Research Article

Vegetation Classification and Habitat Types of Gambella National Park

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Gambella National Park has a diverse set of habitat types which Ethiopia shares with its neighbor, South Sudan, and the park is considered as one of the top wildlife areas of Ethiopia. The objectives of this research were to determine vegetation types and identify habitat types on recent satellite imageries. The method used for vegetation data collection was transects lines. PC-ORD software was used for analyzed vegetation data while Rapid Eye image 5 m resolution 2012 was analyzed by ArcGIS version 10.1 to classify the habitats map of Gambella National Park. The cluster analysis classified the Gambella National Park into 6 vegetation communities, and the relative abundance and relative frequency were used for naming vegetation community types. However, the satellite image had classified the Gambella National Park into 5 major habitat types.

1. Introduction

Gambella National Park was established in 1973 and has a diverse set of habitat types which Ethiopia shares with its neighbor, South Sudan [1]. Vast collections of plains game are found in the park and perhaps that can be considered as one of the top wildlife areas of Ethiopia [1]. The major vegetation types that are observed in the park are woodland, wooded grassland, grassland, and wetlands. Since the 1980s, there has been large scale habitats changed in Gambella National Park mostly due to human pressure. These pressures came from establishment of state farm in Abobo with the area of 3,000 ha of land, situated in the eastern part of Gambella National Park and the Construction of Alewero dam for large scale commercial agriculture [2]. At present, both large scale agricultural investments (e.g., like Karaturi, Rushi, and Saudi Star) [3] and small scale agricultural investments from different national investors reduced the park area from 5,061 km² to 4,575 km². It is assumed that these anthropogenic impacts have affected wildlife and their habitats.

The development of management plan of the Gambella National Park is hindered by lack of information on habitat types within the park. Although there have been few studies focusing on the vegetation of Gambella region as a whole [4, 5], identification and mapping of the habitat types and distribution of wildlife within the national park have never been attempted. This is particularly important for planning sustainable wildlife management. Mapping of wildlife habitat could be used as a tool in wildlife management, a guide for wildlife viewing, and a gauge for the loss of critical wildlife habitats [6].

The main reason for classifying and mapping the habitats of Gambella National Park was to have better understanding on the location of vegetation community types at local level and habitats types at large level. This could allow better understanding of the important habitat types for key conservation species in which the park was established for. This research expected to fulfill a knowledge gap on the information of vegetation communities and habitat types for Gambella National Park.

The objectives of this research are as follows:

To determine the vegetation types in the Gambella National Park

To identify the habitat types on the recent satellite imageries and develop a habitat map of Gambella National Park

2. Materials and Methods

Gambella National Park is located in the lowland plain of the Gambella People's National Regional State of Ethiopia. According to Monico et al. [7], the park is situated between 32°59' and 35°23' longitude and 6°17' and 8° 42' latitude (Figure 1). It is situated between two major rivers Baro and Akobo (Figure 1) and crossed by other three major rivers with three wetlands (Figure 1). It was established in 1973, with new area of 4,575 km².

3. Methods of Data Collection and Analysis

3.1. Data Collection

3.1.1. Vegetation Data Sampling. The method employed for vegetation data collection was systematic sampling. This sampling was done online transects which were laid down across east to west and north to south depending on habitat information (anthropogenic disturbance, physiognomy, etc.), which was designed based on identified areas with high environmental variability. This technique was used because it is simple for ecological surveys and good for sampling a very large area relatively quickly [8].

3.1.2. Data Collection. The vegetation data were collected by transects lines. The first transect was established based on vegetation physiognomy and by avoiding sites of severe human impact, e.g., fire. The remaining transects were put in place systematically at specific intervals of 5 km. In the woodland and wooded grassland areas, sample plots of 40 m × 40 m were laid out at intervals of 500 m along the transect for recording tree and shrub species. For recording herbaceous and grass species, four, 2 m × 2 m sample plots were laid out at the corners of the bigger plot in grassland, savannah, and wetland areas; sample plots of 2 m × 2 m were laid at intervals of 500 m apart for recording herbaceous and grass species. Accordingly, a total of 450 sample plots, woodland (292 plots), wooded grassland (98 plots), grassland (35 plots), savanna (11 plots), and wetland (14 plots), were sampled. Due to inconvenience for these much sample plots for analysis, the screening was done based on species area curve and similarity of the species and, therefore, sample plots with most similar species were excluded from the analysis.

Consequently, 80 sample plots, woodland (26 plots), wooded grassland (20 plots), grassland (12 plots), savanna (8 plots), and wetland (14 plots), were taken for final analysis.

In each sample plot the GPS point, altitude and species list, which included the habits, were recorded. Every plant species was recorded with its estimated percent cover abundance using the scale of Braun Blanquette 1932 as modified by Westhoff and Vander Maarel [9], with 1–2

individuals covering <5% of the sampled area, 3–10 individuals covering <5% of sampled area, abundance individuals covering <5% of the sampled area, plant cover ranging from 5 to 12%, plant covering from 12 to 25%, plant covering from 25 to 50%, plant covering from 50 to 75%, and plant covering from 75 to 100%.

Common plant species were identified in the field and for unidentified 10 species herbarium specimens were taken and identified in the National Herbarium of Ethiopia by comparing them with already identified plant species and referring to the “Flora of Ethiopia and Eritrea” (Vol. 1, Hederg et al. [10]; Vol: 2.1 Edwards et al. [11]; Vol: 2.2 Edwards et al. [12]; Vol: 3 Hederg et al. [13]; Vol 4: 1 Hederg et al. [14]; Vol: 5 Hederg et al. [15, 16]; Vol: 7 Hederg et al. [17]; and Vol: 8 Hederg et al. [10]).

3.2. Data Analysis

3.2.1. Vegetation Data Analysis. The data collected were used to generate a plot-versus-species matrix (using the percentage cover/abundance values of each species). Cluster analysis using resemblance index and ward's method of hierarchical grouping was performed to identify community groups [18]. Resemblance index was used because it refers to similarity or dissimilarity between samples in terms of species composition. Sample plots that share the same species with the same abundance indicate the highest similarity and the lowest dissimilarity and, therefore, they become one group. Statistical validity of the identified groups was evaluated using multiresponse permutation procedure (MRPP) [19–21]. Both cluster analysis and MRPP were performed using PC-ORD software [18]. The groups were designated as community types and named by most significant indicator species in the group [22].

