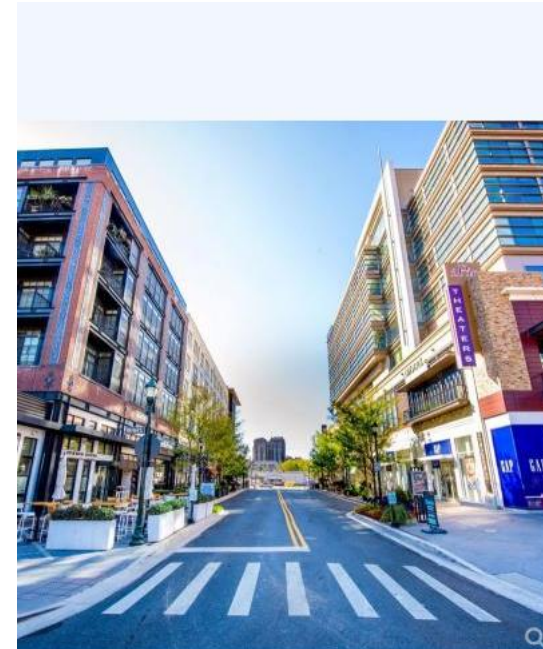*Energy-Water-Land System breakout session*

Theme 1 – Understanding Transitions at Different Scales

Future spatially explicit patterns of land transitions in the United States with multiple stressors

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Earth & Environmental Systems Modeling

EARTH SYSTEM MODEL DEVELOPMENT (ESMD)
REGIONAL & GLOBAL MODEL ANALYSIS (RGMA)
MULTISECTOR DYNAMICS (MSD)

Street view of Bethesda, Maryland. | Image courtesy of Bethesda North Marriott Hotel and Conference Center

Motivation

- Changes in land use: implications on carbon storage, species habitat, biodiversity, water, and broader ecosystem values!

- Multiple forces influencing land use changes at global, regional and local levels:
    - income and population growth
    - yield and productivity improvements
    - climate change
    - changing diets
    - policies (trade, agricultural, environmental)

- How these global forces impact land use at a multiple spatial resolutions?

- *How to combine and/or reconcile different scales?*

Share of land used for agricultural purposes has decreased 11 percent since 1949

Percent of U.S. acres
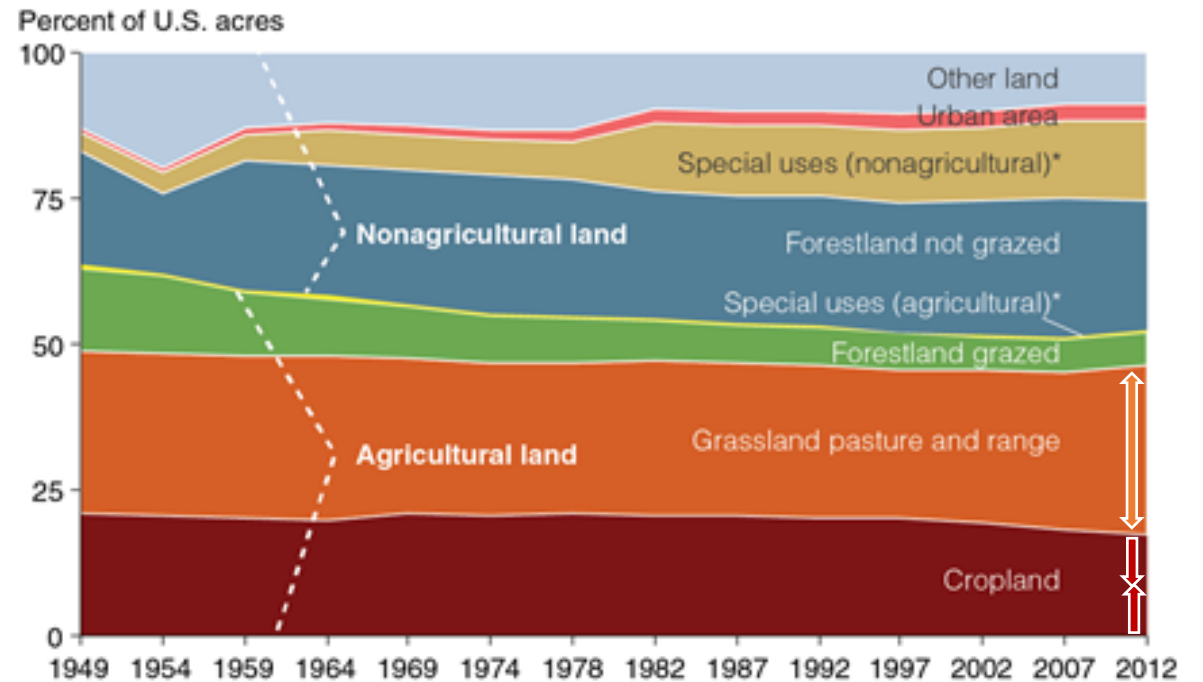
*Special uses include rural parks and wilderness areas, rural transportation areas, defense/industrial lands (all nonagricultural uses), and farmsteads/farm roads (agricultural uses).
Source: USDA, Economic Research Service calculations using data from USDA, U.S. Department of the Interior, U.S. Department of Commerce, and other sources.

