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Phytosociological Analysis of Core and Buffer Zone in Sariska Tiger Reserve, Alwar, Rajasthan

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Abstract

This study examined the density, species composition, basal area (BA) and importance value index (IVI) of trees while, in the Sariska Tiger Reserve (STR) shrubs were examined for density and frequency. Two areas were selected for investigation: the core and the buffer area. The total tree density was 113 species/ha in the core area and 99 species/ha in the buffer area. Furthermore, the BA was 68.40 m²/ha in the core area and 44.47 m²/ha in the buffer area. *Anogeissus pendula Edgew*. was identified as the prominent species of tree in both areas, displaying the highest density, frequency, BA and IVI. The total shrub density in the core area was 2,255 compared to 1,440 species/ha in the buffer area. The most dominant shrub species in both areas was *Justicia adhatoda*, which also exhibited the highest density and frequency. In the tree density, BA significant effect ($p<0.05$) was found and shrub density among core and buffer area, respectively. The diversity indices indicated higher diversity of trees in the core area with increased Shannon index i.e. 2.11 compared to (1.58) buffer values. In contrast, the Simpson (0.77), the Marglef index (6.06), and the Pielou index (0.74) were higher for the tree in the core than the buffer (0.75), (4.1), and (0.62) respectively. However, in the buffer area the shrub species had a higher Shannon index (2.46), Simpson (0.93) and Pielou index (0.82) than core (2.39), (0.92), (0.73) respectively. Additionally, core shrub species had a higher Marglef index (9.02) than core shrubs (7.22). The potential for this study to advance our understanding of the phytodiversity and composition of tree species in the STR makes it significant.

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Introduction

Human life depends on forests since they offer a broad variety of resources and ecological services. Unfortunately, several reasons, such as expanded agricultural practices, timber plantations, urbanization and industrial expansion are causing the forest cover to rapidly decline. These actions seriously endanger forests and damage the ecosystem.

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Maintaining ecological equilibrium, preventing the extinction of endangered species and safeguarding and conserving biodiversity all depend on forest conservation. Forest conservation efforts must understand the age distribution and species mix of trees in order to create effective restoration plans. The distribution and makeup of plant communities within a region reflect a variety of environmental variables. Drylands, which comprise 45% of the planet's surface, are home to about 38% of the world's people. These regions fall under the category of having an aridity index below 0.65. The world's biodiversity may be threatened by rising temperatures and global climate change. India's land area of 37% is made up of semi-arid areas. Rajasthan, India's largest state, is 342,239 km^2 or around 10.40% of the nation's total land area. Rajasthan has a desert climate in the west and a semi-arid climate in the east.[1] The majority of the state's forests are tropical dry deciduous and thorn forests, which make up just 8% of its total land area.[2] These areas frequently face drought due to their low and irregular rainfall, sharp temperature swings, and degraded soil. In these places, vegetation distribution is greatly influenced by topography and climate. To our knowledge, relatively little research has focused on the plant communities and vegetation structures present in semi-arid areas of India. There is still much to learn about the various types of vegetation and plant communities that exist in these areas. Additionally, ongoing urbanization is leading to the destruction and fragmentation of these forests, putting native tree species at risk from invasive species. Three essential aspects of forest ecosystems that are changing as a result of topography, disturbances, succession, climate, and soil conditions are composition, community structure, and function. The distribution and makeup of plant species in a region reflect environmental gradients, so assessing forest composition and community structure is crucial for management and conservation planning.[3] Forest communities nature is greatly influenced by the ecological features of the species diversity, sites, abundance, richness and distribution conditions.[4] This study offers essential baseline data for conserving and managing the forest's species of native tree and vegetation. This research aims to analysed the significance of tree density and basal area (BA), regarding the significance of shrub density in the Sariska Tiger Reserve (STR) buffer and core forest division in Alwar district, Rajasthan. The study also assessed the diversity indices, such as Simpson, Margalef, Shannon index and Pielou of trees and shrubs in this area.

