

Rangeland Biodiversity: Interrelationships of Stocking Density and Grazing Intensity

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Abstract This study aimed to assess the interrelationships of biodiversity with stocking density and grazing intensity in the rangelands of Ifugao Province. Taking into consideration rangeland management practices and climate, this study exhaustively characterized the rangelands or silvipastoral systems of Ifugao Province, identified the plant species (grass and trees) and determined their composition per unit area of the selected rangelands. The biodiversity indices of the various rangeland conditions had been correspondingly estimated.

Keywords Stocking Density, Grazing Intensity, Biodiversity

1. Introduction

Rangeland management as a discipline skillfully applies an organized body of knowledge accumulated by range science for two purposes: (1) protection, improvement, and continued welfare of the basic resources (soils, vegetation, endangered plants and animal species, wilderness, water, and historical sites) in a sustainable way, and (2) optimum production of goods and services in combinations needed by society in a more multiple fashions (the harmonious use of range land resources for more than one purpose, such as livestock, recreation, wild life, water production, and others) Fikre *et al.* (2010).

Grazing has been reported to reduce the diversity of herbs and shrubs in the rangeland. Due to overgrazing, the vegetation species composition, richness and productivity has changed over the past decades, some species have disappeared (Darau *et al.*, 2005) while others have survived through the use of morphological or other adaptations (Blench and Sommer, 1999, Gitay *et al.*, 2002, Ali-Shtayeh and Salahat, 2010). Because of decline of natural species in the area, rangeland managers will tend to grow other species that will help supply forage needed by the animals that will lead to species invasion (Del Pozo *et al.*, 2006).

Rangeland management techniques intend to increase forage production through increase perennial species (Abraham *et al.*, 2009) that is potential to increase above and below ground soil carbon stocks. Grice *et al.* (2006) and FAO (2009) found out that rangeland stores thirty (30%) percent of the world's soil carbon and it is estimated that it

could globally sequester 0.35-0.55Gt-C. per year up to 2030. Likewise, FAO (2009) observed that natural and improved fallow systems under agroforestry and managed for resting of lands has potential sequestration rates of 0.1-5.3 T-C. per hectare per year.

Objectives of the Study

Generally, this study aimed to assess the interrelationships of biodiversity with stocking density and grazing intensity in the selected rangelands of Ifugao Province. Specifically, this study has the following objectives:

1. Characterize the rangelands or silvipastoral systems of Ifugao Province;
2. Identify the plant species (grass) of the selected rangeland in Ifugao Province;
3. Determine the biodiversity indices under various rangeland conditions.

2. Methodology

Research Design

The rangeland that serves as the research site was strategically identified by the researcher with the assistance of the rangeland officer of the Community Environment and Natural Resources Office (CENRO) of Alfonso Lista, Ifugao. Study sites were based from the density of the rangeland (number of stocks and total area) available at the CENRO-Alfonso Lista followed by actual validation of the data. There are three quadrats established in each of the site representing Heavily Grazed Ecosystem (HG); Partially Grazed Ecosystem (PG) and Recently No-grazing Ecosystem (NG). Selected rangelands were located in adjacent Barangays/Villages of the same climatic condition.

Location and Duration of the Study

The study was conducted in the three selected rangelands

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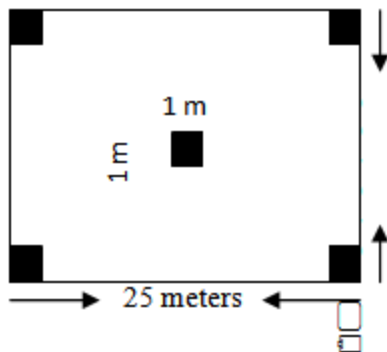
in Alfonso Lista, Ifugao (Figure 2) namely; FLGA No.572 situated at Barangay Namillangan, Alfonso Lista, Ifugao, FLGA No.19-2007 located at Barangay Caragasan, Alfonso Lista, Ifugao and FLGA No.743 located at Sitio Pabalay, Barangay Namillangan, Alfonso Lista, Ifugao. The study was accomplished within six months starting from proposal conceptualization on April 2012 up to September 2012.