Source: Bigelow, 2017

2

Future spatially explicit patterns of land transitions in the United States with multiple stressors
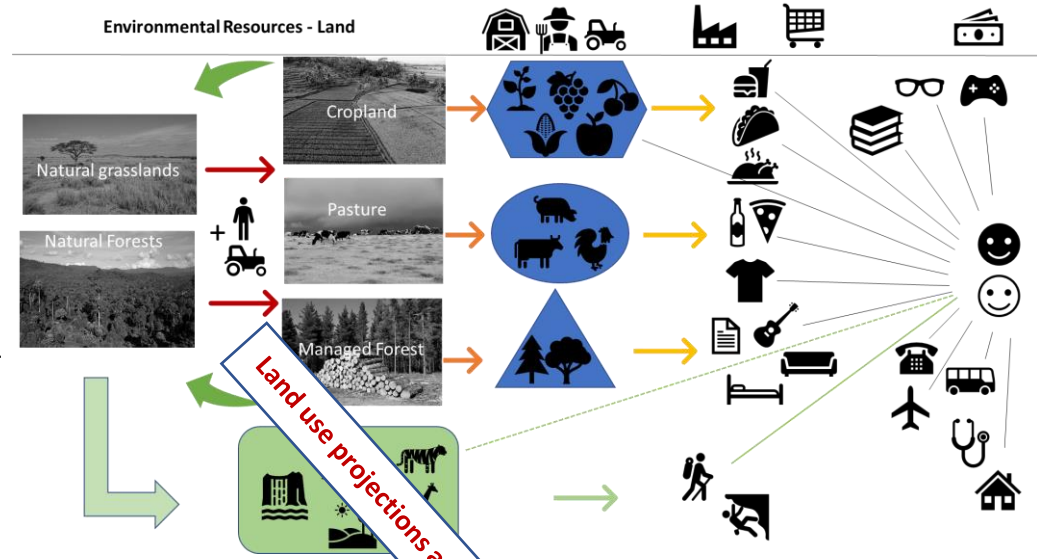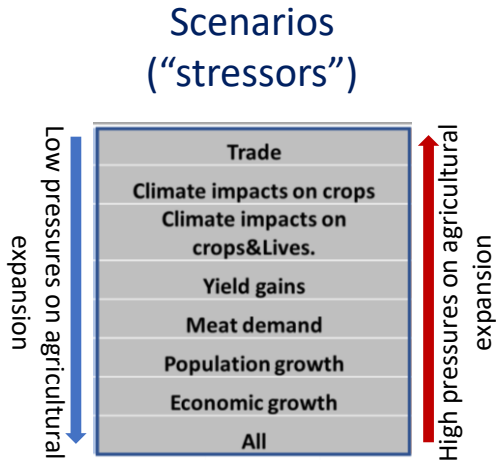
Method

