Implications of Grazing Management on Soil Health and Environmental Quality

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Importance of defining grazing management

Beyond providing forage for grazing livestock, grasslands may provide such environmental services as carbon sequestration, water infiltration, soil and nutrient retention, and wildlife habitat. However, the effects of grazing on environmental quality are the results of biological and physical processes modified by the location, timing, duration, and intensity of grazing. Therefore, management practices to enhance environmental quality will likely manipulate stocking rate and system through alteration of stocking density, number of grazing units, and the lengths of grazing and rest periods. Without defining these variables, stocking systems including Rotational, Management Intensive, Mob, Strip, Adaptive, or Regenerative High Density Grazing are difficult to classify. Therefore, it is difficult to predict or compare the effects of grazing management on environmental quality between different studies or farms particularly if confounded with other management factors like hay harvest, fertilization, or irrigation and environmental factors like soil texture, topography, temperature, and precipitation. Furthermore, as the intensity of forage removal as affected by stocking density and grazing length at any time during the grazing season will influence the rate and nutritional quality of forage regrowth, the stocking rate of a pasture during the entire grazing season may be reduced at excessive stocking densities even if the animals are moved frequently.

For discussion in this paper, continuous stocking is a method of grazing livestock on a specific unit of land where animals have uninterrupted access throughout the time when grazing is allowed (Allen et al., 2011). It is characterized by consumption of less than 30% of the standing forage resulting in non-uniform forage removal and reduced forage productivity and nutritional value. Rotational stocking is a method that utilizes recurring periods of grazing and rest among three or more paddocks in a grazing management unit throughout the time that grazing is allowed (Allen et al., 2011). Usually, each paddock is grazed from 1 to 14 days with rest periods of 14 to 36 days. Although grazing periods and forage removal should be seasonally related to forage productivity, removal of approximately 50% of the standing forage for much of the summer is desired to maintain adequate photosynthetic capacity and root growth. In order to maintain adequate standing forage, stocking densities and grazing periods must be moderated. But the greater standing forage often may allow for an increased stocking rate. Mob-stocking is a method of stocking at a high stocking density for a short time to remove forage rapidly as a management strategy (Allen et al., 2011). Usually, a pasture is divided into multiple permanent or temporary paddocks with movement of grazing animals one or more times daily with rest periods of 90 days or more. Greater than 70% of the forage is removed or trampled in each rotation, resulting in slow forage regrowth, thereby, requiring the long rest periods. Therefore, although stocking density will be increased, stocking rates will need to be decreased if practiced over the entire grazing season. However, mob stocking may be strategically used for short time periods on a portion of pasture acres for purposes like improving pasture botanical composition or stockpiling forage for winter grazing. Other types of pasture stocking systems are derivatives of rotational or mob-stocking and, like them, would be most valuable if defined by their characteristics.

Predicting the effects of a given grazing management system on environmental quality is made more challenging by the modifying effects of soil characteristics and climate on the response. Because the effects of grazing management on botanical composition are highly visible, relatively rapid, and associated with other ecological services like soil organic matter and wildlife habitat, the effects of modifying factors on grassland biodiversity may be most readily demonstrated. While it is commonly believed that the uniform forage removal and rest periods associated with rotational stocking will increase the percentage of legume species in pastures in the eastern United States, this is not always the case. For example, while rotational stocking increased the proportion of red clover in comparison to continuous stocking in a southern Iowa pasture, the effects of the different stocking systems were much greater on the hill slopes than on the summits or toe slopes of hills apparently because of differences in soil fertility and/or water availability (Guretzky et al., 2005). Also in southern Iowa, a single grazing event with fall-calving beef cows at a stocking density of 472,000 lb/acre and movement 4 times daily or at 132,000 lb/acre with movement 1 time daily during a period with 12.9 inches of rain increased the percentage of legume species to 32 and 38% in July of the subsequent year when followed by no grazing or by grazing with rotational stocking, respectively (Bisinger, 2014). However, because of dry conditions later that year and the following year, the proportion of legume species in these pastures subsequently did not differ from nongrazed grasslands not exposed to any initial spring grazing event and the same initial grazing event treatments had no effect on the composition of the plant community in a second set of pastures. Therefore, while botanical composition of a pasture may be modified by pasture management through control of soil pH, fertility, or the seedbank and by grazing management through control of grazing selectivity and regrowth periods, these effects may be superseded by landscape, soil, and climate factors beyond the grazier's control.

