Rangelands and Soils: What we know and don't know

Justin D. Derner

Justin.Derner@ars.usda.gov

USDA

United States Department of Agriculture

Road map

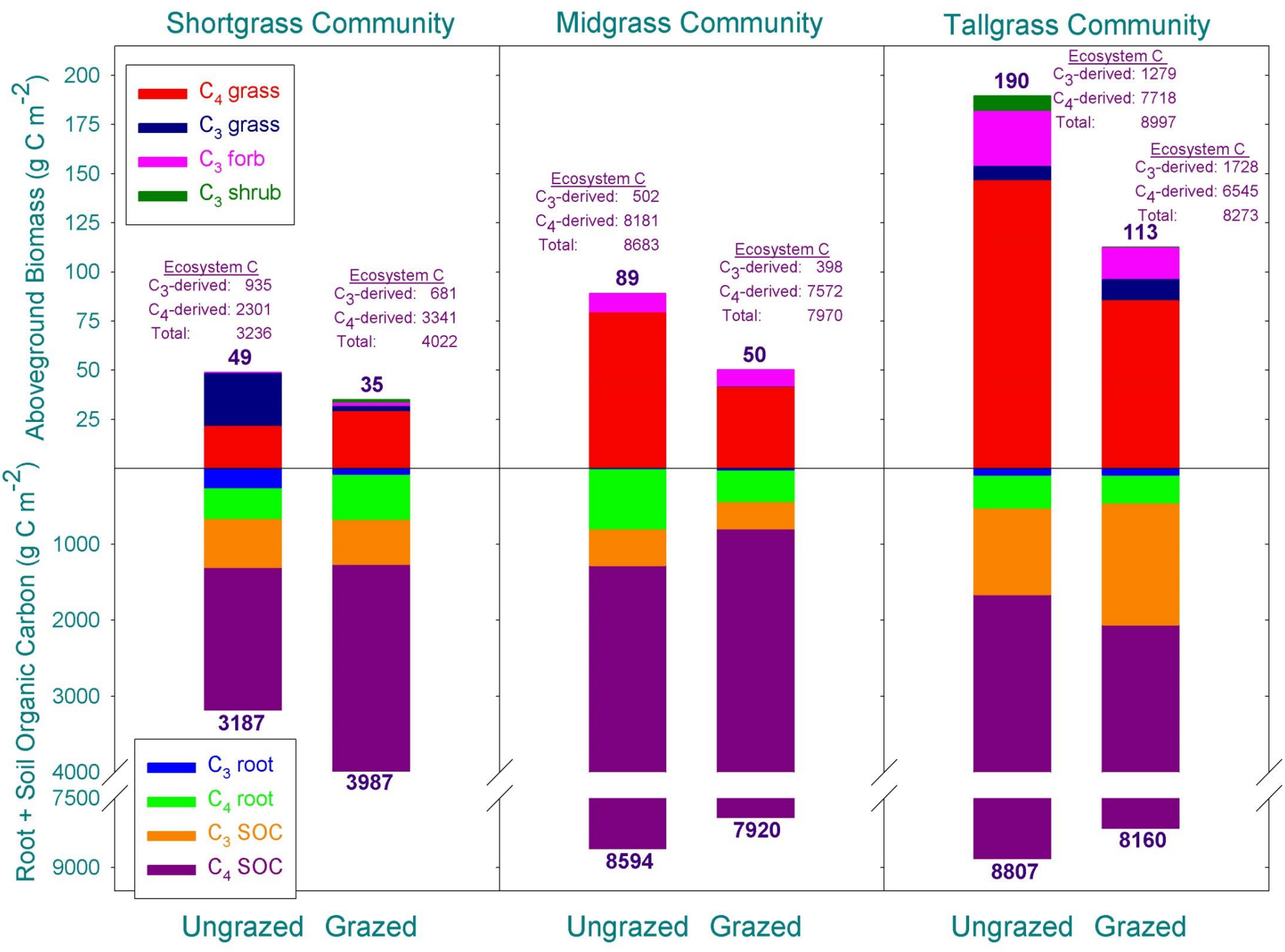
- Importance and characteristics of rangeland
- Rangeland vs. pastures
- What we know:
  - Environmental controls
  - Management
  - Management x environment
- What we don’t know:
  - Where does the thermometer go?

