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A Study on Tree Diversity, Population Structure and Soils in a University Campus in an Indian Dry Tropical Region: Implication for Tree Conservation, Exploitation and Carbon Sequestration

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ABSTRACT

This study assessed the tree species diversity and their population structure in Chaudhary Charan Singh University of Meerut. A total of 19922 tree individuals (>10 cm girth) were measured for their girths at breast height. Girth-size distribution of trees in entire campus and that of dominant tree flora were separately analyzed to understand their growth and regeneration status. Physico-chemical characteristics of soils under dominant tree cover were also estimated. Spread over an area of 222 acres, the campus had 128 tree species distributed over 43 plant families. *Leucaena leucocephala* accounted for over 23.45% of total tree population, followed by *Eucalyptus globulus* (12.02%), *Ficus benjamina* (5.56%), *Monoon longifolium* (5.11%), *Azadirachta indica* (4.41%). However, they were not uniformly distributed. *Eucalyptus globulus* alone accounted for 42% of total campus area under tree cover (>490 m^2) followed by *Mangifera indica* (5%), *Azadirachta indica* (4.9%), *Alstonia scholaris* (3.1%), and *Leucaena leucocephala* (3.1%). A single tree of *Ceiba speciosa* exhibited a basal cover of 3539 cm^2. Largest tree population (9303) occurred in girth range 10-30 cm. *Ficus benghalensis* recorded highest girth (693 cm). *Eucalyptus globulus* showed declining population (77% in 50-150 cm) in contrast to expanding populations of *Monoon longifolium*, *Albizia lebbeck*, and stable populations of *Holoptelea integrifolia*, *Dalbergia sissoo* and *Azadirachta indica.* Soil organic carbon ranged 0.33 – 1.1% and C:N ratio 4.5 – 14.3 in soils under different species cover, indicative of specific tree cover impact. Besides implication for conservation and commercial exploitation of planted trees in this university-campus, study has projected implication for potential carbon sink and sequestration.

Keywords Conservation, Plant diversity, Tree basal-cover, Girth-size, Carbon sequestration.

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INTRODUCTION

For a warming planet that is desperately looking for solutions to climate change, including forests as sinks for carbon emissions, the world has lost about 10.34% of its total of 4.06 billion ha in the last 30 years

(Narain *et al.* 2023). It is estimated that in the absence of additional actions, the tropics alone is likely to witness deforestation of 289 mha of forest cover (FAO 2022). In fact, environmental degradation and loss of biodiversity is being increasingly witnessed the world over on account of rapid industrialization, indiscriminate logging, urbanization, commercial agriculture (Aderounmu *et al.* 2017, Okafor *et al.* 2013). The cumulative impact of such anthropogenic activities calls for cautious and credible management of every available space of landscape in the course of development and modernization. Kyoto Protocol under the United Nations Framework Convention on climate change allows countries to receive credits for their carbon-sequestration activities in the area of land-use change, and forestry as part of their obligations under this protocol. Such activities could include afforestation, reforestation, improved forestry or agricultural practices, and revegetation. According to IPCC these forest-related mitigation activities could make a significant contribution to the removal of carbon dioxide from the atmosphere at much lower cost. In urban areas, tree populations are reported to have a considerable potential to mitigate carbon emissions through carbon sequestration, albeit such studies are highly inadequate (Singh *et al.* 2022).

The alarming adverse effects of the anthropogenic impacts are being increasingly reported in developing countries e.g. Nigeria (Pelemo *et al.* 2011, Corlett 2016). The most populous developing country like India is currently witnessing massive urbanization and developmental activities all around. About one-third of India's population resided in urban areas in 2021 (O'Neill 2022). This urban population is likely to be 50% by 2050 (Mell 2015). With India's proclaimed target of attaining net zero carbon emission by 2070, it needs to rapidly devise ways in its management plans to expand green cover, as sinks for carbon emission, besides going for non-fossil electricity and other preventive/alternate energy generating measures for reduction of carbon emissions. It is noteworthy that urbanization in India is devouring a significant proportion of arable peri-urban area, thus, causing rapid loss of green cover (Lahoti *et al.* 2020). Thus, all educational, government and non-governmental institutions including public and individual level plantation initiatives, especially that of the tree saplings, which has far more potential as carbon sinks, need to be undertaken to mitigate the challenges of climate change.

The present work aimed at understanding the results of over five-decade tree plantation efforts in a University campus in terms of varying soil characteristics, buildup of plant biomass and plant diversity structure, and utilization of information for the understanding of carbon sequestration potential of these tree species populations in the university ecosystems. Age distribution of trees, be it natural or planted in an area, can be considered an important population characteristic which is a consequence of both natality and mortality. The ratio of various age groups in a population determines the reproductive status of the population and indicates the future course (Odum 1971). This is considered true for forest communities (Collins 1962, Odum 1969, Hartshorn 1972, Knight 1975) as well as for plantations too. Successful regeneration of tree species is often suggested as a function of three major components: Ability to initiate new seedlings, ability of seedling and saplings to survive and ability of seedlings saplings to grow (Good and Good 1972).