Grazing management effects on soil organic matter

Because the composition and processes contributing to the synthesis or degradation of soil organic matter are complex, altering the concentration of soil organic matter is more than simply increasing the amount of plant material or manure trampled into the ground. Soil organic matter is a mixture of above- and below-ground plant residues, manure, plant exudates, and microbial matter. The proportion of soil organic matter directly composed of plant residues is relatively small as fresh and decaying plant materials have been estimated to represent 35.0% of the total organic carbon while soil microbes have been estimated to represent 54.3% of the total organic carbon in a field planted with barley with no tillage for 25 years (Plaza et al., 2013). Therefore, factors that increase microbial synthesis such as precipitation and nitrogen fertility will increase soil organic matter while factors that increase oxidation such as increased temperature and oxygen will decrease soil organic matter. The role of plant residues in soil organic matter is largely as substrates for microbial growth. As such, the amounts of plant residues particularly in the roots play a major role in soil organic matter accumulation. Furthermore, the composition of the plant residues will affect soil organic matter accumulation as high quality plant residues with low carbon to nitrogen ratios such as immature plants will

generally result in greater soil organic matter than low quality plant residues characterized by high carbon to nitrogen ratios such a senescent plants (Castellano et al., 2015).
However, as soils have a finite capacity to store carbon, the efficiency of soil organic matter accumulation will decrease as a soil becomes carbon-saturated regardless of the quantity and quality of residue inputs (Castellano et al., 2015).

With these provisions, there are some clear effects of land use on soil organic matter. The amount of soil organic matter will be greater in perennial grasslands than in land used for row crops even if planted with no tillage (Franzluebbers, 2005). In addition, soil organic matter in grazed pastures will be greater than in grasslands that were either unharvested or harvested as hay (Franzluebbers and Stuedemann, 2009). Furthermore, pastures grazed at a low stocking rate (2.3 steers/acre) had greater soil organic matter than those grazed at a high stocking rate (3.5 steers/acre).

Beyond stocking rate, the effects of grazing management on soil organic matter in pastures in the eastern United States are not clear. A study in Virginia reported that pastures on loam and silt loam soils managed by management-intensive grazing for 3 to 25 years contained 22% greater soil organic carbon to a depth of 50 cm than pastures managed by extensive grazing or hay harvest (Conant et al., 2003). However, beyond stating that management-intensive grazing defined as short-rotation grazing compared to pastures that were managed by extensive grazing and hay harvest, stocking rate and management were not defined. A recent study from Michigan reported greater soil organic matter (4.07% OM) in a pasture grazed by rotational stocking at a high stocking rate (1.0 cow/acre) and low stocking density (29,125 lb/acre) than in a pasture grazed by rotational stocking at a low stocking rate (0.40 cows/acre) and high stocking density (99,757 lb/acre; 3.33% OM) or an ungrazed exclosure (3.22% OM; Chiavegato et al., 2015). However, this difference may be the result of the pasture grazed at the low stocking density being irrigated throughout the grazing seasons and fertilized with nitrogen in the first year, neither of which did occurred in either the pasture grazed at the high stocking density or the ungrazed exclosure. In contrast to these studies, soil organic carbon concentration to a depth of 3 inches did not differ among pastures in Iowa that were grazed by season-long rotational, strip, or mob-stocking for 2 years (Dunn, 2013) or after 3 years in pastures at had been either nongrazed or subjected to a single grazing event by high density-short duration or moderate density-moderate duration stocking with or without subsequent rotational grazing (Bisinger, 2014).

Grazing management effects on soil physical properties

Although soil organic matter has important effects on soil compaction and water infiltration, the effects of grazing on soil physical properties is much more rapid than change in soil organic matter. Soil compaction is the loss of air or water from soil pores resulting from load forces estimated to be 123 to 250 kPa under the hoof of a cow depending on whether it’s standing or walking with the greatest influence near the soil surface. Soil compaction will inhibit plant growth by obstructing root growth and, thereby, reducing water and nutrient uptake. In addition, soil compaction may also inhibit water infiltration which will increase precipitation runoff, soil erosion, and nutrient loading of surface water sources while reducing soil water storage.

