

Variations in Herbaceous Composition of Dry Tropics Following Anthropogenic Disturbed Environment

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ABSTRACT

Present study was carried out at Boramdeo Wildlife Sanctuary of Chhattisgarh with the objective to assess the composition, structure and diversity of herb layer. Three circle of Kawardha forest division were selected, comprising of three disturbance gradients *i.e.*, heavily disturbed, moderately disturbed and lightly disturbed site, respectively in each circle. Stratified random sampling was opted to measure the herbaceous vegetation. A total of 39, 39 and 33 herbs species were recorded under Boramdeo circle, Jamunpani circle and Salehwara circle, respectively. The total density of herbs was varied from 67800-146900 individuals ha⁻¹ in Boramdeo circle, 70700-108700 individuals ha⁻¹ in Jamunpani circle and 72000-119200 individuals ha⁻¹ in Salehwara circle. The diversity indices showed that Shannon index value for herb layer in different forest circle along the disturbance gradient varied from 2.50 to 4.25, concentration of dominance (Cd) 0.06 to 0.37, species richness 1.35 to 2.19, equitability 0.76 to 1.34 and beta diversity 1.44 to 2.44. The experimental results clearly indicated that anthropogenic disturbances cause significant impact on ground flora in different circles.

Key words: Composition, Circle, Disturbances, Diversity indices, Herb.

INTRODUCTION

In many forest ecosystems, herbaceous vegetation is key strata and share to largest proportion of species diversity. The changes in herb layer occurred with topographic heterogeneity and biotic disturbances and harbor the majority of plant diversity in deciduous forests ecosystem^{1,2}. Any kind of disturbances resulted to degradation of habitats, especially herbaceous vegetation, which is essential for regulating nutrient cycling as well as ecological balance. The herbaceous species are capable to modify the site conditions to some extent. The composition and luxuriance of ground vegetation in degraded ecosystem are mainly depends upon the secondary site conditions³. The composition of herbaceous layer is varied continuously in space and time due to multiple factors such as fire⁴ land use change, grazing, anthropogenic disturbances⁵, local weather, rainfall, moisture and soil fertility⁶.

Herbaceous vegetation is also affected by both natural and anthropogenic disturbances. Alteration in tree canopy due to tree falls, wildfire, harvesting, illicit felling are tends to moderate to large increases in resource availability^{7,8}. However, disturbances in low severity usually cause little damage to overstorey trees⁹ but affect ground vegetation directly by shifting the habitat available resources^{10,11}. The disturbances with high severity generate relatively homogeneous resource availability while low to moderate severity disturbances partially remove the canopy and generally result in greater resource heterogeneity¹². Anthropogenic disturbances in forests followed by livestock grazing and forest fire adversely affected the composition of herbaceous vegetation^{13,14}, it is therefore imperative to conserve the herbaceous vegetation of these sites. Hence, present study attempts to assess the composition and diversity of herbs following anthropogenic disturbance.

MATERIALS AND METHODS

The present experiment was executed in the Boramdeo Wildlife Sanctuary, located in Kabirdham district. It occupies a special position from biodiversity and tourism point of view. The natural forest of Kawardha (Chhattisgarh) adjacent to Kanha National Park (M.P.) is one of the important natural heritage sites of Central India. It is well known for its rich, complex and diverse flora and fauna¹⁵. The study site is located between 21°23'- 22°00' North latitude and 80°58'- 82°34' East longitudes. The topography is hilly which falls in the Maikal Range of the Satpura hills. The altitude ranges from 600 to 900 m from the sea level and climate is dry tropical with annual average rainfall of 1250-1380 mm. Different types of forest vegetation occur in the study area¹³. Northern and Eastern directions covered with luxuriant forests, whereas Teak plantations mainly occupy in Southern direction. The Western direction covered by degraded and mixed forest and also with bamboo brakes. The herbs widely found in this sanctuary are *Achyranthus aspera* inn., *Apluda mutica* Hack., *Crotalaria calycina* Schrank., *Desmodium pulchellum* (L) Benth., *Eragrostis tenella* Linn., *Ischaemum pilosum* Klein ex Willd., *Paspalidium flavidum* (Retz.) A.Camus, *Tridax procumbens* Linn. etc.¹⁵.

