PASTURE QUALITY INDICATORS FOR CLASSIFYING DEGRADATION LEVELS IN CACHOEIRAS DE MACACU – RJ

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Abstract
Identifying practical, low-cost indicators for diagnosing pasture degradation is crucial for the sustainability of Brazilian livestock farming. This challenge is especially relevant in humid tropical regions, such as Cachoeiras de Macacu, RJ, where extensive livestock farming occurs in hillside areas on clayey Red-Yellow Latosols. In this context, this study aimed to evaluate the effectiveness of vegetative indicators in characterizing different levels of degradation in pastures established under these edaphoclimatic conditions. The assessments were conducted in areas of Urochloa humidicola subjected to three levels of degradation (mild, moderate, and severe), previously defined by visual assessment as proposed by Spain and Gualdrón (1991). Each plot measured 500 m², with height and cover assessed at 50 points distributed throughout the plot. Biomass was assessed by cutting five samples into 0.25 m² squares arranged in a diagonal transect. Forage cover was 97.5% (N1), 76.0% (N2), and 58.5% (N3), associated with an increase in weeds and exposed soil. Pasture height decreased significantly (ANOVA, p = 0.018), ranging from 33 cm (N1) to 4 cm (N3). Biomass followed the same pattern (ANOVA, p = 0.0177), with 3,224, 1,504, and 808 kg DM/ha, respectively. Pearson's correlation showed a strong positive association between height, biomass, and cover (r = 0.94; r = 0.73) and a negative association with weeds and exposed soil (r = -0.87). We conclude that height, biomass, and soil cover are accessible and effective indicators for monitoring pasture degradation, providing valuable input for management decision-making and enabling interventions before the degradation process reaches severe stages.

Keywords: Degraded pasture; biomass; soil cover rate; pasture height; Urochloa humidicola; degradation indicators; latossol

INTRODUCTION

Livestock plays a central role in the Brazilian economy, accounting for up to 22% of the GDP in 2024 (Cepea-CNA, 2025). However, the sector faces a critical challenge: pasture degradation, which compromises productivity, sustainability, and economic viability. In Brazil, it is estimated that there are about 164 million hectares of pastures, equivalent to 19% of the national territory and 59% of the agricultural area, of which 64% show some degree of degradation, with 21% in a severe stage (LAPIG, 2022).

The recovery of these areas is essential for livestock sustainability and environmental preservation, preventing pressure on forest remnants. In this context, the identification and classification of degradation levels are strategic tools for agricultural planning, guiding recovery projects and defining priority areas for intervention (Almeida et al., 2023). The need for financial and technological resources varies according to the intensity of degradation, the timing of detection, and the extent of the affected area (Valle, 2018).

Traditionally, diagnosis on rural properties has been based on visual assessments, such as the method proposed by Spain and Gualdrón (1991). However, this procedure is subjective and depends on the evaluator's perception and experience, which may generate inconsistencies. Thus, it is essential to adopt methods based on objective, low-cost, and easy-to-apply indicators that consider soil, regional, and biome-specific conditions.

In this regard, indicators such as pasture height, ground cover, and biomass estimation emerge as promising alternatives for classifying pasture degradation levels in a practical way, reducing subjectivity. Their simplicity and economic feasibility also enable continuous monitoring, supporting adoption by smallholders and guiding more assertive decisions on management and recovery.

The results of this approach directly contribute to the Sustainable Development Goals (SDGs). They promote SDG 2 (Zero Hunger and Sustainable Agriculture) by supporting practices that increase productivity; SDG 13 (Climate Action) through mitigation of emissions and adaptation to climate change; and SDG 15 (Life on Land) by encouraging ecosystem conservation and the recovery of degraded areas.

The hypothesis is that easily measurable biophysical indicators, such as height, biomass, and soil cover, strongly correlate with visually defined levels of pasture degradation, validating them as objective diagnostic tools.

