# Site and regional validation of G-Range — a new global ecosystem model for rangelands

**Jason Sircely*[1,2], Richard Conant[1,2], and Randall Boone[2]**

[1]International Livestock Research Institute; [2]Natural Resource Ecology Lab, Colorado State University

*j.sircely@cgiar.org

**Abstract**

G-Range is an ecosystem model for grasslands, savannas, drylands, and other grazing lands, capable of simulating and forecasting ecosystem dynamics from global to local scales in response to climatic and management scenarios. The model is designed to address the need for a rangeland ecosystem model incorporating interactions among and differing effects of management on herbaceous versus woody plants. Here we present results for site-scale validation and preliminary regional validation for East Africa and the Greater Horn of Africa. Site-scale above- and below-ground net primary production was validated with field biomass measurements, while regional validation employed MODIS total net primary production. Both site-scale and preliminary regional results are encouraging, and ongoing model fitting and re-parameterization are being used for further model development toward application to address climate and management impacts on ecosystem processes and services, and to rangeland policy questions.

**Introduction**

Researchers and practitioners focused on drylands and other rangeland livestock systems need simulation tools to forecast forage biomass production, soil health, and carbon storage with change in climatic and management regimes. To fulfill these needs, G-Range is an ecosystem model of intermediate complexity, designed to address questions both scientific and practical in grazing lands at a variety of spatial scales.

Drylands or arid and semi-arid lands (ASALs) comprise nearly 50% of global land cover. Drylands are characterized by high spatial and temporal variability in rainfall and vegetation type, leading to variable rates of ecosystem processes and ecosystem service delivery. Meanwhile, severe and intensifying effects of climate change in these systems (MA 2005) are increasing the vulnerability of the ~2.5 billion people who depend on drylands for their livelihoods (UNDP 2008).

The goal in developing G-Range was to create a model of intermediate complexity. The model needed to be complex and robust enough to capture inter- and intra-annual variation and directional shifts in rates of essential ecosystem processes, including in savannas and other systems co-dominated by herbaceous and woody plants, and to allow scenario analysis. Yet the model needed to be simple enough to simultaneously simulate all rangelands globally, and to be relatively to learn and apply in comparison to other ecosystem models. G-Range applies the widely used Century model (Parton et al. 1993) spatially according to modeled cover of herbaceous and woody plants, to spatially represent tree-grass balance dynamics.

**Methods**

Net primary production (NPP), or biomass production, is a key ecosystem process and comprises forage production in rangelands. Total NPP (TNPP) is the sum of above- (ANPP) and below-ground (BNPP) production. Simulations used a spatial resolution of 0.5° latitude and longitude.

*Site scale.* Field data on ANPP and BNPP (g $m^{-2}$) from field herbaceous biomass measurements were compiled from Oak Ridge National Laboratory database and the Long-Term Ecosystem Research network. The 28 datasets represent global rangeland variation in mean annual precipitation (200 to 1300 mm) and temperature (-4 to 29°C). ANPP was quantified as peak standing crop, and BNPP is the mean of high and low estimates of BNPP (methods varied among sites).

*Regional scale.* MODIS TNPP was retrieved from the Global Land Cover Facility for East Africa and the Greater Horn (*i.e.,* Ethiopia, Kenya, Somalia, South Sudan, Sudan, and Tanzania). G-Range TNPP for herbs, shrubs, and trees was summed for comparison with MODIS TNPP.