The study on herbaceous diversity along the disturbance gradient of tropical dry deciduous forest was done after the repeated reconnaissance survey of sanctuary area. Three circles viz., Boramdeo, Jamunpani and Salehwara were selected for the present study. In each of these circles, three disturbance gradients *i.e.*, heavily, moderately and lightly disturbed site were identified following Kumar and Ram¹⁶. The herbaceous vegetation was measured within 1m x 1m quadrat. The vegetational data were quantitatively analysed for frequency, density and abundance¹⁷. The importance value index was calculated followed Phillips¹⁸. Simpson index¹⁹ was used for concentration of dominance and Margalef index²⁰ for species richness. Diversity indices were calculated following Sagar and Singh²¹. A/F ratio (abundance to frequency) for different species was determined by eliciting the distribution pattern. The data was analysed in one-way analysis of variance. The significant differences between

treatment means of all parameters were tested following Snedecor and Cochran²².

RESULTS AND DISCUSSION

Boramdeo circle

Herb density (Table 1) was maximum on heavily disturbed site and minimum on lightly disturbed site. The density of individual species were ranged from 200-86500 individuals ha⁻¹ for heavily disturbed site, 600-40700 individuals ha⁻¹ for moderately disturbed site and 400-22400 individuals ha⁻¹ for lightly disturbed site. *Setaria spp.* and *Xanthium Strumarium* showed highest frequency in highly disturbed site and *Coriandrum sativum*, *Desmodium pulchellum*, *Lavandula bipinnata*, *Oscium gratissimum*, *Setaria spp.* and *Sida cordata* in moderately disturbed site, whereas *Coriandrum sativum*, *Imperata cylindrical*, *Ishaemum pilosum*, *Oscium gratissimum* and *Saccharum spontaneum* in lightly disturbed site. Abundance to Frequency ratio (A/F) was ranged from 0.07 to 0.90 in highly disturbed site which indicated that most of the species were disturbed contagiously and randomly. In moderately disturbed site A/F value was 0.05 to 0.42 which revealed that most of the species performed contagious distribution pattern while a few species were distributed randomly. Under the lightly disturbed site A/F ratio varied from 0.01 to 1.60 and showed that *Asparagus resimosus* only disturbed regularly on the site and rest of the species randomly and contagiously. The IVI values in Boramdeo circle across the disturbance gradient were ranged from 2.12-103.78. The dominant species of herbs on heavily disturbed was *Setaria spp.* Dominant species on moderately disturbed site was *Lavandula bipinnata* and on lightly disturbed site *Saccharum spontaneum* was the dominant species. Analysis of variance indicated that the three sites differed significantly in the herb density ($p < 0.01$). Along the disturbance gradient in Boramdeo circle the value of Shannon index ranged from 2.50-3.18, concentration of dominance from 0.16-0.37, species richness from 1.35-2.19, equitability value from 0.76-1.11 and beta diversity from 1.44-2.44, respectively (Table 4).

Jamunpani circle

Under Jamunpani circle herb density was maximum in heavily disturbed site and minimum in

Table 1. Continues....

(Retz.)DC. <i>Lavandula bipinnata</i> (Roth)	100	40700	40.70	0.41	62.41							
<i>Limnophila sessiliflora</i> (Vahl.)Blume.	30	1200	4.00	0.13	5.88							
<i>Malvestrum</i> <i>coromandelicum</i> (L.)	20	600	3.00	0.15	3.97							
<i>Mimosa pudica</i> L.	40	2300	5.75	0.14	8.67							
<i>Oscium gratissimum</i> L.	40	8200	20.50	0.51	18.24	100	29900	29.90	0.30	48.20	12800	12.80 0.13 41.41
<i>Paspalidium flavidum</i> (Retz.)A. Camus	20	1500	20	0.38	6.31							
<i>Perotis hordeiformis</i>	10	600	6.00	0.60	3.90							
<i>Phyllanthus urinaria</i> L.	40	3200	8.00	0.20	10.13	70	3400	4.86	0.07	11.53	2200	11.00 0.55 14.94
<i>Polygala furcata</i> Royle	20	400	2.00	0.10	3.49	50	1400	2.80	0.06	7.09	30	1200 4.00 0.13 8.66
<i>Rumex dentatus</i> auct.non L.	10	400	4.00	0.40	3.01							
<i>Saccharum .</i> <i>spontananeum</i> L						100	22400			22.40		0.22 63.74
<i>Setaria</i> spp.	100	86500	86.50	0.87	103.78	100	13600	13.60	0.14	26.75		
<i>Sida cordata</i> (Burm.f.) Borss.	20	1200	6.00	0.30	5.54	100	8200	8.20	0.08	19.64	30	600 2.00 0.07 6.08
<i>Tacca leontopetaloides</i> (L.) Kuntze	20	1200	6.00	0.30	5.54							
<i>Toningia cucullata</i> Kuntze.	20	600	3.00	0.15	4.01	40	1400	3.50	0.09	6.62		
<i>Tridax procumben</i> L.						50	1800	3.60	0.07	7.85		
<i>Uraria lagopus</i> DC.						50	1800	3.60	0.07	7.85		
<i>Vigna pilosa</i> Willd.	30	600	2.00	0.07	4.86	20	600	3.00	0.15	3.97		
<i>Xanthium strumarium</i> Boiss.	100	10400	10.40	0.10	23.34	40	2800	7.00	0.18	9.70	30	600 2.00 0.07 6.08
Total	810	146900	265.72	9.67	300	1130	137500	169.82	2.65	300	860	67800 117.44 4.16 300

