Of cows and cars

Improving pasture-based animal production to make room for biofuels

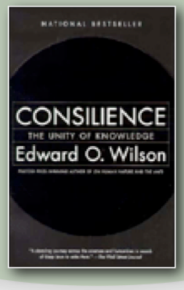
John Sheehan

PhD candidate
natural resources science and management

...where my passion lies

Sustainable development

“The common aim must be to expand resources and improve quality of life for as many people as heedless population growth forces upon Earth, and do it with minimal prosthetic dependence. That, in essence, is the ethic of sustainable development.”



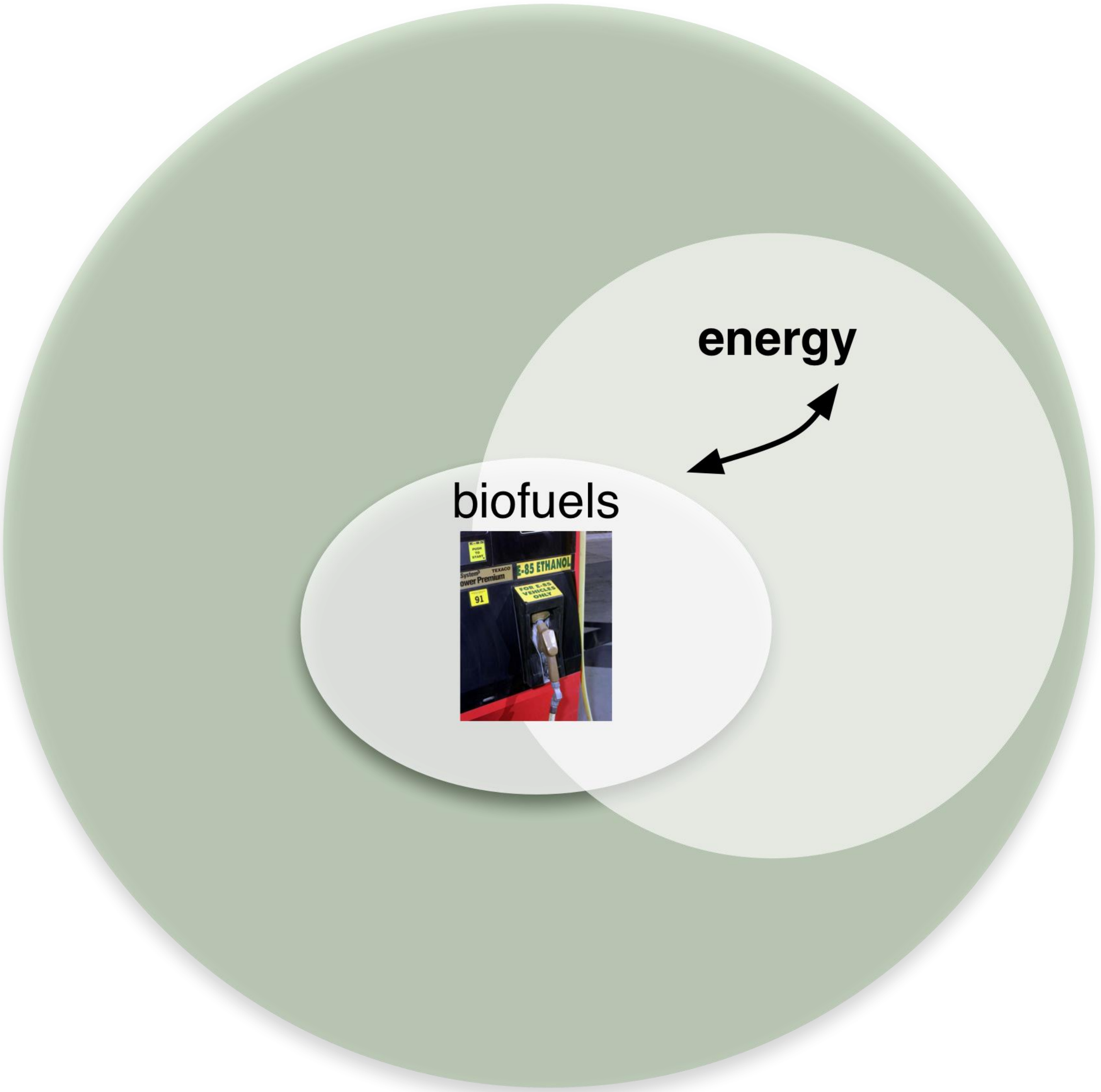
an ethical perspective

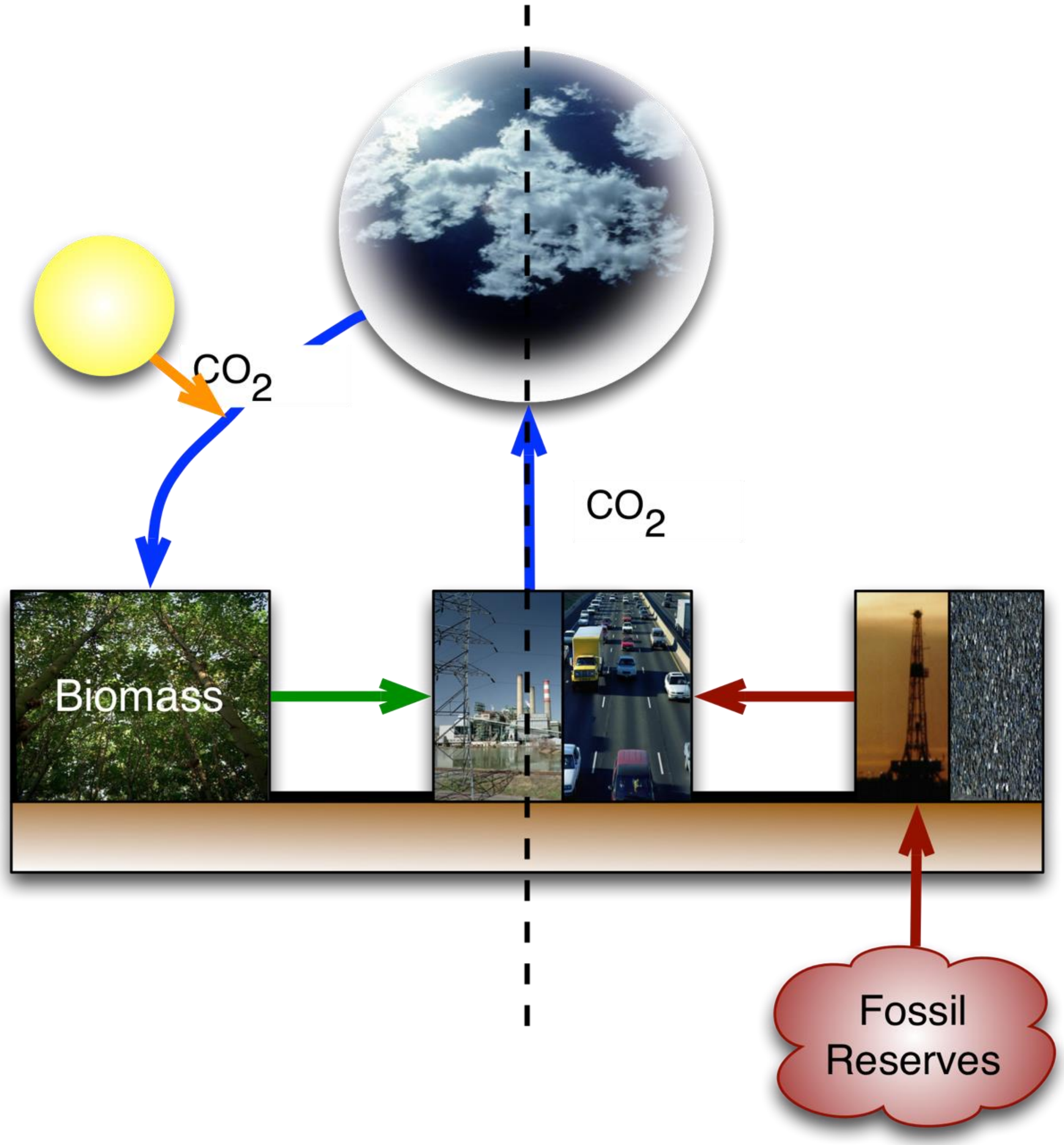
and a systems view

...narrow beginnings

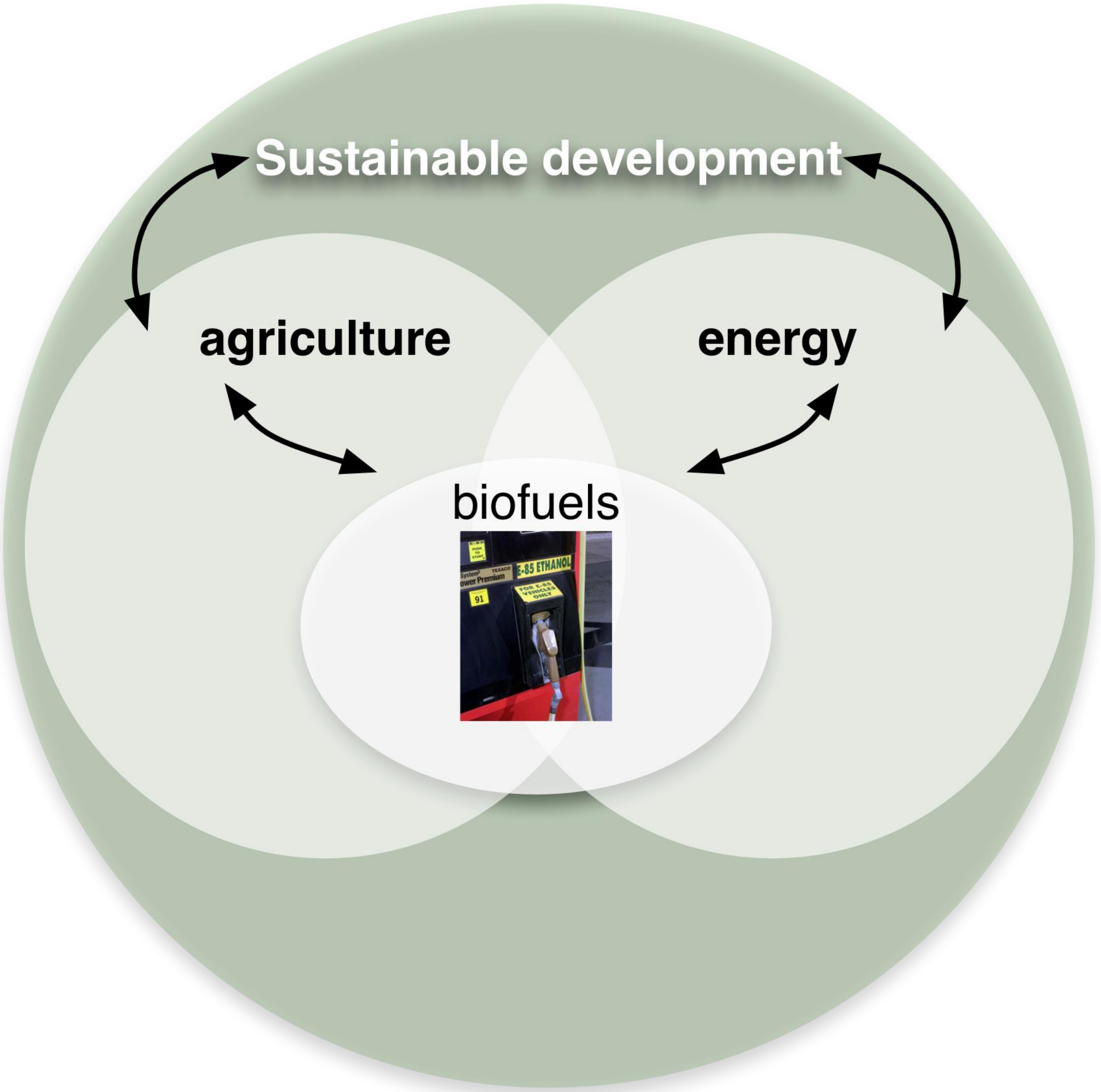
biofuels

...an expanded view

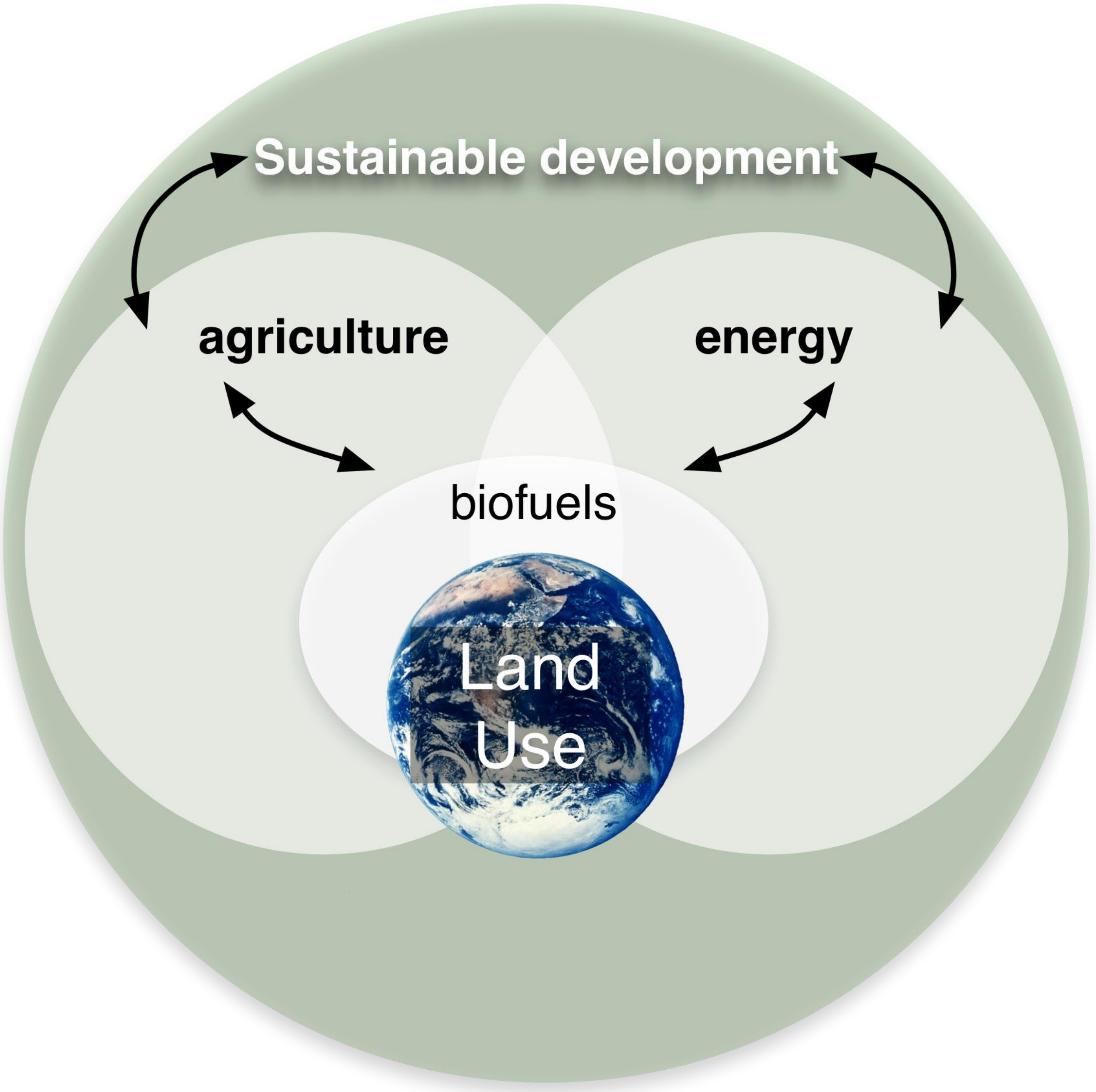


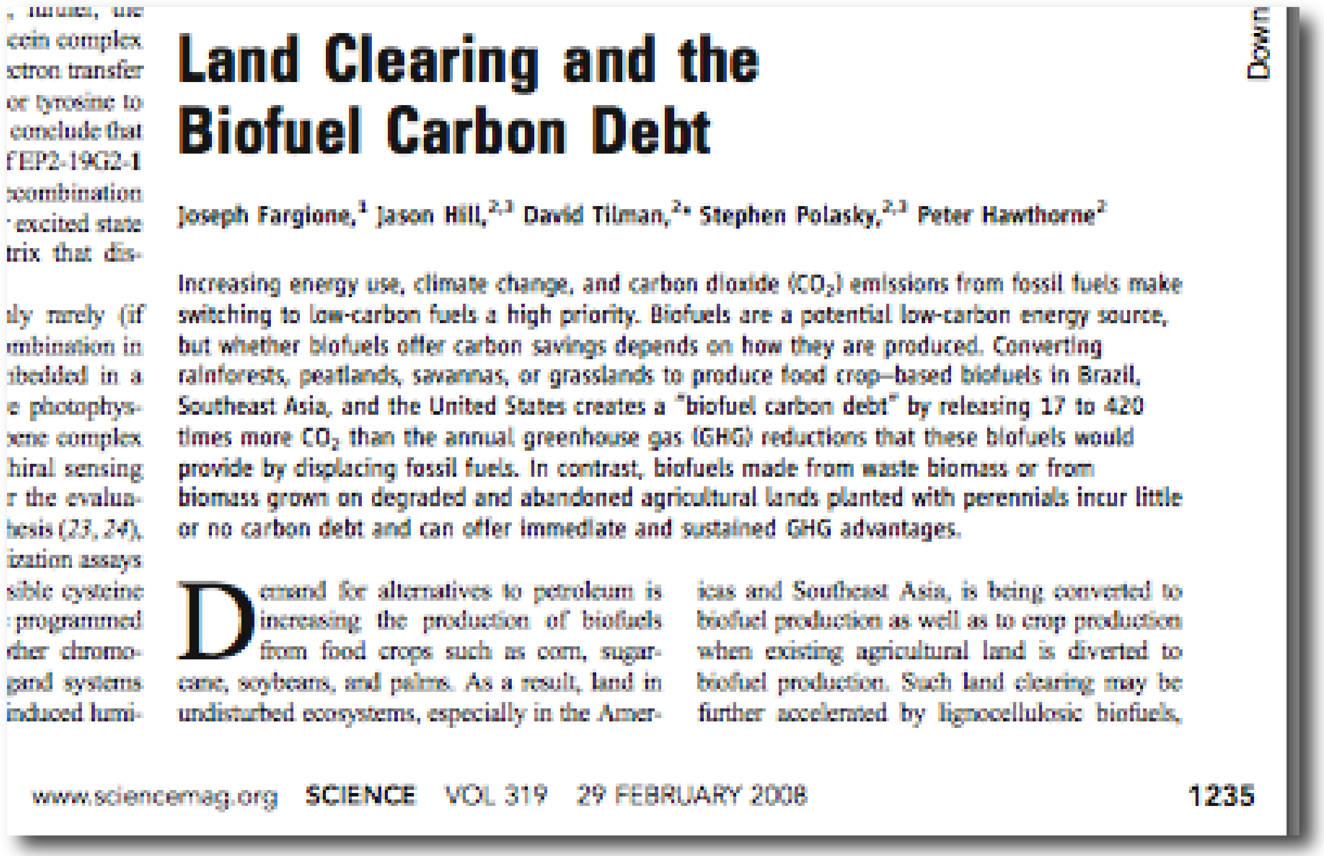


...sustainable agriculture



...and ultimately back to the land





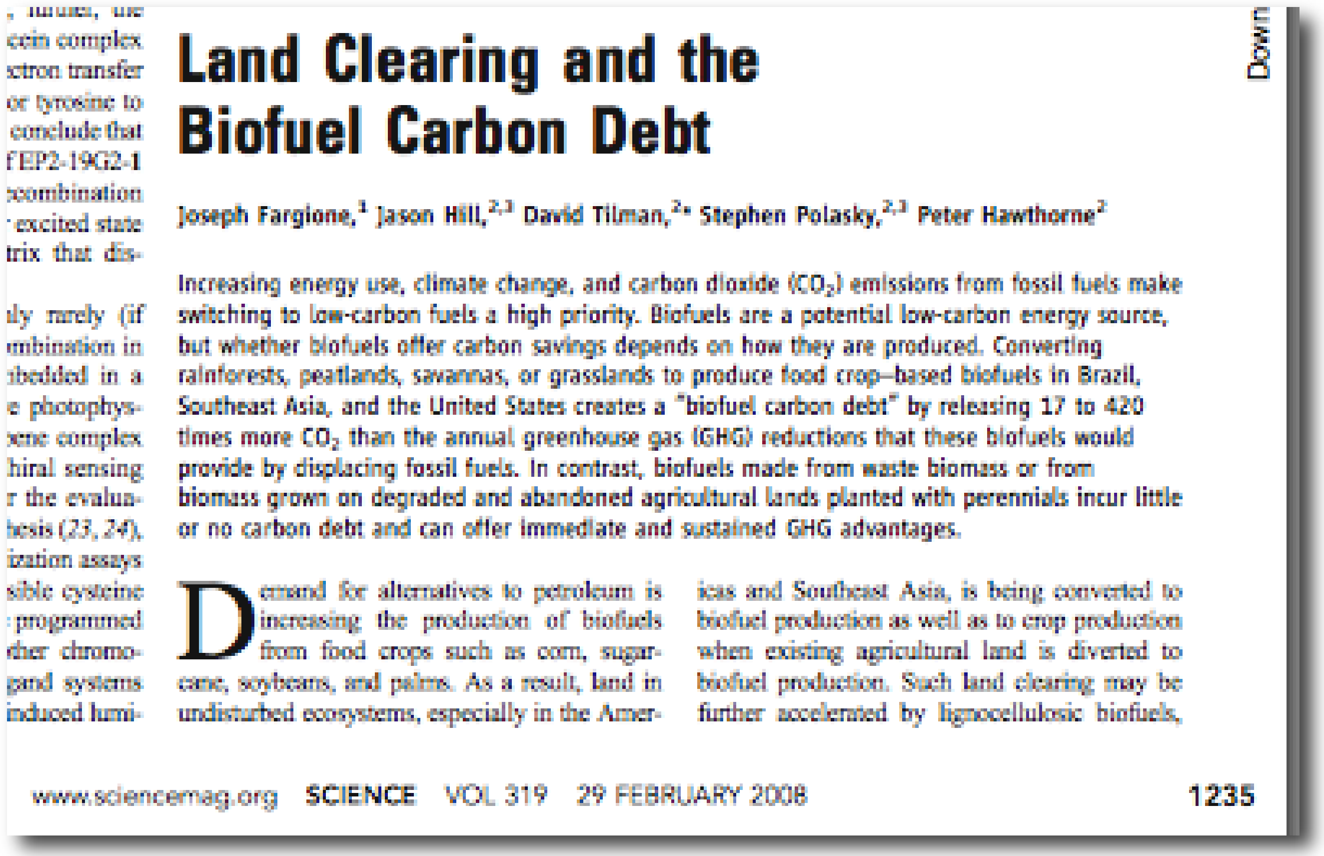
Land Clearing and the Biofuel Carbon Debt

Joseph Fargione,[1] Jason Hill,[2,3] David Tilman,[2]* Stephen Polasky,[2,3] Peter Hawthorne[2]

Increasing energy use, climate change, and carbon dioxide (CO_2) emissions from fossil fuels make switching to low-carbon fuels a high priority. Biofuels are a potential low-carbon energy source, but whether biofuels offer carbon savings depends on how they are produced. Converting rainforests, peatlands, savannas, or grasslands to produce food crop–based biofuels in Brazil, Southeast Asia, and the United States creates a "biofuel carbon debt" by releasing 17 to 420 times more CO_2 than the annual greenhouse gas (GHG) reductions that these biofuels would provide by displacing fossil fuels. In contrast, biofuels made from waste biomass or from biomass grown on degraded and abandoned agricultural lands planted with perennials incur little or no carbon debt and can offer immediate and sustained GHG advantages.