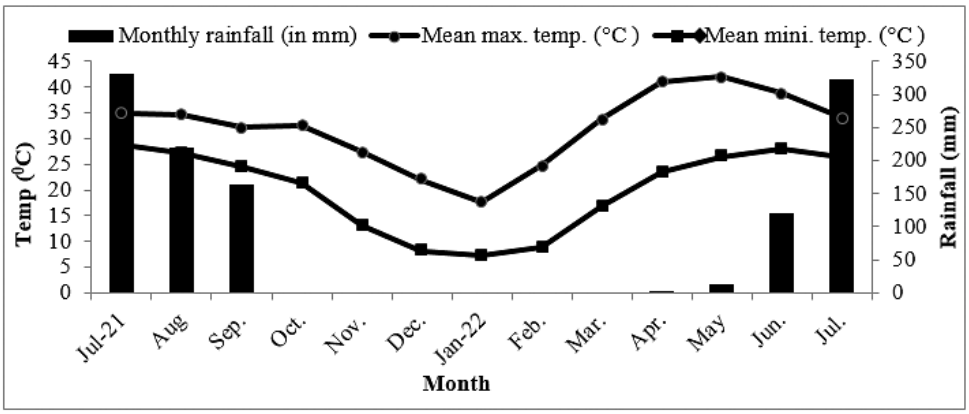

Fig. 1: Climate variables during the study period of 2022: temperature (°C) or rainfall (mm)

Material and Methods

Study Area

This study focused on the STR forests, which are located in Rajasthan's Alwar region. The whole area of Rajasthan is made up of 16,629 km² of forest cover, or 4.86% of the state. STR is situated in the 8,380 km² Alwar district, which has 1,196.66 km² of forest area, or 14.28% of the district's total area.[5] The forested area of Alwar is divided into three categories: 802.70 km² is open forest, 334.96 km² is moderately dense, and 59 km² is very dense forest. Sariska Wildlife Sanctuary and the surrounding territories make up STR, a conservation area established and safeguarded by the national

government. It has core and buffer area. The core area of this forest is between 270 and 360 meters high and the study region is located in the Aravalli hill range, located between longitudes 76° 17′ E to 76° 34′ E and latitudes 27° 05′ N to 27° 45′ N.[6] Numerous ecosystems are supported by the geography, such as grasslands, rocky outcrops, dry deciduous woods, and scrub-thorn forests. The forest is scarce, dispersed across a wide area, and has different soil and geological patterns.[6] It has separate seasons for winter, summer, monsoon, and post-monsoon, with an average of 650 mm of rainfall annually with temperatures between 7.3°C in January and 38°C in June. With the highest mean temperature in June 2022 and the lowest in January 2022 (IMD, 2022), humidity levels range from 21 to 100% (Fig-1).

Sampling and Data Analysis

The phytodiversity study involved sampling conducted over a year, from July 2021 to July 2022. The sampling sites were selected on the basis of their presence in core and buffer area respectively. For sampling random quadrats were laid 20x20 m^2 for trees. The diameter of every tree within the quadrats was determined by measuring breast height (DBH) i.e. 1.37 m above the earth surface, for trees with a DBH> 10 cm.[7] Within this a 5x5 m^2 quadrats was laid for the shrubs analysis. A total of 225 quadrats were established, with 105 located in the core and 120 in the buffer area of STR. The importance value index (IVI) was evaluated sum of relative frequency, relative density and relative dominance. The frequency, BA, density and IVI were analysed using standard methods.[8] These were calculated using the following as.