The objective of the present work was to analyze and understand the tree basal cover and diversity structure of tree flora, their population structure and the resultant soil characteristics, as a result of over six decades of recurrent plantation efforts in the campus of a State University namely Chaudhary Charan Singh University, located in a dry tropical region of Meerut in the most populated State of Uttar Pradesh, India.

MATERIALS AND METHODS

Study area

The study site was located in the campus of Chaudhary Charan Singh University (formerly, Meerut University) that was established in 1965 in Uttar Pradesh, India (Fig. 1). The campus site (28°58'08.88" N latitude and 77°44'25.81" longitude), spread over an area of 222 acres, and is lush green with a large number of planted trees. Ever since its inception the campus attracts a large number of visitors to the

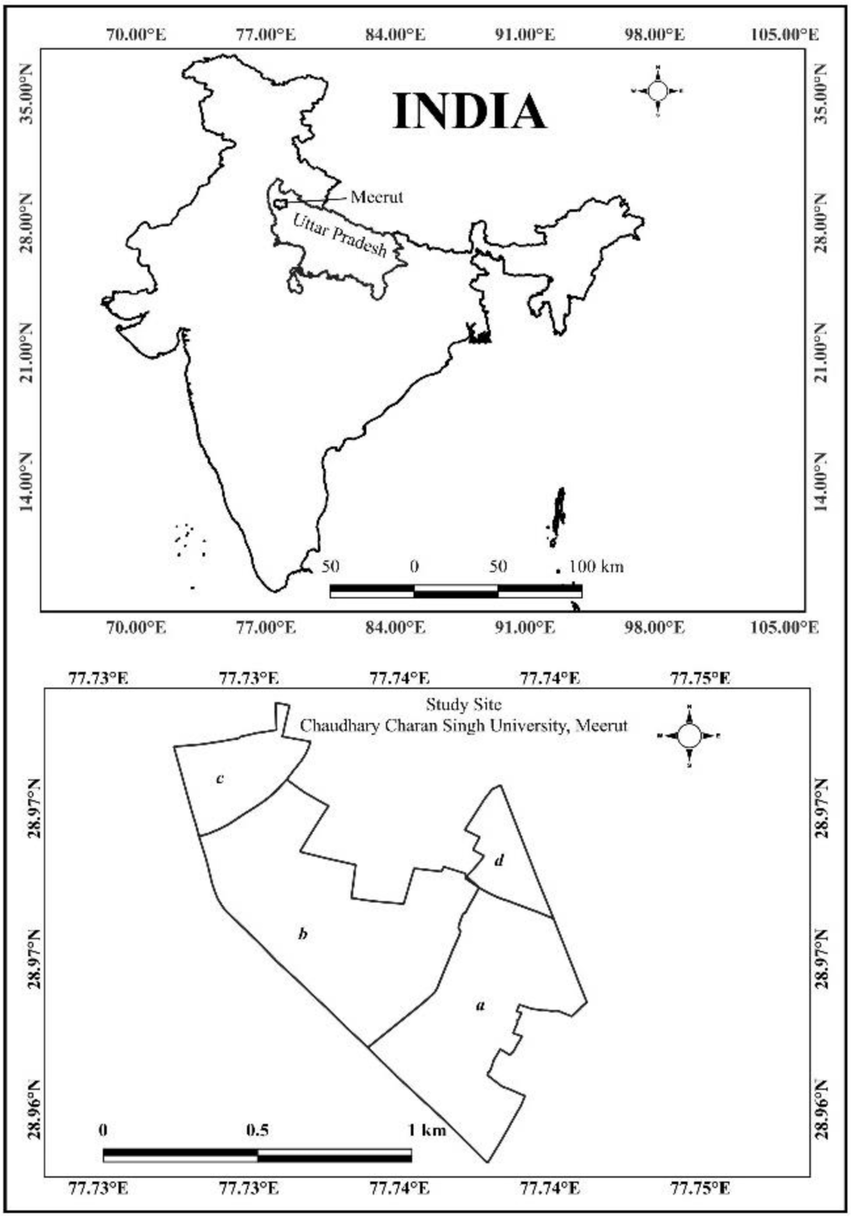

Fig. 1. Map showing study site and sub-sites in the campus of Chaudhary Charan Singh University, Meerut. Sub-site codes - a: South, b: Central, c: SCRIET (Sir Chhotu Ram Institute of Engineering & Technology), d: Tapowan.

campus for its natural beauty and cleanliness. For the purpose of present study, the campus was divided into four sub-sites in this campus were selected a – d (Fig. 1). The campus has witnessed recurrent plantation efforts comprising of avenue trees that were mainly *E. globulus* along the roads and block plantations with mixture of tree species. SCRIET is the one extreme site of the main university campus. While the first three sub-sites has roads and buildings for University's Academic and administrative purposes including residential areas for students and staff, the fourth sub-site "Tapowan" area has no concrete building structure. It has a forest-like physiognomic appearance with planted trees and weedy flora at the ground level. It is basically maintained for public walking pathway in its midst. The campus has rain-water harvesting systems well distributed across the campus in every sub-site.