In general, cattle grazing may increase soil compaction measured either as soil bulk density or penetration resistance at depths of 1 to 6 inches from the soil surface. Because of repeated hoof traffic, the greatest soil bulk density occurs near trails, supplementation or water sites, or shade.at distances as far as 75 feet from these congregation points. Increasing stocking rate has increased soil compaction in some studies, particularly if the increased stocking rate was on fine loam soils (Van Havern, 1983) or when soils were wet (Liebig et al., 2014). However, there are also studies in which stocking rate has had little or no effect on soil compaction, particularly, on soils subjected to treatments for long periods (Warren et al., 1986; Chanasyk and Naeth, 1995: Daniel et al., 2002) or that were grazed when soils were frozen (Clark et al., 2004). Similarly, over an entire grazing season, a range of stocking systems including moderate continuous, heavy continuous, and short-duration stocking (Thurow et al., 1986); continuous, rotationally deferred, and short duration stocking at 3 stocking rates (Abdel-Magid et al., 1987); no stocking, continuous stocking, or rotational stocking to 2 or 4 inches (Haan et al., 2006); rotational, strip, or mob-stocking at equal stocking rates (Dunn, 2013); or no stocking or rotational stocking at a high or low stocking density (Chiavegato et al., 2015) did not affect soil compaction. However, there is evidence that the short grazing period or long rest periods of high stocking density-short duration systems may reduce soil compaction. A single grazing event at a high stocking density-short duration (5 to 9 hours) resulted in lower soil bulk density and penetration resistance measurements over the next three years than a single grazing event at a moderate stocking density-moderate duration (24 hours; Bisinger, 2014). Similarly, soil penetration resistance at the soil surface and at depths greater than 5 inches from the soil surface were lower in strip-stocked paddocks which had rest periods greater than 90 days than pastures grazed by continuous stocking.

Grazing management effects on surface water quality

Sediment, nutrient, and microbial loading of water quality in surface streams and lakes may be affected by precipitation run-off and direct deposition on manure which are directly related to grazing management and to cut bank erosion which is more affected by stream hydrology. As precipitation run off results from water that does not infiltrate the soil, water infiltration rate has important implications on surface water quality. While water infiltration rate of soils is affected by soil bulk density, it is more sensitive to grazing than soil bulk density as water infiltration is consistently less at increased stocking rates and it can be reduced by treading damage for as little as 40 minutes (Russell et al., 2001). The greater sensitivity of water infiltration to grazing is likely related to factors like vegetative cover, plant community composition, ambient soil moisture, soil surface roughness, and slope that affect water infiltration beyond the loss of macropores.

Similar to stocking rate, water infiltration is also more responsive to grazing management than soil compaction. Therefore, on hillsides of smooth bromegrass pastures, grazing by continuous or rotational stocking to a residual height of 2 inches reduced water infiltration and increased P transport in rainfall simulations. But grazing by rotational stocking to a residual height of 4 inches resulted in no greater water runoff or phosphorus (P) transport in simulated precipitation runoff than from nongrazed exclosures (Haan et al., 2006). Similarly, although there were no differences in the infiltration rates of bare areas along stream banks in pastures grazed by continuous stocking or by rotational stocking in which the riparian paddock was managed to maintain a sward height of 4 inches, the lower amount of bare ground along the stream banks in pastures grazed by rotational stocking resulted in less sediment and P transport into the stream in these pastures (Schwarte et al., 2011a,b). Therefore, maintaining a minimum sward height of 4 inches in both upland and riparian areas seems valuable in minimizing the risk of nonpoint source pollution of streams in Midwest pastures.

Beyond controlling forage height, stocking management may also reduce the risk of nonpoint source pollution of pasture streams by controlling manure distribution. Rotational stocking will reduce the proportion of time that cattle are in or near streams which is directly related to deposition of manure in those areas (Haan et al., 2010). However, similar effects may be achieved by limiting access to streams to stabilized access points (Haan et al., 2010; Schwarte et al., 2011b) or by providing shade outside of the pasture riparian areas (Bisinger et al., 2014).

