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RESEARCH ARTICLE **Open Access**

Diversity and abundance of tree species of a protected woodland: Southern Guinea savanna zone (Nigeria)

Korunan bir ormanlık alanın ağaç türlerinin çeşitliliği ve bolluğu: Güney Gine savan bölgesi (Nijerya)

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ABSTRACT

The study was carried out to assess the diversity and abundance of tree species in Federal College of Wildlife Management, New Bussa, Niger State. Twelve rectangular sample plots of 50x50m (3 hectares) were inventoried in the woodland. 273 trees per hectare were recorded, which belonged to 41 species and 18 families. *Anogeissus leiocarpus* was the most abundant tree species in the study area. The total basal area was 11.42m^2 per hectare. *Sterculia setigera* had the highest mean diameter at breast height at 51.29 cm while the highest mean height of 14.87 m was recorded for *Daniellia oliveri*. Shannon-Weiner diversity index (H) value was 3.14. Maximum diversity index (Hmax) was estimated to be 5.61, Pielou's species evenness index (EH) was 0.56 and Margalef's index of species richness (M) was calculated to be 7.13. There is need to ensure continuous availability of trees in the study area through effective conservation programme.

ÖZ

Bu çalışma, Nijer Eyaleti, New Bussa, Federal Yaban Hayatı Yönetimi Koleji'ndeki ağaç türlerinin çeşitliliğini ve bolluğunu değerlendirmek için yapılmıştır. Ormanlık alanda 50x50m (3 hektar) boyutunda on iki dikdörtgen örnek parselin envanteri çıkarılmıştır. Hektar başına, 18 familya ait 41 türe ilişkin 273 ağaç kaydedilmiştir. *Anogeissus leiocarpus,* çalışma alanında en bol bulunan ağaç türüdür. Toplam taban alanı hektar başına 11.42m^2 olarak hesaplanmıştır. *Sterculia setigera;* 51.29 cm ile en yüksek ortalama göğüs çapına sahip iken, en yüksek ortalama boy 14.87 m ile *Daniellia oliveri* için kaydedilmiştir. Shannon-Weiner çeşitlilik indeksi (H) değeri 3.14 olarak hesaplandı. Maksimum çeşitlilik indeksi (Hmax) 5.61, Pielou tür düzgünlük indeksi (EH) 0.56 ve Margalef tür zenginliği indeksi (M) 7.13 olarak hesaplanmıştır. Etkili koruma programları ile çalışma alanındaki ağaçların sürekli mevcudiyetinin sağlanmasına ihtiyaç vardır.

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1. INTRODUCTION

The rate at which loss of biodiversity takes place across the globe has called for a serious concern and this has greatly reduced the number of species, population, domesticated varieties, medicinal herbs and natural habitats (Shameem et al., 2010). Human activities have had significant impact on habitable surface of the earth and this may bring about mass extinction of animal and plant species in the nearest future (Wilson, 1992; Hannah et al., 1995). Conservation biologists warn that 25% of all species could become extinct during the next 20 to 30 years (Khera et al., 2001). The causes for loss of plant and animal species are many but the most significant of them is the loss and fragmentation of natural habitats (Jayakumar et al., 2011).

People and biodiversity coexistence bring about growth in a sustainable manner (Suratman, 2012). A college community like Federal College of Wildlife Management, New Bussa, has been known for conservation of plant and animal species with its rich biodiversity. Trees have contributed to many ecosystem services in the study area such as prevention of soil erosion, species conservation, preservation of habitat for plant and animals, windbreak, etc.

Accurate scientific long-term data in the savanna vegetation all over the world as well as Nigeria is generally limited (Lykke, 1998). As a result of this, tree species that are thought to be abundant might actually be endangered while those that are thought to be endangered might be close to extinction due to dearth of data (Ikyaagba et al., 2015). In the study area, baseline information and preliminary study on tree species composition, abundance and diversity is scanty, scarce, and unpublished. There is therefore the need for accurate and adequate information on the diversity and abundance of tree species as an important step to ensure its continuous conservation efforts which will in turn help in effective management of the resources.

