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Comparative Floristic Analysis of the Classified Forest of Gorou Bassounga (Gaya) and the Total Wildlife Reserve of Tamou and their Conservation Values

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Abstract **Original Research Article**

The objective of this study is to make a comparative floral analysis of two sites (Classified forest of Gorou Bassounga and Tamou) and the conservation value for biodiversity of each site. The floristic survey of the vegetation has been done base on a random laminated plot of 1000 m². Sixthy four (64) species were inventoried at both sites level. 47 species, 37 kinds and 18 families were identified in Gorou Bassounga. Fabaceae constitutes the most important family with 16 species followed by Combretaceae 6 species and Rubiaceae 5. On the other hand, at Tamou 44 counted species are distributed in 31 kinds (genres) and 17 families. Fabaceae constitutes the most represented family with 11especies followed by Combretaceae 8 species, Rubiaceae and Anarcardiaceae with 4 species each. The statistical analysis of the data shows similarity and dissimilarités existing between sites spite of their floral poverty. Conclusion and application: The floral richness of Gorou Bassounga (Gaya) is higher than that of Tamou. The study also allowed to determine the status (dominance, rarity or endangered) of each species. The value of conservation for the sites was estimated. This study can be a tool for management planning for both site.

Keywords: Niger, Tamou, Gaya, species, Families, floristic richness, vegetation.

INTRODUCTION

The world's forests cover 3.9 billion hectares or about one-third of the earth's land area. However, most forests are quantitatively and qualitatively damaged in their original state (FAO, 1999). Woody plants with Sudanian endemism and with broad leaves are regressing while those of the Sahelo-Saharan region with reduced leaves are resistant to the environmental conditions (Ganaba S, 2008). To better understand the causes and extent of degradation, the study of vegetation seems very appropriate (Imorou, 2008). Better conservation of species in a given ecosystem presupposes, on the one hand, knowledge of the current state of their populations at all stages of development (from regeneration to adult subjects) through their structural study and, on the other hand, research and analysis of the factors that interact on this structure (Bonou, 2007).

Since the Earth Summit in 1992, the conservation of biodiversity must take into account the needs and aspirations of local populations. It is important to understand the direct and indirect effects of human activities on biodiversity, which give rise to numerous scientific controversies (Larrere C and Larrere R, 1997). This summit has undoubtedly raised the awareness of researchers, environmental managers, and public and political decision-makers. Niger, like the international community, has embarked on a process of protection and promotion of natural resources against the various factors of degradation (Morou B, 2010). Knowledge of the state, dynamics, and evolutionary trends of Sahelian ligneous vegetation is insufficient (Ganaba S, 2008).

Woody forest resources have greatly diminished. Some species have even disappeared from their usual ecological niche or have become rare there given the decline in annual rainfall and over-exploitation during recent decades (Laoualy A *et al.*, 1999).

The development, sustainable management, and preservation of biodiversity are urgent and this requires a good knowledge of flora, fauna, and their interactions. The objective of this study is to identify and determine the composition and floristic diversity through a comparative analysis of taxa and indicators of plant diversity in the classified forest of Gorou Bassounga and the total wildlife reserve of Tamou, The study also aims to assess the conservation status of each site.

2. METHODOLOGY

2.1. Description of study sites

The study area is composed of the classified forest of Gorou Bassounga located between the commune of Gaya and that of Tanda in the department of Gaya (Region of Dosso); between 1°55 and 2°25 East longitude, 8°80 and 9°10 North latitude (Figure 1). Soils have a wide variety of structure and texture. They are generally lateritic plateaus with a thin sandy-loamy or clayey film on the terraces, detrital on the glacis, and hydromorphic in the river valley. The climate of the department of Gaya is characterized by a rainy season alternating with a dry season. The average annual rainfall is 750 mm.

The Tamou Total Faunal Reserve is located in the commune of Tamou (Figure 1), Department of Say (Tillabery Region). This reserve is between 12°28' and 12°49' North latitude and 2°07' and 2°23' East longitude. There are four classes of soils in the Rural Commune of Tamou (Gavaux, 1967): Lithosols; poorly evolved soils; tropical ferruginous soils, and hydromorphic soils. The climate of the Tamou region is characterized by a rainy season alternating with a dry season. The average annual rainfall is 600 mm.