In this study, the indicator species analysis method proposed by Dufre'n and Legendre [23] was used to identify indicator species. The indicator species are the most characteristic species of each group and present in the majority of the plots belonging to that group (Dufre'n and Legendre [23]).

3.2.2. Habitat Types Identified from Satellite Data Analysis. Rapid Eye satellite imagery (5 m resolution) data acquired in 2012 covering all of the Gambella National Park and its surrounding areas was permitted from Applied Science Department of Berlin University. It was first classified by unsupervised classification. The sensor type used in acquiring this imagery for unsupervised classification was multispectral push broom imager and captured five spectral bands (blue (440–510 nm), green (520–590 nm), red (600–700 nm), Red Edge (690–730 nm), and near-infrared bands (760–850 nm)). ERDAS Imagine 2012 software was used in the preprocessing, pixel-based classification, and postprocessing of the Rapid Eye satellite imagery covering the study area. For the pixel-based classification, the satellite imagery was classified by pixel-based spectral angle mapper (SAM) classifier. The signature file was generated and this involves the training of classes. Areas of interest (AOI) was

FIGURE 1: Location of Gambella National Park within Gambella Regional State.

created and used to train the land cover classes (water body, bare-soil, and vegetation) for every class; random samples were taken across the National Park based on pixel spectra.

The SAM algorithm which is supervised classification approach was then applied. The supervised classification was mainly the ground truth or GPS points. The SAM algorithm was based on the assumption that a single pixel of remote sensing images represents one certain ground cover material, which was uniquely assigned to only one ground cover class. This algorithm was based on the measurement of the spectral similarity between two spectra. The spectral similarity was obtained by considering each spectrum as a vector in q -dimensional space, where q is the number of bands.

4. Results

4.1. Cluster Classification of Plant Species of Gambella National Park. Six vegetation groups were identified using cluster analysis in combination with multiresponse permutation procedure (MRPP) and the cutoff for this classification was 50% (Figure 2).

From 80 sample plots, 4 plots were considered as outliers and thus were excluded from the cluster analysis.

The T value statistic for six groups was -1.28 ($P < 0.001$) which indicated the significant different at P value, while the statistic chance-corrected within group agreement was 0.1. The T statistic is based on Pearson type III distribution. The P value associated with T is determined by numerical integration of type III distribution (Table 1). A statistic is descriptor within a group homogeneity falling between 0 and 1 (Table 1). When the items are identical, $A = 1$. Therefore, A statistic is equal to 1 when all items are identical within groups while the delta is equal to 0. $A = 0$ when heterogeneity within groups equals expectation by chance.

4.2. Naming of Vegetation Communities by Indicator Species of Study Plant of Gambella National Park. The 6 vegetation communities were named based on indicator values indicated by percent perfect indication value (combining relative abundance and relative frequency) (Tables 2 and 3). The species in bold for each group is one with the maximum indicator values for combining relative abundance and relative frequency.

FIGURE 2: Dendrogram of cluster analysis results of species abundance data of the studied plant species of Gambella National Park. Plots forming the same cluster have similar symbols.

TABLE 1: Chance within group agreement.

Chance corrected within group agreement, $A = 0.07734179$
$A = 1$ —(observed delta/expected delta)
$A_{\max} = 1$ when all items are identical within groups (delta = 0)
A statistic is descriptor within a group homogeneity falling between 0 and 1
$A = 0$ when heterogeneity within groups equals expectation by chance
$A < 0$ with more heterogeneity within groups than expected by chance
Probability of a smaller or equal delta, $P = 0.00143541$
Skewness of delta = Pearson type II distribution
Source, 2017 source: result of vegetation analysis, Gatluak, [24]

The maximum indicator values for group 1 species were observed for *Combretum collinum* (49%), *Combretum molle* (47%), *Terminalia brownii* (40%), and *Terminalia laxiflora* (32%). This group had formed the vegetation community known as *Combretum collinum*-*Terminalia brownii* community. The maximum indicator values for group 2 species were observed for *Hyparrhenia rufa* (26%), *Oryza barthii* (23%), and *Oryza longistaminata* (25%). This group formed *Hyparrhenia rufa*-*Oryza longistaminata* community (Table 2), while *Cyperus castaneus* (48%) and *Perpynuo cypress* (40%) were species in group 3 with maximum indicator values. These species formed *Cyperus castaneus*-*Perpynuo cypress* community.

The maximum indicator values for group 4 species were observed for *Ziziphus mucronata* (33%), *Acacia senegal*

TABLE 2: Indicator values (% of perfect indication based on combining values for relative abundance and relative frequency).

Group	1	2	3	4	5	6
Sequence	1	2	3	4	5	6
Identifier	1	5	6	8	7	9
Number of items	30	11	11	8	8	8
Species MaxGrp						
<i>Combretum collinum</i>	1	49	0	7	9	4
<i>Combretum molle</i>	1	47	1	0	0	0
<i>Cyperus castaneus</i>	3	0	0	48	0	0
<i>Hyparrhenia rufa</i>	2	0	26	0	22	0
<i>Oryza barthii</i>	2	0	23	0	1	0
<i>Oryza longistaminata</i>	2	0	25	0	0	0
<i>Perpynuo cypress</i>	3	2	8	40	0	0
<i>Terminalia brownii</i>	1	40	0	0	0	0
<i>Terminalia laxiflora</i>	1	32	0	0	0	0
<i>Ziziphus mucronata</i>	4	6	3	6	33	0

MaxGrp = maximum indicator value in group.

(32%), *Acacia polyacantha* (22%), *Acacia nilotica* (20%), and *Hyparrhenia rufa* (22%). These species formed *Ziziphus mucronata*-*Acacia senegal*-*Hyparrhenia rufa* community. Group 5 was named *Acacia nilotica*-*Acacia bussei* community because the maximum indicator values were observed in the *Acacia nilotica* (30%) and *Acacia bussei* (25%). The maximum indicator values for group 6 were observed in the *Balanites aegyptiaca* (32%), *Acacia nilotica* (22%), and *Acacia asak* (21%). These species formed vegetation community known as *Balanites aegyptiaca*-*Acacia nilotica*.

TABLE 3: Data for vegetation abundance of Gambella National Park.