Climate

The study area has a monsoon-influenced dry tropical climate characterized by hot summers and cooler winters with mean annual rainfall 816.4 mm. The mean maximum temperature ranged from 21.9^{o}C (January) to 32.6^{o}C (August) and the mean minimum temperature varied from 7.2^{o}C (January) to 25.5^{o}C (August) according to the meteorological data of Chaudhary Charan Singh University, Meerut.

Sampling of the campus vegetation

Every tree species in the entire campus of CCS University was measured for its girth (at breast height 135 cm, GBH), with the help of a metallic tape. The plants were identified with the help of local flora and Botanical Survey of India, Dehradun. The girth estimations of trees from four sub-sites of the University campus, as well as the entire campus, were analyzed for girth-size frequency distribution using Microsoft Excel application.

Soil characteristics

Three surface soil samples (0 – 10 cm) were collected randomly from each of the four areas dominated by tree species dominated areas viz. *E. globulus*, *L. leucocephala*, *A. indica*, *A. lebbeck* and air-dried and sieved (2 mm). Soil pH was determined by Digital pH meter (Eutech Instruments pH 700) (1:5 soil:water) according to Piper (1944), organic carbon by Walkley and Black method (1934), total nitrogen by Semi micro-kjeldahl method (KjelTRON by Tulin), and exchangeable cations (Na, K and Ca) flame photometrically.

RESULTS

Floristics

A total of 128 tree species (125 angiospermic and 03 gymnospermic) belonging to 43 families (40 angiospermic and 03 gymnospermic) were recorded (Table 1). A total of 19922 tree individuals (19881 angiospermic and 41 gymnospermic) of these tree species were measured for their girth sizes. The dominant families (in terms of number of individuals of species belonging to a family) was in the order of Fabaceae (7631) >Myrtaceae (3507) >Moraceae (2035) >Meliaceae (1075) >Annonaceae (1021). The dominant species (in terms of the total number of individuals) was in the order *Leucaena leucocephala* (4672) >*Eucalyptus globulus* (2394) >*Ficus benjamina* (1108) >*Monoon longifolium* (1018) >*Azadirachta indica* (878) >*Holoptelea integrifolia* (813) >*Albizia lebbeck* (713) >*Psidium guajava* (575) >*Dalbergia sissoo* (568) (Table 2). The total number of non-leguminous plant individuals recorded were 12291, thus leguminous non-leguminous ratio is 2:3.

Leucaena leucocephala population accounted for 23.5% of the total tree population in the campus, followed by *Eucalyptus globulus* (12%) and

Table 1. Dominant angiospermic and gymnospermic plant families in the campus of Chaudhary Charan Singh University, Meerut in terms of the total number of individuals of plant species belonging to the respective families. Families with >100 individuals are shown.

Sl. No.	Family		Total number of individuals
1	Fabaceae		7631
2	Myrtaceae		3507
3	Moraceae		2035
4	Meliaceae		1075
5	Annonaceae		1021
6	Ulmaceae		813
7	Apocynaceae		766
8	Rutaceae		470
9	Anacardiaceae		455
10	Arecaceae		286
11	Bignoniaceae		236
12	Proteaceae		209
13	Putranjivaceae		204
14	Lythraceae		164
15	Rhamnaceae		150
16	Combretaceae		143
17	Lamiaceae		121
18	Malvaceae		119
Total number of other families		Angiospermic (22)	**477**
		Gymnospermic (03)	**40**
		Total (43)	**11922**

Table 2. Dominant angiospermic and gymnospermic plant species (in terms of the number of their individuals recorded) in the campus of Chaudhary Charan Singh University, Meerut. Plant species >200 individuals as shown.

Sl. No.	Plant species name	Family	Total number of individuals
1	*Leucaena leucocephala*	Fabaceae	4672
2	*Eucalyptus globulus*	Myrtaceae	2394
3	*Ficus benjamina*	Moraceae	1108
4	*Monoon longifolium*	Annonaceae	1018
5	*Azadirachta indica*	Meliaceae	878
6	*Holoptelea integrifolia*	Ulmaceae	813
7	*Albizia lebbeck*	Fabaceae	713
8	*Psidium guajava*	Myrtaceae	575
9	*Dalbergia sissoo*	Fabaceae	568
10	*Pongamia pinnata*	Fabaceae	457
11	*Mangifera indica*	Anacardiaceae	455
12	*Alstonia scholaris*	Apocynaceae	404
13	*Morus alba*	Moraceae	397
14	*Aegle marmelos*	Rutaceae	391
15	*Cassia fistula*	Fabaceae	362
16	*Syzygium cumini*	Myrtaceae	288
17	*Streblus asper*	Moraceae	255
18	*Senna siamea*	Fabaceae	253
19	*Melaleuca viminalis*	Myrtaceae	219
20	*Grevillea robusta*	Proteaceae	209
21	*Putranjiva roxburghii*	Putranjivaceae	204
Total number of other angiospermic species **(104)**			**3248**
Total number of other gymnospermic species **(03)**			**41**
Total number of tree species **(128)**			**19922**

