Technical Notes:

The Relationship of Stocking Intensity and Stocking Pressure to Other Stocking Variables

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Abstract

Stocking intensity and stocking pressure have been defined and used as technical stocking variables describing animals on pasture. Relationships between these variables and stocking variables such as stocking density and stocking rate are discussed. One conclusion is that stocking intensity and stocking pressure are not informationally unique variables, but are equivalent to stocking variables defined in other work. Retention of the terms *stocking intensity* and *stocking pressure* is recommended for nontechnical use in describing livestock grazing.

Quantifying animals on pasture requires descriptive stocking variables such as stocking density and stocking rate. To date there has been little uniformity in the use of these variables among individuals or among countries conducting grazing research. Scarnecchia and Kothmann (1982) presented a time-dynamic description of stocking variables derivable from the basic variables of animal demand, forage quantity, land area, and time (Table 1). Missing from this description were 2 variables, stocking intensity and stocking presure, which have been discussed in previous works by other investigators (Voisin 1959, Booysen 1966, Society for Range Management 1974). Analyses of these 2 variables are offered here and their relationships to other stocking variables are discussed.

Stocking Intensity

Stocking intensity is described as a technical variable by Booysen (1966). The earliest description of stocking intensity discovered was that of Voisin (1959), who, in an effort to develop a single variable combining both the degree of animal concentration and the period of grazing, proposed the term *grazing intensity*. Calculation of grazing intensity over a discrete period of time involved multiplying a mean stocking density (SD) for that period of time (Table 1) (e.g., in animal-units (AU) per hectare) by the period of grazing. This product describes what has since been defined by the Society for Range Management (1974) and Scarnecchia and Kothmann (1982) as the *stocking rate*, with units of animal-unit-days per hectare (AUD/ha) or animal-unit-months per hectare (AUM/ha) (Table 1).

Booysen (1966) proposed that the technical term *stocking intensity* be obtained by *dividing* a mean stocking density (AU/ha) for a discrete period of grazing by the length of that period of grazing. Using this definition, stocking intensity had units of AU/ha-day and appeared to differentiate between situations in which the stocking rates were identical but were derived from different combinations of mean stocking densities and grazing periods. For example, if pasture A had a mean stocking density (Scarnecchia and Kothmann 1982) of 20 AU/ha for a grazing period of 2 days, and pasture B had a mean stocking density of 10 AU/ha for a grazing period of 4 days, both pastures had stocking rates of 40 AUD/ha. For pasture A, the stocking intensity (as defined above) was 20 AU/ha ÷ 2 days = 10 AU/ha-day, while the stocking intensity in pasture B was 10 AU/ha ÷ 4 days = 2.5 AU/ha-day. Although stocking intensity apparently differentiates between the 2 situations described here, further analysis of the variable produces interesting results.

For a given mean stocking density (AU/ha, Table 1), as the grazing period *increases* the stocking intensity as defined here *decreases*. In fact, in either of the examples above, if livestock were allowed to graze forever (grazing time → infinity) the stocking intensity would approach zero. This apparent mathematical anomaly reveals the true identity of stocking intensity. Note that the typical unit of stocking intensity is AU/ha-day, which is the same unit used to describe the rate of change in the stocking density (RCSD) (Table 1). RCSD is derived (Scarnecchia and Kothmann 1982) by differentiating the stocking density with respect to time. Over a discrete period of time, mean RCSD is derived by calculating its differences over a period of time, Δt. Mean RCSD and stocking intensity are derived over a discrete period of time from the same basic variables and have the same units. Any time a stocking intensity is calculated from a mean stocking density, it *always* is equal to the mean RCSD needed to increase stocking density from 0 to that mean stocking density. For example, in

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Table 1. Summary of stocking variables derived from basic variables of animal demand, forage quantity, pasture area, and time. 1 AU = 1 animal-unit = 12 kg forage dry matter/day in animal demand. Adapted from Scarnecchia and Kothmann (1982).

Animal/Area	Animal/Forage	Forage/Animal
Stocking Rate $= \int_{t_0}^{t}$ stocking density • dt Units: AUD/ha AUM/ha	Grazing Pressure Index $= \int_{t_0}^{t}$ grazing pressure • dt Units: Ratio of animal demand to forage over a period of time	Cumulative Herbage Allowance $= \int_{t_0}^{t}$ herbage allowance • dt Units: kg - days/AU ton - months/AU
Stocking Density = animal demand per unit area at any instant Units: AU/ha	Grazing Pressure = animal demand per unit weight of forage at any instant. Units: AU/kg AU/ton	Herbage Allowance = weight of forage per unit animal demand at = any instant Units: kg/AU ton/AU
Rate of Change in Stocking Density $= \frac{d(\text{stocking density})}{dt}$ Units: AU/ha-day AU/ha-hr	Rate of Change in Grazing Pressure $= \frac{d(\text{grazing pressure})}{dt}$ Units: AU/kg-day AU/kg-hr	Rate of Change in Herbage Allowance $= \frac{d(\text{herbage allowance})}{dt}$ Units: kg/AU-day kg/AU-hr

pasture A in the example above, the value (10 AU/ha-day) of the stocking intensity as defined by Booysen is actually the mean RCSD (Scarnecchia and Kothmann 1982) needed over the grazing period (2 days) to achieve a stocking density of 20 AU/ha at the end of 2 days. Similarly, for pasture B, 2.5 AU/ha-day is the mean RCSD needed to achieve a stocking density of 10 AU/ha at the end of the 4-day grazing period. Thus, the stocking intensity as defined by Booysen (expressed in AU/ha-day) is not a unique variable combining stocking density and duration of grazing, but is equivalent to a mean RCSD needed to achieve a given stocking density from SD=0. The continuous and discrete forms of stocking rate, stocking density, and RCSD appear to completely summarize the physically meaningful stocking variables among the basic variables of animal demand, land area, and time. Any *ad hoc* variables produced by combining the basic variables by common mathematical operations (multiplication, division, integration, differentiation, etc.) should be equivalent to either the continuous or discrete forms of one of these three stocking variables.

Stocking Pressure

Stocking pressure has been defined by the Society for Range Management (1974) as the weight of forage allocated per animal-unit for a relatively short grazing period of specified length. Herbage allowance has been defined (Scarnecchia and Kothmann 1982) as the weight of forage per animal-unit at any instant (Table 1). Since herbage allowance is defined only instantaneously, the mean value of the weight of forage/animal-unit relationship over any discrete time period is the mean herbage allowance for that period. Stocking pressure, as defined by Booysen (1966) and the Society for Range Management (1974), corresponds to a mean herbage allowance, i.e., an herbage allowance for a discrete time interval. Thus stocking pressure, like stocking intensity, is not a distinct technical variable, and is equivalent to another variable, in this case mean herbage allowance.

Conclusions

Based on the foregoing discussions, the terms *stocking pressure* and *stocking intensity* should be excluded from technical use as technical variables, but retained for nontechnical use to refer in a general way to the degree of grazing by livestock. Both terms are descriptive and useful in that capacity.

Also, common mathematical operations (multiplication, division, integration, differentiation, etc.) on the basic variables of animal demand, forage quantity, land area, and time have yet to yield new physically meaningful stocking variables other than the continuous and discrete forms of those already listed (Table 1). Future efforts should focus instead on the correct technical use of these variables in research and management, and on establishing quantitative relationships between these stocking variables and other variables in range management and livestock production.

Literature Cited

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