Grazing Management for Healthy Soils

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Science of Rangeland Soil Health and Management Implications

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Today's Points

Grazingland resilience and soil health

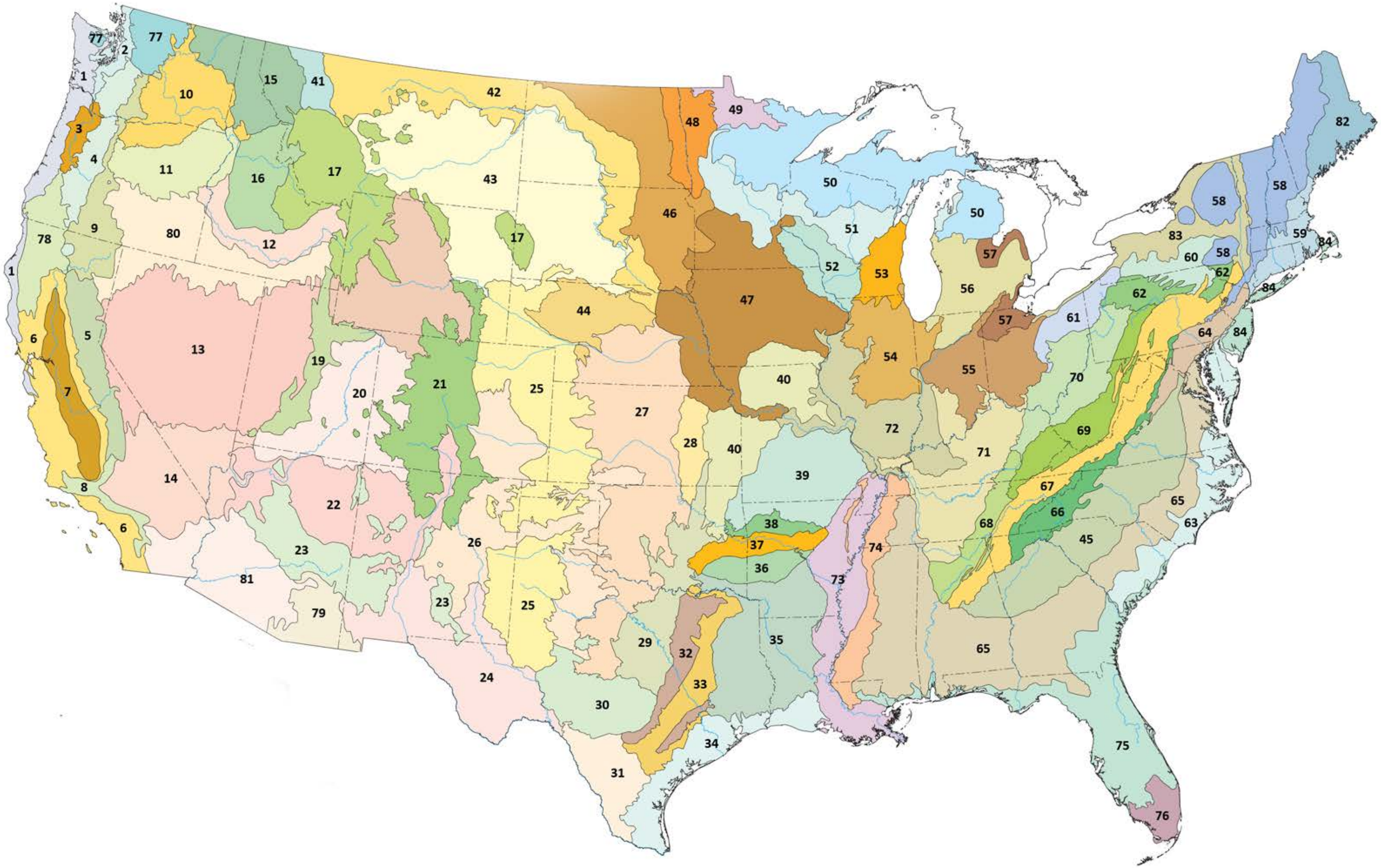
- Background, knowledge gains/gaps, opportunities
- Refocusing management from practices to processes
  - Example: *Soil C sequestration on grazinglands*

Multiple ecosystem services

- Beware of single focus management
- Managing for win-wins

Ecological complexity of working landscapes

Ecoregional differences influence forage species composition, plant growth patterns, operation scale, and management used on rangelands and pasturelands.