Plot no.	Species name	Abundance
1	<i>Combretum aculeatum</i>	2
1	<i>Combretum collinum</i>	4
1	<i>Combretum molle</i>	4
1	<i>Terminalia brownie</i>	5
1	<i>Terminalia laxiflora</i>	4
1	<i>Terminalia macroptera</i> Guill. & Perr.	1
1	<i>Terminalia schimperiana</i> Hochst.	1
1	<i>Commiphora africana</i>	1
1	<i>Commiphora habessinica</i>	1
1	<i>Albizia malacophylla</i>	1
1	<i>Sterculia africana</i>	1
1	<i>Securidaca longipedunculata</i>	1
2	<i>Combretum collinum</i>	4
2	<i>Combretum molle</i>	4
2	<i>Terminalia brownie</i>	5
2	<i>Terminalia laxiflora</i>	4
2	<i>Terminalia schimperiana</i> Hochst	1
2	<i>Commiphora africana</i>	1
2	<i>Commiphora habessinica</i>	1
2	<i>Cordia africana</i>	1
2	<i>Sterculia africana</i>	1
2	<i>Securidaca longipedunculata</i>	1
3	<i>Combretum collinum</i>	4
3	<i>Combretum molle</i>	4
3	<i>Terminalia brownie</i>	5
3	<i>Terminalia laxiflora</i>	4
3	<i>Terminalia macroptera</i> Guill. & Perr.	1
3	<i>Terminalia schimperiana</i> Hochst.	1
3	<i>Commiphora africana</i>	1
3	<i>Diospyros mespiliformis</i>	1
1		
3	<i>Celtis toka</i>	1
3	<i>Securidaca longipedunculata</i>	1
4	<i>Combretum collinum</i>	4
4	<i>Combretum molle</i>	5
4	<i>Terminalia brownie</i>	4
4	<i>Terminalia laxiflora</i>	3
4	<i>Terminalia macroptera</i> Guill. & Perr.	1
4	<i>Diospyros mespiliformis</i>	1
4	<i>Sarcocephalus latifolius</i>	1
4	<i>Sterculia africana</i>	1
5	<i>Combretum aculeatum</i>	2
5	<i>Combretum collinum</i>	4
5	<i>Combretum molle</i>	4
5	<i>Terminalia brownie</i>	5
5	<i>Terminalia laxiflora</i>	4
5	<i>Terminalia macroptera</i> Guill. & Perr.	1
5	<i>Terminalia schimperiana</i> Hochst.	1
5	<i>Commiphora africana</i>	1
5	<i>Diospyros mespiliformis</i>	1
5	<i>Sarcocephalus latifolius</i>	1
5	<i>Sterculia africana</i>	1
5	<i>Securidaca longipedunculata</i>	1
6	<i>Combretum collinum</i>	4
6	<i>Combretum molle</i>	4
6	<i>Terminalia brownie</i>	5
6	<i>Terminalia laxiflora</i>	4
6	<i>Terminalia schimperiana</i> Hochst.	1
6	<i>Commiphora africana</i>	1
6	<i>Commiphora habessinica</i>	1

TABLE 3: Continued.

Plot no.	Species name	Abundance
6	<i>Sarcocephalus latifolius</i>	1
6	<i>Sterculia africana</i>	1
6	<i>Securidaca longipedunculata</i>	1
7	<i>Combretum collinum</i>	4
7	<i>Combretum molle</i>	4
7	<i>Terminalia brownie</i>	5
7	<i>Terminalia laxiflora</i>	4
7	<i>Terminalia macroptera</i> Guill. & Perr.	1
7	<i>Terminalia schimperiana</i> Hochst.	1
7	<i>Commiphora africana</i>	1
7	<i>Commiphora habessinica</i>	1
7	<i>Sarcocephalus latifolius</i>	1
7	<i>Securidaca longipedunculata</i>	1
8	<i>Combretum collinum</i>	4
8	<i>Combretum molle</i>	5
8	<i>Terminalia brownie</i>	4
8	<i>Terminalia laxiflora</i>	3
8	<i>Terminalia macroptera</i> Guill. & Perr.	1
8	<i>Commiphora africana</i>	1
8	<i>Sarcocephalus latifolius</i>	1
8	<i>Ficus sycomorus</i>	1
9	<i>Combretum aculeatum</i>	2
9	<i>Combretum collinum</i>	4
9	<i>Combretum molle</i>	4
9	<i>Terminalia brownie</i>	5
9	<i>Terminalia laxiflora</i>	4
9	<i>Terminalia macroptera</i> Guill. & Perr.	1
9	<i>Terminalia schimperiana</i> Hochst.	1
9	<i>Commiphora africana</i>	1
9	<i>Sclerocarya birrea</i>	1
9	<i>Ficus sycomorus</i>	1
9	<i>Sterculia africana</i>	1
9	<i>Securidaca longipedunculata</i>	1
10	<i>Combretum aculeatum</i>	3
10	<i>Combretum collinum</i>	3
10	<i>Combretum molle</i>	5
10	<i>Terminalia brownie</i>	4
10	<i>Terminalia laxiflora</i>	4
10	<i>Terminalia macroptera</i> Guill. & Perr.	1
10	<i>Terminalia schimperiana</i> Hochst.	1
10	<i>Commiphora africana</i>	1
10	<i>Commiphora habessinica</i>	1
10	<i>Sarcocephalus latifolius</i>	1
10	<i>Sterculia africana</i>	1
10	<i>Sclerocarya birrea</i>	1
11	<i>Combretum collinum</i>	4
11	<i>Combretum molle</i>	4
11	<i>Terminalia brownie</i>	5
11	<i>Terminalia laxiflora</i>	4
11	<i>Terminalia schimperiana</i> Hochst.	1
11	<i>Commiphora africana</i>	1
11	<i>Commiphora habessinica</i>	1
11	<i>Sclerocarya birrea</i>	1
11	<i>Sterculia africana</i>	1
11	<i>Ficus sycomorus</i>	1
12	<i>Combretum collinum</i>	4
12	<i>Combretum molle</i>	4
12	<i>Terminalia brownie</i>	5
12	<i>Terminalia laxiflora</i>	4
12	<i>Terminalia macroptera</i> Guill. & Perr.	1
12	<i>Terminalia schimperiana</i> Hochst.	1

TABLE 3: Continued.