Ficus benjamina (5.6%) and other co-dominants or sub-dominants that included *Monoon longifolium* (5.1%), *Azadirachta indica* (4.4%), *Holoptelea integrifolia* (4.1%), *Albizia lebbeck* (3.6%), *Psidium guajava* (2.9%), *Dalbergia sissoo* (2.8%), *Pongamia pinnata* (2.3%), *Mangifera indica* (2.3%), *Alstonia scholaris* (2%).

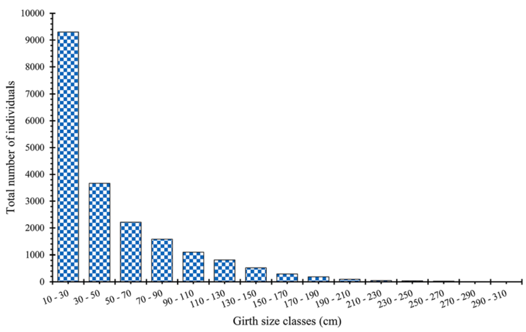

Fig. 2. Size class distribution of all tree species in the campus of Chaudhary Charan Singh University. Meerut (Only those species with >15 individuals in a size class are shown, (Highest size class was 690 cm - 710 cm).

These dominant species were not uniformly spread in the campus and they occurred differently in different sub-sites of the campus Tables 3–4. *Leucaena leucocephala* was absent in a-south but was maximum at Tapowan. *Eucalyptus globulus* was found in every sub-sites of the campus with highest population in the b-central (1699). Similarly, *Monoon longifolium* population was maximum in a-south, followed by SCRIET and b-central. *Azadirachta indica* was maximum at Tapowan followed by b-central and a-south.

Tree basal cover

The total university campus area (222 acres) under tree (>10 cm girth) basal cover was >490 m^2 of the 128 tree species recorded in this campus, a total of nine dominant tree flora viz. *Eucalyptus globulus*, *Mangifera indica*, *Azadirachta indica*, *Alstonia scholaris, Leucaena leucocephala, Ficus benjamina*, *Dalbergia sissoo, Grevillea robusta, Ficus religiosa* occupied had 67.51% of the total tree basal cover here (Table 5). These nine species represented about 63.94% of the tree populations in the campus. Of these, *Eucalyptus globulus* alone accounted for nearly 42.05% of the total tree basal cover in the campus, albeit it had only about 12.02% of tree population here. Only 51 tree species exhibited >10000 cm^2 mean basal cover. The highest mean basal cover of a single tree species was recorded for *Enterolobium contortisiliquum* (3953 cm^2, n=3) followed by *Ailanthus excelsa* (3607 cm^2, n=2). A single tree of *Ceiba speciosa* showed a basal cover of 3539 cm^2 followed by *Pterygota alata* (3023 cm^2).

Girth-size distribution

The tree size of the sampled trees in this study in the university campus ranged from 10 cm to a maximum of 693 cm. The size class distribution showed largest population of 9303 tree individuals in the range 10 cm - 30 cm girth size (Fig. 2), followed by 3667 in the size 30-50. There was gradual decrease in population size with increasing girth size (upto >300 cm). However, the tree individuals were recorded in every class

Table 3. Floristic structural characteristics of tree layer across four sectors in the campus of Chaudhary Charan Singh University, Meerut. a: South sub-site, b: Cantral sub-site, c: West, Sir Chhotu Ram Institute of Engineering & Technology (SCRIET), d: North sub-site (Tapowan).

Sl. No.	Plant species name	a-South	b-Central	c-West SCRIET	d-Tapowan	Entire campus
1	Total number of species recorded	107	80	57	57	128
2	Total number of Angiospermic and Gymnospermic families	41	30	26	23	43 (40+03)
3	Total number of individuals (All species)	4303	6320	1816	7483	19922

size between 320-340 to 690-710 albeit very few in number. In *Eucalyptus globulus* population (n=2394) the maximum girth recorded was 321 cm. The highest girth was recorded for *Ficus benghalensis* (639 cm) followed by *Ficus racemosa* (368 cm).

The soil characteristics varied with tree flora above it (Table 6). While the soils across the different sites tended to be neutral in pH, the moisture content varied from 6.5% (*Albizia lebbeck*) to 8.4% (*Azadirachta indica*). Soil organic carbon was higher under *Eucalyptus globulus* and *Albizia lebbeck* dominated sub-sites. In contrast, C:N ratio was highest at *Leucaena leucocephala*-dominated sub site followed by *Eucalyptus globulus*-dominated sub site. Exchangeable cations were much higher at *Eucalyptus*-dominated site compared to other sites.