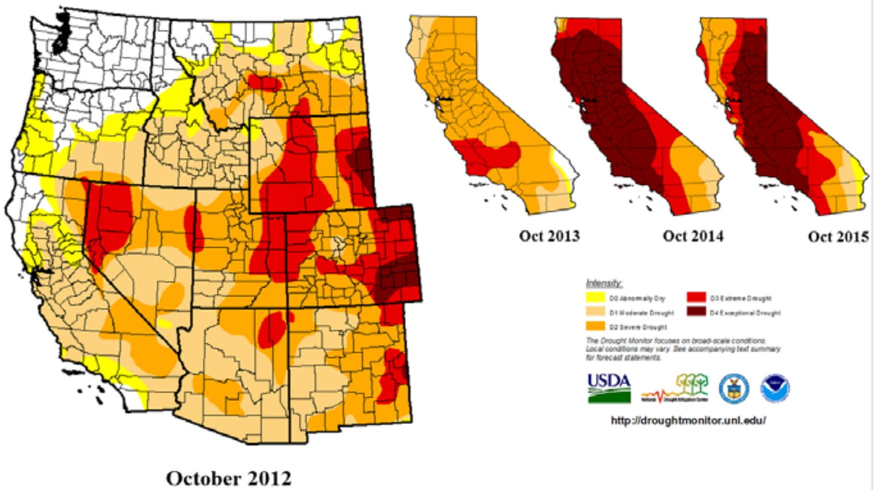
US EPA Level III Ecoregions

Multiple ecosystem goods and services





Building resilience to environmental change



Physical-chemical-biological components of soil health enable soil's capacity to function as a vital living ecosystem that sustains and promotes plants and animals (+ people!).

Maintaining and improving soil health, the foundation upon which many ecosystem services depends, may help increase resiliency of grazinglands.

Doran, JW, MR Zeiss. 2000. Soil health and sustainability: managing the biotic component of soil quality. Appl Soil Ecol 15:3-11.

Doran, JW. 2002. Soil health and global sustainability: translating science into practice. Agric Eco Env 88:119-127.

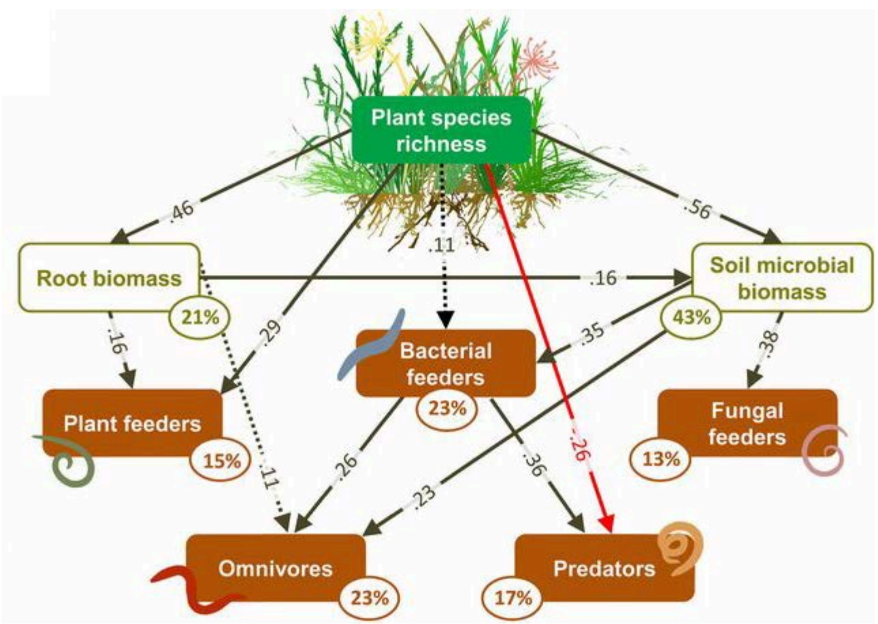
USDA NRCS 2014. Soil Health. www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health.