2. MATERIAL AND METHOD

2.1. Study area

The study took place in Federal College of Wildlife Management, New Bussa, Nigeria, latitude 7°31'-10°00'N and longitude 4°30'- 4°33'E (Figure 1). It has an average temperature of 34°C with a relative humidity of 60% and mean annual rainfall of 650 mm to 1300 mm (Aguihe et al., 2016). The study area is a savanna zone in Northern Nigeria and consist largely of native tree species. Some of the tree species include; *Pterocarpus erinaceous, Anogeissus leiocarpus, Vitellaria paradoxa, Lannea acida, Lannea schimperi, Afzelia africana, Burkea africana, Terminalia glaucoscens* etc. Besides the tree species, the woodland also contains animals that are of great importance. Amongst these are the Grimm's duiker (*Sylvicapra grimmia*), Red-flank duiker (*Cephalophus rufilatus*), Ground Squirrel (*Xerus erythropus*), Green Monkey (*Chlorocebus sabaeus*), Stone patridge (*Ptilopachus petrosus*), African grey hornbill (*Lophoceros nasutus*) etc.

2.2. Method of data collection

The study was limited to the woodland of the college which largely consist of indigenous species. Twelve (12) sample plots of 50x50 m (3 hectares) were inventoried using systematic line transect technique. Four (4) transects of 600 m long, each well distributed over the college woodland were marked at interval. On first transect, 4 plots of 50m x 50m were marked out alternatively at 100m interval, on second transect, 2 plots were laid, on third and fourth transects, three plots were marked out along each of the transects. All plots were of the same size. An interval of 50m between transects was used. Measurement was carried out only on plant species with diameter at breast height equal or greater than 10 cm.

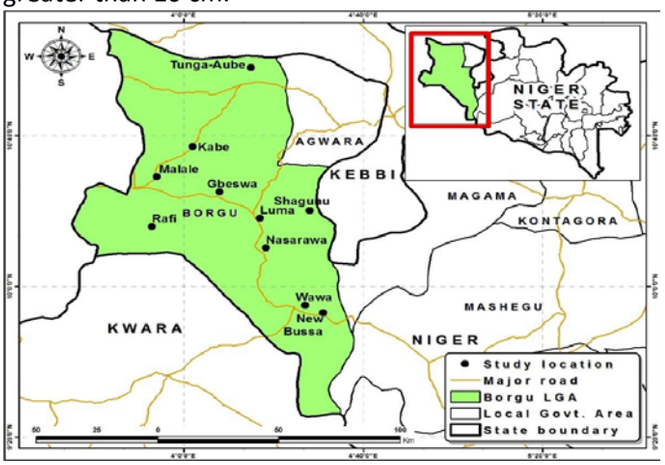

Figure 1. The study location

2.3. Method of data analysis

The analysis of data was carried out with the use of Microsoft Excel and the following formulas were used:

(1) Basal area**:** it is the cross sectional area of a tree at breast height (1.3m or 4.5ft above ground). The basal area of all trees were estimated using this formula:

$$BA = \frac{\pi D^2}{4}$$

BA = Basal area, Π= 3.142 (constant), D = Tree's diameter at breast height.

(2) Tree species relative density; this is used to assess tree species relative distribution in the study area, it was computed using this formula;

$$RD = \frac{n_i}{N} \times 100$$ (Brashears et al., 2004).

RD (%) = Tree species relative density; ni =individuals number of species i; N = total number of all individual trees.

(3) Relative dominance; this is used in determining the relative space that is being occupied by trees in the study area. It was calculated using this formula;

$$RD_O = \frac{\sum Ba_i \times 100}{\sum Ba_n}$$ (Adekunle et al., 2014).

Ba_i = Basal area of all trees of a particular species i; Ba_n = basal area of the entire stand

(4) Importance Value Index: This was achieved by adding the values of Relative Density and Relative Dominance together and then divided by 2, that is, (RD + RDo / 2) (Adekunle et al., 2014). This was used to determine the share of each tree species in the study area.

Other indices used by Kent and Coker (1992), Magurran (2004), Lu et al., (2010) and Adekunle et al., (2014) were also employed to carry out the analysis of this work, these are;

(5) Shannon-Wiener diversity index: this is commonly used in ecology and it is used to determine tree species diversity. The formula is given below as;

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

H' = Shannon-Wiener diversity index, S = total number of species in the study area, p_i = proportion of S (species in the family) in ith species, ln = natural logarithm. The values of Shannon-Wiener diversity index is usually between 1.5 and 3.5 and rarely higher than 4.5 (Magurran, 2004).

