Can Adaptive Multi-Paddock (AMP) grazing contribute to sequestering carbon in soils and improve delivery of ecosystem services & socio-ecological resilience in grazing ecosystems?
The **AMP Grazing Research Project (AMP Research)** seeks to find out whether this grazing method can regenerate soils, clean water supplies, feed many more people on much less land while drawing down enormous amounts of $\text{CO}_2$ from the atmosphere.

Based on early data showing significant soil carbon storage, we believe it is well worth the time and expense to conduct robust systems science to better understand whether grazing management alone can produce resilient farmland ecosystems.

AMP Research will be coordinated by **carbon nation**, in collaboration with Arizona State University. AMP Research development was funded by Shell GameChanger, Rodel Foundation, Jim & Paula Crown, Sarah & Evan Williams Foundation, The World Bank, The Thornburg Foundation and The Rob and Melani Walton Sustainability Solutions Initiatives.
Adaptive Multi-Paddock (AMP) Grazing

(please watch *Soil Carbon Cowboys*)

- AMP grazing mimics predator/prey relationship of roaming herds
- Small paddocks grazed quickly, then long rest periods
- Photosynthesis pumps carbon from the air, through plants into soil
- Photosynthesis spikes during rest after AMP grazing, increasing \( \text{CO}_2 \) uptake
- Plants exhale oxygen & send carbon to feed soil microbes
- Leads to significant build up of organic carbon in soil
Carbon rich soils benefit whole ecosystem
- Increased water retention & biodiversity: microbes, plants, insects & wildlife
- Reduced soil erosion & GHG emissions (CO₂, methane, nitrous oxide)
- Improves both livestock and rancher well-being
- We will conduct rigorous scientific measurement of all the above
Will The Carbon Stay In The Soil?

Soil Carbon Storage Pools

- Carbon stored in 3 basic pools in soil, where it stays for:
  - Days - microbes respire carbon; it returns to air as CO$_2$
  - Decades - carbon embeds in old root systems
  - Centuries - carbon binds to soil aggregates
Human activities emit 8.9 Gigatons of carbon (GtC) annually.
Soil+Plants absorb 2.6 GtC; Oceans absorb 2.3 GtC; 4.0 GtC remains in air.
Up to 1/5 of all this airborne carbon originates from poor soil stewardship.
Degraded soils have very high additional carbon storage potential.
Soils already hold more carbon than plants and air: 1,500 to 2,400 GtC
- 343 GtC in pastures alone
- 3.5 billion hectares of pasture land on earth
- Capturing extra 1 ton of carbon/hectare/year on all 3.5 billion hectares would be 3.5 GtC, nearly equal to the 4 GtC excess carbon left in air
• Peer reviewed TX study: AMP ranches store +3 tons more carbon/hectare/yr
• Alberta, Canada data showing +1.2 to +2.2 tons more C/ha/yr - soon to be submitted for publication
• Anecdotal evidence shows success in varying regions, soil types & rainfall
• More rigorously collected scientific data is needed
• AMP Research will compare conventional & AMP grazing to get this data

*Teague et al (2011). Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie.
Can Adaptive Multi-Paddock (AMP) grazing contribute to sequestering carbon in soils and improve delivery of ecosystem services & socio-ecological resilience in grazing ecosystems?
AMP Research – Systems Science: 12 Modules

- Data collection, analysis, modeling and communications in 12 Modules
- 1) Soil carbon & water; 2) Greenhouse gas cycling; 3) Vegetation; 4) Soil microbiology; 5) Arthropods; 6) Grassland Birds; 7) Livestock well-being; 8) Farmer/rancher well-being; 9) Resilience; 10) Life cycle analysis; 11) Simulation modeling; and 12) Film and communications
Experimental Design: 2 Regions - Landscape Scale

- Research is landscape scale as opposed to small plot scale.
- Research conducted in the Southeast U.S. (in 2017) represents a warmer, wetter climate with longer growing season & lower latitude.
- Research conducted in the Upper Great Plains U.S. (in 2018) represents a cooler, drier climate with shorter growing season & higher latitude.
Experimental Design: Triads of Grazing Methods

- Research compares AMP grazing with High-Stock Continuous (HCG) and Low-Stock Continuous (LCG) grazing, a Triad of Grazing Methods
- ‘Apples to Apples’ comparisons wherever possible: similar size operations; similar # of cattle; same soil types; same slopes on hillsides
- 3 replicates of triads per region
Experimental Design: 25 Additional AMP per Region

- 25 AMP ranches (per region) will be measured for soil carbon accrual with a baseline Time Zero sampling and 3 years later, a Time One sampling.
- This is to see whether AMP grazing sequesters carbon, and if it does, whether this accrual can be measured in a short, 3 year period of time.
Module 1: Soil carbon & water

- Soil carbon is a key indicator of healthy soils.
- Essential to understand which grazing systems either increase or decrease soil carbon levels & how long increased soil carbon will remain there.
- Amount of carbon in soil is closely associated with the capacity of land to absorb and retain water & thus directly associated with resilience to drought and flood.
Grazing cattle act as ecosystem engineers.

Understanding how cattle affect the ranch ecosystem requires study of GHG cycles and whether these grazing systems are net emitters or net sinks of GHG, specifically carbon dioxide (CO$_2$), methane (CH$_4$) and nitrous oxide (N$_2$O).

