Modelling sustainable grazing land management

Relevant research in Agriculture and Global Change Programme

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Outline of relevant research in CSIRO Agriculture and Global Change Programme

- Grazing land assessment for soil C sequestration
  - Global Sequestration potential of grazing management and legume sowing
  - Century (soil, forage, C); GLEAM (livestock production, GHGs)

- G-Range [Global Rangeland model]
  - Simplified representation of Century, covering the world's rangelands

- Global forage/feed database activities
  - Based on PNAS study by Herrero et al. (2013)
  - Combines spatial data on forage/feed, animal production, GHGs

- Brazilian grazing land intensification study
  - Joint study between CSIRO, University of São Paulo, CTBN (Campinas), TNC (Brazil), Chalmers University
  - Assess potential for intensification

- Summary of weaknesses in global spatial data for grazing lands modelling. How can GEOGLAM RAPP help?

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Grazing lands – some facts

- Grazing systems: Largest land use system on Earth – 26% of all ice-free land
- Supply almost 50% of biomass consumed by livestock
- Grazing systems contribute:
  - 25-40% of global small ruminant meat production
  - 30% of global small ruminant milk production
  - 22% and 55% of beef production in Latin America and Oceania
- Maintain the livelihoods of large numbers vulnerable people
- Maintain significant supplies of ecosystems services (carbon, water, biodiversity)

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Grazing land assessment :
soil C sequestration

FAO, CSIRO, CSU

Grazing land assessment – soil C sequestration

- Collaborative effort [FAO, CSIRO, CSU]
- Identifying/calculating grazing land area
  1. Maximum spatial extent of world's grazing lands was defined by grassland/woodland land cover classes in GAEZ data layers (IIASA/FAO, 2012).
  2. Area adjusted to match national permanent pastures/meadows in FAOSTAT
  3. Areas without animals according to FAO's GLW data (FAO 2007, 2011), were excluded, leaving 2.6 billion ha [< FAOSTAT's 3.4 billion ha]
  4. Mask of grazing lands, separating rangelands and pasturelands:
     a) Rangelands: info about native vegetation was derived for the Potsdam model inter-comparison study
     b) Pasturelands: obtained residually

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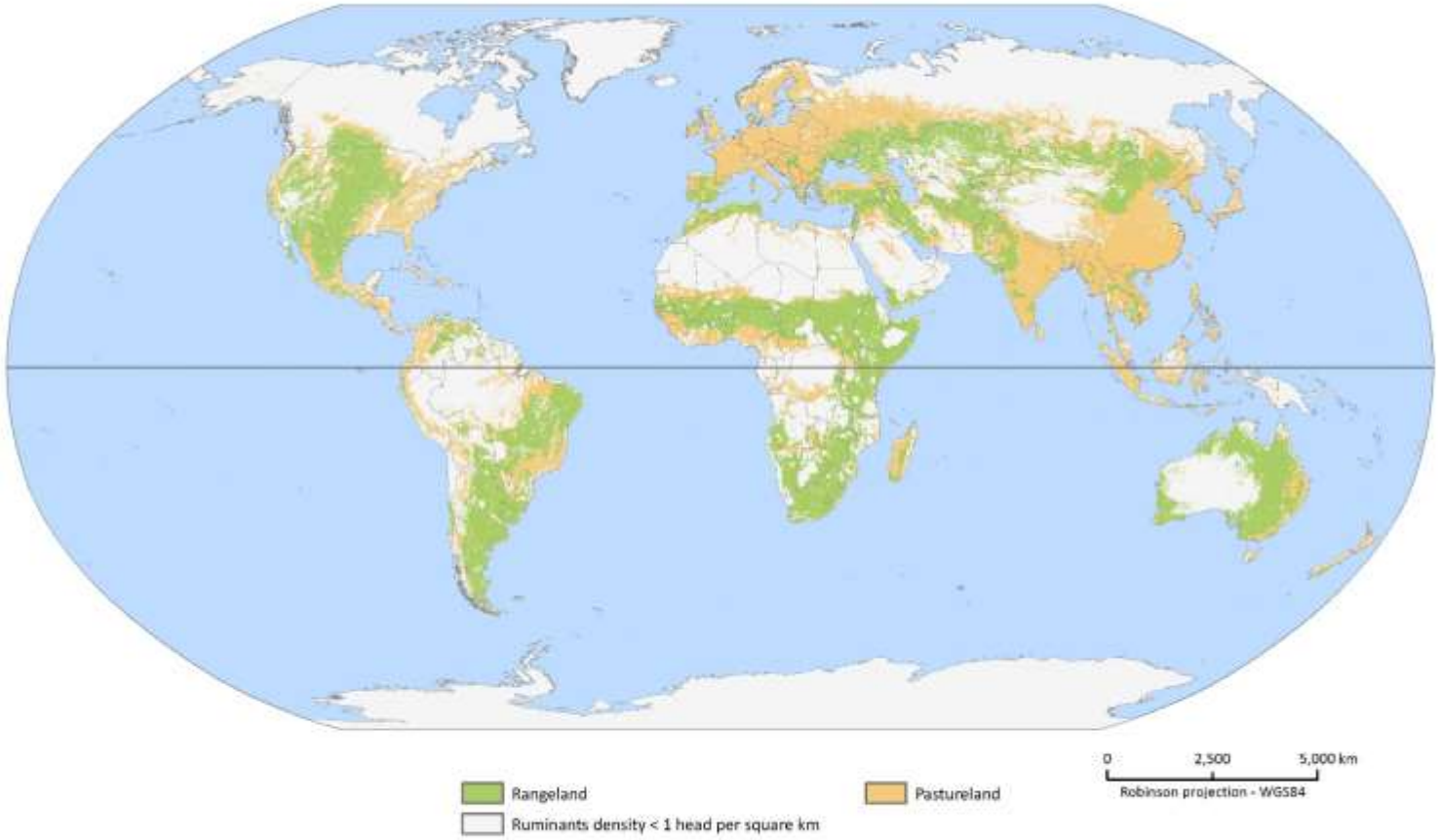
Grazing land area mask



