The Rangeland Vegetation Simulator: A User-Driven System for Quantifying Production, Succession, Disturbance and Fuels in Non-Forest Environments

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Introduction

Rangeland landscapes occupy roughly 662 million acres in the coterminous U.S. (Reeves and Mitchell 2011) and their vegetation responds quickly to climate and management, with high relative growth rates and inter-annual variability. Current national decision support systems in the U.S. such as the Interagency Fuels Treatment Decision Support System (IFT-DSS) require spatially explicit information describing production, fuels, grazing capacity and successional trajectory. However, no single system presently offers this information. In addition, issues of increasing national attention, such as preservation of lekking birds (e.g. greater sagegrouse (*Centrocercus urophasianus*), and greater prairie chicken (*Tympanuchus cupido*)), has prompted new management guidelines such as stubble height standards, but ecological tools for predicting this type of management outcome on rangelands are quite limited in their ability to predict these variables. Therefore a system is needed that quantifies these vegetation and fuel characteristics in sufficient detail to permit estimations of annual production, treatment success, grazing capacity, and fire behavior and effects. This situation inspired our project to develop a comprehensive program for simulating succession, productivity, and fuels in non-forest environments. This system is called the Rangeland Vegetation Simulator (RVS).

Materials and Methods

The RVS is a multithreaded, portable program written in C#. It also operates in a spatially explicit mode using a series of Python scripts through ArcGIS 10.X. A minimum of six inputs is required for simulating forage and fuels with the RVS (Table 1). The geospatial location is especially critical since it enables sampling of either the Biophysical Settings (BPS) geospatial data product (Rollins 2009) and their associated successional models, or state – transition models from Ecological Sites (Caudle et al. 2013) Growth and production of herbaceous species is governed by the site for which the simulation is being conducted, annual precipitation, and Normalized Difference Vegetation Index (NDVI) (Table 1). Growth and production of shrubs is controlled by allometric relationships and the site on which the shrubs are found. In a similar manner, quantifying fuel loadings of various fuel size classes is also accomplished using allometric equations for shrubs. For example, using height, cover, and species information, the loading of 0.64, 0.64 - 2.54, 2.54 - 7.62 and 7.62 - 20.32 cm. fuel size classes can be estimated using these equations. The RVS offers 46 allometric equations for quantifying and mapping biomass, production and fuels across the landscape. These fuel and production estimates are also influenced by management treatments including mechanical thinning, wildfire and herbivory. The RVS permits user-designed shrub overstory reduction as a treatment option and offers simulation of wildfire effects on shrub mortality and accompanying herbaceous response. Likewise the RVS simulates the effects of herbivory by both grazers and intermediate species (e.g. cattle vs. goats) on standing crop, stubble height, successional trajectory, shrub stature and associated fuel bed components.

Table 1. Minimal inputs needed to run RVS.

Data element	Use
Latitude and longitude	Enables sampling of 9 geospatial data layers
Vegetation composition	Ecological Site, production and fuels
Vegetation structure	Ecological Site State and Phase, production and fuels
Treatment & length	Treatments (Herbivory, Mechanical, Fire), length of simulation
Estimated climate	Spatially explicit climate and growing conditions

Results and Discussion

The RVS has a rich set of outputs for quantifying carrying capacity, fuels, fire behavior, and successional trajectories. The list of major summarized outputs is found in Table 2. Each of these outputs can be available in tabular or as a spatially explicit map.

Table 2. Simulation output resulting from climate, and proposed treatment (both pre and post treatment estimates available).

Outputs	Units
Species composition	% by species
Shrub density	Stems ha^{-1}
Shrub cover	%
Herbaceous cover	%
Herbaceous height	meters
Standing dead herbaceous	kg ha^{-1}
Shrub height	meters
Stubble height	meters
Fuel loading by size	kg ha^{-1} (0-0.64, 0.64-2.5, 2.5-7.6, 7.6-20 cm)
Surface Fire Behavior Fuel Model and Fuel Loading Model	Unitless
Succession class / state	Unitless
Annual production (for both herbs and shrubs)	kg ha^{-1}
Standing crop	(Live + dead herbaceous)
Utilization	[from herbivory] % (kg ha^{-1})

Conclusions and Implications

The RVS offers projections of future vegetation conditions thereby improving our ability to estimate the effects of management actions on future fuels, productivity and grazing capacity across 128 rangeland systems. The model is presently being used and tested across a variety of projects nationally including, 1) estimating sequestered carbon in shrubs, 2) 2015 fuel maps for more precise emission estimates, 3) Setting stocking rates across California and New Mexico (U.S.) rangelands, 4) development of a decision support system supporting stubble height requirements and estimates for sage grouse guidelines.

References

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