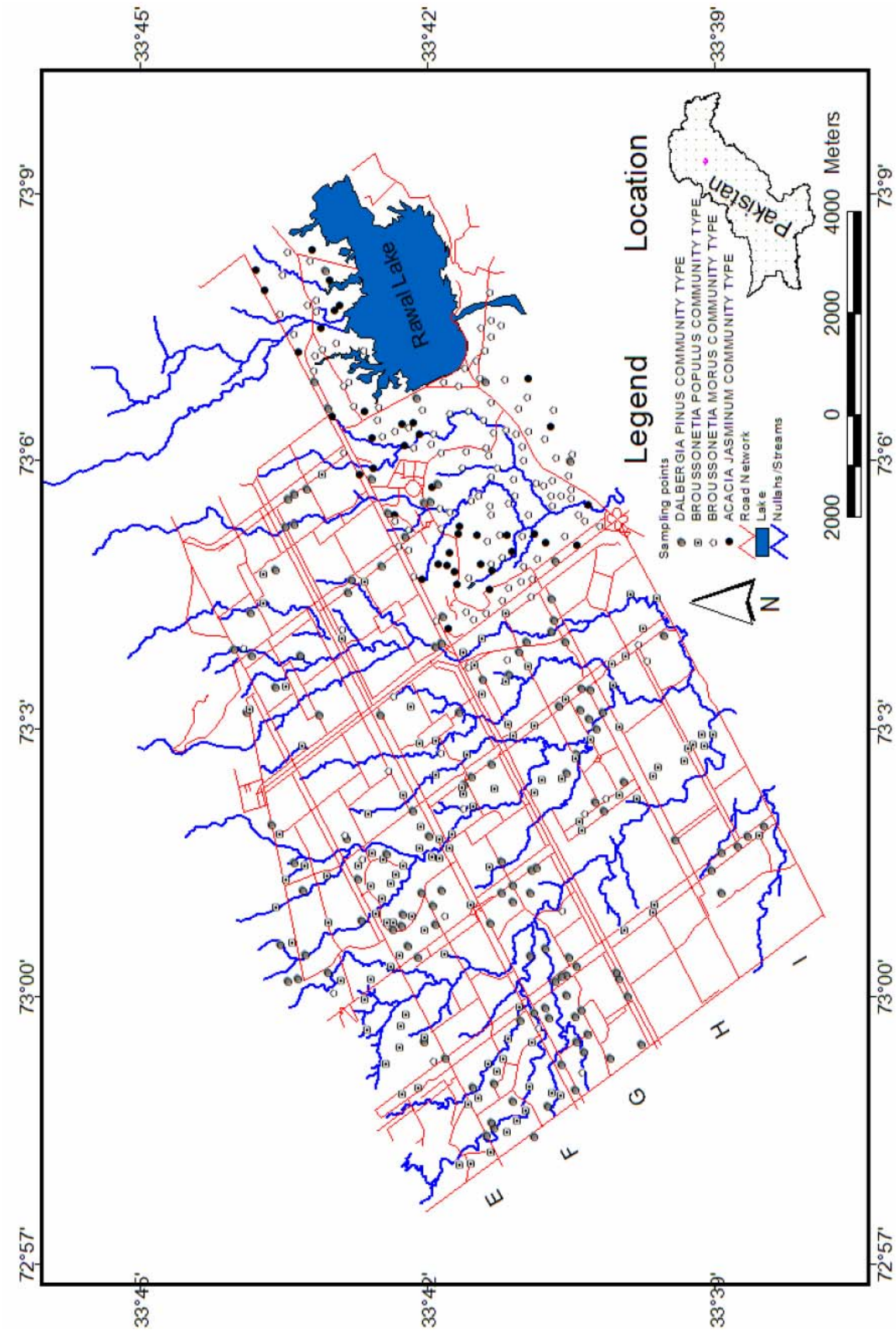

Fig 1. Map of the study area showing the location of sampling sites overlaid with vegetation types identified using TWINSPAN.