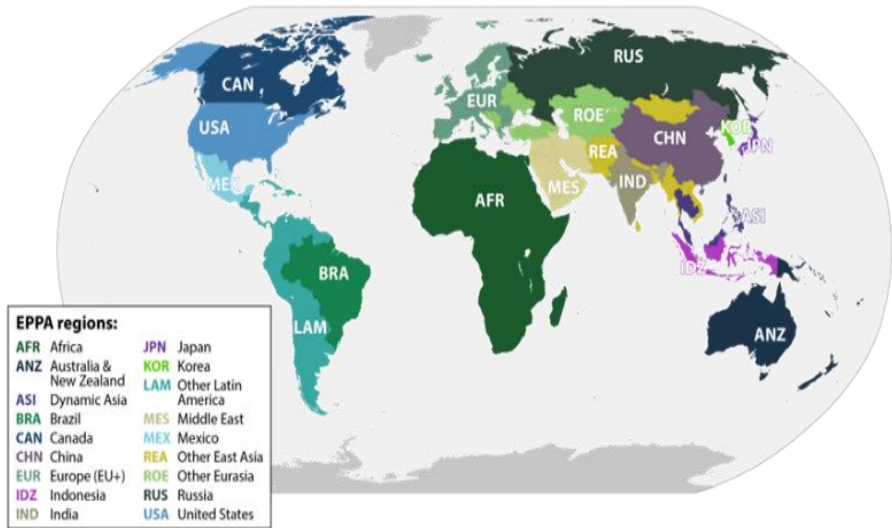- Multisectoral, multisystem dynamics (MSD) perspective focused on understanding dynamics in complex interdependent systems;

- Interaction among economic sectors and natural systems;

- Allows investigating vulnerability or resilience of systems to compounding forces and stressors;

