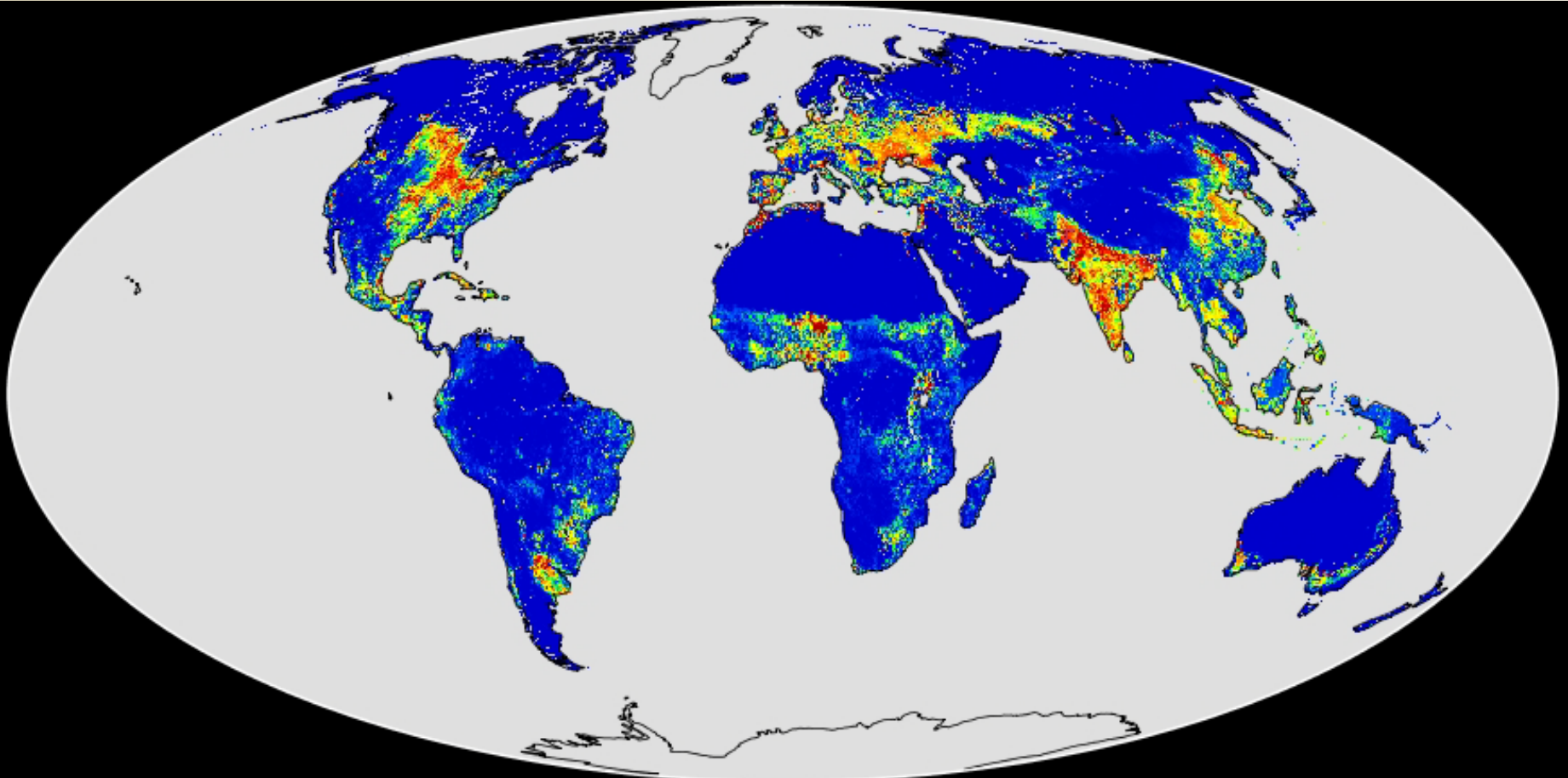
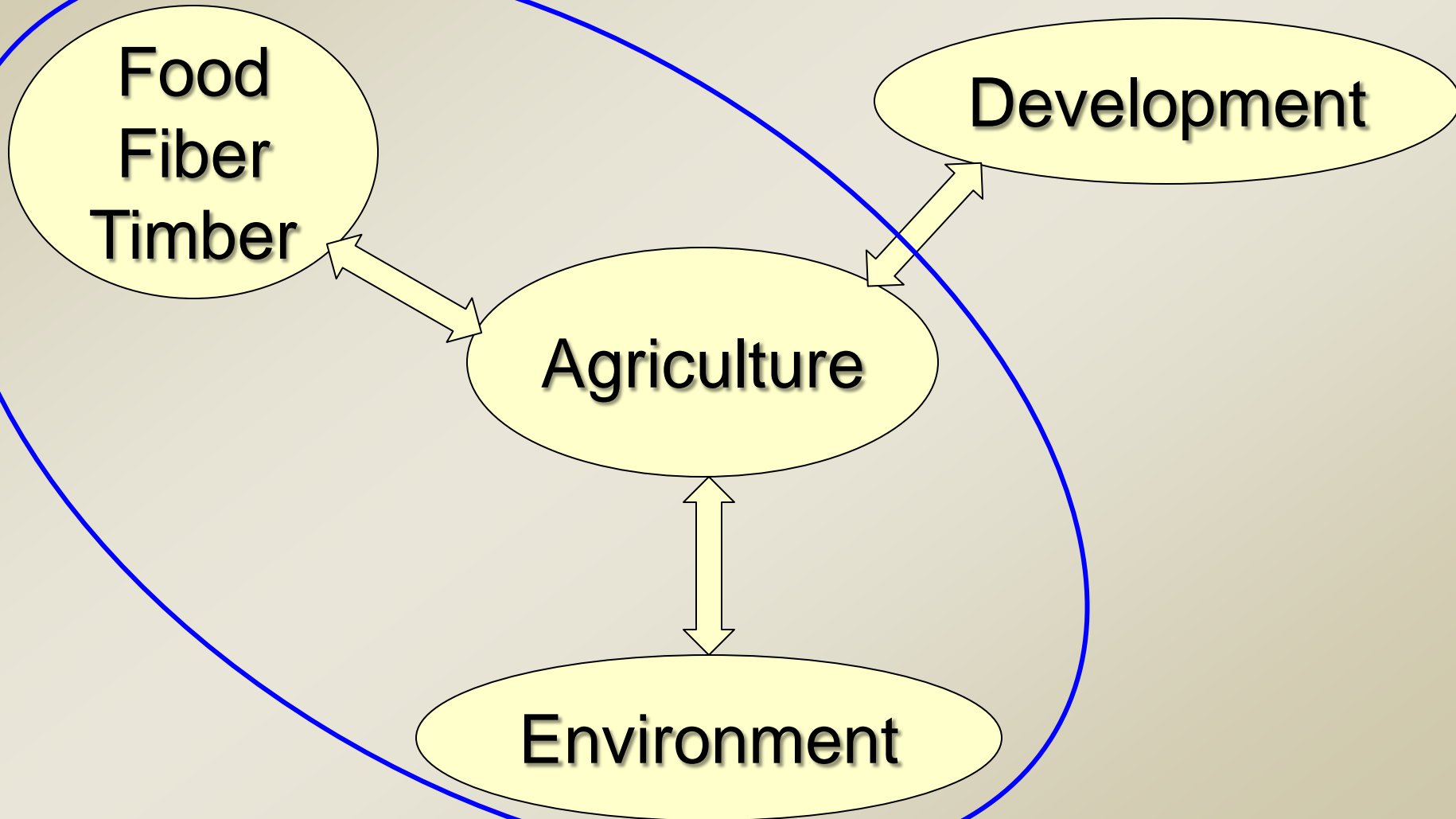


