# G-Range: An intermediate complexity model for simulating and forecasting ecosystem dynamics and ecosystem services in grazing lands at scales from local to global

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**Abstract**

Researchers and practitioners focused on drylands and other grazing systems need simulation tools to forecast future vegetation production, soil health, and carbon storage with changing climates and management. 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. Initial comparisons of G-Range outputs with field data demonstrate the strong potential of G-Range to effectively, efficiently simulate ecosystem dynamics in savannas and rangelands.

**Goals**

G-Range is built for more rapid forecasting of biomass production, soil conditions, and C stocks in grazing lands. The objective here is to summarize preliminary site-scale model validation using field data on vegetation biomass production (i.e., net primary productivity; NPP).

**Methodology**

G-Range builds upon established models of ecosystem dynamics (CENTURY[1] and SAVANNA[2]). The model is modified to represent important ecological elements of grazing lands (tree/grass balance, grazing effects, spatial exchanges), and has an intermediate degree of complexity to accelerate model parameterization and application.

A semi-arid site, Nairobi National Park, Kenya[3] (677 mm rain $yr^{-1}$) and a humid site, Lamto savanna, Côte d'Ivoire[4] (1165 mm rain $yr^{-1}$) provided a strong climatic contrast. 2 methods of calculating biomass production from above- and below-ground field data gave 'liberal' and 'conservative' estimates of biomass production: A) for both above- and below-ground, peak standing crop should be liberal (esp. for below-ground); and B) summed positive live+dead biomass increments for above-, and max.-min. live+dead biomass for below-ground, should be conservative (esp. for below-ground).[5] These methods also have relatively low uncertainty.[6]