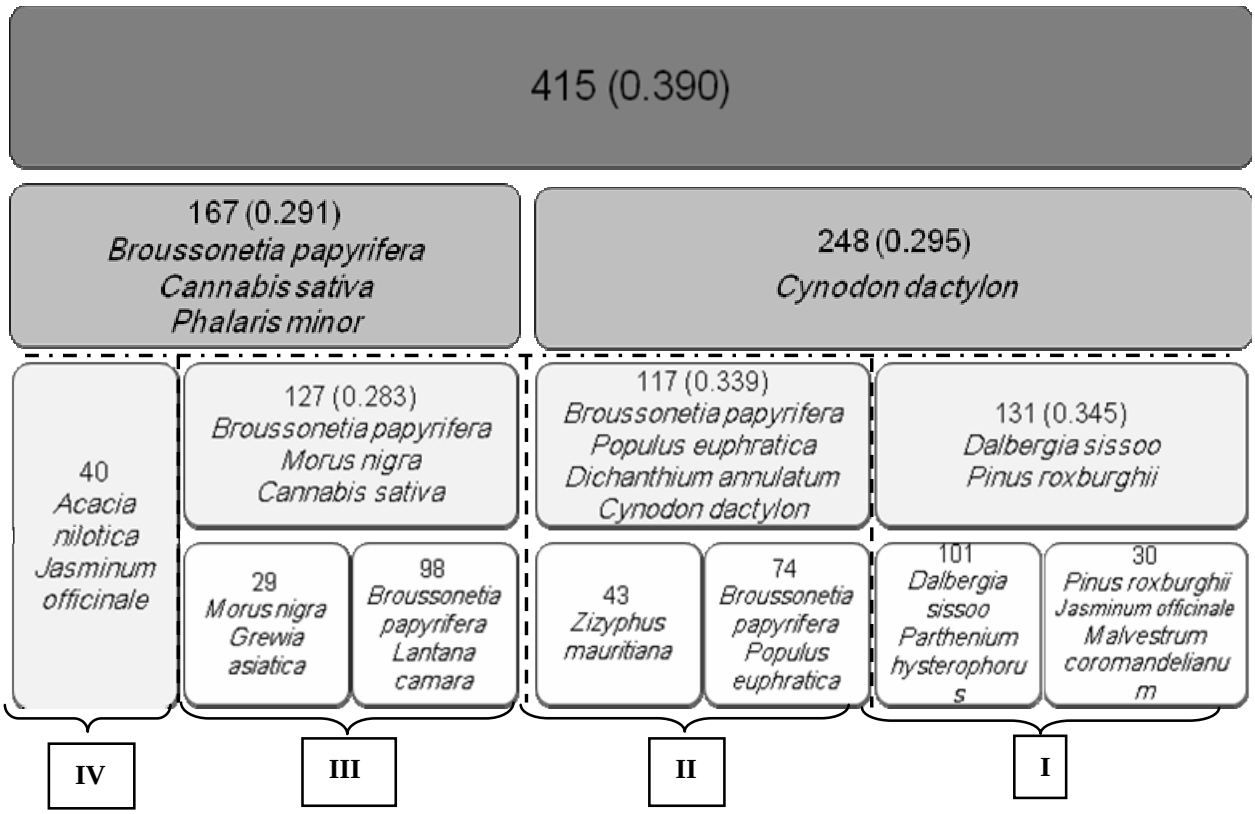

Fig. 2. Dendrogram generated through TWINSPAN classification technique.

(*Levels in the dendrogram are represented by different shades)

Results and Discussion

Green belts and parks generally represent vegetation which is seldom found in the city**.** Islamabad which has significant importance for urban greenery and species richness of green spaces comprised 162 indigenous and invasive plant species representing 137 genera and 58 families. Amongst plant families recognized Asteraceae was the most prevalent followed by Euphorbiaceae, Fabaceae, Moraceae, Oleaceae and Poaceae. *Acacia, Albizzia, Broussounetia, Cassia, Dalbergia, Ficus, Jasminum, Morus, Populus* and *Zizyphus* genera were recorded more frequently. Herbaceous species such as *Cannabis sativa, Cynodon dactylon, Dichanthium annulatum, Lantana camara, Parthenium hysterophorus, Malvestrum coromandelianum* and *Silybum marianum* were recorded with higher densities in shrub and field layers.

