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The construction of Grassland Degradation Index for Alpine Meadow in Qinghai-Tibetan Plateau

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Abstract

Diagnosing the degradation degree of grassland ecosystem is the basis for ecological restoration. However, there is no literature documenting how to quantify the grassland degradation degree by using visible indicators. In this study, an integrated degradation index was developed to assess the grassland condition on the basis of applicability and certainty analysis through a cases study from degraded alpine grassland on Qinghai-Tibetan Plateau of China.

Keywords: Grassland Degradation Index (GDI); Alpine grassland; Qinghai-Tibetan Plateau (QTP).

1. Introduction

Qinghai-Tibet Plateau, the “roof” of the world, is an important eco-region in both China and the world. It is the source regions of Yangtze, Yellow and Mekong Rivers and is called “China Water Tower”. Alpine grasslands covers more than 85% of the total land in this area, which is regarded as one of major natural pastures in China, and provide great ecosystem function and services[1]. However, alpine grasslands in this area have suffered from severe degradation driven by coupled effects of climate change, population growth, livestock overgrazing and rodent damage etc., alpine meadow has suffered from quite severe degradation[2-3]. Moreover, degraded grassland is expanding with the increase rate of 1.2-7.44% annually[4]. Under such circumstances, the restoration of degraded alpine grasslands is urgently needed. To design the restoration strategies properly, reliable diagnosis of grassland degradation should be implemented. In this context, the present study was conducted to quantify the degradation degree of the alpine grassland through developing an integrated grassland degradation index (GDI) on the basis of visible indicators.

Diagnosis of degradation degree of grassland ecosystem is the basis and the precondition of ecological restoration [5]. Estimates of the area variously categorized as degraded throughout China generally and on the QTP specifically

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have been published [6-9]. In these literatures, grassland degradation was defined by some visible indicators such as species diversity, plant height, vegetation cover and plant productivity [10]. These classification criteria are all qualitative or semiquantitative. So far, there is no literature documents discussed how to quantify the grassland degradation degree by visible indicators. In addition, there is no way to assess the degraded degree, if the data collected form survey can not completely suit the classification criteria. In this paper, our aims are to quantifying the degradation degree of the alpine meadow by visible indicators, construct the Grassland Degradation Index (GDI) based on the classification criteria for alpine grassland in QTP from Ma et al(2002), and evaluate the condition of the grassland degradation degree in Maqin country in Qinghai Province.

2. Materials and Methods

2.1. Study area

The study was conducted in Dawu village, Maqin county of Guoluo Tibetan Autonomous Prefecture, Qinghai Province. The average elevation of this area is 4200m with typical continental climate. The annually average temperature is -0.6℃, the lowest temperature is -34.9℃, annual accumulated temperatures above 0℃ and 5℃ are 1202.6℃ and 865.0℃ respectively. Annual precipitation is 513mm, occurring mainly from May to September. Annual evaporation is 1459mm. Annual sunshine hours are 2571h. There is no absolutely frost-free period. The soil is silt-clay, which is classified as alpine meadow soil according to Chinese Soil Classification System. The primary vegetation of alpine grassland was dominated by alpine meadows composed mainly of Kobresia spps. Polygonum spp. and Poa spps. [11].

2.2. Field survey and sampling

The vegetation composition and cover were surveyed with four 100cm×100cm quadrats in each site of alpine grassland at different degradation degrees to testify the feasibility of grassland degradation classification in present study. Plant biomass (primary production) in differently degraded grasslands was measured by clipping vegetation samples from these quadrats.

2.3. Data analysis

Data analyses were preformed using the Excel 2007. The important value (IV) of each species is calculated by the formula.

$$IV = \frac{C_r + B_r + H_r}{n} \quad (1)$$

$$C_r = \frac{C_i}{\sum_{i=1}^{n} C_i} \quad (2)$$

$$B_r = \frac{B_i}{\sum_{i=1}^{n} B_i} \quad (3)$$

$$H_r = \frac{H_i}{\sum_{i=1}^{n} H_i} \quad (4)$$

Note: C_r represents relative coverage, B_r represents relative dry biomass, H_r represents relative height. C_i represents the coverage of specie *i*; B_i represents the biomass of specie *i*; H_i represents the height of specie *i*.