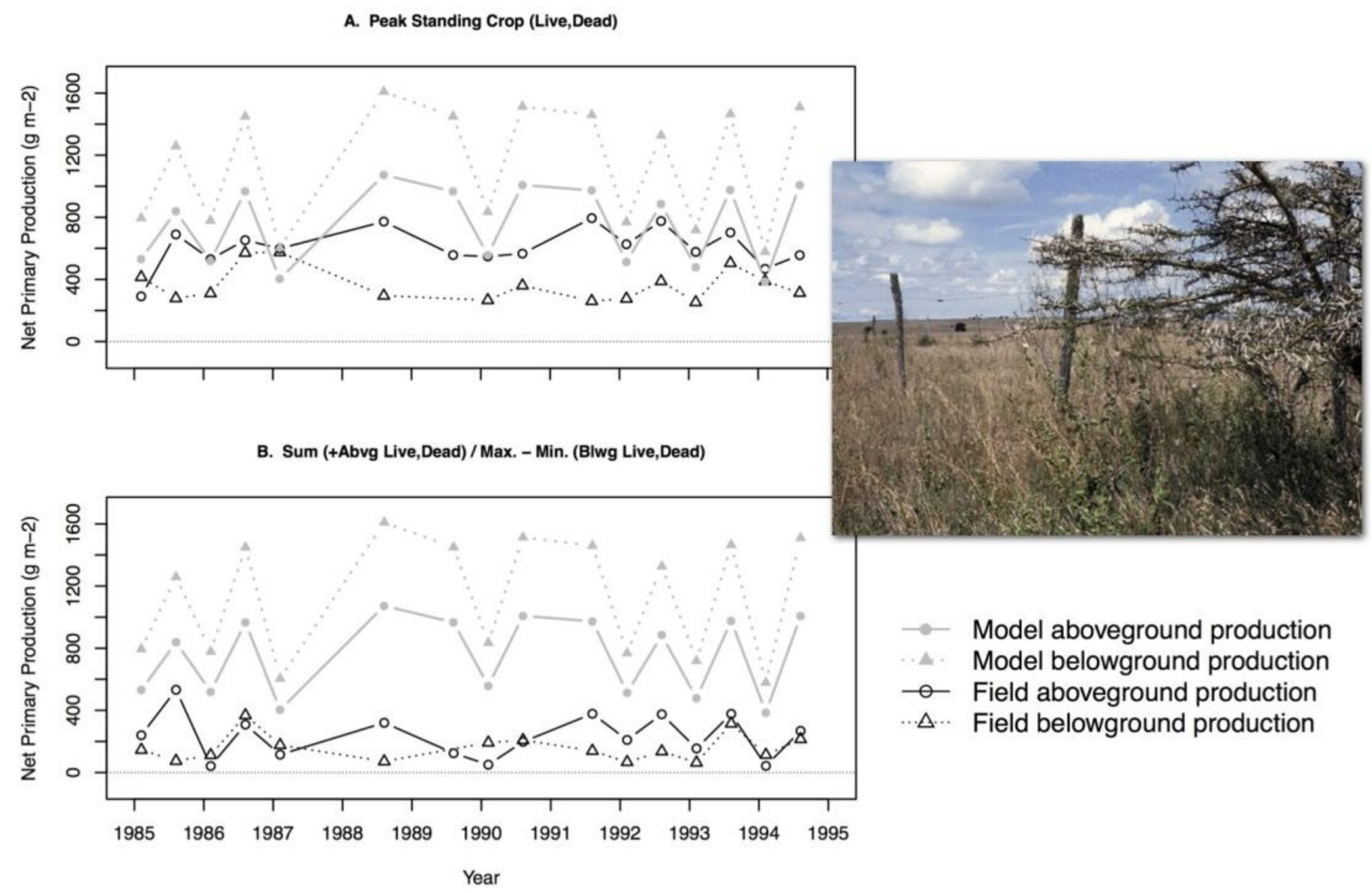


**Figure 1: Nairobi National Park, Kenya.** Preliminary G-Range validation based on production estimates from field data using **A)** 'liberal' and **B)** 'conservative' methods of calculation (see Methodology).