- Tools: socio-economic-environmental modeling (EPPA-Agriculture) combined with a land-use downscaling tool (Demeter)
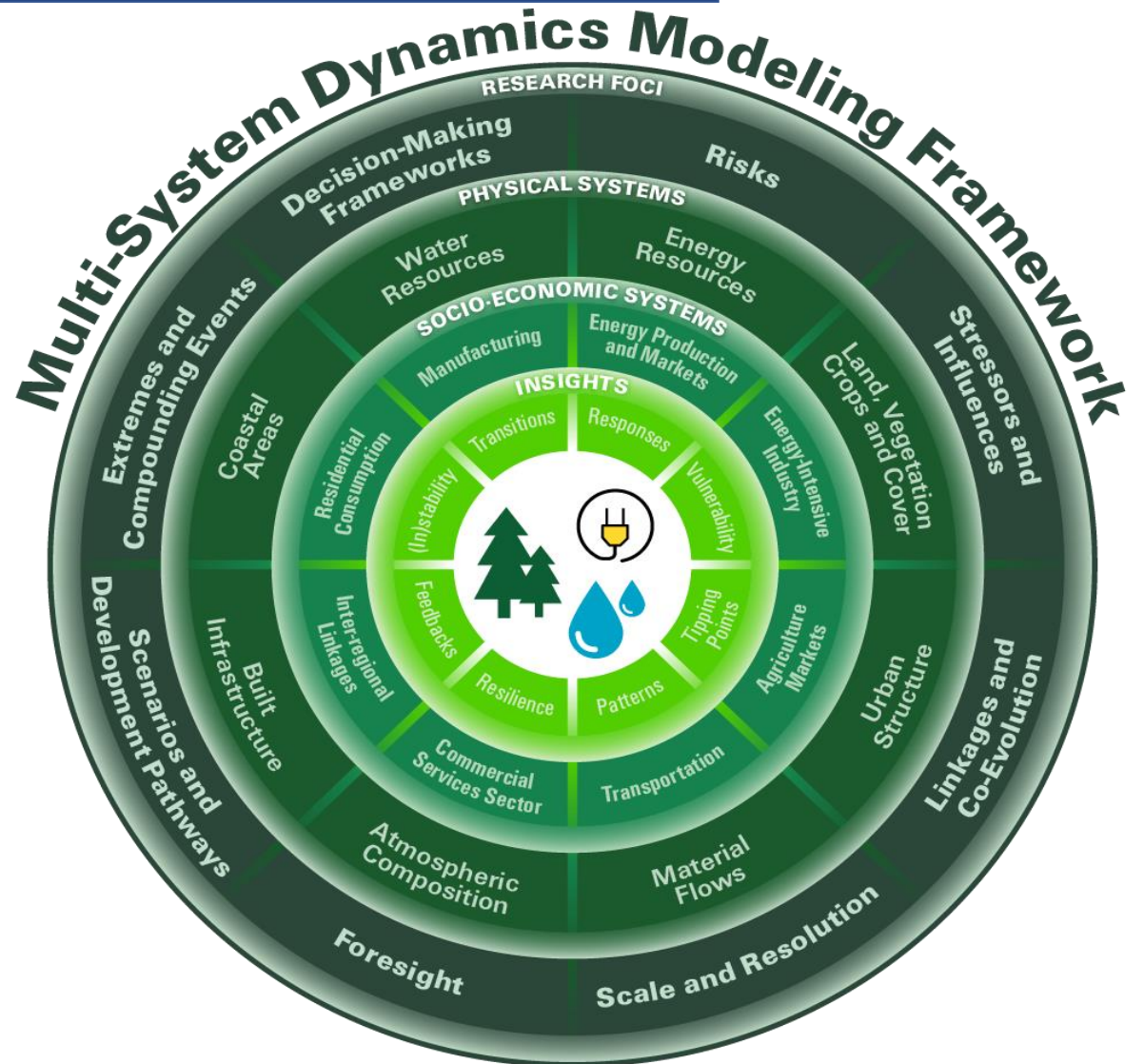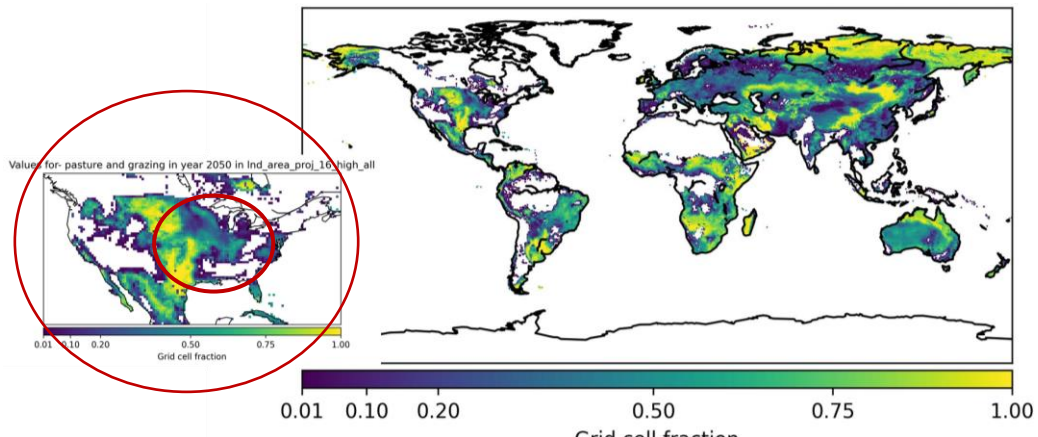
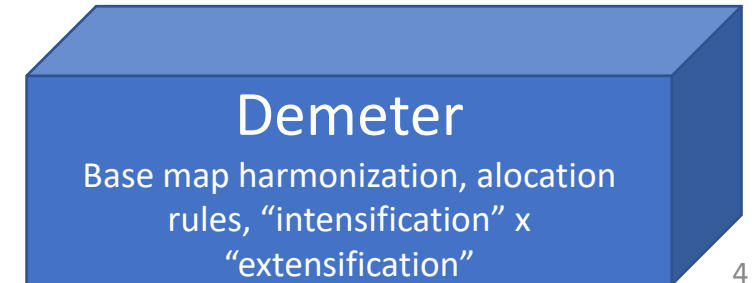# Future spatially explicit patterns of land transitions in the United States with multiple stressors

Method

Dynamic multi-regional multi-sectoral *"human-system"* modeling

Scenarios ("stressors")

Low pressures on agricultural expansion

| Trade |
| Climate impacts on crops |
| Climate impacts on crops&Lives. |
| Yield gains |
| Meat demand |
| Population growth |
| Economic growth |
| All |

High pressures on agricultural expansion

Environmental Resources - Land

Land use projections at regional level

Land use downscaling model

Values for- pasture and grazing in year 2050 in Ind_area_proj_16 high_all

Grid cell fraction

Land use projections at grid level

Demeter
Base map harmonization, alocation rules, "intensification" x "extensification"

EPPA regions:
AFR Africa
ANZ Australia & New Zealand
ASI Dynamic Asia
BRA Brazil
CAN Canada
CHN China
EUR Europe (EU+)
IDZ Indonesia
IND India
JPN Japan
KOR Korea
LAM Other Latin America
MES Middle East
MEX Mexico
REA Other East Asia
ROE Other Eurasia
RUS Russia
USA United States