Four vegetation communities were identified at second level of TWINSPAN division with a definite floristic characteristic (Table 1).

Group I is named as *Dalbergia-Pinus* Community type comprised 131 quadrats which characterized the vegetation of green belts and city parks (Fig. 2) planted mainly for beautifying street landscape (Table 1). This community type contributed significantly to the vegetation of street corridors of the city. This community type can be further subdivided into sub community types: Sub community type I was dominated by *Pinus roxburghii* associated with *Jasminum officinale.* These species were planted for the beautification of the city and distributed widely in 'F' sectors of the city (Fig. 1). *Malvestrum coromandelianum* was the coordinated species. Socio-economic profile of the residents is considered important which have determined the tree landscape of this

community type. Sub community type II is dominated by *Dalbergia sissoo,* a native plant of the area, generally dominate natural forest with an understory vegetation of *Parthenium hysterophorus,* an invasive intruder. Natural factors such as geological diversity, soil diversity and landscape diversity support the rapid growth of invasive species (Kühn *et al*., 2003). The presence of *Dalbergia sissoo* saplings in shrub layer indicates favorable environmental conditions for the indigenous vegetation in absence of biotic stress. Other frequently occurred species in this community type were *Albizzia lebbeck, Alternanthra pungens, Avena sativa, Bidens bipinnata, Cassia occidentalis, Chenopodium album, Conyzanthes graminifolius, Convolvulus arvensis, Dichanthium annulatum, Euphorbia prostrata, Grewia asiatica, Jacaranda mimosifolia, Rumex chalepensis, Sapium sebiferum, Verbena tenuisecta* and *Xanthium strumarium.*

Second group is named as *Broussonetia-Populus* community type comprised of 117 quadrats and represents the characteristic vegetation along drain sides. *Broussonetia papyrifera* has been recognized as one of the worst plants invaders of highly impact species in Pakistan which thrives along streams, nullahs and drains due to presence of high moisture content which favors its vigorous growth. This species has the potential to lower richness and diversity of herbaceous as well as woody species (Khatoon & Ali, 1999). Although its growth is generally been associated in areas of greater water availability but is capable of occupying drier sites (Malik & Husain, 2006). During February until April proximity to *Broussonetia papyrifera* contributes to severe pollen allergy (Birsel, 2007). Pollen count during this period reaches approx. 40000 per m^3 causing severe asthma related problems to the local population. Presence and relatively high density of invasive species can be attributed to CDA policy to import large number of plants since the establishment of the city for its beautification subsequently reducing the natural flora. Invasive species carries a risk of environmental damage therefore, it is suggested that species should be planted which do not affect the health of the residents in cities. Changes in species composition at a rapid rate indicate the deterioration of natural habitat mainly due to the transformation of open green land into constructed land and can also be attributed to the continuous reshuffling of soil for construction and road building projects. *Acacia modesta, Mimosa himaliyaca, Ficus glomerata, Ipomoea carnea, Lantana camara, Zizyphus mauritiana, Adhatoda vasica, Alternanthra pungens, Conyzanthes graminifolius, Coronopus didymus, Cynodon dactylon, Oxalis corniculata, Panicum officinale* and *Silybum marianum* were other commonly occurring species of this community type.

Group III was named as *Broussonetia-Morus* community type consisted of 127 quadrats supporting most of the plants of innate origin (Fig. 2) which showed distribution in Shakarparian area that has less disturbances by human activities (Fig. 1). *Broussonetia papyrifera* invasion has transformed the species composition of the area from native to a mixture of introduced and natives species. This group can further be sub-categorized into *Morus-Grewia* sub community type and *Broussonetia-Lantana* sub community type. *Broussonetia papyrifera* have been reported which has changed the xerophytic vegetation to mesophytic vegetation (Malik & Husain, 2007) due to its rapid growth. CDA attempted to eradicate the plant by replanting indigenous vegetation like *Bauhinia variegata, Cassia fistula* and *Dalbergia sissoo*. Other native plants found in this community type were *Acacia modesta, Ficus glomerata, Avena fatua, Cynodon dactylon, Dichanthium annulatum, Impereta cylindrica, Phalaris minor, Rumex chalapensis* and *Silybum marianum.*

Table 1. Classification of 415 quadrats into four vegetation groups using TWINSPAN.

