Carbon exchange
Pasture-based beef cattle production systems in Florida.

Rosvel Bracho
UF/RCREC
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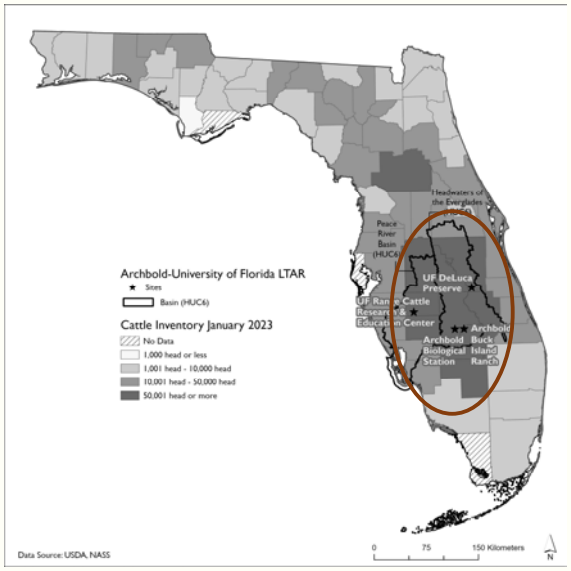

- The core of the cow-calf production systems is in South-Central, FL (Vendramini, 2006).
- Provides societal & environmental services.
- e.g, FL; Top States in cow-calf production ~ $1.7 billion (USDA/NASS, 2024).
- **However:**
- Provision of services relies on ecosystem productivity, the foundation service for many other ecosystem services.

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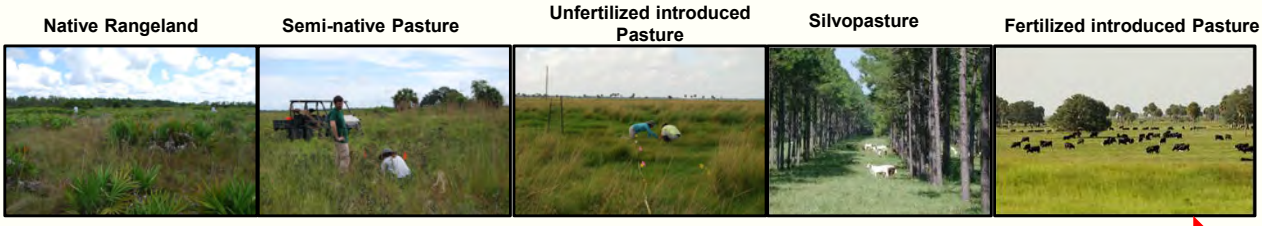
In their efforts to increase productivity, forage production and nutritional value to livestock, producers often intensify grazing land management…..



This comes with challenges:

- Low fertility soils
- Low ecosystem productivity
- Seasonal & interannual climatic variability
- Economic uncertainties

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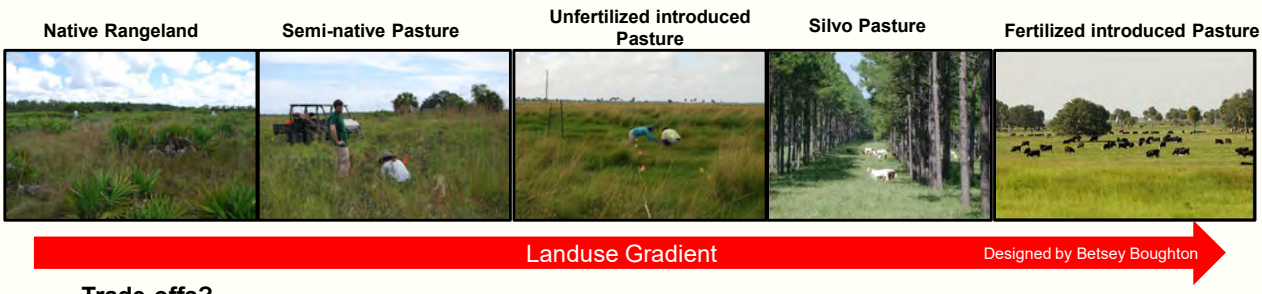
In their efforts to increase productivity, forage production and nutritional value to livestock, producers often intensify grazing land management…..



Trade-offs?