Data Gathering Techniques and Tools

The criteria in the selection of specific rangeland that served as the study site were based on the stocking density of the rangelands as well as the grazing intensity. Density of rangeland was based on the following criteria: (1) **low density** if ratio of number of stock and the rangeland area (m^2) is 1: above 20, 000; (2) **moderate density** and (3) **high density** if the ratio of number of stock and the area (m^2) of rangeland is 1: 11, 000-20, 000 and 1: 10, 000 below, respectively.

Vegetative and species composition of the rangelands were determined by ecosystem stratification. There are three ecosystems commonly considered in the three rangelands such as: (1) **Heavily Grazed Ecosystem (HG)** which is characterized as grazing of cattle is throughout the year, (2) **Partially Grazed Ecosystem (PG)** is cattle grazing in the area for five months and below, and (3) **Recently No-grazing Ecosystem (NG)** is a rangeland with no grazing in the area for at least five months.

Considering sampling intensity and consistency, site reconnaissance was done to identify the points where plots in each ecosystem were established. Plots in square meter method (Darau *et al.*, 2005) as shown below are enclosed in a 25 meters by 25 meters quadrant (Wanner, 2009) where vegetation analysis was done.



Set-up of the quadrat and the plots for the study.

Data Processing and Analysis

Index of diversity, species evenness, dominance, and relative abundance of species and plant diversity was calculated with Shannon techniques as follows:

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

where: H' = Index of diversity
 $p_i = n_i / N$ = Relative Abundance
 s = total number of species

n_i = number of individuals in each species

N = total number of individuals of all species

Index of diversity is ranging from 0 (Low community complexity) to 4 (High community complexity).

The data gathered was processed using codes and encoded in the Microsoft Excel Program. Through this software, descriptive analyses such as means, frequency, and percentages, was undertaken and subsequently to be transformed to tables and graphs.

3. Results and Discussion

A. Physical Characteristics of the Study Sites

1. General profile of the Low Density Rangeland

The study site (Study Site 1) located at Barangay Caragasan, Alfonso Lista, Ifugao has an approximate area of 100 hectares. The area is under Forest Land Grazing Management Agreement (FLGMA No. 19-2007) for 25 years started on November 27, 2007 and up to December 31, 2032. At present, the rangeland has a stoking rate of 37 cow heads (Low Density). It is bounded on the north by timberland project 5-D, on the eastern part is alienable and disposable land BLK I, Project 5-B, on the south is timberland and on the west is the Cosili River.

Some part of the area is devoted for food production with an area of approximately 5 to 6 hectares on the northern part of the pasture area. The area to graze is 85 hectares and the remaining area is devoted to protection or watershed part of the rangeland area.

a). Vegetation and topography. The pastureland is dominantly grown to Amorsecio, Carabao grass, Cogon and Samsamon. Shrubs and trees to include are Hagonoy, Subsuban, Guava, Lagundi and other pioneer species like Anabiong, Tebbeg, Hauili and Is-is.

The general terrain of the area is rolling and more or less categorized as follows: 5 hectares has slope with 18 percent below, 90 hectares with 19-50 percent and 5 hectares having 51 percent and above slopes.

b). Soil and water supply. The general soil type of the area is clay loam to sandy loam particularly along creeks and it is semi black to brownish in color. The effective soil depth ranges from 25-65 centimeters (DENR-CENRO, 2012).

There are seven creeks and one water impounding located at the north part of the pasture area. Out of seven creeks on the study site, five are all year round that would supply water for the animals all throughout the year.

c). Accessibility. The pasture area could be reached through hiking for about 10 to 20 minutes from the national road with a distance of about one kilometer from the high way. The existing farm road however, is passable to four-wheeled vehicle when well improve (i.e., when surface gravelling is undertaken) usually for easy transport of the animals to and from the

national road (DENR-CENRO, 2012).

- d). Existing improvement.** The rangeland has been set up to five layers of barbed-wire perimeter fence that would control the animals from getting out from the area and avoiding to destroy neighboring properties particularly agricultural crops. A corral is also constructed on the southern part of the pasture.

2. General profile of the Medium Density Rangeland

Study site 2 is located at Sitio Pabalay, Barangay Namillangan, Alfonso Lista, Ifugao with an approximate area of 50 hectares. The area is under Forest Land Grazing Management Agreement (FLGMA No. 572-2007) for 25 years which started on November 2007 and expires on December 31, 2032. At present, the rangeland has a stocking rate of 48 cow heads which is considered as having a medium stocking density.

