Center for Regenerative Agriculture
MICHIGAN STATE UNIVERSITY

Ruminants - contribution to a sustainable grassland environment, it is not as it seems

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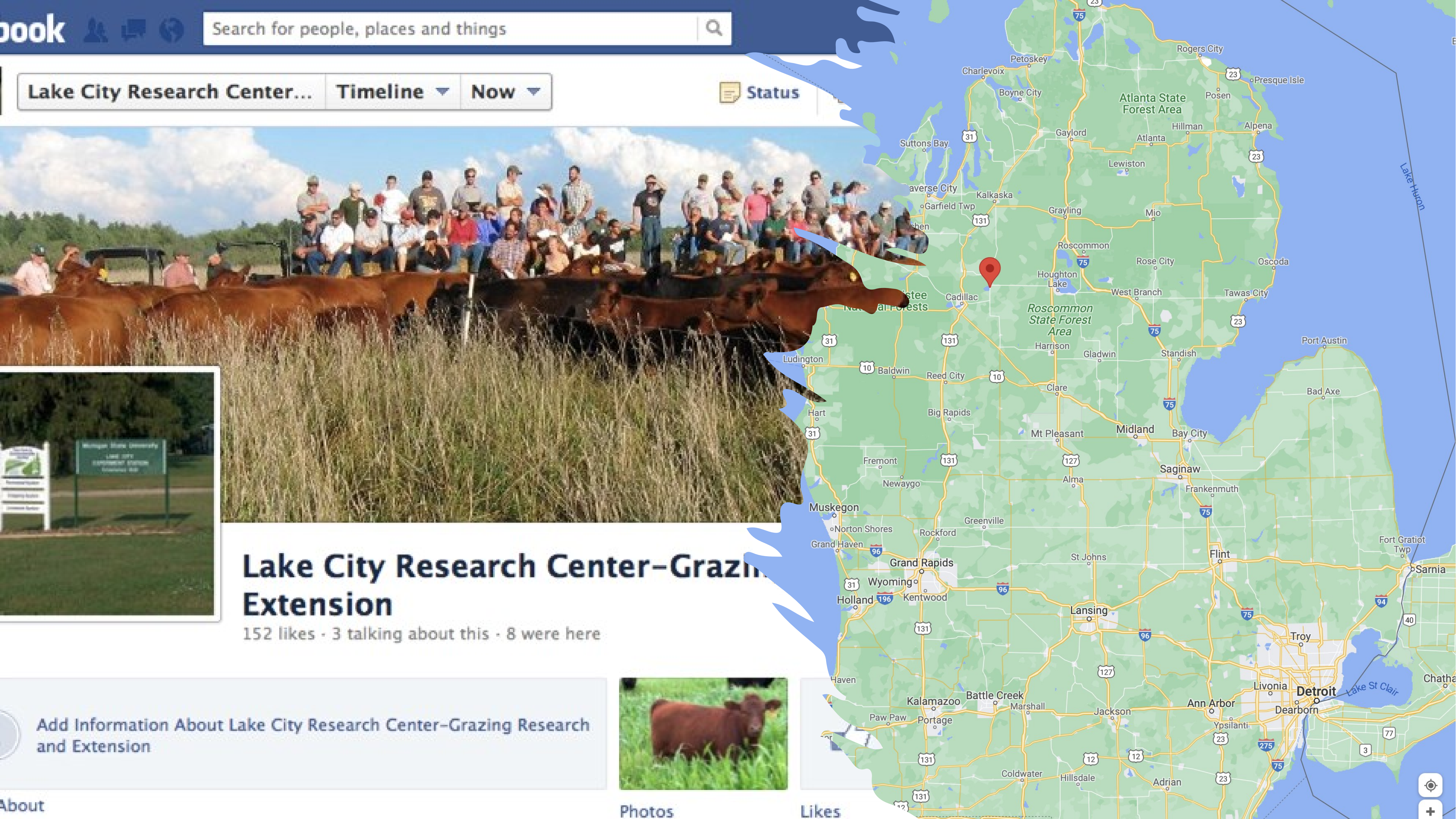
October 19th, 2022