Rangelands: 1.84 billion ha Pasturelands: 0.74 billion ha

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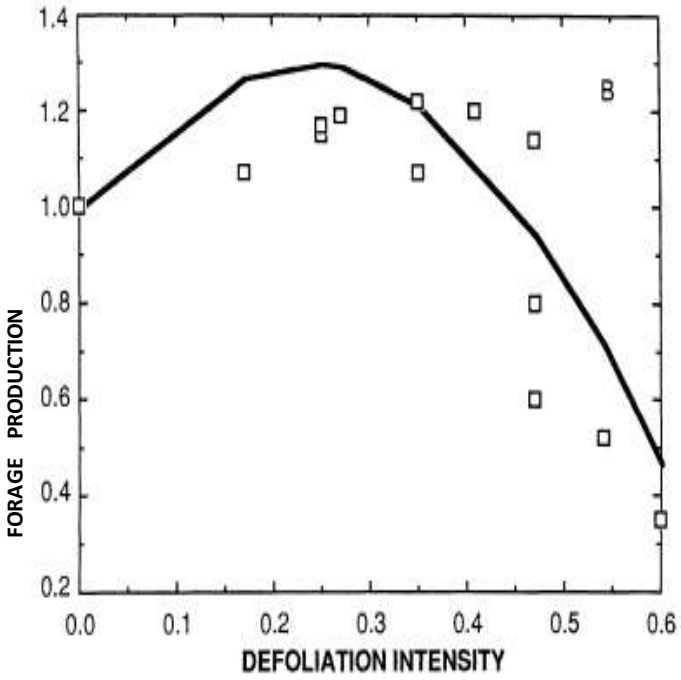
Grazingland practices

Each scenario: 20 years

- Grazing management (Century):
  - ruminant forage offtake rates adjusted, to maximize forage production:
    - rates ↑ in under-utilized grasslands, and
    - rates ↓ in over-utilized grasslands.
- Legume sowing (Daycent model):
  - Only applied in pasturelands
  - Legumes oversown with grass, approx. 20% cover

