RESEARCH ARTICLE

Tree Inventory and diversity analysis along a primary road in Palghar, Maharashtra, India

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Manuscript details:

Received: 12.05.2017
Accepted: 29.05.2017
Published : 30.06.2017

Editor:
Dr. Arvind Chavhan

Cite this article as:
Joshi Nitesh, Mule Prachiti and Joshi Ambika (2017) Tree Inventory and diversity analysis along a primary road in Palghar, Maharashtra, India*; International J. of Life Sciences*, 5 (2): 219-226.

Acknowledgement
The authors are thankful to the Department of Science and Technology, Ministry of Science and Technology, Government of India for the research grant under Women Scientist Scheme (WOS – A) (SR/WOS-A/LS-367/2012).
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ABSTRACT

Inventory of the arboreal cover occurring along a primary road in Palghar was prepared for understanding the diversity of the trees. During the survey 17 kilometres road was monitored which had two main types of land uses viz. Forest and urbanised area. Both the areas showed presence of different types of trees. A total of 97 tree species belonging to 33 different families with a count of 2052 were observed during the survey. Frequently distributed trees in forest area were *Terminalia crenulata* Roth., *Butea monosperma* (Lam.) Taub., *Bombax ceiba* Burm.f., *Pterocarpus marsupium* Roxb., *Bridelia retusa* (L.) A.Juss., *Mitragyna parvifolia* (Roxb.) Korth. while urbanised showed presence of *Streblus asper* Lour., *Gliricidia sepium* (Jacq.) Walp., *Dalbergia lanceolaria* L.f., *Pithecellobium saman* (Jacq.) Benth., *Cassia siamea* Lam., *Delonix regia* (Hook.) Raf., *Peltophorum pterocarpum* (DC.) K., *Moringa oleifera* Lam., *Borassus flabellifer L.*, *Mangifera indica* L., Annona reticulata L., *Annona squamosa* L.

Keywords: Tree inventory, diversity analysis, semi urban area, Palghar

INTRODUCTION

Palghar, a town in Thane district is situated 87 kilometres away from Mumbai. The town is rapidly growing and is classified as semi- urban as it has areas demarcated for agriculture and industry. The tehsil is connected to Mumbai by road as well as railway routes. The first bypass road to this tehsil is located on National Highway 8 at Varai (lat 19°37'22.17"N long 72°54'35.28"E). This primary road is an important road in the tehsil as it provides connectivity to many small villages such as Makunsar, Navghar, Rambaug, Kelwe etc. This road is preferred by many travellers as next bypasses to the tehsil are situated at Mastan naka and Chiillar phata and provide connectivity to the urbanized areas of Palghar and Boisar MIDC only. Therefore the first bypass is the only access to many small villages.

Road network in any part of the country is of immense importance as it aids communication among different cities for trade and economy. At the same time, roads also act as habitat or linear corridors for various species.

Sometimes it may also cause a negative impact such as habitat fragmentation and source of barrier for seed dispersion of many species (Angold, 1997). Road verges are ecologically and environmentally unique areas that act as habitat for many species. Therefore, study of roadside vegetation has been proposed and accepted throughout the world (Wilson et.al., 1992). The small marginal habitats in a landscape serve as important passage for movement of a species and support community structure of that area (Sara, 2006). Therefore, an attempt was made to study the roadside arboreal diversity along above mentioned road in order to assess the diversity and distribution of the trees on a road that passes through a forest and merges into an urbanised area. The objective of the study was to make an inventory of all roadside tree species and was to study the diversity of within different types of habitats.

MATERIALS AND METHODS

A tree survey was carried out from Varai (lat 19°37'22.17"N long 72°54'35.28"E) and the end point was at Saphale railway station (lat 19°34'39.99"N long 72°49'17.23"E). The road has further secondary extensions to villages like Aagarwadi, Vilangi, Kardal, Kapase and it ends in Palghar. The study site, was selected as it shows various types of habitats. The remaining part of the road is predominated by human settlements. A total length of 17km was surveyed.