3. Results

3.1. Construction and assessment of the Grassland Degradation Index (GDI)

At present, scholars general use ecological methods to assess the condition of the degraded grassland, based on vegetation survey. They survey the vegetation composition, coverage, biomass and some other indicators, and compared to the non-degradation grassland then evaluate the degradation degree. On the foundation of the succession theory (monoclimax theory or polyclimax theory), they define the classification standard by some visible indicators. Table 1 shows the criterion of grassland degradation degree revised on the criterion form Ma et al (2002), and then as a basis for construct the GDI.

Table1 The indicator and criterion of degree of grassland degradation (revised on the criterion from Ma)

Degradation degree	coverage(%)	The proportion of the grassland productivity (%)	the proportion of the edible plants(%)	the height of the edible plants(cm)
ND	85-100	100	70	>25
LD	70-85	50-75	50-70	20
MD	50-70	30-50	30-50	12
HD	30-50	15-30	15-30	2
SD	<30	<15	almost 0	almost 0

Note: ND, LD, MD, HD, SD represent non-degradation, light degradation, moderate degradation, heavy degradation and severe degradation, respectively.

The weight is calculated on the basis of the decrease amplitude of each indicators. Then multiply these indicators by their weight and summation. GDI is calculated in accordance with the following formula.

GDI=(100-C)×28% + (100-P)×39% + (70-E) ×26% + (25-H)×7%

Note: C% represents coverage of the total; P% represents the proportion of the grassland productivity; E% represents the proportion of the edible plants; H (cm) represents the height of the edible plants.

According to the standard of classification, GDI of different degradation degree is given in the following table (Table 2).

Table 2 Grassland Degradation Index of different degradation degree

Gradation degree	GDI	Gradation degree	GDI
ND	<13.9	LD	13.9-33.5
MD	33.5-52.4	HD	52.4-68.4
SD	68.4-87		

Note: ND, LD, MD, HD, SD represent non-degradation, light degradation, moderate degradation, heavy degradation and severe degradation, respectively.

3.2. The case of the usage for GDI

Based on the method of calculation for GDI, we can qualify the degradation degree of alpine grassland by some visible factors. This index can solve the problem that the investigate data can not suit the criterion very well. Table 3 shows the evaluate results by using GDI for alpine grassland in Maqin Country. Form the result, in heavy degradation grassland, the dominant species are *Ligularia virgaurea,* the subdominant species are some other forbs like *Morina coulteriana, Leontopodium nanum, Frigida willd*. In moderate degradation, dominant species and subdominant species are *Ligularia virgaurea* and *Polygonum viviparum*. For light and non degradation grassland, the dominant species almost are Palatable *Polygonum macrophyllum*.

Table 3 Evaluate results by using GDI for alpine grassland in Maqin Country

Sample plots	Dominant species		Subdominant species		GDI	Degree of grassland degradation
	species	IV	species	IV		
1	Ligularia virgaurea	16.0	Morina coulteriana	11.8	61.5	Heavy degradation
2	Ligularia virgaurea	14.9	Leontopodium nanum	14.6	66.1	Heavy degradation
3	Ligularia virgaurea	16.5	Frigida willd	12.2	64.0	Heavy degradation
4	Ligularia virgaurea	26.4	Polygonum viviparum	14.1	33.7	Moderate degradation
5	Polygonum viviparum	30.2	Ligularia virgaurea	20.3	37.0	Moderate degradation
6	Ligularia virgaurea	22.8	Polygonum viviparum	21.6	43.6	Moderate degradation
7	Ligularia virgaurea	15.9	Polygonum viviparum	15.4	41.9	Moderate degradation
8	Polygonum macrophyllum	21.2	Lingua linn	11.2	29.1	Light degradation
9	Ligularia virgaurea	16.3	Polygonum macrophyllum	16.1	28.0	Light degradation
10	Polygonum macrophyllum	23.1	Ligularia virgaurea	19.0	29.1	Light degradation
11	Polygonum macrophyllum	18.3	Ligularia virgaurea	7.3	27.6	Light degradation
12	Polygonum macrophyllum	26.2	Ligularia virgaurea	12.7	1.2	Non degradation
13	Polygonum viviparum	22.9	Ligularia virgaurea	14.8	4.8	Non degradation
14	Polygonum macrophyllum	23.2	Ligularia virgaurea	14.9	4.9	Non degradation
15	Polygonum macrophyllum	21.2	Ligularia virgaurea	12.7	1.8	Non degradation

Note: IV represent important value.

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