Plot no.	Species name	Abundance
12	<i>Commiphora africana</i>	1
12	<i>Sclerocarya birrea</i>	1
12	<i>Sarcocephalus latifolius</i>	1
12	<i>Securidaca longipedunculata</i>	1
13	<i>Combretum collinum</i>	4
13	<i>Combretum molle</i>	5
13	<i>Terminalia brownie</i>	4
13	<i>Terminalia laxiflora</i>	3
13	<i>Terminalia macroptera</i> Guill. & Perr.	1
13	<i>Commiphora africana</i>	1
13	<i>Sarcocephalus latifolius</i>	1
13	<i>Sclerocarya birrea</i>	1
14	<i>Combretum aculeatum</i>	2
14	<i>Combretum collinum</i>	4
14	<i>Combretum molle</i>	4
14	<i>Terminalia brownie</i>	5
14	<i>Terminalia laxiflora</i>	4
14	<i>Terminalia macroptera</i> Guill. & Perr.	1
14	<i>Terminalia schimperiana</i> Hochst.	1
14	<i>Commiphora africana</i>	1
14	<i>Ceiba pentandra</i>	1
14	<i>Ficus vasta</i> Forssk.	1
14	<i>Sterculia africana</i>	1
14	<i>Sclerocarya birrea</i>	1
15	<i>Combretum aculeatum</i>	3
15	<i>Combretum collinum</i>	3
15	<i>Combretum molle</i>	5
15	<i>Terminalia brownie</i>	4
15	<i>Terminalia laxiflora</i>	4
15	<i>Terminalia macroptera</i> Guill. & Perr.	1
15	<i>Sclerocarya birrea</i>	1
15	<i>Commiphora africana</i>	1
15	<i>Commiphora habessinica</i>	1
15	<i>Sarcocephalus latifolius</i>	1
15	<i>Sterculia africana</i>	1
15	<i>Securidaca longipedunculata</i>	1
16	<i>Combretum collinum</i>	4
16	<i>Combretum molle</i>	4
16	<i>Terminalia brownie</i>	5
16	<i>Terminalia laxiflora</i>	4
16	<i>Terminalia schimperiana</i> Hochst	1
16	<i>Commiphora africana</i>	1
16	<i>Commiphora habessinica</i>	1
16	<i>Salvadora persica</i>	1
16	<i>Sterculia africana</i>	1
16	<i>Ficus vasta</i> Forssk.	1
17	<i>Combretum collinum</i>	4
17	<i>Combretum molle</i>	4
17	<i>Terminalia brownie</i>	5
17	<i>Terminalia laxiflora</i>	4
17	<i>Salvadora persica</i>	1
17	<i>Terminalia schimperiana</i> Hochst.	1
17	<i>Commiphora africana</i>	1
17	<i>Ficus vasta</i> Forssk.	1
17	<i>Sarcocephalus latifolius</i>	1
18	<i>Securidaca longipedunculata</i>	1
18	<i>Combretum collinum</i>	4
18	<i>Combretum molle</i>	5
18	<i>Terminalia brownie</i>	4
18	<i>Terminalia laxiflora</i>	3
18	<i>Terminalia macroptera</i> Guill. & Perr.	1

TABLE 3: Continued.

Plot no.	Species name	Abundance
18	<i>Commiphora africana</i>	1
18	<i>Sarcocephalus latifolius</i>	1
18	<i>Sterculia africana</i>	1
19	<i>Terminalia brownie</i>	5
19	<i>Capparis erythrocarpus</i>	1
19	<i>Terminalia laxiflora</i>	4
19	<i>Salvadora persica</i>	1
19	<i>Tamarindus indica</i>	2
19	<i>Acacia oerfota</i>	1
19	<i>Maytenus senegalensis</i>	1
19	<i>Ziziphus mucronata</i>	2
20	<i>Terminalia brownie</i>	4
20	<i>Capparis erythrocarpus</i>	1
20	<i>Terminalia laxiflora</i>	4
20	<i>Boswellia rivae</i>	1
20	<i>Tamarindus indica</i>	2
20	<i>Acacia oerfota</i>	1
20	<i>Maytenus senegalensis</i>	1
20	<i>Grewia bicolor</i>	2
20	<i>Terminalia brownie</i>	5
20	<i>Capparis erythrocarpus</i>	1
20	<i>Terminalia laxiflora</i>	4
20	<i>Boswellia rivae</i>	1
20	<i>Tamarindus indica</i>	2
20	<i>Acacia oerfota</i>	1
20	<i>Grewia bicolor</i>	1
20	<i>Ziziphus mucronata</i>	1
21	<i>Terminalia brownie</i>	4
21	<i>Capparis erythrocarpus</i>	1
21	<i>Terminalia laxiflora</i>	4
21	<i>Boswellia rivae</i>	1
21	<i>Tamarindus indica</i>	2
21	<i>Grewia bicolor</i>	1
21	<i>Maytenus senegalensis</i>	1
21	<i>Ziziphus mucronata</i>	1
23	<i>Terminalia brownie</i>	5
23	<i>Terminalia laxiflora</i>	5
23	<i>Boswellia rivae</i>	1
23	<i>Tamarindus indica</i>	1
23	<i>Maytenus senegalensis</i>	1
23	<i>Ziziphus mucronata</i>	1
24	<i>Terminalia brownie</i>	5
24	<i>Capparis erythrocarpus</i>	1
24	<i>Terminalia laxiflora</i>	4
24	<i>Boswellia rivae</i>	1
24	<i>Tamarindus indica</i>	2
24	<i>Acacia oerfota</i>	1
24	<i>Maytenus senegalensis</i>	1
24	<i>Ziziphus mucronata</i>	2
25	<i>Terminalia brownie</i>	4
25	<i>Capparis erythrocarpus</i>	1
25	<i>Terminalia laxiflora</i>	4
25	<i>Boswellia rivae</i>	1
25	<i>Tamarindus indica</i>	2
25	<i>Acacia oerfota</i>	1
25	<i>Maytenus senegalensis</i>	1
25	<i>Ziziphus mucronata</i>	2
26	<i>Terminalia brownie</i>	5
26	<i>Capparis erythrocarpus</i>	1
26	<i>Terminalia laxiflora</i>	4
26	<i>Boswellia rivae</i>	1

TABLE 3: Continued.