Sampling methodology

During field survey, two transects of width 1.5 meters and length 17 kilometres each were marked on both sides of the road that completely covered road verges. The width of these transects was measured from the road edge. As the purpose of the study was to assess the roadside arboreal cover, both transects were marked parallel to route of the road under study. This road was then divided in to 3 different segments as per the surrounding land use. Details of these segments are given in table 1.

These segments were further divided into sub segments (refer

Table 1 and Figure 1) on the basis of distance (one sub segment per kilometre). This segme-ntation was helpful in data analysis and interpretation. Trees present within the marked boundary were noted using list count quadratic method. Precise girth at

Table 1: Details of the segments and sub segments used for sampling the study site

	Sub segment name	Land use	Running Kilometres
Segment 1	1A	Forest	1
	1B	Forest	1
	1C	Forest	1
	1D	Forest	1
	1E	Forest	1
	1F	Forest	1
	1G	Forest	1
	1H	Forest	1
	1I	Forest	1
	1J	Forest	1
	1K	Forest	1
	1L	Forest	1
Segment 2	2A	Hilly terrain of forest	1
	2B	Hilly terrain of forest	1
	2C	Hilly terrain of forest	1
Segment 3	3A	Urbanized area	1
	3B	Urbanized area	1

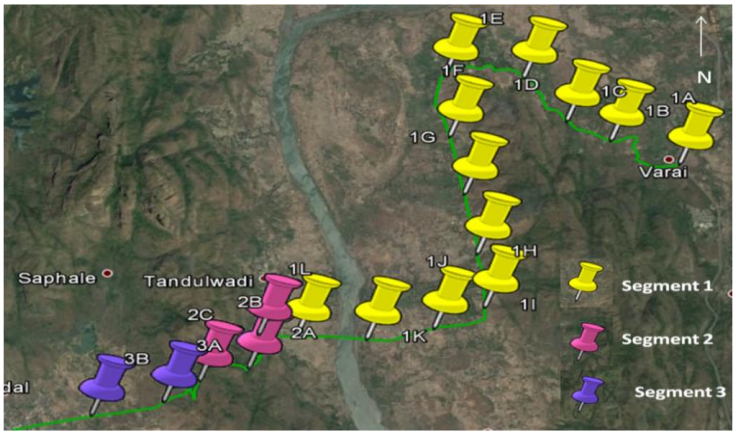

Figure 1: Image showing sampling route and sub segments

breast height (GBH) was measured for each tree with the help of measuring tape. Different canopy shapes for various species were noted down.

Formulae used

Data analysis was done by using following formulae:

Shannon Weiner Index

Shannon – Wiener Index (H') = – ∑Pi logn Pi (Shanon and Weaver, 1949)

Where Pi = Number of individual of one species /Total Number of all species

Species Richness

SR =log S (Krebs, C.J., 2013)

Where S = total number of species

Species Evenness Index

Evenness Index =H' ⁄ SR (Heip et al, 1998)

Where H'= Shannon – Wiener diversity index; SR = Species Richness .

Based on the diversity index value, a map of road showing variations in the arboreal diversity was prepared using ArcGIS.

RESULTS AND DISCUSSION

The gathered data was then analysed using various diversity indices and distribution pattern in each sub segment was assessed to understand the variations in the diversity.

Tree inventory

During tree inventory, 97 tree species belonging to 33 different families were observed. Total 2052 numbers of trees were found in the marked transects. Details of the tree species found are given in **Error! Not a valid bookmark self-reference.**.

Dominant families of the trees were Leguminosae, Moraceae and Rubiaceae. Many species of these families such as *Acacia auriculiformis* Benth., *Butea monosperma* (Lam.) Taub., *Ficus benghalensis L., Morinda pubescens* Sm. were frequently distributed in the study site. Out of 101 species found during the survey, 26 species belonged to Leguminosae family accounting for approximately 26% while other 32 families represented 74% of the total trees. Subfamily Mimosae was dominant amongst other sub families of Leguminoase.