Global Agricultural Land Cover and Use: Data and Applications



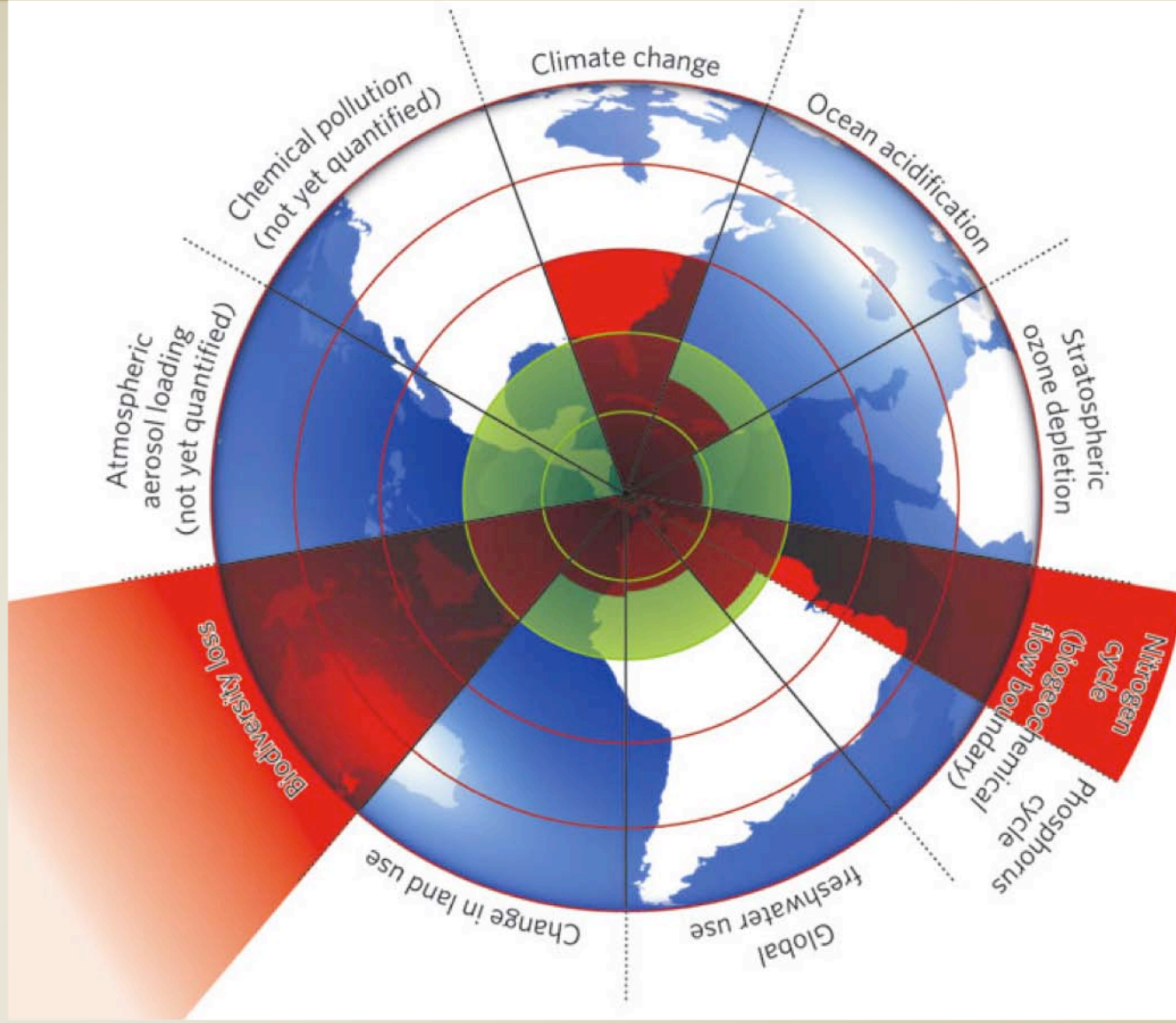
Navin Ramankutty
Department of Geography
McGill University (formerly SAGE, Univ. of Wisconsin)

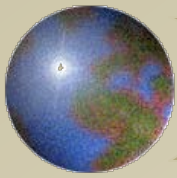
Critical role of agriculture



Planetary Boundaries

(Rockstrom et al. 2009)

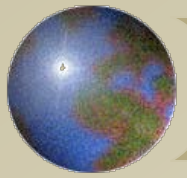




Planetary Boundaries

Planetary Boundary	Role of Agriculture
Climate change	20-30% of GHG
Biodiversity loss	Biggest driver (37% for birds)
Nitrogen & Phosphorus cycle	Biggest driver
Global freshwater use	70% of withdrawals
Change in land use	Biggest driver (34% of land)
Ocean acidification	9-15% of CO ₂
Chemical pollution	? (Pesticides)
Atmospheric aerosol loading	? (Biomass burning)
Stratospheric ozone depletion	

✚ Agriculture is a major driver!



Spatial databases

- ✦ Spatially explicit data are key for understanding the global role of agriculture
 - ▣ Location matters for understanding the food-environment-development tradeoffs
 - ▣ Impacts: GHGs, poverty, water quality, ...
 - ▣ Policies: production, development, conservation...
- ✦ Need to move beyond national statistics
- ✦ Global Earth observations need grounding

Data needed to understand tradeoffs between agriculture and the environment

Resources:

- Climate
- Population
- Land (soil)
- Water
- Cultivars
- Livestock
- Energy
- Other Assets

Economic and institutional factors:

- Land tenure
- Market Access
- Credit Availability

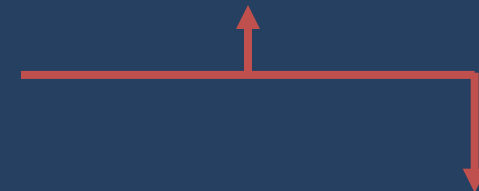
Environmental and socio-economic variables:

- Poverty
- Greenhouse gas fluxes
- Biodiversity
- Water quality
- Soil degradation



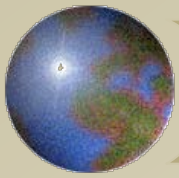
Management:

- Planting/harvest dates/cropping intensity
- Irrigation
- Fertilization
- Plant protection
- Labor
- Other management practices



Marketed products:

- Food
- Fiber
- Fuel
- Timber
- Carbon credits



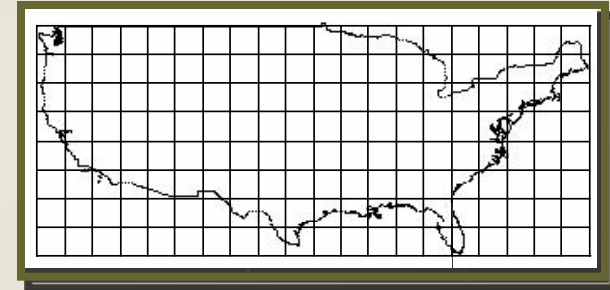
Earth observations

1. Interpolate between point observations
 - Historical climate (CRU)
 - Ecological (NPP)
2. Remote sensing
 - Land cover/Forest cover & change (GLC2000, SDSU/UMD)
 - Topography (SRTM, Aster)
 - Irrigation (IWMI)
3. Census data
 - Population (CIESIN)
 - Irrigation (Bonn/FAO)
4. Data fusion/models
 - Population (Landscan)
 - Urban areas (SAGE, GRUMP)
 - Agricultural land use/cover (M3, SPAM)

Sources of Global Land Data

✦ Satellite Data

- ✦ Spatially-explicit
- ✦ Consistent
- ✦ Only for the last ~40 yrs



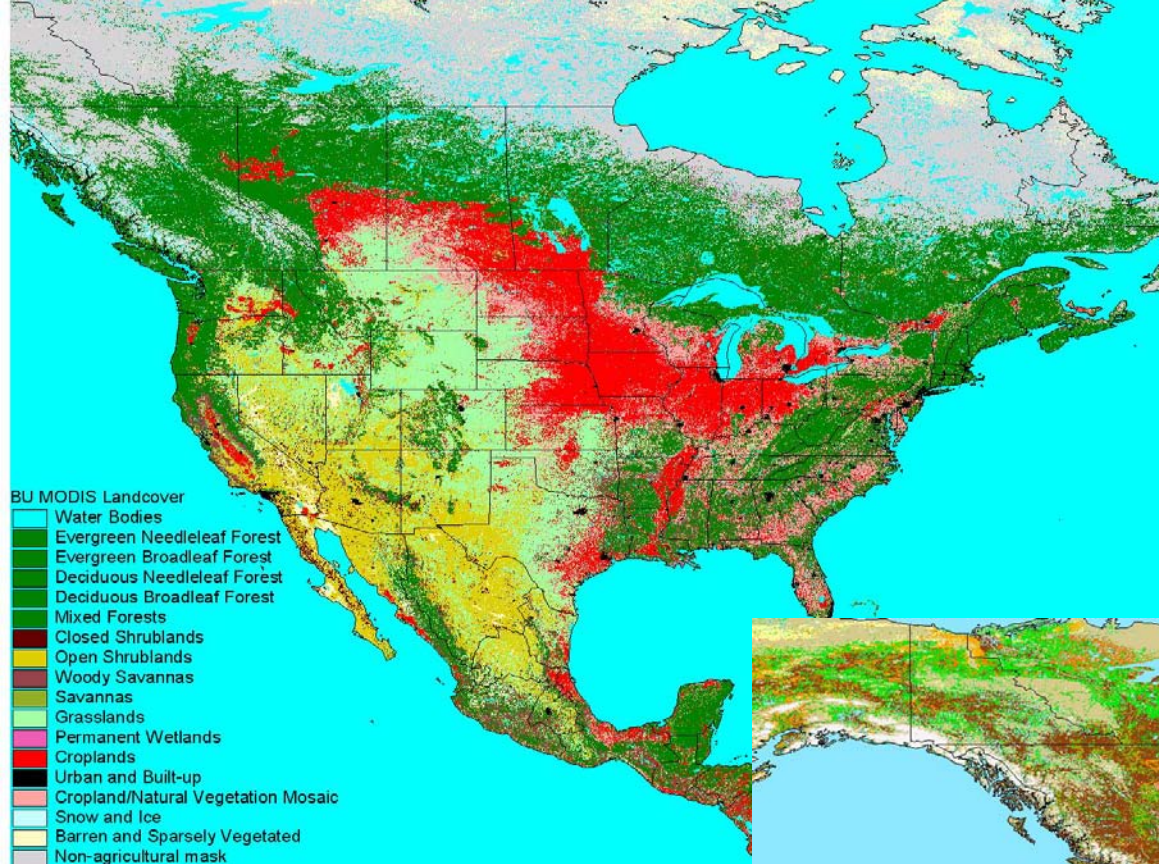
✦ Inventory/census Data

- ✦ Available for the last few centuries
- ✦ Collected at “administrative unit” level (countries, states, etc,...)
- ✦ Inconsistent