Both sites belong to the North-Western Sudanian A 1 phytogeographical compartment of Niger (Saadou M, 1990).

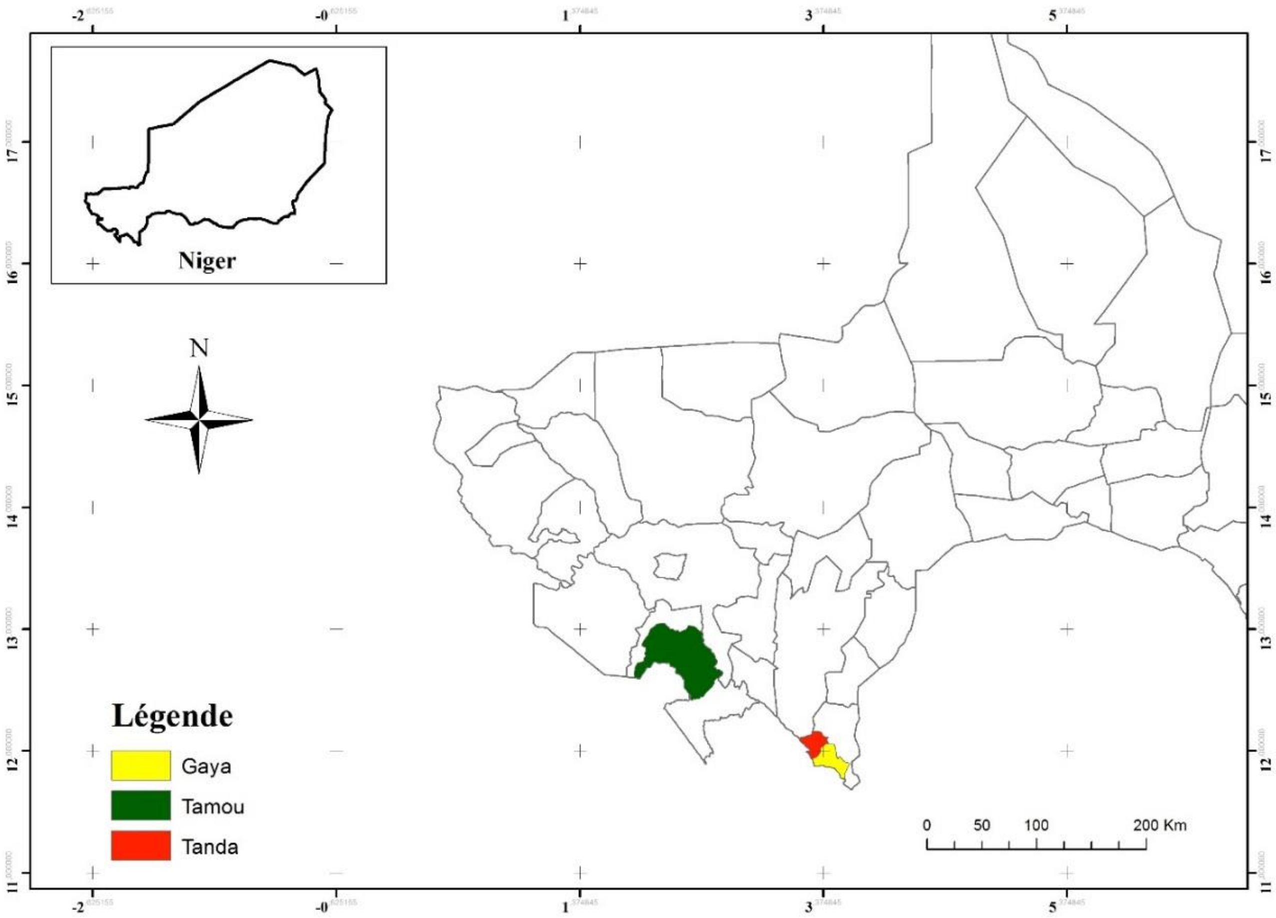

Figure 1: Location of study sites

2.2. Methodology

Collection of data

Inventories are an integral part of the process of quantifying potentialities and planning for the sustainable management of forest resources (Ganaba S, 2008).

For the different sites, the sampling plan adopted is random and the basic statistical unit is the plot of 50 m x 20 m (1000 m²).