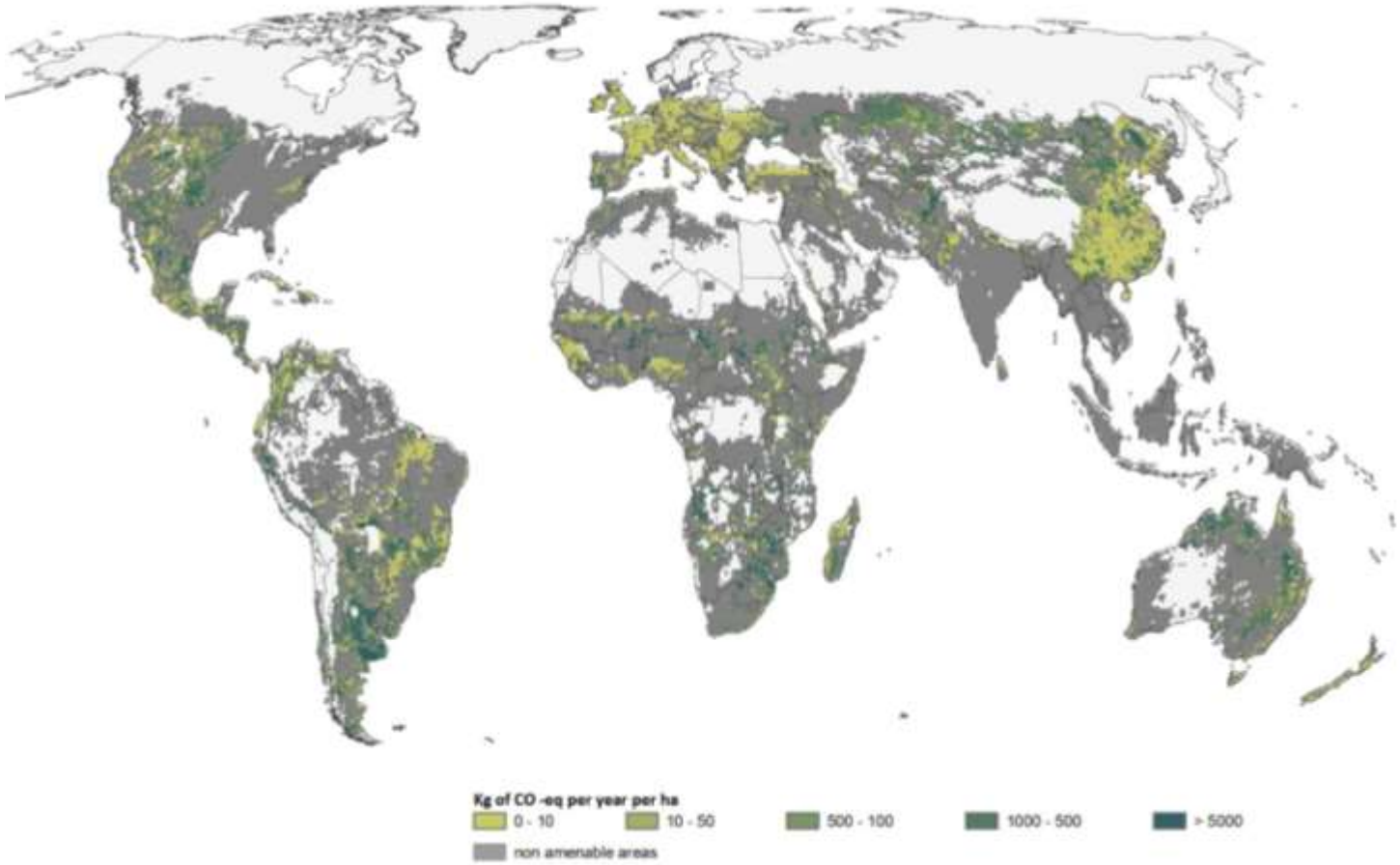


Holland et al. 2011.

Soil C sequestration: grazing management

Grazing manag. = **148** $MtCO_2 yr^{-1}$
- applied over 712 million ha

Legumes = **147** $MtCO_2$-eq yr^{-1}
- applied over 72 million ha



Henderson et al. (2015). Agriculture Ecosystems Environment

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Global rangeland model: G-Range