While grazing management has potential to reduce the risks of nonpoint source pollution of surface waters by precipitation runoff from upland and riparian areas and direct manure deposition by grazing cattle, the amounts of sediment and P contributed by cut bank erosion are nearly 1000 times greater than those from runoff or direct manure deposition (Schwarte et al., 2011a). Therefore, while grazing management to reduce nutrient transport in precipitation run off and direct fecal deposition may reduce the risk of nonpoint source pollution, the greatest improvements in water quality would result from management practices that would reduce cutbank erosion.

Conclusions

While pasture management practices like fertilization, irrigation, and hay harvest or management of stocking rate affect the quality of plant community, soil, and water resources in pastures, the effects of stocking system on environmental quality beyond plant biodiversity and water quality of surface resources is less clear. Perhaps there are individual cases in which a given stocking system like season-long high density stocking is providing environmental benefits beyond other forms of grazing management. However, they have yet to be proven in the literature and may relate to specific management systems or climatic or biotic characteristics of that farm or even region. What seems more practical is the strategic use of such practices for a specific goal such as increasing plant diversity or initiating stockpiling of forage for winter grazing.

Another question is whether the desired environmental result from a given stocking system may be achieved without reducing animal productivity as there is no system that will maximize animal productivity and every possible ecological service that could be provided by a grassland. If stocking management is used to enhance environmental quality, a key will be to maintain animal productivity while obtaining the desired environmental effects. For grazing management systems that utilize high stocking density, this may be challenging. It has been our experience that increasing stocking density means reducing individual animal production or stocking rate and, thus, animal production per acre. For example, we recently concluded an experiment in which fall-calving cows that strip-grazed paddocks at forage allowances of 2.0 to 3.0 of their body weight tended to have lower methane production in spite of lower forage quality compared to cows that grazed pastures by continuous or rotational (4.0 to 6.0% BW forage allowances) stocking. However, the strip-stocked cows also had lower body weights and condition scores. While landowners and producers should be aware to these competing relationships, animal productivity may not always be the primary goal of a grazing system. For instance, if a grassland such as land enrolled in a government program like CRP were grazed to enhance plant and animal biodiversity, then perhaps the desired environmental result may supersede grazing animal productivity. But in most cases, given the increasing price and decreasing amounts of grazing land in the eastern United States, maximizing animal production per acre is essential. The key is to identify the desired results and develop a grazing program to achieve them while minimizing any possible negative effects on the other components of the system.

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IMPLICATIONS OF GRAZING MANAGEMENT ON SOIL HEALTH AND ENVIRONMENTAL QUALITY

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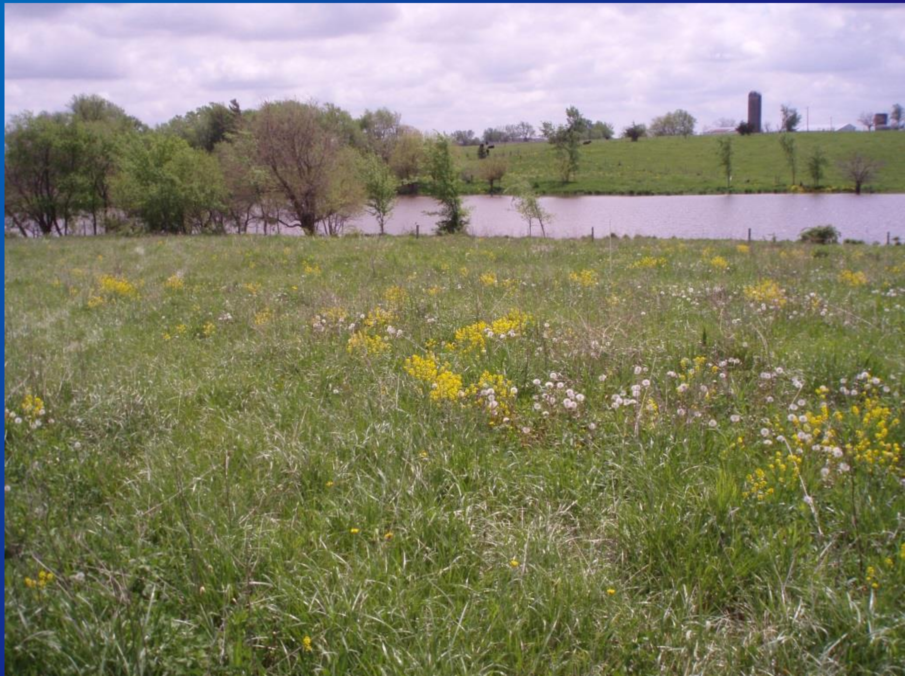
GRASSLAND SERVICES

- Grazing
- Soil retention
- Water infiltration
  - Flood control
- Nutrient cycling
  - Nutrient management
- Carbon sequestration
- Wildlife habitat



WILL GRAZING MANAGEMENT ENHANCE GRASSLAND SERVICES?

