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 availability 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).
- **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^{-1}); soil carbon and nitrogen parameters; CO_2 concentration in air
- **Outputs (daily):** above-ground and root biomass (kg d.m. ha^{-1}) by functional group; cattle mass (kg $head^{-1}$); soil profile water content (cm^3 cm^{-3}); soil organic carbon (kg ha^{-1}); total soil organic nitrogen (kg ha^{-1})

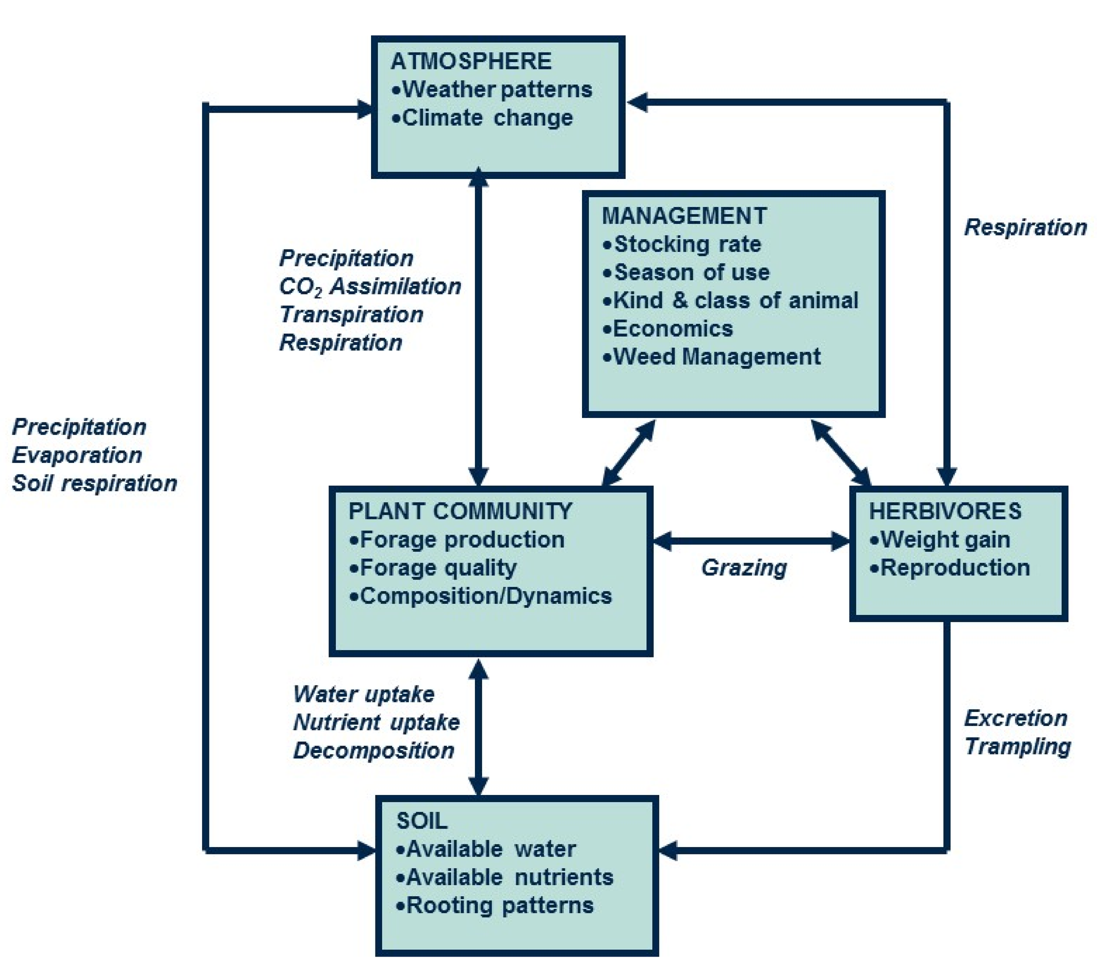

Figure 1. Important state variables and processes in a rangeland-livestock production system.

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^{-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_2 concentration (720 ppm) resulted in increased water use efficiency for C_3 (cool season) grasses. The GPFARM-Range simulations agreed well with observed data.