Grazingland Soil Health

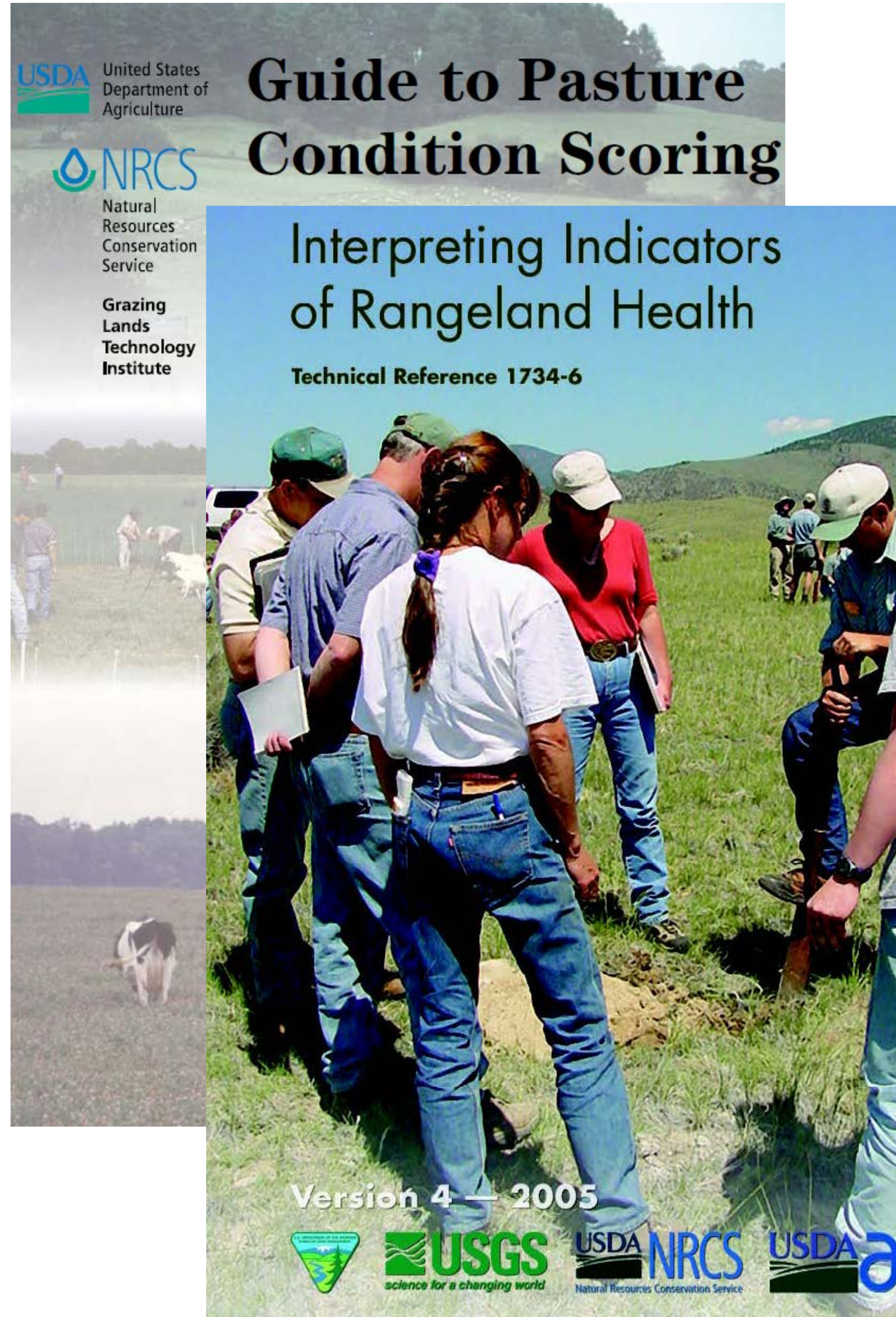
- Soil health indicators (esp. hydrologic function, and plant community) as a component of monitoring assessment

- Knowledge gaps – grazing and soil bacteria, fungi, and macro-invertebrate interactions

trophic dynamics are complex



Eisenhauer et al. PNAS 2013;110:6889-6894



Grazing management is the art and science of efficiently utilizing forage with livestock to achieve…

