# Role of Local Grassland Under Climate Change– Historic & Future Perspectives


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## Introduction

To determine the effects of future warming and elevated $CO_2$ in Pennsylvania, we need to consider realistic land use and management, including forests, urban, crop, and dairy farm landscapes. Process-based biogeochemical modeling approaches typically require the incorporation of biome-specific calibrated parameters. In the Terrestrial Ecosystems Model (TEM), however, Konza grassland in Kansas has been used to represent dairy farms everywhere in the US, leaving uncertainties in reporting local grassland productivity in Pennsylvania.

Field-experiments were therefore performed to determine carbon fluxes in the grass and soil for *Dactylis glomerata L.* (orchard grass) at Rodale Farm, Pennsylvania. We report local grassland productivity by constructing the annual flux patterns. Incorporating such information into TEM, we modeled what the future IPCC global warming scenarios (A2 and B1) would mean to local grassland productivity at Lehigh.

## Materials & Method

Plant physiology

**Konza Prairie**
- Indian Grass + Big bluestem
- Perennial warm-season grasses
- Mixture of C3 & C4 plants

**Rodale Farm**
- Orchard grass
- Perennial cool-season grasses
- Dairy livestock grazing
- C3 plant

Field measurement

Carbon uptake response to Photosynthetically Active Radiation (PAR) at the leaf level was determined using the LICOR-6400 in October 2012 (warm season proxy) and February 2013 (cold season proxy), and soil respiration (heterotrophic + roots) was determined by LICOR-8100.

**LI-6400 – Leaf flux**
- Leaf photosynthesis (Pleaf)
- Leaf respiration (Rleaf)

**LI-8100 Soil flux**
- Soil respiration (Rsoil)
- Root respiration (Rroot) = (Rsoil – Rleaf)/2

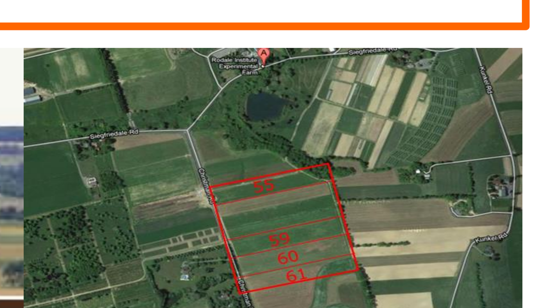
Flux upscaling

High order polynomial equations were used to capture the carbon uptake at different PAR levels for each season. Annual GPP and NPP were estimated using observed PAR in 2010-12 in Bethlehem and an average annual LAI of 1.7[1], following:

$$GPP = (Pleaf + Rleaf) * LAI$$
$$NPP = GPP - Rleaf * LAI - Rroot$$

Modeling

Site-specific Model Calibration → Transient - historic 1901 - 2000 → Transient - future 2001 – 2099: IPCC A2 & B1 Scenarios