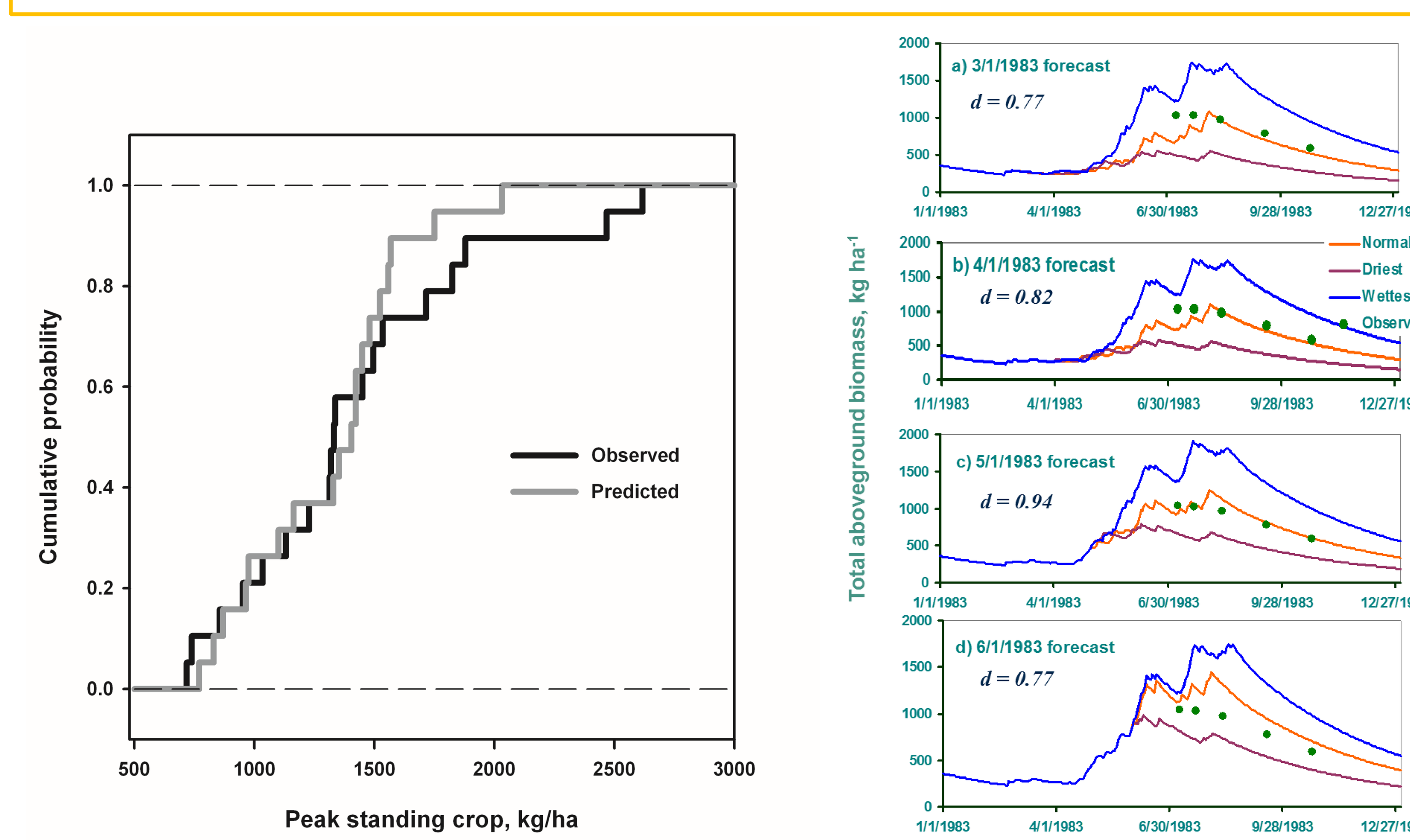

Figure 2. Cumulative probability (non-exceedance) of peak standing crop generated from 20 years (1982 – 2001) of predicted (GPFARM-Range) and observed data at a northern mixed-grass prairie site in Cheyenne, Wyoming (left chart); and tactical prediction of forage production using forecasted weather data commencing from 4 different dates (right chart) at the same site. (Andales et al., 2006)

