THE GRAZING MANAGER: A NEW APPLICATION OF THE CARRYING CAPACITY CONCEPT

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ABSTRACT
Common approaches to evaluating carrying capacity are stocking rate trials for research and trial and error adjustments for ranchers. These approaches are inadequate as operational decision guides for grazing management. The Grazing Manager (TGM) is a generalized management level dynamic model that provides a new approach to stocking rate analysis. Grazing pressure is integrated over time with a function called pasture demand ratio (PDR) which is based on cumulative forage demand relative to cumulative forage production within a forage year. PDR is a dynamic variable that standardizes the forage balance relationship and makes the analysis of stocking rate data more understandable and transferable to other locations. TGM is also highly effective for determining average and current year's carrying capacity (CC) for individual paddocks and for predicting outcome of grazing management plans.

KEYWORDS
Simulation model, grazing management, stocking rate, grazing pressure, adaptive management

INTRODUCTION

Grazing managers, both ranchers and researchers, must analyze forage balance data to determine optimal stocking rates. Traditional approaches to analyzing forage balance generally use averages across years and do not explicitly consider either forage (stocking rate) or time (grazing pressure) (Harlan, 1958; Mott, 1961; Riewe, 1961; Cowlishaw, 1969; Hart, 1972, 198; Edwards, 1981; Wilson et al., 1984; Gudmundsson and Bement, 1986; Heitschmidt and Taylor, 1991). Eyles et al., (1956) stated, 'In grazing trials the rates of stocking depend on the experimenter's assessment of CC from time to time, and unless these rates of stocking all bear the same relation to the pasture available, the results will not reflect the proper relative values of the treatments under investigation.' The optimal stocking rate must be determined for each paddock each year, since it depends upon the objective function selected by the manager (Behnke and Scoones, 1992) and climatic fluctuations will affect seasonal and annual forage production. A major limitation has been the inability of managers to adequately monitor forage production and availability and to relate forage values to animal production and carrying capacity. Because grazing management is a dynamic process, it cannot be analyzed adequately by empirical static models. TGM is a simple model which simulates temporal dynamics of forage balance. The objectives for this paper are to describe TGM and explain how it can be used in grazing management research and practice.

MATERIALS AND METHODS

Managers must develop effective grazing plans to meet specific economic, vegetation and animal management objectives. The Grazing Manager (software may be purchased from the authors at the address above) analyzes forage balance and provides support for grazing management decisions (Kothmann and Hinnant, 1994). It is a demand-side model that operates at the paddock and herd levels with monthly time steps. Both forage production and demand are expressed in the same units, demand days (DD). Criteria for model development were to: incorporate adaptive management techniques at a level of resolution appropriate for grazing management, use a minimum number of variables, imbed no site specific functions or equations that limit model applicability, make it suitable for ranchers with limited time and technical skill to readily obtain input data, calibrate, and validate it. The model is based on six parameters: (1) cumulative forage year (CFY), (2) total demand days produced (TDD), (3) seasonality of forage growth, (4) monthly adjustment to forage growth (MAF), (5) animal demand days, and (6) pasture demand ratio (PDR).

The manager estimates each parameter for each pasture. The cumulative forage year represents the annual cycle of forage production and utilization. It begins with the first month that production normally exceeds demand and excess production can be carried forward for later consumption. Total demand days represent the number of demand days that can be obtained from the paddock if it is completely utilized in an average year. Seasonality of forage growth is used to allocate production of demand days to months for a normal year and MAF is used to adjust normal monthly production to reflect the current year's production. Animal demand is converted to demand days with a user defined demand day equivalent (number X demand day equivalent X days = demand days). A PDR value (6 X cumulative demand days grazed / cumulative demand days produced = PDR) is calculated monthly by TGM. A monthly value for PDR is estimated visually using a descriptive guide to rate the level of pasture use on a scale of 0-6 (Fig. 1). TGM is validated by comparing monthly PDR values. If the calculated values do not match the field estimated values, TDD and/or seasonality are adjusted to obtain a fit. The new parameter estimates are tested during the next year. Thus, the model provides a mechanism for grazing managers to formulate and test hypotheses.

RESULTS AND DISCUSSION

Commercial ranches across Texas and in Oregon and Utah and experimental ranches at Sonora, Barnhart and Vernon, Texas have tested TGM for planning and monitoring grazing management. Continuous use of the model at numerous locations since 1988 has provided a thorough understanding of the capabilities and limitations of TGM.