1. Income and livelihood.

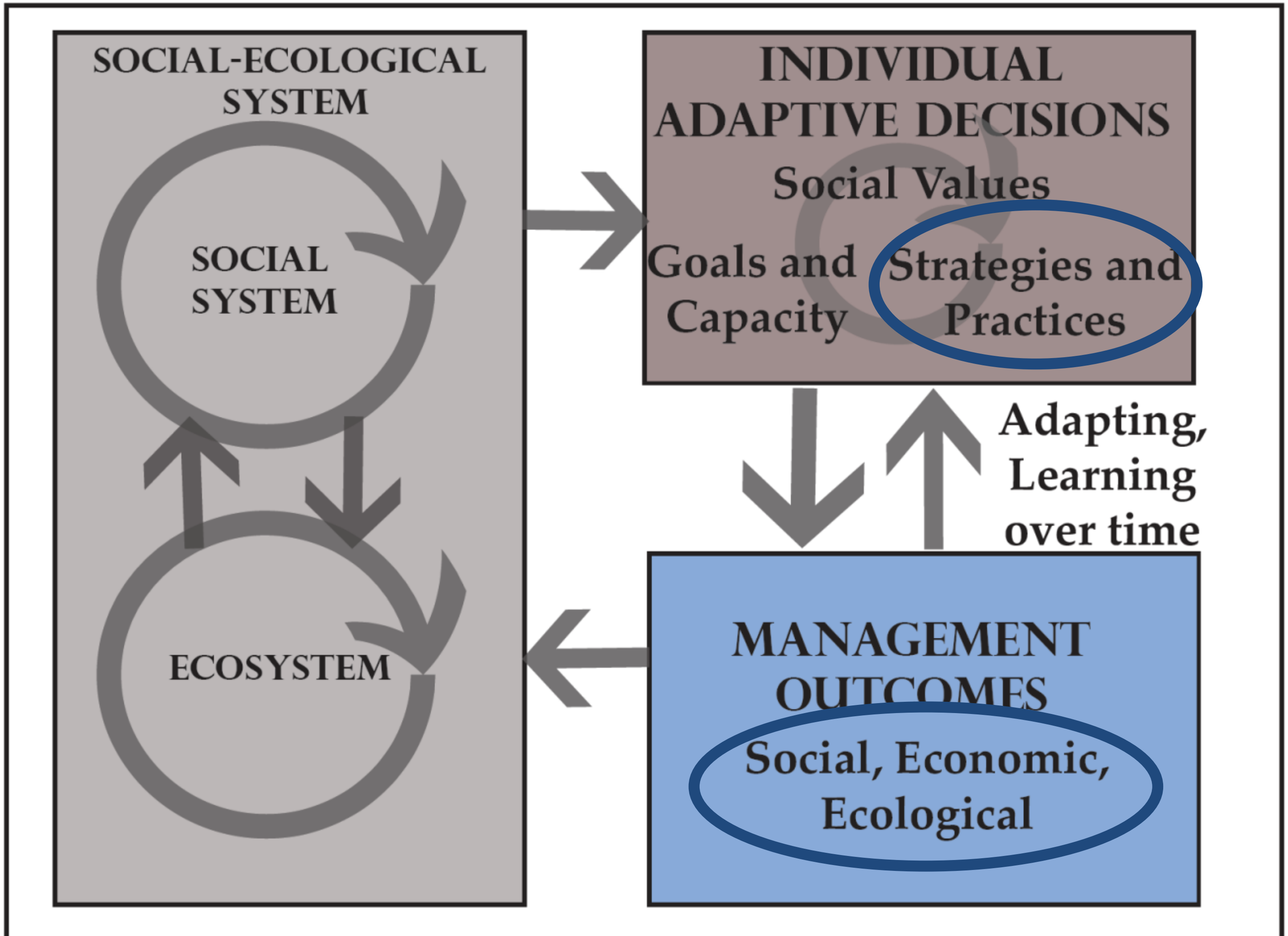
2. Sustainable forage, and thus production capacity.

3. Social benefits – healthy communities and environments.

Working Landscapes

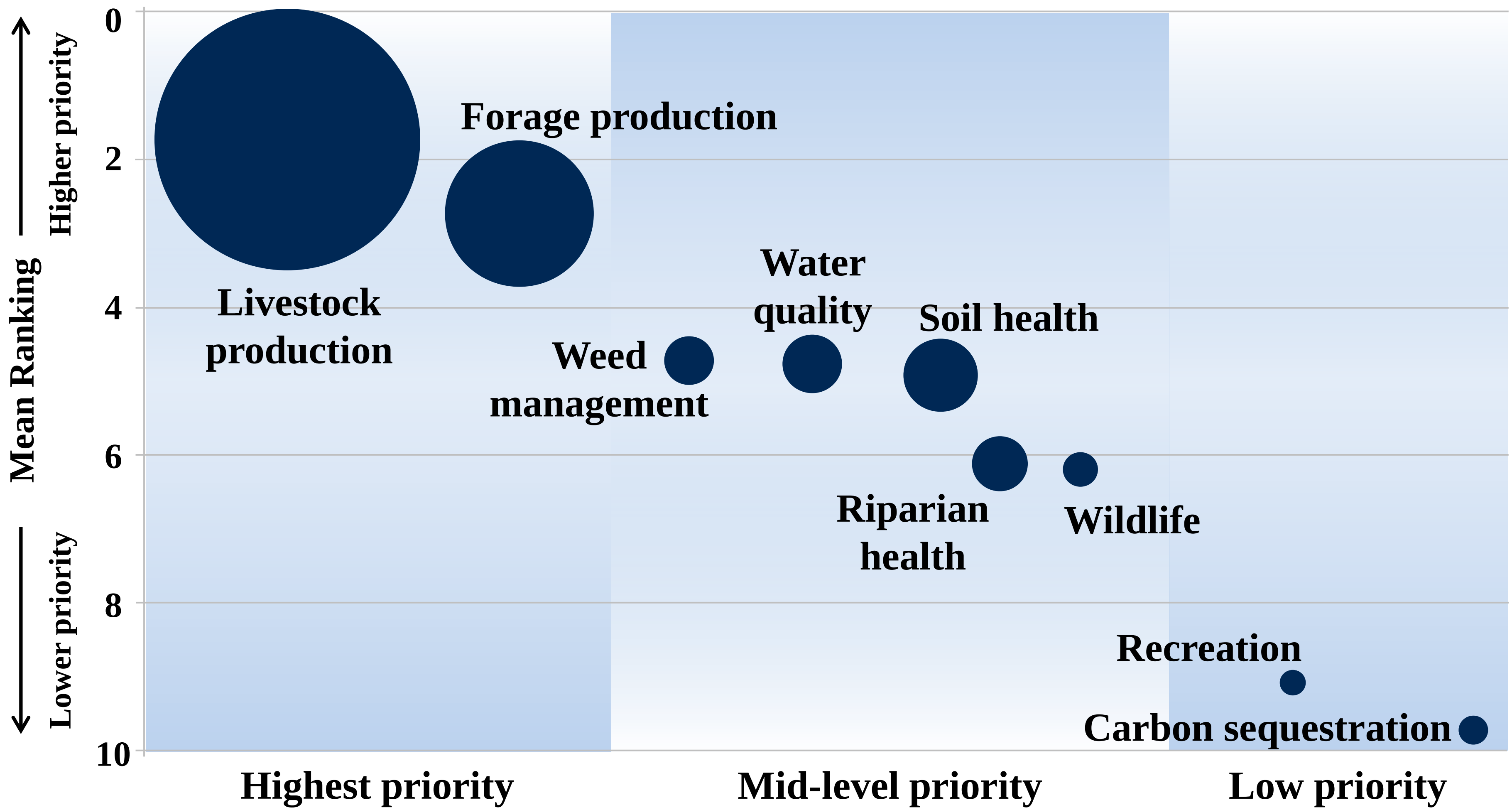
Integrating Soil Health into Adaptive Management