It is bounded by the North by open grassland, to the east by barangay road to sitio Pabalay, to the south by PLA No. 431 and to the west by the provincial road of Ifugao.

- a). Vegetation and topography.** The area is dominated by cogon, amorseco, trigo-trigohan and carabao grass. Generally, the area is rolling to slightly rugged in slope. The topography of the area consisted of 15 hectares under the 18 percent slope and below category while the remaining 35 hectares falls within 19 percent and above category.
- b). Soil and water supply.** The soil varies from clay loam to sandy loam. The source of water is a spring which provides continuous water throughout the year. There are also five fishponds established in the area serving as reservoirs of water. Two fish ponds are supported by water pump connected to the spring that serves as source of water for the cattle during summer

specifically when water supply is limited.

- c). Accessibility.** Aside from the provincial road which serves as the area boundary on the southern and western portion, there are also trails which radiates from the barangay road from the Sitio Pabalay going to the cowboy/ranchers quarter about 200 meters in length.

The presence of these trails and roads make the area accessible anytime of the season.

- d). Existing Improvements.** The area is well secured having a perimeter fence of five layers barbed-wire with three layers of barbed-wire in each of the three compartments. A part of this rangeland, with an area of more or less five hectares, was developed into different land-uses such as; mango plantation, a corn production area and vegetable production area, aside from being used as grazing area for the animals. This practice of maintaining different land uses in the rangeland would definitely generated additional income to the manager-owner (DENR-CENRO, 2012).

3. General profile of the High Density Rangeland

Study site 3 is located at Namillangan Proper, Alfonso Lista, Ifugao, with an approximate area of 50 hectares. The area is under Forest Land Grazing Management Agreement (FLGMA No. 743-2007) for 25 years started on August 6, 1997 up to December 31, 2022. At present the rangeland has a stoking rate of 63 cow heads (High Density).

It is bounded by the North by a provincial road going to Barangay Calupaan, on the west by a development site to be undertaken by the National Housing Authority and the south east is the NIA Dam and Reservoir of Ramon, Isabela.