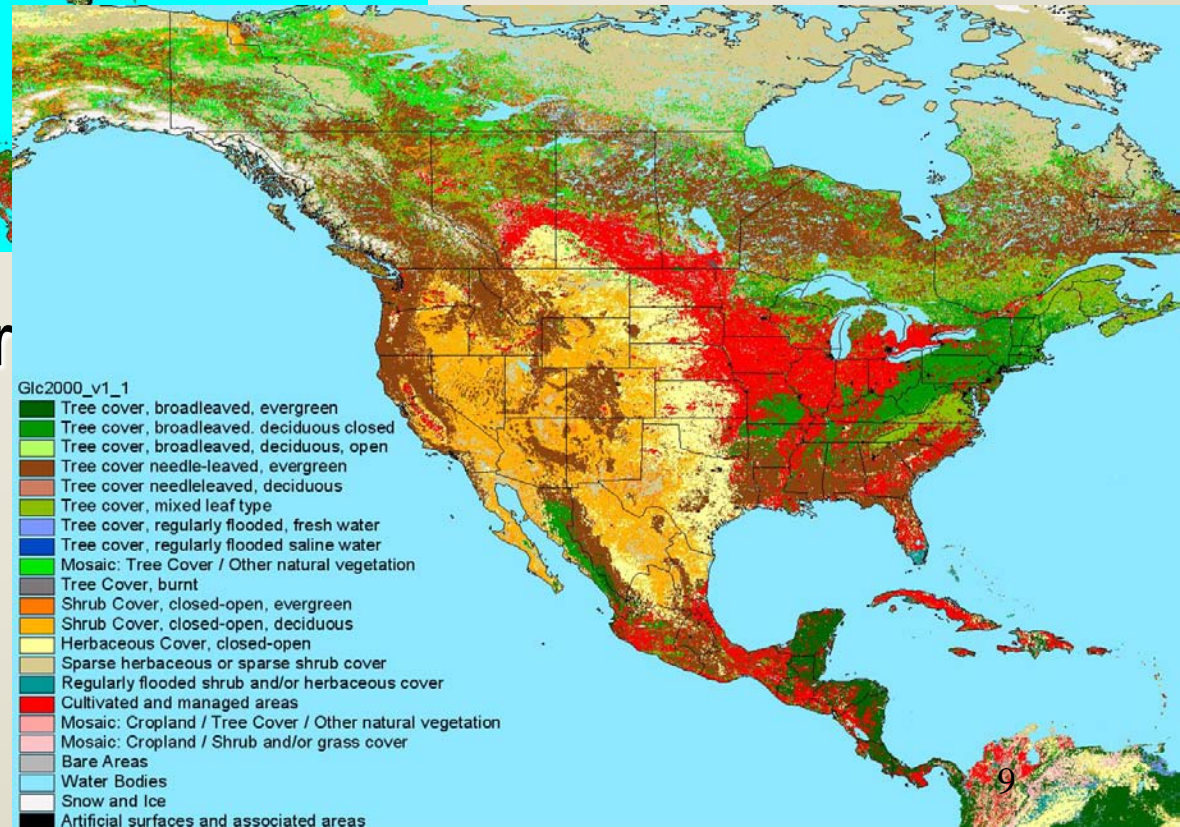
✉ *Statistical Data Fusion*

Satellite Data



- Water Bodies
- Evergreen Needleleaf Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Deciduous Broadleaf Forest
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up
- Cropland/Natural Vegetation Mosaic
- Snow and Ice
- Barren and Sparsely Vegetated
- Non-agricultural mask

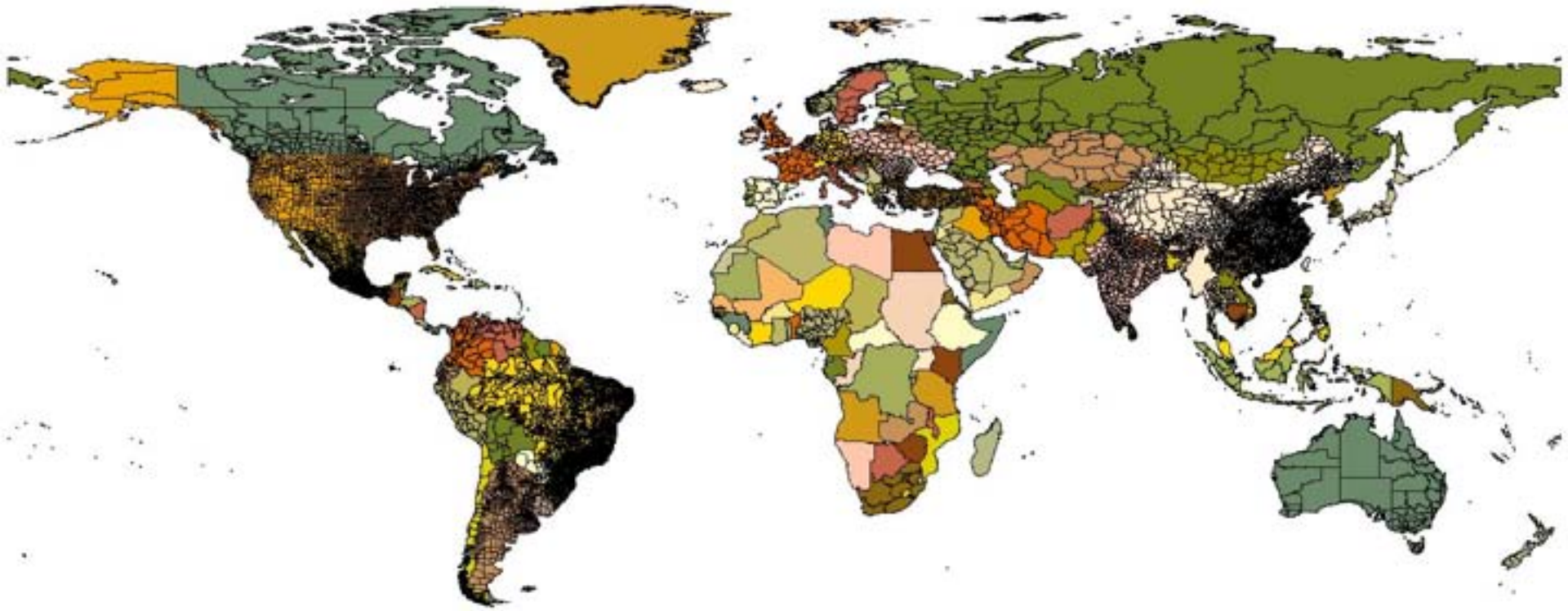
BU MODIS land cover



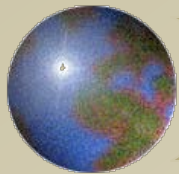
- Tree cover, broadleaved, evergreen
- Tree cover, broadleaved, deciduous closed
- Tree cover, broadleaved, deciduous, open
- Tree cover needle-leaved, evergreen
- Tree cover needleleaved, deciduous
- Tree cover, mixed leaf type
- Tree cover, regularly flooded, fresh water
- Tree cover, regularly flooded saline water
- Mosaic: Tree Cover / Other natural vegetation
- Tree Cover, burnt
- Shrub Cover, closed-open, evergreen
- Shrub Cover, closed-open, deciduous
- Herbaceous Cover, closed-open
- Sparse herbaceous or sparse shrub cover
- Regularly flooded shrub and/or herbaceous cover
- Cultivated and managed areas
- Mosaic: Cropland / Tree Cover / Other natural vegetation
- Mosaic: Cropland / Shrub and/or grass cover
- Bare Areas
- Water Bodies
- Snow and Ice
- Artificial surfaces and associated areas