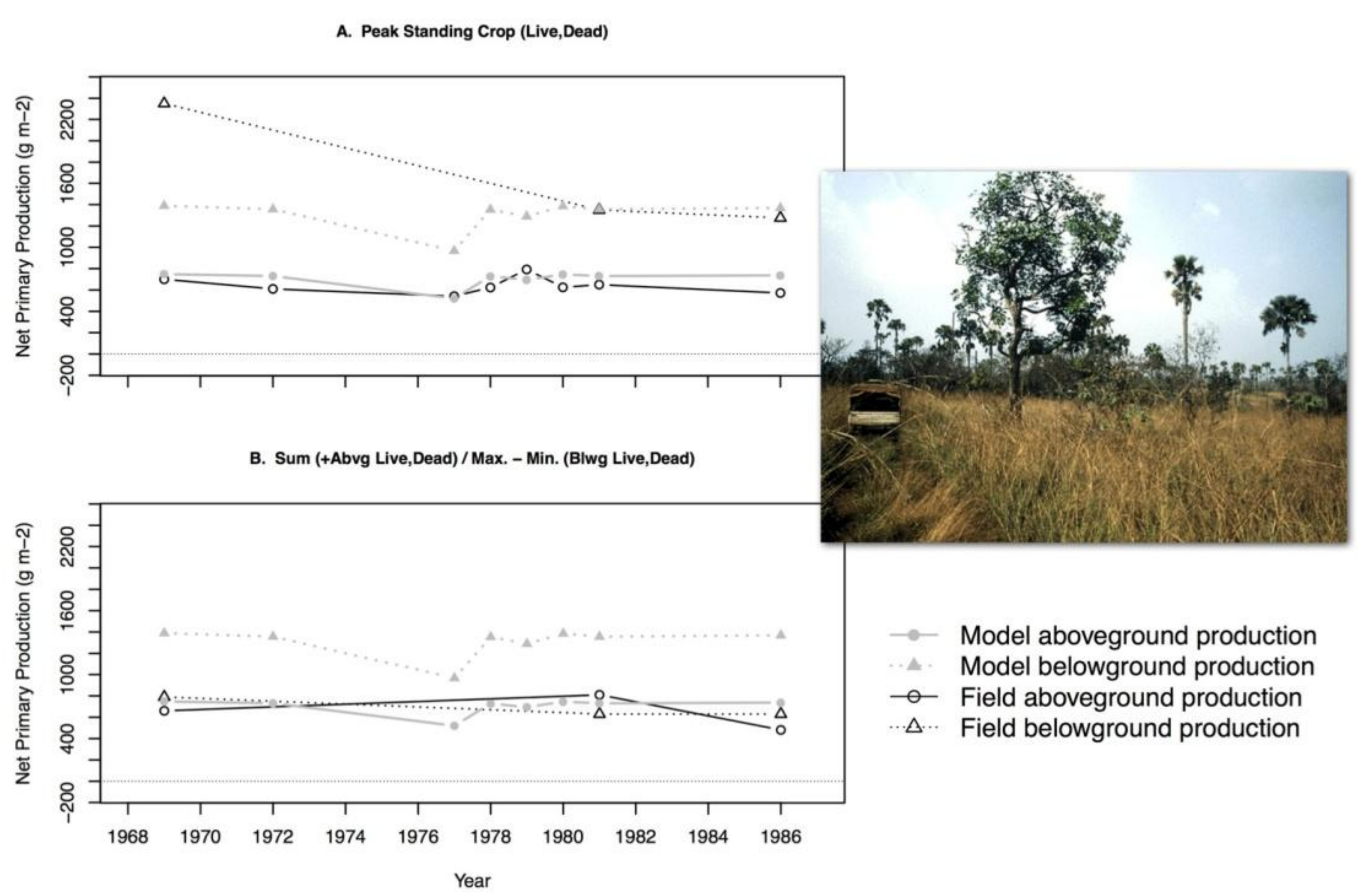


**Figure 2: Lamto, Côte d'Ivoire.** Preliminary G-Range validation based on production estimates from field data by **A)** 'liberal' and **B)** 'conservative' methods of calculation (see Methodology).

**Results**

This preliminary test (default parameter values) of G-Range simulations found reasonable agreement between modeled and measured production in Nairobi NP ("NRB"), and excellent agreement in Lamto ("LMT").

In NRB (Figure 1), modeled above-ground production (ANPP) was somewhat higher than measured ANPP, and more so in wetter seasons. Modeled belowground production (BNPP) was quite high, indicating a need for sensitivity analysis to refine parameterization of factors influencing root:shoot ratios, e.g. root allocation and soil N and $H_2O$ limitation of root growth.

In LMT (Figure 2), G-Range ANPP tracked measured ANPP closely, regardless of the method of calculation for field data. Modeled BNPP fell within the range provided by the 2 calculation methods (except, barely, in 1986), indicating satisfactory simulation of BNPP using default parameter values.

Finally, 'liberal' and 'conservative' methods for BNPP successfully bracketed the probable true value of BNPP in sites with vastly different climates, while also minimizing the uncertainty of field estimates.

**Partners**

NREL, Colorado State Univ.: Dan Milchunas, Bill Parton. USDA-ARS: David Augustine.

**Literature Cited**

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## 3 strategic lessons on:

### Delivering science

1. Improving ecosystem modeling in grazing lands will benefit forecasting of ecosystem service delivery
2. Simpler validation approaches can reduce data needs as well as uncertainty
3. Sophisticated ecosystem models can be successfully adapted to address practical questions and challenges

### Developing capacity

1. Models with intermediate complexity can be more rapidly taught to new users
2. Moderate data requirements enable faster model parameterization and validation
3. The ability to generate short-term forecasts rapidly will accelerate dissemination to land managers

### Influencing decisions

1. Efficient modeling tools will improve anticipation of livestock mortality and efforts to address it, e.g., insurance
2. Forecasting climate impacts in grazing lands enables projection of medium- to long-term livestock production capacity
3. Ecosystem models can effectively gauge carbon storage potential in grazing lands

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