- Changes in soil nutrient levels
- Water yield and quality
- Changes in biodiversity
- Revenues
- Sustainability

For example;

- Proper management of modified areas → leads to increased SOC → improved soil health → Productivity.
- Inadequate management → to soil degradation → low productivity → ecosystem deterioration → loss of services (Silveira et al, 2024)

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In their efforts to increase productivity, forage production and nutritional value to livestock, producers often intensify grazing land management…..

Information on *Net Ecosystem Productivity (NEP)* across this gradient, along with the trade-offs, is scarce & needed

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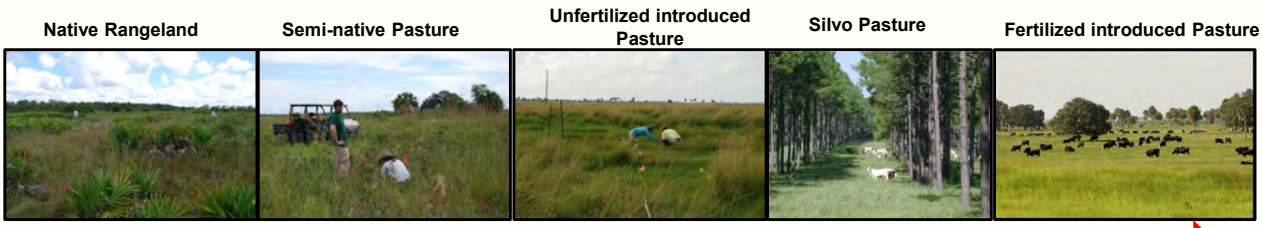
In their efforts to increase productivity, forage production and nutritional value to livestock, producers often intensify grazing land management…..



How can this info help?

- **Weigh the costs – benefits**
- **Improve life quality**
- **Soil health**
- **Water yield & quality**
- **Biodiversity**
- **Preservation of services**
- **Sustainability**

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Through the ABS-UF LTAR site, we seek to understand the ecosystem services provided by grazing lands across a gradient of management intensity

NEP as the foundational service

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UF-RCREC

- Native Rangelands
- Improved pastures
- Silvopasture

ARCHBOLD

- Seminative pasture
  grazed – ungrazed
- Improved pastures
  Occasionally fertilized
  lower stocking rate -Ona

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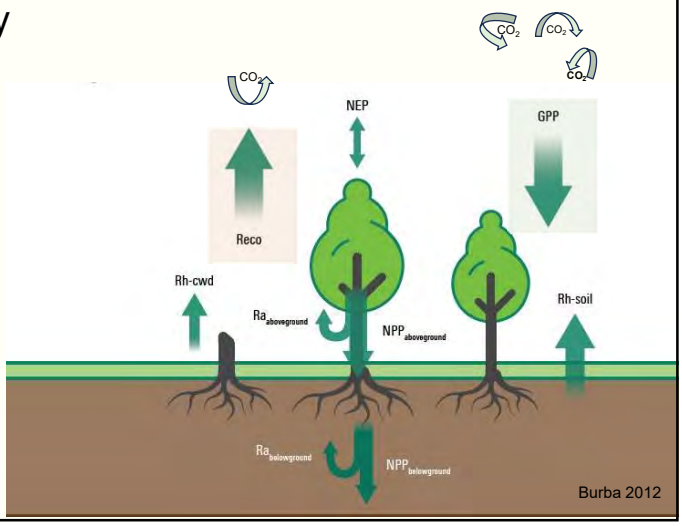
NEP = Net Ecosystem Productivity

NEP = GPP – Reco

GPP = Gross Primary Productivity
Reco = Ecosystem Respiration

If GPP > Reco = Carbon sink.



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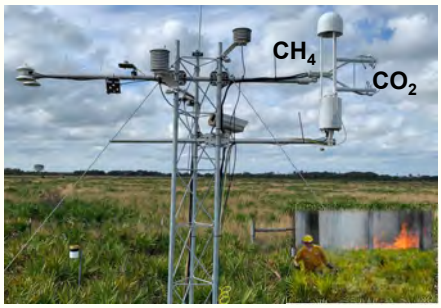
NEP – Eddy Covariance (EC)
(management gradient)



Native Rangeland:
- 4-year fire cycle
- Grazed at
- 125 animal days ha^{-1} yr^{-1}
- Never fertilized
- EC: 01/2016 - Present