Population structure of the dominant tree species across different size classes, showed differing trends Figs. 3–4. The most populous *Leucaena leucocephala* tree population was maximally represented (95%) in young stage 10–30 cm girth class and declined sharply in next girth class and exhibited even-aged character in later classes. In contrast, a trend to convex form of population structure was evinced for *Eucalyptus globulus*, where the largest number of tree individuals occurred in 50–150 cm range that accounted for 77% its total population in the campus. The mean GBH of *Eucalyptus globulus* was 109 cm (maximum 321, n=2394). *Monoon longifolium*, *Albizia lebbeck* and *Holoptelea integrifolia* showed a trend of population structure comparable to that of *Leucaena leucocephala*, indicative of mainly young individuals. *Azadirachta indica*, and *Dalbergia sissoo*, although in relatively fewer numbers at larger sizes, showed a general smoother declining trend with increasing size classes. Even-aged character is however, the general trend in most of the tree species populations recorded in the campus.

Tree density distribution across different girth-size classes at all four campus sub-sites (Fig. 4) indicated in general, increasing mortality with increasing size classes and even-agedness at higher sizes (>150 cm GBH). Heavy mortality (>50%) from 10-30 to 30-50 is intelligible in tree populations when viewed at the entire campus level, albeit a similar declining trend of density is evident in this study at all sub-sites.

Table 4. Dominant tree species and the total number of individuals recorded across four sectors in the campus of Chaudhary Charan Singh University, Meerut. a: South sub-site, b: Cantral sub-site, c: West, Sir Chhotu Ram Institute of Engineering & Technology (SCRIET), d: North sub-site (Tapowan).

Sl. No.	Plant species name	a-South	b-Central	c-West SCRIET	d-Tapowan	Entire campus
1	*Leucaena leucocephala*	-	52	1	4619	4672
2	*Eucalyptus globulus*	460	1699	88	147	2394
3	*Monoon longifolium*	506	246	261	5	1018
4	*Azadirachta indica*	215	294	69	300	878
5	*Ficus benjamina*	394	399	167	148	1108
6	*Holoptelea integrifolia*	99	191	12	511	813
7	*Albizia lebbeck*	41	19	-	653	713
8	*Psidium guajava*	140	362	70	3	575
9	*Dalbergia sissoo*	160	225	129	54	568

Table 5. Dominant tree flora in terms of basal cover occupancy in Chaudhary Charan Singh University campus.

Sl. No.	Plant species name	Total basal cover (cm^2)	Number of individuals	Maximum girth (cm)	Mean girth ± SE
1	*Eucalyptus globulus*	2249881	2394	321	108.73 ± 0.89
2	*Mangifera indica*	261968	455	293	85.10 ± 2.40
3	*Azadirachta indica*	260263	878	243	61.06 ± 1.35
4	*Alstonia scholaris*	166698	404	224	72.04 ± 1.94
5	*Leucaena leucocephala*	164480	4672	172	21.04 ± 0.20
6	*Ficus benjamina*	136621	1108	198	39.38 ± 0.79
7	*Dalbergia sissoo*	135415	568	259	54.76 ± 1.62
8	*Grevillea robusta*	127888	209	180	87.73 ± 2.27
9	*Ficus religiosa*	108810	94	427	120.67 ± 10.76
10	*Roystonea regia*	95770	129	277	96.64 ± 3.25
11	*Morus alba*	87810	397	297	52.75 ± 2.35
12	*Aegle marmelos*	83046	391	287	51.69 ± 1.97
13	*Ficus racemosa*	80174	58	368	131.86 ± 12.54
14	*Pongamia pinnata*	79861	457	140	46.88 ± 1.30
15	*Monoon longifolium*	79241	1018	227	31.29 ± 0.75
16	*Holoptelea integrifolia*	72442	813	261	33.48 ± 1.14
17	*Syzygium cumini*	68493	288	254	54.69 ± 2.39
18	*Senna siamea*	66426	253	288	57.47 ± 2.31
19	*Albizia lebbeck*	60362	713	184	32.63 ± 0.97
20	*Cassia fistula*	58474	362	127	45.08 ± 1.23
21	*Caryota urens*	58185	63	224	107.78 ± 4.35
22	*Livistona chinensis*	51929	92	143	84.26 ± 2.65
23	*Kigelia africana*	46183	55	270	102.77 ± 8.62
24	*Putranjiva roxburghii*	43834	204	116	51.99 ± 1.66
25	*Morus macroura*	42538	17	358	177.41 ± 20.35
26	*Delonix regia*	36121	78	187	76.32 ± 4.65
27	*Populus deltoides*	31855	49	165	90.43 ± 4.06
28	*Ziziphus jujuba*	28963	150	186	49.28 ± 2.27
29	*Ficus virens*	27708	11	665	178.00 ± 50.84
30	*Melia azedarach*	26808	160	168	45.91 ± 2.31
31	*Tectona grandis*	26454	121	180	52.44 ± 2.90
32	*Acacia auriculiformis*	26043	165	114	44.56 ± 1.21
33	*Araucaria columnaris*	25558	36	160	94.50 ± 9.16
34	*Terminalia arjuna*	25246	99	273	56.64 ± 4.40
35	*Psidium guajava*	25217	575	82	23.49 ± 0.43
36	*Neolamarckia cadamba*	20908	32	148	90.66 ± 5.06
37	*Ficus benghalensis*	20146	43	693	76.77 ± 16.94
38	*Streblus asper*	20036	255	138	31.44 ± 1.57
39	*Melaleuca viminalis*	18372	219	96	32.48 ± 1.02
40	*Ficus tsjakela*	17730	26	307	92.62 ± 14.18
41	*Cascabela thevetia*	16665	128	170	40.47 ± 2.01
42	*Toona ciliata*	13316	31	172	73.51 ± 6.75
43	*Terminalia bellirica*	12760	40	185	63.35 ± 6.10
44	*Plumeria obtusa*	12160	158	66	31.11 ± 0.84
45	*Mimusops elengi*	11976	48	96	56.02 ± 3.15
46	*Enterolobium contortisiliquum*	11860	3	378	223.00 ± 107.29
47	*Phyllanthus emblica*	11712	67	126	46.89 ± 3.17
48	*Bauhinia purpurea*	11158	129	112	32.98 ± 1.39
49	*Madhuca longifolia*	10844	35	148	62.43 ± 4.92
50	*Casuarina equisetifolia*	10645	8	190	129.38 ± 13.89
51	*Lagerstroemia speciosa*	10526	115	87	33.93 ± 1.66