Diversity Analysis

Diversity indices for each sub segment were calculated to understand the correlation. Details of these indices are shown in Figure 3.

It was seen that the Shannon-Weiner values are positively correlated to the species richness and evenness values. (Stirling and Wisley, 2001). Sub segment 1B has lowest values of indices. The abundance in this sub segment is not equally distributed within all species hence it shows low evenness index value. Also, less number of species reflects into low species richness value. Sub-segment 1I and 2B shows highest values amongst all sub-segments mainly due to high number of various species with more or less equal distribution over an area. Species richness of sub segments 1H and 2 B was

Table 2: Details of the tree species observed during survey

SN	Botanical Name	Family	Subfamily
1	*Acacia auriculiformis* Benth.	Leguminosae	Mimosae
2	*Acacia catechu* (L.f.) Willd.	Leguminosae	Mimosae
3	*Acacia ferruginea* DC.	Leguminosae	Mimosae
4	*Acacia mangium* Willd.	Leguminosae	Mimosae
5	*Acacia nilotica* (L.) Delile	Leguminosae	Mimosae
6	*Albizia procera* (Roxb.) Benth.	Leguminosae	Mimosae
7	*Albizia lebbeck* (L.) Benth.	Leguminosae	Mimosae
8	*Anacardium occidentale* L.	Anacardiaceae	-
9	*Annona reticulata* L.	Annonaceae	-
10	*Annona squamosa* L	Annonaceae	-
11	*Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guillem. & Perr.	Combretaceae	-
12	*Araucaria columnaris* (G.Forst.) Hook.	Araucariaceae	-
13	*Azadirachta indica* A.Juss.	Meliaceae	-
14	*Barringtonia acutangula* (L.) Gaertn.	Lecythidaceae	-
15	*Bauhinia malabarica* Roxb.	Leguminosae	Caesalpiniaceae
16	*Bauhinia racemosa* Lam.	Leguminosae	Caesalpiniaceae
17	*Bombax ceiba* Burm.f.	Malvaceae	-
18	*Borassus flabellifer L*.	Arecaceae	-
19	*Bridelia retusa* (L.) A.Juss.	Phyllanthaceae	-
20	*Butea monosperma* (Lam.) Taub.	Leguminosae	Caesalpiniaceae
21	*Careya arborea* Roxb.	Lecythidaceae	-
22	*Cascabela thevetia* (L.) Lippold	Apocynaceae	-
23	*Casearia tomentosa* Roxb.	Salicaceae	-
24	*Cassia fistula* L.	Leguminosae	Caesalpiniaceae
25	*Cassia siamea* Lam.	Leguminosae	Caesalpiniaceae
26	*Casuarina equisetifolia* L.	Casuarinaceae	-
27	*Cocos nucifera* L.	Arecaceae	-
28	*Cordia dichotoma* G.Forst.	Boraginaceae	-
29	*Crataeva tapia* L.	Capparaceae	-
30	*Crescentia cujete* L.	Bignoniaceae	-
31	*Dalbergia lanceolaria* L.f.	Leguminosae	Fabaceae
32	*Dalbergia sissoo* DC.	Leguminosae	Fabaceae
33	*Delonix regia* (Hook.) Raf.	Leguminosae	Caesalpiniaceae
34	*Diospyros melanoxylon* Roxb.	Ebenaceae	-
35	*Ehretia laevis* Roxb.	Boraginaceae	-
36	*Erythrina stricta* Roxb.	Leguminosae	Fabaceae
37	*Eucalyptus s*pp.	Myrtaceae	-
38	*Eugenia jambolana* Lam.	Myrtaceae	-
39	*Ficus amplissima* Sm.	Moraceae	-
40	*Ficus benghalensis* L.	Moraceae	-
41	*Ficus exasperata* Vahl	Moraceae	-