Importance of rangeland

- >50% of earth's land area
- Contains 10-30% of global soil organic carbon (SOC)
  - Improper management can release this back to atmosphere
  - Carbon sequestration rates are low (0.07 to 0.30 Mg C ha/yr), but large land area available
- Ecosystem co-benefits
  - Greater soil water holding capacity
  - Improved soil structure and
  - Enhanced nutrient cycling

Characteristics of rangelands

- **Inherent high degree of spatial and temporal variability**
  - **Soils**
  - **Topography**
  - **Plant communities**
  - **Seasonal distribution and total precipitation**
  - **Climate**
- **Ecosystem C storage >90% in soil organic matter (SOM)**
- **Slow vegetation change**



Derner et al. 2008

Rangelands vs. Pastures

- **Rangelands**
  - Native species (mix of C3/C4)
  - Low inputs (if any)
  - Often extensive rotational grazing management
- **Pastures**
  - Improved species (often C3 grasses and legumes)
  - Inputs of water, fertilizer and chemical control
  - Intensive grazing management
    - Keep plants in vegetative state
  - Capacity for increased soil C due to prior management and inputs

What we know: environmental controls

- Spring (AMJ) precipitation drives aboveground biomass production
- Soil C sequestration characterized by short periods (2-3 months) of high C uptake and long periods of C balance or small losses
- Lag effect following drought where flush of accumulated soil N is incorporated into biomass
- Clay and loamy soils have more soil C capacity than sandy soils
- Need for increased resilience
  - Healthy soils are important
    - Intra- and inter-seasonal precipitation variability
  - Adaptive management emphasis

Summary of different rangelands

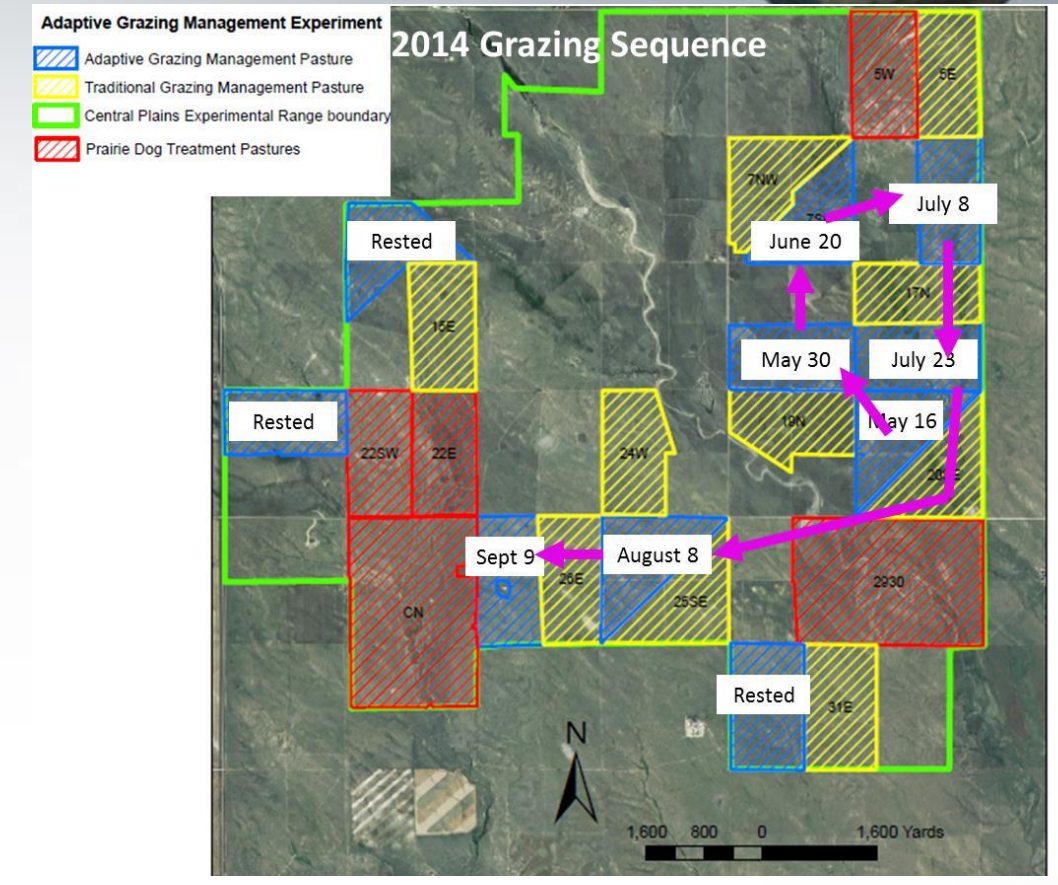
Location	Vegetation	Mean (and range) annual net ecosystem exchange (g C/m^2/yr)
Las Cruces, NM	Desert grassland	-160 (-254 to 94)
Lucky Hills, AZ	Desert shrub	-93 (-162 to 55)
Burns, OR	Sagebrush steppe	73 (-61 to 229)
Dubois, ID	Sagebrush steppe	83 (-47 to 260)
Mandan, ND	Northern mixed prairie	53 (-27 to 119)
Nunn, CO	Shortgrass steppe	107 (4 to 227)