## Result

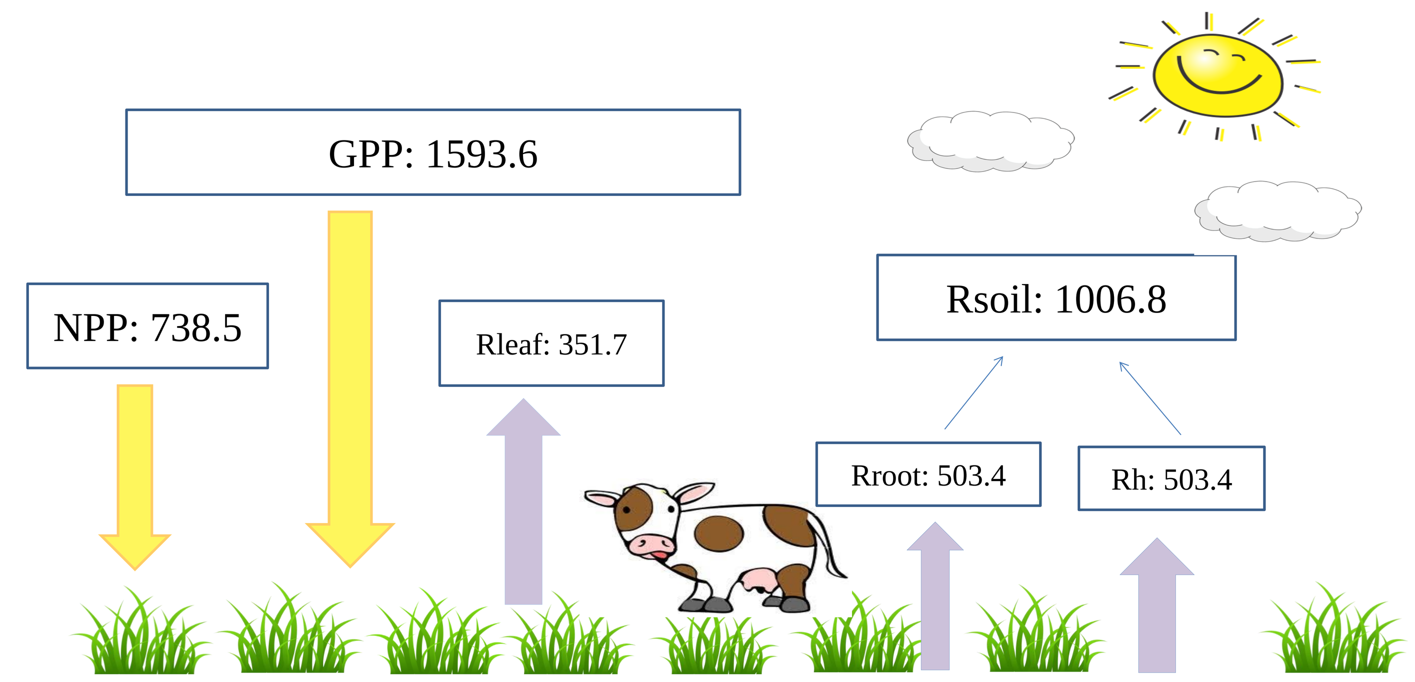



Fig. 1 Schematic diagram: the carbon cycle at Dairy Farm, PA (Unit: g C $yr^1$ $m^2$ )