Silvopasture:
- South Florida Slash pine, planted 01/2024.
- Fertilized: 03/20 ; 03/22 150 lbs./Acre NH_4NO_3
- Ungrazed.
- EC: 12/2024 - Present

Bahiagrass:
- ~ 30 years
- Grazed at 360 animal days ha^{-1} yr^{-1}
- Rotational grazing
- Fertilized yearly 150 lbs./Acre NH_4NO_3
- EC: 01/2021- Present

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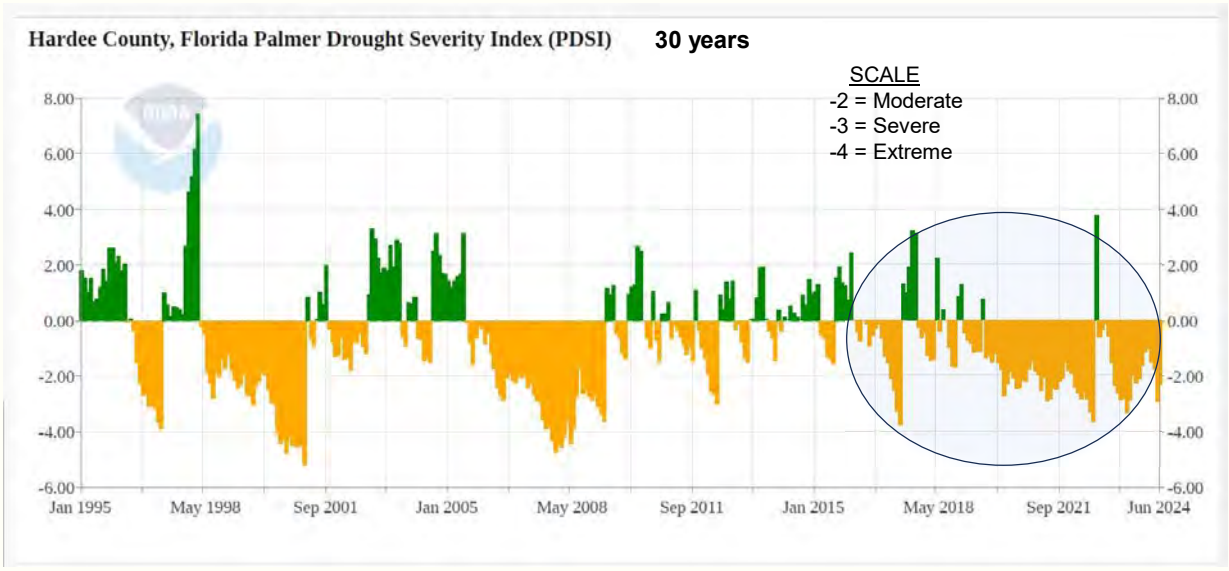
Hardee County, Florida Palmer Drought Severity Index (PDSI)
30 years
SCALE
-2 = Moderate
-3 = Severe
-4 = Extreme
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
Jan 1995
May 1998
Sep 2001
Jan 2005
May 2008
Sep 2011
Jan 2015
May 2018
Sep 2021
Jun 2024

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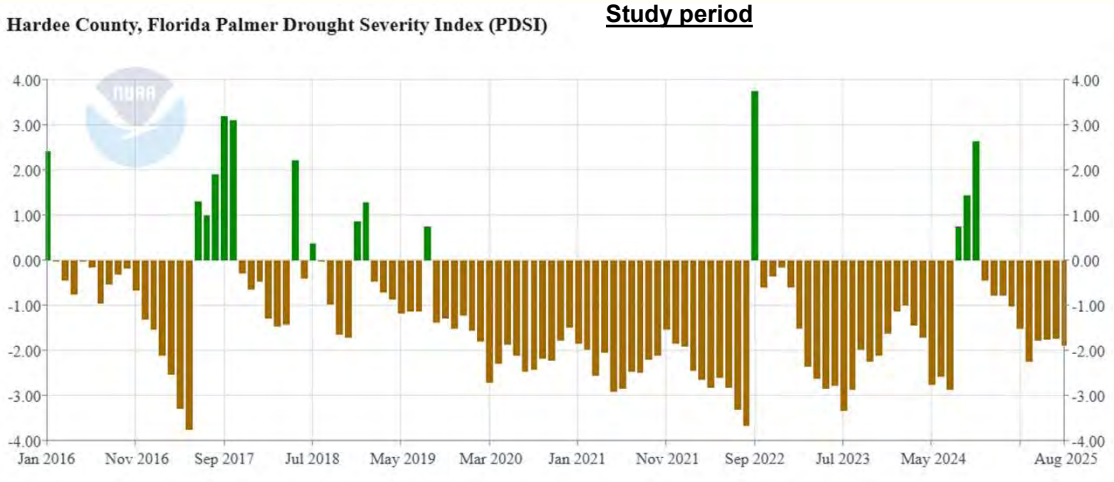
Hardee County, Florida Palmer Drought Severity Index (PDSI)
Study period
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
Jan 2016
Nov 2016
Sep 2017
Jul 2018
May 2019
Mar 2020
Jan 2021
Nov 2021
Sep 2022
Jul 2023
May 2024
Aug 2025