F, D, A, A/F and IVI respectively, are frequency in percentage, density (individuals ha⁻¹), abundance, abundance/frequency and Importance Value Index.

Table 2: Species structure of herb layer along the disturbance gradient in Jamunpani circle of Bhoramdeo Wildlife Sanctuary

Species	Heavily disturbed site					Moderately disturbed site					Lightly disturbed site				
	F	D	A	A/F	IVI	F	D	A	A/F	IVI	F	D	A	A/F	IVI
<i>Achyranthus aspra</i> L.	50	9200	18.40	0.37	21.34	30	1200	4.00	0.13	7.40	80	5900	7.38	0.09	19.85
<i>Andrographis paniculata</i> (Burm F.)Wallich						30	2400	8.00	0.27	11.83					
<i>Apluda mutica</i> L.											50	3400	6.80	0.14	13.74
<i>Aristida cumingiana</i> Trin. & Rupr.															
<i>Asparagus resimosus</i> Willd.						40	800	2.00	0.05	6.46					
<i>Bacopa procumbence</i> (Mill.) Greenm.											40	1800	4.50	0.11	9.24
<i>Cajanus scarbaeoides</i> (L.) Canavalia gladiata (Jacq.)DC	40	3500	8.75	0.22	10.75	50	800	1.60	0.03	7.17					
<i>Cassia tora</i> L.	40	2800	7.00	0.18	9.30										
<i>Cenchrus setigerus</i> Vahi.	50	6300	12.60	0.25	15.98										
<i>Chrolophytum tuberosum</i> (Roxb.)Baker						40	500	1.25	0.03	5.52					
<i>Coriandrum sativum</i> L.	100	12700	12.70	0.13	26.26	60	4000	6.67	0.11	16.15	70	4100	5.86	0.08	15.72
<i>Crysopogon montanus</i>	50	7600	15.20	0.30	18.38										
<i>Curculigo serratum</i>						50	1600	3.20	0.06	9.40	50	1300	2.60	0.05	8.19
<i>Curcuma aromatica</i> Salibs.						30	800	2.67	0.09	5.92	30	800	2.67	0.09	5.78
<i>Cyprus exaltatus</i> Rottb.						70	5900	8.43	0.12	21.03					
<i>Desmodium pulchellum</i> (L.)						40	2100	5.25	0.13	10.52	50	2800	5.60	0.11	12.15
<i>Dioscorea glabra</i> Roxb.						30	1000	3.33	0.11	6.66					

Table 2. Continues....

