Mapping the spatial distribution of mushroom diversity

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Abstract: Mushroom resources are one of the most important non-wood forest products because of food, medicinal, commercial and recreational benefits. Furthermore, wild mushrooms have an important ecological role for forest ecosystems. Therefore it is quite necessary to document of mushroom diversity, spatial distribution and abundance of this resources to conserve of this natural resources. Searching of all mushroom species with observation over the landscape is not a useful method. However, building of a spatial database based on geographical location of mushroom species by using Geographic Information Systems (GIS) would be useful for mapping of mushroom diversity. The objective of the present study is to develop and implement a conceptual approach for creating the thematic map of mushroom diversity in Kemerköprü planning unit of Turkey based on some diversity indexes and GIS. 75 permanent sample plots were installed randomly in nearly pure even-aged stands characterized by *Picea orientalis* and *Fagus orientalis.* The sampling plots cover a square in shaped of 100 m^2. The plots were selected to cover the widest range of aspect, slope, elevation and stand characteristics. The each plots were inventoried from August to November at about ten days interval in 2013. All visible macrofungi were counted and measured fresh weight after harvested from each plot. Some diversity indexes such as Shannon weiner (H') and Simpson diversity index (D) were calculated to compare the abundance and richness of macrofungi from each plot. A point layer showing diversity index of each sample point was created and a scale identifying mushroom diversity was generated using GIS. Then, all points with the same scale for mushroom diversity were combined through Thiessen polygon method. The results showed that the used method is quite useful and practical method for mapping of mushroom diversity.
Keywords: Mapping, Mushroom diversity, GIS, Spatial distribution, Thiessen polygon

1. Introduction

Mushroom resources are one of the most important non-wood forest products because of food, medicinal, commercial and recreation benefits. Furthermore, wild mushrooms have an important ecological role for healthy of forest ecosystems. Therefore, it is quite necessary to document of mushroom diversity, spatial distribution and abundance of this resources to conserve of this natural resources.

Biodiversity is defined as variety of organisms in a space. In other words, biodiversity covers the genes in a region, the species carrying these genes, the ecosystems that contain these species, and the events that link them together. This definition draws attention to many dimensions of biodiversity such as genetic, taxonomic, ecosystem and events diversity (Erten, 2004; Gülsoy and Özkan, 2008).

Diversity indices should be calculated so that the diversity level is expressed as a numerical value and the diversity ratings of the different systems can be statistically compared (Odum ve Barrett 2005). The ability to calculate diversity with this mathematical measure is an especial tool for biologists to understand community structure. Though diversity indices provide important information about diversity, dominancy, richness and evenness of species in a community, there is no single index sufficiently calculating biodiversity concept such as rarity and commonness of species in a community (Hurlbert, 1971; Purvis and Hector, 2000).

The diversity of species in a particular area depends on not only the number of species, but also in their numbers that is relative abundance. While experts determine species richness as the number of species in an area, they determine species evenness as the relative abundance of species in an area. Richness (S) is explained as the number of species and is the most common indication for diversity (Magurran, 2004). Margalef and Menhinicks indices are the some of the common used indexes to characterize species richness in a community. The simplest diversity indices is Berger and Parker diversity indices that reports the proportional abundance of only the most abundant species in a community (Berger and Parker, 1970). Also, Pielou-R indice accounts evenness of the species present. The Shannon-Wiener diversity index (H') and the Simpson index are the most widely used diversity indices to obtain information on species diversity or dominancy in stations and distribution of individuals between species (Jorgensen et al., 2005).

Because natural events and human activities such as forest management practices, fire etc. change stand structures, biological diversity as well as occurrence, abundance and reproduction of mycorrhizal mushrooms can be affected (Pilz and Molina, 2002). Spatial information and mapping of biological diversity can offer several advantages in the planning of forest ecosystems. Especially, determining the state of biodiversity in a unit, obtaining the priority areas in conservation and providing biodiversity strategies can be ensured through mapping of biodiversity. To protect the mushroom diversity in forests accurate information such as spatial distribution maps, productivity models is required. Therefore, developing mushroom diversity maps is essential for conservation and sustainable management of forest ecosystems. This kind of maps are essential for identification of high priority areas and protected areas (Carrol, 1998; Myers et al., 2000). However, searching of all mushroom species with observation over the landscape is not a useful method. Building of a spatial database based on geographical location of mushroom species by using Geographic Information Systems (GIS) would be useful for mapping of mushroom diversity.