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Changes in Soil Organic Carbon and total ecosystem carbon after 20 years of management

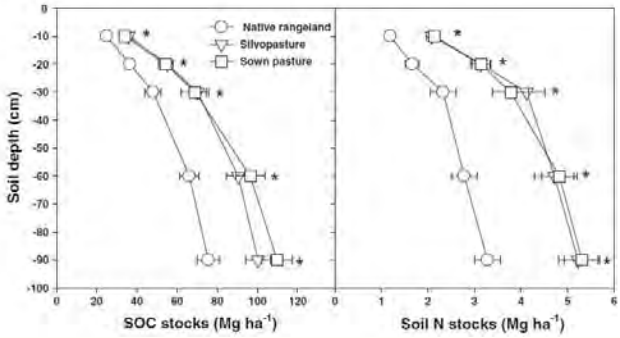

Table 4 Ecosystem C stocks and distribution among the various above- and below-ground pools as affected by land use type

Land use type	Ecosystem C pools (Mg ha^{-1})				
	Total ecosystem C	Aboveground biomass C	Litter C	Root C	Soil organic C
Native rangeland	94b[a]	3.8b (4.1 %)	0.2b (0.2 %)	14a (15 %)	76b (80.7 %)
Silvopasture	168a	59a (34.5 %)	2.4a (1.4 %)	6.0c (3.5 %)	101a (60.6 %)
Sown pasture	121b	2.1b (1.7 %)	0.3b (0.3 %)	9.1b (7.5 %)	110a (90.5 %)

[a] Data represent means of two seasons. Means in parenthesis are % of total ecosystem C. Means followed by the same letter within ecosystem pool are not different (P>0.05) based on the LSD test

Xu, Silveira et al, 2016. Plant Soil

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Native Rangeland

Contents lists available at ScienceDirect

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

Carbon dynamics and soil greenhouse fluxes in a Florida's native rangeland before and after fire

Rosvel Bracho [a,*], María Lucia Silveira [b], Raoul Boughton [c], Joao M.D. Sanchez [b], Marta M. Kohmann [b], Carolina B. Brandani [d], Gerardo Celis [e]

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[e] Agronomy Department, University of Florida, Gainesville FL 32611, USA

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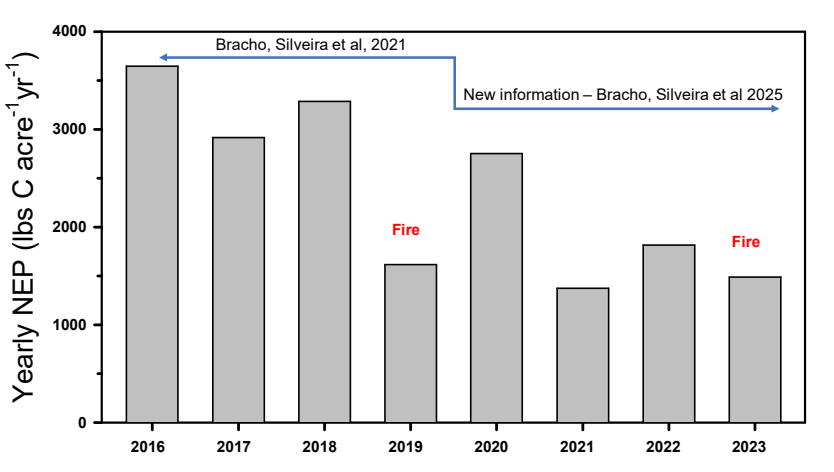
Native Rangeland