College of Agriculture and Natural Resources
MICHIGAN STATE UNIVERSITY



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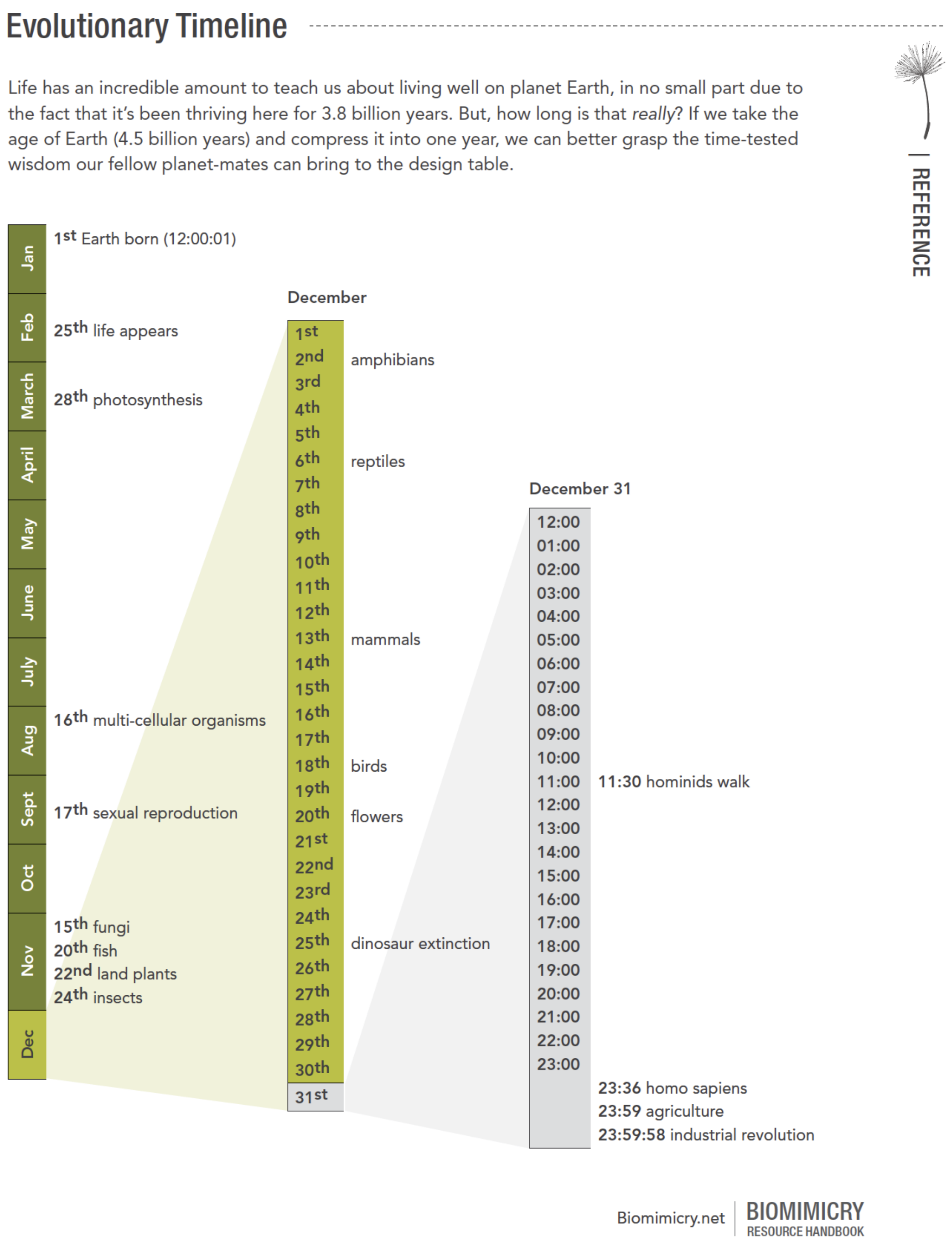
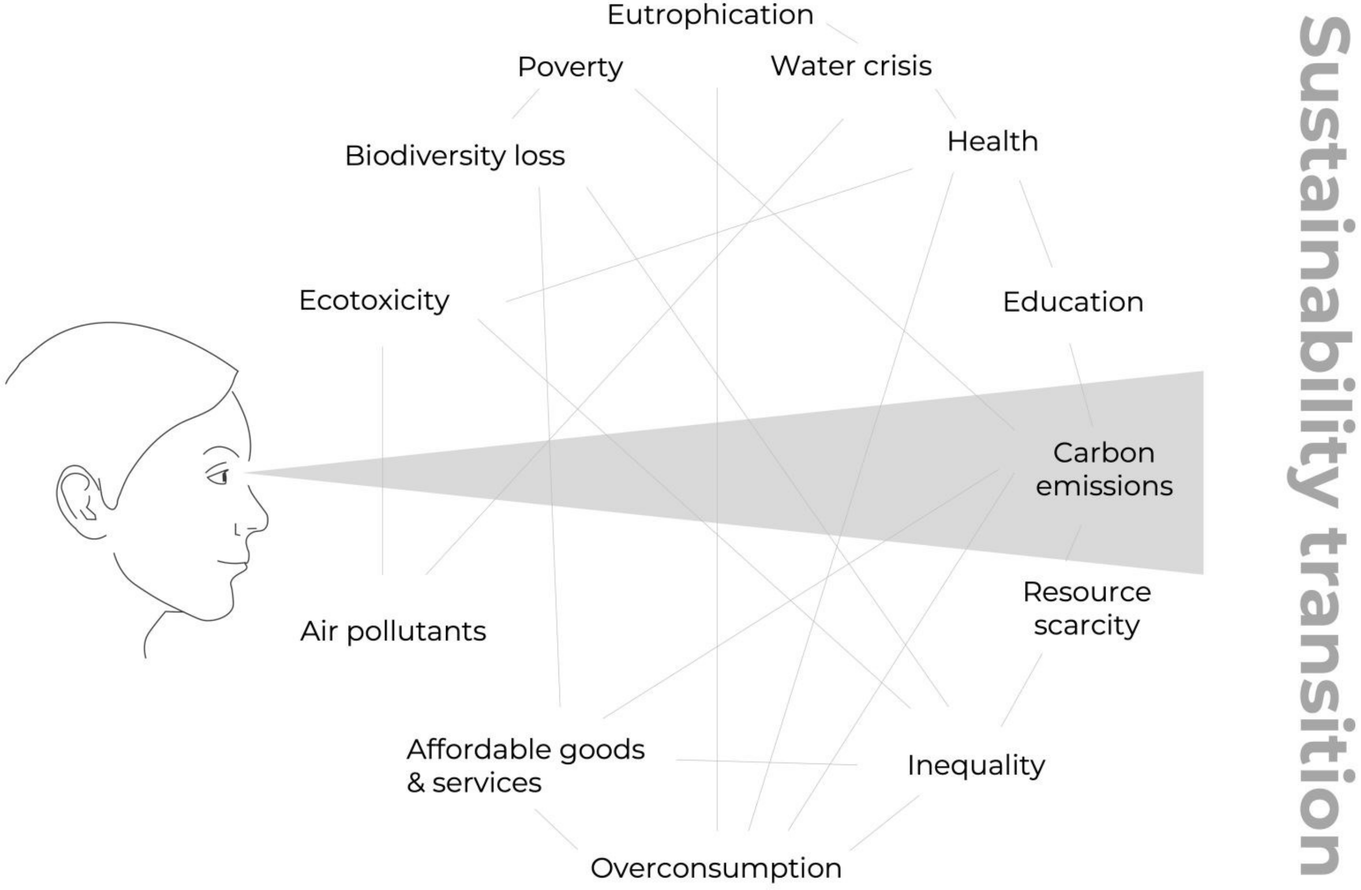


Ruminants and Grass

- Ruminants evolved 50 M years ago
- Ruminant numbers globally have largely been consistent
- Methane numbers have risen considerably since the industrial revolution

Carbon Tunnel Vision



Graphic by Jan Konietzko

National herd halved and enough trees to cover Dublin five times over – what we must do to hit climate targets

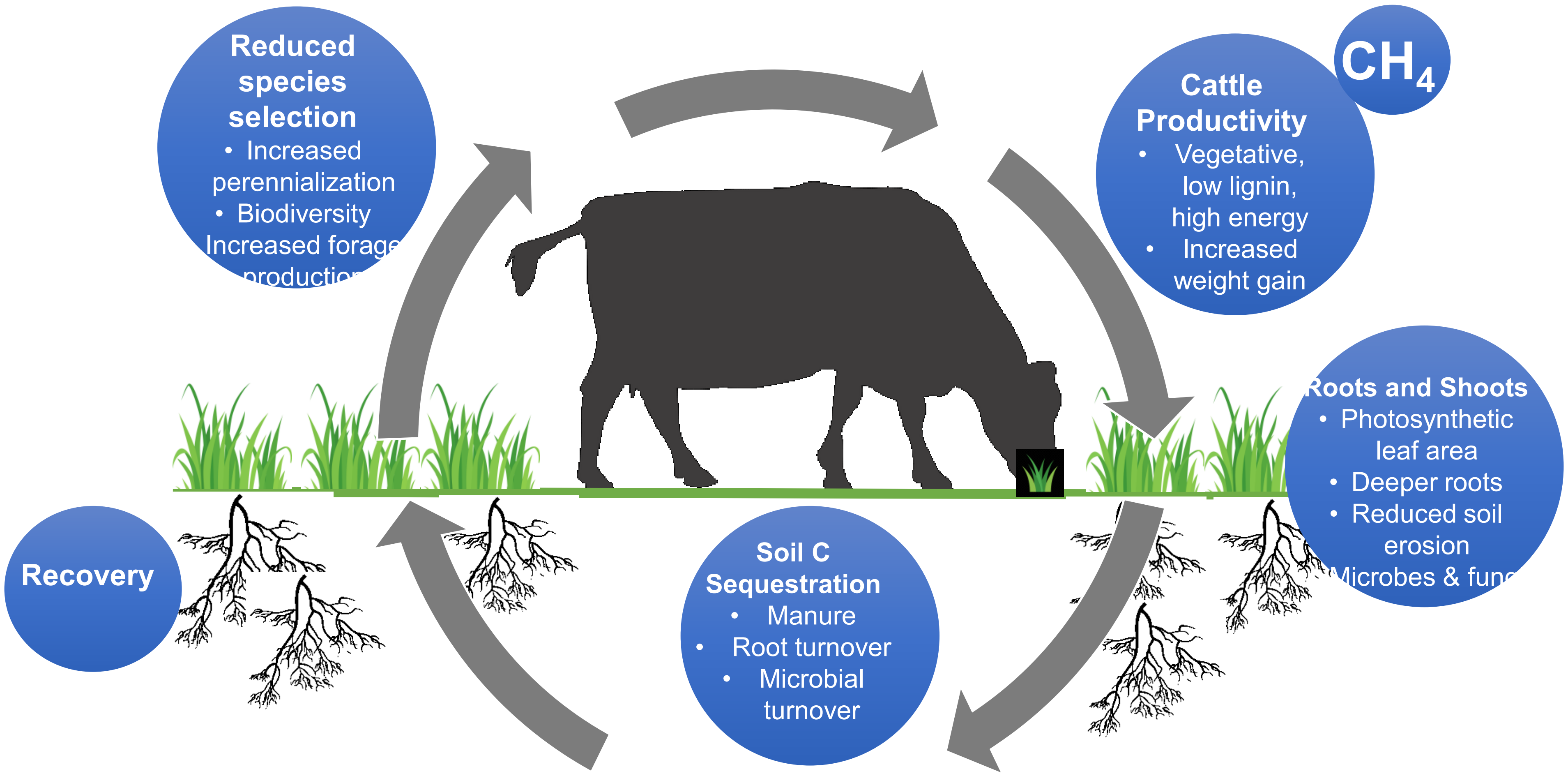
New study lays out what's needed to reach reach 'net zero' by 2050