Demand for alternatives to petroleum is increasing the production of biofuels from food crops such as corn, sugarcane, soybeans, and palms. As a result, land in undisturbed ecosystems, especially in the Americas and Southeast Asia, is being converted to biofuel production as well as to crop production when existing agricultural land is diverted to biofuel production. Such land clearing may be further accelerated by lignocellulosic biofuels,

...the ceteris paribus experiment



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Changing one variable at a time (biofuels) means freezing the rest of the agricultural system

...free of <u>ceteris paribus</u>

“

Why, then, the world's mine

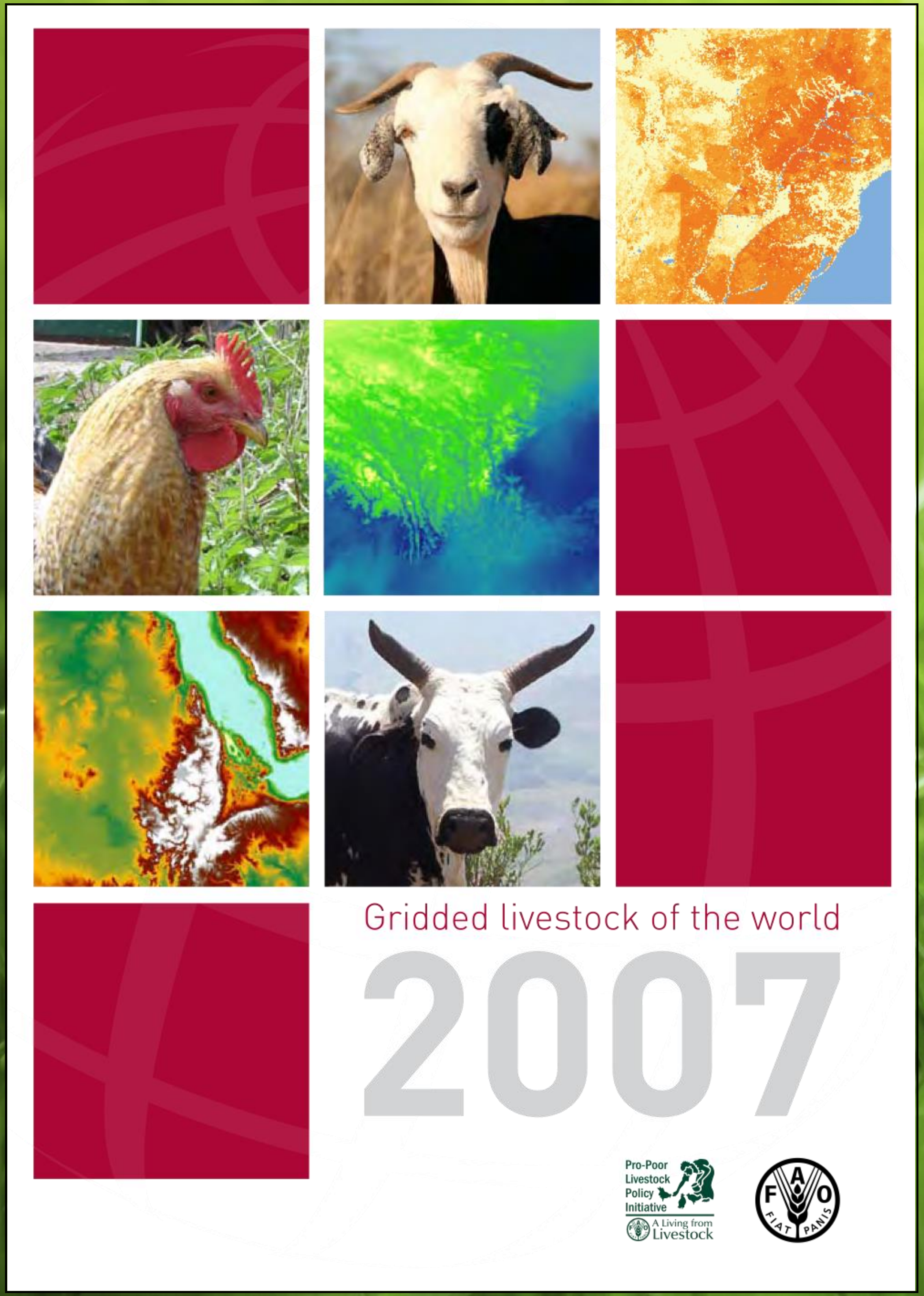
oyster”

William Shakespeare

...I can look anywhere for change

pasture for livestock is the **LARGEST** human use of land on the **planet**

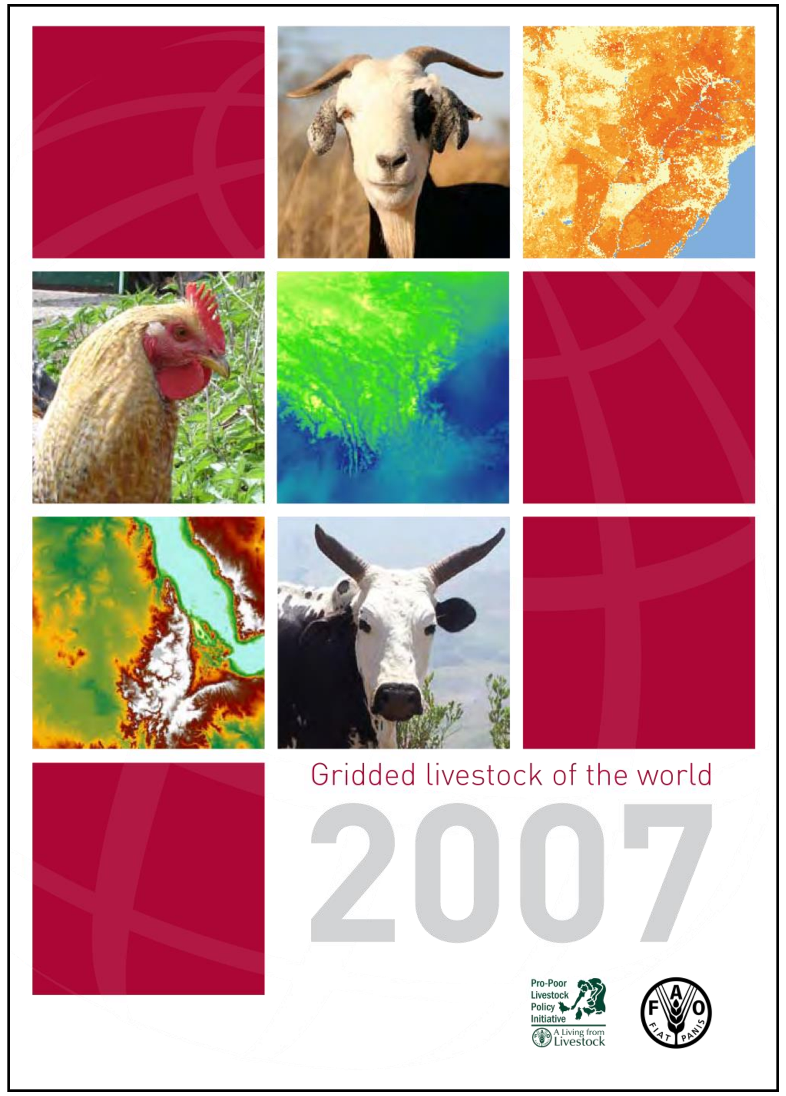
Livestock data



Cattle
Sheep
Goats

Data processing

FAO census data
3 min x 3 min



Data screening

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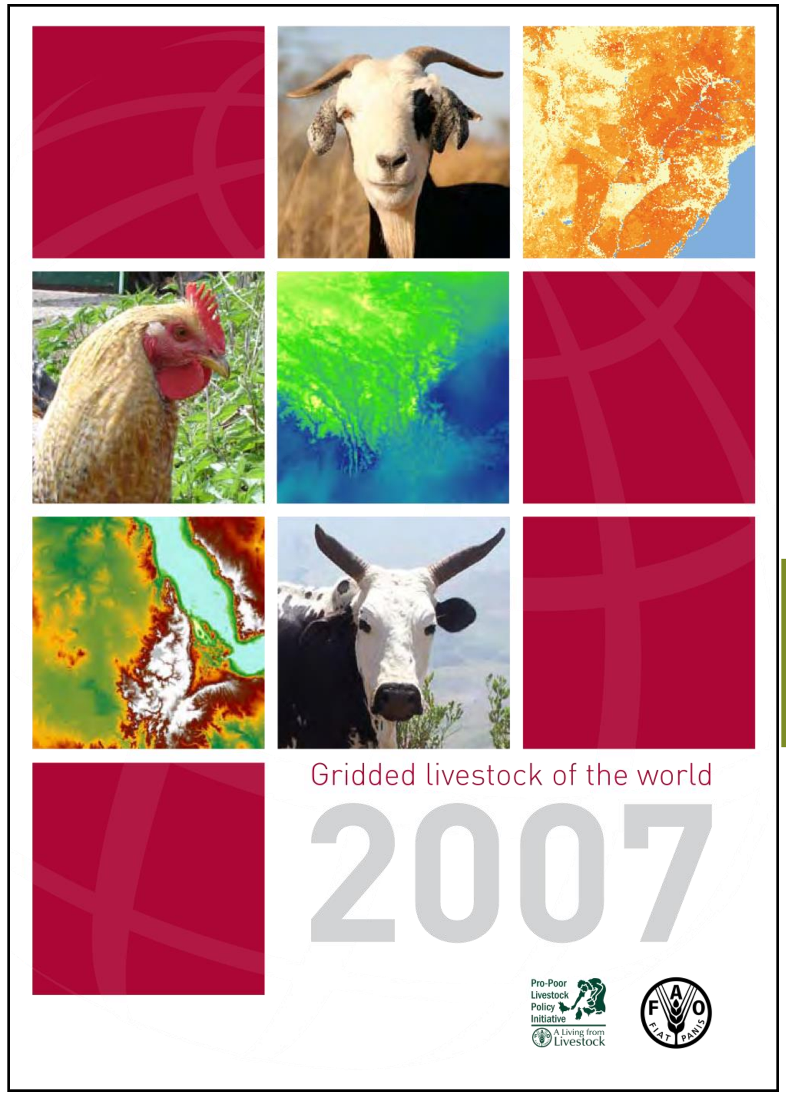

Ramankutty pasture 5 min x 5 min

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 22, GB1003, doi:10.1029/2007GB002952, 2008

Farming the planet:
1. Geographic distribution of global agricultural lands in the year 2000

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Data processing

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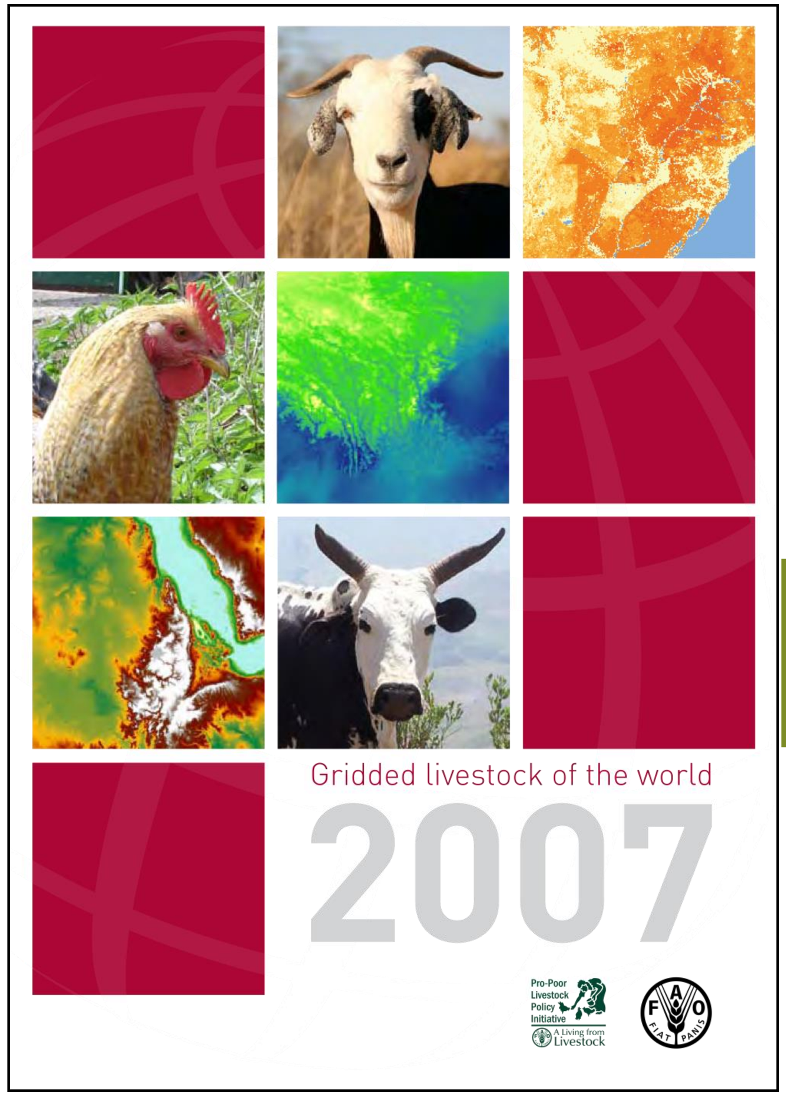

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Remove CAFOs and mixed systems

≦10 head per ha each animal type

Data processing

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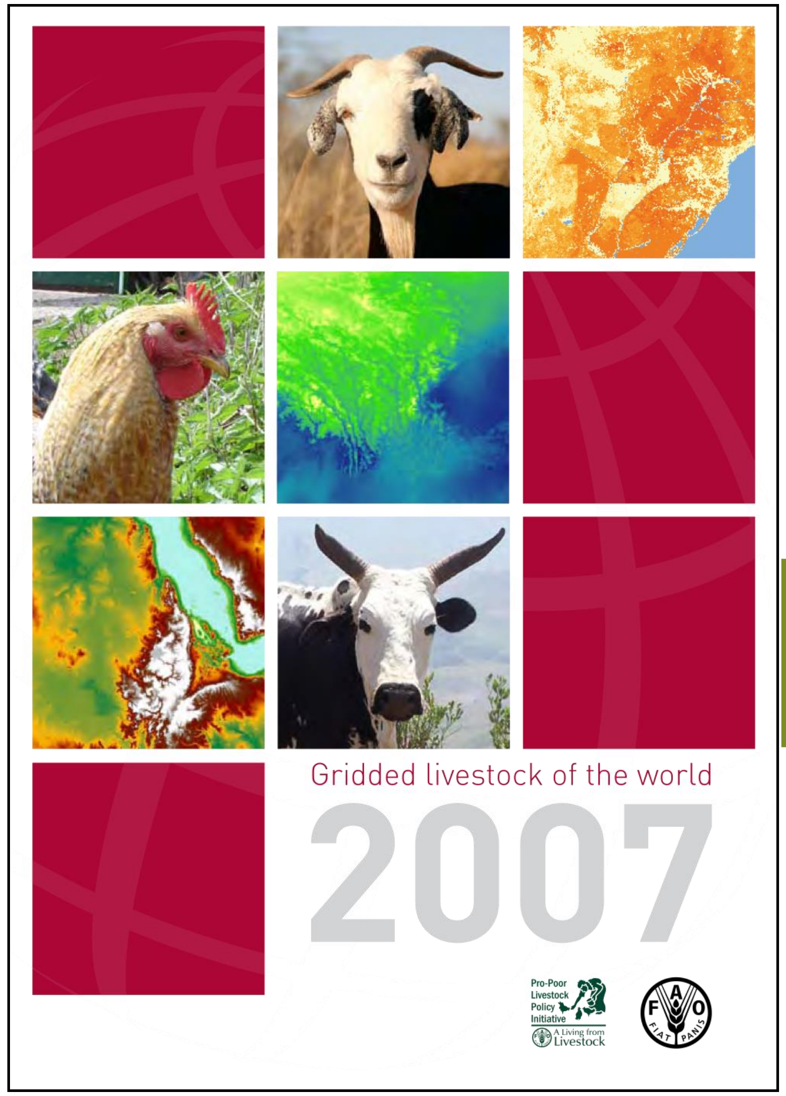