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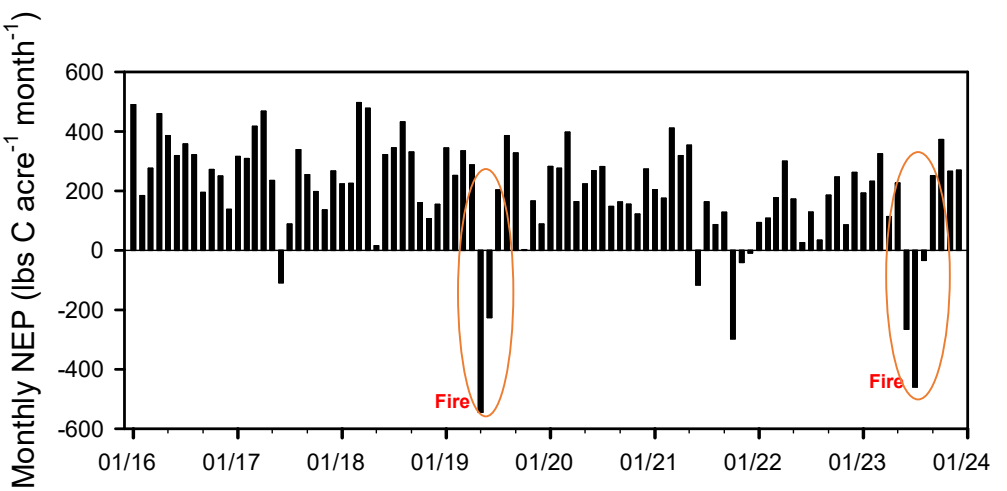
Native Rangeland NEP



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Science of the Total Environment xxx (xxxx) 180924

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Science of the Total Environment

journal homepage: www.elsevier.com

Carbon and methane fluxes from typical pasture-based beef cattle production systems in the Southeastern USA

Rosvel Bracho [a, b], Maria L. Silveira [c, *], Joao M.B. Vendramini [d], Marta M. Kohmann [e], Abmael da Silva Cardoso [e], Priscila Junia Rodrigues da Cruz [f], Gerardo Celis [g], Namrata Ghimire [a]

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ARTICLE INFO

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Greenhouse gas emissions
Methane
Beef cattle
Eddy covariance

ABSTRACT

Grazing lands covers approximately one-quarter of the global land surface and provides critical ecosystem services such as carbon (C) sequestration. In Florida, ~ 2 million hectares of native and cultivated pastures support a robust cattle industry. This 3-yr study evaluated net ecosystem C exchange (CO_2 and CH_4) in two representative pasture-based beef systems in the Southeastern USA: a native rangeland (low-intensity management) and a cultivated pasture (high-intensity management). The study captured broad climatic variability, including a hurricane event that resulted in prolonged wet conditions after an extended period of drought. Cultivated pasture exhibited significantly higher C uptake, with a mean annual net ecosystem productivity (NEP) of −4.91 ± 1.16 Mg C ha^{-1} yr^{-1}, compared to −1.75 ± 0.26 Mg C ha^{-1} yr^{-1} for the native rangeland. Cumulative NEP over three years was −14.74 Mg C ha^{-1} for the pasture and − 5.25 Mg C ha^{-1} for the rangeland. Although methane emissions were considerably higher from the pasture (2.43 vs. 0.16 Mg C-CO_{2eqv} ha^{-1}), they were offset by greater CO_2 uptake, resulting in a more favorable total C balance (−6.26 vs. −3.55 Mg C-CO_{2eqv} ha^{-1}). However, native rangeland exhibited greater stability under climatic extremes, including both drought and hurricane, maintaining consistent NEP and total C balance. These findings underscore the importance of maintaining a mosaic of well-managed pastures and native rangelands. While cultivated pasture offers high productivity and C sequestration potential, native rangelands provide a more stable C sink under climatic extremes. Both systems demonstrated strong potential to mitigate GHG emissions while delivering essential environmental and societal benefits.

