Brush Dynamics in South Texas Rangelands under Four Climate Scenarios

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Objective

The objective is to project brush and grass dynamics on a South Texas refuge in response to different grazing and brush control schemes under different climate change scenarios using systems modeling.

Introduction

Dryland rangelands support approximately 50% of the livestock globally, however, 10-20% of dryland has already been degraded (Millennium Ecosystem Assessment 2005). Rangeland ecosystems and the people they support are highly vulnerable to climate change, and past climate is likely to become an increasingly poor predictor of the future. Thus, management responses adapted to existing climatic variability likely will not lead to sustainable ecosystems and livelihoods. A diversity of proactive management options will be required to enhance ecological and social resilience of rangelands (Ash et al. 2012). Ecological simulation models that can be updated with new knowledge to explore potential consequences of future environmental variability are key tools for overcoming challenges to rangeland management as it adapts to global change (Bestelmeyer & Briske 2012). Additionally, simulation modeling has been identified as an important component to adaptive protocols in grazing management research that provides a way to understand the processes of nature and to monitor and assess ecosystem responses to management (Kothmann et al. 2009). In particular, modeling rangelands as a complex adaptive system can aid in the evaluation of management schemes (Wang et al. 2020). Therefore, the objective is to project brush and grass dynamics on a South Texas refuge in response to different grazing and brush control schemes under different climate change scenarios using systems modeling.

Overview of the Model

This conceptual model was created in STELLA Professional 2.1.1 and is composed of two submodels, one for brush and the other for grass. The time unit chosen for the simulation is months because it captures the seasonal changes in temperature, precipitation, grazing, and burning. The driving variables will be temperature and precipitation and their climate scenario will be controlled using a switch. The switch will allow the user to change between four different climate scenarios, and one historical climate. The four future scenarios come from WorldClim Bioclimatic variables, and include the shared socio-economic pathways (SSP): SSP 126, SSP 245, SSP 370, and SSP 585. The grazing management options will include varying schemes of rotational cattle grazing, such as the high intensity-low frequency system (HILF) as well as a continual grazing system for comparison. Prescribed burning schemes can include a late winter/early spring burning schedule among others. The max growth rates for grass and brush will be dependent on temperature and precipitation. In addition, the brush and grass cover will have a positive feedback loop as shown by the growth rate adjustment variable for both grass and brush. The shading effect of the canopy cover of brush slows the growth of grass, and the lack of fine fuel (i.e., the lack of grass) reduces fire intensity, and hence reduces the impact of fire on brush canopy cover. Of course, grazing reduces the amount of grass.

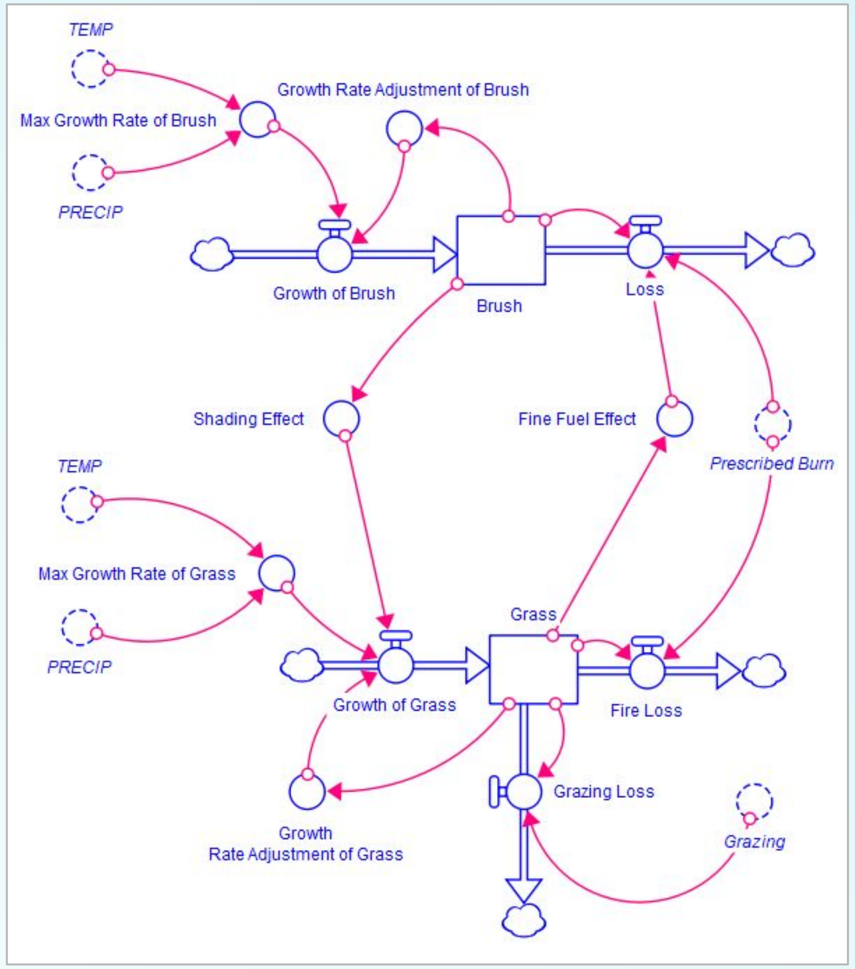

Figure 1. Model diagram of brush and grass dynamics on a South Texas refuge.

Next Steps and Expected Results

Now that the conceptual model of the system-of-interest has been developed, the next step will be to quantify and document the variables. Then, the model will be evaluated for usefulness in meeting the objective using a sensitivity analysis. The expected results should show an increasing trend in brush with increasing temperatures and precipitation which slows grass growth due to shading. Therefore, the lack of fine fuel reduces fire intensity and reduces the impact of fire on canopy cover. The expected feedbacks would be the key processes affecting brush encroachment.

Model Application

My proposed model could be adopted and used by South Texas rangeland managers to explore potential consequences of future environmental variability and overcome challenges in adapting to global change while helping build flexibility into rangeland management plans. A limitation in the model when trying to deal with climate scenarios, is that while it accounts for a changing temperature and precipitation, it does not account for the expected increase in extreme weather events. For example, the constant rainfall overtime would look the same in the model as rare, extreme precipitation events which would not reflect reality. Moreover, grazing management that utilizes goat, sheep, or a mix should be added in the future.

References

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