Land manager adaptive decision-making: 1) place-based understanding, 2) management experience and capacity, and 3) changing operational constraints of the ranch enterprise



Wilmer et al. In Review

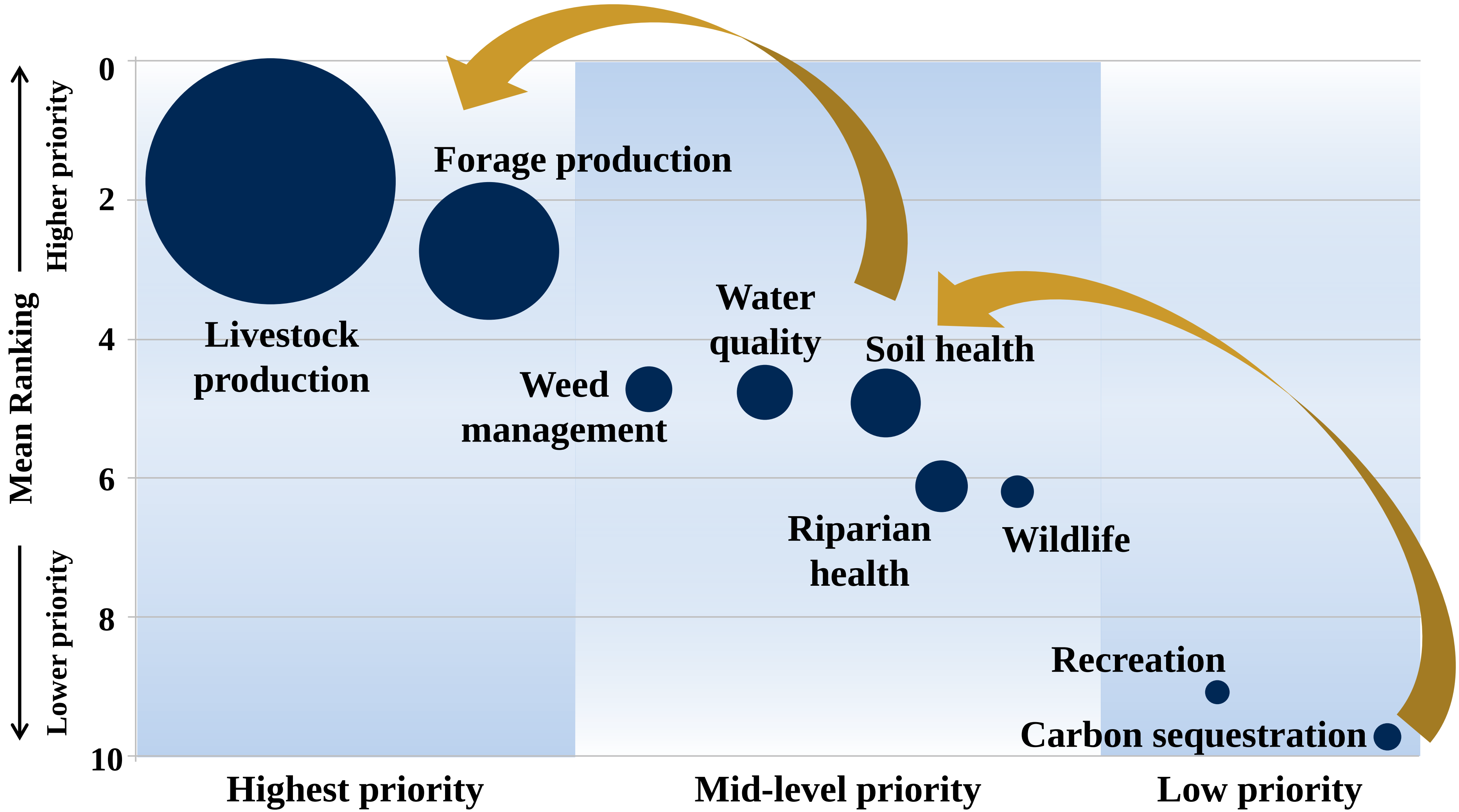
Integrating Soil Health into Adaptive Management