For the scientific names of the species, the determination and the synonymy were made by referring to the nomenclature of Lebrun & Stork (1991-1997). The biological types used are those of Raunkiaer (1934) and the phytogeographic elements of White (1986). These biological types by their distribution faithfully reflect the ecological conditions of a region and their study provides an idea of the vegetation of a given region (Mahamane A, 2005).

Data Processing

For the phytosociological surveys, dominance abundance coefficients were assigned to the species according to the scale established by Braun Blanket. This method makes it possible to describe the plant communities and to understand the spatiotemporal organization on the quantitative and qualitative level of the constituent species (Houinato, 2001 in Marou, 2010).

To assess the floristic composition of each site, the data collected was analyzed, listing the species inventoried, their families, biological types, and their chorology.

According to Aké Assi (1984 in Saadou 1990), a flora is all the more diversified as it includes fewer large families and large multispecific genera. The family-gender ratio was therefore calculated.

To calculate the degree of maturity and stability of the two sites, the specific quotient was calculated using the formula: Q=S/Ge with S the number of species and Ge the number of genera. This formula has been used by Hazikimana P *et al*., 2010.

The generic coefficient was also calculated: It is the ratio between the number of genera and the number of species.

Study of alpha diversity: Floristic diversity was measured by several parameters.

Specific richness (S): this is the total number of species in the community studied.

The Shannon and Weaver index (H'); is calculated as follows:

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

pi = (ni/N), relative frequency of species; ni = relative frequency of species i in the sampling unit; N = sum of specific relative frequencies. The higher the index, the greater the diversity.

The Pielou index (E) is written as follows:

$$E = \frac{H'}{\log_2 S}$$

The Margalef index was used because it takes into account the surface area of the samples (Maguran, 2004) and is calculated using the following formula: R_Mg=S-1/(ln(N))

With S the number of species and N the number of individuals. As for the Menchnick index, it is calculated using the following formula: R_Mn=S/√N

The beta diversity index (ß): For this parameter, the analysis was done with the Sorensen index, and is calculated as follows:

$$P_S = \frac{2c}{a+b} \times 100$$

With a = number of species from site A; b = number of species at site B; c = number of common species.

This index was chosen because it gives twice as much weight to the joint presence of two species in the same place as to the presence of only one of the two. Also, it ignores records where both species are absent. This coefficient expresses the degree of similarity between two groupings. It makes it possible to know whether two sites a and b compared on the floristic level belong to the same plant community. For a Ps value greater than 50, it can be concluded that the two sites belong to the same plant community. Otherwise, they belong to different plant communities.

To determine the status of the species inventoried at the two sites, the rarefaction index used by several authors (Kokou K *et al*., 2005; Dro B *et al*., 2013; Vroh B *et al*., 2014; Kemeuze V *et al*., 2015; Piba S *et al*., 2015) was used according to equation of Gehu Gehu (1980) the as follows:

$$RI = \left[1 - \left(\frac{n_i}{N}\right)\right] \times 100$$

With RI: the rarefaction index; ni: the number of records in which species i is present, and N: the total number of records.

Following this relationship, species whose rarefaction index is less than 80% are considered to be preferential species, very frequent, and abundant in the areas studied. Those whose rarefaction index is greater than 80% are called rare species. A rarefaction index of 100% means that the presence of the species has not been observed anywhere in the areas studied; that the latter is highly threatened with extinction in the region (Dro B *et al*., 2013).

For the conservation value of different species, the concept of High Conservation Value (HCV) initiated by the Forest Stewardship Council (FSC) (Jennings *et al*., 2003) used by several authors (Ouattara *et al*., 2013, Adou *et al*., 2013, Gone Bi *et al*., 2013) was used.

RESULTS

Flora analysis

The floristic inventory in the classified forest of Gorou Bassounga has identified 47 species distributed in 37 genera and 18 families. The Fabaceae family is the largest with 16 species followed by Combretaceae 6 species, Rubiaceae 5 species, Anarcardiaceae 3 species, Tilliaceae, Bombacaceae and Capparidaceae each have 2 species. Eleven (11) families are represented by a single species (Table 1).

The family-species ratio of the Gorou Bassounga classified forest is 0.34. For the generic diversity of the Gorou Bassounga classified forest, the Fabaceae family is the best represented with 13 genera, followed by Combretaceae and Rubiaceae with 4 and 3 genera respectively. Two families (Bombacaceae, Anacarcadiaceae) are represented by two genera. The generic coefficient of the Gorou Bassounga classified forest is 0.7826 or 78.26%.