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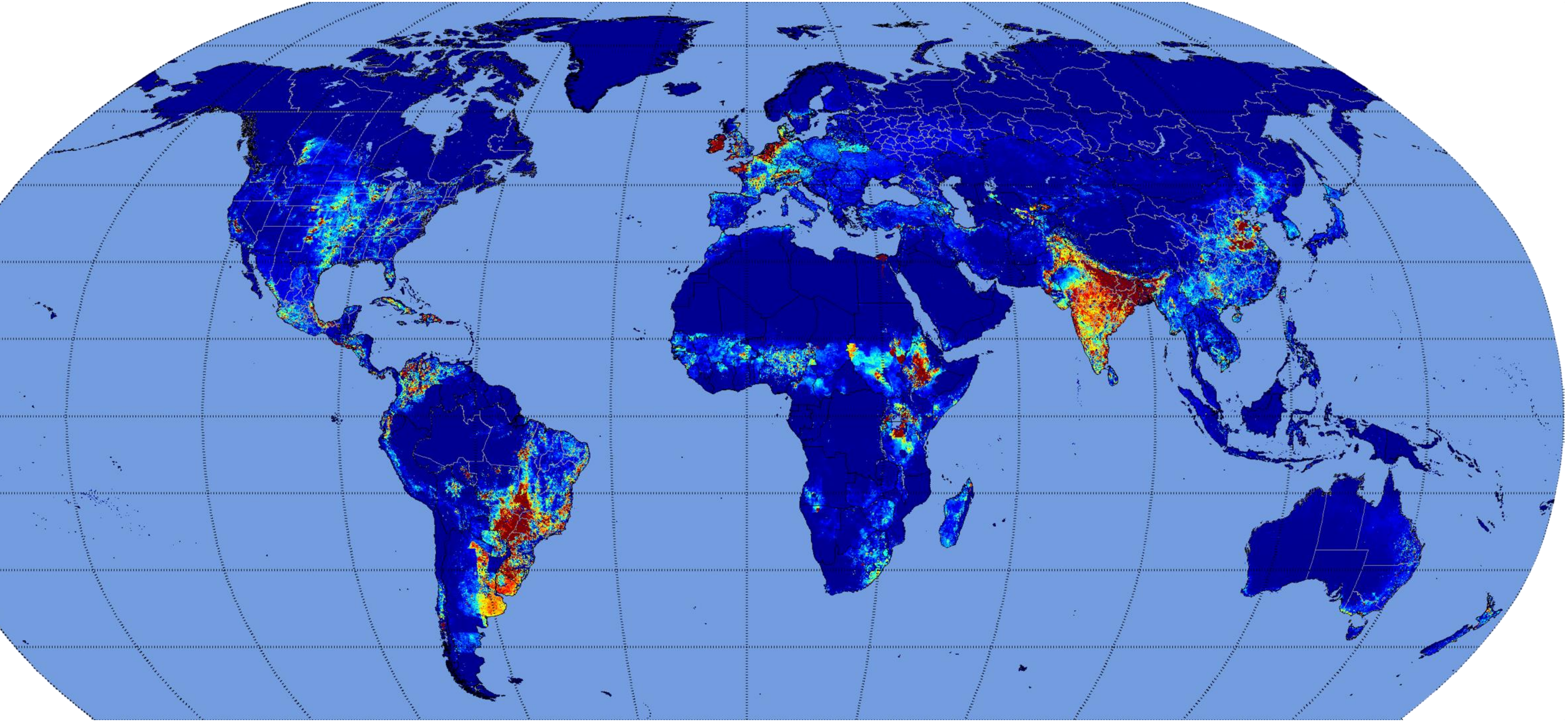
Remove CAFOs and mixed systems