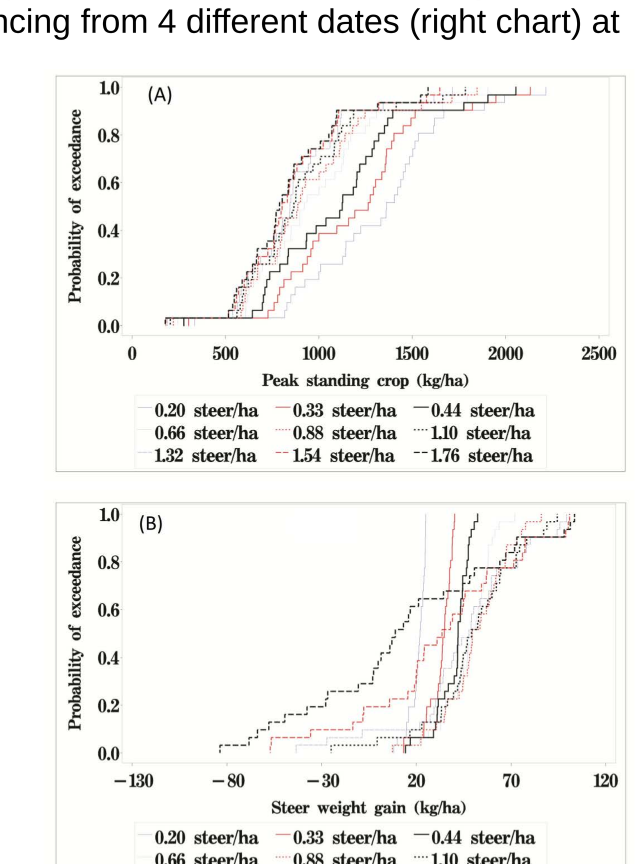

Figure 3. Cumulative probabilities (non-exceedance) of peak standing crop (PSC) and steer weight gain at different stocking rates for northern mixed-grass prairie, Cheyenne, Wyoming. Stocking rates > 1.10 steer/ha show likelihood of weight loss and declining PSC.