Frequency (%) = Total number of quadrats where the species occurred/(Total number of quadrats studied)×100

Density (species/ha) = (Tatal number of individual of one species)/(Total number of quadrats studied)×100

Importance value index (IVI) = Relative Frequency + Relative Dominance + Relative Density

Basal area (m^2/ha) = $(DBH)^2/125600$

Diversity Indices Analysis

Tree and shrub is measured using the following diversity indices: Simpson for the concentration of dominance (CD),[9] Margalef (d) for species richness,[10] Shannon index of diversity (H') for diversity analysis[11] and Pielou for evenness (SE)[12] for tree and shrubs in both areas. The Shannon index (H') is used to measure abundance and richness of species. The Simpson Index (CD) reflects species dominance.

$$CD = \Sigma (ni \times (ni-1)) / (N \times (N-1))$$

where ni is the no. of individuals in the ith species and N is the total no. of individuals.

The Margalef Index (d) was also considered.

$$d = (S - 1) / \log (N)$$

where N is no. of individuals, S is total no. of species and log is natural logarithm.

The Shannon index (H') is utilize for measurement abundance and richness of species, taking both into account.

$$H' = -\Sigma (pi \times \ln (pi))$$

where pi is proportion of species i, and ln is natural logarithm.

The evenness of a community can be expressed using Pielou index.

$$SE = H' / \ln(S)$$

where H' is Shannon index and S is total no. of species.

Statistical Analysis

To identify the significant variations for tree density, BA and diversity indices, while for shrubs density and diversity indices between the core and buffer areas, using XLSTAT (version 2024), we compared these two areas by using an analysis of variance (ANOVA). At p value less than 0.05, the significant level was established.

Results

Floristic Composition

In the research area, 51 species (shrub and tree) belonging to 28 families and 42 genera were found in 225 plots. Total 19 tree species from 13 families present the both forest areas; of which 17 tree species (11 families) were in the core area and 12 species

of tree (7 families) were found within the buffer area (Table 1). There were just 10 species common in both area. The dominant species in both area was determined to be the *A. pendula* Edgew. tree species. With 14 species, the Fabaceae family was the most varied of the plant families. Then came the families Malvaceae and Astaraceae, which each represented eight species, and Moraceae and Zygophylaceae, which each represented two species. With three species, Acacia was the most diverse genera discovered.

In the both forest area of the research area, there were 39 shrub species found, representing 24 families and 32 genera. Among them, the core zone contained 28 shrub species (18 families) while the buffer zone contained 25 species (18 families) (Table 1). Only 12 species were found to share both area. The most dominant shrub in the reserve was *Justicia adhatoda*.

Table 1: Tree stand structure and diversity indices of STR, Alwar, Rajasthan

Variable	Core	Buffer	Core	Buffer
Trees			**Shrubs**	
No. of families	11	7	18	18
Species	17	12	28	25
TD (species/ha)	113	99	2255	1440
TBA (m2/ha)	68.40	44.47	-	-
H’	2.11	1.58	2.39	2.46
CD	0.77	0.75	0.92	0.93
SE	0.74	0.62	0.73	0.82
D	6.06	4.1	9.02	7.22

CD = Simpson index; H’ = Shannon index; SE = Pielou index; d = Margalef;
TBA = Total Basal Area; TD = Tree Density

Frequency and IVI

In the research area the highest frequency with IVI of trees in core (232.75 %, 301.8) and lowest in buffer area (207.4 %, 300.2). The species that was most prevalent in the study area was *A. pendula* Edgew. The core (60.95%, 99.54) and buffer areas (70%, 119.86) had the greatest frequency of *A. pendula* Edgew. with the highest IVI value. *Azadirachta indica* A. Juss. had the lowest frequency with IVI value in core zones (0.9 %, 1.56) and *Balanities aegyptiaca* (L.) Delile had the lowest frequency with IVI value in buffer zones (0.83 %, 0.66) (Table 2).

In the research area, shrubs had the highest frequency in core (371.26 %) and the lowest in buffer area (283.26 %). *Justicia adhatoda* was the dominant species in this area. It had the greatest frequency in core (60.95%) and the lowest in buffer area (42.5%). *Mucuna pruriens* had the lowest frequency in core (1.9 %) and *Calotropis gigantea* (L.) Dryand. had the lowest frequency with IVI value in buffer area (3.3 %) (Table 3).