A charolais bull

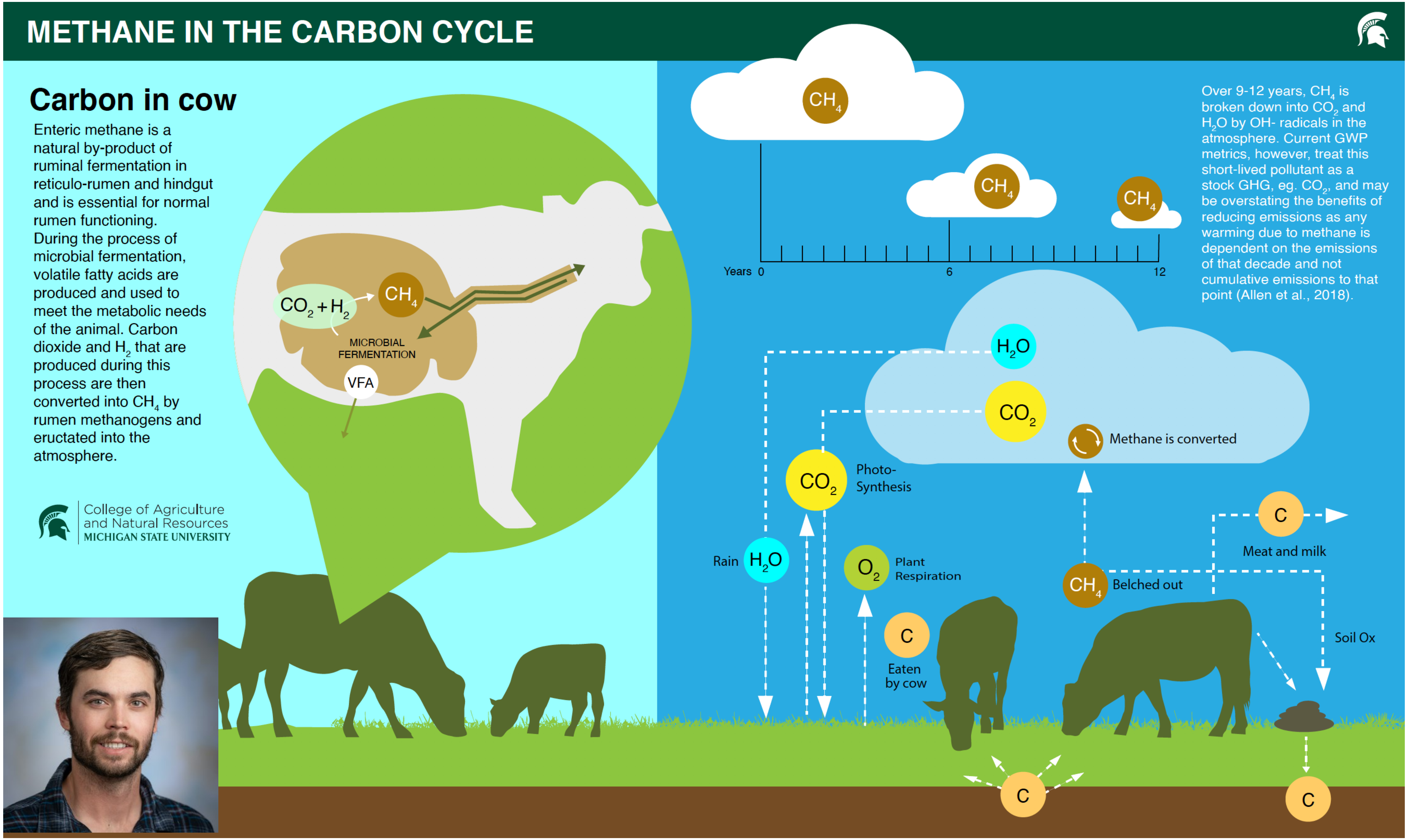
Seán Duke

September 13 2022 12:50 PM

Adaptive Multi-paddock Grazing (AMP)



(Savory and Butterfield, 2016, Stanley, et al., 2018)



(Thompson and Rowntree, 2020)

Costa et al., 2021

“For example, using GWP100, a constant annual rate of CH4 emissions may be misinterpreted as having a 3-4 times higher impact on warming than observed. The use of GWP* can correct this misestimation. - GWP* was used here to evaluate the impact of agricultural CH4 emissions scenarios from 2020- 2040, finding that: - A sustained ~0.35% annual decline is sufficient to stop further increases in global temperatures due to agricultural CH4 emissions. This is analogous to the impact of net-zero CO2 emissions. - A ~5% annual decline could neutralize the additional warming caused by agricultural CH4 since the 1980s. - Faster reductions of CH4 emissions have an analogous impact to removing CO2 from the atmosphere.”

Published August 6, 2015

Carbon flux assessment in cow-calf grazing systems[1]

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azil; and †Department of Animal Science, Michigan State University, 424 S. Shaw Lane, East Lansing 48824

TRACT: Greenhouse gas (GHG) fluxes and ganic carbon (SOC) accumulation in grassland stems are intimately linked to grazing manage- This study assessed the carbon equivalent flux $_{ux}$) from 1) an irrigated, heavily stocked, low- y grazing system, 2) a nonirrigated, lightly d, high-density grazing system, and 3) a graz- clusion pasture site on the basis of the GHG ions from pasture soils and enteric methane ions from cows grazing different pasture treat- . Soil organic carbon and total soil nitrogen were measured but not included in Ceq_{flux} nination because of study duration and time d to observe a change in soil composition. and heavy-stocking systems had 36% and 43% r Ceq_{flux} than nongrazed pasture sites, respec- ($P < 0.01$). The largest contributor to increased Ceq_{flux} from grazing systems was enteric CH_4 emi sions, which represented 15% and 32% of the overa emissions for lightly and heavily stocked grazing sy tems, respectively. Across years, grazing systems als had increased nitrous oxide (N2O; $P < 0.01$) and CH emissions from pasture soils ($P < 0.01$) compared wi nongrazed pasture sites but, overall, minimally co tributed to total emissions. Results indicate no cle difference in Ceqflux between the grazing systen studied when SOC change is not incorporated (P 0.11). A greater stocking rate potentially increase total SOC stock ($P = 0.02$), the addition of SOC deep into the soil horizon ($P = 0.01$), and soil OM conte to 30 cm ($P < 0.01$). The incorporation of long-ter annual carbon sequestration into the determination Ceq_{flux} could change results and possibly differentia the grazing systems studied.