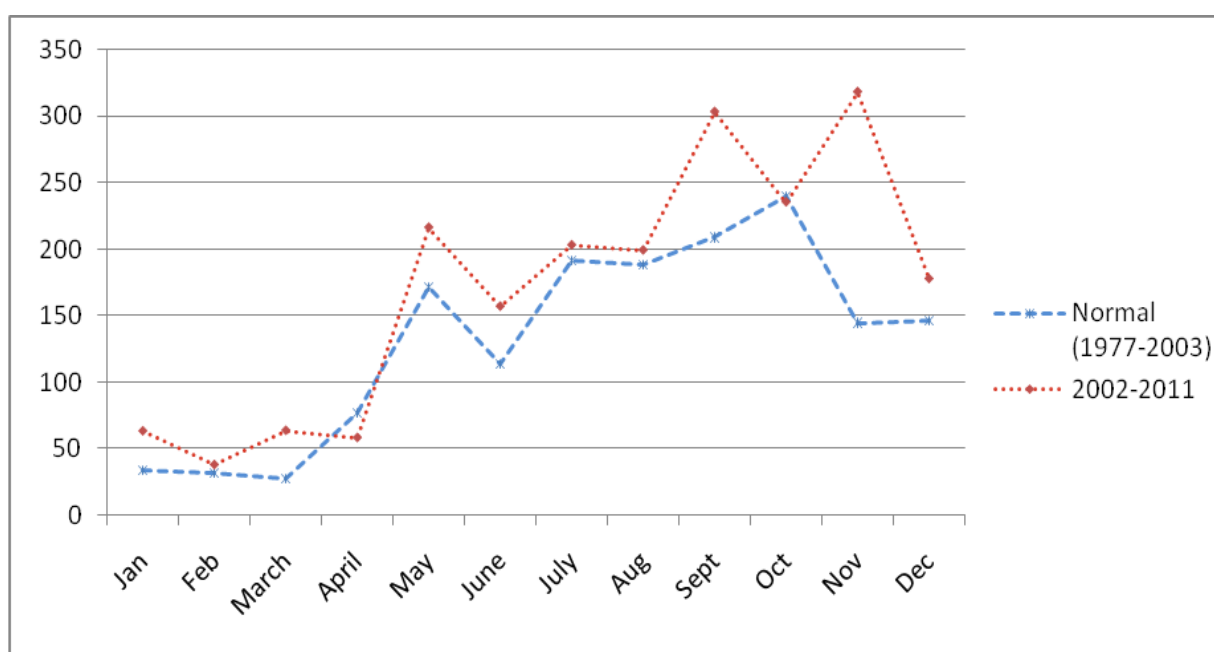


Figure 1. Average monthly and annual rainfall (mm) in the study site

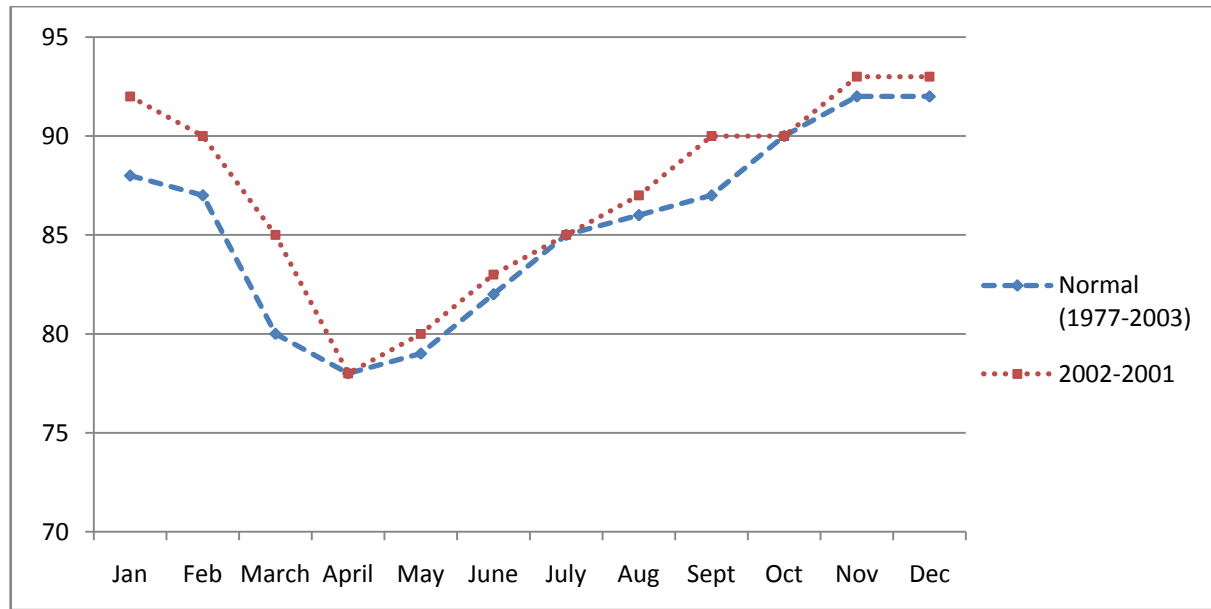


Figure 2. Average monthly and annual relative humidity

- a). **Vegetation and topography.** The area is dominated by cogon, amorseco, and samsamon. Generally, the area has a slope of rolling to slightly rugged. The topography of the area consists of 10-15 hectares under the 18 percent slope and below category while the remaining 35-40 hectares falls within the slope of 19 percent and above category.
- b). **Soil and water supply.** The soil varies from clay loam to sandy loam. There are three natural perennial springs which provides continuous water for the animals throughout the year.
- c). **Accessibility.** The area is located on northern part of the national road with an approximate distance of 1.5 kilometers from the NIA Dam and Reservoir of Ramon, Isabela and a provincial road going to Barangay Calupaan, Alfonso Lista, Ifugao, intersecting the area on the northeastern part. The rangeland is just located beside the provincial road which makes it very accessible any time of the year (DENR-CENRO, 2012).

B. Climatic conditions of the study sites

The climate of Ifugao falls under the First and Third climatic types. Type I, which affects the western part of the province, is characterized by two pronounced seasons; dry from December to May and wet from June to November. Type III climate, which affects the major portion of the eastern part of the province, is characterized by no very pronounced maximum rain period with a short dry season lasting only from one to three months. The hottest months are March and April while the coolest months are November up to February (PAGASA, 1992).