Plot no.	Species name	Abundance
26	<i>Tamarindus indica</i>	2
26	<i>Acacia oerfota</i>	1
26	<i>Maytenus senegalensis</i>	1
26	<i>Ziziphus mucronata</i>	1
27	<i>Terminalia brownie</i>	4
27	<i>Capparis erythrocarpus</i>	1
27	<i>Terminalia laxiflora</i>	4
27	<i>Boswellia rivae</i>	1
27	<i>Tamarindus indica</i>	2
27	<i>Acacia oerfota</i>	1
27	<i>Maytenus senegalensis</i>	1
27	<i>Ziziphus mucronata</i>	1
28	<i>Terminalia brownie</i>	5
28	<i>Terminalia laxiflora</i>	5
28	<i>Boswellia rivae</i>	1
28	<i>Tamarindus indica</i>	1
28	<i>Maytenus senegalensis</i>	1
28	<i>Ziziphus mucronata</i>	1
29	<i>Terminalia brownie</i>	4
29	<i>Terminalia laxiflora</i>	5
29	<i>Boswellia rivae</i>	1
29	<i>Tamarindus indica</i>	2
29	<i>Maytenus senegalensis</i>	1
29	<i>Ziziphus mucronata</i>	1
30	<i>Terminalia brownie</i>	5
30	<i>Terminalia laxiflora</i>	5
30	<i>Boswellia rivae</i>	1
30	<i>Tamarindus indica</i>	1
30	<i>Ricinus communis</i>	1
30	<i>Ziziphus mucronata</i>	1
31	<i>Terminalia brownie</i>	5
31	<i>Terminalia laxiflora</i>	5
31	<i>Boswellia rivae</i>	1
31	<i>Tamarindus indica</i>	1
31	<i>Maytenus senegalensis</i>	1
31	<i>Ricinus communis</i>	1
32	<i>Tamarindus indica</i>	5
32	<i>Terminalia brownie</i>	4
32	<i>Terminalia laxiflora</i>	3
32	<i>Steganotaenia araliacea</i>	1
32	<i>Strychnos innocua</i>	1
32	<i>Sterculia africana</i>	2
32	<i>Vitellaria paradoxa</i>	2
33	<i>Tamarindus indica</i>	5
33	<i>Terminalia brownie</i>	4
33	<i>Terminalia laxiflora</i>	4
33	<i>Ricinus communis</i>	1
33	<i>Strychnos innocua</i>	1
33	<i>Sterculia africana</i>	1
33	<i>Vitellaria paradoxa</i>	2
34	<i>Tamarindus indica</i>	4
34	<i>Terminalia brownie</i>	4
34	<i>Terminalia laxiflora</i>	3
34	<i>Steganotaenia araliacea</i>	1
34	<i>Ricinus communis</i>	1
34	<i>Sterculia africana</i>	1
34	<i>Vitellaria paradoxa</i>	1
35	<i>Tamarindus indica</i>	5
35	<i>Terminalia brownie</i>	4
35	<i>Terminalia laxiflora</i>	4
35	<i>Steganotaenia araliacea</i>	1

TABLE 3: Continued.

Plot no.	Species name	Abundance
35	<i>Strychnos innocua</i>	1
35	<i>Sterculia africana</i>	1
35	<i>Vitellaria paradoxa</i>	2
36	<i>Tamarindus indica</i>	5
36	<i>Terminalia brownie</i>	4
36	<i>Terminalia laxiflora</i>	4
36	<i>Steganotaenia araliacea</i>	1
36	<i>Grewia mollis</i> A.Juss.	1
36	<i>Sterculia africana</i>	2
36	<i>Vitellaria paradoxa</i>	1
37	<i>Tamarindus indica</i>	5
37	<i>Terminalia brownie</i>	4
37	<i>Terminalia laxiflora</i>	4
37	<i>Steganotaenia araliacea</i>	1
37	<i>Strychnos innocua</i>	1
37	<i>Sterculia africana</i>	1
37	<i>Vitellaria paradoxa</i>	2
38	<i>Tamarindus indica</i>	4
38	<i>Terminalia brownie</i>	4
38	<i>Terminalia laxiflora</i>	3
38	<i>Grewia mollis</i> A.Juss.	1
38	<i>Strychnos innocua</i>	1
38	<i>Sterculia africana</i>	1
38	<i>Vitellaria paradoxa</i>	1
39	<i>Tamarindus indica</i>	5
39	<i>Terminalia brownie</i>	4
39	<i>Terminalia laxiflora</i>	4
39	<i>Steganotaenia araliacea</i>	1
39	<i>Strychnos innocua</i>	1
39	<i>Sterculia africana</i>	2
39	<i>Vitellaria paradoxa</i>	1
40	<i>Balanites aegyptiaca</i>	5
40	<i>Acacia seyal</i>	3
40	<i>Acacia senegal</i>	3
40	<i>Acacia polyacantha</i>	2
40	<i>Acacia tortilis</i>	2
40	<i>Acacia oerfota</i>	2
40	<i>Tamarindus indica</i>	1
40	<i>Flueggea virosa</i>	1
40	<i>Ziziphus mucronata</i>	1
40	<i>Piliostigma thonningii</i>	1
41	<i>Balanites aegyptiaca</i>	5
41	<i>Acacia seyal</i>	3
41	<i>Acacia senegal</i>	3
41	<i>Acacia polyacantha</i>	2
41	<i>Acacia tortilis</i>	2
41	<i>Acacia oerfota</i>	2
41	<i>Tamarindus indica</i>	1
41	<i>Flueggea virosa</i>	1
41	<i>Saba Florida</i> (Benth.) Bullock	1
42	<i>Balanites aegyptiaca</i>	5
42	<i>Acacia seyal</i>	4
42	<i>Acacia senegal</i>	3
42	<i>Acacia polyacantha</i>	2
42	<i>Acacia tortilis</i>	2
42	<i>Acacia oerfota</i>	2
42	<i>Flueggea virosa</i>	1
42	<i>Grewia mollis</i> A.Juss.	1
42	<i>Piliostigma thonningii</i>	1
43	<i>Balanites aegyptiaca</i>	5
43	<i>Acacia seyal</i>	3

TABLE 3: Continued.