Key words: beef cattle, enteric methane, grazing management, nitrous oxide

 J. Anim. Sci. 2015.93:4189–419
doi:10.2527/jas2015-903

INTRODUCTION

reenhouse gas (**GHG**) fluxes from grassland eco- ns are intimately linked to grazing management. sslands, CO_2 is exchanged with the soil and veg- ı, N_2O is emitted by soils, and CH_4 is emitted by bial activities in the digesta and exchanged with il. When CO_2 exchange with vegetation is includ- ed in net GHG exchange calculation, these ecosysten are often observed as GHG sinks (Allard et al., 200 Soussana et al., 2007). Similarly, the inclusion of sc organic carbon (**SOC**) accumulation over time in n GHG exchange accounting might result in grasslanc with GHG sink potentials (Liebig et al., 2010).

Grassland management choices to reduce GH budget may involve important trade-offs. Allard al. (2007) observed that enteric CH_4 emissions e pressed as CO_2 equivalent strongly affected GH budget in intensively and extensively manage grasslands (average 70% offset of total CO_2 sink a tivity). Conversely, Soussana et al. (2007) observe that the addition of enteric CH_4 and N_2O emissior from pasture soils resulted in a relatively small offs of total CO_2 sink activity (19% average). Grasslanc management affects SOC storage by modifying inputs to the soil, primarily through root turnov

e authors thank Michigan State University Animal Agriculture e for financial support of this project. In addition, the authors Guilherme Signorini, Brooke Latack, Rachel Baumgardner, Schilling, Jolene Roth (Michigan State University), and Carmichael (Lake City AgBioResearch Center, MSU) for t during sampling and sample analyzes.
orresponding author: marilia.chiavegato@usp.br
eived February 20, 2015.
epted June 1, 2015.

Table 3. Pearson correlation (r) and significance (*P*-value) between GHG emissions sources and C-equivalent flux (C-eq flux) in dairy grazing systems of Brazil and in beef grazing systems of United States of America.

Emission source	**C-eq flux**	**GHG contribution**	**C-eq flux**
Dairy grazing systems			
$CH_{4\ animals}$	0.671	$CH_{4\ animals}$	-0.526
$N_2O_{\ soil}$	0.505	$N_2O_{\ soil}$	0.465
$CH_{4\ soil}$	0.082^{NS}	$CH_{4\ soil}$	0.157
$CO_{2\ soil}$	0.382	$CO_{2\ soil}$	0.093^{NS}
Beef grazing systems			
$CH_{4\ animals}$	0.005^{NS}	$CH_{4\ animals}$	-0.643
$N_2O_{\ soil}$	0.693	$N_2O_{\ soil}$	0.354
$CH_{4\ soil}$	0.332	$CH_{4\ soil}$	0.123^{NS}
$CO_{2\ soil}$	0.963	$CO_{2\ soil}$	0.366

Chiavegato et al., 2022 (In Review)

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Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems

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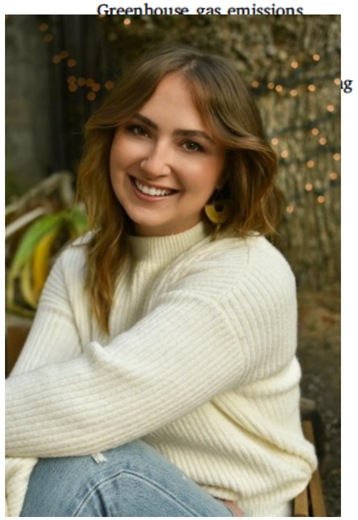
A R T I C L E I N F O

Keywords:
Life cycle assessment
Greenhouse gas emissions



A B S T R A C T

Beef cattle have been identified as the largest livestock-sector contributor to greenhouse gas (GHG) emissions. Using life cycle analysis (LCA), several studies have concluded that grass-finished beef systems have greater GHG intensities than feedlot-finished (FL) beef systems. These studies evaluated only one grazing management system – continuous grazing – and assumed steady-state soil carbon (C), to model the grass-finishing environmental impact. However, by managing for more optimal forage growth and recovery, adaptive multi-paddock (AMP) grazing can improve animal and forage productivity, potentially sequestering more soil organic carbon (SOC) than continuous grazing. To examine impacts of AMP grazing and related SOC sequestration on net GHG emissions, a comparative LCA was performed of two different beef finishing systems in the Upper Midwest, USA: AMP grazing and FL. We used on-farm data collected from the Michigan State University Lake City AgBioResearch Center for AMP grazing. Impact scope included GHG emissions from enteric methane, feed production and mineral supplement manufacture, manure, and on-farm energy use and transportation, as well as the potential C sink arising from SOC sequestration. Across-farm SOC data showed a 4-year C sequestration rate of 3.59 Mg C ha^{-1} yr^{-1} in AMP grazed pastures. After including SOC in the GHG footprint estimates, finishing emissions from the AMP system were reduced from 9.62 to −6.65 kg CO_2-e kg carcass weight $(CW)^{-1}$, whereas FL emissions increased slightly from 6.09 to 6.12 kg CO_2-e kg CW^{-1} due to soil erosion. This indicates that AMP grazing has the potential to offset GHG emissions through soil C sequestration, and therefore the finishing phase could be a net C sink. However, FL production required only half as much land as AMP grazing. While the SOC sequestration rates measured here were relatively high, lower rates would still reduce the AMP emissions relative to the FL emissions. This research suggests that AMP grazing can contribute to climate change mitigation through SOC sequestration and challenges existing conclusions that only feedlot-intensification reduces the overall beef GHG footprint through greater productivity.