Vegetation groups	Sub groups	1st dominant spp.	2nd dominant spp.	Habitat	Functional features
Group I (n=131)	i. (n=30)	*Pinus roxburghii*	*Jasminum officinale*	Green Belts and managed parks	Mainly for beautifying street landscape
	ii. (n=101)	*Dalbergia sissoo*	*Parthenium hysterophorus*	Natural land, managed parks and road sides	City area occupied by original native vegetation also influenced by the effect of invasive spp.
Group II (n=117)	i. (n=74)	*Broussonetia papyrifera*	*Populus euphratica*	Drain sides	Tree composition of exotic plants effecting not only natural vegetation but also human health
	ii. (n=43)		*Zizyphus mauritiana*	Graveyards, abondoned land	emerging naturally and adding up to species diversity (natural flora)
Group III (n=127)	i. (n=98)	*Broussonetia papyrifera*	*Lantana camara*	Open green spaces, Drain sides	Exotic species widely planted to increase species richness
	ii.(n= 29)	*Morus nigra*	*Grewia asiatica*	Natural areas and Green belts	protecting and restoring original green infrastructure
Group IV (n=40)		*Acacia nilotica*	*Jasminum officinale*	Undisturbed green spaces and green belts	Beautifying developed city landscape

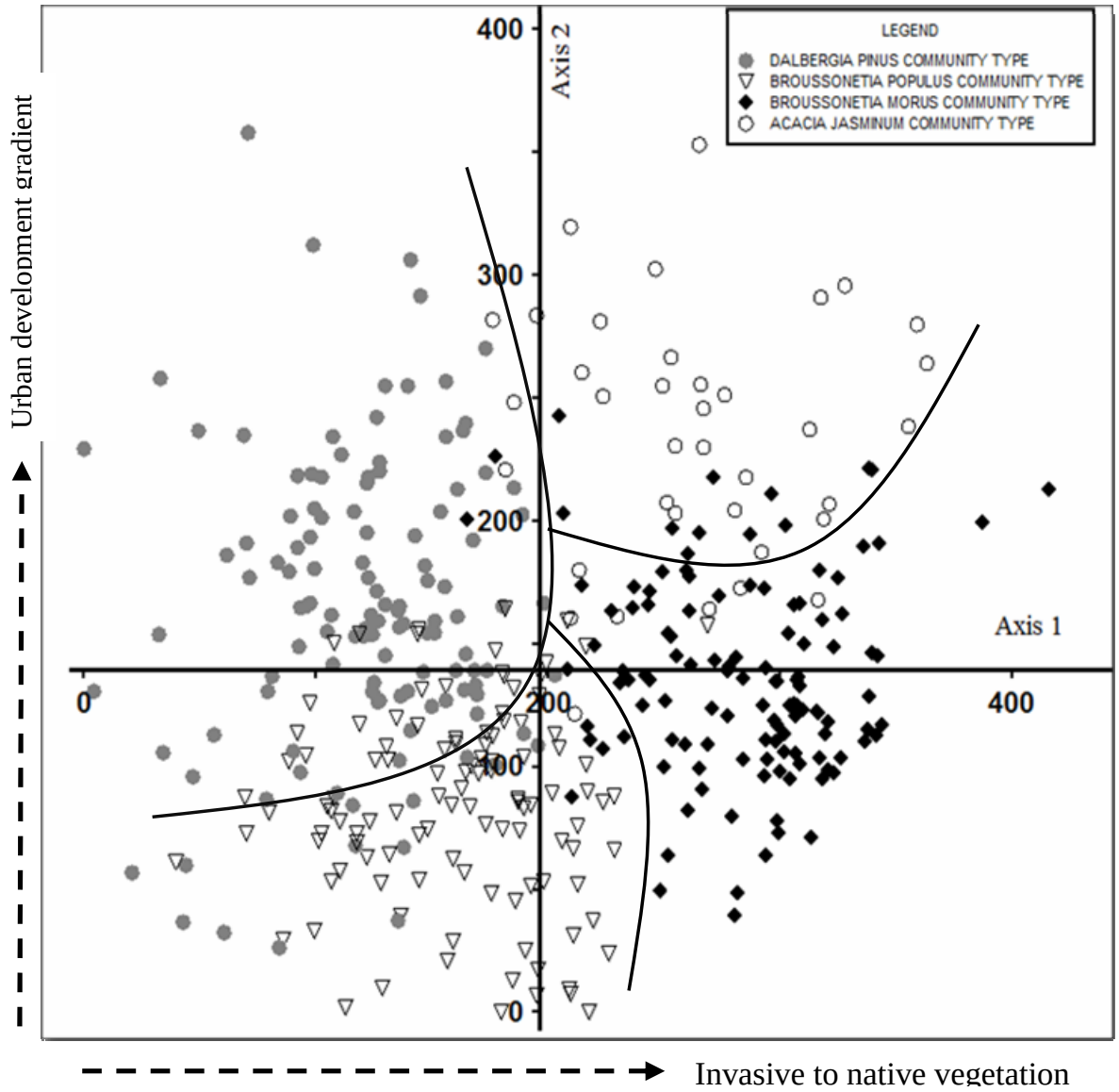

Fig. 3. DCA plot ordination of vegetation data (percent cover by species).
Lines and Symbols indicate community type identification.

Group IV was described as *Acacia-Jasminum* community type comprising of 40 quadrats dominated by xerophytic vegetation. *Acacia nilotica* and *Jasminum officinale* were the main woody species which have the ability to absorb moisture from deeper layers of soil. Drier surface soils restrict the colonization of surface feeders, as a result only few herbaceous species such as *Barleria cristata, Calotropis procera, Scandix pecten-veneris, Impereta cylindrica* and *Malvestrum coromendilianum* were recorded. *Azadirachta escelsa* was also recorded frequent in this community type. This community type is generally interpreted as native vegetation zone suggesting a relative "natural condition" with relatively good ecological conditions (Fig. 3).