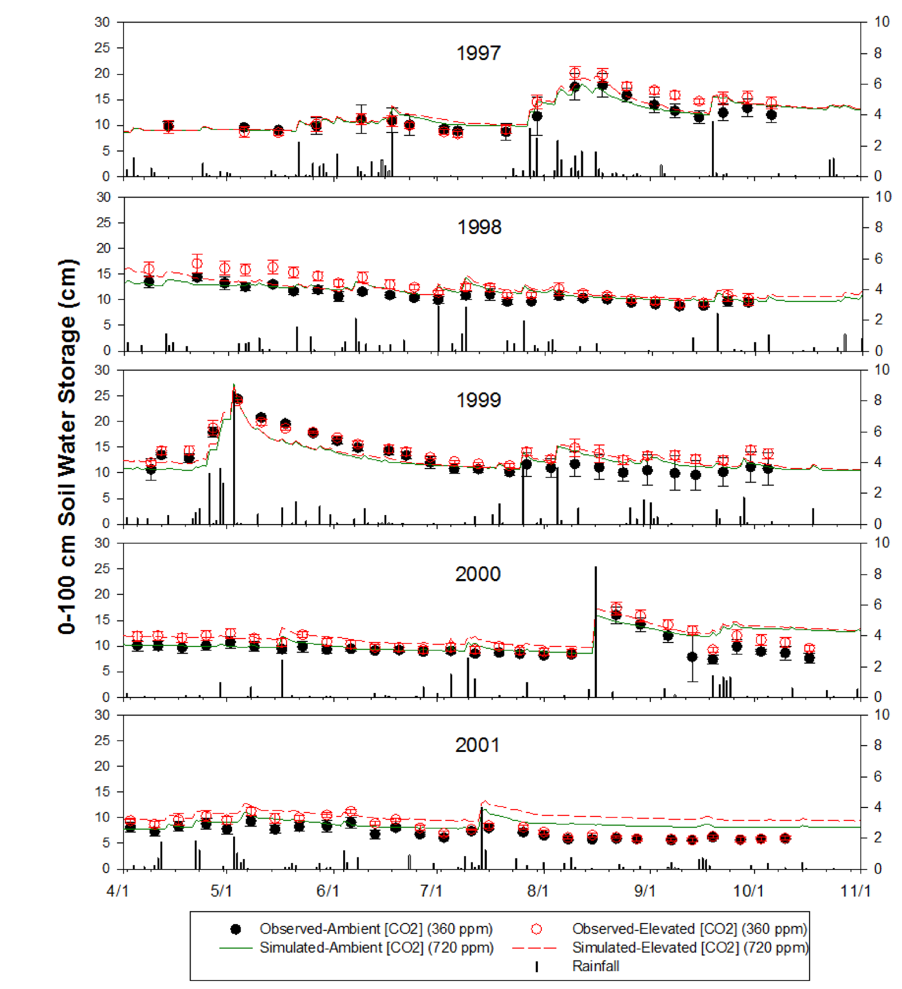

Figure 4. Observed and simulated soil water storage in 0–100 cm soil for ambient (PBIAS=8%, NSE=0.50, D=0.83, and RMSD=2.3 cm) and elevated (PBIAS=3%, NSE=0.68, D=0.88, and RMSD=2.0 cm) [CO_2] conditions for shortgrass steppe near Nunn, Colorado. Error bars represent±1 standard deviation. D indicates index of agreement; NSE, Nash-Sutcliffe model efficiency; PBIAS, percent bias; RMSD, root mean squared deviation.

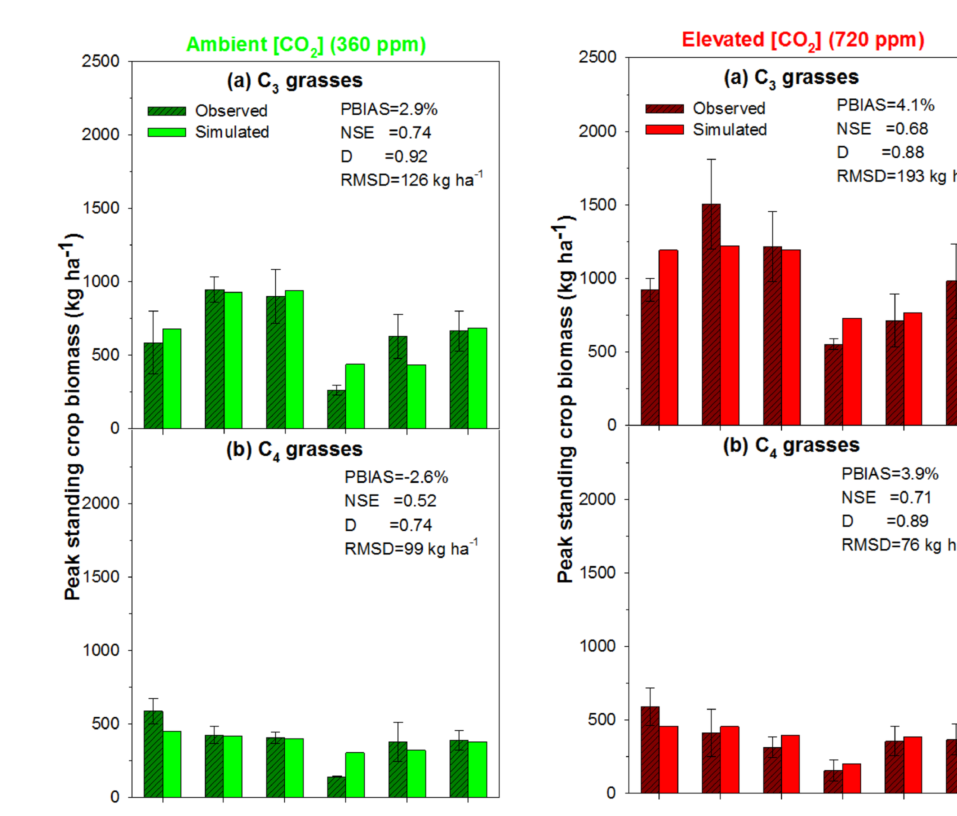

Figure 5. Peak standing crop for C_3 (cool season) and C_4 (warm season) grasses under ambient (360 ppm) and elevated (720 ppm) CO_2 concentrations at a shortgrass steppe site near Nunn, Colorado.

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