TGM begins with entry of basic resource data for each paddock and calculates the projected DD produced per month and cumulative DD for the forage year. The second step is to enter the grazing plan for the forage year. This consists of assigning numbers of animals, animal demand equivalents, and dates of stocking for each grazing period within a paddock. TGM calculates the monthly and cumulative DD of grazing, subtracts DD provided from hay and supplemental feed, and analyzes forage balance for each pasture (Fig. 2). The third step is to modify forage production and grazing to represent current year's conditions by monthly monitoring of forage growth, pasture demand ratio, and adjustments to the grazing plan. The final step is verification of input data and, if necessary, calibration of TDD and seasonality parameters based on comparison of computer generated and visually estimated PDR values. TGM facilitates monitoring and forecasting forage production in relation to projected demand so that livestock numbers and grazing plans can be adjusted early to prevent forage shortages or loss of excess production.

PDR is a dynamic variable that is similar to Hart's (1972) grazing pressure (D/F), but both D and F are expressed in the same units which makes PDR more useful. Hart found in all cases that D/F gave a better relationship to ADG than herbage allowance (F/D) which was non-linear. Hart called for much more research measuring more variables. Harlan (1958) described stocking rate in terms of light, moderate and heavy and assigned constant numeric values to these classes for analysis. He fitted animal production data from several studies to a negative double exponential function and concluded that this was a generally applicable response curve. He noted the difficulty in finding data at rates beyond heavy stocking. His model predicted negative weight gains at one increment above heavy stocking and he noted that researchers are reluctant to graze at such high stocking rates. At heavy stocking rates, extra feed was required or trials were terminated because of lack of forage during dry years.

Regression analyses of animal production/stocking rate data generally extrapolate the relationship beyond the highest stocking rate reported to the point of zero gain (Harlan, 1958; Mott, 1961; Wilson et al., 1984; Hart, 1986; Heitschmidt and Taylor, 1991). Our results with field tests of TGM support Harlan's observations that data do not exist at these very high stocking rates because no reasonable manager will keep animals on pasture at these rates. A PDR of 6 represents the upper limit of stocking rate and production responses should not be extrapolated beyond this point. TGM provides an effective method for analyzing forage balance and determining where the current and projected stocking rates fall on a standardized response curve defined by a range of PDR values from 0-6. TGM is a tool that managers can use on their property to analyze stocking rates and grazing plans with model parameters they have calibrated and validated for their individual paddocks.

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Figure 1
A guide to visual appraisal of the PDR based on cumulative grazing use of the top, middle, and bottom thirds of the cumulative forage produced during a CFY. Top middle, and bottom refer to preference for plant part and species by the grazing animal.

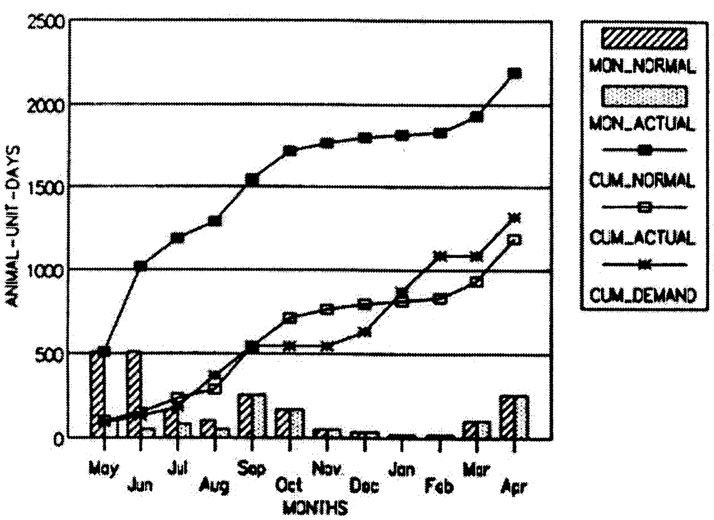

Figure 2
Analysis of normal and adjusted monthly and cumulative DD, and the cumulative grazing demand for the Cabin pasture. The original grazing plan was adjusted to reduce animal demand in response to adjustments for drought conditions during May-August.

Rating	Top 1/3	Middle 1/3	Bottom 1/3
0	Negligible	None	None
1	Light	Negligible	None
2	Moderate	Light	Negligible
3	Heavy	Moderate	Light
4	Severe	Heavy	Moderate
5	Severe	Severe	Heavy
6	Severe	Severe	Severe