QUANTIFYING SPECIES DIVERSITY OF STREETSIDE TREES IN OUR CITIES

by Wen Quan Sun[1]

Abstract. Biological/genetic diversity is a key factor in the stability and disease tolerance of streetside tree populations. Low species diversity may leave the tree population more vulnerable to new stress environments, both abiotic and biotic. Monitoring and enriching the species diversity level has become an important issue in streetside tree planning and management. The present study introduces an index to species diversity in streetside tree populations (SDI). SDI allows quantitative comparisons of species diversity between tree populations. SDIs of 21 cities and towns are calculated based on literature published in the past 10 years. The diversity levels of streetside trees in our cities may have to be doubled to avoid species-specific catastrophic losses.

After Dutch elm disease eliminated American elms from city after city, the biological/genetic diversity has been considered as one of the key factors in the stability of streetside tree populations. (9). Low diversity due to using a limited number of tree species leaves the tree population more vulnerable to the challenges of uncertain future environments (both abiotic and biotic) (16). Monitoring and enriching species diversity levels has become more important than ever for streetside tree planning and management. The purposes of this study are to introduce a simple measure of species diversity for streetside tree populations and to examine the current diversity levels of streetside tree populations in many cities. The term "streetside tree" is borrowed from a paper by Zipperer et al. (21), which could include both street trees and yard trees.

Species Diversity Index

Species diversity of streetside trees depends on two factors: the number of species and the evenness of all species in the population. One of the best indicators to show the diversity of a population is Simpson's diversity index (17). It integrates both the richness of the groups (species or genus) and the evenness of the groups distribution in a given streetside tree population. Simpson's index is calculated through the following equation:

$$\text{Simpson's Index} = \frac{\Sigma\, Nj(Nj - 1)}{\Sigma\, Nj \cdot (\Sigma Nj - 1)} \qquad (1)$$

where Nj is the number of individuals in the jth (j = 1,2 ••• n) group (species or genus) and n is the total number of groups in a particular population.

This index is the probability that two trees chosen randomly and independently from the population fall into the same group. In this paper, the inverse of Simpson's index is used as a measure of species diversity (SDI) of streetside tree populations.

$$\text{SDI} = \text{Inverse of Simpson's Index} = \frac{\Sigma\, Nj \cdot (\Sigma\, Nj - 1)}{\Sigma\, Nj\, (Nj - 1)} \qquad (2)$$

The inverse of this index can be simply interpreted as the expected number of samples with two randomly-selected trees, of which one sample could have two trees belonging to the same species. The greater the SDI the higher the diversity level. This SDI can be considered as the "adjusted" number of species in a street tree population based on species composition. This is because SDI equals the number of species if all species are evenly represented in a population. Any street tree population with a SDI + x is diverse as much as an evenly-distributed population with x species. The SDI permits linear comparisons of species diversity levels between any streetside tree populations. An example of SDI calculation is demonstrated in Table 1.

State of Species Diversity in Streetside Populations

The SDI of streetside tree populations in 21 cities and towns are calculated based on literature

1. Present address. Boyce Thompson Institute, Cornell University, Ithaca, New York 14853

Table 1. An example of SDI calculation for streetside tree populations.

Species	*Number of trees (Nj)*	*Nj • (Nj - 1)*
Longyan County, Fujian, China		
Platanus x acerifolia	297	77562
Michelia alba	269	72092
Salix babylonica	171	29070
Aleurites moluccnan	75	5550
Ficus religiosa	67	4422
Casssia surattensis	62	3782
Grevillea robusta	44	1892
Ligustrum lucieum	40	1560
Ficus microcarpa	12	132
Acacia confusa	10	90
Eucalyptus citriodora	9	72
Delonix regia	8	56
Cinnamonomum camphora	7	42
Callistemon rigidus	6	30
Trachycarpus fortunei	6	30
Bauhinia variegata	5	20
Bombax malabricum	4	12
Eucalyptus robusta	4	12
Casuarine equisetifolia	4	12
Morus alba	2	2
Total	1084	196440

The original data were published by Jim (11). $\sum$ Nj is the total of streetside trees and $\sum$ Nj•($\sum$ Nj - 1) = 1084 x (1084 - 1) = 1173972. SDI =$\sum$ Nj • ($\sum$ Nj - 1) / $\sum$ Nj (Nj - 1) = 1173972 / 196440 = 6.0.

Table 2. Species diversity index (SDI) of streetside tree popuylations in 21 cities and towns. SDI was calculated according to the formula (2).

City or town	*SDI*	*Original data from*
United Kingdom		
Northamptonshire	4.4	(1)
Avon County	4.5	(1)
Churchyards in Gwynedd, Wales	5.8	(5)
Lambeth Borough, London	6.0	(13)
Manchester City	6.9	(19)
District of Arfon,Gwynedd, Wales	7.3	(7)
Norfolk	8.4	(1)
Unites States		
Reed Keppler Park trees	5.0	(8)
Syracuse, NY	6.5	(15)
New Orleans, LA	7.6	(18)
Urban Springfield, MA	9.2	(4)
Prince Georges, MD	10.0	(21)
40 towns in Iowa	11.5	(20)
Urban Amherst, MA	11.7	(4)
Wicomico, MD	13.6	(21)
Northwestern University campus, IL	14.9	(12)
Two Urbana, IL neighborhoods	15.9	(3)
Anne Arundel, MD	20.1	(21)
Other countries		
Longyan, Fujian, China	6.0	(11)
Athens, Greece	11.4	(14)
Hong Kong	12.7	(10)

published in the past 10 years (Table 2). In 12 cities or towns, SDIs were below 10, and only one population had a SDI slightly above 20. The average SDI of these 21 street tree populations was 9.5 (i.e. less than 10 "adjusted" species). For the 11 tree populations of USA cities and towns, the average of SDI was 11.5. In 21 other USA cities where date of street tree populations were not published, the average SDI was 13.3.

Bassuk proposed a 5% criterion for urban street tree planting (2). She found that many under-used tree species could well adapt to the urban environment, and suggested that any species in a streetside tree population should not be more than 5%. A equivalent SDI to this criterion is 20. To raise SDI from the current level to 20, the diversity of many street tree populations has to be more than doubled. However, urban environments are particularly stressful, and cause low diversity of streetside trees due to a low survival rate of newly-planted trees and the short life-span for many tree species (15, 16). Therefore the species diversity of streetside trees can only be increased when plant materials are selected with respect to both biological/genetic diversity and the specific characteristics of planting sites.

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Urban Horticulture Institute
Cornell University
20 Plant Sciences Bldg.
Ithaca, NY 14853

Résumé. La diversité biologique et génétique est un facteur clé à la stabilité et à la tolérance aux maladies pour les populations d'arbres en alignement. Une faible diversité d'espèces peut rendre les populations d'arbres plus vulnérables aux stress environnementaux, tant abiotiques que biotiques. Contrôler et enrichir le niveau de diversité en espèces est devenu une solution importante à la planification et à la gestion des arbres de rues. La présente étude introduit une mesure de a doversité en espèces des populations d'arbres de rues (SDI). Cette mesure (SDI) permet une comparaison quantitative de la diversité en espèces entre populations d'arbres de rues en alignements. Cette mesure de diversité (SDI) est calculée pour 21 villes et municipalités en accord avec la littérature publiée au cours des dix dernières années. Les niveaux de diversité en arbres d'alignements de rues doivent être doublés pour éviter une perte catastrophique d'espèces spécifiques dans nos villes.