<i>Echinochloa colonum</i> (L.) Link	50	2400	4.80	0.10	8.78					60	2300	3.83	0.06	11.21	
<i>Euphorbia heterophylla</i> L.	50	1800	3.60	0.07	7.67										
<i>Euphorbia hypericifolia</i> L.	40	1800	4.50	0.11	7.22										
<i>Evolvus nummularius</i> L.	40	3600	9.00	0.23	10.96	40	1600	4.00	0.10	8.96					
<i>Imperata cylindrica</i> (L.) Phigenia indica (L.) A. Gray	70	6600	9.43	0.13	16.53										
<i>Justicia latispica</i> Gamble	10	1500	15.00	1.50	9.20										
<i>Malvestrum coromandelicum</i> (L.) <i>Mimosa pudica</i> L.	70	4600	6.57	0.09	13.36	40	1400	3.50	0.09	8.33					
<i>Oscium gratissimum</i> L.	40	2800	7.00	0.18	9.30	40	1400	3.50	0.09	8.33					
<i>Parthenium hysterophorus</i> L.	80	10200	12.75	0.16	22.25	60	14000	23.33	0.39	41.68	80	5600	7.00	0.09	19.23
<i>Phyllanthus urinaria</i> L. <i>Rumex dentatus</i> auct. non L.	20	1000	5.00	0.25	4.98										
<i>Setaria spp.</i> <i>Sida cordata</i> (Burm.f.) Bors.	30	800	2.67	0.09	4.58	50	2000	4.00	0.08	10.51	60	2600	4.33	0.07	11.92
<i>Thysanolaena maxima</i> (Roxb.) Kuntz.	70	8600	12.29	0.18	19.69	80	17600	22.00	0.28	47.84	80	41100	51.38	0.64	92.83
<i>Toningia cucullata</i> Kuntze.	40	4300	10.75	0.27	12.41	30	800	2.67	0.09	5.92	50	1300	2.60	0.05	8.19
<i>Utraria lagopus</i> DC. <i>Ventigo calycuta</i> Tulasne <i>Vigna pilosa</i> Willd.	50	2500	5.00	0.10	8.96										
<i>Xanthium strumarium</i> . Boiss	20	1200	6.00	0.30	5.62	20	400	2.00	0.10	3.91	30	1000	3.33	0.11	6.50
<i>Total</i>	60	5700	9.50	0.16	14.86	50	200	4.00	0.08	10.51	90	6200	6.89	0.08	20.78
<i>Total</i>	1150	108700	215.84	5.80	300	1010	70700	146.39	3.78	300	1050	88600	132.33	2.17	300

F, D, A, A/F and IVI respectively, are frequency in percentage, density (individuals ha⁻¹), abundance, abundance/frequency and Importance Value Index

Table 3. Continues....

<i>Eragrostis atrovirens</i> (Desf.) Trin.ex Steud.	50	6400	12.80	0.26	22.69	50	2300	4.60	0.09	12.36
<i>Evolvulus</i>	60	3200	5.33	0.09	14.09					
<i>nummularius</i> (L.)						60	5200	8.67	0.14	20.92
<i>Fimbristylis dichotoma</i> auct.non Vahl.						60	3000	3.75	0.05	15.72
<i>Imperata</i>	30	1200	4.00	0.13	7.45	80	5000	6.25	0.08	20.65
<i>cylindrica</i> (L.)										
<i>Iphigenia indica</i> (L.)A.gray	50	2100	4.20	0.08	9.73	80	4500	5.63	0.07	18.04
<i>Maivestrum</i>										
<i>coromandelicum</i> (L.)	40	1000	2.50	0.06	6.67	60	2000	3.33	0.06	11.05
<i>Mimosa pudica</i> L.	60	3900	6.50	0.11	13.75	50	3000	6.00	0.12	13.29
<i>Oscium gratissimum</i> L.						60	1800	3.00	0.05	11.33
<i>Paspalidium flavidum</i> (Retz)A. Camus						60	9800	16.33	0.27	33.90
<i>Perotis hordeiformis</i>	30	500	1.67	0.06	4.66	40	1000	2.50	0.06	7.12
<i>Phyllanthus urinaria</i> L.	50	1200	2.40	0.05	7.84	30	800	2.67	0.09	5.97
<i>Rumex dentatus</i> auct.non L.	60	9200	15.33	0.26	23.77	60	3600	6.00	0.10	15.10
<i>Setaria glauca</i> (L.)P.Beauv.	100	55800	55.80	0.56	92.64	70	18300	26.14	0.37	50.15
<i>Setaria</i> spp.	50	1400	2.80	0.06	8.26					
<i>Sida cordata</i> (Burm.f.) Borss.						20	200	1.00	0.05	2.98
<i>Toningia cucullata</i> Kuntze.	50	2300	4.60	0.09	10.15	50	5500	11.00	0.22	20.20
<i>Xanthium strumarium</i> Boiss.	940	119200	158.57	2.37	300	1000	74500	140.63	2.91	300
Total										
						960	72000	116.36	1.96	300

