ID NO. 1387

APPLICATION OF THE PHYGROW FORAGE PRODUCTION-RUNOFF MODEL FOR REGIONAL STOCKING ANALYSIS

J.W. Stuth, J.R. Conner, W.T. Hamilton and D.M. Schmitt

Ranching Systems Group, Department of Rangeland Ecology and Management, Texas A&M University, College Station, Texas 77843-2126 USA

ABSTRACT

A hydrologic-based forage production model, PHYGROW, was used to simulate forage production and carrying capacity of a subtropical shrubland complex of over 34 species grazed by various ratios of cattle and goats with a population of indigenous white-tailed deer over a 20-yr simulated weather profile. The diet selection algorithm allowed the three animal populations to selectively graze preferred foods based on preferences of plant species, plant parts, and live:dead status by phenological stage. A level of maximum utilization of key species was specified. An incremental analysis of cattle:goat demand ratio was analyzed to determine how different combinations of livestock were impacted by variation in weather. Goats were less sensitive to rainfall variation with a greater frequency of severe reductions in numbers of cattle.

KEYWORDS

cattle, goats, rangeland, modeling, stocking rate, grazing, diet selection

INTRODUCTION

The current set of simulation models addressing plant growth and hydrologic processes on rangelands can only represent one to seven categories of plants in a community. The cap on species categories has restricted application of these models for analyzing complex forage conditions where issues of mixed animal populations are involved. Primary issues of concern are: 1) representation of an adequate number of species and functional groups of species to capture selective behavior of a diverse animal population, 2) characterization of preference by phenological stage of the species/functional groups and 3) representation of forage and diet selection response in relation to variation in climatic conditions.

In order to address this challenge, the PHYGROW simulation model was developed to provide resource analysts a tool to determine how variations in landscapes, animal populations (composition, demand and timing) and weather impact carrying capacity, hydrology and stability of forage production (RSG 1995). The purpose of this paper is to provide an overview of the PHYGROW model and an example of how it can be used to analyze variation in stocking of representative landscapes in a region to determine impact of weather variation on stocking rates of mixed animal populations.

METHODS

Data were assembled for a typical landscape comprised of 30% clay loam and 70% sandy loam range sites in the subtropical shrubland regions of South Texas. Thirty eight critical plant species or functional groups were identified in the region. Experts provided growth, preference and hydrological attributes of each species/functional group. Vegetation surveys of the La Copita Research Area near Alice, Texas were used as a basis to determine deWitt relative yield values for each species/functional group for modal plant communities in the region. Relative yield values are the proportion (%) of full potential site occupancy of a single species or functional group in a plant community. Soil layer characteristics of modal soils typical of each range site were assigned based on predominate acreage available in soil surveys of the region. The Falfurris, Texas weather station located approximately 50 km south of the research center was used to create a long-term historical data set to develop weather generator parameters. These were then geographically adjusted for elevation, annual precipitation deviation and longitude/latitude at the La Copita Research Area.

The soil layer characteristics, surface features, species/functional group, plant community relative yield and weather generation parameters were entered into PHYGROW's netCDF databases. PHYGROW is an object oriented model capable of running on a wide array of UNIX platforms. The model is written in C++, with a tk/tcl graphical user interface. PHYGROW retains accumulation files which serve as repositories of all intermediate values generated in the analysis. These record bases allow PHYGROW to link to other models and GIS via object data managers.

PHYGROW simulates daily forage growth, senescence and turnover by species, leaf:stem and live:dead in response to weather and animal selectivity. The user establishes an initial condition for soil moisture, forage standing crop by species, schedule of demand and increment of analysis of livestock demand (eg. 10% changes in cattle:goat ratios). For each daily time step, forage growth (leaf and stem) is determined by modeled soil moisture by layer relative to root distribution, average daily temperature relative to the plants effective temperature range, leaf area index, energy:biomass ratio, heat units to seed formation/death. Standing crop is also impacted by leaf and stem transfer rates of green to dead and dead turnover rates. Plant-related hydrology parameters impact water balance of the site including leaf/stem water surface storage capacity and leaf:stem water transfer ratio. These parameters allow computation of interception loss and stemflow of incoming precipitation.

A demand scheduler (number head times dry matter intake for days(x)) is imposed on the landscape, either as point information of an aggregated landscape (eg. single grid) or across a landscape if gridded GIS datasets are available. A newly developed RLUM-Ruminant Landscape Use module was not used in this study but can provide a physio-behavioral based analysis of livestock movement considering spatial arrangement of plant communities, water, and terrain. Animals selectively graze the site(s) using algorithms developed by Quirk and Stuth (1995). Descriptions of the modeling components can be found at the following URL on the World Wide Web:

OVERALL	---	http://ranch.tamu.edu/rsg
PHYGROW	---	http://ranch.tamu.edu/rsg/phygrow
RLUM	---	http://ranch.tamu.edu/~erickson/rumlum.html
netCDF	---	http://www.unidata.ucar.edu/packages/netcdf

RESULTS AND DISCUSSION

Two cattle:goat ratios were selected based on trends in the region for expanding meat goat populations, 70:30 and 50:50. Although daily information of forage growth, species selection, and soil moisture were available, only annual production and consumption data were used in this analysis.

The 70:30 and 50:50 ratios yielded cattle stocking rates of 1.48 and 1.13 AUM/ha, respectively. The standard deviation of stocking was 0.72 and 0.54 AUM/ha, respectively for cattle. Goat stocking rates and standard deviations for the 70:30 and 50:50 ratios were 0.119 (SD=.06) and 0.185(SD=.09), respectively.

After running the 20-yr analysis of the 70% cattle and 30% goat demand ratio, there were 9 “normal” stocking years for goats and 7 for cattle (Figure 1). Normal years are considered to be those that have less than 20% deviation of the long-term average stocking rate of a 20-yr simulation. Below normal stocking years (-20 to -50%) for cattle and goats comprised 25% of the years. Cattle would experience a higher percent of extremely low stocking years than goats, 15% vs. 10%. Ten percent of the years experienced stocking rates greater than 50% above normal stocking level. Analysis of the 50:50 ratio resulted in similar trends. These data support the observation that a higher ratio of goats to cattle stabilize annual variation in stocking as ecological conditions shift from a grassland domain to a shrubland domain and climatic conditions become drier.

REFERENCES

Quirk, M.F. and J.W. Stuth. 1995. Preference-based algorithms for predicting herbivore diet composition. Ann. Zootech. 44, Suppl. p. 110.

Ranching Systems Group (RSG). 1995. PHYGROW-An object oriented hydrologic based, multispecies forage production model. Ranching Systems Group Document 95-1. Department of Rangeland Ecology and Management, Texas A&M University, College Station.

Figure 1
Simulated annual deviation from a 20-yr average stocking rate of a mixed livestock population of 70% cattle and 30% meat-type goats with a resident herd of white-tailed deer (4.86 ha/head).