The floristic inventory in the total wildlife reserve of Tamou has identified 44 species distributed in 31 genera and 17 families. Fabaceae are the most represented family with 11 species followed by Combretaceae with 8 species, Rubiaceae and Anarcardiaceae with 4 species each, and Tiliaceae (2 species). The other families, 11 in total, are represented by a single species (Table 1).

The family-species ratio of the Tamou site is 0.38. The generic diversity of the Tamou site shows that the Fabaceae family is the best represented with 8 genera, followed by Combretaceae, Rubiaceae and Anarcadiaceae with 3 genera each. A single family (Capparidaceae) is represented by two genera. Twelve families are represented by only one genus. Tamou's generic coefficient is 0.6818 or 68.18%.

Table 1: Analysis of species families in the Gorou Bassounga Classified Forest (Gaya) and the Tamou Total Faunal Reserve

Families	Number of genera		Number of species		Species percentage	
	Gaya	Tamou	Gaya	Tamou	Gaya	Tamou
Anacardiaceae	2	3	3	4	6,38	9,09
Apocynaceae	1	1	1	1	2,13	2,27
Asclepiadaceae	-	1	-	1	-	2,27
Balanitaceae	1	1	1	1	2,13	2,27
Bignoniaceae	-	1	-	1	-	2,27
Bombacaceae	2	1	2	1	4,25	2,27
Capparidaceae	1	2	2	4	4,25	9,09
Cesalpiniaceae	-	1	-	1	-	2,27
Combretaceae	4	3	6	8	12,76	18,18
Ebenaceae	1	1	1	1	2,13	2,27
Euphorbiaceae	1	1	1	1	2,13	2,27
Fabaceae	1	8	16	11	34,04	25
Hymenocardiaceae	1	-	1	-	2,13	-
Loganiaceae	-	1	-	1	-	2,27
Meliaceae	1	1	1	1	2,13	2,27
Moraceae	1	-	1	-	2,13	-
Olacaceae	1	1	1	1	2,13	2,27
Rubiaceae	3	3	5	4	10,64	9,09
Sapotaceae	1	-	1	-	2,13	-
Simaroubaceae	1	-	1	-	2,13	-
Sterculiaceae	1	-	1	-	2,13	-
Tiliaceae	1	1	2	2	4,25	4,55

Analysis of phytogeographic forms

Table 2 gives the results of the phytogeographical distribution of the species observed in the classified forest of Gorou Bassounga (Gaya) and the total wildlife reserve of Tamou. Thus in Gaya, the Sudano-Zambesians are the most represented with 18 species (38.30%) followed by the Sudanese with 13 species (27.70%), then the Sahelo-Saharans with 6 species (12.76%), the other types phytogeographical (Sudano-Guinean, Pantropical, Guinean-Congolese and Afro-Malagasy) are represented by only one species.

For the total wildlife reserve of Tamou, there is a dominance of Sudano-Zambéziens with 12 species or 27.27%; closely followed by the Sudanese 10 species, i.e. 22.72%. Then come the Pantropics 20.1% and the Afro-tropics 6 species or 13.64%. Four phytogeographical types (Sudano-Guinean, Afro-Malagasy, Guinean-Congolese) are represented by a single species, i.e. 2.27%.

Table 2: Analysis of biological types by site

TB	GAYA		TAMOU	
	Species number	Percentage of species (%)	Species number	Percentage of species (%)
Mph	2	4,26	1	2,273
LmPh	2	4,26	3	6,818
mPh	35	74,46	28	63,64
nPh	8	17,02	12	27,27

Diversity and Equity

Values for species richness and other indices of diversity and evenness are provided in Table 5 for the two sites. At the level of the classified forest of Gorou Basssounga, the Shannon-Weaver index is evaluated at 34.19 bits and that of Pielou at 0.75. On the other hand in Tamou these indices (Shannon-Weaver and Pielou) are respectively 3.55 and 0.65 bits.

For beta diversity, the value of the Sorensen index is 63, 73. For the Margalef index for Gaya it is 4.23 and Tamou 3.71. The flora of the classified forest of Gorou Bassounga (Gaya) and that of the total wildlife reserve of Tamou have an average diversity.