Roche *et al.* 2015. Rangeland Ecology & Management.

Integrating Soil Health into Adaptive Management

Opportunities to tie goal-based management decision-making in an integrated manner with soil-vegetation-livestock ecological processes



Roche *et al.* 2015. Rangeland Ecology & Management.

What do we know?

Grazing management has the *potential* to influence

- **Vegetation composition**
- **Above-ground production**
- **Below-ground production**
- **Soil cover**
- **Soil organic matter**
- **Soil biology**
- **Nutrient cycling**
- **Soil compaction**
- **Water infiltration**
- **…**

What do we know?

Example: How can we mange grazing to protect/increase SOC?

Soil organic carbon fluxes on rangelands are primarily driven by

- Long-term changes in production and quality of above and belowground biomass.
- Long-term changes in global environment, such as rising temperatures, altered precipitation, rising CO_2 concentrations, that affect plant community composition and forage quality.
- Effects of short-term weather conditions and interannual variability in climate (droughts) .

Svejcar et al. 2008. Range Ecol Manag; Briske et al. 2011. Rangeland CEAP.

How can we mange grazing to protect/increase SOC?

1. Grazing must not create soil compaction which <u>functionally</u> limits root and water penetration of the entire soil profile

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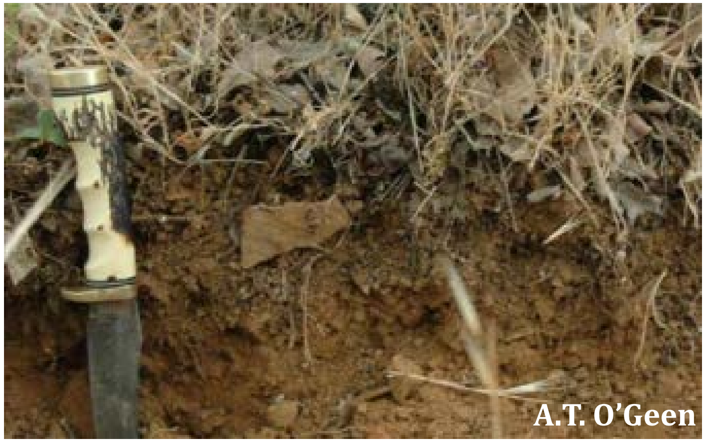
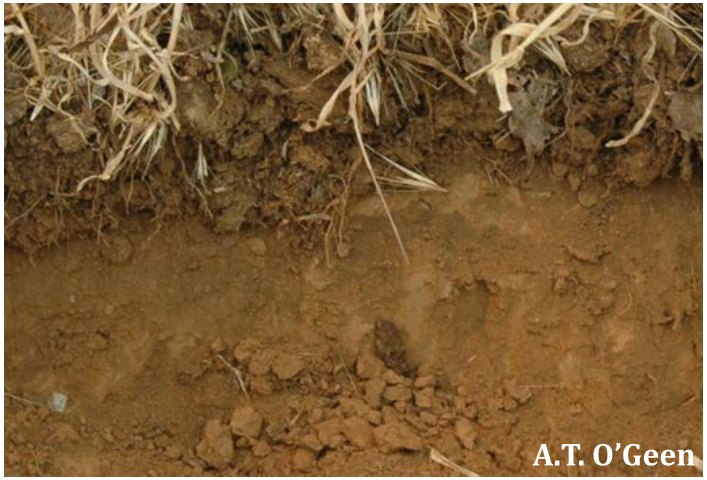
"Cow Pan" ("Traffic Pan")

- A compacted soil layer due to long-term hoof action on moist to wet soil.
- 4 to 6 inches below soil surface.
- Impedes water and root downward penetration.
- Indicators - Platy or massive structure; roots mainly on top of layer; and white mottles indicating moisture accumulation.