Svejcar et al. 2008

Livestock grazing: Adaptive management

Outcome-based decision making incorporating monitoring feedback

- Management-science partnerships
- Spatial and temporal movement flexibility of livestock
  - Within and across years
- Adaptation to weather variability

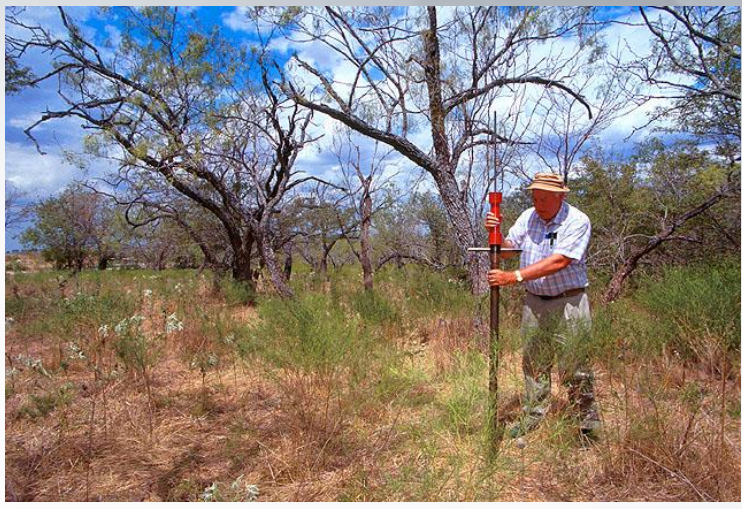


What we know: management controls

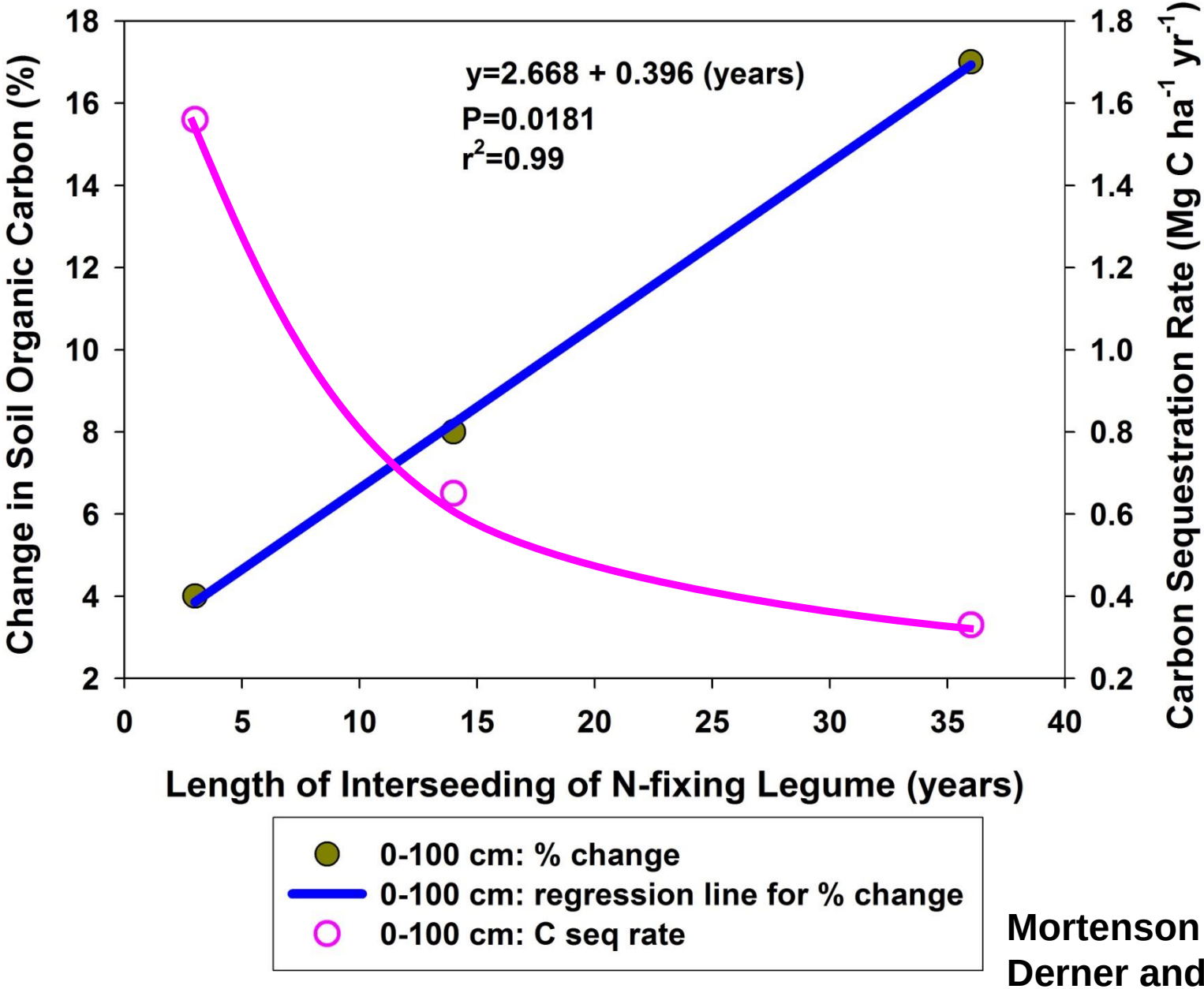
- Moderate grazing for livestock production
- Vegetation heterogeneity needed, however
  - Patch burning
  - Adaptive management
  - Grassbanking
- Soil bulk density increases with stocking rate
- Grazing increases soil C compared to non-grazing
- Light to moderate grazing enhances soil C
- Heavy grazing: C gains in wet years and large losses in dry years/seasons
- Improper management could release C stocks
- Adding legumes has large potential for soil health

Management to increase soil C

- **Stimulate C cycling**
  - **Aboveground plant litter to soil**
- **Stimulate aboveground production**
  - **Alter vegetation composition**
  - **Adding legumes for N**
- **Alter above:below ground C allocation**
  - **Shift allocation more belowground**



Adding a legume



Mortenson et al. 2004
Derner and Schuman 2007

What we know: management x environment

- Soil C dynamics related to precipitation trends
- Soil C dynamics greatest with heavy grazing
- Short-term soil respiration is a good indicator of soil biological activity and nitrogen cycling
- Little known about adaptive management and soil C for application to ranches
- Difficulty with rangeland health in Great Plains, especially grazing resistant systems
  - Protocols developed for arid systems of Intermountain West and desert Southwest (shrub-dominated systems)

What we don’t know

- Soil health research lacking for rangelands
  - Lots of efforts on croplands, but not directly applicable
- Where does the thermometer go?
  - What do we “measure” for soil health?
  - Do we focus on structural, chemical or biological components of soil health?
  - What are the key “tests” for soil health?
- With prior proper management, is there capacity for improving soil health?
- How to correct misinformation that is available

Questions?