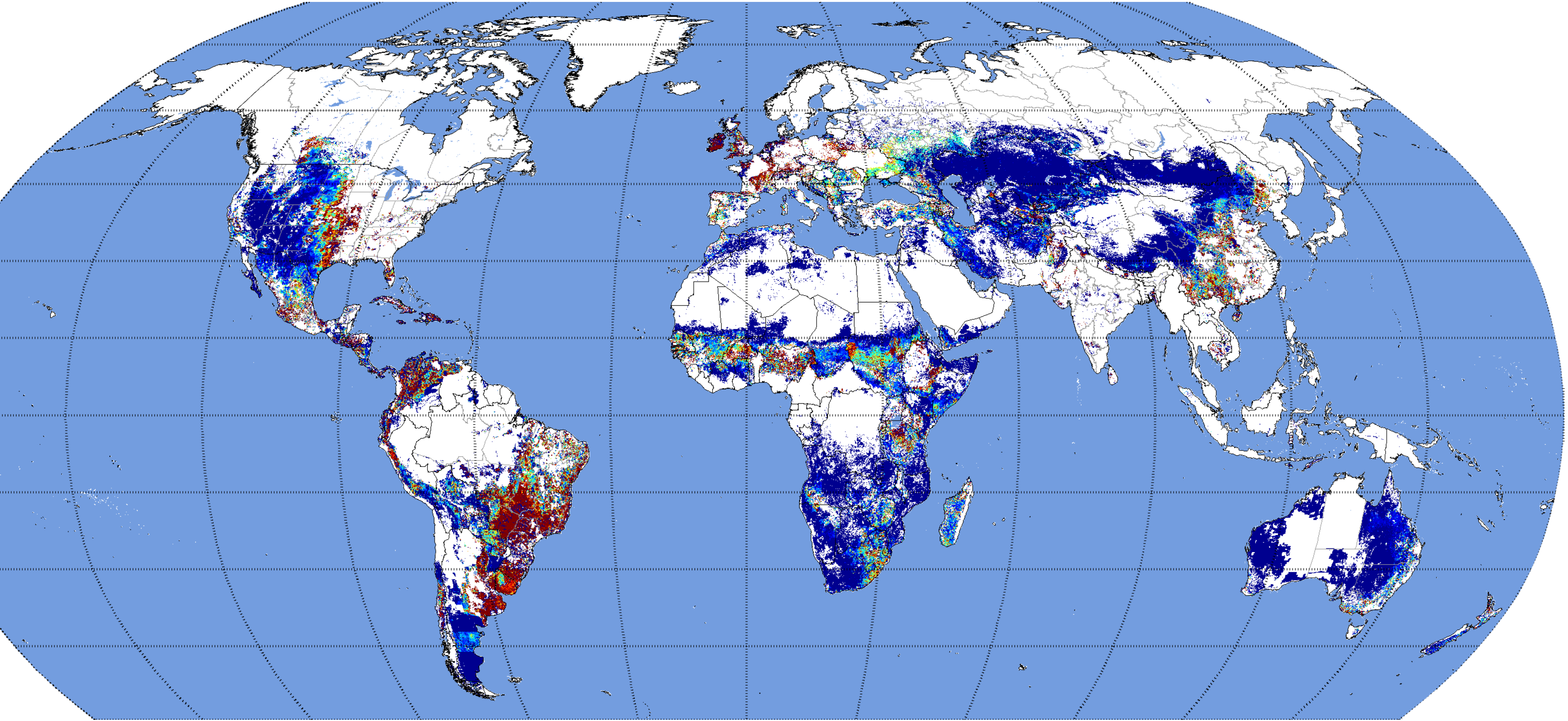
≦10 head per ha each animal type

≦2 AU per ha for ∑ cows, goats, sheep

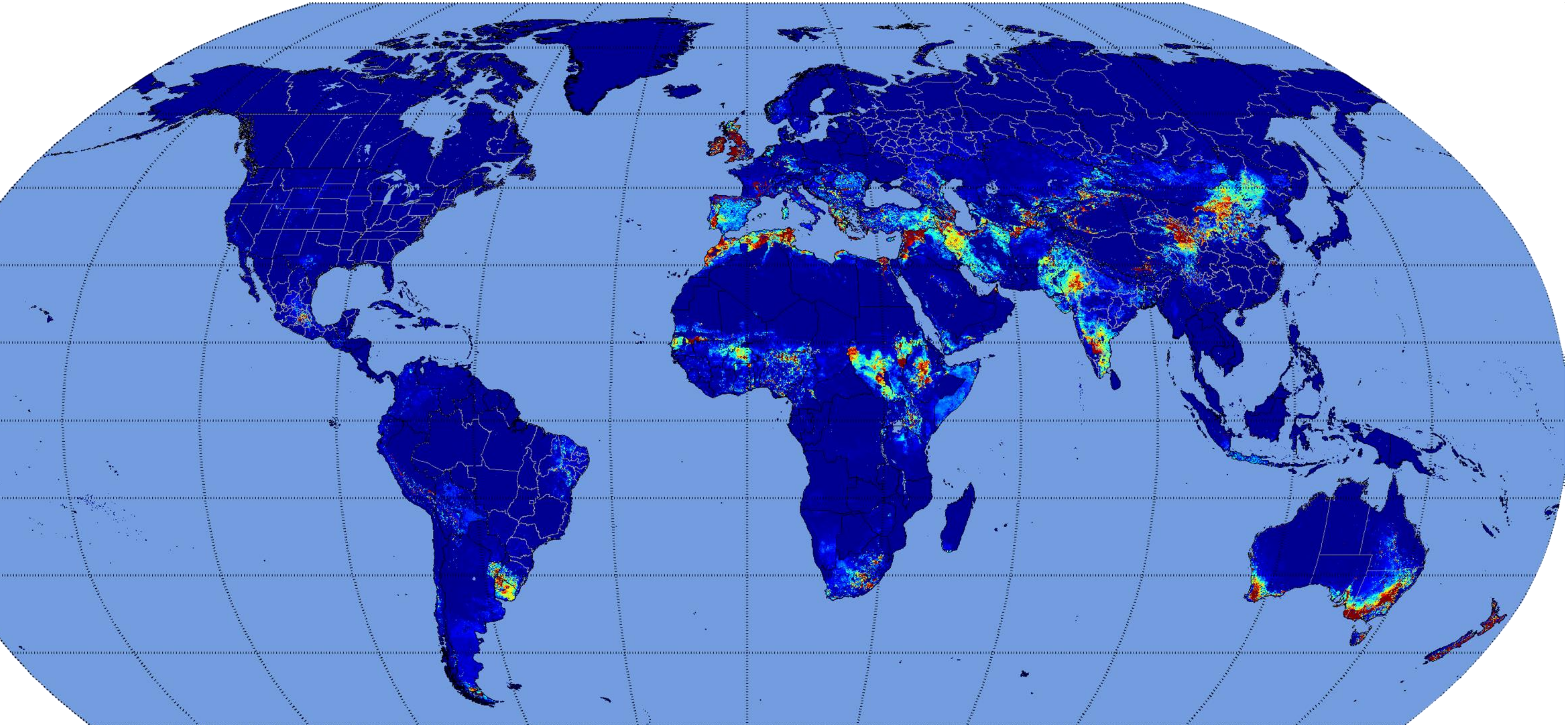
FAO cattle distribution



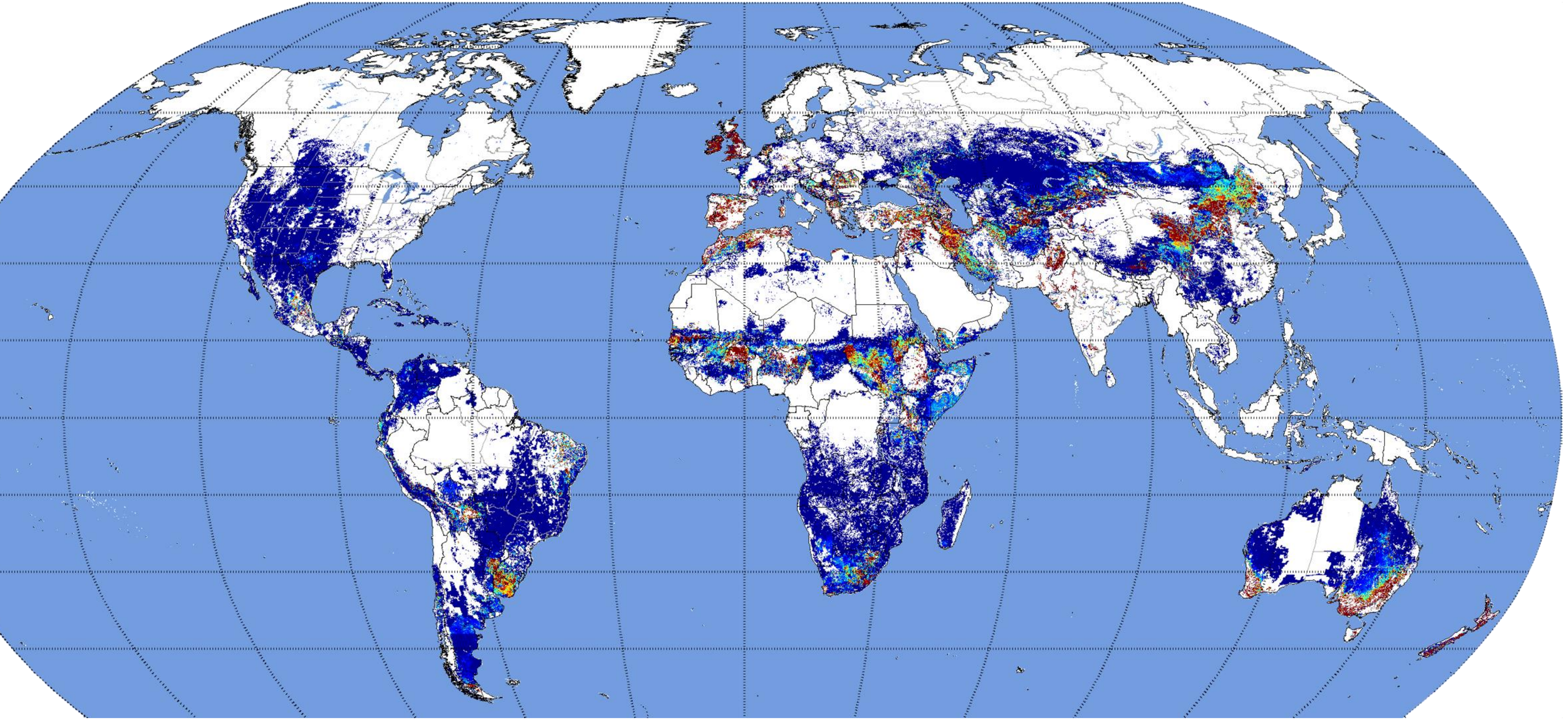
Cattle redistributed on pastureland



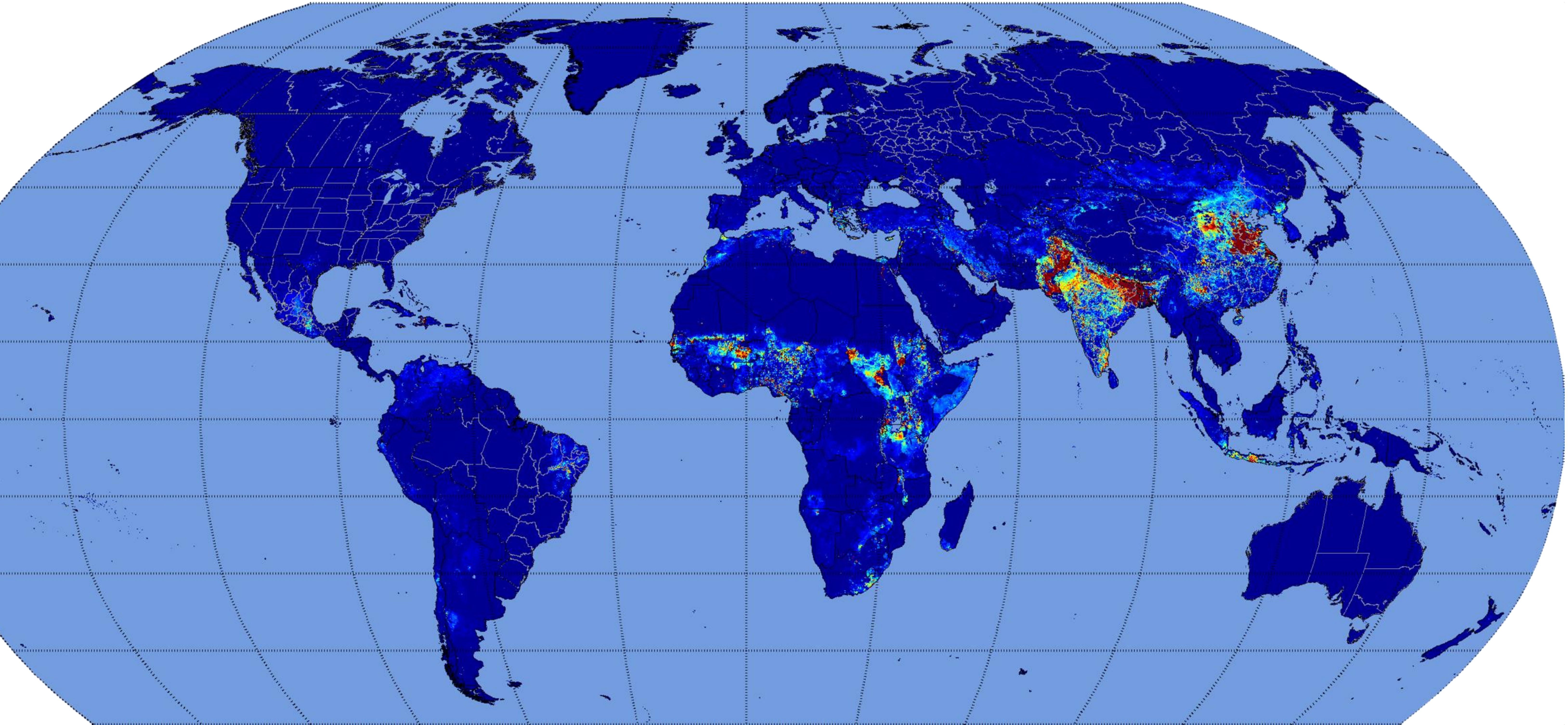
FAO sheep distribution



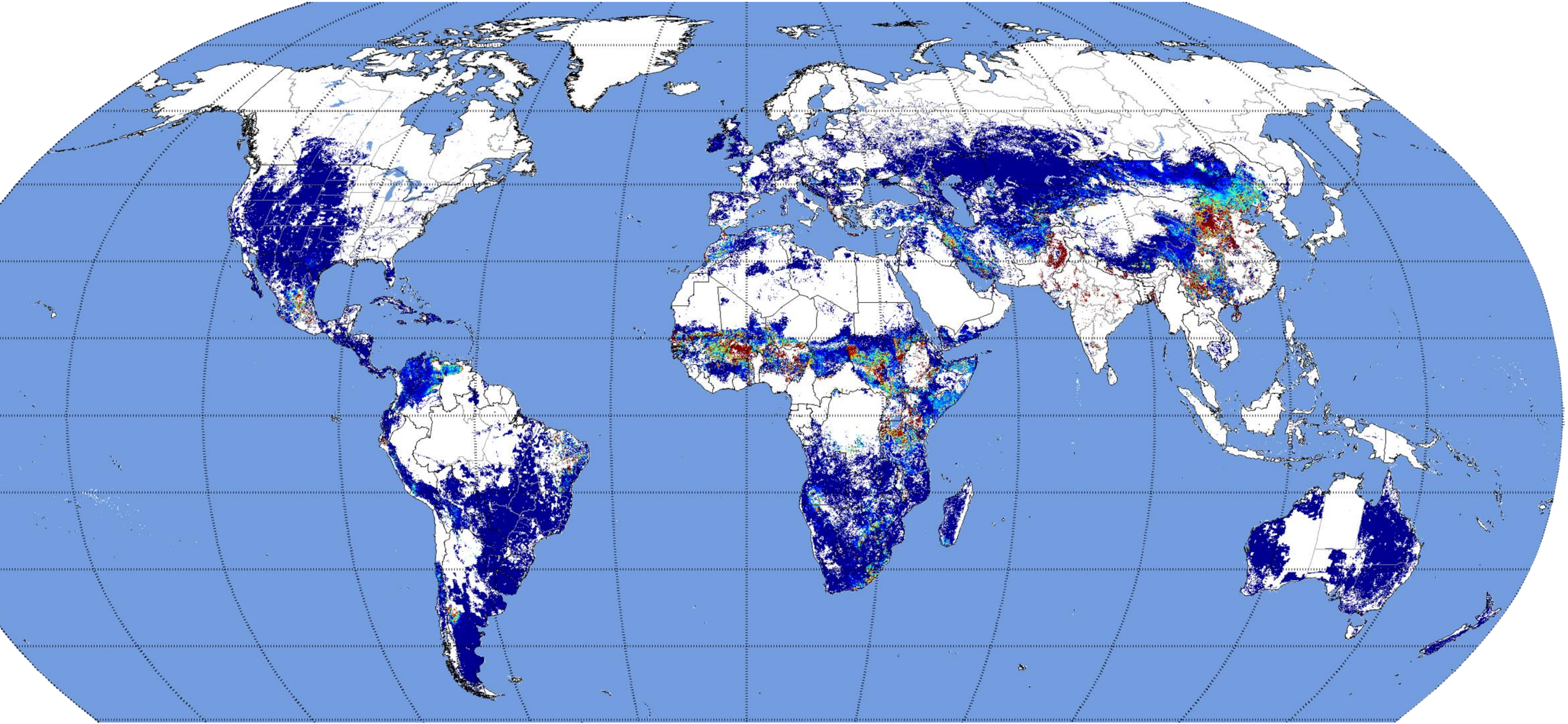
Sheep redistributed on pastureland



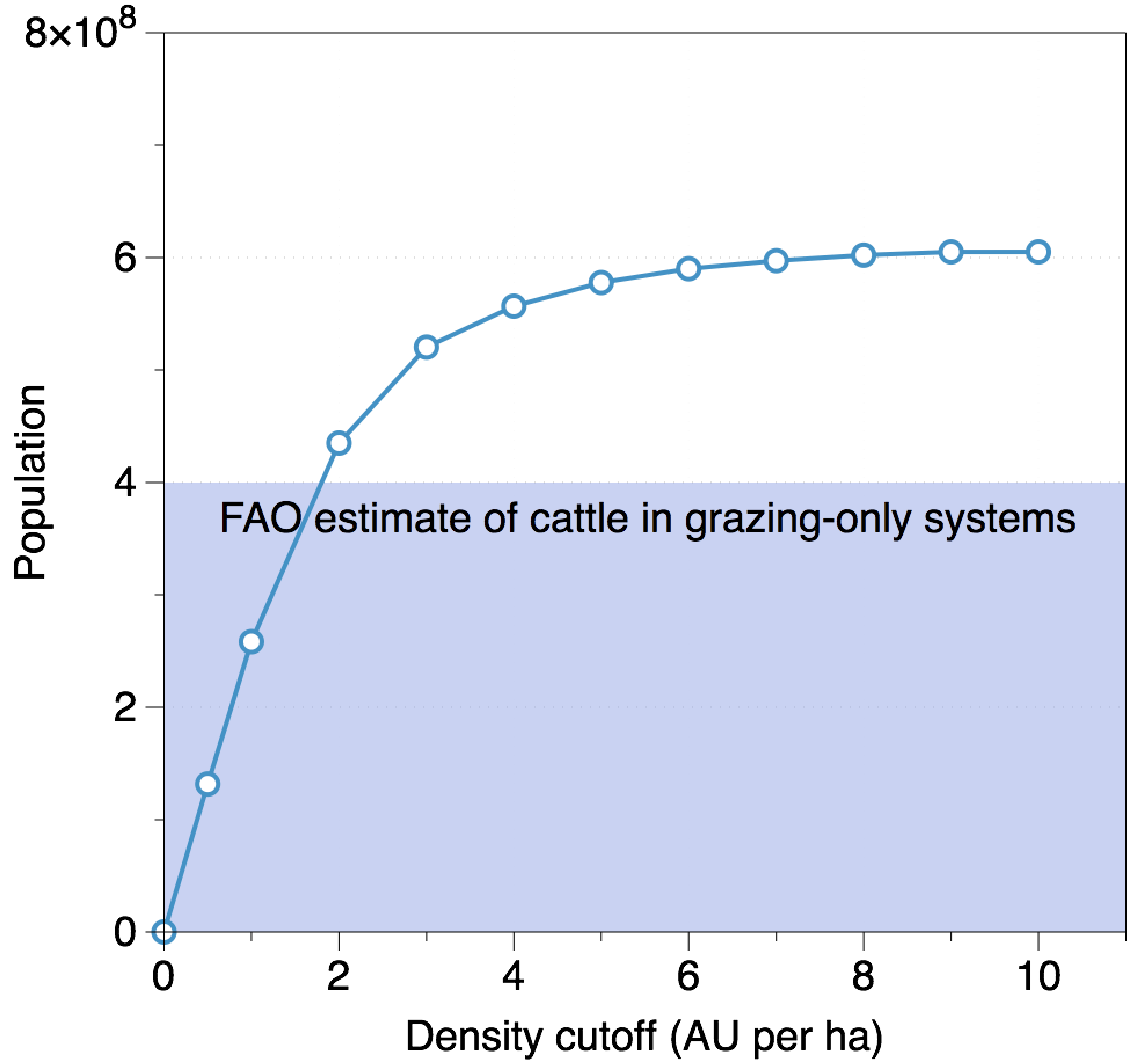
FAO goat distribution



Goats redistributed on pastureland

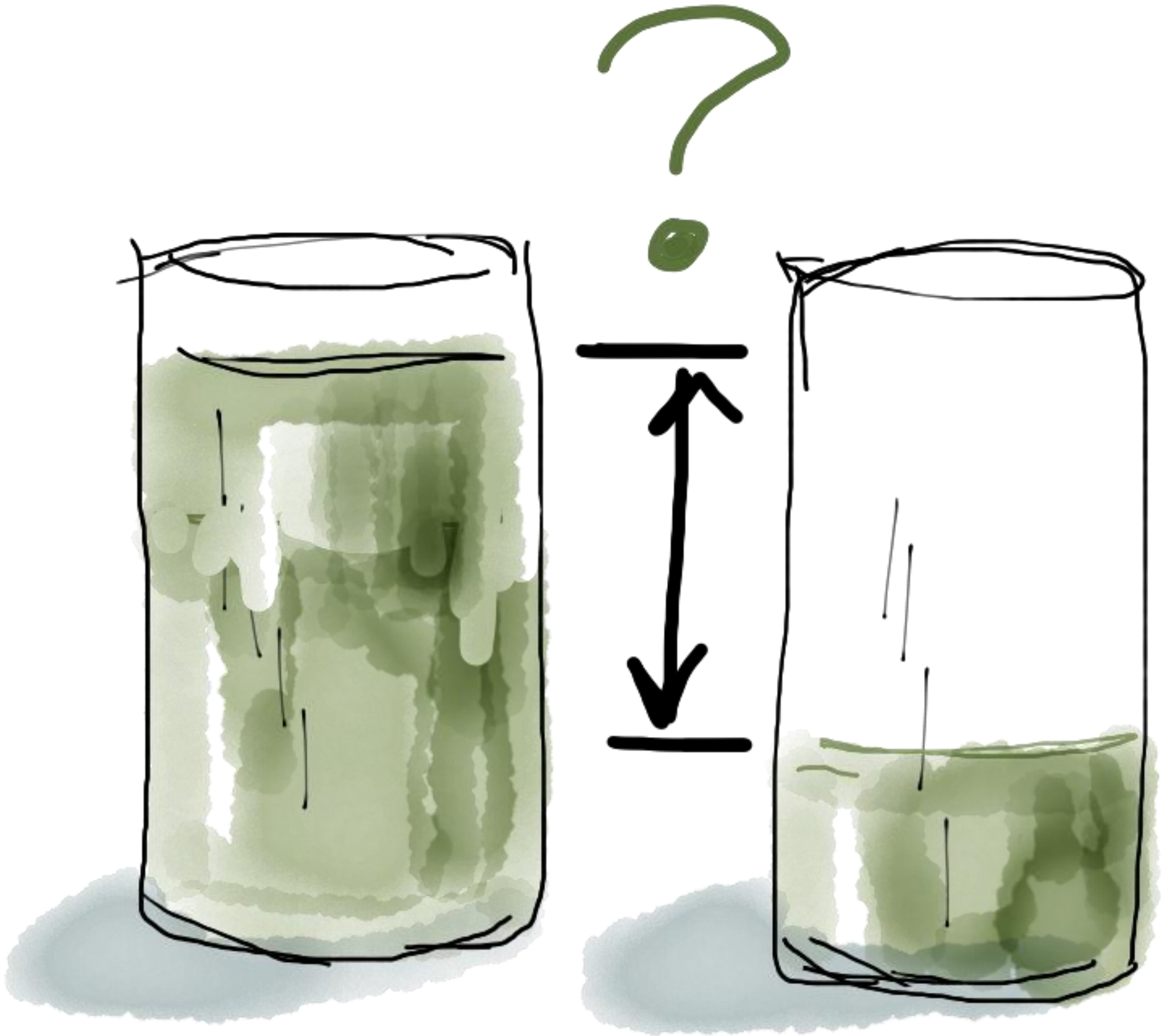


Total cattle vs AU cutoff

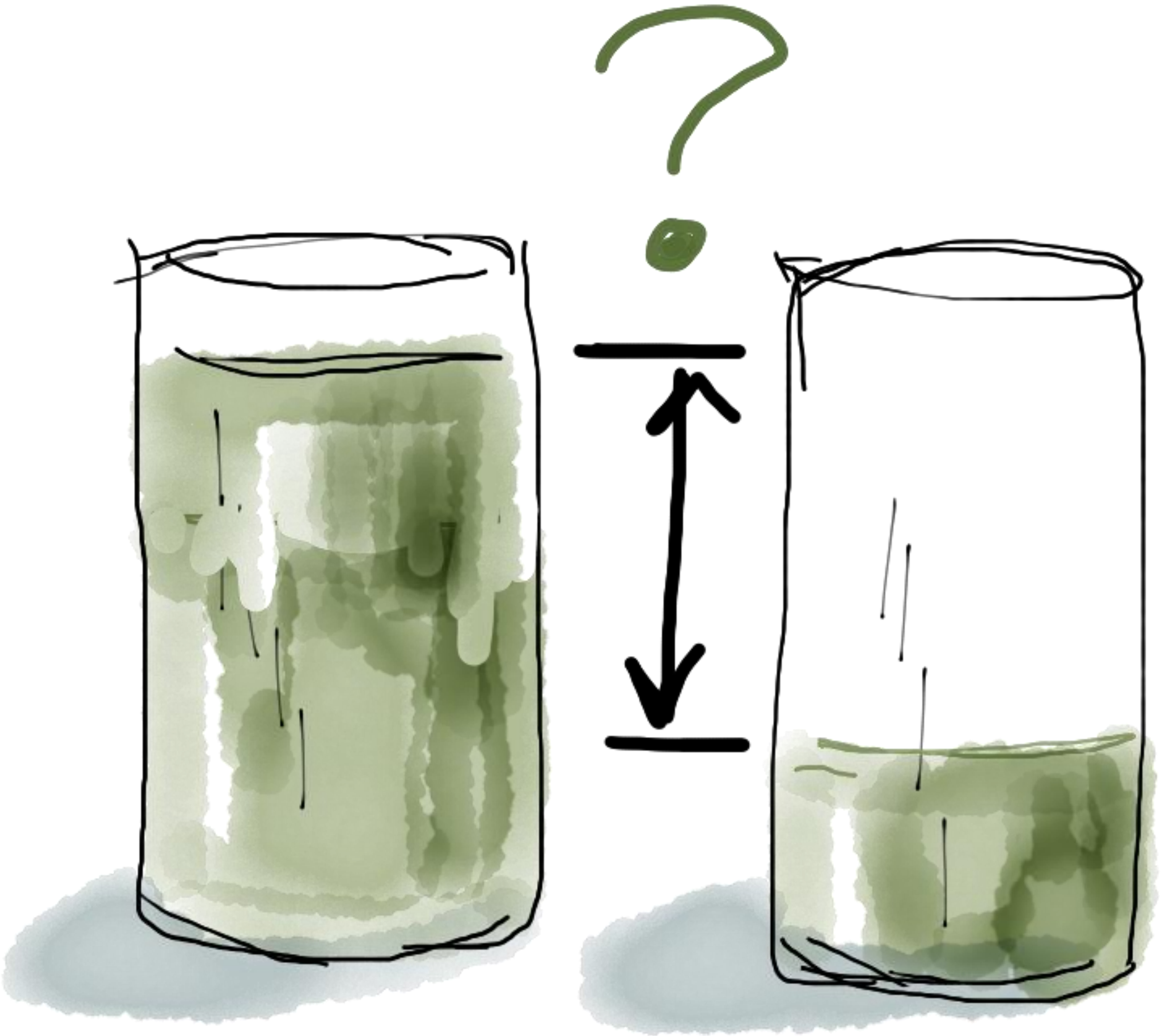


Total cattle at AU cutoff of 2 is 435 million versus 400 million estimated on grazing-only systems according the Steinfeld 2006 (Livestock's long shadow)

Yield gap analysis



Glass half empty or half full?

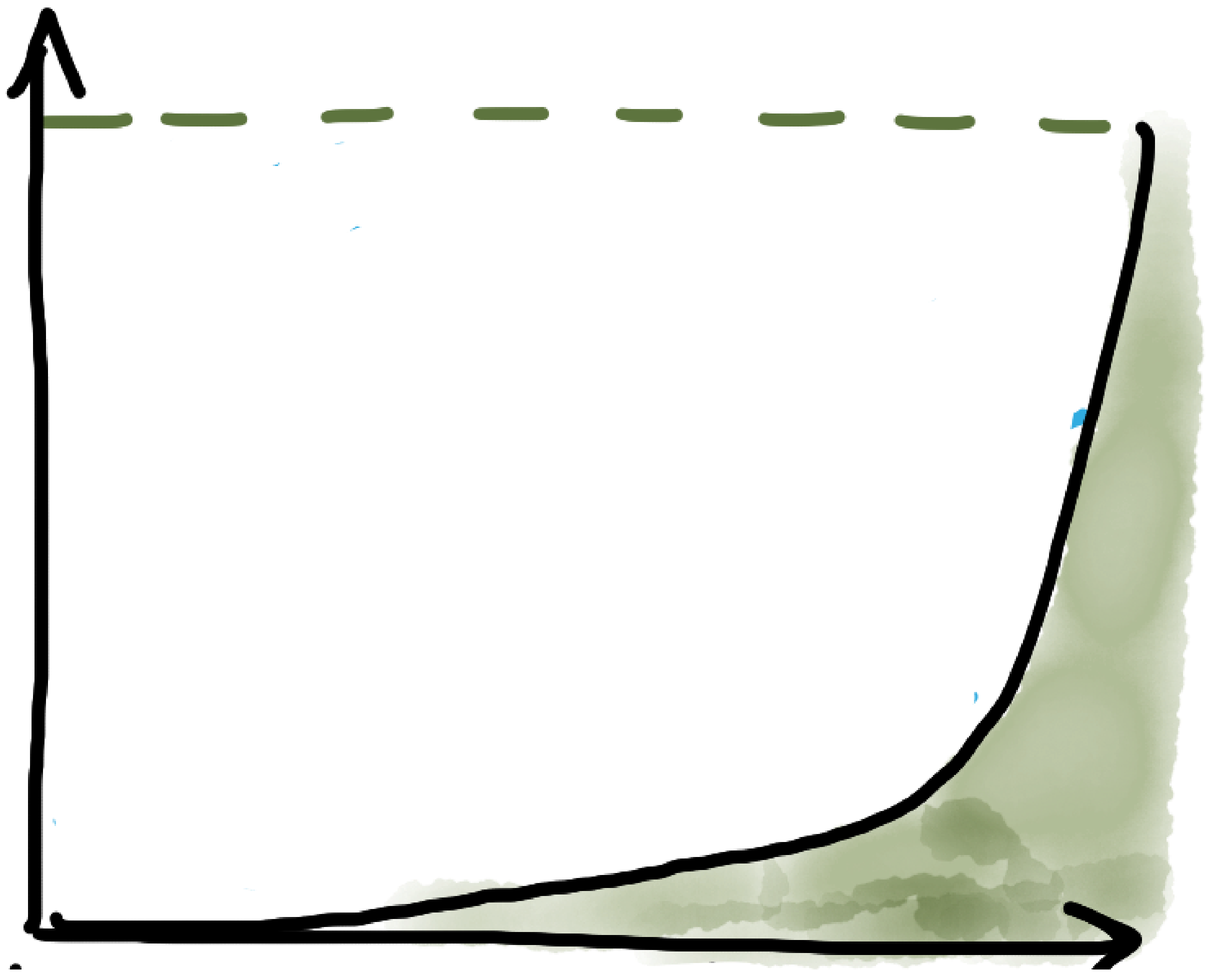


Yield gap analysis

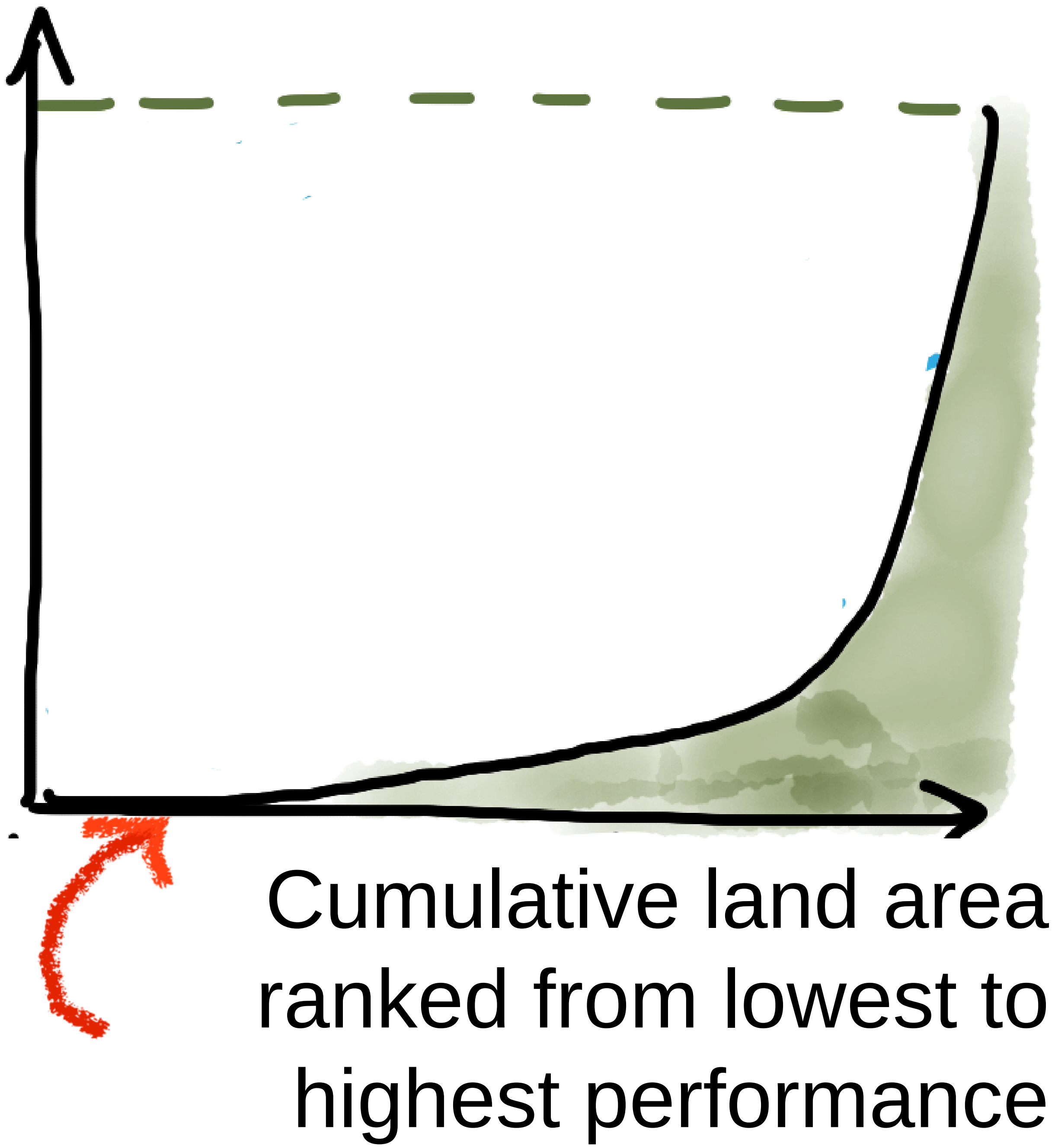
~~Glass half empty or half full?~~

How far from the top are we?