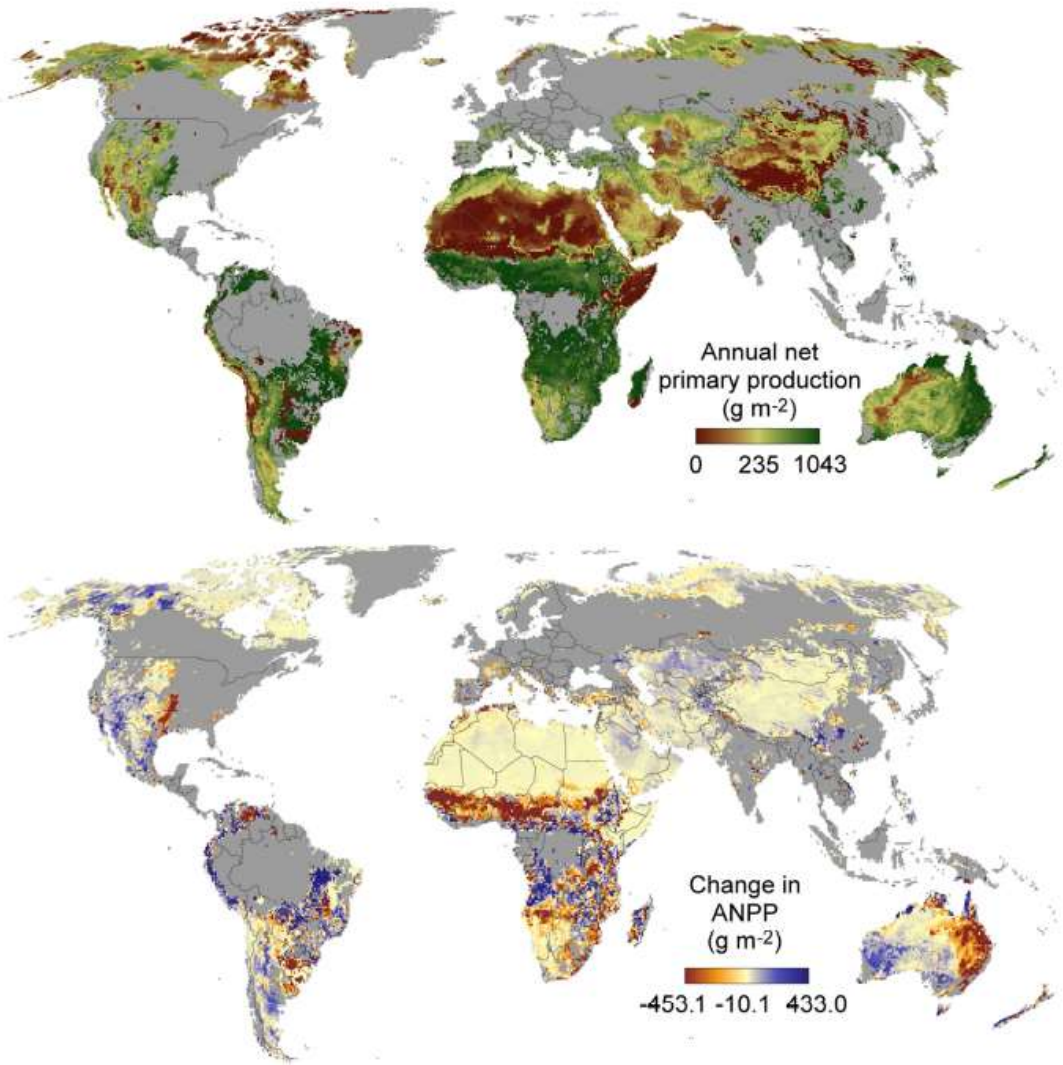
CSIRO, CSU, ILRI [CCAFS]

Global rangeland models

G-Range created to:

- Represent global rangelands, with moderate complexity: more user friendly than Century
  - Simplified representation of Century – tracks biogeochemistry in a gridded global landscape
- Respond to main climate variables
- Represent main functional biomass groups
- Responsive to fire, grazing intensity, and other management practices
- Permit change in shares of vegetation types over time
- Randy Boone, Rich Conant, Jason Sircely, Jared Stabach
- With support from: CSIRO, ILRI (CCAFS)

G-Range results (1)



Changes in ANPP from 1997/2006 to 2050/59 RCP 8.5:

- ANPP ↑ >= 250 gm^{-2} in areas of equatorial South America & Central Africa,
- ANPP ↓ >= 250 gm^{-2} in African rangelands bordering tropical forests, S Africa, E Australia, & parts of Argentina, & eastern Great Plains.

- G-Range does not presently include animals

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Boone et al, in preparation

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Global feed/livestock database

Herrero et al PNAS 2013

Global Feed/livestock database (Herrero et al PNAS 2013)

- Biologically consistent, spatially disaggregated global livestock dataset
- Combines feed data with herd model (DynMod) and animal model (RUMINANT), and estimates:
  - biomass use, production, feed efficiency, excretion, and greenhouse gas emissions for 28 regions, 8 livestock production systems including ruminants and monogastrics:

- Results provided at 10x10km grid cell level
- Relevant highlights:
  - Importance of grasslands as global resource:
    - Supplying almost 50% of biomass for animals
    - feed efficiency as a key driver of productivity, resource use, and GHG intensities
  - Database being used in a number of additional studies (GLOBIOM, yield gaps)