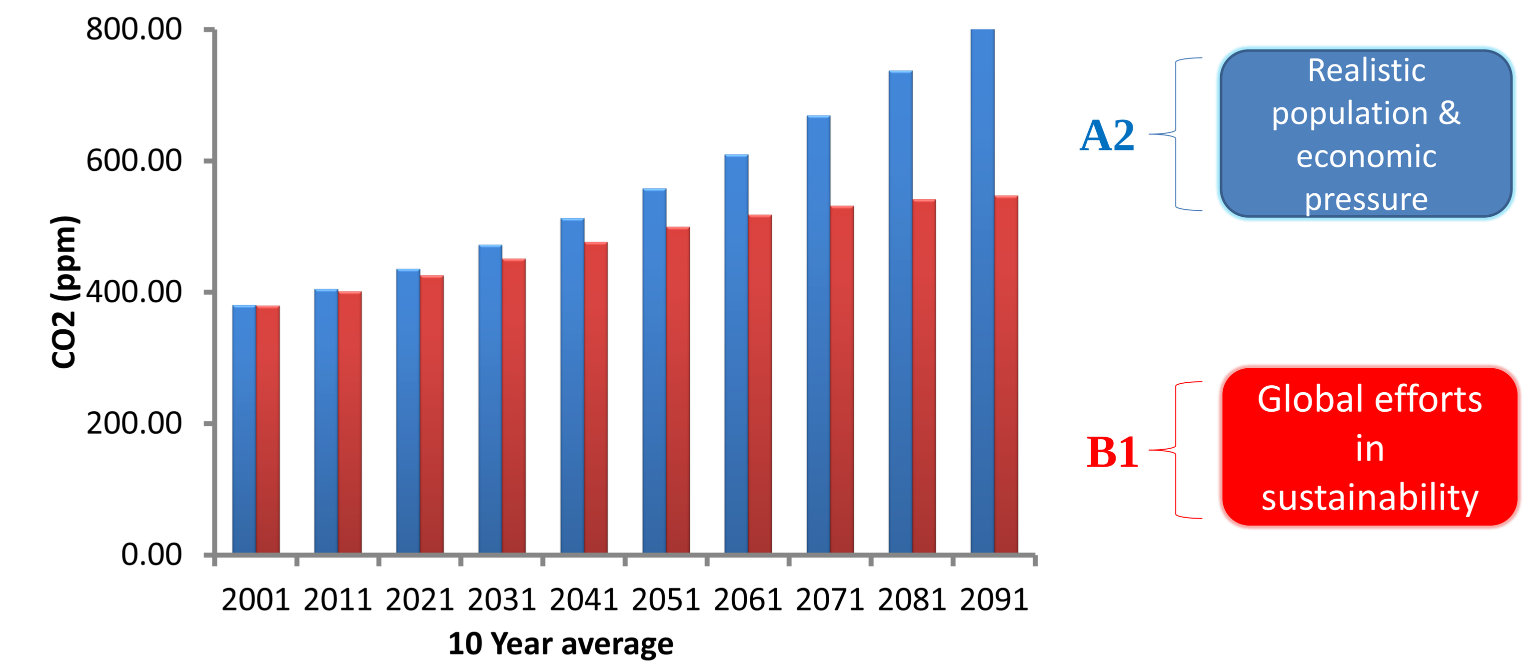



Fig. 2 IPCC A2 & B1 future $CO_2$ concentration scenarios

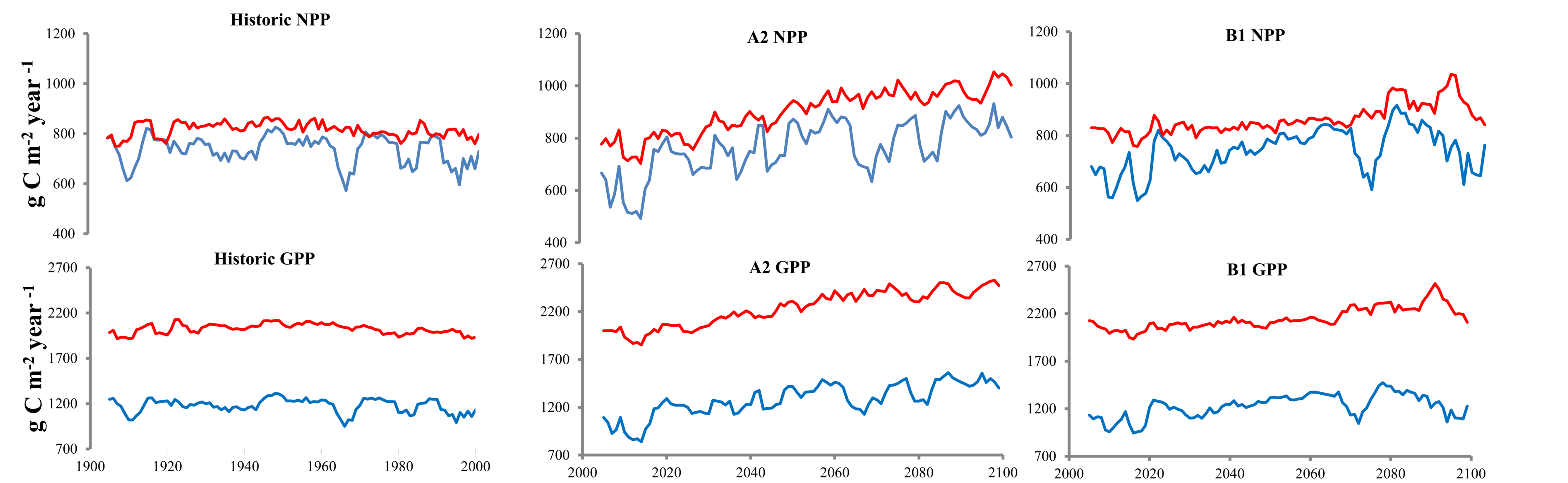



Fig.3 Lehigh grassland NPP & GPP using Rodale proxy vs. Konza proxy, for historic (1901-2000), and future (2001-2099) A2 and B1 scenarios. Rodale proxies were at all times significantly greater in NPP and GPP. Nested-ANOVA results (not shown) indicate there are significantly increased trend of future NPP and GPP, and the increases are always more sensitive using Rodale proxy.