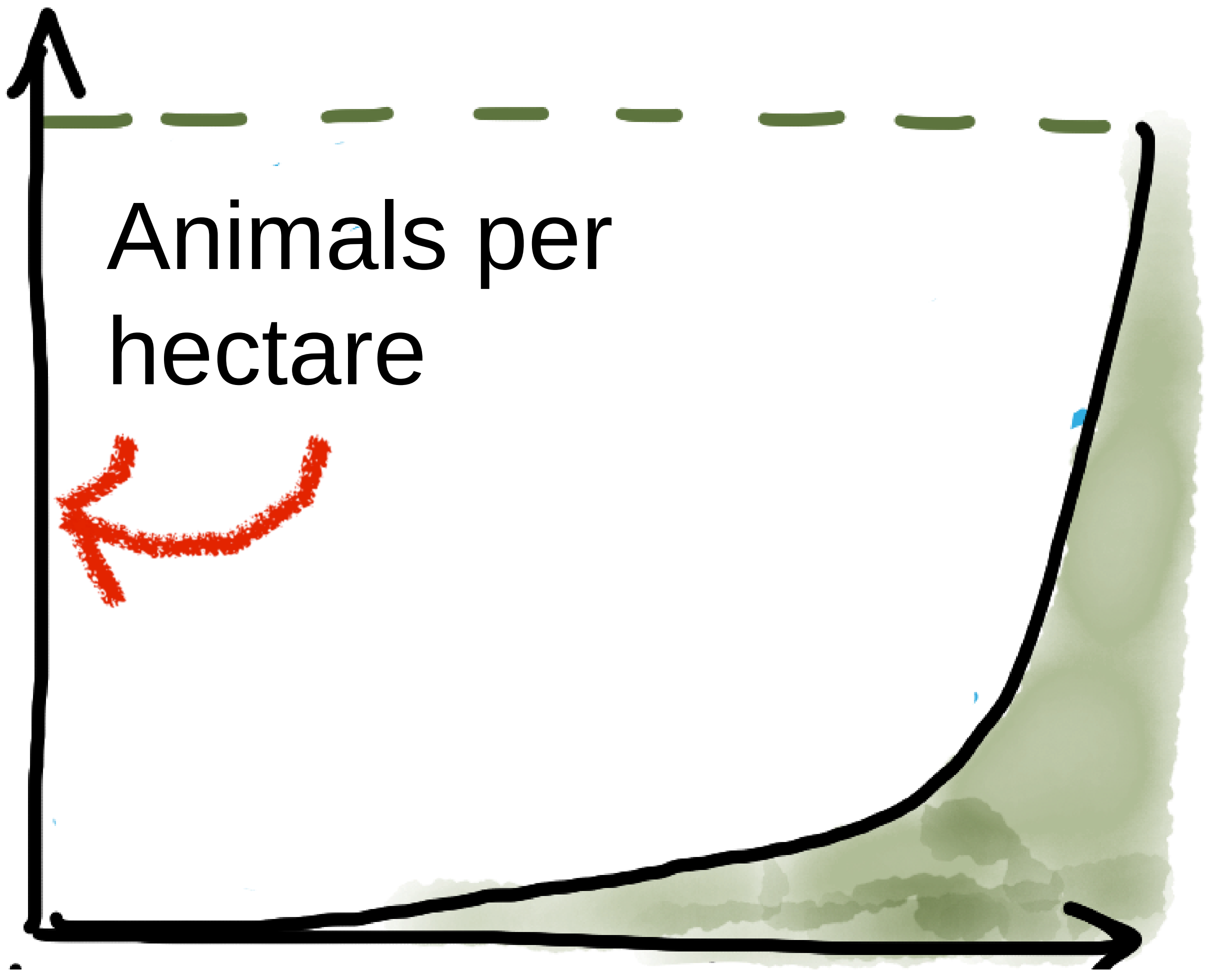
Closing gaps is deliberately
and holistically dynamic



Grading pasture on a curve

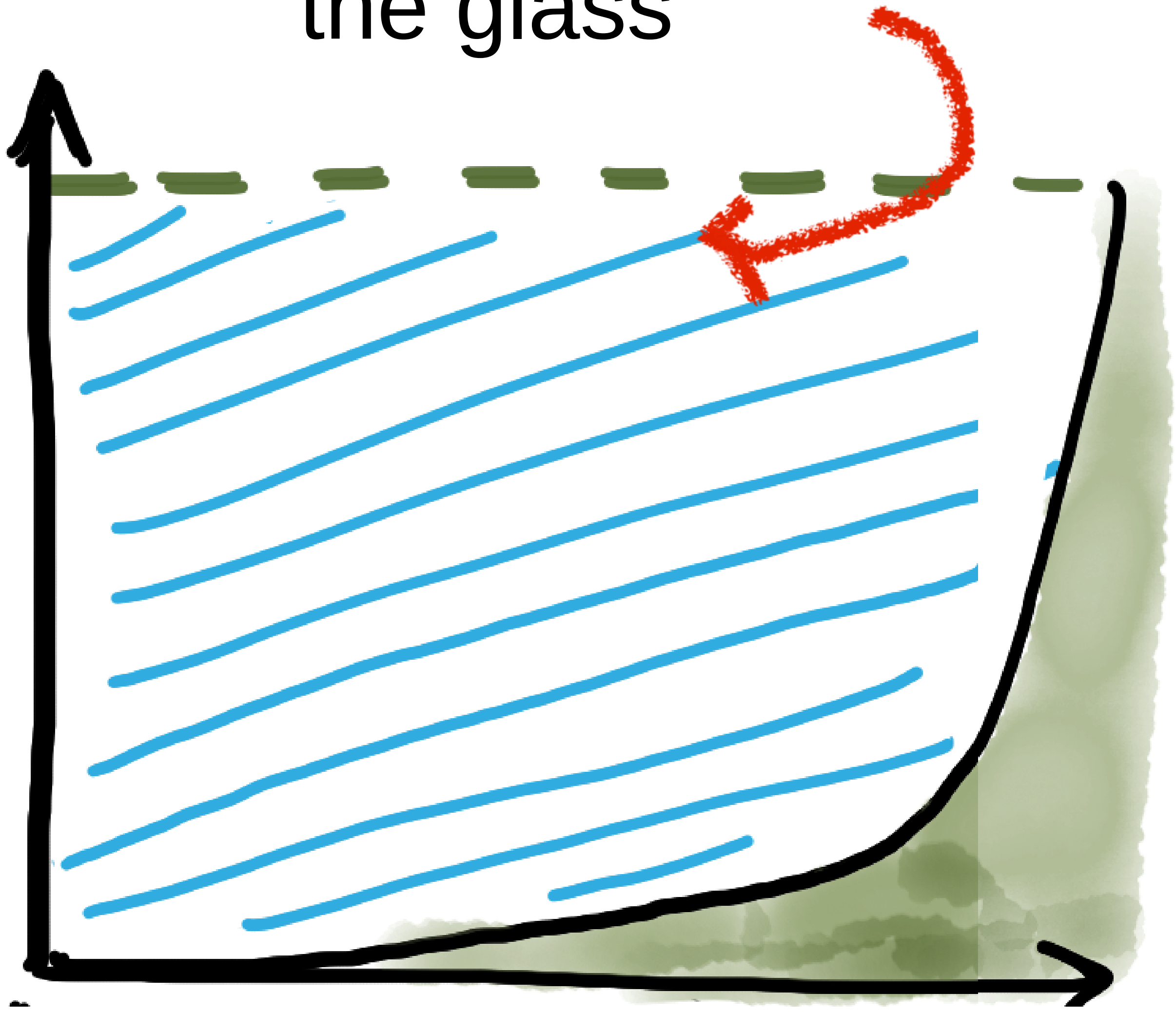

Cumulative land area ranked from lowest to highest performance


MIND THE GAP


Animals per
hectare


WESTMINSTER
MIND THE GAP

The empty part of the glass




Climate bins

Climate space

10				50	60	70	80	90	100
9				49					99
8				48					98
7				47					97
6				46	56				96
5	15	25	35	45	55	65	75	85	95
4									94
3									93
2									92
1	11	21	31	41	51	61	71	81	91

10				50	60	70	80	90	100
9				49					99
8				48					98
7				47					97
6				46	56				96
5	15	25	35	45	55	65	75	85	95
4									94
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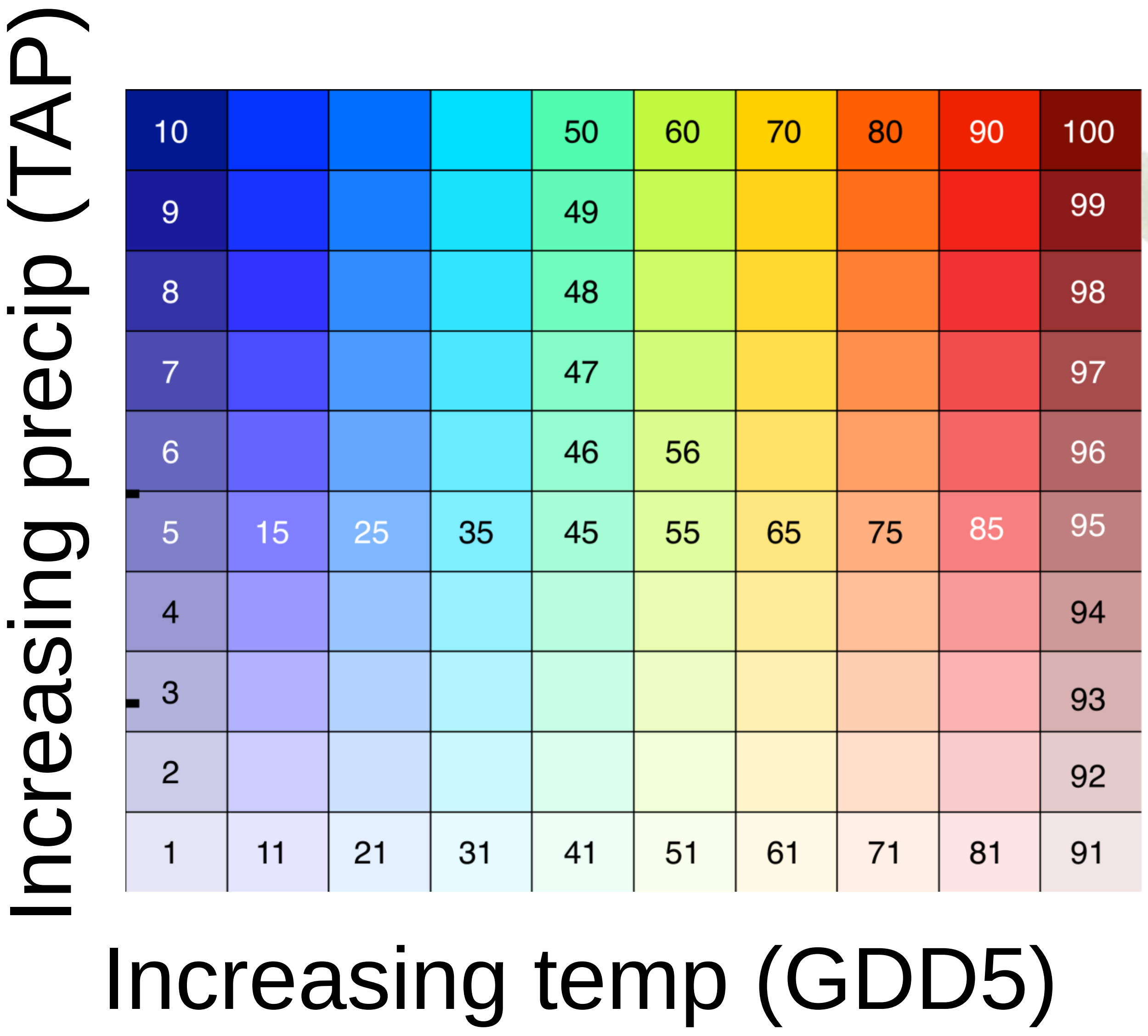
Increasing temp (GDD5)

Climate bins



Climate bins

Each bin contains ~ equal area

10				50	60	70	80	90	100
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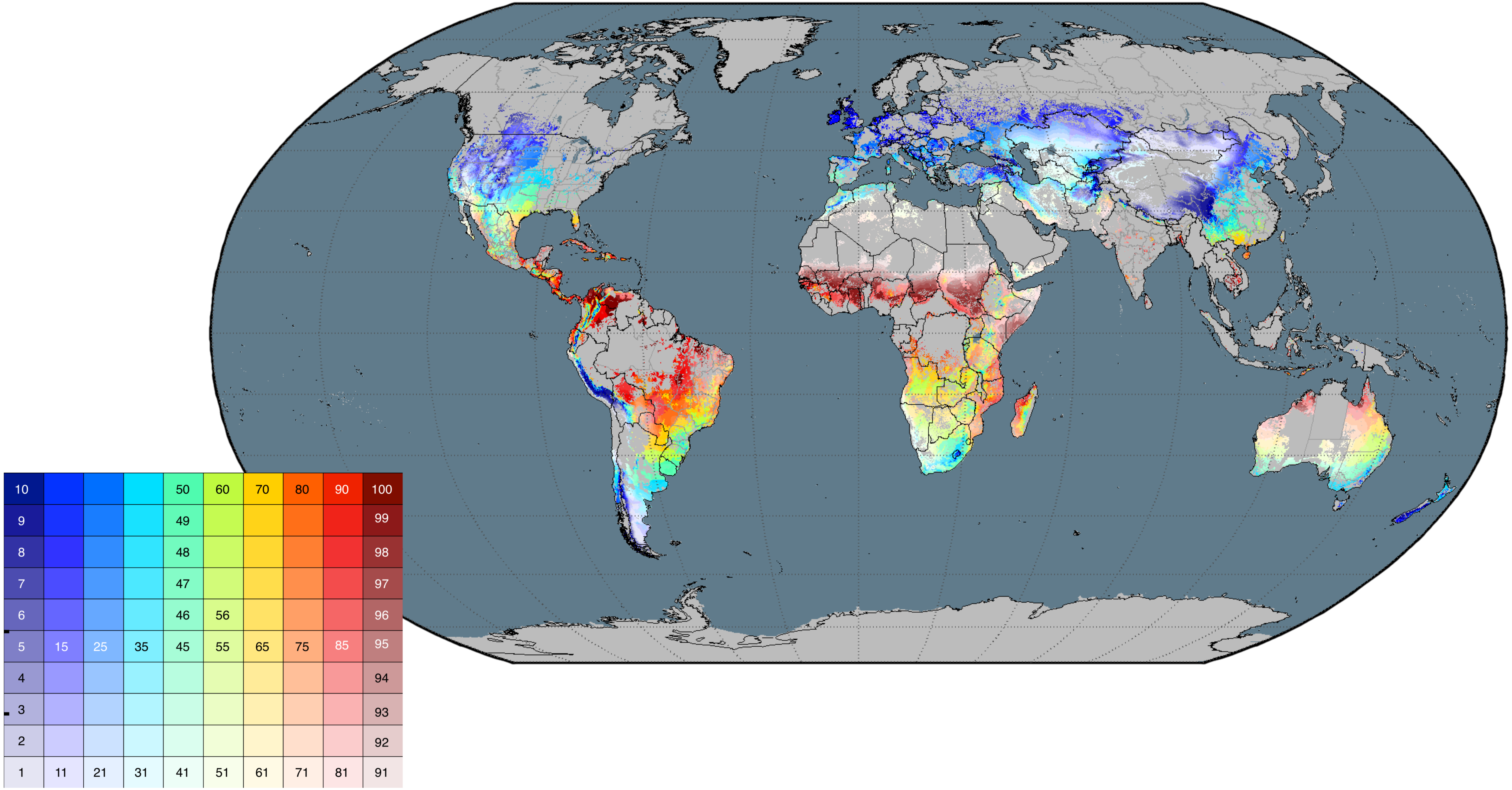
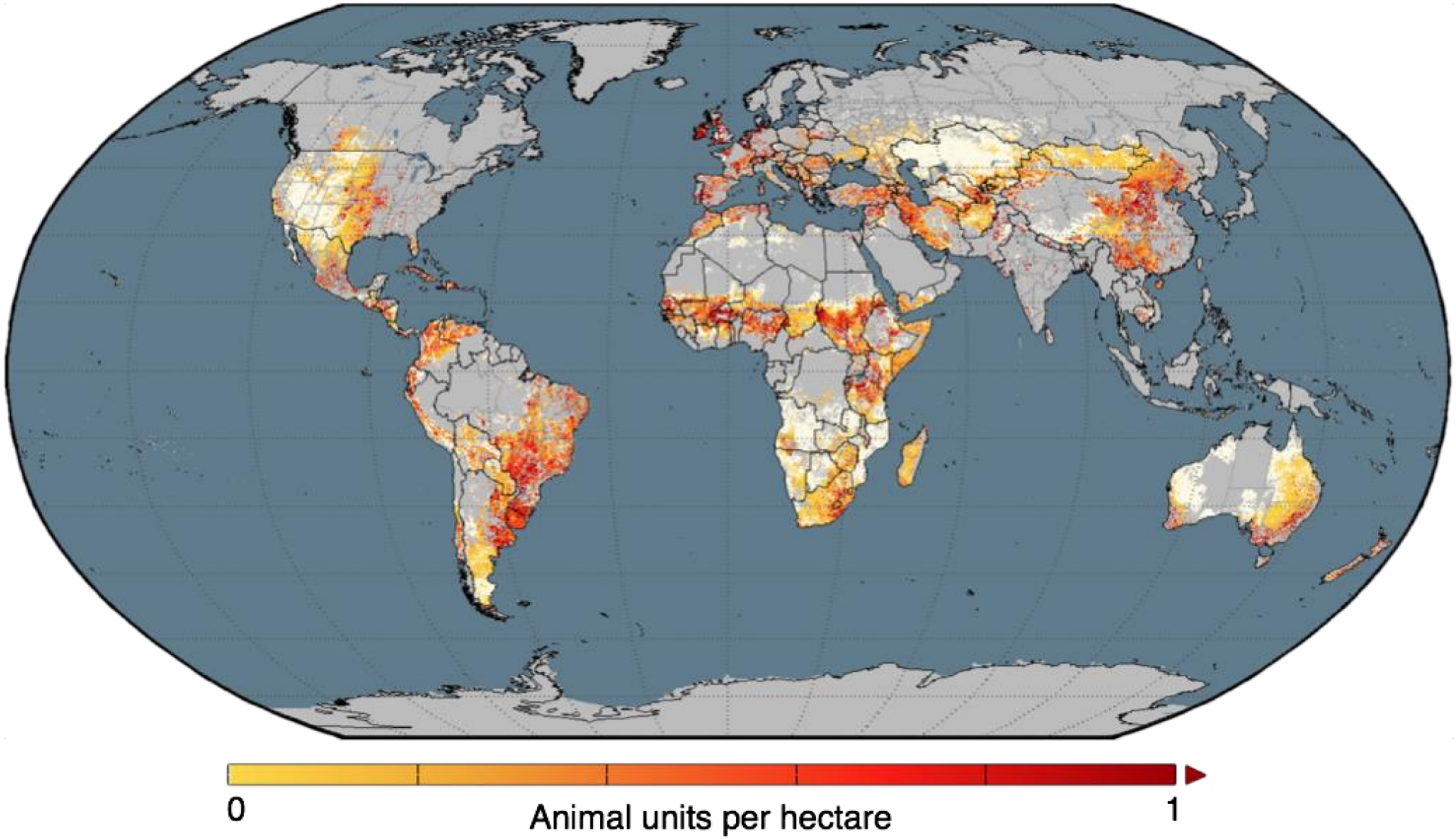
8				48					98
7				47					97
6				46	56				96
5	15	25	35	45	55	65	75	85	95
4									94
3									93
2									92
1	11	21	31	41	51	61	71	81	91