Rotational stocking

MIG

Strip stocking

Mob grazing

Holistic grazing

Adaptive grazing

Regenerative High Density Grazing

Increased animal production

Increased grazing season length

Enhanced stability to disturbance

Lower greenhouse gas emissions

Greater soil OM

Reduced soil erosion

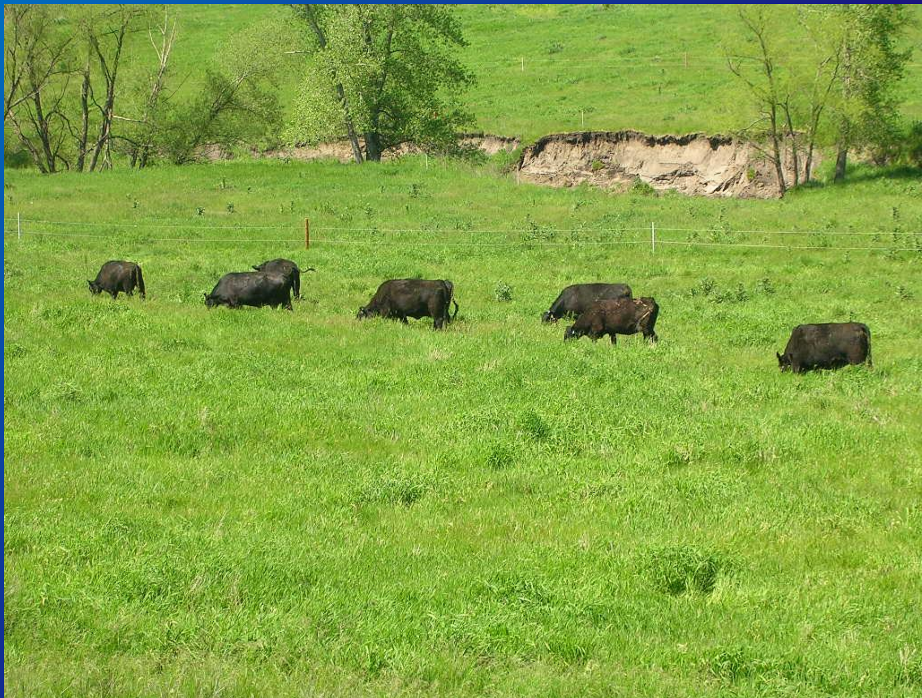
Greater H_2O infiltration

Improved wildlife habitat

FACTORS CONTROLLING THE EFFECTS OF GRAZING ON ENVIRONMENTAL QUALITY

- **Location of grazing**
- **Timing of grazing**
- **Intensity of grazing**
- **Duration of grazing**

(CAST, 2002)



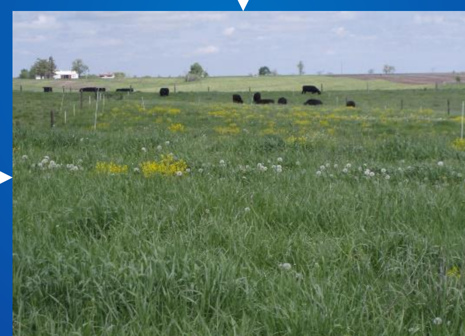
DEFINING GRAZING MANAGEMENT IS MORE IMPORTANT THAN LABELLING IT

- What is mob grazing?
  - 98,000 lb BW/acre moved 3 times daily?
  - 312,000 lb BW/acre moved 4 times daily?
  - 471,000 lb BW/acre moved 4 times daily?
  - 1,000,000 lb BW/acre moved 8 times daily?
- What is rotational grazing?
  - 4 pastures moved every 14 to 28 days?
  - 10 paddocks moved every 4 days?
  - 48 paddocks moved every 2 times daily?