Results: GHG Emissions

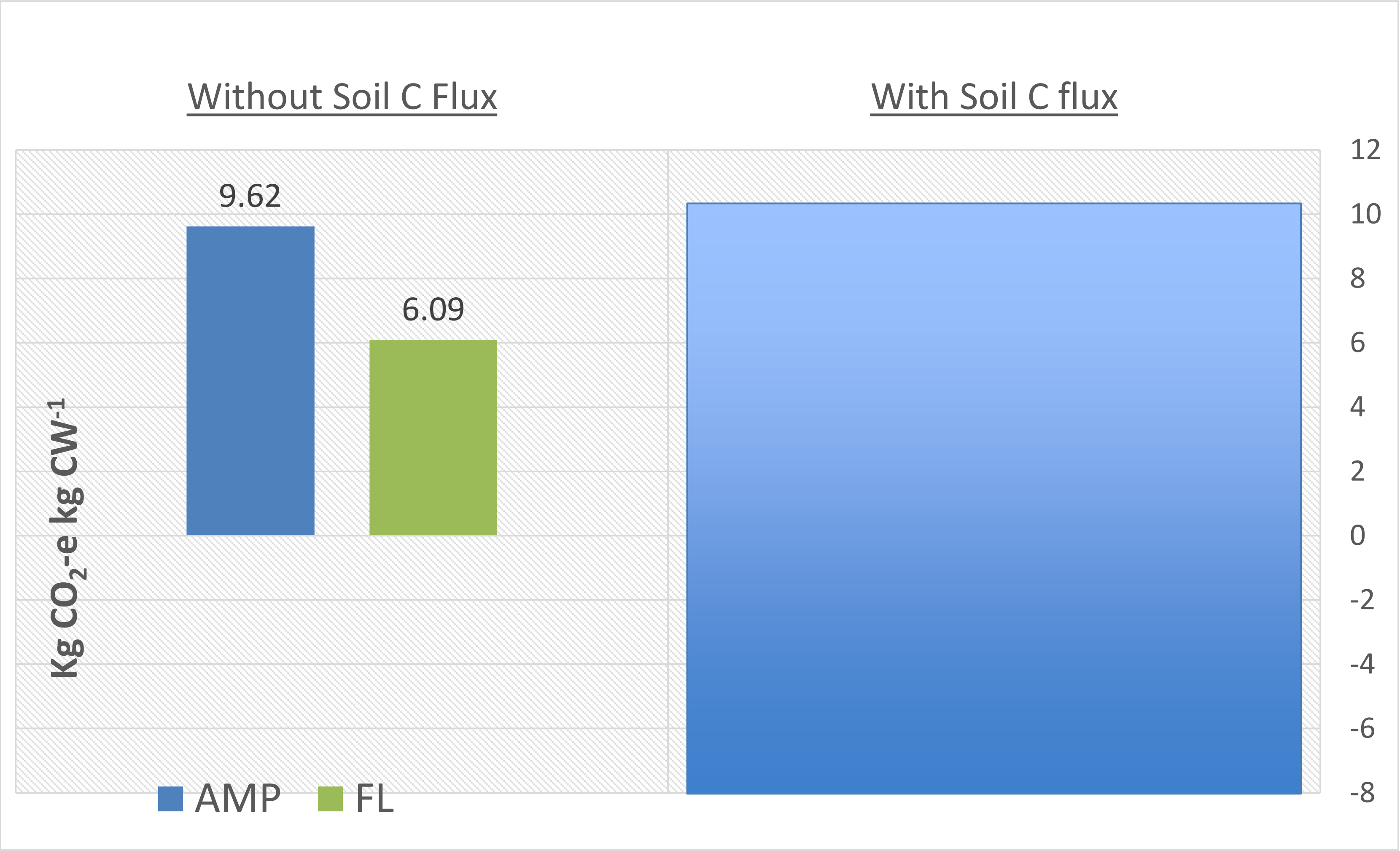
Feedlot

- Similar to finishing emissions reported by other studies (Lupo et al., 2013; Pelletier et al., 2010)

AMP

- ~45% lower than continuous grazing emissions reported by other studies (Capper, 2012; Lupo et al., 2013; Pelletier et al., 2010)
  - Shorter finishing time
  - Greater forage quality
  - Pasture fertilization

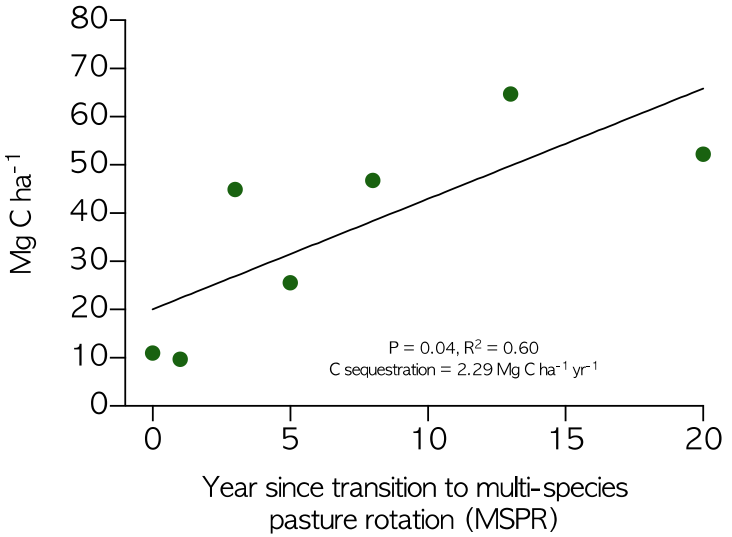
Results: Net GHG Flux



1993

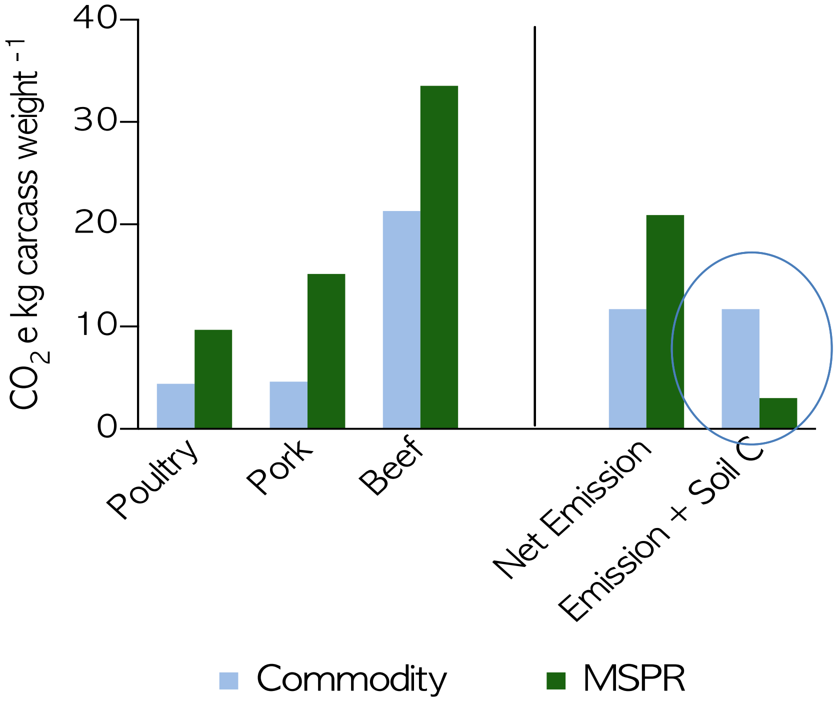
2017

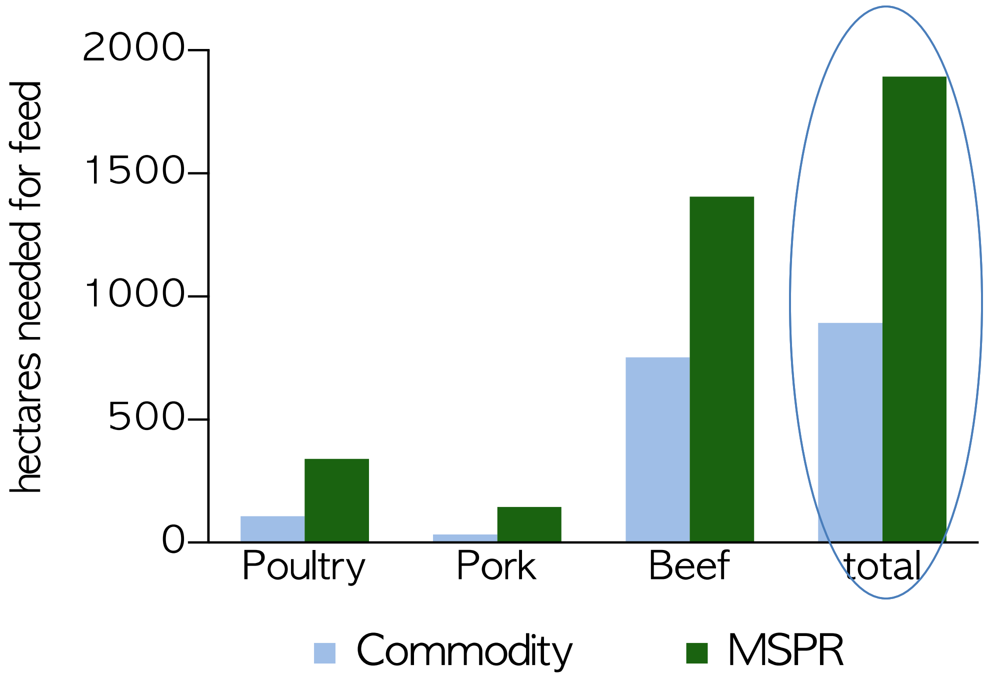
Multi-Specie Pasture Rotations and Carbon