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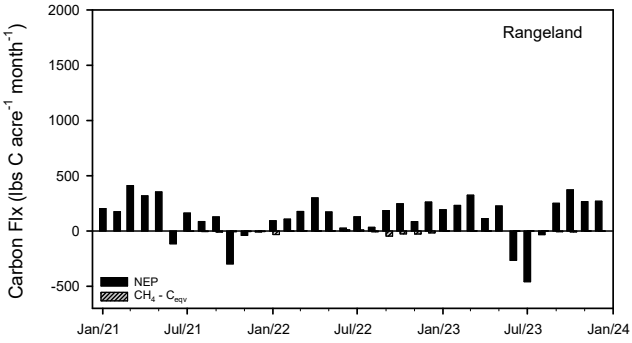
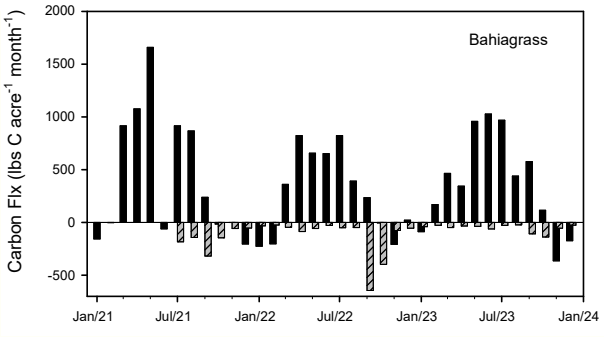


Three years

Monthly NEP & CH_4

Native Rangeland vs. Bahiagrass.



Bracho et al 2025
In press- STOTEN

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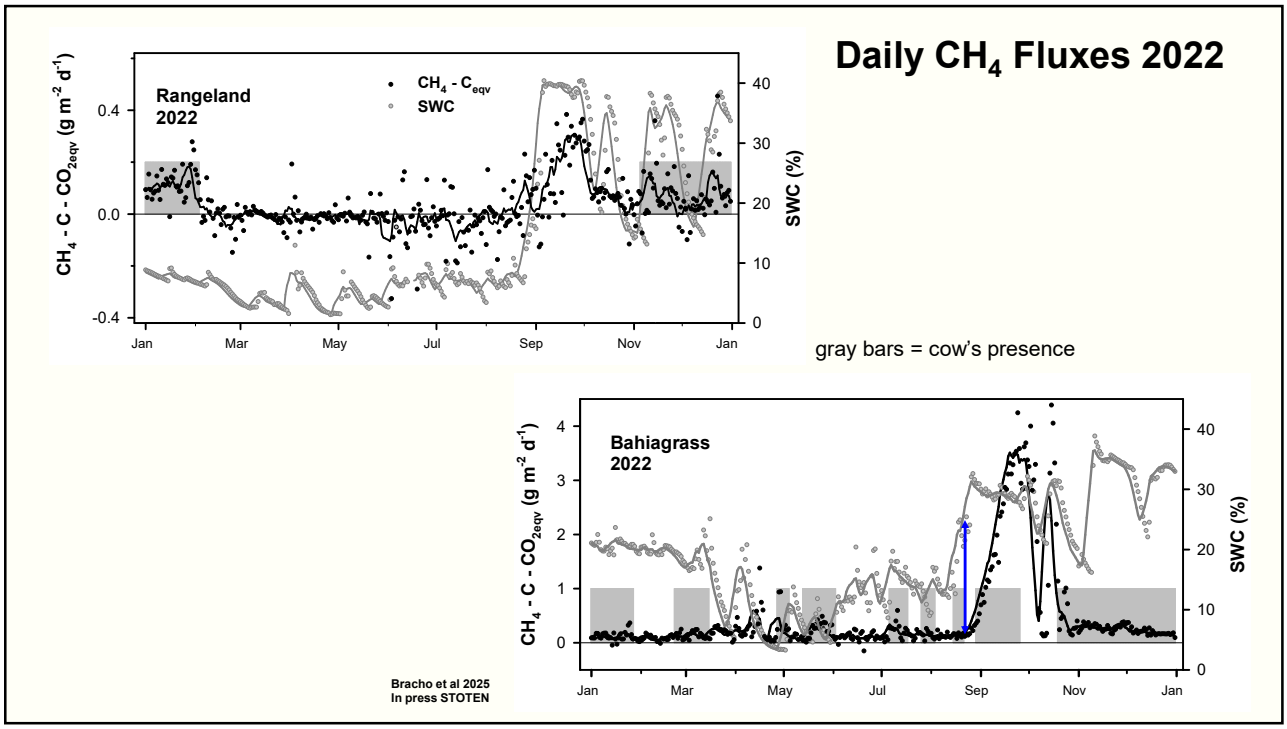
Daily CH_4 Fluxes 2022
Rangeland
2022
CH_4 - C_{eqv}
SWC
CH_4 - C - CO_{2eqv} (g m^{-2} d^{-1})
SWC (%)
Jan
Mar
May
Jul
Sep
Nov
Jan
gray bars = cow's presence
Bahiagrass
2022
Bracho et al 2025
In press STOTEN