A number of studies obtain the relationship with biological diversity and some stand or ecological variables based on biodiversity indexes and analyze biodiversity (Gülsoy and Özkan, 2008; Bonet et al., 2010; Küçüker, 2017a,b). Although a limited number of studies about mapping of non-wood forest products have been presented (Yang et al., 2006; Franca-Plata et al., 2012; Kucuker and Baskent, 2015; Kucuker, 2017c), there have been very few studies to map the biological diversity (Hernandez-Stefanoni and Ponce-Hernandez, 2004). The objective of the present study is to develop and implement a conceptual approach for creating the thematic map of mushroom diversity in Kemerköprü planning unit of Turkey based on some diversity indexes and GIS.

2. Material and methods

2.1. Study area

This study was conducted in the Kemerköprü Planning Unit, northeastern of Turkey. The study area covers about 18,000 ha area with 174 compartments and 879 sub-compartments. The most common tree species in the study area dominantly characterized by *Fagus orientalis, Picea orientalis, Castanea sativa* and *Abies nordmanniana*. The altitude ranges between 80 m and 2045 m above sea level with an approximately average slope of 26.2%. Mean annual temperature of study area is 9^0C and mean annual precipitation is 1813 mm based on long term measurements from the nearest meteorological station from 1975 to 2005. Of the planning unit, about 60% is forested area. The study area hosts a large variety of edible or nonedible mushrooms.

2.2. Field sampling design

Mushroom surveys were performed in 75 permanent sample plots installed randomly in nearly pure even-aged stands (Fig 1). The plots were selected to cover the widest range of aspect, slope, elevation and stand characteristics. The sampling plots cover a square in shaped of 100 m^2. All plots were visited five times at about ten days interval from August to November in 2013. All visible macrofungus were harvested from each plot. Also, all sporocarp number and fresh weight for each different mushroom species were recorded in each plot.

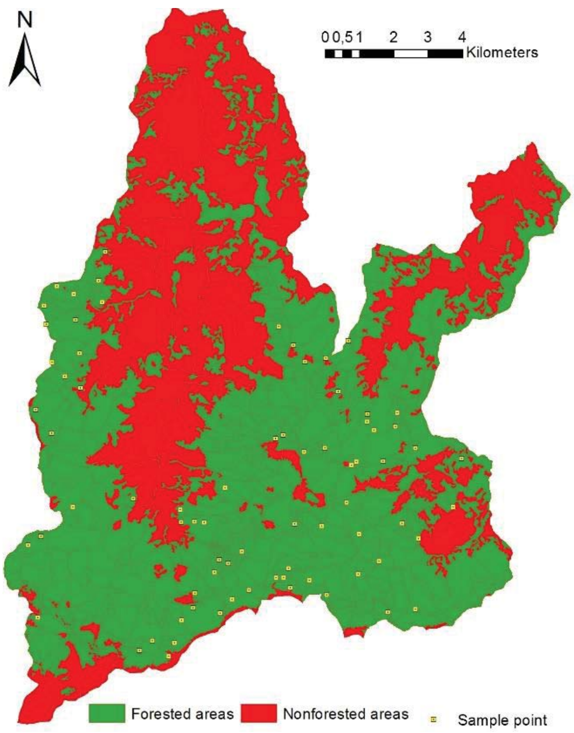

Figure 1. Sampling plots in the study area

2.3. Measures of mushroom diversity

Mushroom diversity was analyzed with the total number of mushroom species in each plot. To measure diversity, abundance and richness of macrofungus in each plot, some diversity indexes such as Shannon Weiner (H'), Simpson index (D), Simpson diversity index (D), Pielou regularity (E), Margalef richness (D), Menhinick's richness and Berger-Parker dominance (BP) were used.

2.4. Mapping method: Thiessen polygon

The diversity indices value of the mushroom species in the each plot were recorded with location through GPS. Spatial database showing the mushroom diversity indexes in the study area was created and then a point layer showing the each mushroom diversity index values in the each sample point was created by using some functions of GIS. Thiessen polygon method was used to allocate all points with the same quality for diversity. Then the created polygon layer indicating mushroom diversity was combined with stand type map of the planning unit.