Discover if, how & why ranchers are capturing significant soil carbon.
• Via photosynthesis, plants store CO$_2$ in soils. Carbon-rich soil in turn increases plant productivity, diversity and nutrient-density.
• Healthy livestock depend on healthy and diverse vegetation.
• Healthy vegetative cover reduces carbon loss from soil erosion, regulates soil temperature, creating an environment conducive for soil microbial life.
• Bacteria, viruses, and fungi (the soil microbiome) break down plant and animal material & contribute to the formation of soil organic matter.
• Arbuscular mycorrhizal fungi can help form & stabilize soil aggregates, further increasing soil organic matter durability.
• Soil microbes make nutrients available, improve water storage and are themselves a huge carbon reservoir.
Insects (i.e.: pollinators, dung beetles) and other arthropods are essential for making above and below ground plant tissue available for soil microbial communities and are key players in soil health and water infiltration and retention.

Via pollination, insects help create and benefit from diverse forage production, which lays the foundation for diverse wildlife.
• The biodiversity of birds is a key indicator of general wildlife biodiversity and overall ecosystem health.
• Carbon-rich soils with biodiverse microbial and insect populations, nutrient-dense forage, and structurally intact grasslands are key factors for bird populations.
Rancher management decisions, like the number of cows and the length of grazing time, greatly affect farm/ranch ecosystem & economic health.

Cattle health is directly linked to forage quality and quantity.

We will measure stress levels of cattle in AMP, HCG, and LCG.

We will measure average daily weight gain & use of medications.
Module 8: Farmer/Rancher Well-being

- Grazing methods (AMP, HCG, LCG) directly impact soil health, which is foundational for farm/ranch production and financial stability.
- This module will establish any differences in wellbeing of ranchers practicing AMP, HCG or LCG.
- This module focuses on gaining knowledge that will lead farmers/ranchers to adopt methods that increase soil carbon and improve ecosystem health.
The research data from Modules 1 through 8 will be synthesized and used to analyze which grazing system (AMP, HCG, LCG) is more resilient to droughts, floods and price shocks.

The outcomes will be used to guide ranchers to more productive livelihoods that are socially, financially, and ecologically sustainable.
Data from Modules 1 through 8 will be used to create a life cycle analysis (LCA) of all flows of energy, materials and nutrients into and out of AMP, HCG and LCG grazing systems to gauge financial and ecosystem efficiency for farmers/ranchers.

This LCA will show if any of these grazing systems (AMP, HCG, LCG) could create greenhouse ($CO_2$, methane, nitrous oxide) sinks.
Data from Modules 1 through 8 will populate models that currently lack the ability to simulate grazing management systems and their impacts on the carbon, water and GHG cycles, forage production and wildlife biodiversity. These models will enable farmers/ranchers to better understand and predict how potential changes to grazing methods will affect land and animal health.
• Film crews will capture farmers/ranchers and the scientists studying their grazing methods, giving context to all the data collected from Modules 1 through 11.
• Making the research results personal, approachable and understandable to all stakeholders (including farmers/ranchers, policymakers, educators, consumers and more) is a key component of the research.
27 Southeast AMP Ranchers Already On Board

Doug Peterson
Greg Judy

Clay Nash

John Lock
Vance Mitchell
Mark Cannon

Larry Sansom
Michael Fitzgerald
Crest Tucker

Randy Shipe
Charles Snowden

R.P. Cook

Randall Hastings
Teddy Gentry

Don Jackson

Allen Williams
Ben Simmons

Dan Glen
Murray Provine

David Morrison
Robert Joyner
Trent Graves
Sid deReoun

Jeremy Engh
Kevin Jennings

Ed Kobels
Jon Kohler
22 Upper Great Plains Ranchers Already On Board

- Gabe Brown
- Josh Duckart
- Ken Miller
- Jay Fuhrer
- Jerry Doane
- Tom DeYoung
- Greg Niwcki
- Rod Ofte
- Dan Marquet

- David Winkler
- Wyatt Fraas
- Tim Eisenbeis
- John Cotton
- Peter Woltz
- Ron Rossman
- Steve Rienart
- Bruce Carney

- Wayne Rasmussen
- Kevin Fulton
- Ron Bolze
- Tim Stein
- Chris Calkins
Closing the Carbon Cycle

...by using the carbon cycle

- Fossil fuel carbon comes from ancient sunlight buried deep, long ago
- Soil carbon storage uses the same process to put that carbon back
- Worldwide, soils have potential to store significant part of human emissions
## Budget: as of September 30, 2016

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- Timeline Goal: Scout & select farms/ranches in Fall 2016
- Conduct Southeast U.S. region field science Summer 2017
- Conduct Upper Great Plains region field science Summer 2018
- Produce analysis/write research papers/edit films throughout 2019
Risks

Project Risks:
- Insufficient AMP Grazing research funding
- Soil Carbon Storage might be much less than projected
- Costs too much to measure soil carbon at all locations
- Project health, safety, environment
- Not enough suitable AMP ranches to study
- Team doesn’t deliver on time

Science Risks:
- Severe drought/flood will impact success of measurements/data collection
- Unable to prove AMP grazing produces sufficiently durable soil carbon
- Methane, carbon dioxide, nitrous oxide emissions not robustly determined
- Cannot measure significant soil carbon increases in 3 years
- Inconclusive, random, uncorrelated results

Rancher Risks:
- AMP grazing poorly executed
- AMP grazing poorly defined
- Ranchers quit AMP and revert to old practices
- AMP grazing not financially beneficial for rancher

Policy Risks:
- Soil Carbon Storage never accepted by policymakers
- NGOs don’t support Pilot
Click here to watch our Science Team Film: *Soil Carbon Curious*