Climate bins in geographic space



Livestock in geographic space



Livestock in climate space

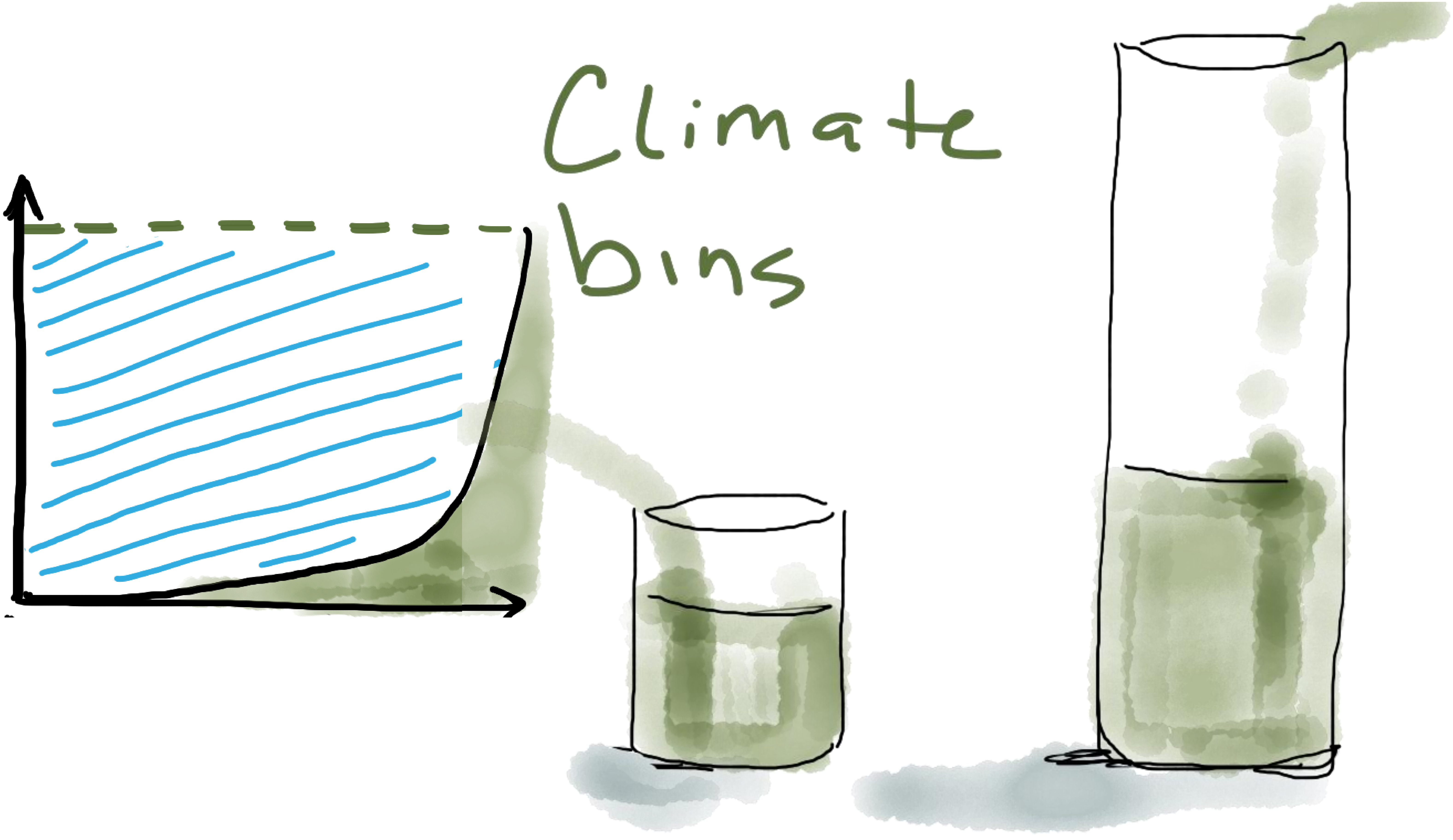
0.242	0.442	0.487	0.589	0.760	0.548	0.536	0.597	0.427	0.432
0.148	0.205	0.370	0.567	0.607	0.238	0.356	0.720	0.514	0.378
0.125	0.235	0.323	0.421	0.449	0.416	0.293	0.464	0.380	0.358
0.133	0.153	0.238	0.252	0.308	0.280	0.235	0.323	0.291	0.445
0.110	0.118	0.172	0.155	0.213	0.147	0.260	0.307	0.207	0.404
0.091	0.075	0.074	0.104	0.131	0.091	0.214	0.302	0.225	0.402
0.080	0.044	0.056	0.076	0.095	0.076	0.110	0.266	0.311	0.282
0.071	0.052	0.051	0.068	0.091	0.053	0.065	0.129	0.222	0.185
0.054	0.053	0.069	0.025	0.121	0.048	0.038	0.043	0.073	0.084
0.064	0.069	0.074	0.110	0.040	0.030	0.036	0.057	0.081	0.046

An average animal density of 0.22 animal unit equivalents per hectare. Drier and cooler regions have the lowest densities

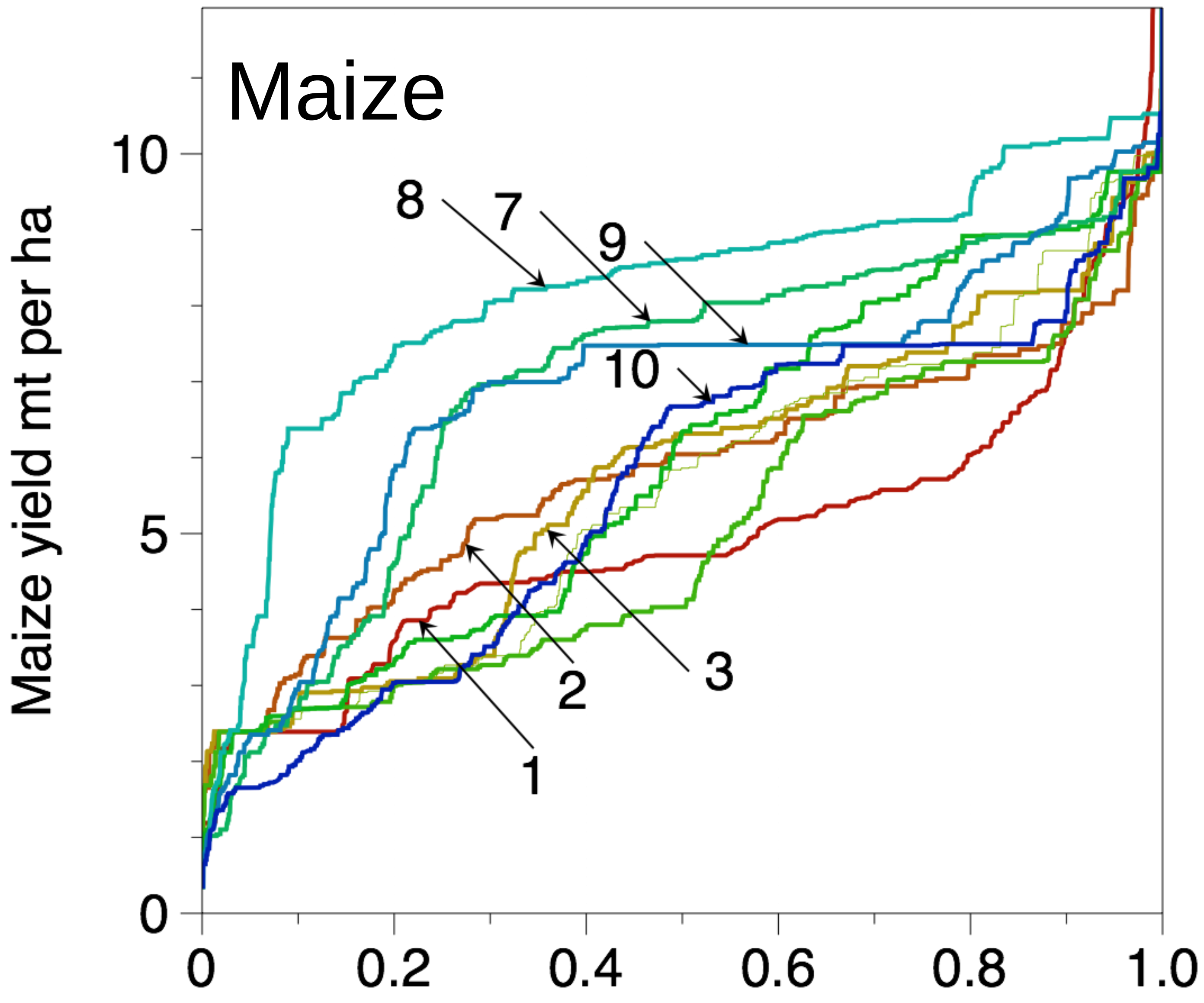
Livestock in climate space

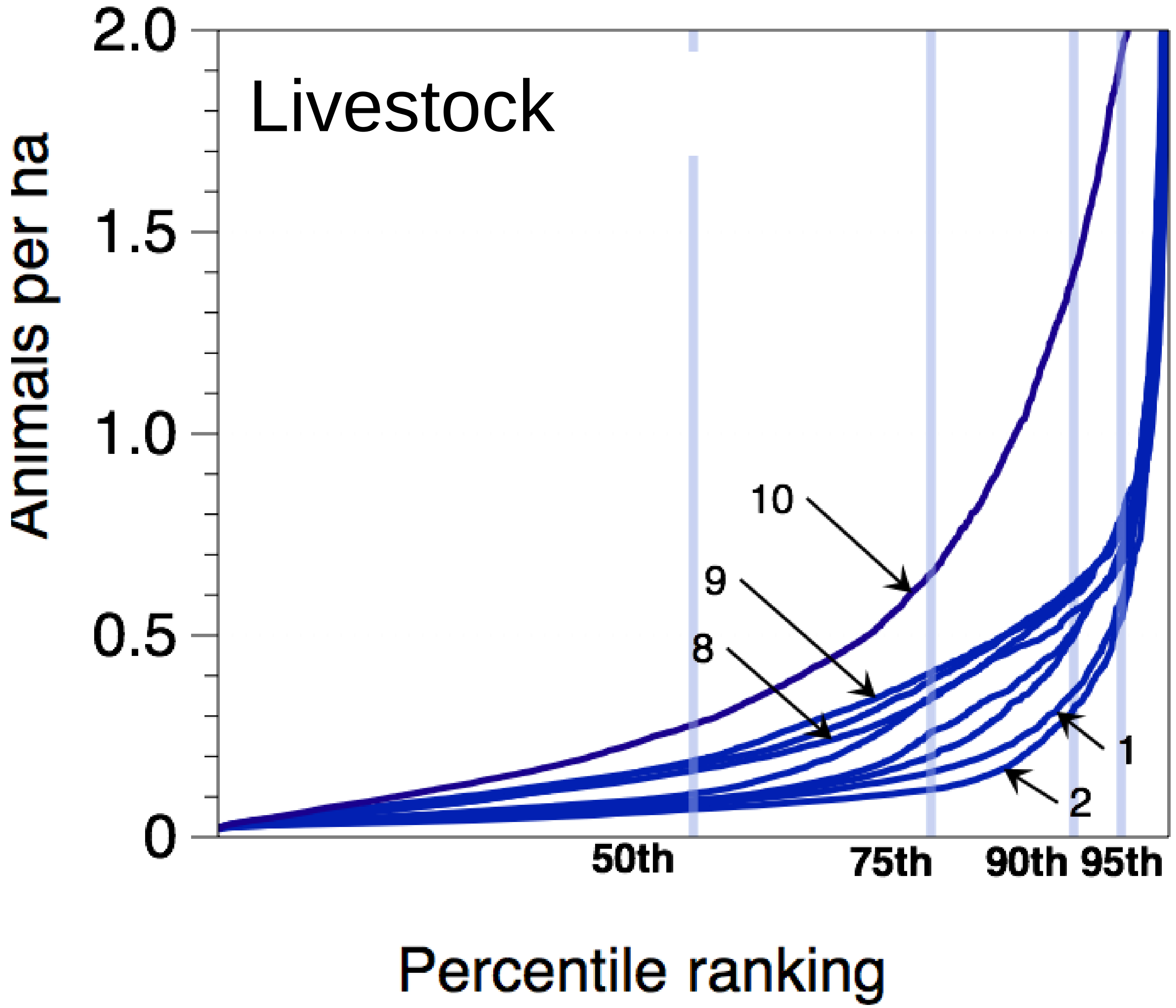
0.683	0.561	0.670	0.742	0.855	0.619	0.661	0.657	0.626	0.746
0.634	0.336	0.695	0.792	0.836	0.443	0.471	0.677	0.756	0.761
0.592	0.569	0.794	0.796	0.859	0.743	0.432	0.552	0.683	0.813
0.445	0.546	0.818	0.694	0.806	0.825	0.477	0.508	0.633	0.874
0.474	0.449	0.636	0.653	0.759	0.822	0.611	0.568	0.451	0.887
0.517	0.382	0.371	0.582	0.674	0.601	0.636	0.660	0.419	0.881
0.553	0.327	0.253	0.383	0.545	0.653	0.583	0.668	0.544	0.760
0.609	0.403	0.224	0.311	0.576	0.494	0.448	0.595	0.551	0.723
0.623	0.563	0.333	0.212	0.579	0.469	0.181	0.265	0.363	0.601
0.610	0.607	0.413	0.350	0.268	0.271	0.273	0.313	0.408	0.347

Only 57% of the land designated as pasture is acturally occupied. Some bins have occupied fractions of less than 0.20. No obvious pattern