3. Results and discussion

A total of 293 sporocarp were sampled in 75 sample plots and a total 12 mushroom species belonged to 6 family were recorded. Of the total number of species identified 24.2% are from Cantharellaceae, 22.2% are from Bankeraceae, 18.4% are from Russulaceae, 17.7% are from Boletaceae, 17.0% are from Hydnaceae and 0.3% are from Agaricaceae family (Table 1).

Table 1. Scientific name, family, genus and the number of the mushrooms in the plots

Scientific name	Family	Genus	N	N%
Boletus edulis	Boletaceae	Boletus	52	17.7
Cantharellus cibarius	Cantharellaceae	Cantharellus	71	24.2
Sarcodon imbricatus	Bankeraceae	Sarcodon	65	22.2
Hydnum repandum	Hydnaceae	Hydnum	50	17.1
Lactarius volemus	Russulaceae	Lactarius	35	11.9
Russula delica	Russulaceae	Russula	5	1.7
Lactarius vellereus	Russulaceae	Lactarius	3	1.0
Lactarius deliciosus	Russulaceae	Lactarius	2	0.7
Lactarius sanguifluus	Russulaceae	Lactarius	1	0.3
Lactarius zonarioides	Russulaceae	Lactarius	4	1.4
Macrolepiota procera	Agaricaceae	Macrolepiota	1	0.3
Lactarius glyciosmus	Russulaceae	Lactarius	4	1.4
Total			293	100

The most common mushroom species are *Cantharellus cibarius, Sarcodon imbricatus, Boletus edulis, Hydnum repandum* and *Lactarius volemus* with 24.2%, 22.2%, 17.7%, 17.1% and 11.9% respectivelly. The rest (6.9%) of species are *Russula delica, Lactarius vellereus, Lactarius deliciosus, Lactarius sanguifluus, Lactarius zonarioides, Macrolepiota procera* and *Lactarius glyciosmus* (Table 1).

To understand the mushroom diversity, dominancy, richness or evenness values in each sample plot some alfa diversity indexes such as Shannon-Wiener, Simpson, Simpson Diversity, Berger Parker, Menhinick, Pielou_R and Margalef diversity indices were calculated. Although these all indexes show biodiversity, the results are different due to the difference of mathematical calculation methods. Based on calculation method, index values in the some sample plots are null.

3.1. Mapping of mushroom diversity

Thiessen polygon method was used to allocate all points with the same quality for the mushroom occurrence (Fig 2). Then the polygon layer indicating occurrence of related mushroom species was combined with stand type map of the planning unit. It is important to clarify that this method can create the polygons in a place where the sample plot was included. Thus, one of the big problem with this method is that the sample areas don't completely cover the study area. That is why thiessen polygon could not be created on the stands where the sample plot did not fall. It should be said that in some places don't have any sample plot, all indexes were assumed to be "null". Besides, the results showed that in the combined layer with stand type map the boundaries of the polygons don't coincide with stand boundaries.

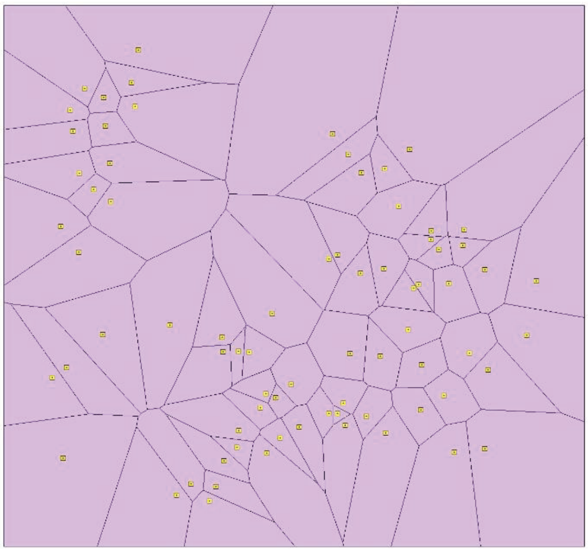

Figure 2. Thiessen polygon created by the sampling plots in the planning unit

Mushroom diversity was analyzed by Shannon-Wiener and Simpson diversity indexes. According to the Shannon-Wiener diversity index value, while the places where the index value close to “1” indicates the greatest diversity, the places where the index value near to “0” have low mushroom diversity (Fig 3a). Based on the maps in figure 3 it can be said that Simpson diversity index also figured out similar results (Fig 3b). The results showed that of the total area just about 3.1% and 2.2% has larger diversity (diversity index is bigger than 0.5) based on Shannon Index and Simpson Index respectively.