Density of Tree and Shrub

The density of tree was significantly higher ($p < 0.05$) in core area, with 113 species/ha, compared to the buffer area, which had 99 species/ha (Table 1). The tree species with greatest density was *A. pendula* in both core and buffer regions, with 39 and 41 species/ha, respectively (Table 2). *Azadirachta indica* A. Juss., *Eucalyptus Lher*, *Dalbegia sissoo* DC., and *Lannea coromandelica* (Houtt.) Merr. had the lowest density among all the trees in the core area. *Balanities aegyptiaca* (L.) Delile, Diospyros melanoxylon Roxb., *Albizia lebbeck* (L.) Bent. and *Barbarea vulgaris* W.T. Aiton had the lowest density in the buffer area.

The total shrub density was significantly ($p<0.05$) higher in core i.e 2255 species/ha as compared

to buffer 1440 species/ha, respectively (Table 1). Within the shrub species, *Justicia adhatoda* had the highest density in both the core and buffer regions i.e 415 and 227 species/ha respectively (Table 3). Among all the shrubs *Mucuna pruriens*, *Commiphora wightii* (Arn.) and *Woodfordia fruticose* had the lowest density in the core, and *Calotropis gigantea* (L.) Dryand. had the lowest density in buffer area.

Table 2. Phytosociological analysis of trees in core and buffer zone in STR

No.	Species of Core Sites	Family	F (%)	TD (species /ha)	IVI	BA (m^2/ha)
1	*Acacia catechu* (L.) Willd. Oliv.	Fabaceae	20	10	21.85	3.15
2	*Acacia leucophloea* (Roxb.) Willd.	Fabaceae	40	19	48.87	10.13
3	*Anogeissus pendula* Edgew.	Combretaceae	60.95	39	99.54	26.8
4	*Albizia lebbeck* (L.) Bent.	Fabaceae	7.6	2	7.24	1.28
5	*Azadirachta indica* A. Juss.	Meliaceae	0.9	1	1.56	0.66
6	*Boswellia serrata* Roxb.	Burseraceae	5.7	2	5.22	0.89
7	*Butea monosperma* (Lamk.) Taub.	Fabaceae	40	20	51.81	11.85
8	*Cassia fistula* (L.)	Fabaceae	9.5	3	9.32	1.71
9	*Dalbergia sissoo* DC.	Fabaceae	0.9	1	2.46	1.13
10	*Diospyros melanoxylon* Roxb.	Ebenaceae	9.5	3	8.61	1.37
11	*Eucalyptus obliqua* Lher	Myrtaceae	0.9	1	4.82	0.22
12	*Ficus benghalensis* (L.)	Moraceae	2.8	1	2.80	0.66
13	*Ficus religiosa* Forst.f.	Moraceae	3.8	1	4.14	1.14
14	*Holoptelea integrifolia* Planch.	Ulmaceae	17	5	18.94	1.79
15	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	1.9	1	1.67	0.3
16	*Vachellia nilotica* (L.) P.J.H. Hurter and Mabb.	Fabaceae	4.7	2	5.66	1.05
17	*Zizipus mauritiana*	Rhamnaceae	6.6	2	7.22	1.27
	Total		232.75	113	301.80	68.40
No.	**Species of Buffer Sites**					
1	*Acacia leucophloea* (Roxb.) Wild.	Fabaceae	58.33	24	76.63	10.55
2	*Anogeissus pendula* Edgew.	Combretaceae	70	41	119.86	19.51
3	*Albizia lebbeck* (L.) Bent.	Fabaceae	2.5	1	2.79	0.42
4	*Balanities aegyptiaca* (L.) Delile	Zygophyllaceae	0.83	1	0.66	0.02
5	*Barbarea vulgaris* W.T. Aiton	Brassicaceae	1.66	1	2.01	0.06
6	*Butea monosperma* (Lamk.) Taub.	Fabaceae	37.5	18	52.37	7.2
7	*Dalbergia sissoo* DC.	Fabaceae	3.33	1	4.21	0.68
8	*Diospyros melanoxylon* Roxb.	Ebenaceae	3.33	1	3.97	0.67
9	*Ficus benghalensis* (L.)	Moraceae	1.66	1	1.79	0.25
10	*Ficus religiosa* Forst.f.	Moraceae	9.1	3	11.43	1.79
11	*Holoptelea integrifolia* Planch.	Ulmaceae	9.16	3	11.98	1.83
12	*Vachellia nilotica* (L.) P.J.H. Hurter and Mabb.	Fabaceae	10	4	12.48	1.49
	Total		207.4	99	300.22	44.47