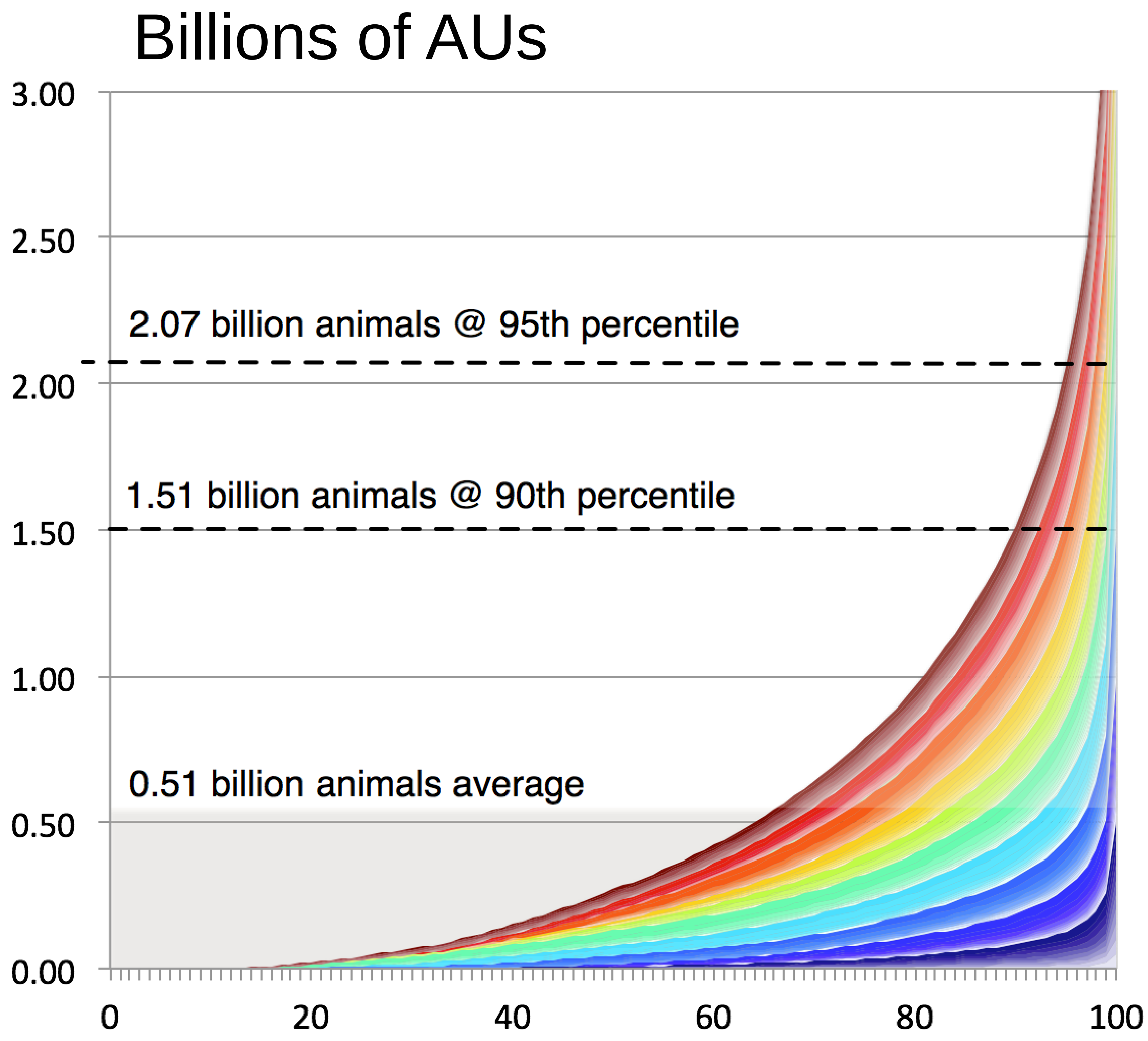

Climate
bins

the shape of things





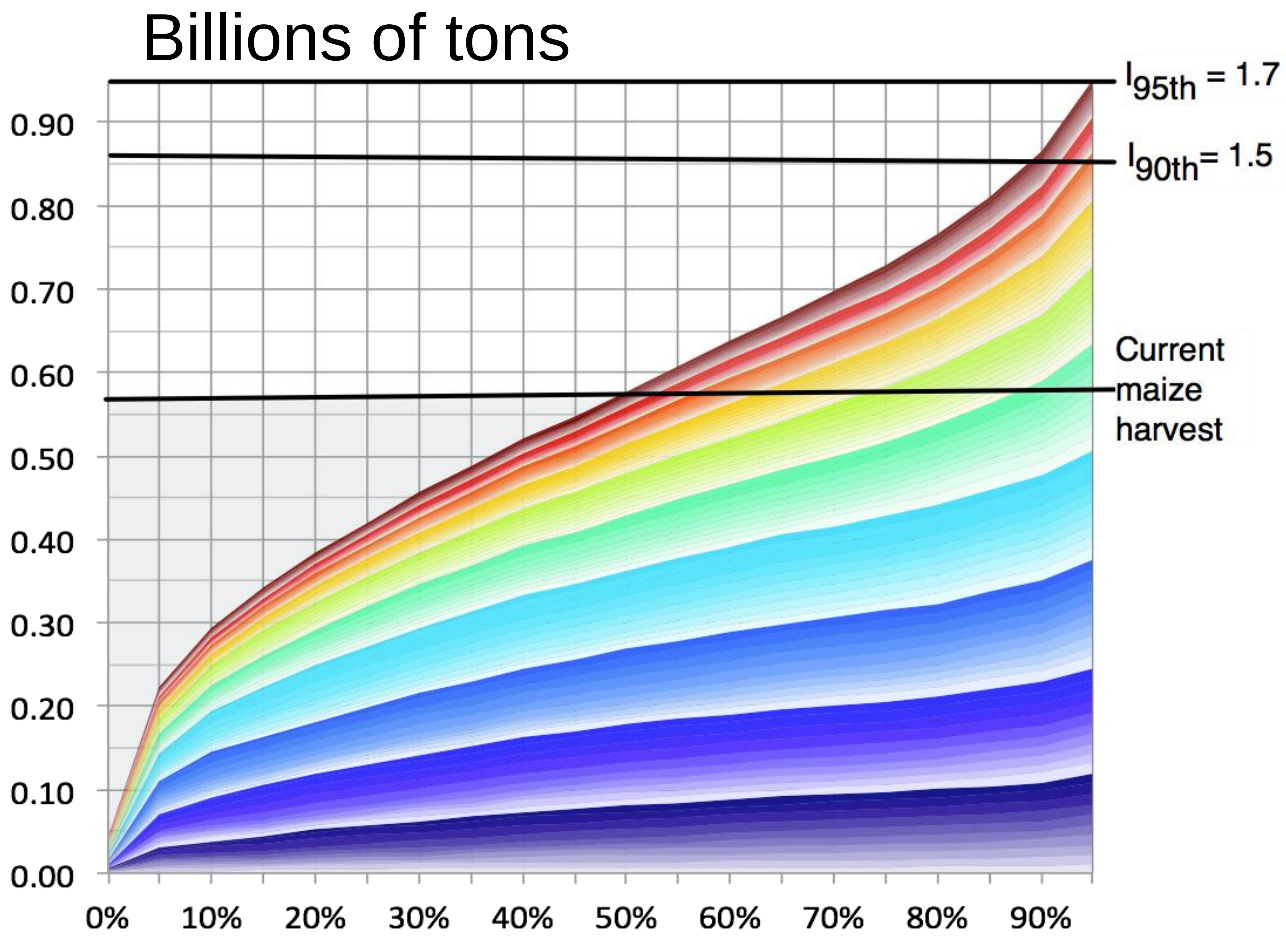
Adding it all up



Aggregate livestock intensification potential of 2.2 to

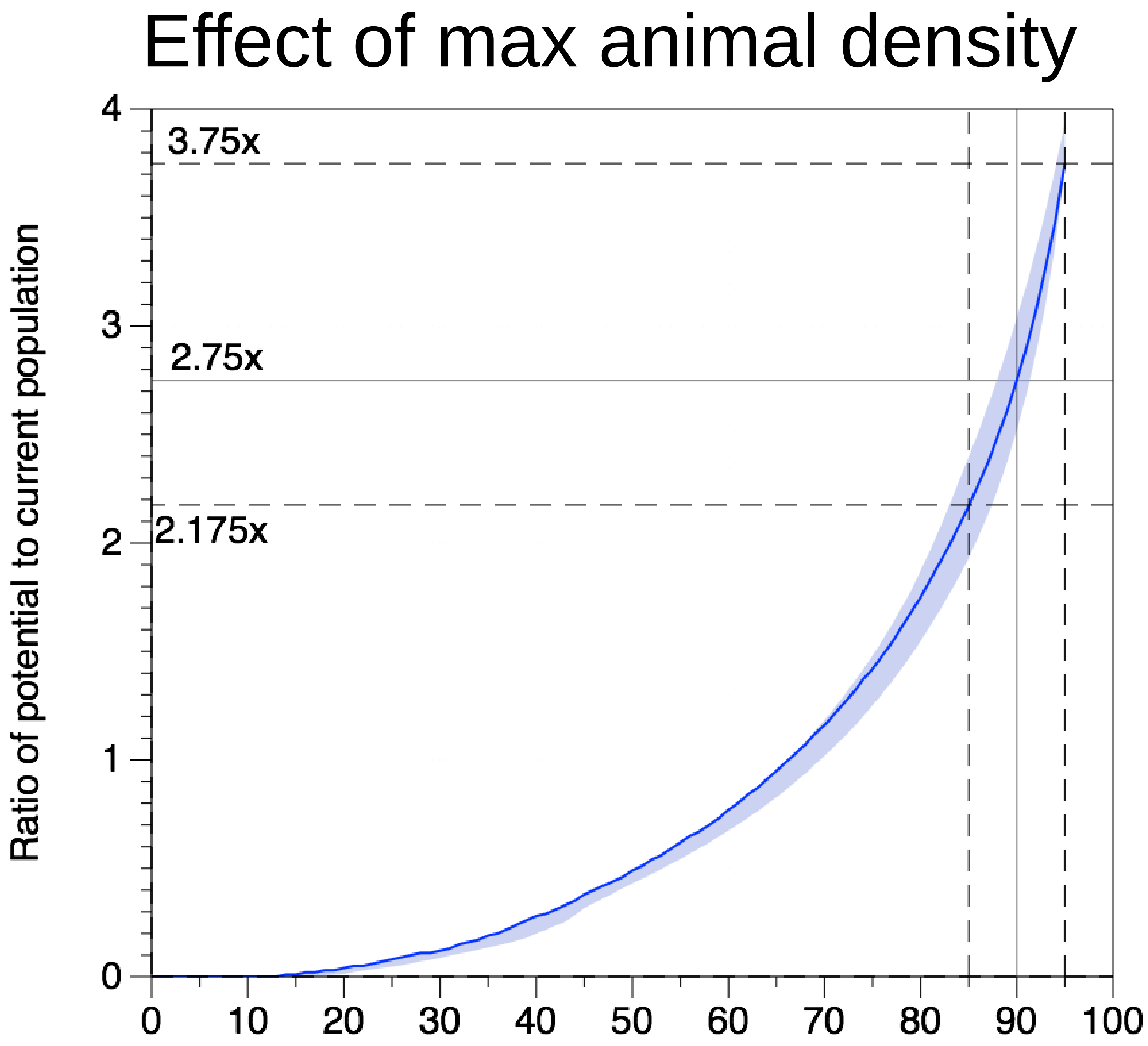
3.75x increase

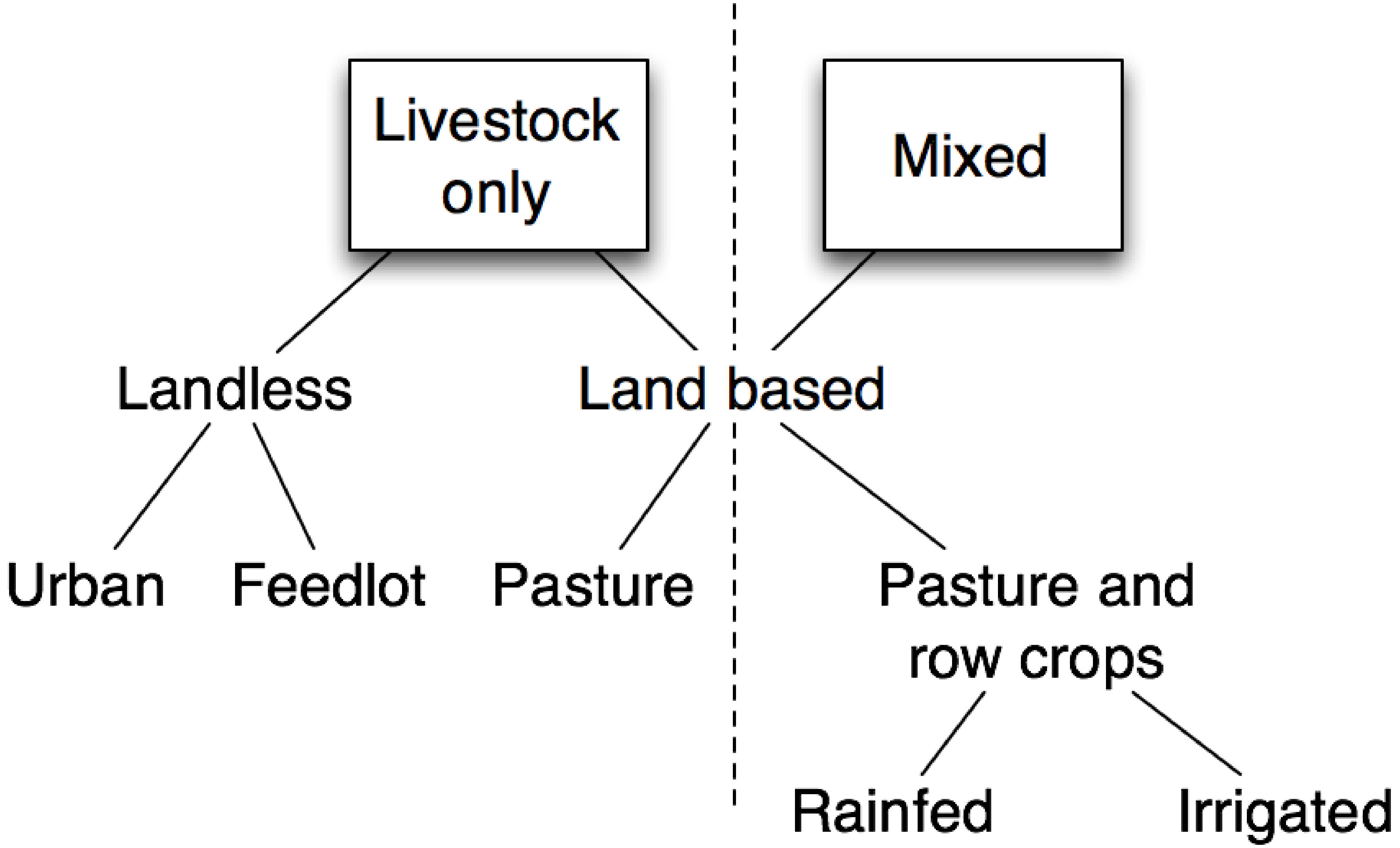
Compare that to maize



Aggregate maize intensification potential of 1.5 to 1.7-fold increase

Uncertainties and ambiguities in data

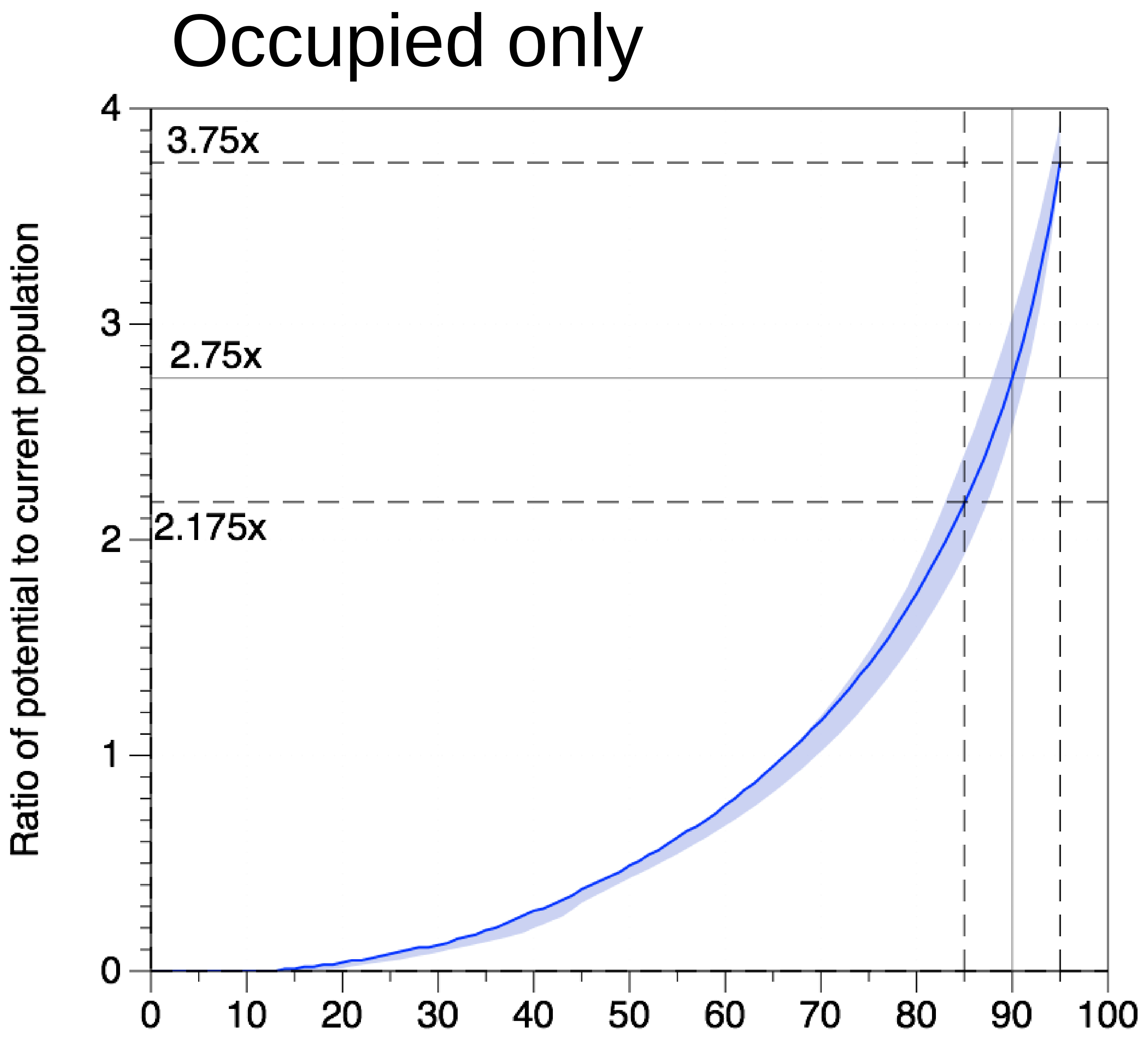


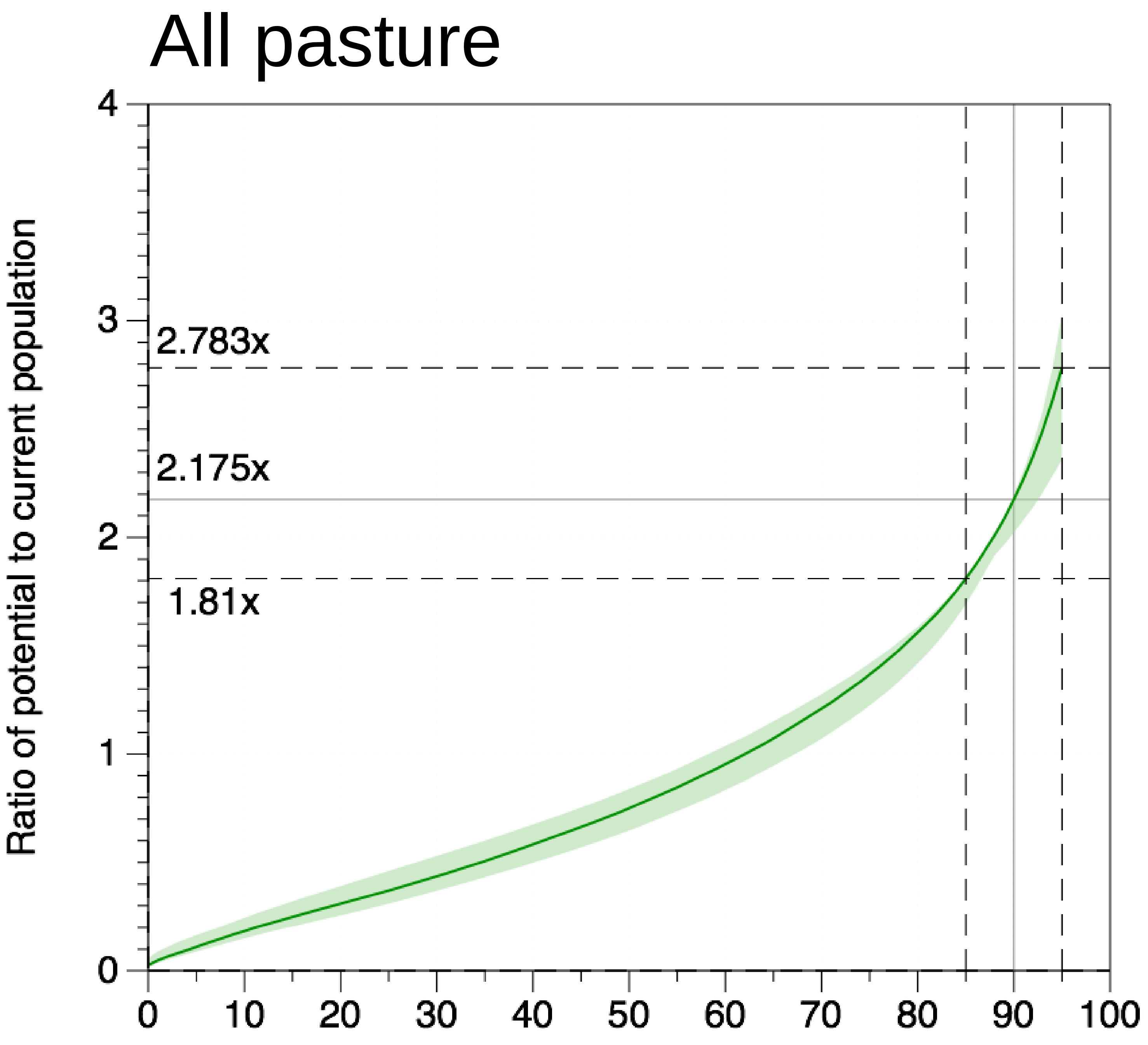


100-1,000? AU/ha

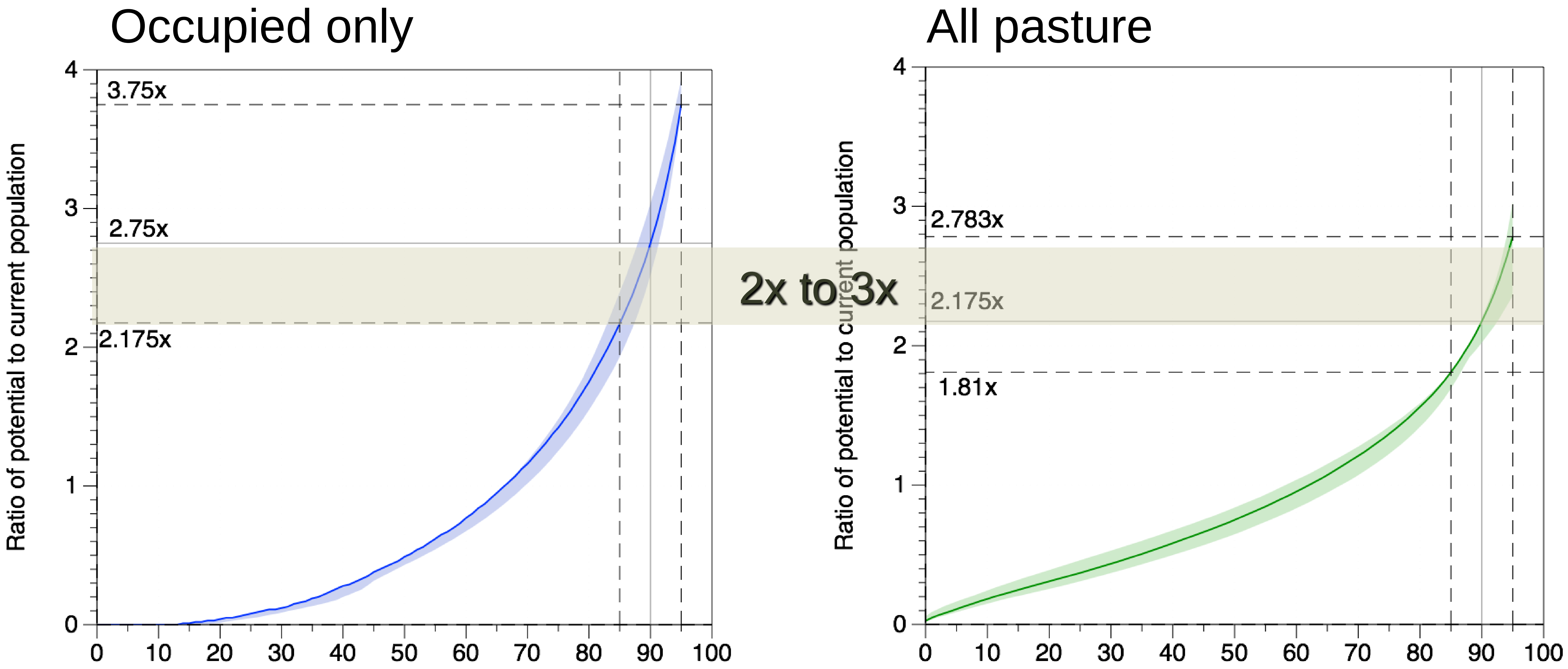
2-3? AU/ha

Uncertainties and ambiguities in data

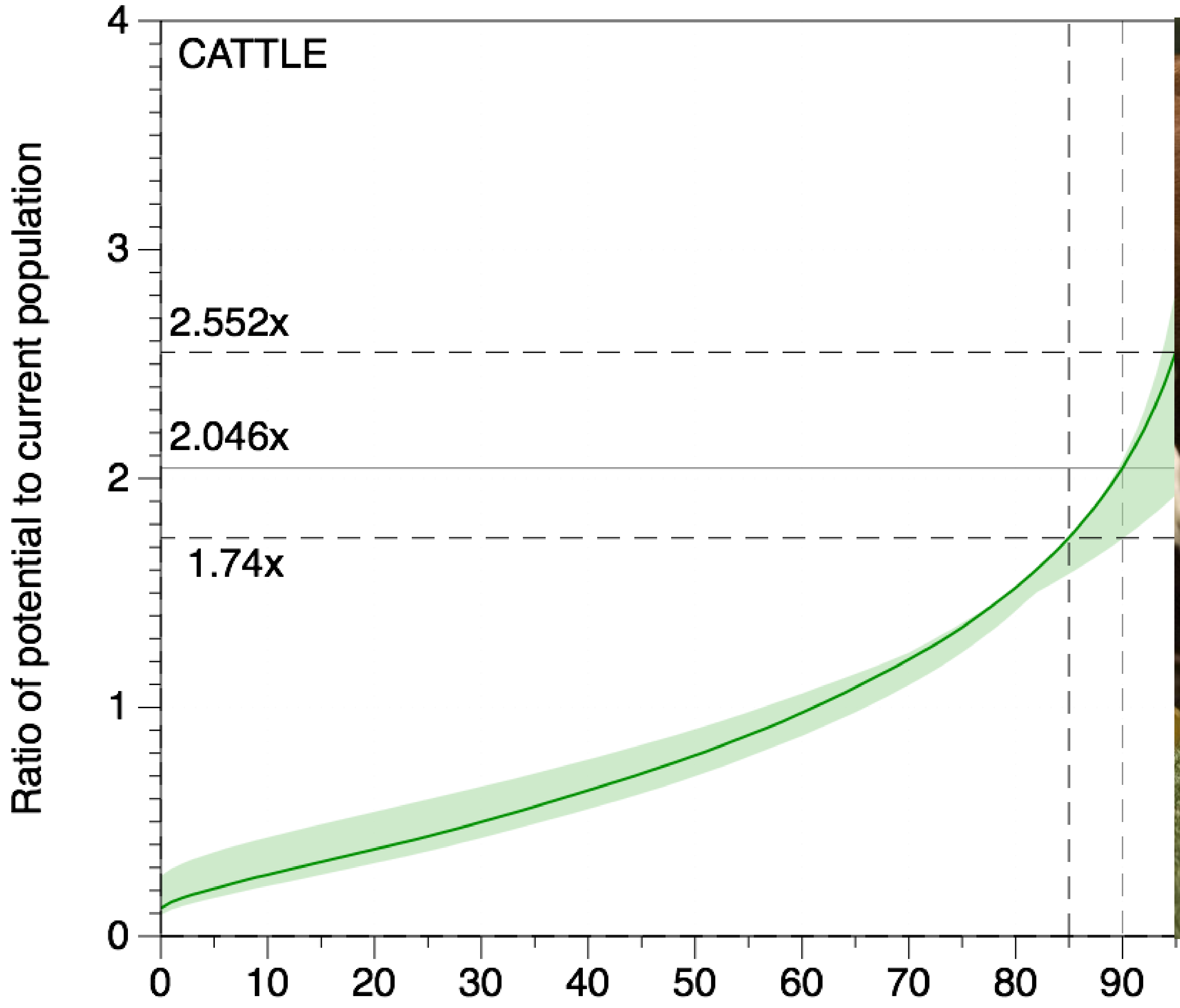




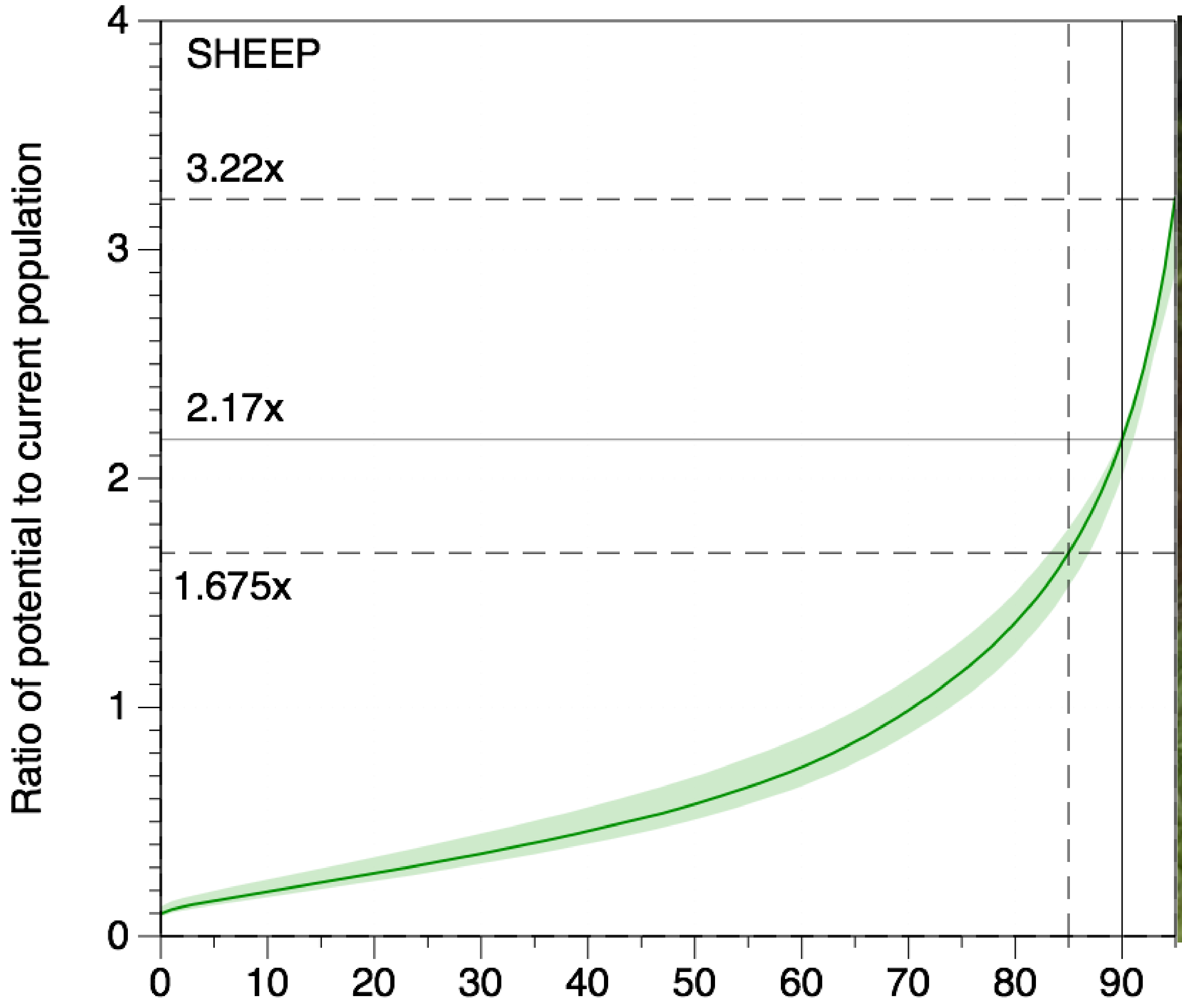
Uncertainties and ambiguities in data



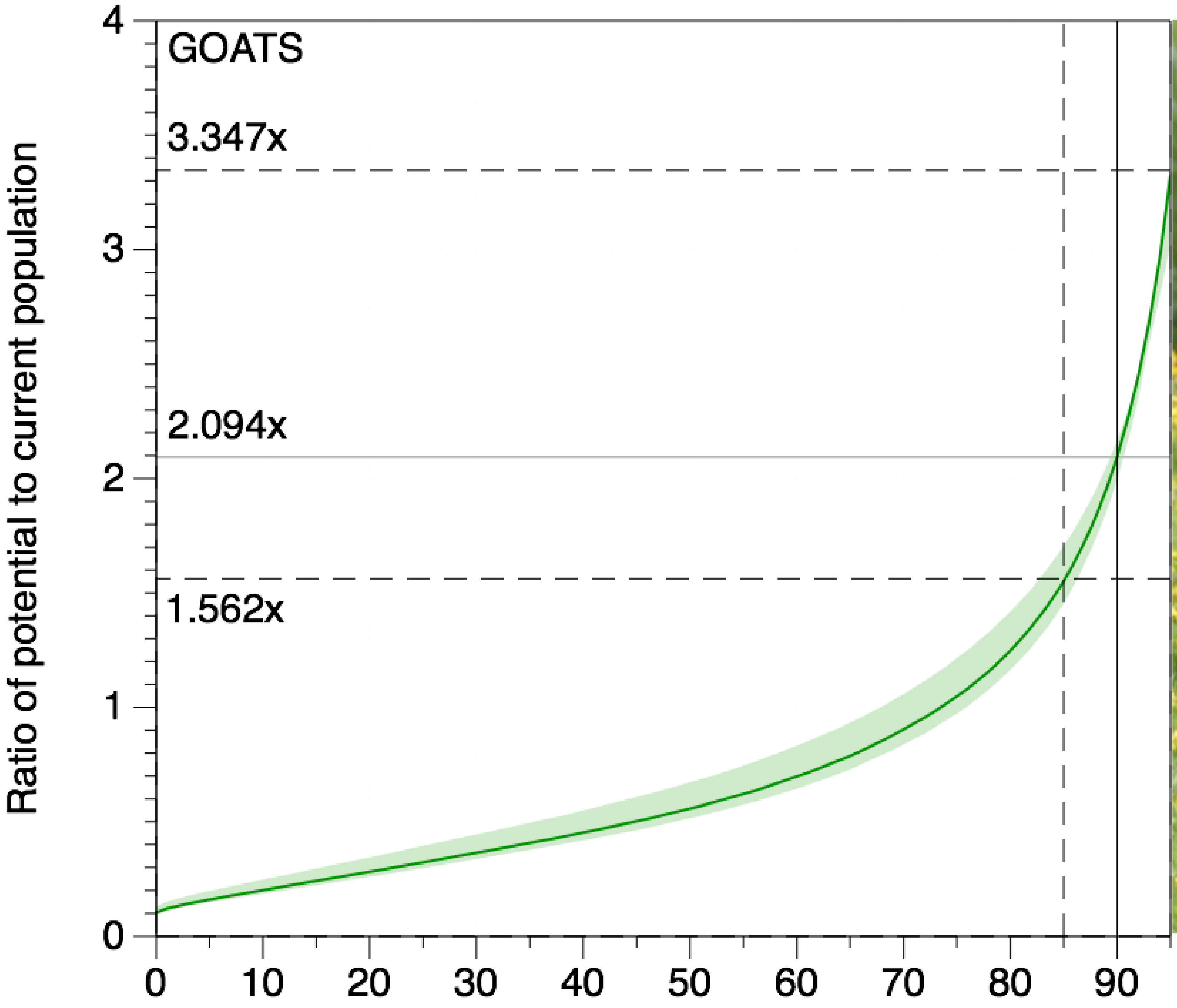
Cattle on occupied land



Sheep on occupied land



Goats on occupied land



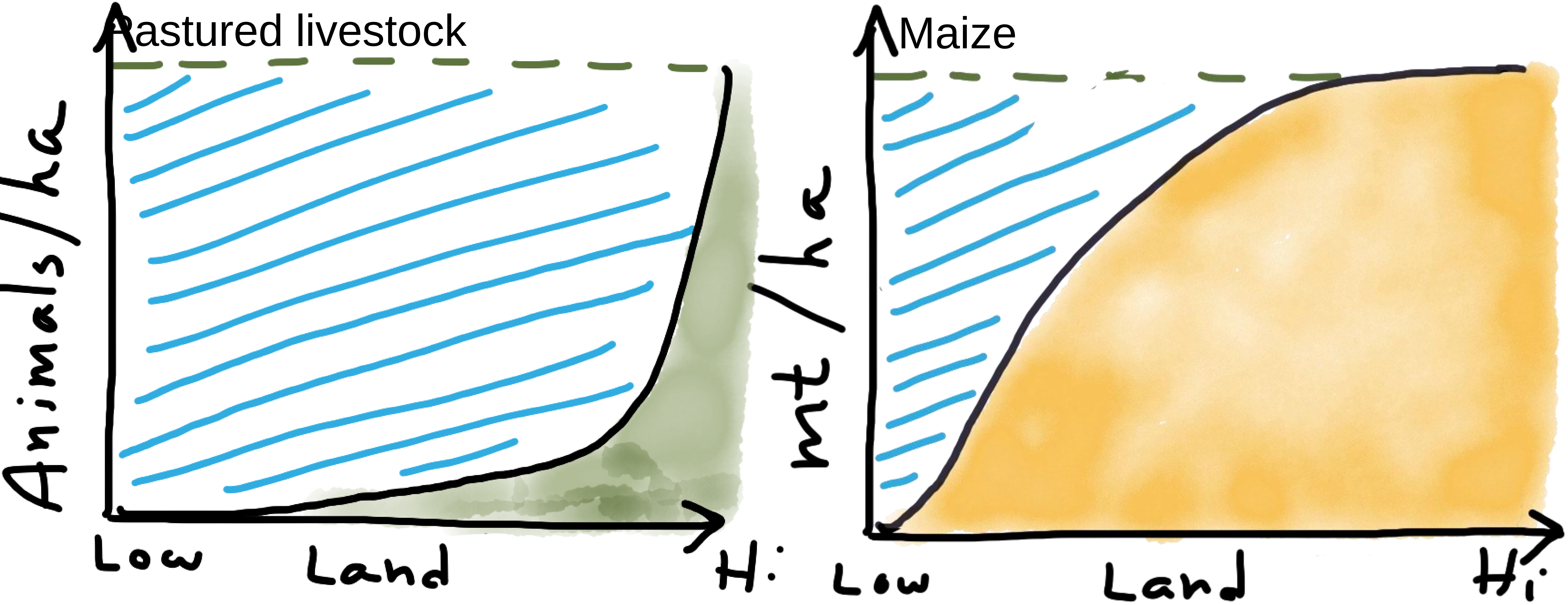
Closing thoughts