MATERIALS AND METHODS

The study was conducted at the Experimental Farm of the Fluminense Federal University (UFF) and on nearby rural properties in the municipality of Cachoeiras de Macacu, Rio de Janeiro, on mid-slope areas over a clayey Red-Yellow Latosol during the fall.

Pasture degradation levels were initially assessed visually, based on an adaptation of the method proposed by Spain & Gualdrón (1991). Areas with three visual levels of degradation were selected: mild, moderate, and severe, totaling three treatments with four replicates. All areas were standardized by landscape position and soil type and were predominantly covered by Urochloa humidicola. Level 1 (mild) was characterized by the predominance of vigorous forage; level 2 (moderate) by the significant presence of invasive plants; and level 3 (severe) by the high incidence of invasive plants and exposed soil, as indicated in the technical report by Donagemma et al. (2025).

The soil cover rate was estimated using the line-point intercept method (Donagemma et al., 2025). A 50-m string, marked every 10 m, was placed on the ground, totaling 50 observation points. After each reading, the string was moved parallel to the previous position, following the contour line, until completing ten repetitions, resulting in 50 points in ten parallel strips, corresponding to a 500 m² plot. At each point, the presence of predominant forage (FP), weeds (PD), or exposed soil (ES) was recorded. At the same points, pasture height was assessed following Donagemma et al. (2025), using the ruler method (Frame, 1981), measuring the average height of the forage leaves. In the case of weeds, the height closest to the forage was measured; in the case of exposed soil, the height was recorded as zero.

Biomass was measured according to Donagemma et al. (2025), using the square method (Mannetje, 2000) with a 0.25 m² (0.5 × 0.5 m) frame. In each 500 m² plot, five samples were collected along a diagonal transect drawn across the entire experimental area, ensuring that the sampling points representatively covered the plot rectangle. The forage was cut at ground level with a serrated sickle, weighed fresh, oven-dried at 65 °C to constant weight (24–72 h), cooled in a desiccator, and weighed again to determine dry weight.

Data were subjected to the Shapiro-Wilk normality test, followed by ANOVA and Tukey's test (5%). Pearson's correlation analysis was also performed. Statistical analyses were performed in R software (version 4.2.1), using the RStudio environment (R CORE TEAM, 2022).

RESULTS AND DISCUSSION

The evaluation of soil and pasture quality indicators revealed a clear distinction between levels of pasture

degradation, validating the effectiveness of simple measurements as a diagnostic tool. The soil cover rate varied significantly between treatments (Figure 1).

Figure 1. Coverage Rate - Rope (%) at different levels of pasture management in Cachoeiras de Macacu, RJ. The bars represent the treatment averages. Capital letters compare management levels within each cover type, while lowercase letters compare different types of cover within each management level (p < 0.05).
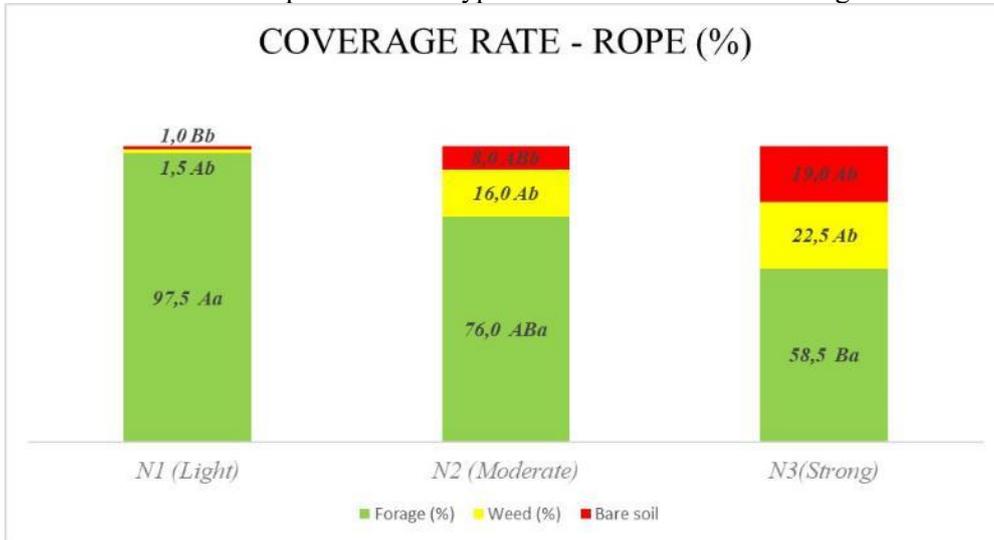
At the mild degradation level (N1), forage showed almost complete dominance (97.5%), with minimal participation of invasive plants (1.5%) and exposed soil (1.0%). In contrast, at the severe level (N3), forage cover was drastically reduced to 58.5%, while the presence of invasive plants and exposed soil increased to 22.5% and 19.0%, respectively. This transition in botanical composition represents the loss of resilience and competitive capacity of forage, a degradation process well documented in tropical pastures (Almeida et al., 2023). The increase in the area of exposed soil is particularly critical, as it increases the risk of erosion and nutrient loss, in addition to creating ecological niches favorable to the establishment of invasive species, which are better adapted to conditions of low fertility and compaction (Valle, 2018), thus establishing a vicious cycle of degradation.