GLC2000

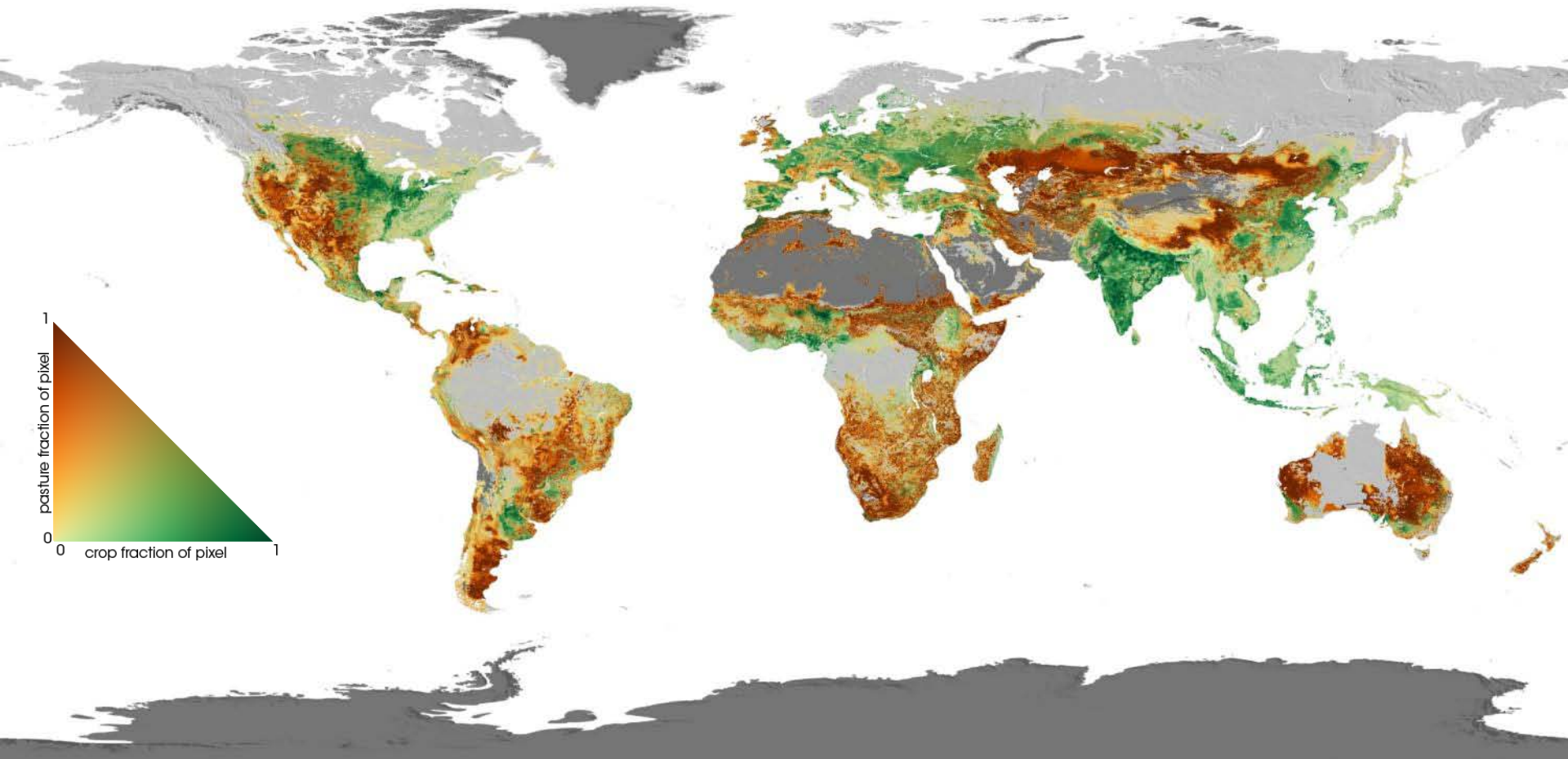
Global Census Data for Year 2000

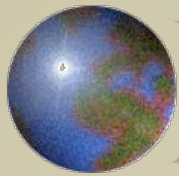


Ramankutty *et al.*, 2008



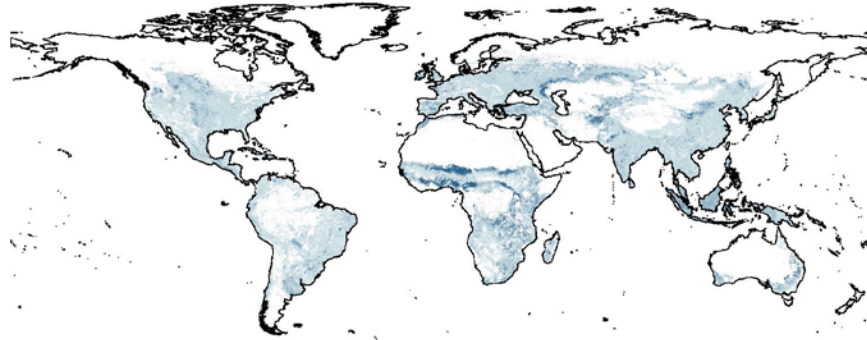
M3LAND (Cropland, Pasture in Yr 2000)





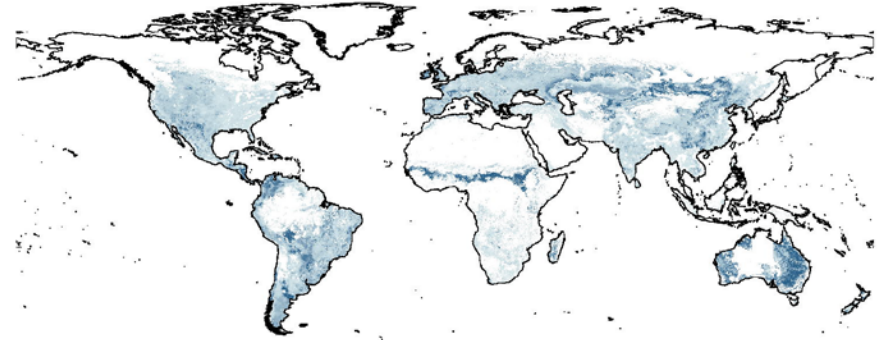
Uncertainty (Confidence Intervals)

Cropland: 5th percentile minus mean



0
<-30%

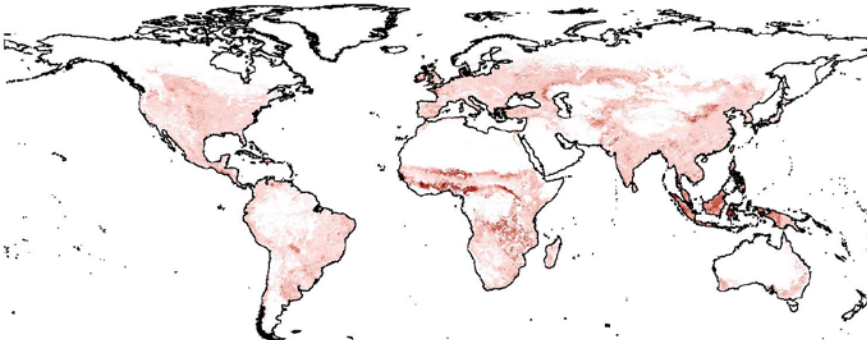
Pasture: 5th percentile minus mean



0
<-30%

Ramankutty et al., 2008

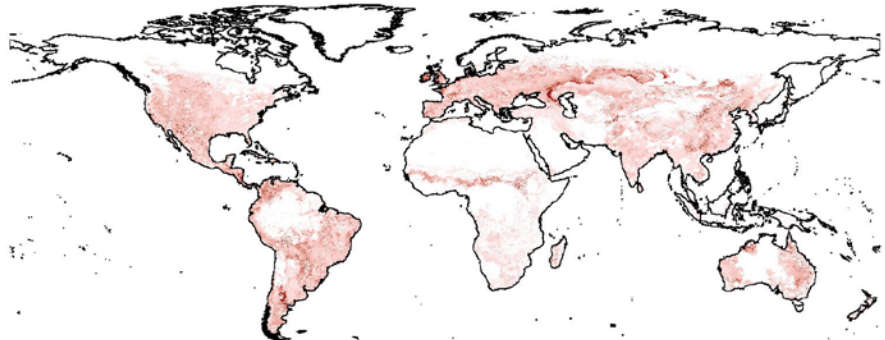
Cropland: 95th percentile minus mean



>30%
0

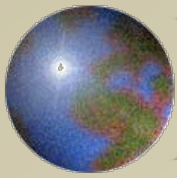
12.2-17.1 million km²
(33% uncertainty)