The flora of the classified forest of Gorou Bassounga (Gaya) and that of the total wildlife reserve of Tamou have an average diversity. The species richness are the most numerous in all biotopes with the exception of wooded area in Tamou than those of Gaya. For wooded area in Tamou we have 40 species while in Gaya it's 42 (Table 4). Others index for all types of biotopes are shown in table 4. The Sorensen similarity index values between the different plant formation units are respectively 48, 78 (Wooded and wooded); 42.55 (Degraded and degraded), and 37.93(Cultivation fields and cultivation fields).

Table 4: Diversity Parameters

	Gaya				Tamou			
	Wooded areas	Degraded areas	Cultivation fields	Total Gaya	Wooded areas	Degraded areas	Cultivation fields	Total Tamou
Species richness	42	23	28	47	40	24	30	44
Shannon index	3,78	2,59	2,88	4,19	3,1	2,23	2,83	3,55
Pielou Fairness Index	0,79	0,85	0,91	0,75	0,68	0,52	0,76	0,65
Margalef index	3,67	3,1	3,32	4,23	3,25	2,86	2,91	3,71
Mennhinick Index	0,9	0,6	0,71	1,16	0,62	0,51	0,56	0,79

The status of species calculated using the equation of Gehu Gerhu (1980) made it possible to distinguish the most represented species (preferential, very frequent and abundant) at the level of one or both sites. Twenty species are most abundant at one or both sites. Of these 20 species, it should be noted that 4 are rare or even endangered in Tamou compared to 10 in Gaya (Table 6).

Table 6: List of preferred, very frequent and abundant species according to the rarefaction index of one or both sites

Espéces	Indice de raréfaction (%)	
	Tamou	Gaya
Acacia ataxacantha	75	100
Acacia machrostachya	35	35
Boscia angustifolia	45	75
Boscia senegalensis	75	65
Combretum glutinosum	45	20
Combretum micranthum	25	15
Combretum nigricans	25	5
Dichrostachys cinerea	75	100
Feretia apodanthera	70	90
Gardenia sokotensis	65	25
Grewia bicolor	75	95
Grewia flavescens	70	45
Guiera senegalensis	15	30
Piliostigma reticulatum	65	95
Entada africana	70	85
ximenia americana	75	90

Espéces	Indice de raréfaction (%)	
	Tamou	Gaya
Cassia sieberiana	84	60
Combretum collinum	90	70
Lannea acida	80	75
Lannea microcarpa	95	70

DISCUSSION

The results of the floristic analysis show that the classified forest of Gaya is richer in families than the total wildlife reserve of Tamou. However, 13 families are common to both sites. We also note that five (5) families (Hymenocardiacaea, Moraceae, Sapotaceae, Simaroubaceae and Sterculiaceae) present in Gaya are absent in Tamou. The same four (4) families (Asclepiadaceae, Bignoniaceae, Cesalpiniaceae, Loganiaceae) find in Tamou were not observed in Gaya.

The analysis of the results shows that the Gaya site has a higher specific richness than Tamou. On the other hand, the value of the specific richness of Gaya is lower than that of Inoussa M (2011) for the population of the open forests of the park W. It is the same that Mama and Adeniyi (2005) obtained in Benin. Tamou's value is lower than those of these authors.

Gaya has the highest generic coefficient than Tamou. The values of this coefficient for our sites are higher than that of Saadou (1990) which is 45.58 percent (%). We also know that high values of this coefficient characterize impoverished flora (Saadou, 1990). This, of course shows that our two sites are poor.

Species coexistence is based on the sharing and use of common resources, where species adapt to different forms of competition, stress or disturbance (Grime 1973, 1974 in Masharabu T *et al*. 2010). The biological types by their distribution faithfully reflect the ecological conditions of a region. Their study provides an idea of the vegetation of a given region (Mahamane, 2005).

Thus twenty-six plant species are common to the two study sites. Twenty-one species are present in the Gaya site and absent in Tamou; while eighteen species are present in Tamou and absent in Gaya. Indeed, the climate plays an essential role in the composition and floristic diversity of a site. Added to this is the action of man on his environment.