The annual rainfall for the year 2002 and 2003 is much lesser than the expected annual rainfall. However, during the period from 2004 to 2011, the average annual rainfall exhibited a value beyond the normal level and almost double

on 2011 with 2,857.9 millimeters. The normal trend for annual rainfall is lower on the months of January, February, March and April.

But there is no such pattern on 2002 for there are observations which are to be lower during the months of June, August and October of 2002 and the month of July in 2005, 2007, and 2008. The month of February 2010 has no rainfall incident recorded.

The months of September and October is expected to be the peak season for rainfall for it is expected to have rainfall intensity of about 208-240 millimeters. This information is inconsistent with the said expectations for it is observed that the highest was on the month of November in 2002, 2004, 2007, 2008, and 2010 and the month of December in 2005 and 2011. A high rainfall intensity incident was observed during the months of July 2004 and May 2007, 2008, and 2009. The distinction of the average monthly and annual rainfall between the normal (1977-2003) rainfall and the rainfall pattern for a 10 years (2002-2011).

April is expected to be the least with only 78 millimeter on its normal level and November and December is expected to be the highest with 92 millimeters on their normal level. The data have the same idea for the last decade only and that the maximum relative humidity noted go beyond the normal level from 2002-2011 except 2010. A high relative humidity was noted also during the months of January and February in 2002 to 2011, and March in 2006 to 2009.

C. Vegetation

In general rangeland in Ifugao Province is dominated by Cogon (*Imperata cylindrica*) and Amorseco (*Crysopogon aciculatus*) representing 32.95% and 31.89% respectively (shown in Table 1). The results of the study indicated that the species diversity in Ifugao province is higher in heavily grazed ecosystem than in partially grazed and recently no-grazing grazing ecosystem. The Analysis of Variance for

the values of index of diversity for each grazing intensity (treated as subplots) and stocking density (treated as main plots) in Completely Randomized Design (CRD Factorial)

however, indicate insignificant differences among the grazing intensity and stocking density.