SN	Botanical Name	Family	Subfamily
42	*Ficus hispida* L.f.	Moraceae	-
43	*Ficus racemosa* L.	Moraceae	-
44	*Ficus religiosa* L.	Moraceae	-
45	*Ficus tsiela* Roxb.	Moraceae	-
46	*Ficus virens* Aiton	Moraceae	-
47	*Flacourtia montana* J.Graham	Flacourtiaceae	-
48	*Garuga pinnata* Roxb.	Burseraceae	-
49	*Gliricidia sepium* (Jacq.) Walp.	Leguminosae	Fabaceae
50	*Gmelina arborea* Roxb.	Lamiaceae	-
51	*Grewia tiliifolia* Vahl	Malvaceae	-
52	*Haldina cordifolia* (Roxb.) Ridsdale	Rubiaceae	-
53	*Heterophragma quadriloculare* (Roxb.) K.Schum.	Bignoniaceae	-
54	*Holoptelea integrifolia* Planch.	Ulmaceae	-
55	*Hymenodictyon orixense* (Roxb.) Mabb.	Rubiaceae	-
56	*Ixora parviflora* Lam.	Rubiaceae	-
57	*Jatropha curcas* L.	Euphorbiaceae	-
58	*Lagerstroemia parviflora* Roxb.	Lytharaceae	-
59	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	-
60	*Leucaena leucocephala* (Lam.) de Wit	Leguminosae	Mimosae
61	*Madhuca indica* J.F.Gmel	Sapotaceae	-
62	*Madhuca longifolia var. latifolia* (Roxb.) A.Chev.	Sapotaceae	-
63	*Mallotus nudiflorus* (L.) Kulju & Welzen	Euphorbiaceae	-
64	*Mallotus philippensis* (Lam.) Müll.Arg.	Euphorbiaceae	-
65	*Mangifera indica* L.	Anacardiaceae	-
66	*Manilkara hexandra* (Roxb.) Dubard	Sapotaceae	-
67	Meyna spinosa Roxb. ex Link	Rubiaceae	-
68	*Miliusa tomentosa* (Roxb.) J.Sinclair	Annonaceae	-
69	*Mitragyna parvifolia* (Roxb.) Korth.	Rubiaceae	-
70	*Morinda pubescens* Sm.	Rubiaceae	-
71	*Moringa oleifera* Lam.	Moringaceae	-
72	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	-
73	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	-
74	*Peltophorum pterocarpum* (DC.) K.Heyne	Leguminosae	Caesalpiniaceae
75	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	-
76	*Phyllanthus emblica* L.	Phyllanthaceae	-
77	*Pithecellobium dulce* (Roxb.) Benth.	Leguminosae	Mimosae
78	*Pithecellobium saman* (Jacq.) Benth.	Leguminosae	Mimosae
79	*Plumeria alba* L.	Apocynaceae	-
80	*Polyalthia longifolia* (Sonn.) Thwaites	Annonaceae	-
81	*Pongamia pinnata* (L.) Pierre	Leguminosae	Fabaceae
82	*Pterocarpus marsupium* Roxb.	Leguminosae	Fabaceae
83	*Schleichera oleosa* (Lour.) Merr.	Sapindaceae	-
84	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae	-

SN	Botanical Name	Family	Subfamily
85	*Sterculia urens* Roxb.	Sterculiaceae	-
86	*Stereospermum chelonoides* (L.f.) DC.	Bignoniaceae	-
87	*Streblus asper* Lour.	Moraceae	-
88	*Tamarindus indica* L.	Leguminosae	Caesalpiniaceae
89	*Tectona grandis* L.f.	Verbaenaceae	-
90	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	-
91	*Terminalia catappa* L.	Combretaceae	-
92	*Terminalia crenulata* Roth	Combretaceae	-
93	*Thespesia populnea* (L.) Sol. ex Corrêa	Malvaceae	-
94	*Trema orientalis* (L.) Blume	Cannabaceae	-
95	*Wrightia tinctoria* R.Br.	Apocynaceae	-
96	*Ziziphus mauritiana* Lam.	Rhamnaceae	-
97	*Ziziphus xylopyrus* (Retz.) Willd.	Rhamnaceae	-