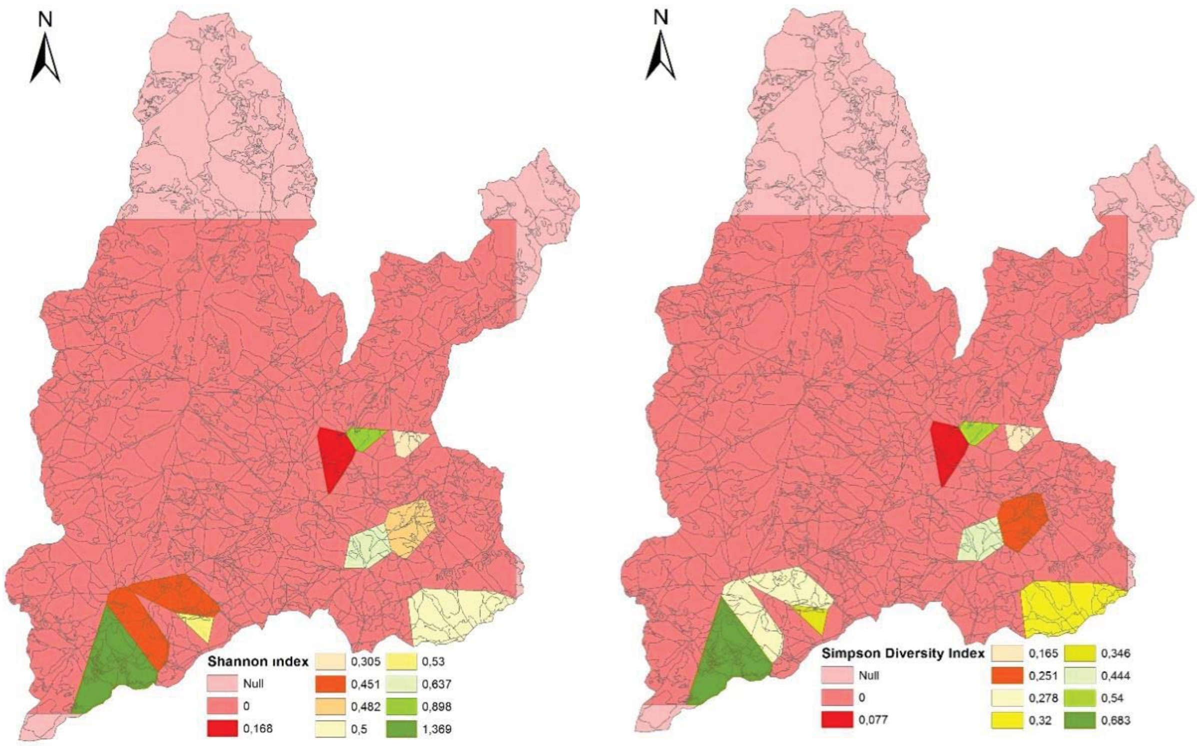

Figure 3. Mushroom diversity maps based on Shannon ındex (a) and Simpson Diversity Index (b)

Dominancy of the mushroom species was analyzed by Simpson D and Berger Parker indexes. The fact that Simpson D index and Berger Parker index value is close to “1” means the mushroom dominancy is high and the value is close to “0” means the mushroom dominancy is low (Fig 4 a,b). The values of two indexes obtained similar results. The results observed that dominancy is low in a unit where diversity is high. According to Simpson Index, about in about 29% of the area mushroom dominancy is very high that is Simpson index value is bigger than 0.5.