Pasture: 95th percentile minus mean



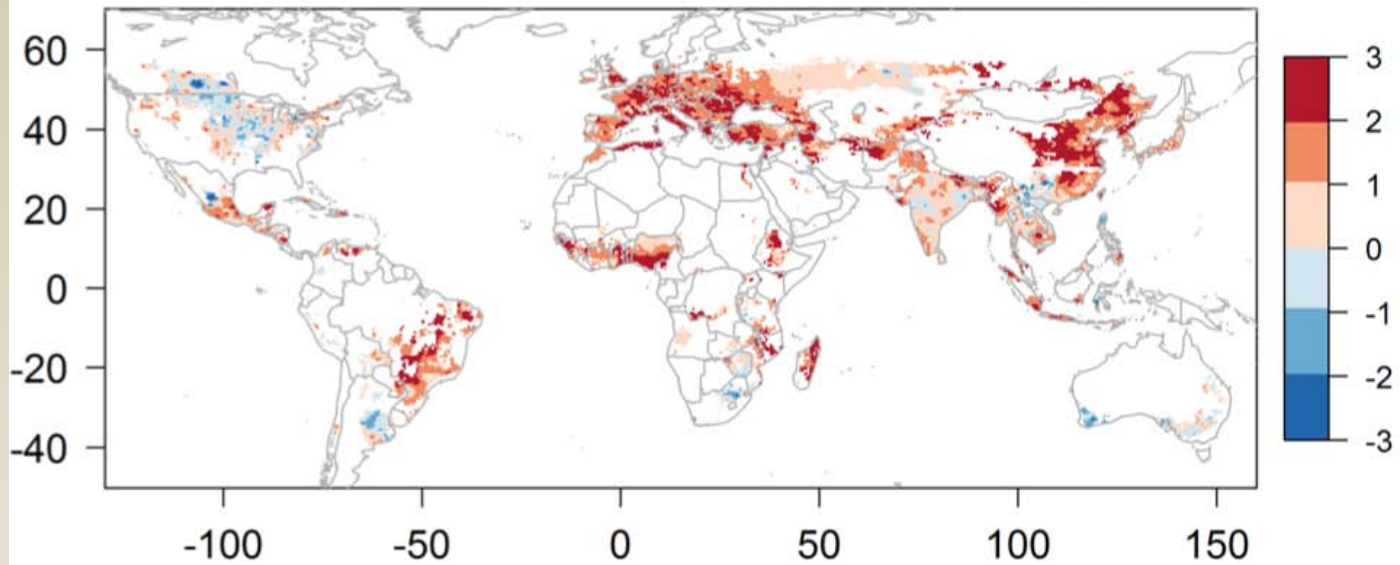
>30%
0

23.6-30.0 million km²
(23% uncertainty)

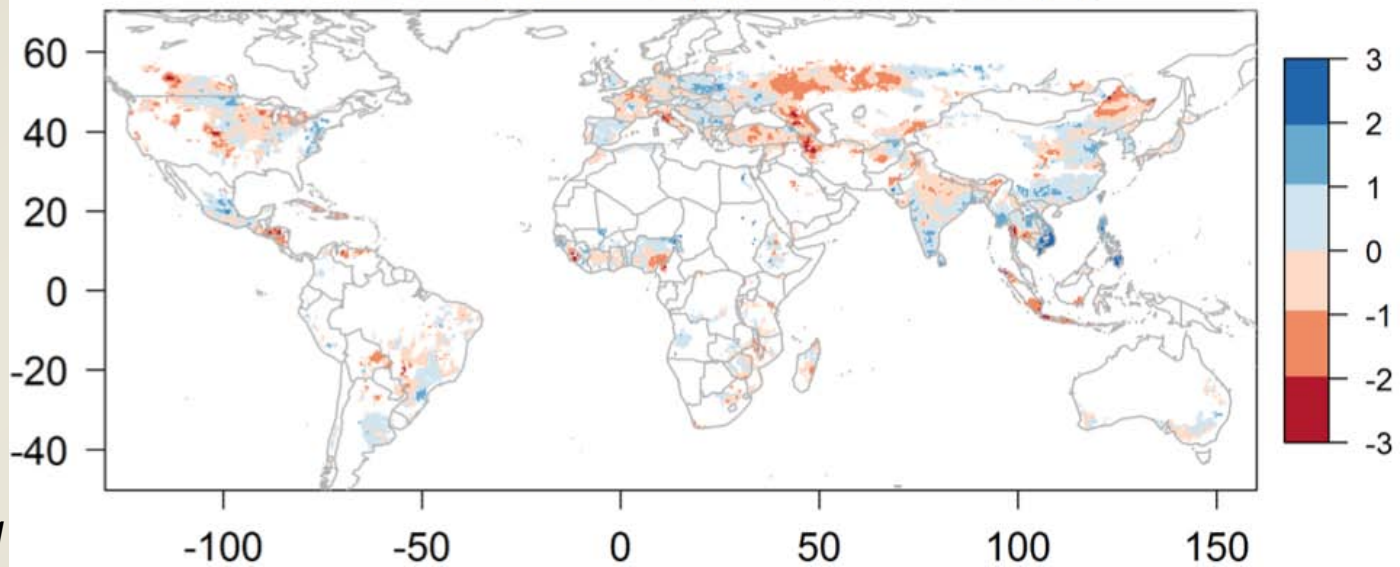


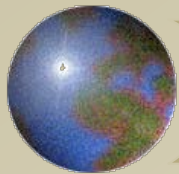
Application: Climate impact on crop yields

(A) Linear Trend in Temperature, 1980-2008 (sd)

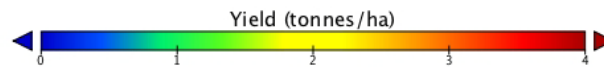
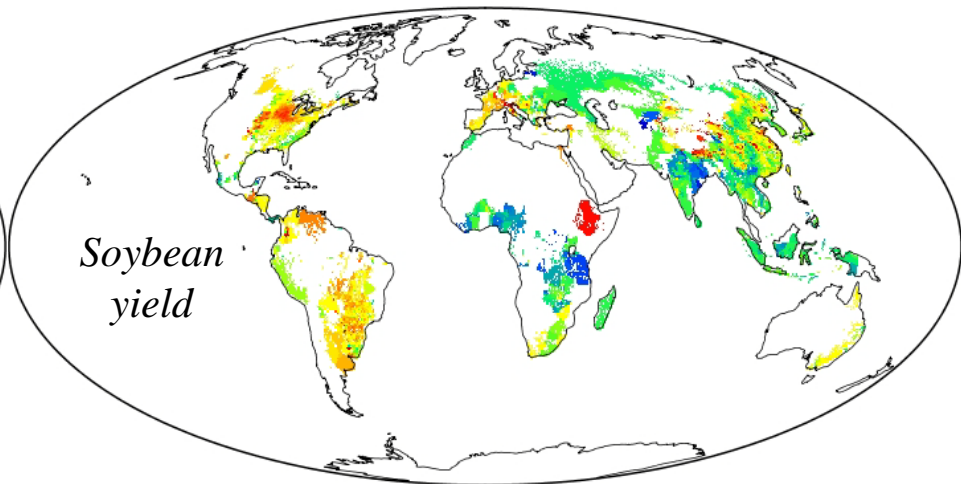
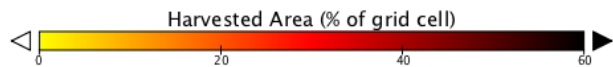
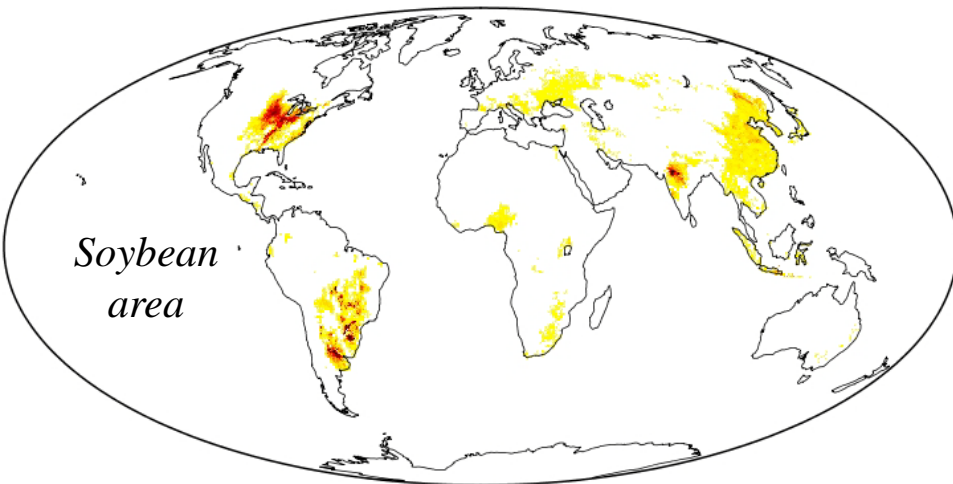
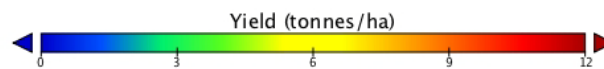
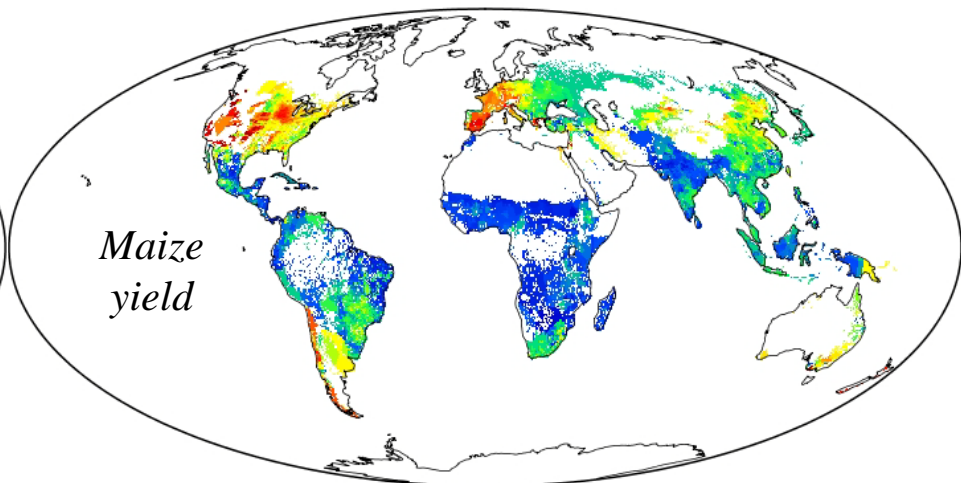
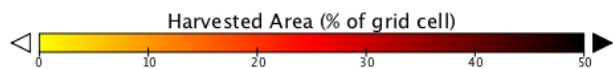
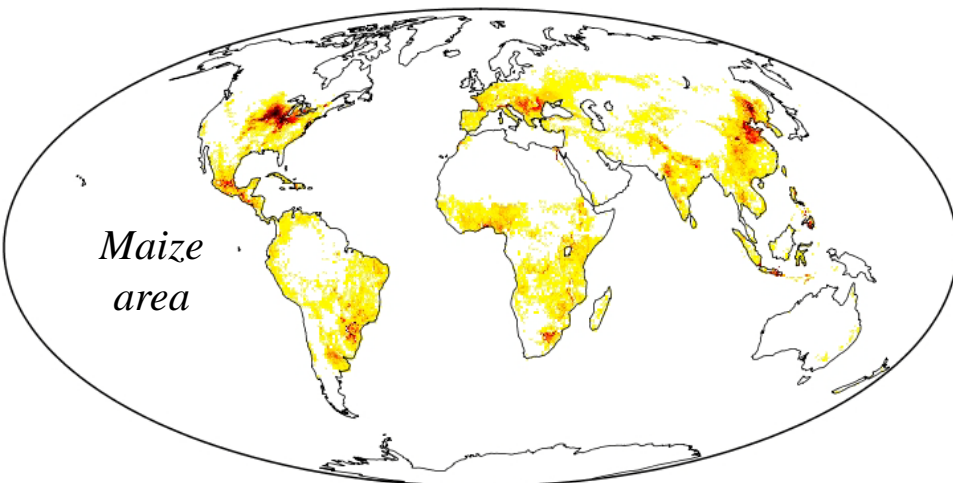