(6) Pielou's evenness index (EH): Is the ratio of the observed diversity (H) to the maximum diversity (Hmax), it is calculated using the formula:

$$E_H = \frac{H'}{H_{Max}} = \frac{\sum_{i=1}^{S} P_i \ln(P_i)}{\ln(S)}$$

The values of EH is between 0 to 1.0 with 1.0 denoting a case in which all species are equally abundant

(7) Margalef's index of species richness (M): Species richness is a count of different species in the study area. The index was calculated using the formula below;

$$M = \frac{(S-1)}{LnN}$$

Where S is the total number of species, N is the total of individuals and Ln is the natural logarithm.

3. RESULTS

3.1. Species composition and abundance

There were 816 individual trees in all the plots inventoried and 273 trees on per hectare basis, A total of 41 species and 18 families were also identified (Table 1). Fabaceae family had the largest number of species (11), close to it was Combretaceae having 9 species. In terms of abundance, Combretaceae had the most number of stems (87 stems per hectare, 32 %). *Anogeissus leiocarpus* (Combretaceae) had the highest frequency (39 stems per hectare) and was the most abundant species in the woodland, next to it was *Vitellaria paradoxa* (Sapotaceae) with 29 stems/ha.

Table 1. Tree species composition and abundance.

Family	***Species***	**Freq.**	**Density (N/Ha)**
Anacardiaceae	*Haematostaphis barteri*	4	1
	Lannea acida	25	8
	Lannea schimperi	3	1
Annonaceae	*Annona senegalensis*	1	1
Araliacea	*Cussonia arborea*	4	1
Bignoniaceae	*Stereospermum kumthiantum*	11	4
Burseraceae	*Boswellia dalzielii*	2	1
Calastraceae	*Maytenus senegalensis*	6	2
Chrysobalanaceae	*Maranthes polyandra*	5	2
Combretaceae	*Anogeissus leiocarpus*	118	39
	Combretum apiculatum	7	2
	Combretum glutinosum	19	6
	Combretum micranthum	2	1
	Combretum mollis	21	7
	Combretum nigricans	7	2
	Combretum seyal	3	1
	Terminalia glaucescens	76	25
	Terminalia macroptera	11	4
Euphorbiaceae	*Bridelia ferruginea*	55	18
Fabaceae	*Acacia gourmaensis*	20	7
	Acacia seyal	46	15
	Afzelia africana	4	1
	Burkea africana	16	5
	Daniella oliveri	6	2
	Detarium microcarpum	13	4
	Entada africana	5	2
	Pericopsis laxiflora	28	9
	Piliostigma thoningii	20	7
	Prosopis africana	14	5
	Pterocarpus erinaceus	53	18
Loganiaceae	*Strychnos spinosa*	15	5
Malvaceae	*Bombax costatum*	19	6
	Grewia mollis	33	11
	Sterculia setigera	8	3
Meliaceae	*Pseudocedrela kotschyi*	4	1
Moraceae	*Ficus sycomorous*	3	1

Phyllaanthaceae	*Hymenocardia acida*	6	2
Polygalaceae	*Securidaca longepedunculata*	3	1
Rubiaceae	*Crossopteryx febrifuga*	31	10
	Gardenia sokotensis	1	1
Sapotaceae	*Vitellaria paradoxa*	88	29
Total		**816**	**273**

3.2 Basal area and tree structure estimation

The total basal area of the woodland was 11.42m^2/ha. *Pterocarpus erinaceus* had the highest basal area of 2.11m^2/ha, closely followed by *Anogeissus leiocarpus* with the basal area of 2.02 m^2/ha. *Sterculia setigera* had the largest mean dbh (51.29 cm) while the least mean dbh (10.00 cm) was taken for *Annona senegalensis*. *Daniellia oliveri* and *Annona senegalensis* had the highest (14.87 m) and lowest (5.50 m) mean heights respectively (Table 2).