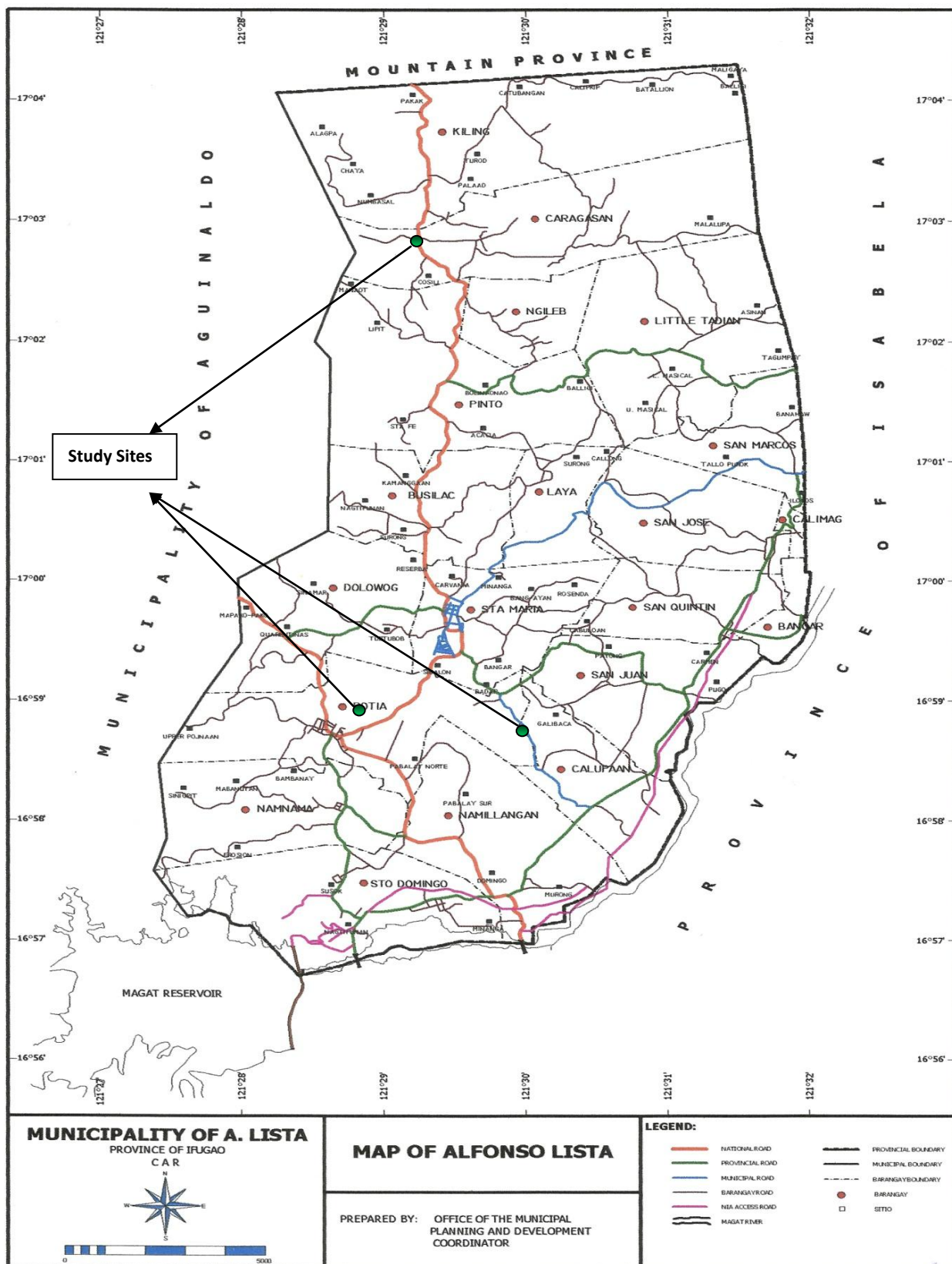
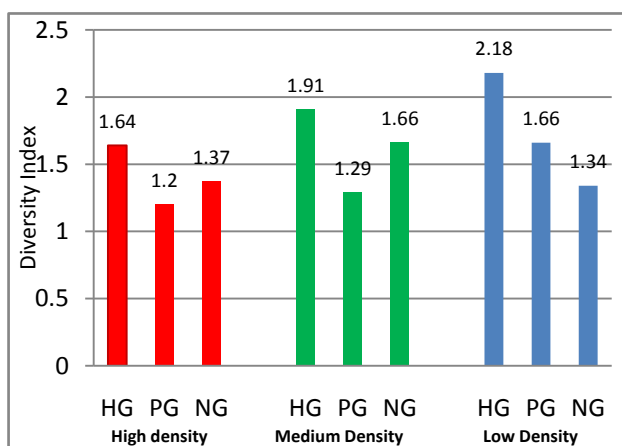


Figure 3. The study sites

Table 1. Overall results of the assessment of rangelands' biodiversity in Ifugao Province (HG=heavily Grazed; PG=Partially Grazed; NG=No Grazing)