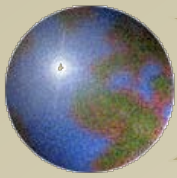
(B) Linear Trend in Precipitation, 1980-2008 (sd)





M3CROPS (Crop Area/Yield in Yr 2000 for 175 crops)

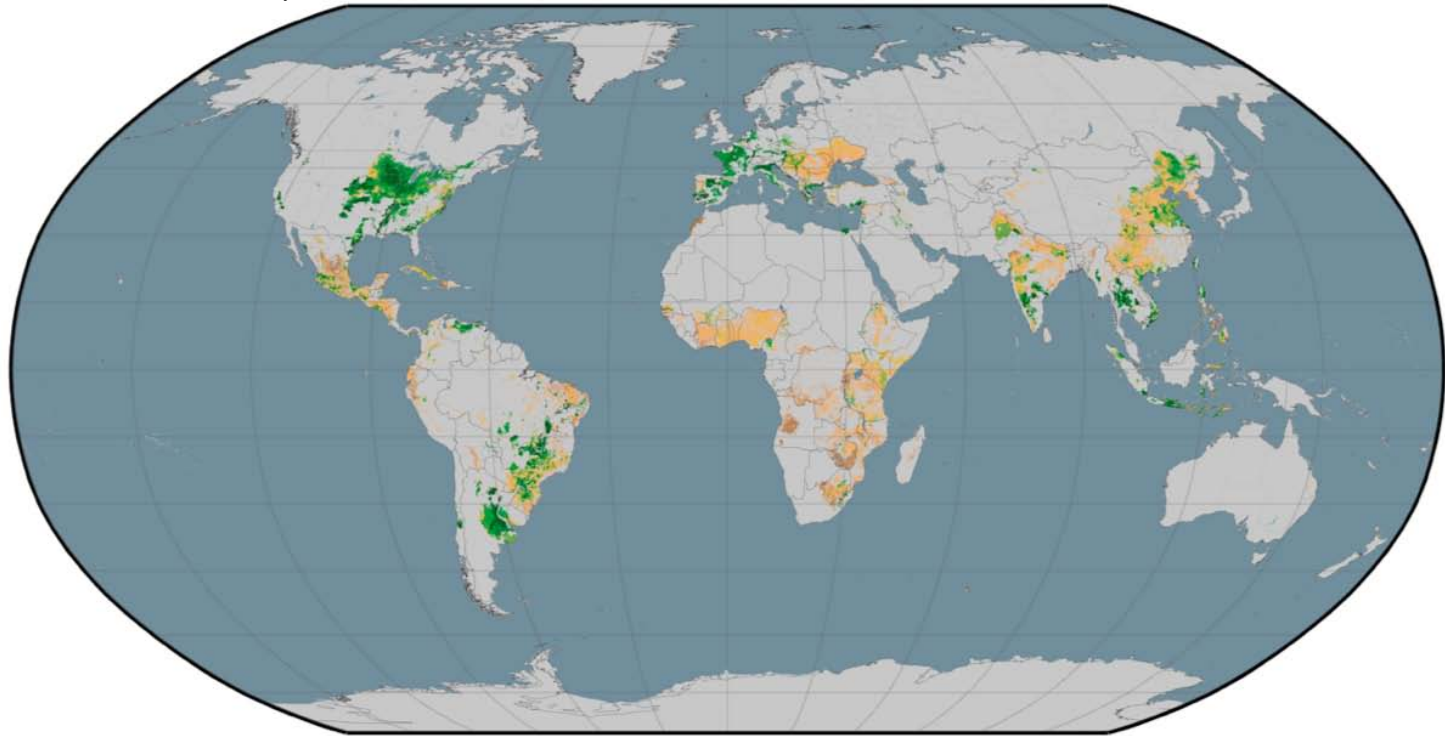




Application: Close yield gaps

(Foley, Ramankutty,
et al., submitted)