The vertical structure of the forage canopy was also a sensitive indicator of the degradation process (Figure 2).

Figure 2. Pature height (cm) at different levels of pasture management in Cachoeiras de Macacu – RJ. Means followed by the same letter do not differ statistically by the multiple comparison test (p < 0.05).
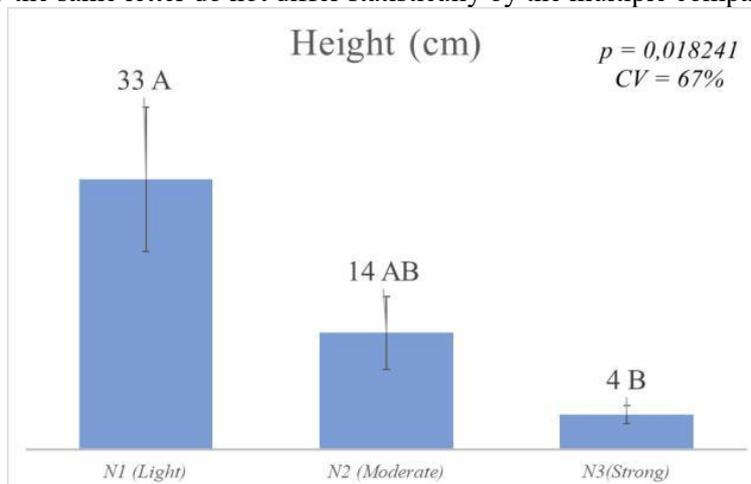
The average sward height was significantly influenced (ANOVA, p = 0.018), decreasing from 33 cm at level N1 to only 4 cm at level N3. The intermediate treatment (N2), at 14 cm, did not differ statistically from the extremes, characterizing its transitional position. Sward height is a direct reflection of management intensity and plant physiological condition (Frame, 1981). The drastic reduction observed at N3 suggests an overgrazing

scenario, where the forage does not have enough time to recover its leaf area and replenish its energy reserves, leading to plant exhaustion. A low canopy severely limits the interception of solar radiation, reducing photosynthetic capacity and, consequently, biomass accumulation. As a direct result of the deterioration of pasture cover and structure, biomass production was significantly affected by the level of degradation (ANOVA, $p = 0.0177$), as illustrated in Figure 3.