Good rangeland soil structure



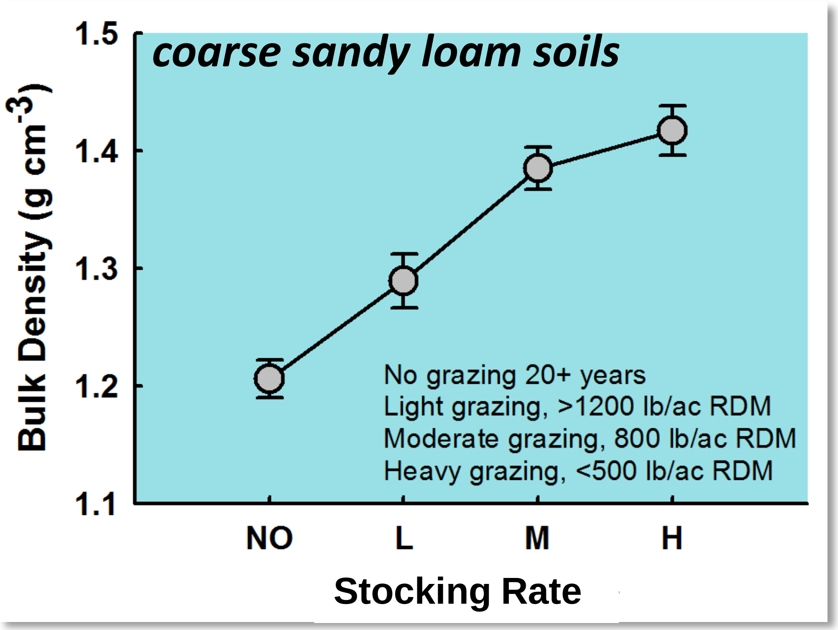
Compacted soil structure



1. *Grazing must not create soil compaction which **functionally** limits root and water penetration of the entire soil profile.*

Soil properties such as texture dictate ***resilience*** to compaction and subsequent…

↓root and water penetration ↓ moisture
↓ organic matter and fertility ↓ forage and livestock production



Tate et al. 2004. Rangeland Ecology and Management

Soil Texture	Root/H_2O restrictive bulk density (g/cm^3) thresholds
Sand	1.8
Loam	1.7
Silt Loam	1.5
Clay	1.4

How can we mange grazing to protect/increase SOC?

1. Grazing must not create soil compaction which <u>functionally</u> limits root and water penetration of the entire soil profile

2. Grazing must not reduce plant vigor and capacity to fully develop rooting system (mass and depth in soil)

3. Grazing must shift plant community towards species which have greater rooting volume and depth, **and/or** increase <u>long-term</u> net primary productivity