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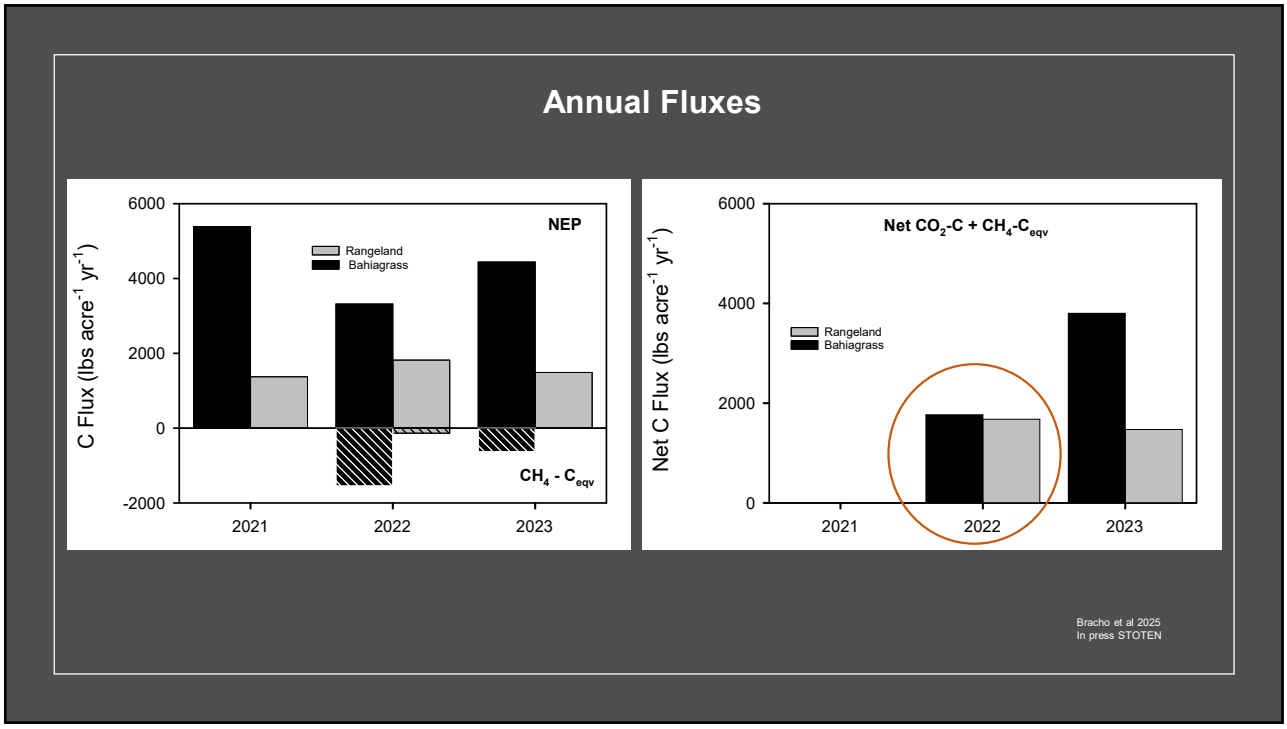
Annual Fluxes
NEP
Rangeland
Bahiagrass
C Flux (lbs $acre^{-1}$ yr^{-1})
CH_4 - C_{eqv}
2021
2022
2023
Net CO_2-C + CH_4-C_{eqv}
Net C Flux (lbs $acre^{-1}$ yr^{-1})
Bracho et al 2025
In press STOTEN

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From the three-year study

- Bahiagrass pasture had nearly 3 times the annual C uptake of native rangelands.
- Both systems acted as C sinks under climate extremes –drought & hurricane.
- Methane emissions were 15 times greater in pastures but offset by stronger C uptake.