However, sharpest decline is noteworthy at Tapowan sub-site where density in 30-50 cm size class is about one-fifth of that in 10-30 cm size class.

DISCUSSION

More than 490 m^2 area of land under tree (>10 cm

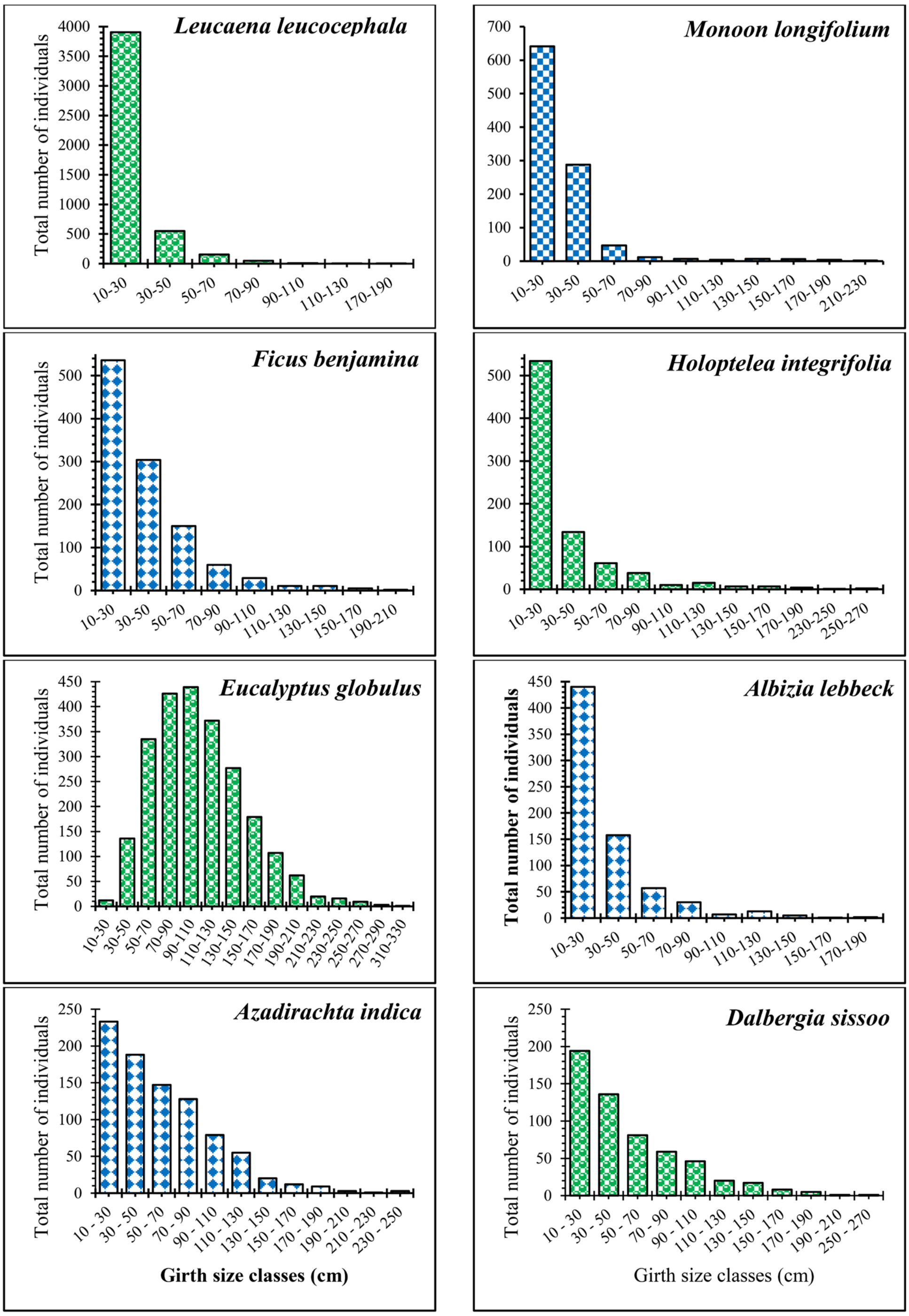

Fig. 3. Population structure of dominant tree flora in the campus of Chaudhary Charan Singh University.

girth) basal cover recorded in the presently investigated university campus spread over 222 acres, indicated a significant proportion of land under tree cover. This considerable achievement of a green cover is the

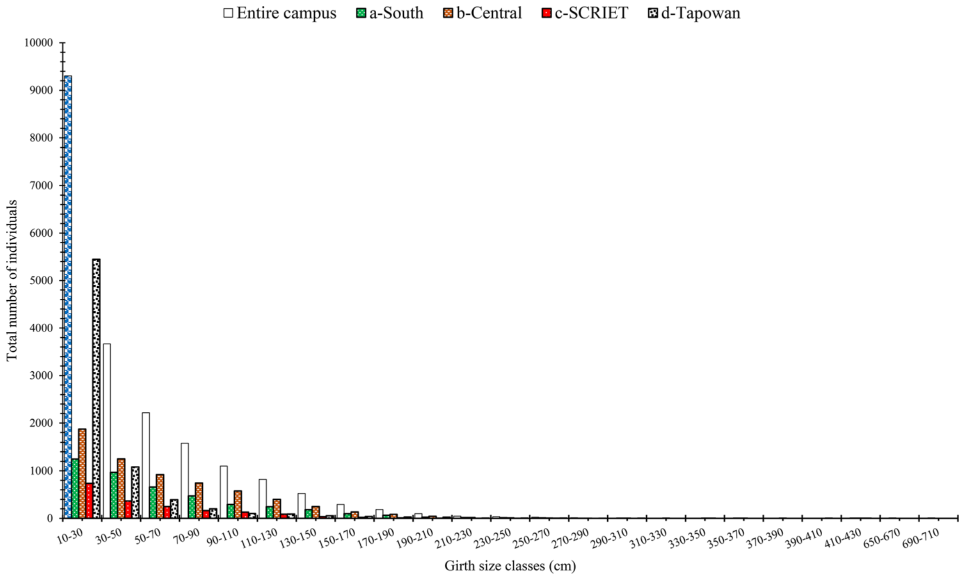

Fig. 4. Showing the number of individuals of trees in different girth size classes across four sectors of Chaudhary Charan Singh University, Meerut.

result of long-planned repeated-plantations over six decades in a dry tropical urban region of Meerut in India. This is reflective of a very significant contribution in mitigating the adverse impact of climate change in the midst of massive developmental activities in Meerut and its urban sprawl, through biological carbon sequestration by 19922 tree individuals recorded in the campus, withdrawing atmospheric carbon dioxide (Singh *et al.* 2019). Ferrini and Fini (2011) suggested that by urban plantations, net reduction in carbon emission could be achieved upto 18 kg CO_2 / year/tree. These tree species may vary in their carbon sequestration abilities, yet, urban tree plantations have significant potential to sequester carbon in highly dynamic dry tropical anthropo-ecosystems locally at source and to stock this carbon in their biomass for long time period (Ugle *et al.* 2010).

Fifty one tree species out of a total of the 128 tree species recorded in the present study had >10000 cm^2 basal cover (Table 5). It is evident that through plantation efforts, fairly large tree diversity level (43 higher vascular plant families) has been achieved. However, it is also noteworthy that nine top dominant tree flora in the campus contributed to 67.5% of the total tree basal cover, and they accounted for only 54.1% of total tree populations. These flora included *Eucalyptus globulus*, *Mangifera indica*, *Azadirachta*

Table 6. Physico-chemical properties of soils under various dominant tree flora in the campus of Chaudhary Charan Singh University, Meerut (Mean±SE).