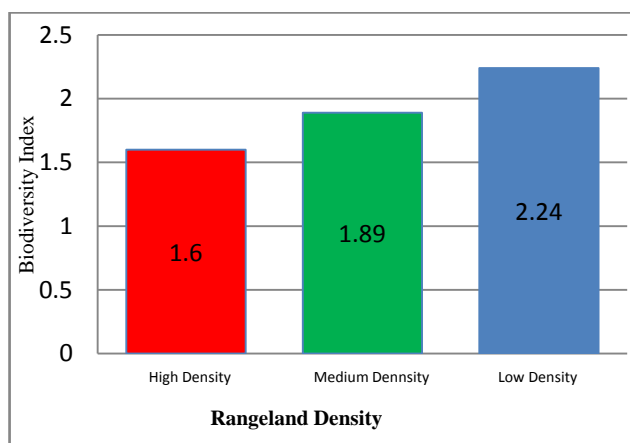
NAME OF Species	Stocking Density									Total	PERCENTAGE (%)
	High Density			Medium Density			Low Density				
	Grazing Intensity			Grazing Intensity			Grazing Intensity				
	HG	PG	NG	HG	PG	NG	HG	PG	NG		
<i>Alternantera sessilis</i>											
<i>Amgid (leersia hexandra)</i>											
<i>Amorseco (Crysopogon aciculatus)</i>											
<i>Bakbaka (Paspalum distichum)</i>	---	---	---	---	---	8	17	---	---	25	0.20
<i>Balbas Kalabaw (Sporolus indicus)</i>	8	---	---	---	---	---	---	---	---	8	0.06
<i>Bangbangsit (Lantana camara)</i>	754	1508	37	124	784	---	---	847	---	4054	31.89
<i>Barsanga (Cyperus rotundus)</i>	64	142	---	5	55	41	2	161	---	470	3.70
<i>Bayakibok (Echinocloa crus-galli)</i>	---	---	---	---	---	---	---	---	135	135	1.06
<i>Borreria levis</i>	5	---	---	5	---	---	---	---	---	10	0.08
<i>Buntot-pusa (Panicum geniculatum)</i>	---	---	---	---	---	---	6	62	---	68	0.53
<i>Cogon (Imperata cylindrica)</i>	---	---	---	2	---	---	---	---	---	2	0.02
<i>Colliaris digitaria</i>	---	---	---	11	---	1	---	---	---	12	0.09
<i>Crab Grass (Digitaria ciliaris)</i>	---	---	---	---	---	---	---	---	8	8	0.06
<i>Gamosa (Mimosa invisa)</i>	314	950	815	434	503	419	77	59	617	4188	32.95
<i>Hagonoy (Chromolaena odorata)</i>	---	---	---	---	---	12	---	---	---	12	0.09
<i>Hedyotis biflora</i>	---	---	---	---	---	---	14	178	---	192	1.51
<i>Lisang kalabaw (Paspalidium flavidum)</i>	---	---	7	3	---	7	---	---	---	17	0.13
	---	---	18	27	---	32	---	---	21	98	0.77
<i>Lobi-lobi (Hedyotis corymbosa)</i>	4	---	---	---	---	---	---	---	---	4	0.03
<i>Luyaluyahan (Panicum repens)</i>	---	---	---	17	---	---	---	---	---	17	0.13
<i>Makahiya (Mimosa pudica)</i>	---	---	---	---	---	---	33	8	25	66	0.52
<i>Maragata (Euphorbia hirta)</i>	---	---	---	---	93	32	---	104	---	229	1.80
<i>Marakauayan (Paspalum conjugatum)</i>	19	5	6	1	2	3	---	---	---	36	0.28
	---	---	---	---	---	2	10	---	---	12	0.09
<i>Ngalug (Portulaca oleracea)</i>	14	60	---	82	---	---	2	---	---	158	1.24
<i>Pagitpit(Eriochloa procerata)</i>	3	---	---	---	---	---	---	---	---	3	0.02
<i>Pakong Buwaya (Pteridium aquilinum)</i>	---	---	---	---	---	22	25	---	---	47	0.37
	---	---	---	3	---	---	---	---	---	3	0.02
<i>Pakpak Langaw(Desmodium trifolium)</i>	46	13	---	204	48	174	24	160	7	676	5.32
	---	---	---	2	---	---	---	---	---	2	0.02
<i>Sakasaka (Digitaria sitigera)</i>	---	---	222	---	---	36	54	---	210	522	4.11
<i>Samsamon</i>	---	---	---	11	---	2	---	---	---	13	0.10
<i>Siksik-parang (Borreria ocymoides)</i>	90	78	39	---	---	---	---	---	---	207	1.63
	---	---	---	---	---	1	---	---	---	1	0.01
<i>Sirau-sirau (Fimbristylis milliacea)</i>	---	---	---	---	---	---	---	---	21	21	0.17
<i>Sonchus oleraceus</i>	41	11	---	4	---	---	---	---	---	56	0.44
<i>Talahib (Saccharium spontanium)</i>	---	---	---	---	---	---	---	---	5	5	0.04
<i>Taltalikod (Phyllantus amarus)</i>	121	33	274	76	---	---	6	124	23	657	5.17
<i>Tanglag</i>	---	---	---	7	---	---	---	---	---	7	0.06
<i>Tayok-tayok (Fimbristylis dichotoma)</i>	---	---	---	---	---	---	---	---	5	5	0.04
	40	40	84	276	112	41	34	39	---	666	5.24
<i>Tikiw (Scirpus grossus)</i>											
<i>Tridax procumbens</i>											
<i>Trigo-trigohan(Ischaemum rugusom)</i>											
Total	1523	2840	1502	1294	1597	833	304	1642	1077	12,712	100.00
Index of Diversity	1.64	1.20	1.37	1.91	1.29	1.66	2.18	1.66	1.34		
Species Evenness	0.22	0.15	0.19	0.27	0.18	0.25	0.38	0.22	0.19		
Species Dominance	0.62	0.51	0.62	0.65	3.24	0.60	0.85	0.72	0.56		