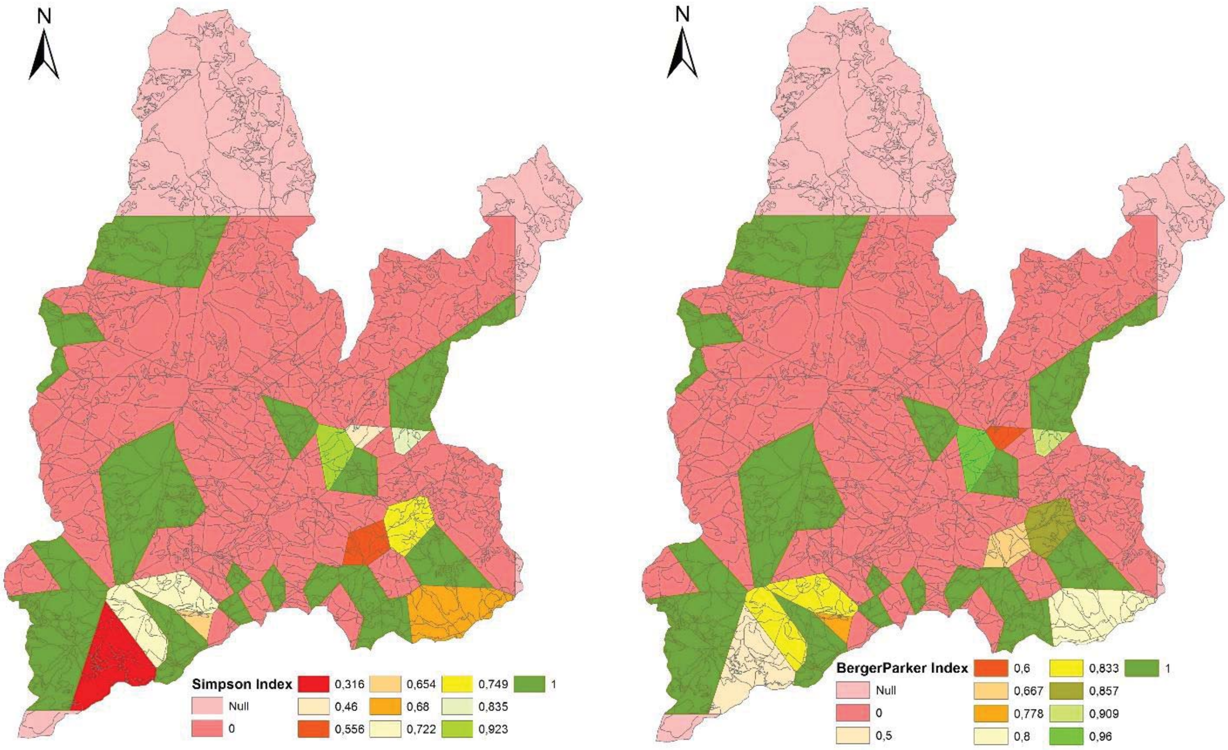

Figure 4. Mushroom diversity maps based on Simpson Index (a) and BergerParker Index (b)

Species richness means the number of species in the community and is the simplest measure of diversity. This measure capture only the number of the species but does not represent the relative abundance of the species in the community. Species richness is measured with Margalef and Menhinick's richness indexes. While high index values indicate high mushroom richness, low values show low mushroom richness (Fig 5a,b). Due to mathematical calculation technique of Margalef index, it could not calculate the index values of some sample plot. These areas are shown as "Null" value in the Margalef index map (Fig 5a).