F, D, A, A/F and IVI respectively, are frequency in percentage, density (individuals ha⁻¹), abundance, abundance/frequency and Importance Value Index

Table 4: Diversity pattern of herb layers along the disturbance gradient in forest circle of Boramdeo Wildlife Sanctuary

Circles	Shannon index (H')	Simpson's index (Cd)	Species richness (d)	Equitability (e)	Beta diversity
Heavily Disturbed Site					
Boramdeo	2.50	0.37	2.19	0.76	1.44
Jamunpani	4.25	0.06	1.98	1.34	1.67
Salehwara	2.81	0.26	1.37	0.99	1.94
Moderately Disturbed Site					
Boramdeo	3.18	0.16	1.44	1.10	2.17
Jamunpani	3.71	0.12	2.06	1.17	1.67
Salehwara	3.75	0.23	1.87	1.21	1.50
Lightly Disturbed Site					
Boramdeo	3.08	0.17	1.35	1.11	2.44
Jamunpani	3.08	0.24	1.58	1.05	2.11
Salehwara	3.40	0.15	1.43	1.20	1.94

moderately disturbed site (Table 2). The density of individual species in highly disturbed site was 800-12700 individuals ha⁻¹, 200-17600 individuals ha⁻¹ in moderately disturbed site and 800-41100 individuals ha⁻¹ in lightly disturbed site. The maximum frequency value was represented by *Coriandrum sativum* in highly disturbed site, by *Setaria spp.* in moderately disturbed site and *Xanthium strumarium* in lightly disturbed site. A/F value and IVI value in this circle across the disturbance gradient were ranged from 0.03 to 1.50 and 3.91 to 92.83, respectively. The dominant species of herbs on heavily disturbed was *Coriandrum sativum*, *Oscium gratissimum* and *Achyranthus aspra*. Dominant species on moderately disturbed site was *Setaria spp.* and *Oscium gratissimum*. On lightly disturbed site *Setaria spp.* was the dominant species. Analysis of variance indicated that the three sites differed significantly (p<0.05) in the herb density. The diversity indices in Jamunpani circle (Table 4) along the disturbance gradient shows that the value of Shannon index varied from 3.08-4.25, concentration of dominance 0.06-0.24, species richness 1.58-2.06, equitability 1.05-1.34 and beta diversity values from 1.67-2.11.

Salehwara circle

In this circle the density of herb (Table 3) was maximum in heavily disturbed site and minimum in lightly disturbed site showing same trend as in

Boramdeo circle. The density of individual species were ranged from 300-55800 individuals ha⁻¹ on heavily disturbed site, 200-18300 individuals ha⁻¹ on moderately disturbed site and 400-22900 individuals ha⁻¹ on lightly disturbed site. The highest frequency value is achieved by *Cassia tora* and *Setaria spp.* under highly disturbed site, *Malvestrum coromandelicum* under moderately disturbed site whereas in lightly disturbed site by *Imperata cylindrica* and *Iphigenia indica*, respectively. The value of A/F ratio and IVI were ranged from 0.04 to 0.56 and 2.98 to 92.64, respectively in this circle across the disturbance gradient. The dominant species of herbs on heavily disturbed was *Setaria spp.* and *Cassia tora*. Dominant species on moderately disturbed site was *Setaria spp.*, *Cassia tora* and *Eragrotis atrovirens*. On lightly disturbed site *Setaria spp.*, *Paspalidium flavidum* and *Fimbristylis dichotoma* was the dominant species. Analysis of variance indicated that three sites differed significantly in herb density (p<0.01). In Salehwara circle the value of Shannon index were ranged from 2.81-3.75, concentration of dominance from 0.15-0.26, richness from 1.37-1.87, equitability from 0.99-1.21 and value of beta diversity from 1.50-1.94, respectively along the disturbance gradient (Table 4).