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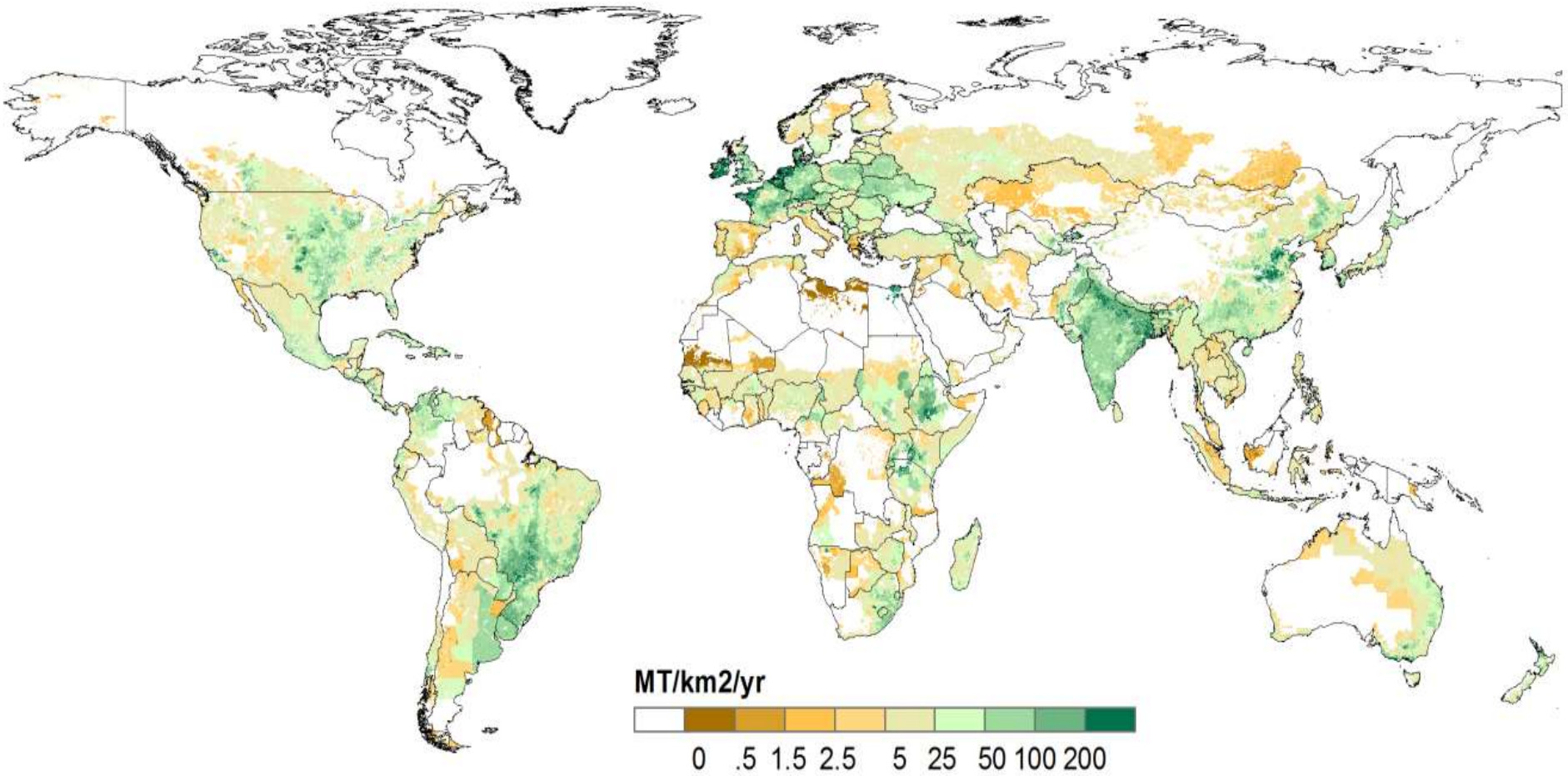
Grazed biomass from livestock (Herrero et al PNAS 2013)



Grass represents 48% of the biomass consumed by livestock: 2.3 billion tonnes

Brazilian grazing land intensification study

CSIRO, University of São Paulo, CTBE (Campinas), TNC (Brazil), Chalmers University

Brazilian grazing land intensification study

- Joint effort between Australian, Brazilian and Swedish institutes [CSIRO, University of São Paulo, CTBE (Campinas), TNC (Brazil), Chalmers University]
- Main objectives:
  - assess **potential** for increased productivity in Brazilian beef production, using **high-resolution**, detailed **physical** and **economic** modeling
  - assess GHG mitigation from ↑ productivity
  - Overcome current limitations:
    - lack of biophysical detail, and high spatial aggregation in equilibrium models (e.g. GLOBIOM, MAgPIE)
    - lack of explicit economic analysis