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Graphical Abstract

Grazing lands provide essential ecosystem services, including carbon sequestration

Native rangeland (low input system)

Bahiagrass pasture (high input system)

1.75 Mg C ha^{-1} yr^{-1}

4.91 Mg C ha^{-1} yr^{-1}

Greater stability

Greater productivity

Maintaining a mosaic of well-managed native and cultivated pastures is essential for mitigating greenhouse gas emissions and delivering critical environmental and societal benefits

Bracho et al 2025
In press

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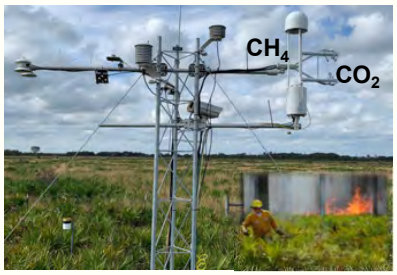
NEP – (management gradient)



Native Rangeland:
- 4-year fire cycle
- Grazed at xx cows/year from November -February
- Never fertilized
- EC: 01/2016 - Present

Silvopasture:
- South Florida Slash pine, planted 01/2024.
- Fertilized: 03/20 ; 03/22 150 lbs./Acre NH_4NO_3
- Ungrazed.
- EC: 12/2024 - Present

Bahiagrass:
- ~ 30 years
- Grazed at xxxxxx Rotational grazing
- Fertilized yearly 150 lbs./Acre NH_4NO_3
- EC: 01/2021- Present

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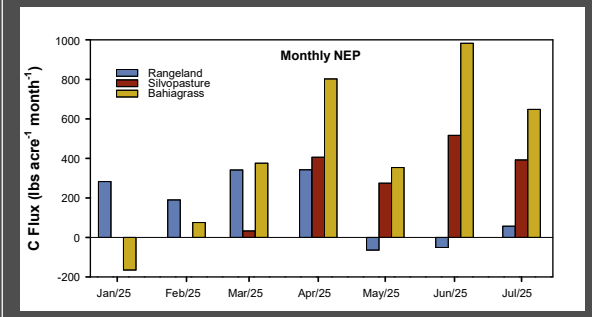
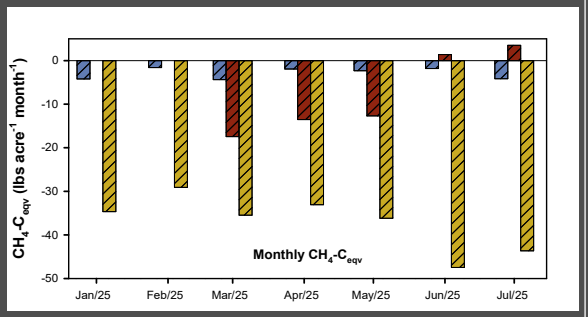
Rangeland, Silvopasture & Bahiagrass





Preliminary results

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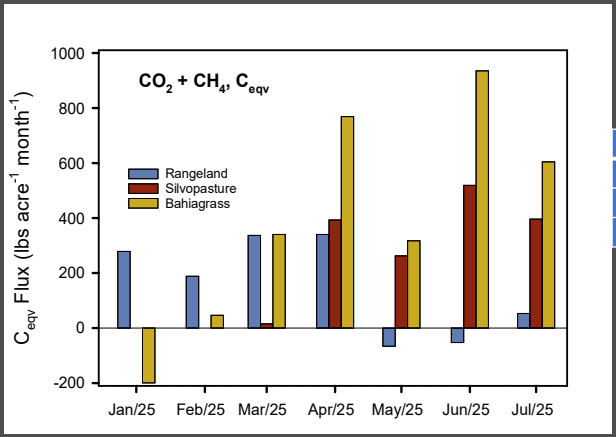
Rangeland, Silvopasture & Bahiagrass
CO_2-C + CH_4, C_{eqv}



March - July

Flux	Rangeland	Silvopasture	Bahiagrass
NEP	626	1623	3163
CH_4-C_{eqv}	-15	-39	-196
Total	612	1584	2967

Carbon Fluxes, NEP, CH_4-C_{eqv}, and total C exchange from three grazinglands from March to July 2025. Values in lbs./acre

Preliminary results

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Thank you!

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