Figure 3. Biomass (kg DM/ha) at different levels of pasture management in Cachoeiras de Macacu, RJ. Means followed by the same letter do not differ statistically according to the multiple comparison test ($p < 0.05$).
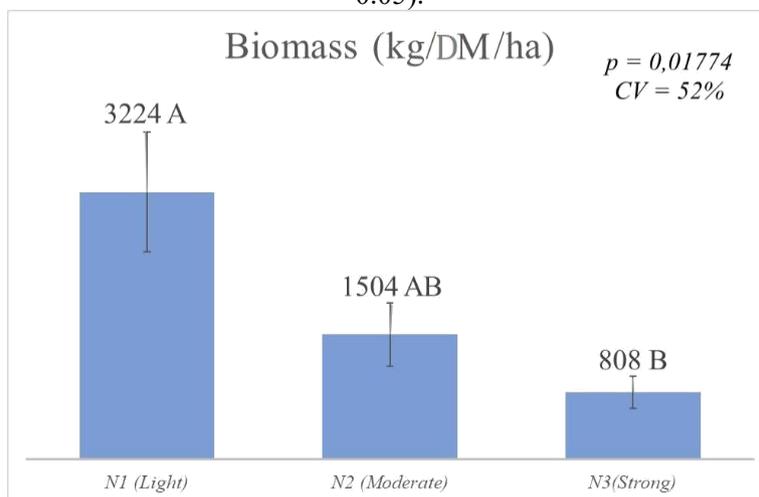
Pastures with mild degradation (N1) produced 3,224 kg DM/ha, a value statistically higher than the 808 kg DM/ha produced under severe conditions (N3). This approximately 75% drop in forage availability represents a severe impact on the area's carrying capacity and the economic viability of livestock farming. Although data variability was high (CV = 52%), which is common in field studies due to the spatial heterogeneity of pastures (Mannetje, 2000), the robust difference between extreme stages confirms the diagnostic power of biomass as an indicator of pasture production status.

Correlation analysis (Figure 4) mathematically confirmed the strong interdependence between the evaluated indicators.

Figure 4. Pearson correlation matrix between height, biomass, bare soil, forage, and weed at different levels of pasture management in Cachoeiras de Macacu, RJ.
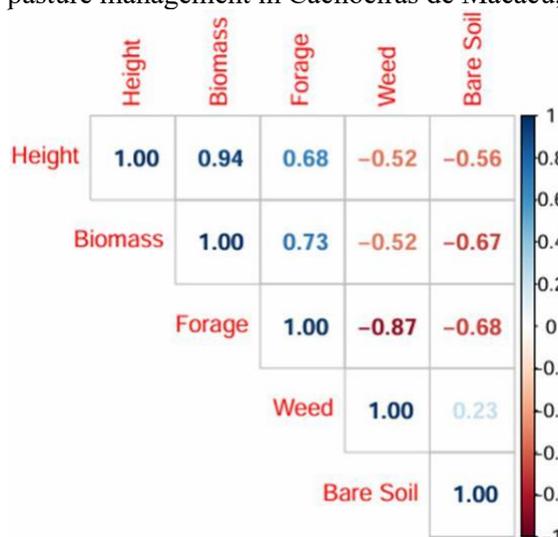
Pasture height showed a very strong positive correlation with biomass ($r = 0.94$), demonstrating that vertical canopy structure is a key driver of productivity. Similarly, forage cover correlated positively with production ($r = 0.73$) and negatively with the presence of invasive plants ($r = -0.87$), quantifying the intense competitive relationship for resources. These correlations demonstrate that the indicators do not act in isolation, but rather

as components of an integrated system.

Degradation, therefore, can be understood as a cascade of events, where reduced pasture height and cover lead to decreased biomass production and the dominance of less desirable species, validating this set of indicators as a cohesive and effective tool for monitoring pasture health.

FNAL CONSIDERATIONS

This study validated a set of low-cost and easily measurable biophysical indicators for the diagnosis of pasture degradation in Oxisols. It is concluded that canopy height, biomass production, and the cover rates of forage, invasive plants, and exposed soil are, together, a robust and sensitive toolkit for characterizing pasture health. The strong correlation between these variables confirms that they are not just isolated indicators, but part of an interconnected system that reflects the degradation process. The main practical implication of this work is the provision of an objective method that allows farmers and technicians to make faster and more assertive management decisions, enabling corrective interventions before degradation reaches severe and more costly stages of recovery. The validation of these indicators in other seasons and with different forage species is suggested to broaden their applicability.

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