4

Future spatially explicit patterns of land transitions in the United States with multiple stressors

Method

Dowscaling model information flow and connections with the economic model
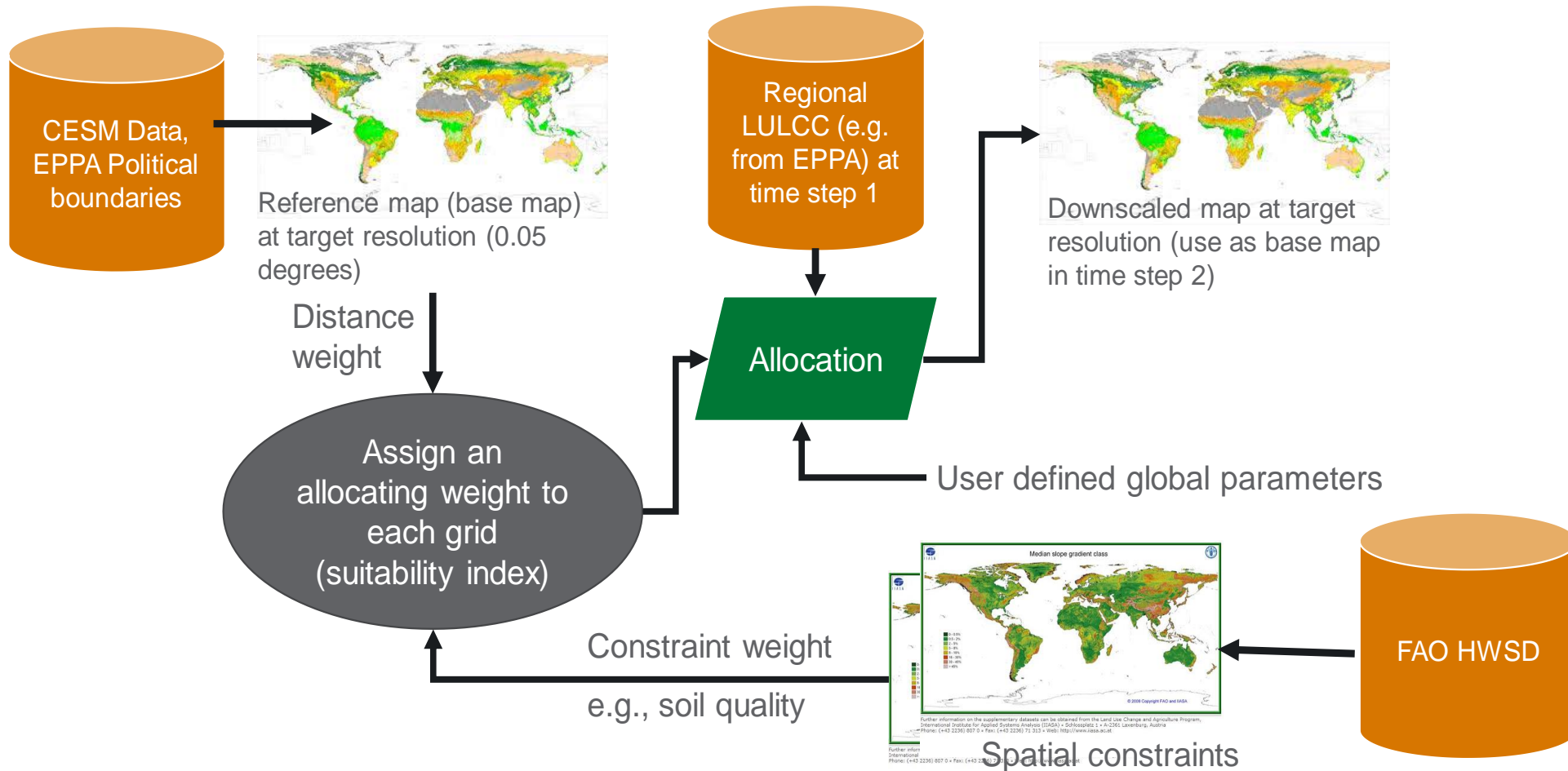
Future spatially explicit patterns of land transitions in the United States with multiple stressors

Results

Trajectories of global aggregated land areas

Differences in Fractional Land Cover between 2050 and 2020 in the BAU and "high all" scenario in the U.S.