Plot no.	Species name	Abundance
43	<i>Acacia senegal</i>	3
43	<i>Acacia polyacantha</i>	2
43	<i>Acacia tortilis</i>	2
43	<i>Acacia oerfota</i>	2
43	<i>Tamarindus indica</i>	1
43	<i>Flueggea virosa</i>	1
43	<i>Ziziphus mucronata</i>	1
43	<i>Saba Florida</i> (Benth.) Bullock	1
44	<i>Balanites aegyptiaca</i>	5
44	<i>Acacia seyal</i>	3
44	<i>Acacia senegal</i>	3
44	<i>Acacia polyacantha</i>	2
44	<i>Acacia tortilis</i>	2
44	<i>Acacia oerfota</i>	2
44	<i>Tamarindus indica</i>	1
44	<i>Piliostigma thonningii</i>	1
44	<i>Saba Florida</i> (Benth.) Bullock	1
45	<i>Balanites aegyptiaca</i>	4
45	<i>Acacia seyal</i>	4
45	<i>Acacia senegal</i>	3
45	<i>Acacia polyacantha</i>	2
45	<i>Acacia tortilis</i>	3
45	<i>Acacia oerfota</i>	2
45	<i>Tamarindus indica</i>	1
45	<i>Grewia mollis</i> A.Juss.	1
45	<i>Capparis tomentosa</i>	1
46	<i>Balanites aegyptiaca</i>	5
46	<i>Acacia seyal</i>	4
46	<i>Acacia senegal</i>	3
46	<i>Acacia polyacantha</i>	2
46	<i>Acacia tortilis</i>	2
46	<i>Piliostigma thonningii</i>	2
46	<i>Flueggea virosa</i>	1
46	<i>Ziziphus mucronata</i>	1
46	<i>Capparis tomentosa</i>	1
47	<i>Balanites aegyptiaca</i>	5
47	<i>Acacia seyal</i>	3
47	<i>Acacia senegal</i>	3
47	<i>Acacia polyacantha</i>	2
47	<i>Acacia tortilis</i>	2
47	<i>Piliostigma thonningii</i>	2
47	<i>Tamarindus indica</i>	1
47	<i>Flueggea virosa</i>	1
47	<i>Ziziphus mucronata</i>	1
48	<i>Balanites aegyptiaca</i>	4
48	<i>Acacia seyal</i>	4
48	<i>Acacia senegal</i>	3
48	<i>Acacia polyacantha</i>	2
48	<i>Acacia tortilis</i>	3
48	<i>Acacia oerfota</i>	2
48	<i>Tamarindus indica</i>	1
48	<i>Flueggea virosa</i>	1
48	<i>Grewia tenax</i> (Forssk.) Fiori	1
49	<i>Balanites aegyptiaca</i>	5
49	<i>Acacia seyal</i>	4
49	<i>Acacia senegal</i>	3
49	<i>Acacia polyacantha</i>	2
49	<i>Acacia tortilis</i>	2
49	<i>Acacia oerfota</i>	2
49	<i>Flueggea virosa</i>	1
49	<i>Grewia tenax</i> (Forssk.) Fiori	1

TABLE 3: Continued.

Plot no.	Species name	Abundance
49	<i>Capparis tomentosa</i>	1
50	<i>Balanites aegyptiaca</i>	5
50	<i>Acacia seyal</i>	3
50	<i>Acacia senegal</i>	3
50	<i>Acacia polyacantha</i>	2
50	<i>Acacia tortilis</i>	2
50	<i>Acacia oerfota</i>	2
50	<i>Grewia tenax</i> (Forssk.) Fiori	1
50	<i>Flueggea virosa</i>	1
50	<i>Ziziphus mucronata</i>	1
50	<i>Balanites aegyptiaca</i>	4
50	<i>Acacia seyal</i>	3
50	<i>Acacia senegal</i>	3
50	<i>Acacia polyacantha</i>	2
50	<i>Acacia tortilis</i>	3
50	<i>Acacia oerfota</i>	2
50	<i>Tamarindus indica</i>	1
50	<i>Flueggea virosa</i>	1
50	<i>Capparis tomentosa</i>	1
51	<i>Balanites aegyptiaca</i>	5
51	<i>Acacia seyal</i>	4
51	<i>Acacia senegal</i>	3
51	<i>Acacia polyacantha</i>	2
51	<i>Acacia tortilis</i>	2
51	<i>Acacia oerfota</i>	2
51	<i>Flueggea virosa</i>	1
51	<i>Ziziphus mucronata</i>	1
51	<i>Capparis tomentosa</i>	1
52	<i>Balanites aegyptiaca</i>	5
52	<i>Acacia seyal</i>	3
52	<i>Acacia senegal</i>	3
52	<i>Acacia polyacantha</i>	2
52	<i>Acacia tortilis</i>	2
52	<i>Acacia oerfota</i>	2
52	<i>Tamarindus indica</i>	1
52	<i>Flueggea virosa</i>	1
52	<i>Ziziphus mucronata</i>	1
52	<i>Capparis tomentosa</i>	1
53	<i>Balanites aegyptiaca</i>	5
53	<i>Acacia seyal</i>	3
53	<i>Acacia senegal</i>	3
53	<i>Acacia polyacantha</i>	2
53	<i>Acacia tortilis</i>	2
53	<i>Acacia oerfota</i>	2
53	<i>Tamarindus indica</i>	1
53	<i>Flueggea virosa</i>	1
53	<i>Ziziphus mucronata</i>	1
54	<i>Balanites aegyptiaca</i>	4
54	<i>Acacia seyal</i>	4
54	<i>Acacia senegal</i>	2
54	<i>Acacia polyacantha</i>	2
54	<i>Acacia tortilis</i>	3
54	<i>Acacia oerfota</i>	2
54	<i>Tamarindus indica</i>	1
54	<i>Flueggea virosa</i>	1
54	<i>Capparis tomentosa</i>	1
55	<i>Balanites aegyptiaca</i>	5
55	<i>Acacia seyal</i>	4
55	<i>Acacia senegal</i>	3
55	<i>Acacia polyacantha</i>	2
55	<i>Acacia tortilis</i>	2

TABLE 3: Continued.