Can cows make room for cars?

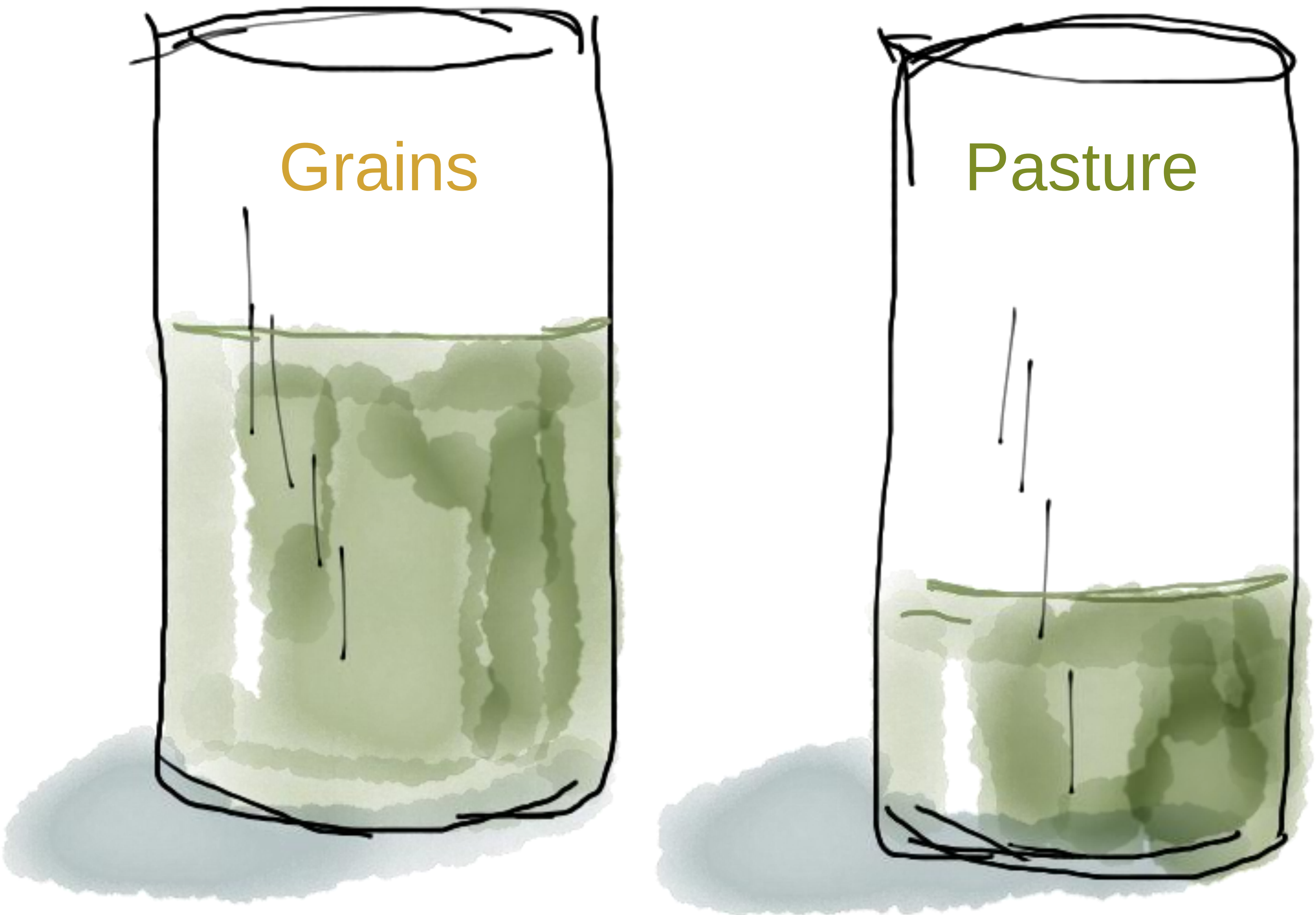
Can cows make room for cars?

A particular example of the broader question "Is the world full?"

Can cows make room for cars?



Can cows make room for cars?



Foley et al (2011): potential

58% improvement.

This analysis:

200% for pasture systems

Can cows make room for cars?

The uncertainties are
high

The data needs are great
But so is the potential

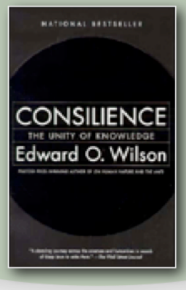
Can cows make room for cars?

Mixed crop livestock sytems are an UNTAPPED opportunity we need to explore

Can cows make room for cars?

Sustainable development

"The common aim must be to expand resources and improve quality of life for as many people as heedless population growth forces upon Earth, and do it with minimal prosthetic dependence. That, in essence, is the ethic of sustainable development."



An imperative from an an ethical perspective

and a systems view to look