Results

Gross land change between 2020 and 2050 by transition type by basin for three alternative scenarios
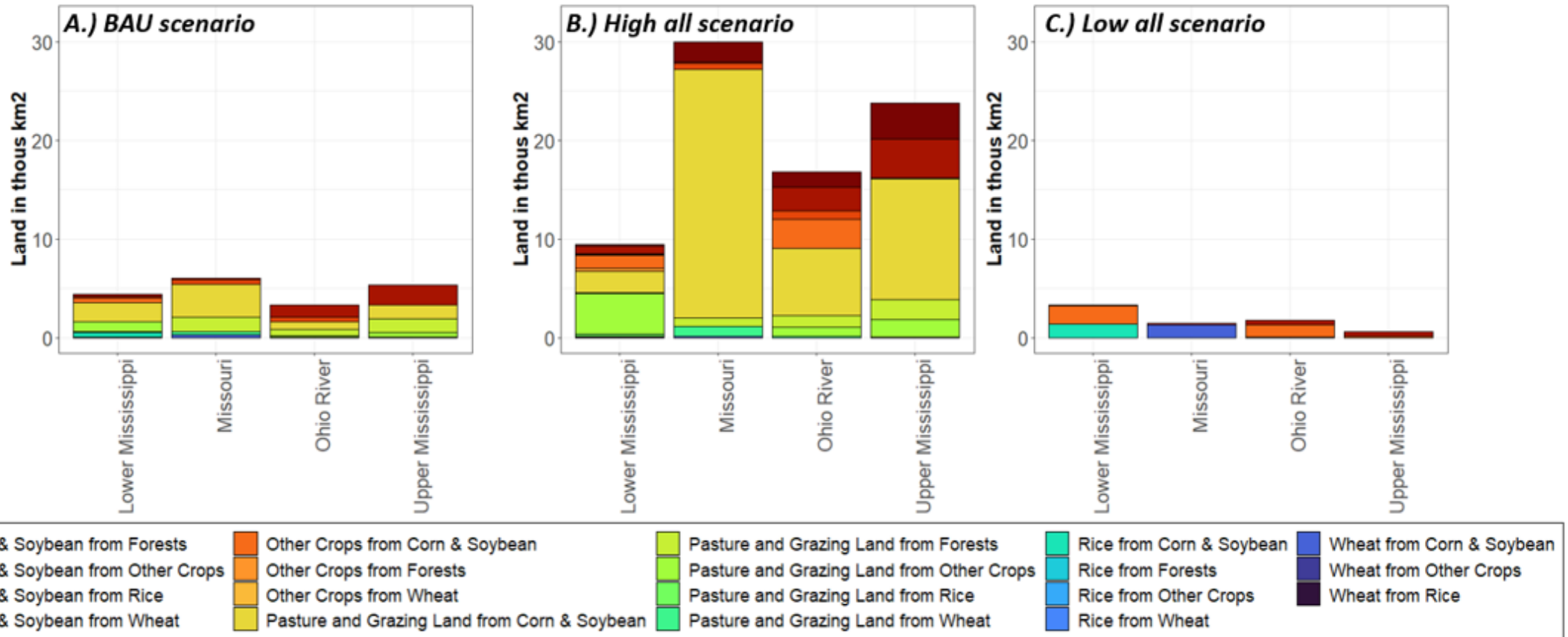
* Note that flows are arranged as "inflows" from "outflows"

Final Remarks

- Global forces will affect future land use in the U.S. at the regional and local levels: implications to ecosystem services?

Gaps in research: how to represent and combine (feedbacks) key drivers and behavior of human and natural systems in multiple and overlapping dimensions (global, regional and local)?

- Socio-economic models: overall macro and sectoral responses at global and regional levels

- Downscaling models: bridge regional results to spatial determinants of land use allocation

Ex.: increase in the U.S. comparative advantage in livestock production in the long term: spatial answers in land transitions differs along the Mississippi River Basin

- *Opportunities to overcome gaps and DOE strengths and capabilities:*

- Connect different research teams: combine models and tools to overcome the research gaps

Ex.: Economic model (MIT) + downscaling tool (PNNL): dynamic connections between human and natural system models operating across different spatial scales

Outcomes allow further investigation on multi-sector feedbacks and impacts on land-energy-water resources, carbon storage, soil erosion, chemical use, hydrology, and water quality.

Thanks!

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