	Year									
	0	1	3	5	8	13	20	Equation	p-value	R^2
Water-stable aggregation (%)	-	0*	11	7	47	47	53	y=2.9 +2.9x	0.02	0.76
Microbial Respiration (mg CO_2 day^{-1})	-	0*	0.56	0.54	0.94	1.16	1.16	y=0.07+0.01x	0.03	0.75
Active C (ppm)	-	80	325	380	522	884	844	y=167+41x	<0.01	0.85
Water Holding Capacity (g water g $soil^{-1}$)	-	0.19	0.2	0.15	0.15	0.28	0.21	-	0.44	-
ACE Soil Protein (mg g^{-1})	-	0*	5	3	15	22	23	y=0.2 +1.3x	<0.01	0.86

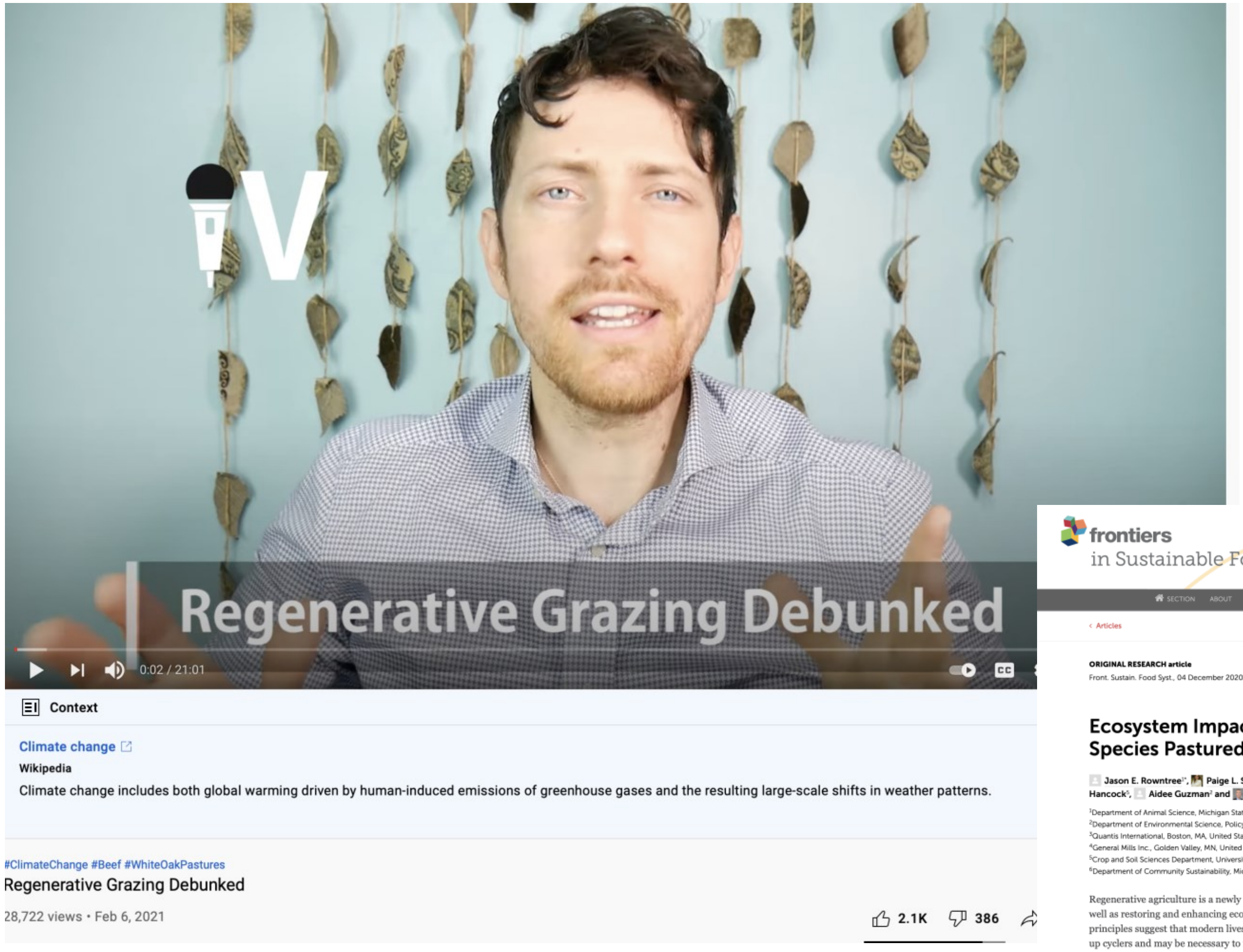
Emission and Land Use Needs

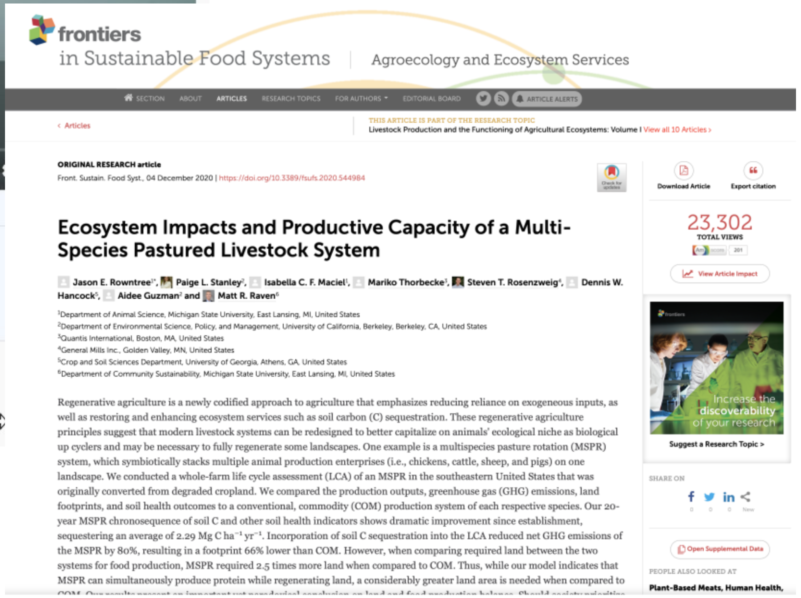




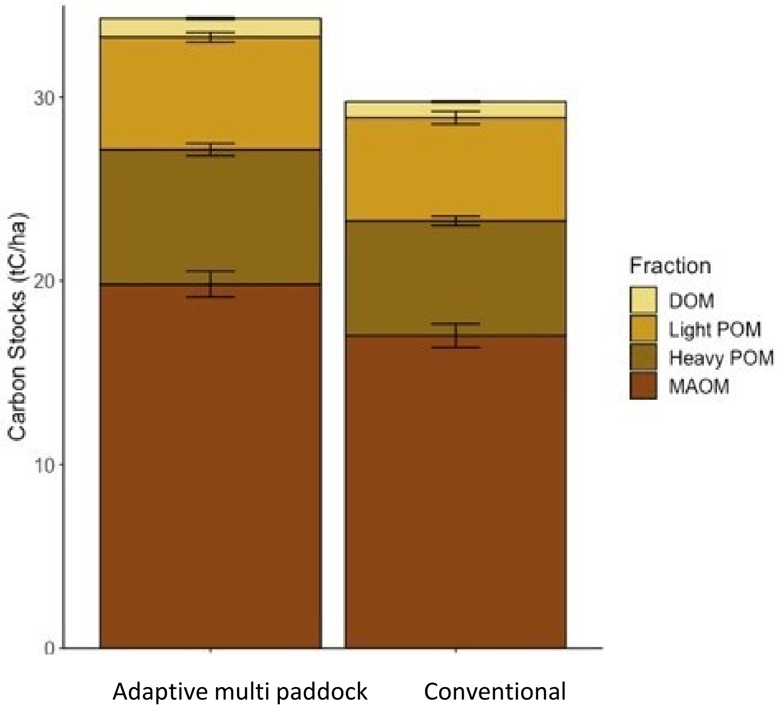
(Rowntree et al., 2020)

What is Truth?