3.3 Species density and diversity indices

The results showed that Relative density (RD) in the woodland ranged from 0.24 to 14.41%. Species with high relative density are; *Anogeissus leiocarpus, Vitellaria paradoxa, Terminalia glaucescens, Pterocarpus erinaceus, Bridellia ferruginea*, etc. *Anogeissus leiocarpus* recorded the largest relative density of 14.41% while *Pterocarpus erinaceus* recorded the highest relative dominance of 18.51%. *Anogeissus leiocarpus* had the highest Importance Value Index (IVI) of 16.06, followed closely by *Pterocarpus erinaceus* with the value of 12.49. Shannon-weinner index (H') obtained for the woodland was 3.14. Maximum diversity index (Hmax) was estimated to be 5.61, Pielou's species evenness index (EH) was 0.56 and Margalef's index of species richness (M) was calculated to be 7.13 (Table 3).

Table 2. Basal area and tree structure estimation.

Family	Species	Nha^{-1}	Mdbh	Mth	Baha^{-1}
Anacardiaceae	*Haematostaphis barteri*	1	27.17	11.17	0.08
	Lannea acida	8	23.54	9.33	0.40
	Lannea schimperi	1	21.86	12.78	0.05
Annonaceae	*Annona senegalensis*	1	10.00	5.50	0.01
Araliacea	*Cussonia arborea*	1	22.11	8.95	0.06
Bignoniaceae	*Stereospermum kumthiantum*	4	15.84	8.52	0.08
Burseraceae	*Boswellia dalzielii*	1	21.15	9.55	0.02
Calastraceae	*Maytenus senegalensis*	2	12.50	6.95	0.03
Chrysobalanaceae	*Maranthes polyandra*	2	21.25	10.31	0.06
Combretaceae	*Anogeissus leiocarpus*	39	23.28	12.28	2.02
	Combretum apiculatum	2	23.01	10.25	0.13
	Combretum glutinosum	6	12.60	7.85	0.09
	Combretum micranthum	1	16.71	8.78	0.02
	Combretum mollis	7	14.18	7.58	0.12
	Combretum nigricans	2	14.76	7.67	0.04
	Combretum seyal	1	13.26	7.02	0.02
	Terminalia glaucescens	25	16.50	8.44	0.66
	Terminalia macroptera	4	12.36	8.12	0.05
Euphorbiaceae	*Bridelia ferruginea*	18	13.21	7.43	0.27
Fabaceae	*Acacia gourmaensis*	7	14.42	7.89	0.12
	Acacia seyal	15	13.13	8.23	0.24
	Afzelia africana	1	36.24	12.00	0.14
	Burkea africana	5	21.67	10.44	0.25
	Daniella oliveri	2	40.80	14.87	0.28
	Detarium microcarpum	4	15.71	8.34	0.09
	Entada africana	2	14.82	7.16	0.03

	Pericopsis laxiflora	9	22.33	9.56	0.40
	Piliostigma thoningii	7	15.36	7.64	0.13
	Prosopis africana	5	22.44	10.29	0.22
	Pterocarpus erinaceus	18	36.36	13.24	2.11
Loganiaceae	*Strychnos spinosa*	5	13.80	8.33	0.08
Malvaceae	*Bombax costatum*	6	38.44	13.11	0.84
	Grewia mollis	11	12.78	7.19	0.15
	Sterculia setigera	3	51.29	13.66	0.71
Meliaceae	*Pseudocedrela kotschyi*	1	17.90	9.48	0.04
Moraceae	*Ficus sycomorous*	1	25.01	9.27	0.06
Phyllaanthaceae	*Hymenocardia acida*	2	10.67	6.71	0.02
Polygalaceae	*Securidaca longepedunculata*	1	13.41	7.57	0.01
Rubiaceae	*Crossopteryx febrifuga*	10	20.05	9.10	0.37
	Gardenia sokotensis	1	12.73	7.10	0.01
Sapotaceae	*Vitellaria paradoxa*	29	19.00	8.47	0.94
Total		**273**	**823.63**	**378.11**	**11.42**
Mean			**20.09**	**9.22**	**0.28**

Nha-1 = Number of stems per hectare; Mth = Mean Total Height (m); Mdbh = Mean diameter at breast height (cm); Ba ha-1 = Basal Area per Hectare (m2)

Table 3. Tree species density and diversity indices.