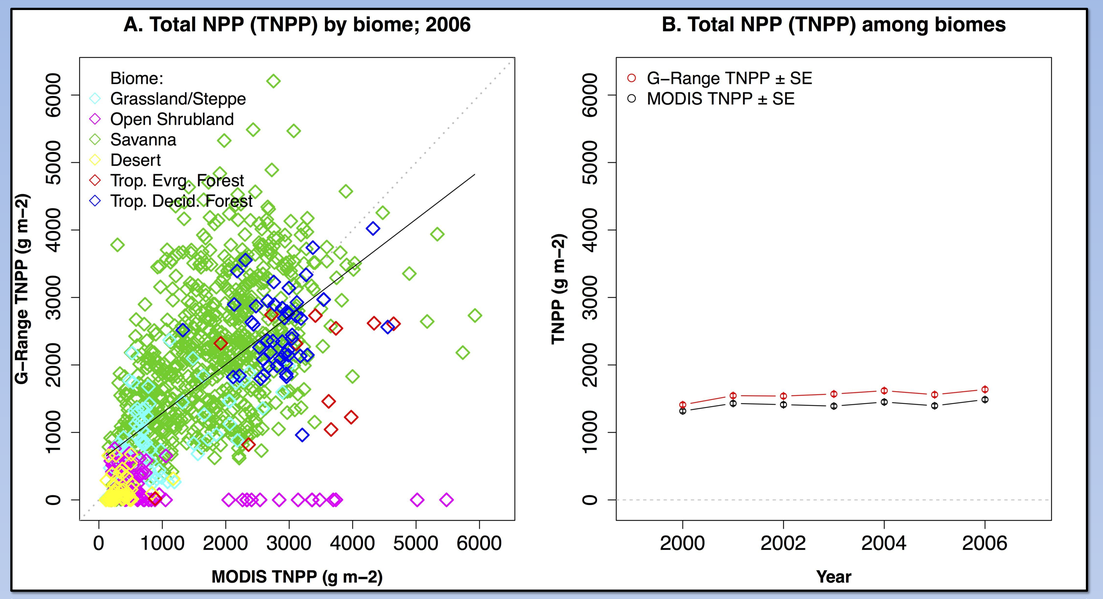


**Figure 2.** G-Range regional validation using MODIS total NPP for East Africa and the Greater Horn of Africa, **A.** within biomes in 2006, and **B.** among biomes.

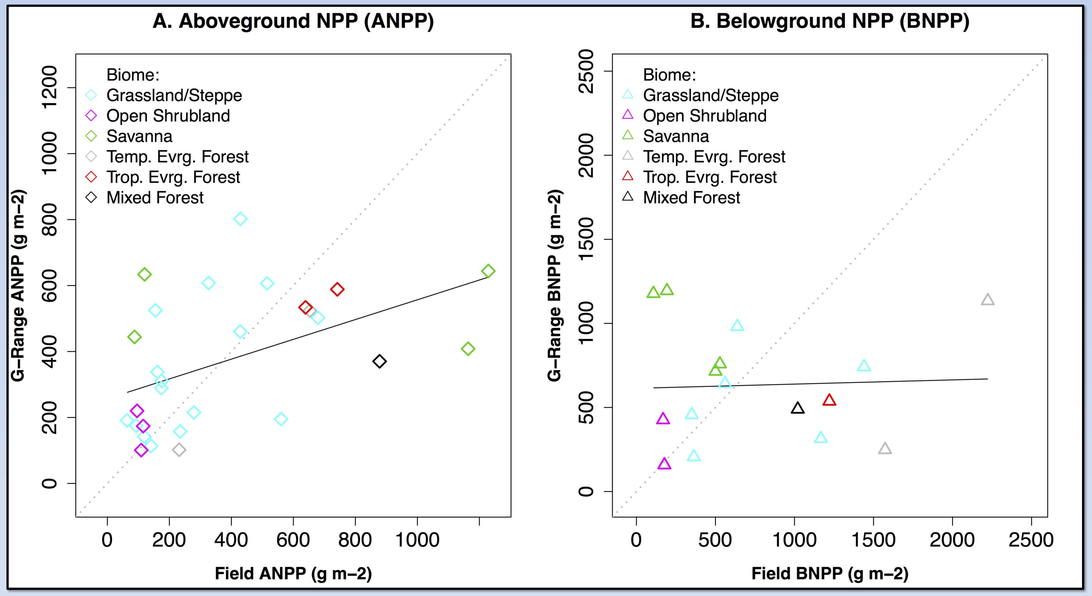


**Figure 1.** G-Range site-scale validation using field **A.** above- and **B.** below-ground net primary productivity (NPP) among years from field sites globally

**Results & Discussion**

At site scales, model fit for herbaceous ANPP (Figure 1A) was substantially better than for BNPP (Figure 1B), the latter a well-known uncertainty in ecosystem ecology and modeling. Overall, more typical rangeland biomes exhibited better model fit, including 'Grassland/Steppe', 'Open Shrubland' (*i.e.,* semi-desert), and 'Savanna', as well as 'Tropical Evergreen Forest', than did biomes with less extensive rangeland areas, 'Temperate Evergreen Forest' and 'Mixed Evergreen/ Deciduous Forest'. In 'Savanna' sites field ANPP ranged widely, and BNPP estimates were low relative to ANPP.

At the regional scale of East Africa and the Greater Horn, preliminary model fit results were similarly encouraging. All biomes exhibited reasonable values (with the exception of 'Open Shrubland', which appears to contain irrigated sites with implausibly high MODIS TNPP).

In addition to ongoing site-scale and regional-scale validation in East Africa and the Greater Horn, we are applying G-Range in several African systems to forecast forage biomass. These current efforts will lead to applications including informing local, national, and regional policies and programs seeking to improve destocking and other drought responses, provide livestock insurance, target feed supplementation, and quantify resilience.