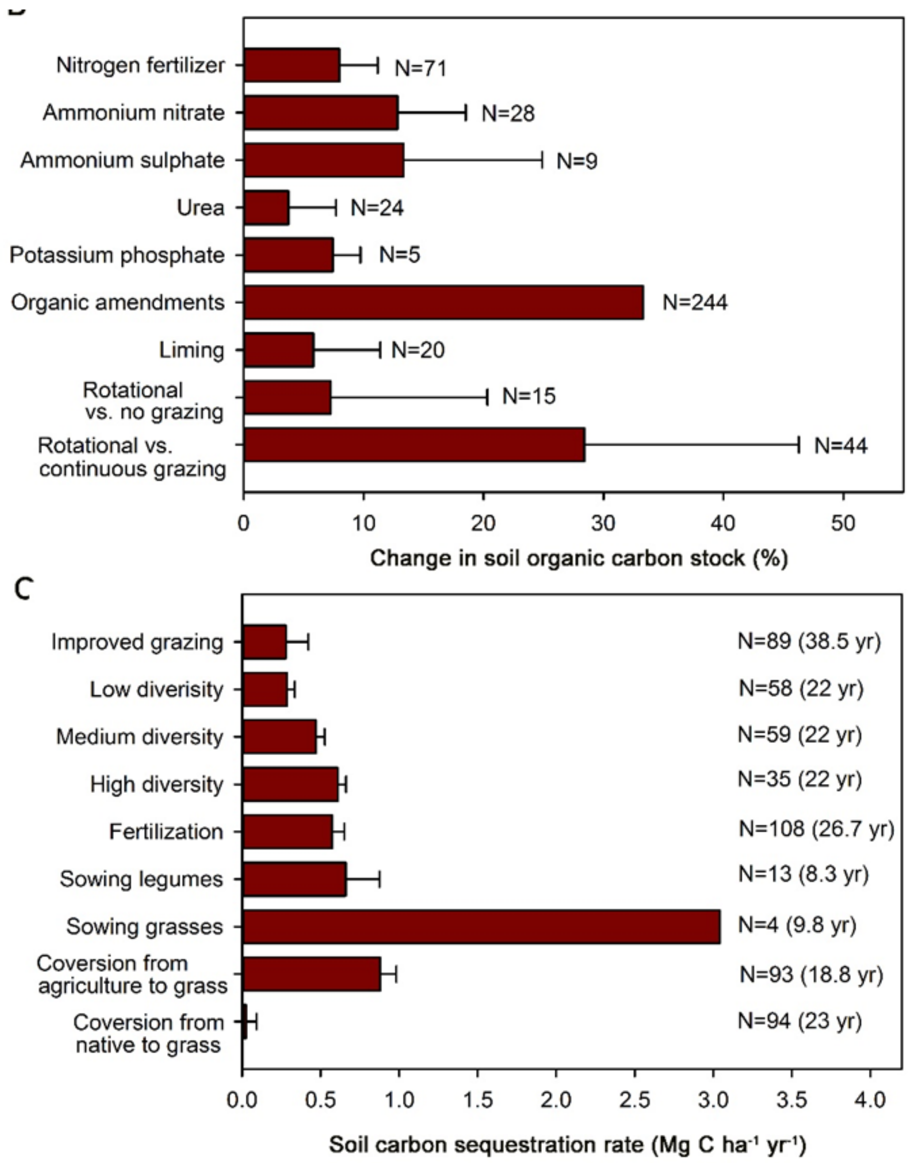




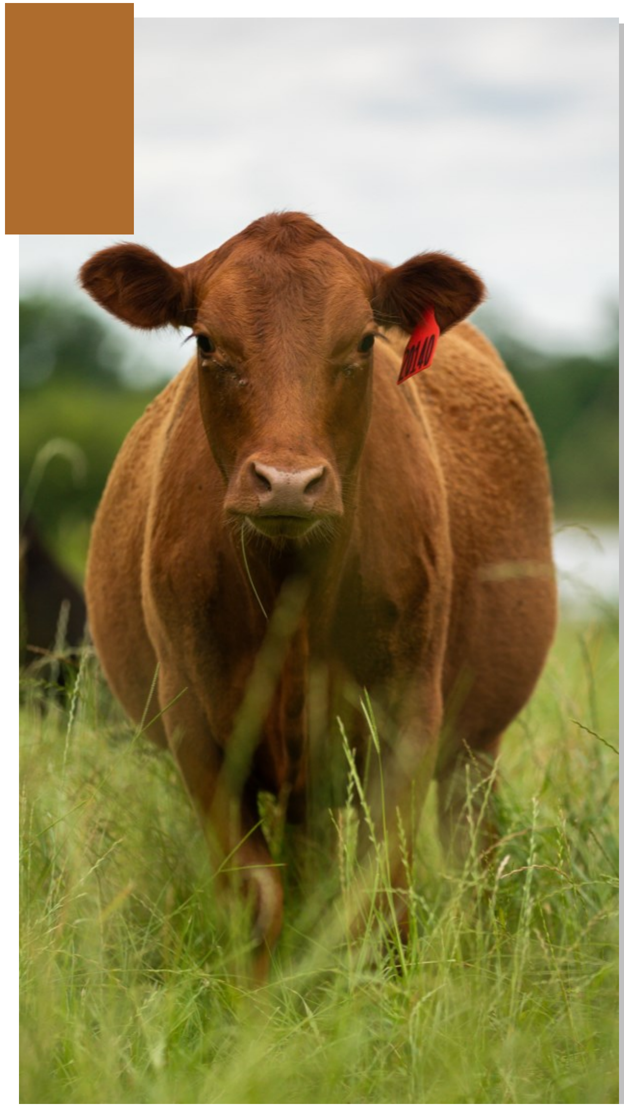
Improving grassland management has high potentials for soil C sequestration



Mosier et al., JEM, 2021



Bai & Cotrufo, Science, 2022



METRICS, MANAGEMENT, AND MONITORING

AN INVESTIGATION OF PASTURE AND RANGELAND SOIL HEALTH AND ITS DRIVERS

TOTAL COST:

More than

$19M

FUNDING:

FFAR

$9,000,000

NOBLE RESEARCH INSTITUTE

$7,500,000

ADDITIONAL FUNDING PROVIDED BY

GREENACRES

The Jones Family Foundation

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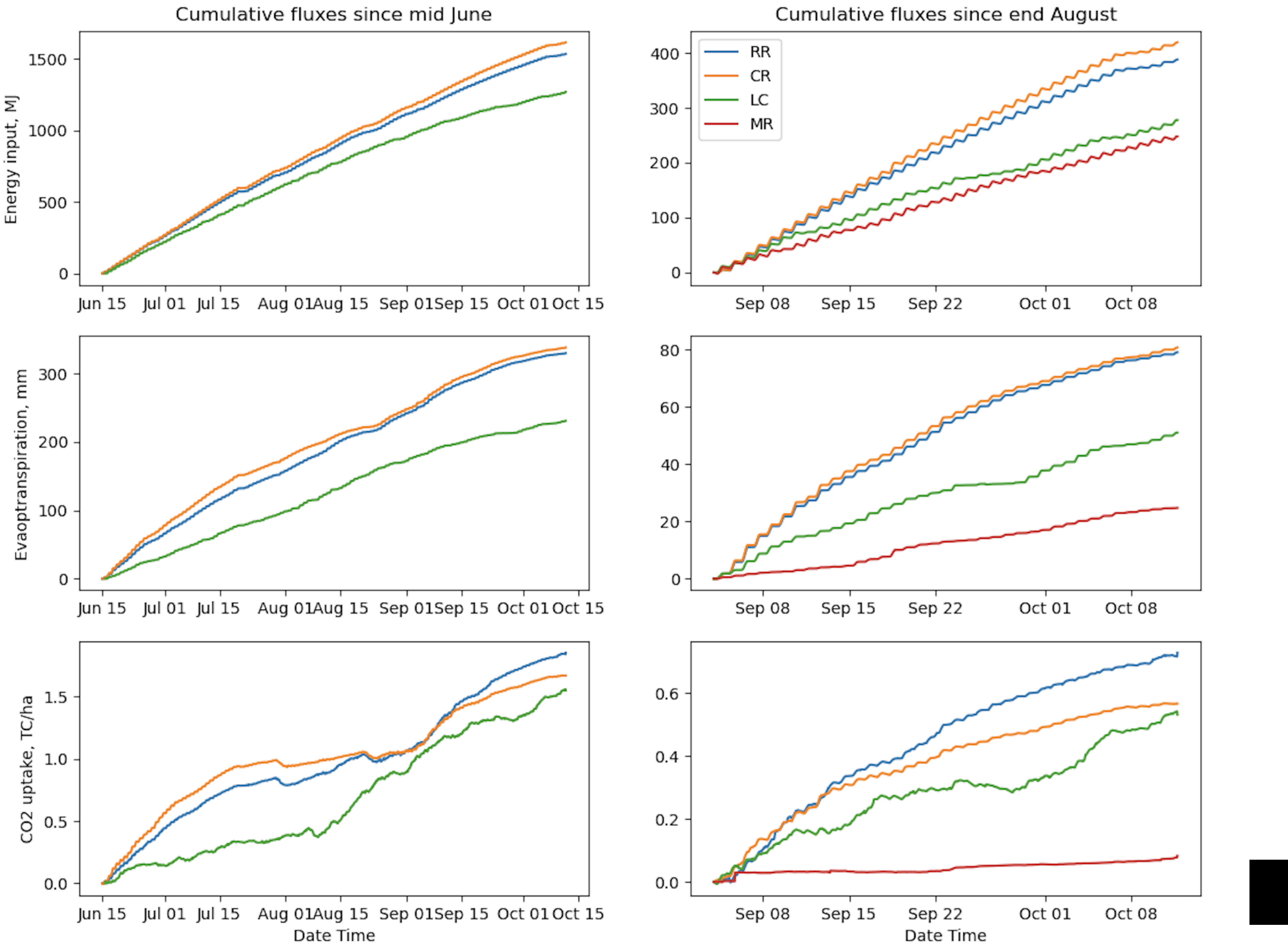
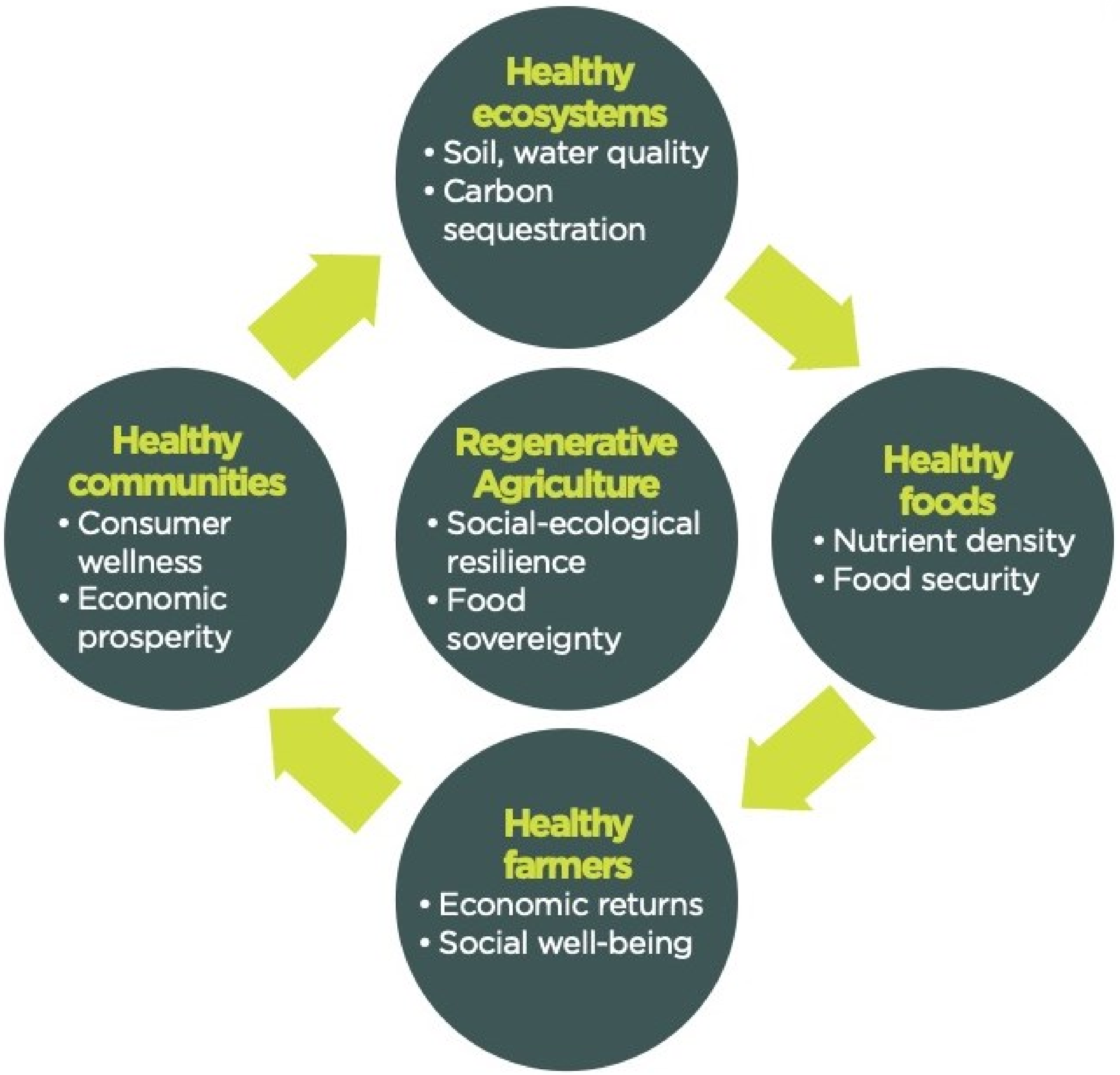
A. EAGLE


Cumulative fluxes since mid June
Cumulative fluxes since end August
Energy input, MJ
0
500
1000
1500
Evaoptranspiration, mm
0
100
200
300
CO2 uptake, TC/ha
0.0
0.5
1.0
1.5
Jun 15
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Date Time
RR
CR
LC
MR
0
100
200
300
400
0
20
40
60
80
0.0
0.2
0.4
0.6
Sep 08
Sep 15
Sep 22
Oct 01
Oct 08
Date Time

[redacted]

Health

- Regen Agriculture Adoption Driven by Data
- Food Nutrient Density and Food Security
- Value Chain Resilience
- Profitability
- Social-ecological resilience



Take Home Points

- GHG Gas Tradeoffs (and their actual Global Warming Potential) plus land use need be considered in analyzing impacts of agriculture production
- Under certain management context, we have measured considerable soil C changes in land under grazing scenarios, of which have little to no added nitrogen. Management matters.
- More holistic and systematic approaches to quantifying ecological impact of animal agriculture are needed.