BA = Basal area; F = Frequency; IVI = Importance value index; TD = Tree density

Basal Area of Tree

Tree total basal area (TBA) was estimated as 68.40 and 44.47 m^2/ha in the core and buffer areas, respectively (Table 1). Among the all trees, *A. pendula* Edgew. had the highest TBA in both areas, 26.8 m^2/ha in the core and 19.51 m^2/ha in the buffer area. *Eucalyptus Lher* had the lowest TBA (0.22 m^2/ha) in core and *Balanities aegyptiaca* (L.) Delile had the lowest TBA (0.02 m^2/ha) in the buffer area Table 2). ANOVA showed that the TBA of trees has a significant difference on the trees ($p<0.05$).

Diversity Indices

The diversity parameter analysis of trees in the core is shown in Table 1. The tree diversity was higher in core zone with H' values as 2.11 and 1.58, d as 6.06 and 4.1 and SE as 0.74 and 0.63, CD values as 0.77 and 0.75 for core and buffer zones respectively. However, the diversity indices were found to be non-significant in both the zones ($p>0.05$)

The diversity parameter analysis of shrubs in the core and buffer area are shown in Table 1. The shrubs diversity was higher in buffer zone with H' values as 2.46 and 2.36, CD as 0.93 and 0.92, SE as 0.82 and 0.73 for core and buffer zones respectively but d was higher in core zone with 9.02 and 7.22 core and buffer respectively. The CD, H' and d no any significant effect ($p > 0.05$) was found there in shrub populations in both the core and buffer regions. However, the SE did reveal a significant difference in shrub diversity ($p < 0.05$). Thus, particular tree species show different values for BA and density in both areas, indicating that the phytosociological parameters have a significant impact on the growth, structure, and distribution of shrubs and trees.

Table 3: Phytosociological analysis of shrubs in core and buffer area in STR.

No.	Species of Core Sites	Family	F (%)	SD (species/ha)
1	*Justicia adhatoda*	Acanthaceae	60.95	415
2	*Calotropis procera* (Aiton) W.T.Aiton	Asclepiadaceae	20	95
3	*Calotropis gigantea* (L.) Dryand.	Asclepiadaceae	4.76	19
4	*Capparis sepiaria* Linn.	Capparidaceae	25.71	133
5	*Capparis decidua* (Frosk.) Edgew.	Capparidaceae	8.57	50
6	*Cayratia carnosa Gagnep*.	Vitaceae	13.33	61
7	*Cissus quadrangularis*	Vitaceae	5.71	23
8	*Commiphora wightii* (Arn.)	Burseraceae	2.85	11
9	*Datura fastuosa* L.	Solanaceae	6.66	30
10	*Gardenia florida* L.	Rutaceae	13.33	69
11	*Grewia tenax* (Forssk.) Fiori	Tiliaceae	8.57	50
12	*Grewia flavescens*	Tiliaceae	21.9	145
13	*Hibiscus micranthus*	Malvaceae	20	126
14	*Helicteres isora*	Sterculiaceae	4.76	42
15	*Holarrhena antidysenterica*	Apocynaceae	6.66	38
16	*Lantana camara*	Verbenaceae	26.66	156
17	*Lantana indica*	Verbenaceae	9.52	61
18	*Leptadaenia pyrotechnica*	Asclepiadaceae	5.71	23
19	*Melhania futteyporensis* Munro	Stercualiaceae	8.5	61
20	*Mucuna pruriens*	Fabaceae	1.9	11
21	*Opuntia elatior*	Cactaceae	16.19	99
22	Parthenium hysterophorus	Asteraceae	36.19	270
23	*Ricinus communis*	Euphorbiaceae	3.8	19
24	*Vitex nirgundo*	Verbenaceae	1.9	15
25	*Woodfordia fruticose*	Lythraceae	1.9	11
26	*Ziziphus nummalaria*	Rhamnaceae	35.23	221
	Total		371.26	2255