Plot no.	Species name	Abundance
55	<i>Acacia oerfota</i>	2
55	<i>Flueggea virosa</i>	1
55	<i>Ziziphus mucronata</i>	1
55	<i>Capparis tomentosa</i>	1
56	<i>Balanites aegyptiaca</i>	5
56	<i>Acacia seyal</i>	3
56	<i>Acacia senegal</i>	3
56	<i>Acacia polyacantha</i>	2
56	<i>Acacia tortilis</i>	2
56	<i>Acacia oerfota</i>	2
56	<i>Tamarindus indica</i>	1
56	<i>Flueggea virosa</i>	1
56	<i>Ziziphus mucronata</i>	1
56	<i>Capparis tomentosa</i>	1
57	<i>Balanites aegyptiaca</i>	5
57	<i>Acacia seyal</i>	3
57	<i>Acacia senegal</i>	3
57	<i>Acacia polyacantha</i>	2
57	<i>Acacia tortilis</i>	2
57	<i>Acacia oerfota</i>	2
57	<i>Tamarindus indica</i>	1
57	<i>Flueggea virosa</i>	1
57	<i>Ziziphus mucronata</i>	1
58	<i>Balanites aegyptiaca</i>	4
58	<i>Acacia seyal</i>	4
58	<i>Acacia senegal</i>	3
58	<i>Acacia polyacantha</i>	2
58	<i>Acacia tortilis</i>	3
58	<i>Acacia oerfota</i>	2
58	<i>Tamarindus indica</i>	1
58	<i>Flueggea virosa</i>	1
58	<i>Capparis tomentosa</i>	1
59	<i>Balanites aegyptiaca</i>	5
59	<i>Acacia seyal</i>	3
59	<i>Acacia senegal</i>	3
59	<i>Acacia polyacantha</i>	2
59	<i>Acacia tortilis</i>	2
59	<i>Acacia oerfota</i>	2
59	<i>Tamarindus indica</i>	1
59	<i>Flueggea virosa</i>	1
59	<i>Ziziphus mucronata</i>	1
59	<i>Capparis tomentosa</i>	1
60	<i>Balanites aegyptiaca</i>	5
60	<i>Acacia seyal</i>	3
60	<i>Acacia senegal</i>	3
60	<i>Acacia polyacantha</i>	2
60	<i>Acacia tortilis</i>	2
60	<i>Acacia oerfota</i>	2
60	<i>Tamarindus indica</i>	1
60	<i>Flueggea virosa</i>	1
60	<i>Ziziphus mucronata</i>	1
61	<i>Balanites aegyptiaca</i>	4
61	<i>Acacia seyal</i>	4
61	<i>Acacia senegal</i>	3
61	<i>Acacia polyacantha</i>	2
61	<i>Acacia tortilis</i>	3
61	<i>Acacia oerfota</i>	2
61	<i>Tamarindus indica</i>	1
61	<i>Flueggea virosa</i>	1
61	<i>Capparis tomentosa</i>	1
62	<i>Balanites aegyptiaca</i>	5

TABLE 3: Continued.

Plot no.	Species name	Abundance
62	<i>Acacia seyal</i>	4
62	<i>Acacia senegal</i>	3
62	<i>Acacia polyacantha</i>	2
62	<i>Acacia tortilis</i>	2
62	<i>Acacia oerfota</i>	2
62	<i>Flueggea virosa</i>	1
62	<i>Ziziphus mucronata</i>	1
62	<i>Capparis tomentosa</i>	1
63	<i>Balanites aegyptiaca</i>	5
63	<i>Acacia seyal</i>	3
63	<i>Acacia senegal</i>	3
63	<i>Acacia polyacantha</i>	2
63	<i>Acacia tortilis</i>	2
63	<i>Acacia oerfota</i>	2
63	<i>Tamarindus indica</i>	1
63	<i>Flueggea virosa</i>	1
63	<i>Ziziphus mucronata</i>	1
63	<i>Capparis tomentosa</i>	1
64	<i>Balanites aegyptiaca</i>	5
64	<i>Acacia seyal</i>	3
64	<i>Acacia senegal</i>	3
64	<i>Acacia polyacantha</i>	2
64	<i>Acacia tortilis</i>	2
64	<i>Acacia oerfota</i>	2
64	<i>Tamarindus indica</i>	1
64	<i>Flueggea virosa</i>	1
64	<i>Ziziphus mucronata</i>	1
65	<i>Balanites aegyptiaca</i>	4
65	<i>Acacia seyal</i>	4
65	<i>Acacia senegal</i>	3
65	<i>Acacia polyacantha</i>	2
65	<i>Acacia tortilis</i>	3
65	<i>Acacia oerfota</i>	2
65	<i>Tamarindus indica</i>	1
65	<i>Flueggea virosa</i>	1
65	<i>Capparis tomentosa</i>	1
66	<i>Balanites aegyptiaca</i>	5
66	<i>Acacia seyal</i>	3
66	<i>Acacia senegal</i>	3
66	<i>Acacia polyacantha</i>	2
66	<i>Acacia tortilis</i>	2
66	<i>Acacia oerfota</i>	2
66	<i>Tamarindus indica</i>	1
66	<i>Flueggea virosa</i>	1
66	<i>Ziziphus mucronata</i>	1
66	<i>Capparis tomentosa</i>	1
67	<i>Balanites aegyptiaca</i>	5
67	<i>Acacia seyal</i>	3
67	<i>Acacia senegal</i>	3
67	<i>Acacia polyacantha</i>	2
67	<i>Acacia tortilis</i>	2
67	<i>Acacia oerfota</i>	2
67	<i>Tamarindus indica</i>	1
67	<i>Flueggea virosa</i>	1
67	<i>Ziziphus mucronata</i>	1
68	<i>Balanites aegyptiaca</i>	4
68	<i>Acacia seyal</i>	3
68	<i>Acacia senegal</i>	3
68	<i>Acacia polyacantha</i>	2
68	<i>Acacia tortilis</i>	3
68	<i>Acacia oerfota</i>	2

TABLE 3: Continued.