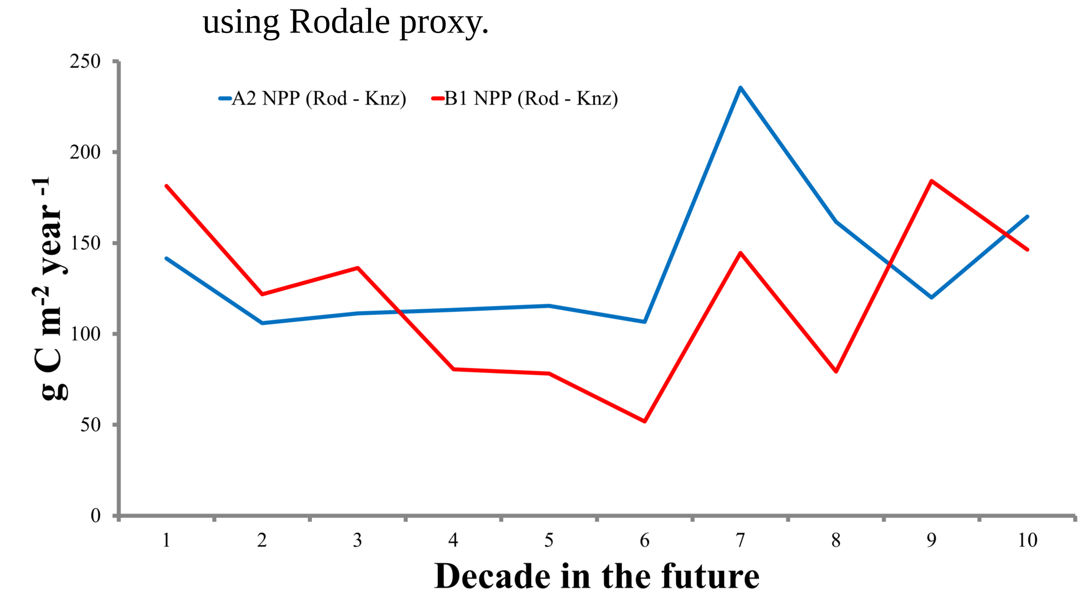



Fig. 4 Sensitivity test of NPP between Rodale and Konza proxy (see text for explanation)

### Historic – Grass physiology controls response to environmental changes

- As a dry-season C4 grassland, productivity of Konza grassland correlated well with precipitation (Pearson correlation = 0.47; p < 0.001);
- As a cool-season C3 grassland, Rodale productivity correlates well with air temperature and $CO_2$ ( $R_p$= 0.34, p < 0.001; $R_p$= -0.22, p < 0.05; respectively).

### Future – Increased productivity but decreased resilience

- Proxy of Rodale is more sensitive to future environmental changes than Konza under both A2 and B1 scenarios (Fig. 4);
- Using realistic proxy, Lehigh grassland productivity will be subject to changes of more environmental variables (i.e. temperature, $CO_2$ and precipitation) in the future.

## Modeling – TEM-Hydro

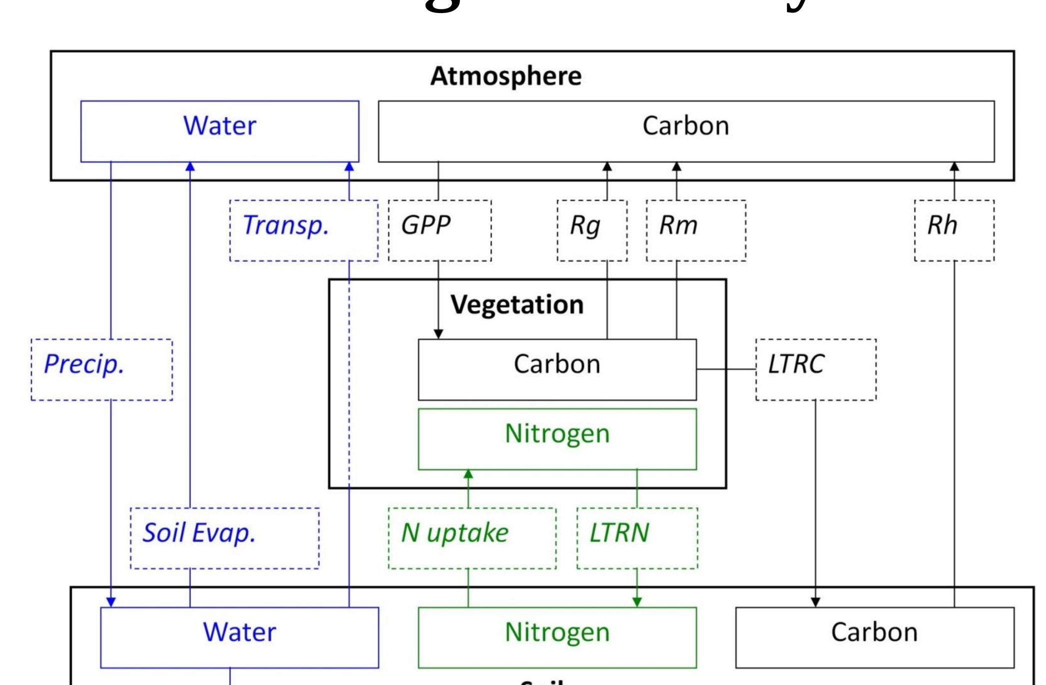



Fig. 5 Schematic biogeochemical interaction in TEM-HYDRO[2].

## Reference


1. Scurlock et al. (2001) Global leaf area index data from field measurements, 1932-2000.
2. Felzer *et al.* (2011) Nitrogen effect on carbon-water coupling in forests, grasslands and shrublands in the arid western United States. J. of Geophysical Research, 116, G03023.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