Family	*Species*	Nha^{-1}	Ba ha^{-1}	RD	Rdo	IVI	H=PiLnPi	Hmax	EH	M
Anacardiaceae	*Haematostaphis barteri*	1	0.08	0.49	0.74	0.61	-0.03	5.61	0.56	7.13
	Lannea acida	8	0.40	3.05	3.50	3.28	-0.11			
	Lannea schimperi	1	0.05	0.37	0.44	0.40	-0.02			
Annonaceae	*Annona senegalensis*	1	0.01	0.37	0.07	0.22	-0.02			
Araliacea	*Cussonia arborea*	1	0.06	0.49	0.49	0.49	-0.03			
Bignoniaceae	*Stereospermum kumthiantum*	4	0.08	1.34	0.69	1.01	-0.06			
Burseraceae	*Boswellia dalzielii*	1	0.02	0.24	0.21	0.22	-0.01			
Calastraceae	*Maytenus senegalensis*	2	0.03	0.73	0.22	0.48	-0.04			
Chrysobalanaceae	*Maranthes polyandra*	2	0.06	0.61	0.53	0.57	-0.03			
Combretaceae	*Anogeissus leiocarpus*	39	2.02	14.41	17.72	16.06	-0.28			
	Combretum apiculatum	2	0.13	0.85	1.15	1.00	-0.04			
	Combretum glutinosum	6	0.09	2.32	0.77	1.55	-0.09			
	Combretum micranthum	1	0.02	0.24	0.13	0.19	-0.01			
	Combretum mollis	7	0.12	2.56	1.02	1.79	-0.09			
	Combretum nigricans	2	0.04	0.85	0.37	0.61	-0.04			
	Combretum seyal	1	0.02	0.37	0.14	0.25	-0.02			
	Terminalia glaucescens	25	0.66	9.28	5.75	7.52	-0.22			
	Terminalia macroptera	4	0.05	1.34	0.40	0.87	-0.06			
Euphorbiaceae	*Bridelia ferruginea*	18	0.27	6.72	2.37	4.54	-0.18			
Fabaceae	*Acacia gourmaensis*	7	0.12	2.44	1.02	1.73	-0.09			
	Acacia seyal	15	0.24	5.62	2.09	3.85	-0.16			
	Afzelia africana	1	0.14	0.49	1.27	0.88	-0.03			
	Burkea africana	5	0.25	1.95	2.15	2.05	-0.08			

	Daniella oliveri	2	0.28	0.73	2.44	1.59	-0.04
	Detarium microcarpum	4	0.09	1.59	0.79	1.19	-0.07
	Entada africana	2	0.03	0.61	0.27	0.44	-0.03
	Pericopsis laxiflora	9	0.40	3.42	3.47	3.45	-0.12
	Piliostigma thoningii	7	0.13	2.44	1.13	1.79	-0.09
	Prosopis africana	5	0.22	1.71	1.88	1.80	-0.07
	Pterocarpus erinaceus	18	2.11	6.47	18.51	12.49	-0.18
Loganiaceae	*Strychnos spinosa*	5	0.08	1.83	0.71	1.27	-0.07
Malvaceae	*Bombax costatum*	6	0.84	2.32	7.37	4.84	-0.09
	Grewia mollis	11	0.15	4.03	1.31	2.67	-0.13
	Sterculia setigera	3	0.71	0.98	6.21	3.59	-0.05
Meliaceae	*Pseudocedrela kotschyi*	1	0.04	0.49	0.31	0.40	-0.03
Moraceae	*Ficus sycomorous*	1	0.06	0.37	0.50	0.43	-0.02
Phyllaanthaceae	*Hymenocardia acida*	2	0.02	0.73	0.16	0.45	-0.04
polygalaceae	*Securidaca longepedunculata*	1	0.01	0.37	0.13	0.25	-0.02
Rubiaceae	*Crossopteryx febrifuga*	10	0.37	3.79	3.23	3.51	-0.12
	Gardenia sokotensis	1	0.01	0.37	0.11	0.24	-0.02
Sapotaceae	*Vitellaria paradoxa*	29	0.94	10.74	8.22	9.48	-0.24
Total		**273**	**11.42**	**100.12**	**99.99**	**100.06**	**-3.14**
Mean			**0.28**				
							H=3.14

Nha-1=Number of stems per hectare; Ba ha^{-1}= Basal Area per Hectare (m^2); RD = Relative Density (%); RDo = Relative Dominance (%); IVI = Importance Value Index; H = Shannon-Weiner Diversity index; Eh = Pielou's species evenness index; M=Margalef's index of species richness; Hmax = Maximum diversity index.