Plot no.	Species name	Abundance
68	<i>Tamarindus indica</i>	1
68	<i>Flueggea virosa</i>	1
68	<i>Capparis tomentosa</i>	1
69	<i>Balanites aegyptiaca</i>	5
69	<i>Acacia seyal</i>	4
69	<i>Acacia senegal</i>	3
69	<i>Acacia polyacantha</i>	2
69	<i>Acacia tortilis</i>	2
69	<i>Acacia oerfota</i>	2
69	<i>Flueggea virosa</i>	1
69	<i>Ziziphus mucronata</i>	1
69	<i>Capparis tomentosa</i>	1
70	<i>Balanites aegyptiaca</i>	5
70	<i>Acacia seyal</i>	3
70	<i>Acacia senegal</i>	3
70	<i>Acacia polyacantha</i>	2
70	<i>Acacia tortilis</i>	2
70	<i>Acacia oerfota</i>	2
70	<i>Tamarindus indica</i>	1
70	<i>Flueggea virosa</i>	1
70	<i>Ziziphus mucronata</i>	1
71	<i>Balanites aegyptiaca</i>	4
71	<i>Acacia seyal</i>	4
71	<i>Acacia senegal</i>	3
71	<i>Acacia polyacantha</i>	2
71	<i>Acacia tortilis</i>	3
71	<i>Acacia oerfota</i>	2
71	<i>Tamarindus indica</i>	1
71	<i>Flueggea virosa</i>	1
71	<i>Capparis tomentosa</i>	1
72	<i>Balanites aegyptiaca</i>	5
72	<i>Acacia seyal</i>	4
72	<i>Acacia senegal</i>	3
72	<i>Acacia polyacantha</i>	2
72	<i>Acacia tortilis</i>	2
72	<i>Acacia oerfota</i>	2
72	<i>Flueggea virosa</i>	1
72	<i>Ziziphus mucronata</i>	1
72	<i>Capparis tomentosa</i>	1
73	<i>Balanites aegyptiaca</i>	5
73	<i>Acacia seyal</i>	3
73	<i>Acacia senegal</i>	3
73	<i>Acacia polyacantha</i>	2
73	<i>Acacia tortilis</i>	2
73	<i>Acacia oerfota</i>	2
73	<i>Tamarindus indica</i>	1
73	<i>Flueggea virosa</i>	1
73	<i>Ziziphus mucronata</i>	1
74	<i>Balanites aegyptiaca</i>	5
74	<i>Acacia seyal</i>	3
74	<i>Acacia senegal</i>	3
74	<i>Acacia polyacantha</i>	2
74	<i>Acacia tortilis</i>	2
74	<i>Acacia oerfota</i>	2
74	<i>Tamarindus indica</i>	1
74	<i>Flueggea virosa</i>	1
74	<i>Ziziphus mucronata</i>	1
75	<i>Balanites aegyptiaca</i>	4
75	<i>Acacia seyal</i>	3
75	<i>Acacia senegal</i>	3
75	<i>Acacia polyacantha</i>	2

TABLE 3: Continued.

Plot no.	Species name	Abundance
75	<i>Acacia tortilis</i>	3
75	<i>Acacia oerfota</i>	2
75	<i>Tamarindus indica</i>	1
75	<i>Flueggea virosa</i>	1
75	<i>Capparis tomentosa</i>	1
76	<i>Balanites aegyptiaca</i>	5
76	<i>Acacia senegal</i>	3
76	<i>Acacia polyacantha</i>	2
76	<i>Acacia tortilis</i>	2
76	<i>Acacia oerfota</i>	2
76	<i>Flueggea virosa</i>	1
76	<i>Ziziphus mucronata</i>	1
77	<i>Balanites aegyptiaca</i>	5
77	<i>Acacia seyal</i>	3
77	<i>Acacia senegal</i>	3
77	<i>Acacia polyacantha</i>	2
77	<i>Acacia tortilis</i>	2
77	<i>Acacia oerfota</i>	2
77	<i>Tamarindus indica</i>	1
77	<i>Flueggea virosa</i>	1
77	<i>Ziziphus mucronata</i>	1
78	<i>Balanites aegyptiaca</i>	4
78	<i>Acacia seyal</i>	3
78	<i>Acacia senegal</i>	3
78	<i>Acacia polyacantha</i>	2
78	<i>Acacia tortilis</i>	3
78	<i>Acacia oerfota</i>	2
78	<i>Tamarindus indica</i>	1
78	<i>Flueggea virosa</i>	1
78	<i>Capparis tomentosa</i>	1
79	<i>Balanites aegyptiaca</i>	5
79	<i>Acacia seyal</i>	4
79	<i>Acacia senegal</i>	3
79	<i>Acacia polyacantha</i>	2
79	<i>Acacia tortilis</i>	2
79	<i>Acacia oerfota</i>	2
80	<i>Balanites aegyptiaca</i>	5
80	<i>Acacia seyal</i>	3
80	<i>Acacia Senegal</i>	3
80	<i>Acacia polyacantha</i>	2
80	<i>Acacia tortilis</i>	2
80	<i>Acacia oerfota</i>	2
80	<i>Tamarindus indica</i>	1
80	<i>Flueggea virosa</i>	1
80	<i>Ziziphus mucronata</i>	1
80	<i>Capparis tomentosa</i>	1

Source: vegetation raw data for Ph.D. thesis, Gatluak [24].

4.3. Habitat Types of Gambella National Park. The Rapid Eye image classified the Gambella National Park into five major habitat types which included woodland, wooded grassland, savanna, grassland, and wetlands (Figure 3). Other minor habitat types classified on the map were temporary burned, water body, and rivers.

The woodland comprised three vegetation community types. These were *Combretum collinum*-*Terminalia brownii*, *Acacia nilotica*-*Acacia bussei*, and *Balanites aegyptiaca*-*Acacia nilotica* communities while *Ziziphus mucronata*-*Acacia senegal*-*Hyparrhenia rufa* community was found in wooded

FIGURE 3: Habitat types of Gambella National Park.

TABLE 4: Area covered by each habitat type.

No.	Habitat classification	Area in km ²	Percentage
1	Grassland	395.50	8.74
2	Savannah	68.63	1.52
5	Wet land	645.99	14.27
4	Wooded grassland	1650.04	36.45
3	Woodland	1716.50	37.92
6	Others		
6.1	Settlements/roads	0.16	0.00
6.2	Temporary burned	23.15	0.50
6.3	Water body	27.15	0.60
	Total	4,527.12	100

grassland habitat of the park. *Hyparrhenia rufa*-*Oryza longistaminata* and *Cyperus castaneus*-*Perpyrnuo cypress* community was found in open grassland and wetland, respectively.

The classification of habitats for Gambella National Park had also shown that woodland in Gambella National Park cover an area of 1,716.50 square kilometers (37.92%) of the land cover of the park followed by wooded grassland which had an area coverage of 1,650.04 square kilometer (36.45%) of the land coverage of the park (Table 4). The wetland had also relative large share of the area of the park, 645.99 square kilometer (14.27%) of the area coverage as compared with grassland and savannah, comprising 8.74% and 1.52% of the land coverage, respectively.

5. Conclusion

It can be concluded that at microlevel the Gambella National Park is classified into 6 vegetation communities, whereas at a

large level of the park, it was classified into 5 major habitat types.

Data Availability

The data used to support the findings of this study are included within the supplementary information file.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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