The ANOVA for the values of Index of Diversity, shows insignificant differences among grazing conditions and types of stocking densities. The results might be due to the grazing practices in the rangelands that allowed the re-emergence or reappearance of the original species upon grazing as well as of other species when the dominant species had been grazed or subdued through grazing by the cattle. Further, in this study, it is interesting to note that the assessment of biodiversity of vegetation (grass) in the area showed that there are still endemic species such as Samsamon, Trigo-trigohan (*Ischaemum rugosum*) and carabao grass/ Marakauayan (*Paspalum conjugatum*) which is available for animal consumption.



Wherein: HG=heavily Grazed; PG=Partially Grazed; NG=No Grazing

Figure 4. Biodiversity indices in relation to grazing intensity



Wherein: HG=heavily Grazed; PG=Partially Grazed; NG=No Grazing

Figure 5. Biodiversity Indices in Relation to Stocking Density

This result, however, is inconsistent with the general theory of Noy-Meir as cited by Abraham *et al.* (2009) and Del Pozo *et al.* (2006). According to them, species diversity increases between grazing intensities over a wide range from ungrazed grassland up to fairly heavy grazing. The main reason is that more intensively grazing may lead to the disappearance of species or suspension of growth.

Generally, after the commencement of growth in May or early June, plants grow rapidly and the daily accumulation of dry matter can get to the peak within six to eight weeks. Thus,

this phase of vegetative growth, as it is known, mainly leads to an increase in both the mean height of herbaceous communities and their densities (Abraham *et al.*, 2009 and Wanner, 2009). This observation however, did not further explain about the likelihood of the emergence of other species upon removal – even for a short period – of dominant species.

Table 2. Analysis of Variance of Index of Diversity Different Rangelands

Source of Variation	DF	SS	MS	Computed F	Tabular F	
					5%	1%
Replication	4					
Treatment	8					
A	2	0.0186	0.0093	0.0307	3.32 _{ns}	5.39 _{ns}
B	2	0.3194	0.1597	0.5275	3.32 _{ns}	5.39 _{ns}
AxB	4	0.2953	0.0738	0.2438	2.69 _{ns}	4.02 _{ns}
Error	32	9.6898	0.3028			
Total	44	10.323				

Wherein: A is Rangeland Density; B is Grazing Intensity; _{ns} is not significant

Nevertheless, Hickman *et al.* (2004) observed that grazing by cattle increased diversity of plant communities. He concluded that cattle stocking density and grazing intensity had significant effects on the composition, species richness, species diversity, and growth form diversity of plants.

Moreover, the complex relationships between grazing animals and plant communities have long been recognized by rangeland workers (Kamau, 2004 and Ning *et al.* (2002). It should be pointed out that in most experimental work making use of herbivores, it is virtually impossible to control more than a few variables at any one time. Accordingly, grazing has three main effects on vegetation: (a) the sward is defoliated, (b) nutrients in the form of dung and urine are returned or removed from the rangeland ecosystem, and (c) the plant life suffers physical damage by trampling. Hickman *et al.* (2004) also suggested important components of a grazing management strategy influencing plant communities which include the animal stocking density and the grazing system. The stocking density (number of animals per unit area) influences the overall intensity of herbivory and physical impacts, and the grazing system determines the spatial and temporal patterns of grazing and their effects across the landscape.

In regards to the types of rangelands, the results of this study indicated that the species diversity index is higher in low density rangeland than in medium and high density rangeland which is opposite to the observation pointed out earlier that the highest stocking density resulted to highest diversity (Hickman *et al.*, 2004). Thus, the relationship between grazing intensity, stocking density (rangeland density) and species diversity is complicated. It could be affected by herbivore species and their grazing behavior, climate and productivity of the area, rangeland supplementary feeding practices, and length of evolutionary grazing history of vegetation (Abraham *et al.* 2009). These

phenomena could explain the scenario observed in this study and thus requiring more and sustained years of observations in order to have pertinent information specifically on the effects of grazing intensity and rangeland density on rangelands' biodiversity in Ifugao province.

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