Table 4. Summary of tree species structure, abundance and diversity indices in the woodland

Variables /Indices	Values obtained
Number of Trees per hectare (N/ha)	273
Number of Species (NS)	41
Number of Family (NF)	18
Mean DBH (cm)	20.09
Mean Total Height (m)	9.22
Total Basal Area/ha (m^2)	11.42
Shannon-Weinner Index (H')	3.14
Pielou's Evenness Index (E)	0.56
Maximum Diversity Index (Hmax)	5.61
Margalef's Index of species richness (M):	7.13

4. DISCUSSION

The vegetation cover of the study area is characterized by savanna plant species such as *Anogeissus leiocarpus, Vitellaria paradoxa, Pterocarpus erinaceous, Terminalia glaucescens* etc which recorded the highest number at various sample plots. Result from this work has revealed that the college is highly rich in many tropical tree species of different families. This is substantiated by the 816 individual stems encountered in all the plots inventoried belonging to 41 species and 18 families (Table 4). This is very close to the results of Sani et al., (2019) in their study carried out in Falgore game reserve, Kano State, where they had 1102 individual stems consisting of 37 tree species and belonging to 17 families. The number of trees in this study area was more than that of Saka et al., (2013) in Gireri forest reserve in Adamawa State, Ikyaagba et al., (2015) in Makurdi, Benue State, Wakawa et al., (2017) in North East Nigeria, Suleiman et al., (2018) in Kwara State, and Ademoh et al., (2018) in Kogi State.

The family Combretaceae had the most number of stems in the study area. This is expected due to its abundance in the savanna part of the country and in turns

contribute immensely to the livelihood of the people in the region (Attua & Pabi, 2013; Wakawa et al., 2016).

The total basal area of the woodland per hectare is lower than what was obtained by Sani et al., (2019) in their study carried out in Falgore game reserve, Kano State, where they had 36.28 m^2, this could be as a result of higher DBH values of trees in the study area. The highest mean height for this study 14.87 metre is almost the same with that of Sani et al., (2019) where they recorded 14.81 meter for the tallest tree species. This is not surprising, because savannah tree species are not generally very tall (Abdullahi, 2013).

Biodiversity indices recorded for this study is higher than that of Wakawa et al., (2017), for instance, Margalef's index of species richness (M) was calculated to be 7.13 for this study is higher than 2.52 recorded in their study, Shannon-weinner diversity index (H') obtained for this study was 3.14 as against the lower value of 1.97 in their study, Pielou's species evenness index (EH) for this study was 0.56 compared to 0.38 obtained in their study (Table 4). This is expected because of differences in climatic condition, though, both study areas belong to the savannah ecosystem, Guinea savanna receives more rainfall than Sahel savannah. Comparing the diversity indices obtained in the study area to others in similar environment gives a good account of its rich biodiversity, the diversity indices obtained here is higher than what was obtained by Ikyaagba et al., (2015) in Makurdi, Benue State, for instance, Margalef's index of species richness (M) at 7.13 for this study is higher than 6.01 recorded in their study, Shannon-weinner diversity index (H') obtained for this study was 3.14 as against the lower value of 2.24 in their study, Pielou's species evenness index (EH) for this study was 0.56 which is lower compared to 0.82 obtained in their study.

5. CONCLUTION

The results of the study revealed that most of the trees in the woodland were indigenous species. *Anogeissus leiocarpus* had the highest number of occurrence, and is the most abundant tree species in the woodland. The species diversity indices and other assessments are in favorable comparison with other similar ecosystem, the study area is very rich in tree biodiversity and this is evidenced by Shanon-Wiener index of 3.14 and Margalef's index of species richness of 7.13. Due to its high richness and diversity of tree species, the woodland has helped in serving as habitat for wildlife, soil restoration and protection, windbreak etc,

Therefore, the diversity and abundance of tree species in the study area is relatively high and diverse, however, there is need for effective conservation so as to ensure its continuous availability.

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