

Supplementary Information

Dynamic urban land extensification is projected to lead to imbalances in the global land-carbon equilibrium

Ryan A. McManamay^{1*}, Chris R. Vernon², Min Chen³, Isaac Thompson², Zarrar Khan², Kanishka B. Narayan²

1. Department of Environmental Science, Baylor University, Waco, TX USA 76798
2. Pacific Northwest National Laboratory, Richland, WA USA
3. Department of Forest and Wildlife Ecology, University of Wisconsin Madison, Madison WI USA 53706

*Materials and correspondence

One Bear Place #97622

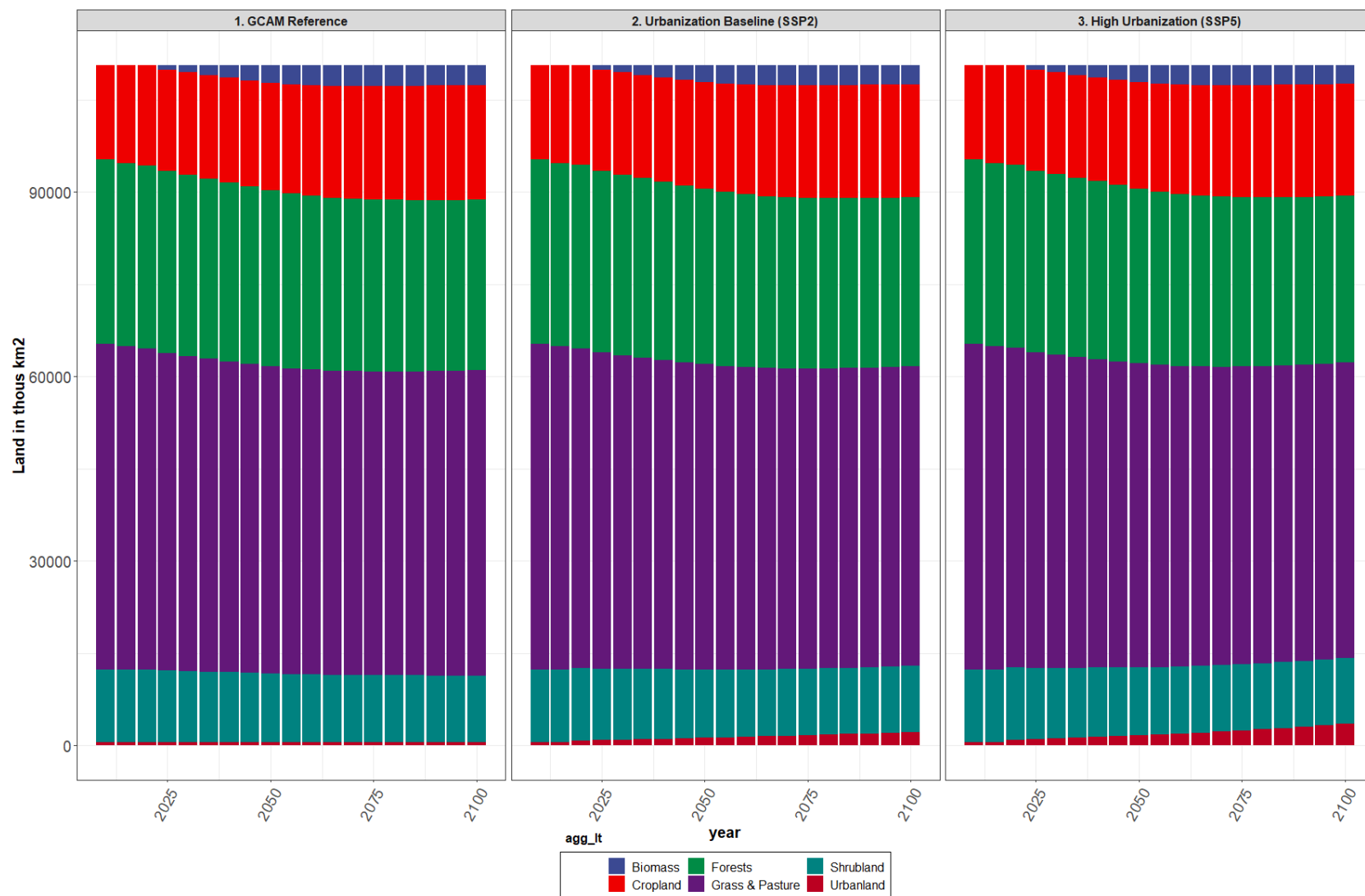
Waco, TX 76798-7266

Ryan_McManamay@baylor.edu

Supplementary Table 1. Scenarios supported in our study. Scenarios of dynamic non-urban lands (static urban) was provided by the Global Change Analysis Model (GCAM) and downscaled by Demeter model. Scenarios of urban land expansion were taken from CLUBS-SELECT model.

Scenario Group	Scenarios
GCAM-Demeter Scenarios	
Shared Socioeconomic Pathways (SSPs)	SSP1, 2, 3, 4, 5
Representative Concentration Pathways (RCPs)	RCP 2.6, 4.5, 6.0, 8.5
Global Circulation Models (GCMs)	GFDL (Global Fluid Dynamics Laboratory), HadGEM2 (Hadley Centre Global Environment Model version 2), IPSL-CM5 (Institut Pierre-Simon Laplace Climate Model), MIROC (Model for Interdisciplinary Research on Climate), NorESM (Norwegian Earth System Model)
Harmonized, Non-harmonized	Harmonized refers to harmonizing the Global Change Analysis Model (GCAM) land class sytem with Community Land Model (CLM) land system used within Coupled Model Intercomparison Project (CMIP6).
CLUBS-SELECT Scenarios	
Shared Socioeconomic Pathways (SSPs)	SSP1, 2, 3, 4, 5

Supplementary Figure 1. Total land area (thousand km²) for aggregated land cover and land use types under the GCAM reference scenarios, and when incorporating dynamic urbanization for SSP2 and SSP 5.



Supplementary Figure 2. Flow chart depicting workflow for our methods. Dynamic land allocations for various non-urban land classes are simulated within GCAM, along with crop yields, and CO₂ emissions. Urban land is held static. Demeter is used to downscale these land classes to a local 0.05° level. CLUBS and SELECT simulates dynamic urban land at a 1-km level, which is aggregated to 0.05° for intersection with Demeter products. Non-urban land class fractions are adjusted to accommodate for new urban land growth. These land fractions are summarized as areas in regions and basins. Crop yield rates (Metric tons per km²) for specific crops within regions and basins are used to estimate crop yield losses based on land area compromised by urban growth. Net primary production (NPP) rates (carbon per km²), summarized at region and basin levels, is multiplied by land area losses to product NPP losses compromised by urban extensification. Updated CO₂ emissions are estimated by converting NPP losses to lost CO₂ sequestration for the land surface.