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Herbage and grazing modeling

- **Herbage growth** and senescence rates from DSSAT model
- **Liveweight gain** (*LWG*) rates from RUMINANT model
- All calculations at pixel level; with monthly time step (*t*)

- **Optimization**
  - stocking rate feedback on herbage intake level and sward state (net growth, tillering)
  - different objectives for growing vs adult animals

- Economic model linked to detailed biophysical model

Summary of weaknesses, needs, and conclusions

"According to the data, there were 28.0 million km2 of pasture (22%) in the year 2000 (90% confidence range of 23.6–30.0).”

Ramankutty et al 2008

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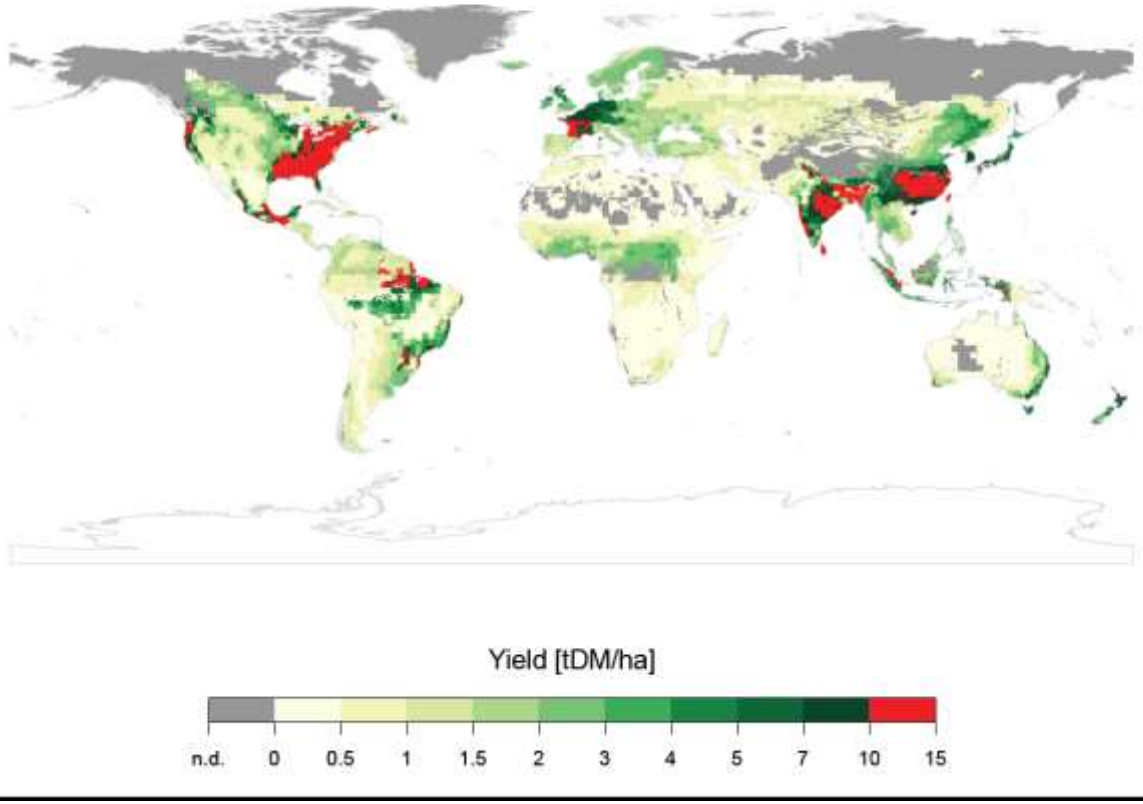
Large discrepancies in rangeland productivity maps



Havlik et al … (EPIC) and Century

We know very little about extent of Grazing lands, but we know even less about average yields

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Next steps in global grazing land modelling

1. Improve accuracy of input layers (G-Range & PNAS database):
    1. rangeland extent, cover, productivity, management history
    2. Include planted pastures

2. Make explicit link with animal numbers, production and forage consumption (G-Range)
    - CSIRO to take lead role

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Conclusions

Great progress in the last decade,

…but still some key issues not solved.
Where GEOGLAM RAPP could help by providing better data

Grazing land:

- Area mask
- Productivities
- Management intensity and input use
- Identify areas that can be intensified
- Responses to grazing and other management options

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Thank you

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