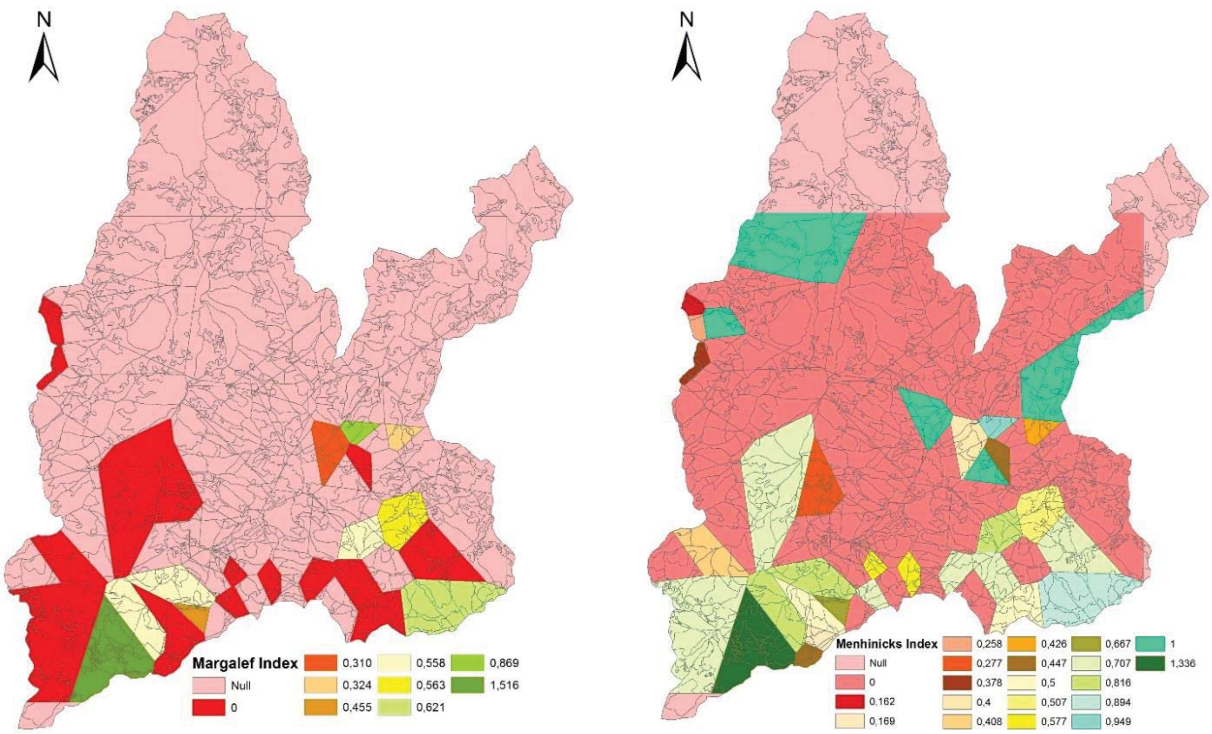

Figure 5. Mushroom diversity maps based on Margalef Index (a) and Menhinick's Index (b)

Pielou-R index -calculated through Shannon index- was used for measure evenness of mushroom species in the planning unit. The values of some places could not estimate because of the mathematical calculation method. The results showed that the high index values show the higher regularity. It means larger values represent more even distributions in abundance among mushroom species. This index indicates if the number of individual between species has a homogeny distribution. The low number of dominant species in the sample plots significantly reduces the Pielou index value.

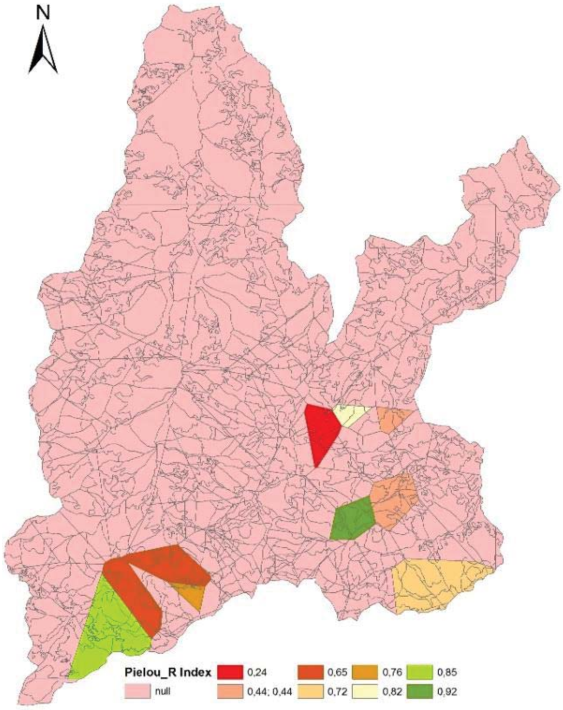

Figure 6. Mushroom evenness map based on Pielou's Index

4. Conclusion

The main objective of this paper was to calculate some diversity indexes for mushroom species and develop an approach for mapping mushroom diversity in the planning unit. In this study, thiessen polygon method was used to map mushroom diversity. The results showed that this method is very useful and practical. However, the accuracy of this map developed by thiessen polygon should be used carefully. This method has some limitations. For example, thiessen polygons can only be created in places where sample plot falls. If a sample plot was not established in any places where the polygon could not be created. In addition the boundaries of this thiessen polygon layer do not overlap with the boundaries of the stand cover type. This situation causes some problems in the implementation of management interventions. Also to improve the accuracy of prediction with these diversity indices, more sampling plots should be established. Besides, all sampling plots should be distributed throughout all the planning unit. Because the right result depends on good inventory data, long term repeated measurements with a short periods on mushroom species should be made for mushroom diversity.

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