To assess the various changes in state, or modifications to the functioning of the environment, induced by natural disturbances, and above all by human intervention, the observer most often has recourse to the measurement or evaluation of simple parameters, attributes, and characteristics of the ecological system studied, but also the use of complex indices calculated from elementary parameters (Pontanier and Foret, 2002 in Masharabu *et al*., 2010). Thus the results of the different floristic parameters of the two sites show that Gaya recorded the highest values for the Shannon-Weaver indices and the Pielou equitability. The Shannon-Weaver index of Gaya (4.19) is higher than that of Tamou (3.55). These two values are lower than that of Mahamane A (2005) which is 4.61 bits. Thus the site of Gaya is more diversified than that of Tamou. Examination of the Shannon diversity index shows that the biotopes of the two sites have different diversity indices. The regularity or fairness of Pielou is also average in the three biotopes of Tamou (0.68; 0.52 and 0.76), and that of Gaya (0.79, 0.85 and 0.91). There is therefore an average diversification of the flora in these biotopes. For the general analysis of the fairness of Pielou, we find that Gaya one is higher than that of Tamou, in addition, these two values are high. There is an average similarity between these sites (high values of beta diversity).

The values of the Margalef index of our two sites are lower than those obtained by Hazikimana P *et al*., (2010) in Burundi. The results of the Margalef index and the Menhinick index show that their values for the Gaya site are higher than those of Tamou. These show that the classified forest of Gorou Bassounga is richer in taxa than the total wildlife reserve of Tamou. This is explained by the fact that the rainfall is higher in Gaya than in Tamou. In addition, the Gaya forest was classified in 1936 while the W park itself was erected as a park following the eviction of the population in 1955 and this may have consequences on the vegetation.

The similarity between the two sites is equal to 63.73. The Sorensen similarity index value between the two sites is higher than 50, which means that the different units are different. This assumes that the plants formations of the two sites are not relatively different from each other. The Sorensen similarity index values between the different plants formation units are lower than 50, this mean that the three units were relatively different from each other.

The rarefaction status of the species made it possible to classify the species of the two sites. *Acacia ataxacantha* and *Dichrostachys cinerea* are present in Tamou and classified as abundant species found in Gaya as endangered species. *Feretia apodonthera*, *Piliostigma reticulatum*, and *Ximenia americana* with respectively 90, 95 and 90% are rare species in Gaya but abundant in Tamou. Similarly *Cassia sieberiana* (80%), *Combretum collinum* (90%), *Lannea acida* (80%) and *Lannea microcarpa* (95%) are rare in Tamou but abundant in Gaya.

At the level of the two sites (Tamou and Gaya), *Sclerocarya birrea* with respectively a rarefaction index of 80 and 100%, is a rare species in the first and endangered in the second. This is confirmed by Dro B *et al*., (2013) in Ivory Coast with an index of 100%. In Burkina Faso, this plant has already been qualified as a vulnerable species (UNEP and GEF, 1999 in Dro B *et al*., 2013).

Three of the six main conservation values resulting from the classification initiated by the Forest Stewardship Council (FSC) (Jennings *et al*., 2003) can be retained for the two research sites, namely:

HCV 1: Forest areas containing concentrations of globally, regionally, or nationally significant biodiversity values. Given the results of the various sites, this value is partly achieved for the two study sites, as they contain threatened, rare and endangered species.

HCV 4: Forest areas that provide basic nature protection services (this includes protection of water sources, protection against erosion, and destructive fire). This value is achieved for both sites because they all protect the Niger River from silting.

HCV 5: Forest areas fundamental to the needs of local communities (subsistence, health). This value is also reached for the two sites because the local populations derive many benefits from these forests such as food with food plants, health (medicinal plants) but also game with traces of rodents, reptiles, and antelopes.

CONCLUSION

The floristic composition in terms of woody species is determined for each site. This study revealed the similarities between the two sites. It made it possible to identify the species of the two sites studied. The different biological and phytogeographical types of the two sites show that they belong to the same agroecological and pedoclimatic zone. These two sites can be classified among the best stocked in ligneous. But additional studies must be carried out to distinguish the real causes of the disappearance of the species. However, among these causes, we can consider the difference in the pressure factors which may be distinct between the two sites.

This is important especially since many species are present in a single state. In addition to the status of each species, a reflection must be carried out to determine the means of introducing the species (extinct or endangered) but also how to protect and conserve the others for sustainable management, to preserve our forests for future generations.

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