More roots and litter incorporation into soil → more soil C

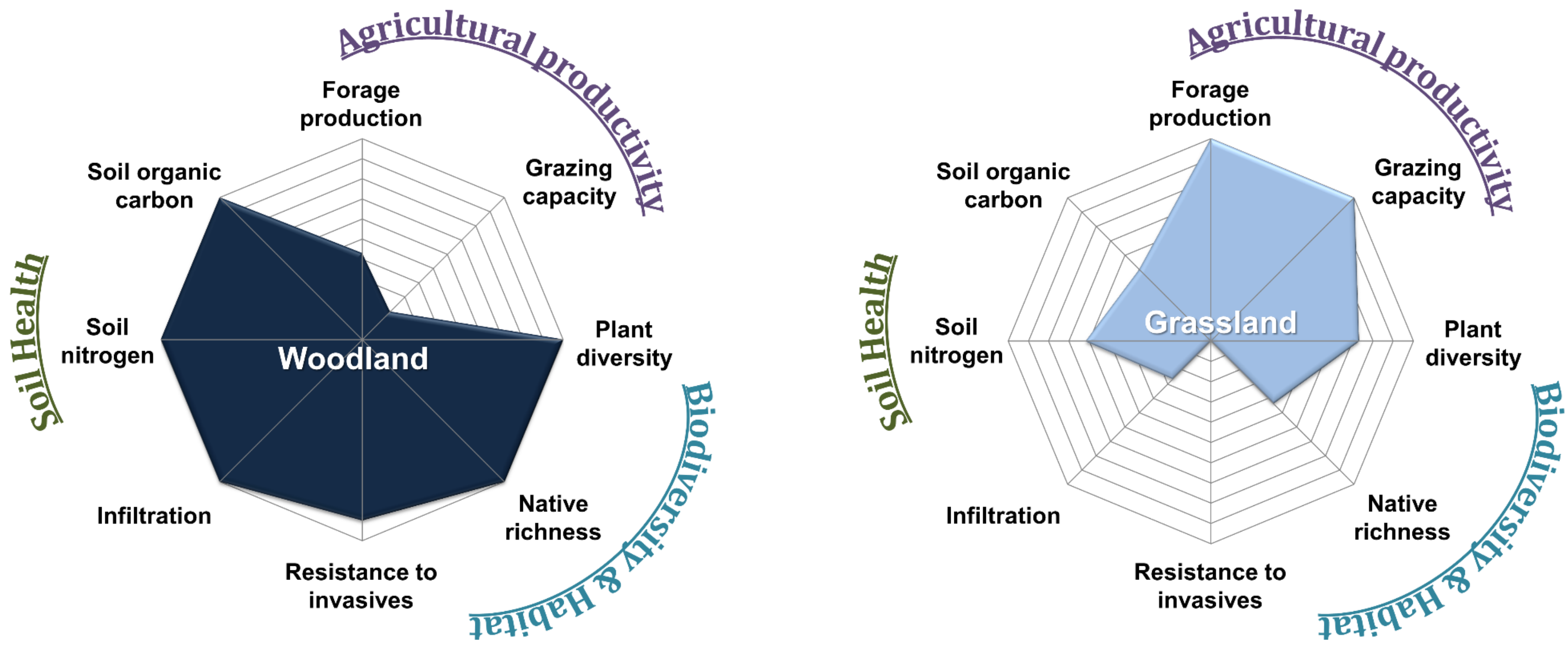
Grazing management – Practices

There is no one perfect prescription…

- Stocking rates must match capacity, adjusted with seasonal and annual conditions.
- Continuous, season-long, moderately stocked strategies can and do sustain ecological and agricultural outcomes (Briske et al. 2011; Wilmer et al. In Review).
- Extensive rotational strategies are common among working ranches – for many reasons (Roche et al. 2015).
- Intensive rotational strategies must include adequate rest for plant recovery from high stock densities.

Managing for multiple ecosystems services

Within a system, what are the short and long-term impacts to multiple outcomes?



Eastburn et al. 2017. PLOS ONE

Win – Wins

Management that supports growth, recovery and vigor of desirable plants; and root and water penetration throughout the soil will...

- Increase forage production and quality
- Improve resilience to drought, weed invasion, and other stresses
- Improve animal performance and return on investments in genetics, reproduction, herd health, supplementation, and infrastructure
- Enhance environmental health and overall productivity

Do livestock grazing regimes influence soil biogeochemical processes and function?

Current meta-analysis of scientific literature

Response variables:
Soil bulk density; Total soil N; Total soil C; Soil C:N

Available management strategy comparisons:
Rotation *vs.* Continuous grazing: 21 articles

Extensive *vs.* Intensive grazing: 51 articles

Continuous *vs.* No grazing: 39 articles

Rotation *vs.* No grazing : 15 articles

Byrnes et al. *In Prep.*

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Table 1. Commonly measured soil health indicators adapted from cropland and forest systems (Adapted from Doran and Jones, 1996; Arias, et al., 2005; Zornoza et al., 2015).

Physical	Chemical	Biological
Particle size	Soil organic carbon	Microbial biomass, C and N
Bulk density	Total nitrogen	Microbial communities
Soil aggregation	pH	Enzyme activities, C and N cycling
Available water holding capacity	Electrical conductivity	Fungi
Porosity	Available nutrients	Invertebrates
Penetration resistance	Cation exchange capacity	Pathogens
Water infiltration rate	Heavy metals	

Derner et al. In Prep.

Table 2. Commonly measured soil health indicators for pasture condition (from Cosgrove et. al., 2001; Adapted in part from M. A. Sanderson, 2014)

Indicator	Description and Purpose
Plant cover	Live stems and green leaf cover of all desirable and intermediate species. Indicator of hydrologic condition
Plant diversity	Number and Proportion of forage grass and legume species
Plant residue	Amount of standing dead and litter ground cover. Related to nutrient cycling
Plant vigor	Visible signs of nutrient, drought or pest stress
Soil compaction	Estimates of animal treading resulting in soil compaction
Soil erosion	Visual estimates of degree of sheet, rill, wind, gully, streambank, shoreline erosion

Derner et al. In Prep.

Sustaining Working Rangelands

Growing demand for ‘*sustainable*’ food systems

Global Roundtable for Sustainable Beef