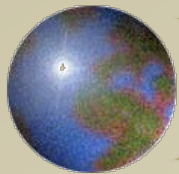
maize yield attainment



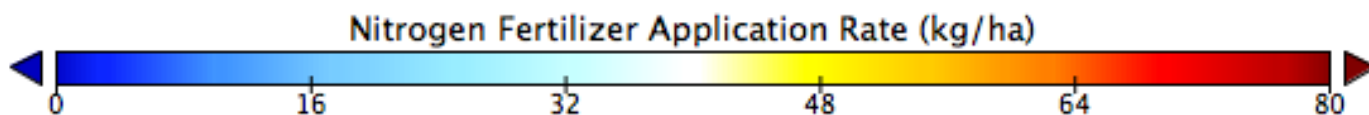
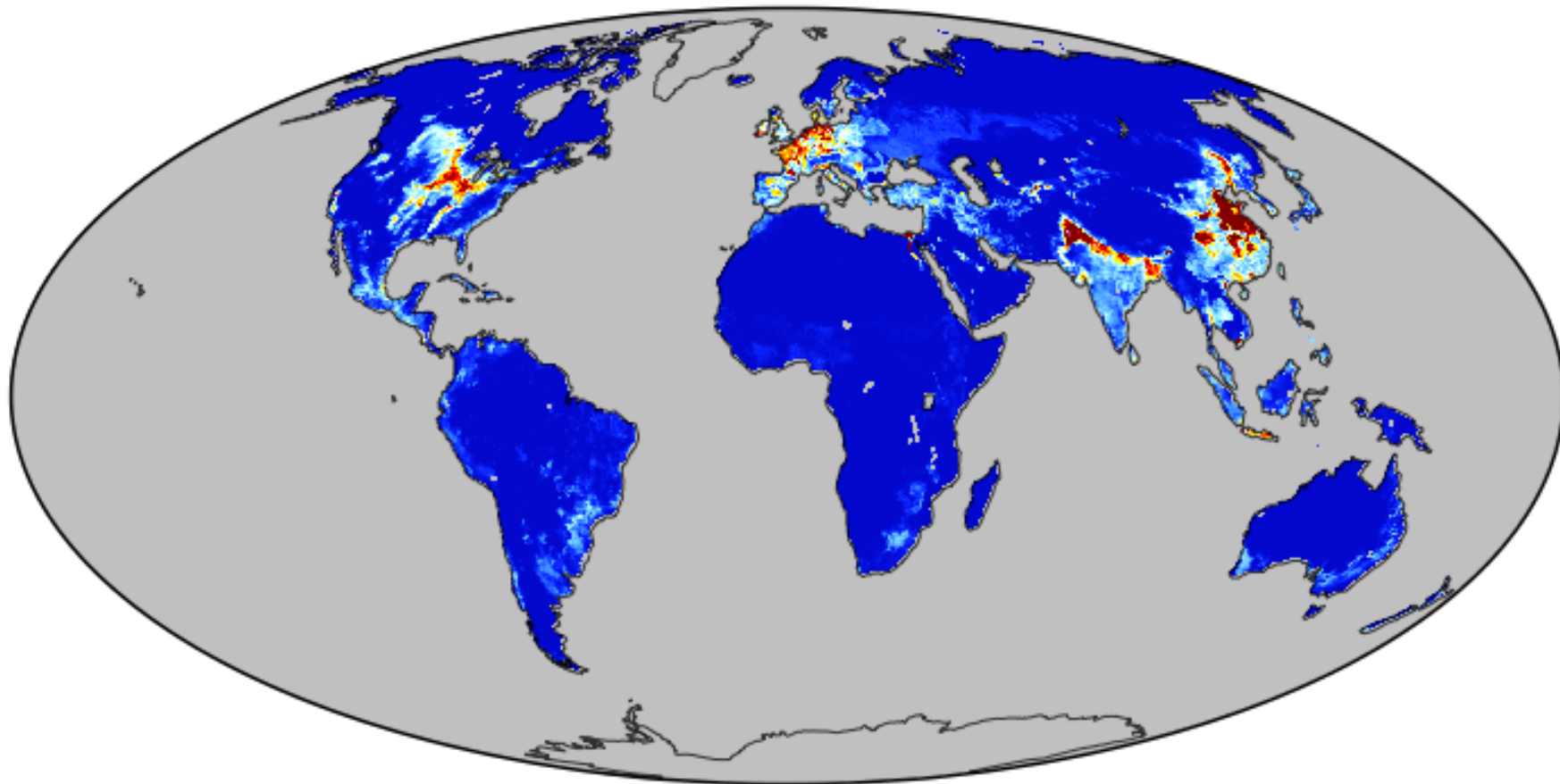
percent of potential yield attained

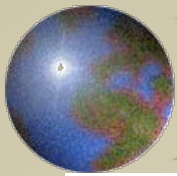


- ✦ Bringing yields of 16 crops to 75th %ile (95th) of potential would increase production by 28% (58%).



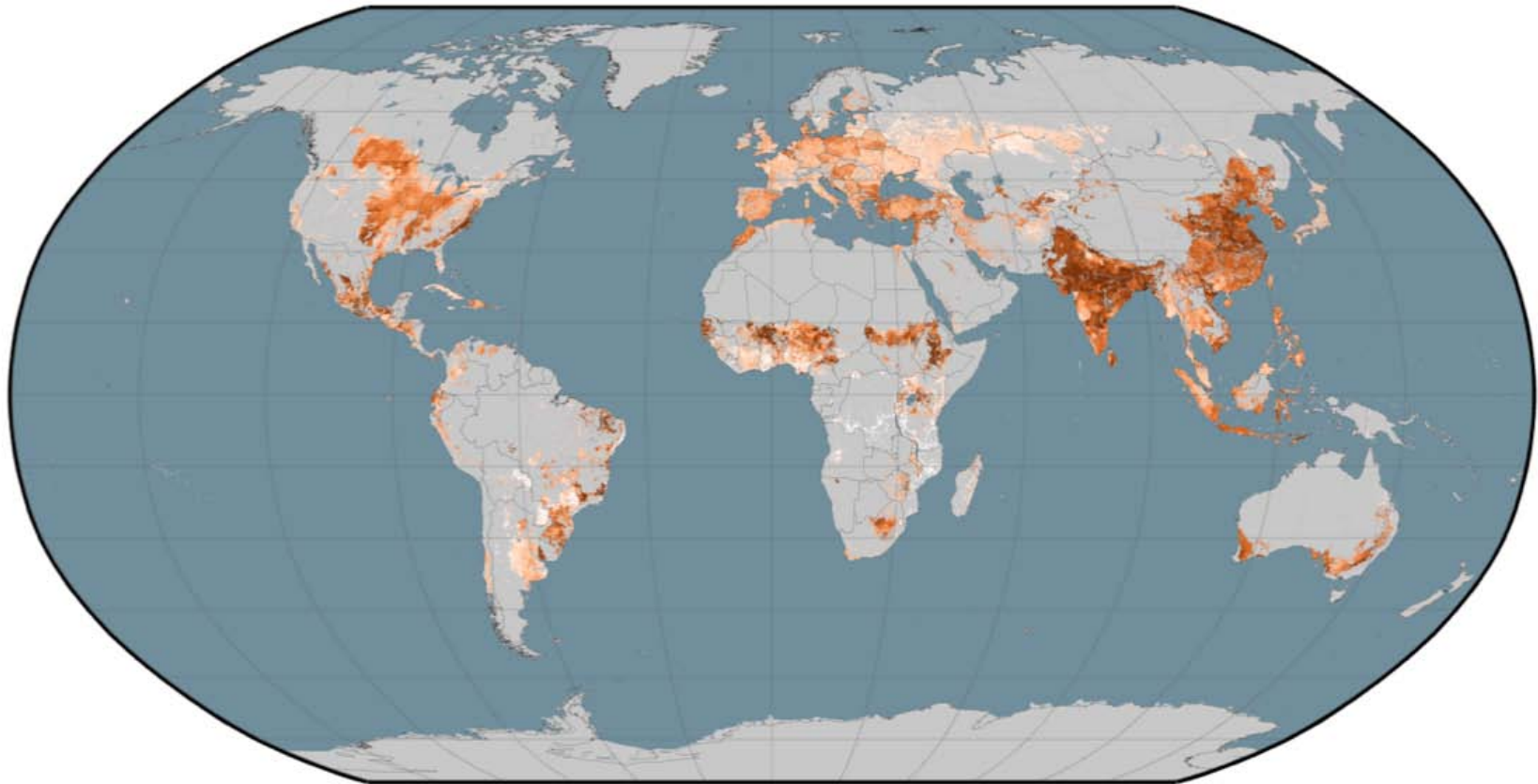
M3FERT (N/P/K Fertilizer application rates in Yr 2000)





