Synthesizing Rangeland Processes for Decision-Making using the GPFARM-Range Model

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Rationale

A modeling approach that assesses impacts of alternative management decisions prior to field implementation would reduce decision-making risk for rangeland and livestock production system managers. The Great Plains Framework for Agricultural Resource Management – Rangeland model (GPFARM-Range; Andales et al., 2005) was developed as a decision support tool that synthesizes field-scale hydrology, forage, carbon-nitrogen (Qi et al., 2012), and cattle processes. The GPFARM-Range model can be used to guide stocking rate decisions, project short-term variability of forage, and estimate impacts of climate variability on rangeland production.

Objective

Develop and apply the GPFARM-Range model to quantify management and climatic effects on rangeland and livestock production systems.

GPFARM-Range model

Simulates the effects of climate, management, and soil on field-scale forage production (5 functional groups: warm season grasses, cool season grasses, legumes, shrubs, forbs) and cattle weight gains on a daily time step (Figure 1).

\textbf{Inputs:} daily weather (solar radiation, air temperature, relative humidity, wind speed; rainfall); soil properties; forage growth parameters; relative proportion of each functional group in the plant community; cattle growth parameters; stocking rate (heads ha\textsuperscript{-1}); soil carbon and nitrogen parameters; CO\textsubscript{2} concentration in air

\textbf{Outputs (daily):} above-ground and root biomass (kg d.m. ha\textsuperscript{-1}) by functional group; cattle mass (kg head\textsuperscript{-1}); soil profile water content (cm\textsuperscript{3} cm\textsuperscript{-3}); soil organic carbon (kg ha\textsuperscript{-1}); total soil organic nitrogen (kg ha\textsuperscript{-1})

Example model applications

- Strategic (long-term) and tactical (in-season) prediction of forage production (Andales et al., 2006; Figure 2). The index of agreement (d) between simulated and observed forage biomass ranged from 77\% to 94\%. Predictions of forage availability can help managers choose the appropriate cattle stocking rate.

- Simulating effects of different stocking rates (steer ha\textsuperscript{-1}) on peak standing crop (PSC) and steer weight gain (Fang et al., 2014; Figure 3). The cumulative probability charts at different stocking rates can also help managers select the correct stocking rate that will maximize weight gains while avoiding overgrazing.

- Simulating carbon dioxide concentration effects on soil water storage (Figure 4) and grass growth (Figure 5) (Qi et al., 2015). Elevated CO\textsubscript{2} concentration (720 ppm) resulted in increased water use efficiency for C\textsubscript{4} (cool season) grasses. The GPFARM-Range simulations agreed well with observed data.

References


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