The floral and faunal communities in the ecosystems is largely influenced by the disturbances frequently occurring either by naturally or man-

made^{23,24,25}. In many of these systems, disturbances may alter the overall community structure²⁶ which in turn affects the community and population dynamics. Herb layer composition is often interrelated with regional climate and site conditions²⁷. Plants may assist other species directly by ameliorating severe environmental circumstances, changing substrate characteristics, or increasing the availability of a resource²⁸. In the present study general structure of herbaceous species in all sites illustrated an increasing fashion as the disturbance rise. The reason for their maximum occurrence due to the availability of resources like space, light, moisture, nutrient and other environmental factors. Comparable to these Alhassan *et al.*²⁹ reported similar aspects which are responsible for the variation in species recovery and diversity. The disturbed site supports more herbs as compared to least disturbed site due to reduction in competition for space and resources. The herb increases immediately due to the anthropogenic disturbance due to general reduction in tree cover that eventually supportive to growth and development of herbaceous vegetation due to availability of resources^{5,13,14,30,31}.

In the present study the total herb density was varied from 67800-146900 individuals ha⁻¹ on Bhoramdeo circle, 70700-108700 individuals ha⁻¹ on Jamunpani circle and 72000-119200 individuals ha⁻¹ on Salehwara circle. These figures are well within the range of herb density measured by Jhariya *et al.*¹³ (112000 to 668000 individuals ha⁻¹ during pre-fire season whereas, 230000 to 510000 after fire season) and Jhariya *et al.*⁵ (502000 to 724000 individuals ha⁻¹). Pande³² studied the ecological status of vegetation in Satpura plateau (M.P.) and reported the total density of herb layer was 15905 to 102078 stems ha⁻¹. Negi and Nautiyal³³ have found the 20-23 species of herbs in study area. Rastogi and Rastogi³⁴ reported that the density of herbs varied between 168000-497800 per ha, which resemble with present estimated value.

Species diversity is known to be one of the key parameters typically describing the ecosystems and ecosystem functioning³⁵. Worldwide, biodiversity is fluctuating at an unprecedented degree as a compound response to numerous biotic changes³⁶. Species diversity tends to be low in physically controlled communities and high in biologically

control communities³. The present estimated values of diversity indices were comparable with various studies. Rastogi and Rastogi³⁴ found the diversity index between 0.918-0.967, while the similarity index was between 33-80%. Negi and Nautiyal³³ reported the concentration of dominance (cd) was 0.1 to 0.13, diversity index varied from 2.41 to 2.69. Beta diversity between two sites of forests was 3.8 and 1.2 for herbs³⁷. Pande³⁸ showed the range of diversity index (Shannon Wiener index) as 0.64-2.34 and also described that diversity index was invariably higher for herbs and it was minimum for least disturbed sites. The species diversity ranged from 1.80 to 3.03 was also reported by Shameem *et al.*³⁹ which are found to be similar with present study. Kittur *et al.*¹⁴ specified the diversity parameters of herb layer showed that Shannon index in different fire zones varied from 2.21 to 2.57, equitability from 1.02 to 1.24, species richness from 0.34 to 0.67, concentration of dominance from 0.21 to 0.31 and beta diversity from 1.81 to 3.33 which are closer to similar with present outcomes. These parameters were also supported by the findings made by Jhariya *et al.*^{5,13}. Analysis of variance calculated by Jhariya and Oraon² indicated that the dissimilarity in density among site were found significant at $p < 0.05$ in both the fire season and the number of species was found significant in post-fire season ($p < 0.05$) which are line agreement with the present investigation.

A/F ratio in present research indicated that most of the species showed contiguous and random distribution pattern while regular distribution found virtually insignificant on the Bhoramdeo Wildlife Sanctuary. Likewise, Jhariya *et al.*^{5,13}; Jhariya and Oraon² and Kittur *et al.*¹⁴ described that most of the species documented in the investigated area follow the contagious and random distribution pattern whereas the regular distribution was negligible.

CONCLUSION

The improvement in vegetation cover is possible through systematic monitoring of livestock grazing and anthropogenic disturbance in these forest areas. Human disturbances have influenced the floristic composition at countless magnitude. Moreover, new sites need to be explored for seasonal grazing as substitute followed by protection for few years that certainly will allow the vegetation

to regenerate which is constantly under threat due to various factors. However, increasing biotic interference at few sites need serious consideration and the human activities for fuel, fodder collection,

harvesting of NTFPs, collecting medicinal plants or herbs, burning of the ground vegetation and uncontrolled livestock grazing requires sustainable management aspects or measures.

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