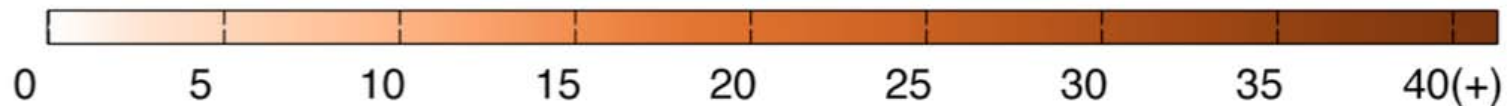
Application: Nutrient-use efficiency

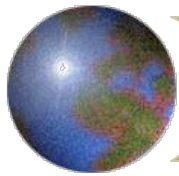
Applied nitrogen per ton yield



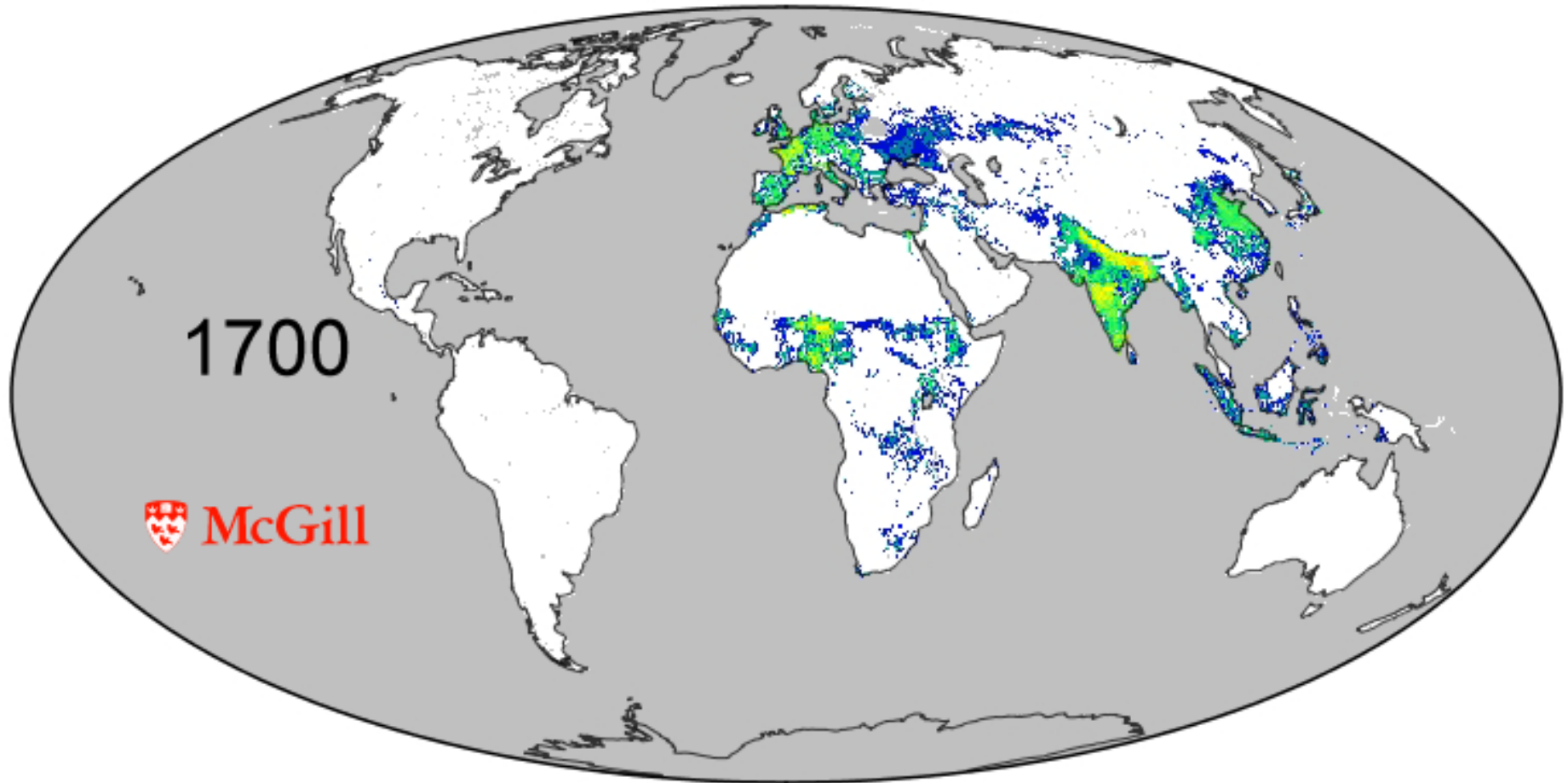
(Foley, Ramankutty,
et al., submitted)

kg N / ton

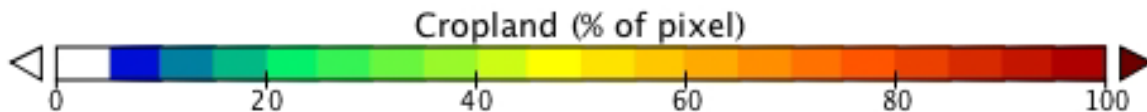




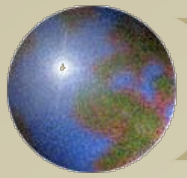
Historical changes



 McGill

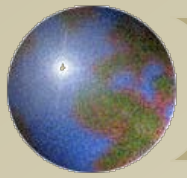


Ramankutty and Foley, 1999; Ramankutty et al., in prep.



Why fund this project?

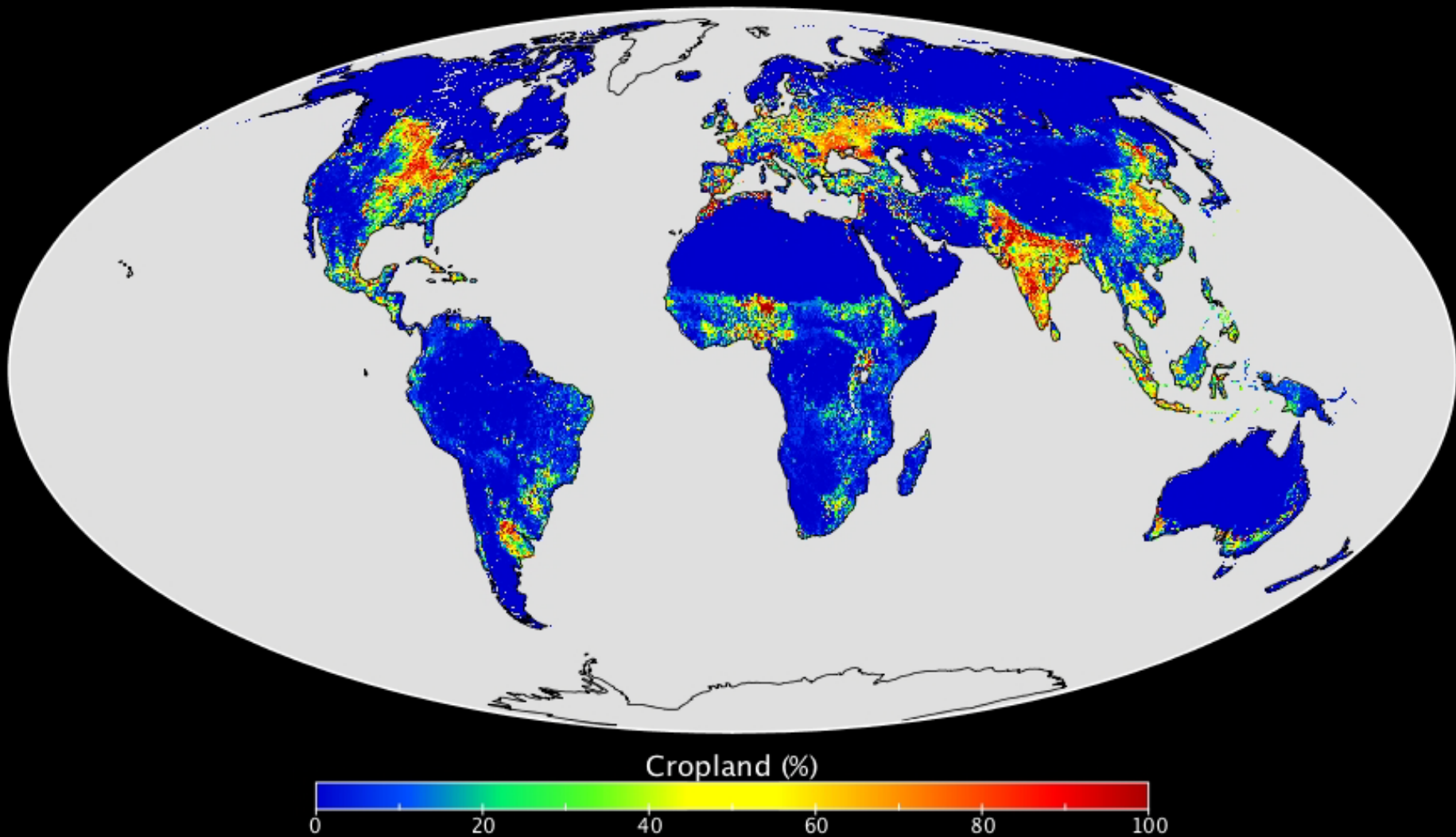
- ✦ Everyone loves data, but no one wants to pay for it.
- ✦ Gathering, reconciling, filling gaps in, data is tedious, often thankless, task
- ✦ Data development is not considered 'science'.
- ✦ We have a group of key players today, who have contributed in the past, and are excited about the opportunity to be funded to work together.

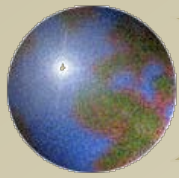


Experience working together

- ✦ AgroMAPS: Collaboration between FAO, IFPRI, CIAT, and SAGE (currently M3 @ Montreal-Minnesota-Madison).
 - ✦ Further led to development of M3CROPS, SPAM, MIRCA2000
- ✦ McGill and CIAT collaborated on a project showing that soybean expansion in Brazil was causing indirect deforestation (Barona et al. 2010).
- ✦ Bonn and McGill are collaborating to develop historical irrigation time series.
- ✦ Purdue and McGill have collaborated to enhance land use by AEZ into GTAP database.

THANK YOU!





Future Database Needs

Data Needs	Purpose
Disentangle arable land from harvested area (Fallow, multiple cropping, crop rotations, crop failure,...)	Productivity change, Climate impacts
Pasture versus Grazing land; Landless livestock	Climate change (biophysical, CH ₄ emissions)
Land cover transitions (forest <-> cropland; forest <-> pasture, etc.)	Climate change (CO ₂ emissions)
Historical crop area and yield data	Productivity change, Climate impacts
Crop-specific irrigation, fertilizer use, pesticide use, mechanization	Productivity change, Water quantity & quality