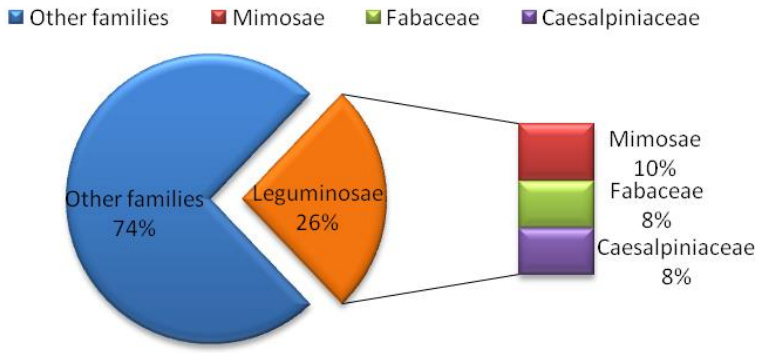

Figure 2: Distribution of trees with respect to families

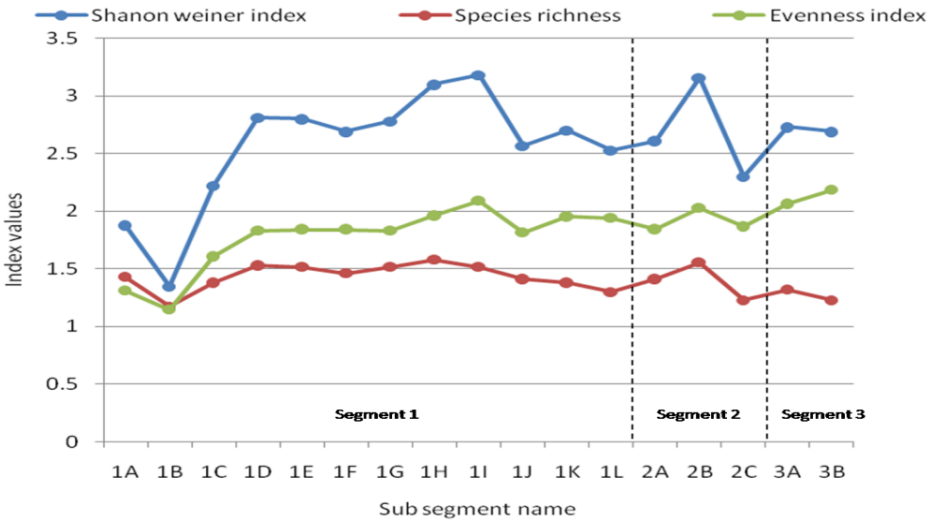

Figure 3: Merged results of diversity indices along different sub segments

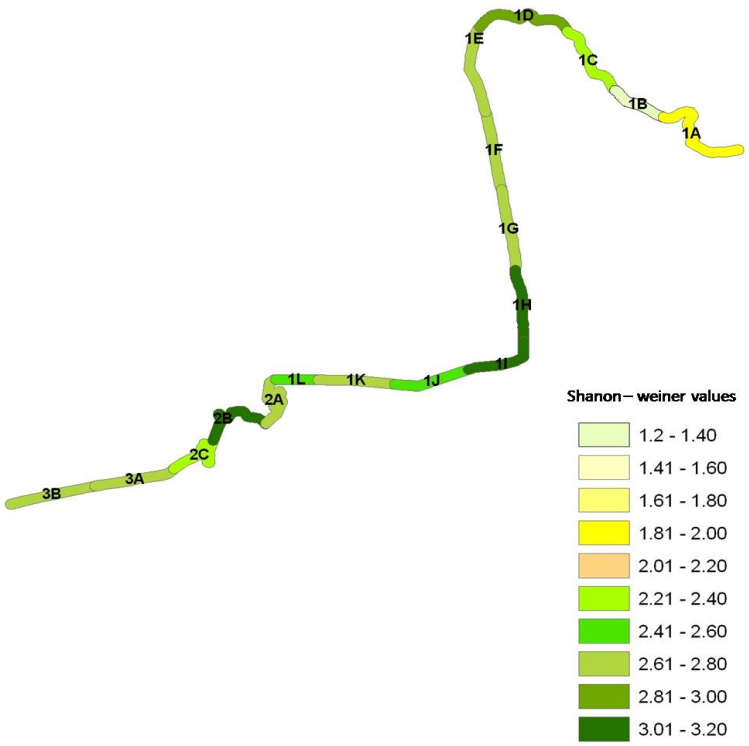

Figure 4: Diversity map showing different sub segments of the inventoried road

highest. Segment 2B was a plateau area of a hilly terrain where number of species encountered was high as compared to other sub segments. Evenness index value for 2B is also high due to uniformity in abundance of a species. Segment 3 showed inversely proportional relation between species richness and evenness index. Being urbanized area numbers of species in these sub-segments were low, but as they were uniformly abundant the evenness value is high. The Shanon- Weiner curve in this graph shows balanced values, as it considers abundance as well as diversity within a community. Therefore, while preparing a diversity map, Shannon- Weiner values were considered.

CONCLUSION

The road under study showed presence of different types of arboreal diversity. The forest patch in the segment 1 showed *Terminalia crenulata* Roth., *Butea monosperma* (Lam.) Taub., *Bombax ceiba* Burm.f. etc as frequently distributed trees. While Segment 2 which was a hilly terrain and extension of forest, showed presence of trees like *Pterocarpus marsupium* Roxb., *Bridelia retusa* (L.) A.Juss., *Mitragyna parvifolia* (Roxb.) Korth. Etc. Segment 3 comprised of 2 sub segments. The first sub segment of segment 3 i.e. 3A started from the base of hilly terrain and eventually merged into an urbanised area, hence showed a slightly different community structure. Trees in this sub segment were combination of forest trees and other roadside trees that are commonly seen in urbanised area. Frequently occurring species in this area were *Streblus asper* Lour., *Gliricidia sepium* (Jacq.) Walp., *Dalbergia lanceolaria* L.f., *Pithecellobium saman* (Jacq.) Benth. etc. In the second sub segment i.e. 3B many common avenue plants such as *Cassia siamea* Lam., *Delonix regia* (Hook.) Raf., *Peltophorum pterocarpum* (DC.) K.Heyne were seen.