No.	Species of Buffer Sites			
1	*Justicia adhatoda*	Acanthaceae	42.5	227
2	*Capparis sepiaria*	Capparidaceae	13.33	60
3	*Capparis decidua*	Capparidaceae	12.5	50
4	*Calotropis procera* (Aiton) W.T.Aiton	Asclepiadaceae	15.83	77
5	Calotropis gigantea (L.) *Dryand*.	Asclepiadaceae	3.33	13
6	*Cissampelos pariera* L.	Menispermaceae	10.83	43
7	*Clerodendrum inerme* (L.)	Verbenaceae	13.33	60
8	*Datura fastuosa* L.	Solanaceae	7.5	37
9	*Grewia damine* Gaertn.	Tiliaceae	3.33	20
10	*Grewia flavescens*	Tiliaceae	5.83	33
11	*Hibiscus micranthus*	Malvaceae	26.66	140
12	*Lantana camara*	Verbenaceae	20.83	106
13	*Lantana indica*	Verbenaceae	28.33	130
14	*Leptadaenia pyrotechnica*	Asclepiadaceae	9.16	43
15	*Parthenium hysterophorus*	Asteraceae	18.33	97
16	*Sarcostemma acidum*	Asclepiadaceae	6.66	37
17	*Tinospora cordifolia*	Menispermaceae	5.83	27
18	*Vetiveria zizaniodes*	Poaceae	9.16	50
19	*Woodfordia fruticosa*	Lythraceae	8.33	50
20	Zizipus nummularia (Burm.f.) Wight & Arn.	Rhamnaceae	21.66	140
	Total		283.26	1440

F = Frequency; SD = Shrubs Density

Discussion

Vegetation Composition

The Fabaceae family is well represented in the examined forests, with 14 species. Previous investigations in Kota, Rajasthan,[13] has also found leguminous plants to be dominant. Nitrogen-fixing species thrive in these forests due to the low soil moisture and nutrient-constrained environment.[14] Additionally, pollination and dispersal in these species are influenced by the conditions that are effectively established.[15] In every location, the study found that *A. pendula* was the most prevalent species in both areas of tree layer with the highest frequency and IVI. The most prevalent species in the shrub layer at both zones core and buffer zones, was *Justica adhatoda.* Due to its effects on seed germination and growth, it has the potential to remove native species because it is an invasive species with superior competitive ability.[16]

Density of Tree and Shrub

The investigation's estimated tree density for the study area 113 species/ha in core and 99 species/ha in buffer, which is similar range to the subtropical forest in Nepal's Udaipur district (1.40 to 431.58 species/ha)[17] and significant difference found for tree at core area in STR, Rajasthan.[18] The tropical dry deciduous forest of Rajasthan Jamwa Ramgarh (1319.53 species/ha), and Nahargarh (994.15 species/ha) Wild Life Sanctuary of Jaipur,[19] have higher tree densities than the current study region. This might be because there are a lot of individuals with little diameters.[20]

Among shrub species, *Justica dhatoda* has the highest density in buffer (2255 species/ha), while a total shrub density of 259.33 species/ha in protected areas and 141.33 species/ha recorded in non-protected-vegetation-stands in India's Nanta forest region in Rajasthan.[21] The density of shrubs is higher in the core zone. Low disturbance levels may result in increased density, as these are protected zones with regulated human activity.