DCA ordination plot also showed separation of the vegetation community types classified using TWINSPAN (Fig. 3) with eigenvalues 0.45, 0.35 and 0.30 for the three DCA axes respectively. First ordination axis demonstrated species distribution influenced by presence of invasive species. Sites belong to open green spaces with relatively undisturbed and representing native vegetation were present along right side of the ordination plot whereas, sites which had invasion of exotic species mostly dominated by *Broussonetia papyrifera* and *Populus euphratica* distributed along left side of the

ordination plot. *Broussonetia-Morus* community type showed overlap with *Acacia-Jasminum* community type which was present in least disturbed zone along 1st axis where construction activities are restricted. Presence of invasive species in the area indicates a serious threat to the native vegetation contributing to changes in species diversity and vegetation composition. Urban vegetation is partly composed of original natural and exotic vegetation. Vegetation of residential green areas and relatively undisturbed green areas can easily be differentiated. The results indicated that urbanization has led to shifts in the species composition of metropolitan remnant vegetation patches and has been linked to the intensity of human disturbance (Guntenspergen & Levenson, 1997).

Axis 2 was interpreted as urban development gradient. Land clearing activities due to the progression of development in the city has resulted in eradication of *Broussonetia* species which has therefore declined from developed areas. Invasive species are now mostly recorded in the undisturbed zone (Shakarparian and Lok-Virsa areas) and open green spaces along drain side areas, away from residential sites due to its threats to human health as it causes pollen allergy.

The master plan of Islamabad city provides a sufficient space for the green areas which should be reserved and secured for the vegetation rather than using it for development purposes and economic gains. The native species could be saved through naturalization efforts to increase the degree of habitat dominance by native species. It is suggested that the current urban green space could be enhanced by incorporating species diversity and associated urban ecological benefits. It is hoped that the results would trigger similar studies in other cities of the country, exploring the urban floristic patterns.

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