In segment 1, product yielding trees such as *Moringa oleifera* Lam., *Borassus flabellifer L.*, *Mangifera indica* L., *Annona reticulata* L., *Annona squamosa* L. were seen as roadside plant near human settlements.

Density of the trees in both transects varied considerably. Approximate distance between two trees in the segment 1 was nearly 5 meters but, it was not consistent, few areas were bare without arboreal

vegetation while few were covered with dense patch of trees. Due to presence of mountainous terrain, segment 2 showed densely occurring trees on the plateau region while sparsely distributed trees on slopes. Segment 3 showed presence of distantly located trees.

The study showed variation in diversity, within each segments. Hilly terrain of forest showed maximum diversity in the form of species richness and abundance. The forest area of segment 1 and 2 showed higher diversity than the urbanised area of segment 3. At the same time, evenness in the urbanised area was much higher as compared to forested area. Diversity is complex, multi-dimensional property of any community. Shanon- Weiner index values increased with increase in species richness and evenness index values. The study showed that distribution of abundance and evenness of an arboreal community was directly dependent on species richness (Jost, 2010). From forested area to urbanised area a trend of decrease in diversity was seen. Based on the Shanon-Weiner index values a diversity map was created using software tool. Main aim behind creating this map was to have a visual tool that can be interpreted easily without having any ambiguity. The map was fashioned by using different color themes. Figure 4 shows various sub segments and its diversity in terms of colors. The diversity values are clubbed together in a group as shown in the legend. The darker shade of green indicates relatively more diversity and pale green indicates relatively low diversity. Majority of sub-segments showed the index value ranging from 2.60 to 2.80. Sub-segments 1H, 1I and 2B showed highest diversity while sub segment 1B showed lowest diversity.

Conflicts of interest: The authors stated that no conflicts of interest.

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