Basal Area of Tree

The TBA of trees is critical for determining plant composition and site characteristics. The TBA values of the tree species taken into consideration in this

study are 68.07 (core) and 44.47 (buffer) m^2/ha. These values have been observed higher than the range reported by earlier research on semi-arid forests in Delhi (26.52 m^2/ha),[22] and in North Indian tropical thorn forests (3.69-11.99 m^2/ha).[23] The species composition, disturbance levels, and forest stand successional techniques all affect a tree's TBA. As seen in other studies, these forests had a reduced TBA because there were fewer individuals in the higher diameter classes.[22]

Diversity Indices Analysis of Trees and Shrubs

Species diversity tends to increase with community stability and is influenced by species adaptability. The reported ranges of 0.67 to 4.86 observed in subcontinent tropical forests of the India (1.85-2.05)[24] H' in the current forest STR 2.11 in core and 1.58 in buffer. The tropical deciduous forest is a diverse ecosystem, according to their findings. Numerous physiographic and biotic factors that affect species distribution at the landscape and forest site levels can be responsible for variations in species richness within forest stands. Other Indian tropical dry forests, the deciduous forests in the North Central Eastern Ghats (3.80),[25] and Bundelkhand (3.60)[26] has greater diversity indices. However, compared to earlier research from tropical dry deciduous forests in areas such as Northern India (3.32),[27] Maharashtra (2.92)[28] and tropical thorn forests in Peninsular India (1.76).[29] The interaction of different species in key areas may be the reason for the higher variety there. One may argue that increased diversity invariably results in higher stability when there are more species with overlapping niches.

For tree species, the CD has 0.77 in the core and 0.75 in the buffer. Species richness had an impact on the CD value; more species richness was indicated by lower values. The CD was significantly impacted by the IVI of the first three reasonably dominant species in a community.[30] SR is 6.6 in the core and 4.1 in the buffer zone of the tree layer.

The H' for shrub layer values 2.39 for core and 2.46 for buffer. H' ranged from 2.06 to 2.29 of shrub layer in Tropical Dry Forest of Northern India.[31] The shrub layer's CD values are 0.92 for the core and 0.93 for the buffer and In Northern India's Tropical Dry Forest, CD ranged from 0.85 to 0.88.[31] Shrub layer's SE equitability values are 0.73 for the core and 0.82 for the buffer and SE ranged from 0.87 to 0.90 in Tropical Dry Forest of Northern India.[31] d for shrubs is 9.02 in core and 7.22 in buffer and d ranged from 1.74 to 2.15 in Tropical Dry Forest of Northern India.[31]

Conclusion

This study investigates the phytodiversity and species composition in the STR forest of Alwar. The Forest ecosystem's composition and structure are influenced by the species of trees that grow there. Scientists, researchers, and forest managers can use the information on species richness, distribution patterns and phytosociological factors in a forest to formulate management strategies that will effectively conserve forests. *A. pendula*'s dominance in these forests is demonstrated by its significant contribution to the overall frequency, basal area, tree density and IVI of both zones. The Fabaceae family had the most species (14), out of the 51 species and 28 families that were reported. It was found that *Justica adhatoda* was the most prevalent shrub species. According to the study, the Core forest out performed Buffer in terms of density. Additionally, the core forest exhibited more overall diversity than the buffer, according to the biodiversity indexes. Research is needed to identify the most effective practices for conserving and managing forests to increase biodiversity.

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Conflict of Interest

The authors do not have any conflict of interest.

Data Availability Statement

Every dataset produced or examined during this study is part of the paper and is available upon request from the corresponding author.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

- **Priyanka Jatav:** contributed by getting up with the idea, writing the first draft, gathering information, developing a graph, and composing the paper.
- **Naveen Kumar:** The manuscript (MS) was reviewed and validated
- **Sonali Tiwari:** The MS was reviewed and validated
- **Dr. Archana Meena:** Recommended a critical assessment of the work and approved the MS for submission to the journal.

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