Parameters	*Albizia lebbeck*	*Azadirachta indica*	*Eucalyptus globulus*	*Leucaena leucocephala*
pH	6.99±0.107	6.63±0.092	6.670±0.202	6.83±0.109
Moisture (%)	6.521±0.708	8.441±2.399	7.073±1.247	7.706±1.138
Org C (%)	0.337±0.004	0.663±0.078	1.100±0.096	0.877±0.015
Tot N (%)	0.099±0.031	0.085±0.004	0.097±0.004	0.061±0.001
C:N ratio	4.494±1.821	7.922±1.259	11.301±0.539	14.255±0.128
Na (mg/g)	0.023±0.001	0.022±0.001	0.045±0.009	0.026±0.001
K (mg/g)	0.060±0.004	0.060±0.009	0.095±0.023	0.060±0.005
Ca (mg/g)	0.249±0.014	0.256±0.017	0.637±0.054	0.253±0.014

indica, Alstonia scholaris, Leucaena leucocephala, *Ficus benjamina, Dalbergia sissoo, Grevillea robusta* and *Ficus religiosa*. Besides these dominant species in this campus, other species cover in this university campus also played their important role in reducing temperatures, pollution and rainwater run-off, and aerial particulate matter (Reis and Lopes 2019). Possibly, this is a primary cause that attracted a large number of city dwellers of Meerut in the morning and evening for healthy walks. Accordingly, tree cover in urban areas is also frequently opined by several other workers to play an important role in improving air and water quality.

Only 21 tree species were recorded whose population size exceeded 200 individuals in the campus, yet, the total diversity of 128 successfully surviving tree species reflected the wellbeing of the ecosystem in the campus. Of course, the tree dominants in the campus could be attributed mainly to the selective plantation efforts in the campus, the existing tree species in the campus could be on account of transported tree propagules or the result of individual or community initiative on planned or unplanned basis. Exceptionally very high girth of tress species of *Ficus* recorded albeit few in numbers has religious or nature traditional implication for conservation in India.

Eucalyptus globulus with a basal cover of 219 m^2 in the campus, accounting for about 45% of total area under tree basal cover in the campus, represented over 13% of tree population in the campus (Table 5). It is evident that *Eucalyptus globulus* plantations were undertaken at a large scale initially, as is evinced from its mean girth of 109 cm (maximum 321 cm) (Table 5) and the largest representation of its tree population (77%) in the girth-size 50—150 cm (Fig. 3). Such population data of timber trees in different girth sizes have immense implication for their commercial value in the market as well as for the conservation decision by foresters who often used such data for conservation or tree removal to avoid overstocking. Such ecological data with corresponding standard wood density and height values, that are generally available with foresters to estimate biomass, can be extrapolated to provide estimates of carbon storage and sequestration for example, Nowak (1993) reported national carbon storage by urban trees 350-750 million tones based on carbon data of Oakland city and tree cover data from various cities. Few workers in India have used such tree girth/cover data in addition to other tree characteristics, especially from urban regions for estimating carbon stock in the tree species e.g., Singh *et al.* (2022).

Educational institutions or other non-carbon-emitting or non-industrial areas can thus, investigate their potential in terms of their carbon credit in the present era of competitions for carbon credit. However, CFC-releasing units, such as air-conditioners in such urban institutions also need to be taken into consideration for evaluation of the net carbon credits.

Analysis of population structure of trees of the entire campus (Fig. 2) indicated a near-expanding tree population structure with the largest representation of population in the younger plant sizes and decreasing population size with increasing girth-size classes (Singh *et al.* 2018). This could also be considered reflective of regular plantation efforts, mortality with increasing tree sizes and felling at larger sizes. However, population structure analysis of different tree species separately depicted different patterns of population growth. *Dalbergia sissoo* and *Azadirachta indica* showed a relatively stable population structure with largest representation in the youngest size-class, followed by gradual decreasing population size with increasing girth-classes. *Eucalyptus globulus* indicated declining trend of population structure, evinced by its urn-shaped population structure, ostensibly on account of poor regeneration and thus, larger representation in the intervening size classes, and even agedness at the higher size classes. In contrast, *Monoon longifolium*, *Albizia lebbeck* and *Holoptelea integrifolia* exhibited a comparable trend of expanding populations and even-agedness at higher girth-classes. The pronounced younger population of *Leucaena leucocephala* is also evident in this study here, which is confined to only one sub-site of the campus at Tapowan, which in terms of area, is very small and protected in nature compared to other sub-sites of study in the campus. Analysis of population structure of the planted tree species especially in urban areas has implications for conservation and commercial exploitation.

The soil under long exposure to a dominant species appears to have influenced soil characteristics, as is evinced by the range of different soil parameters e.g. soil organic carbon ranged from 0.337% to 1.1% and C:N ratio from 4.5 to 14.3. The amount of C in soil organic matter ranges from 40 to 60% by weight, albeit the SOM usually constitutes less than 5% of soil weight, which is considered as one of the most important components of a field ecosystem (Lal 2015).

CONCLUSION

The planted trees need to be managed and taken care of properly to maintain diversity, regeneration, and soil health, especially in light of dominant *Eucalyptus globulus*, which is considered ecologically a criminal water consumer. O'Sullivan *et al*. (2017) opined that retaining mature trees and planting additional ones to replace very old trees could enhance biodiversity, pollution and climate regulation, carbon storage, and storm water management.

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