MORE FACTORS INFLUENCE GRASSLAND SERVICES THAN GRAZING

Environmental modifiers
Soil texture
Soil pH and fertility
Landscape position
Ambient temperature
Precipitation

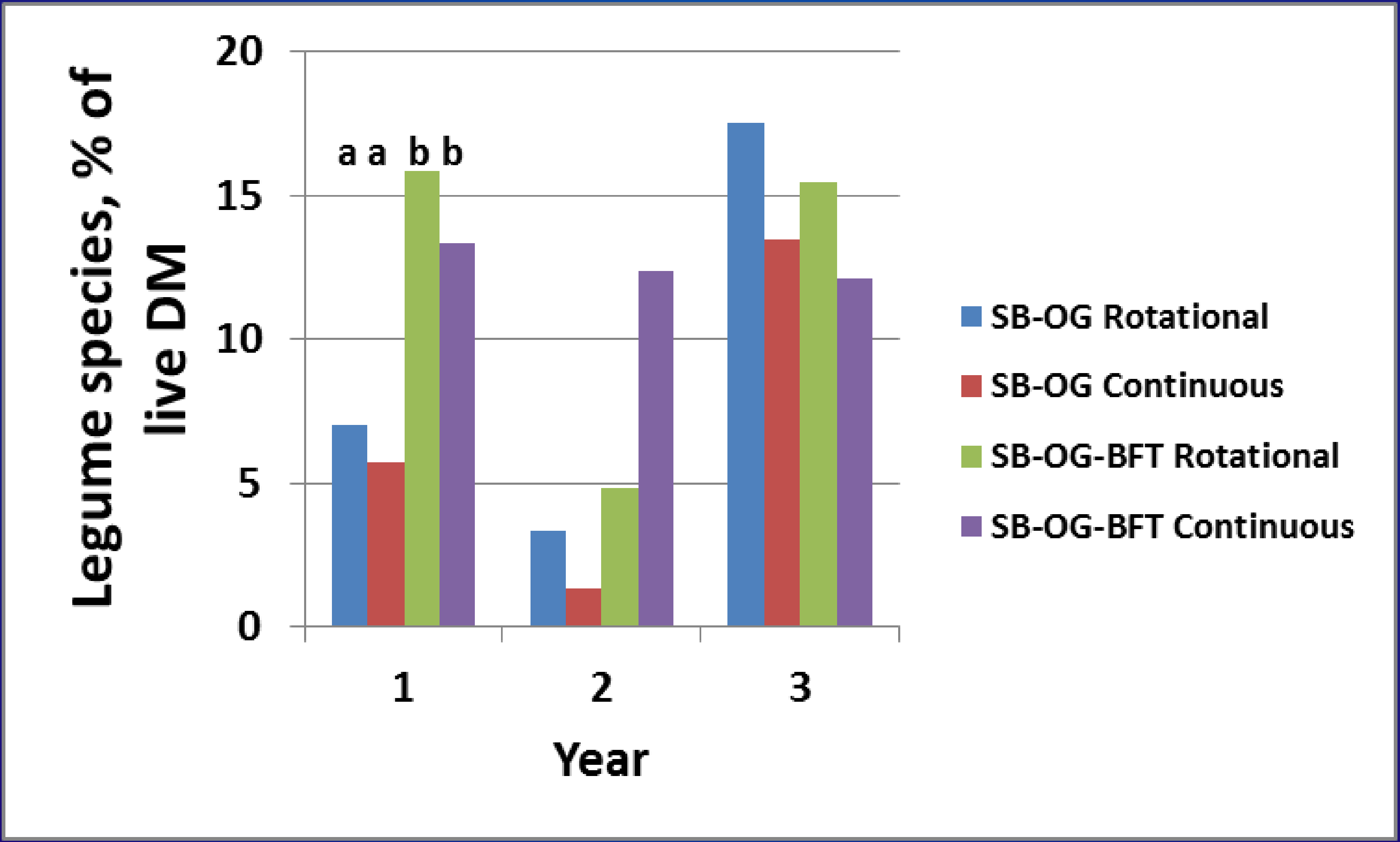
Grazing management



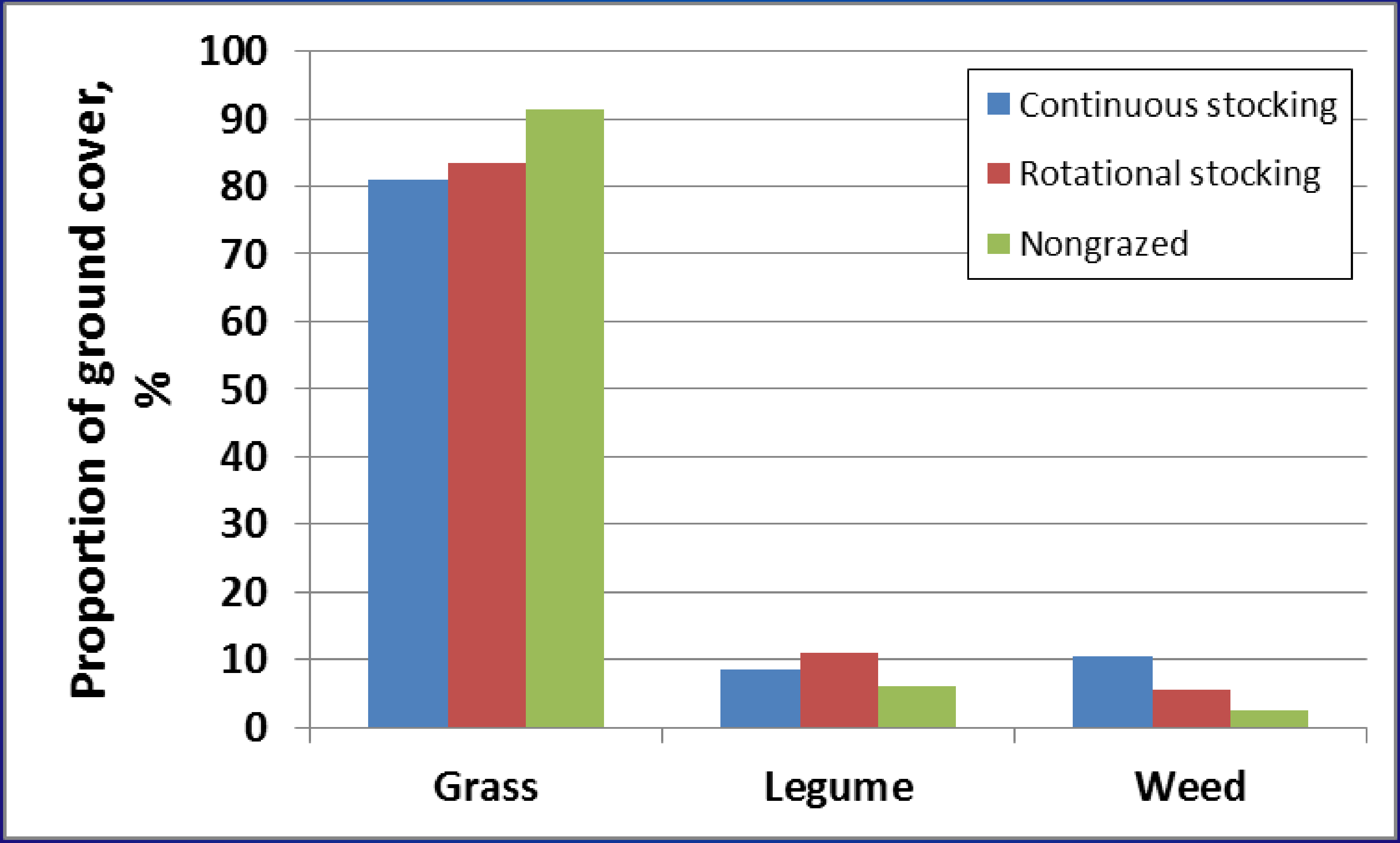
Animal production & Ecological services

Management modifiers
Hay harvest
Fertilization
Irrigation
Previous crop management

EFFECTS OF STOCKING SYSTEM ON PROPORTION OF LEGUME SPECIES IN PASTURES SEEDED IN SMOOTH BROMEGRASS AND ORCHARDGRASS WITHOUT OR WITH BIRDSFOOT TREFOIL

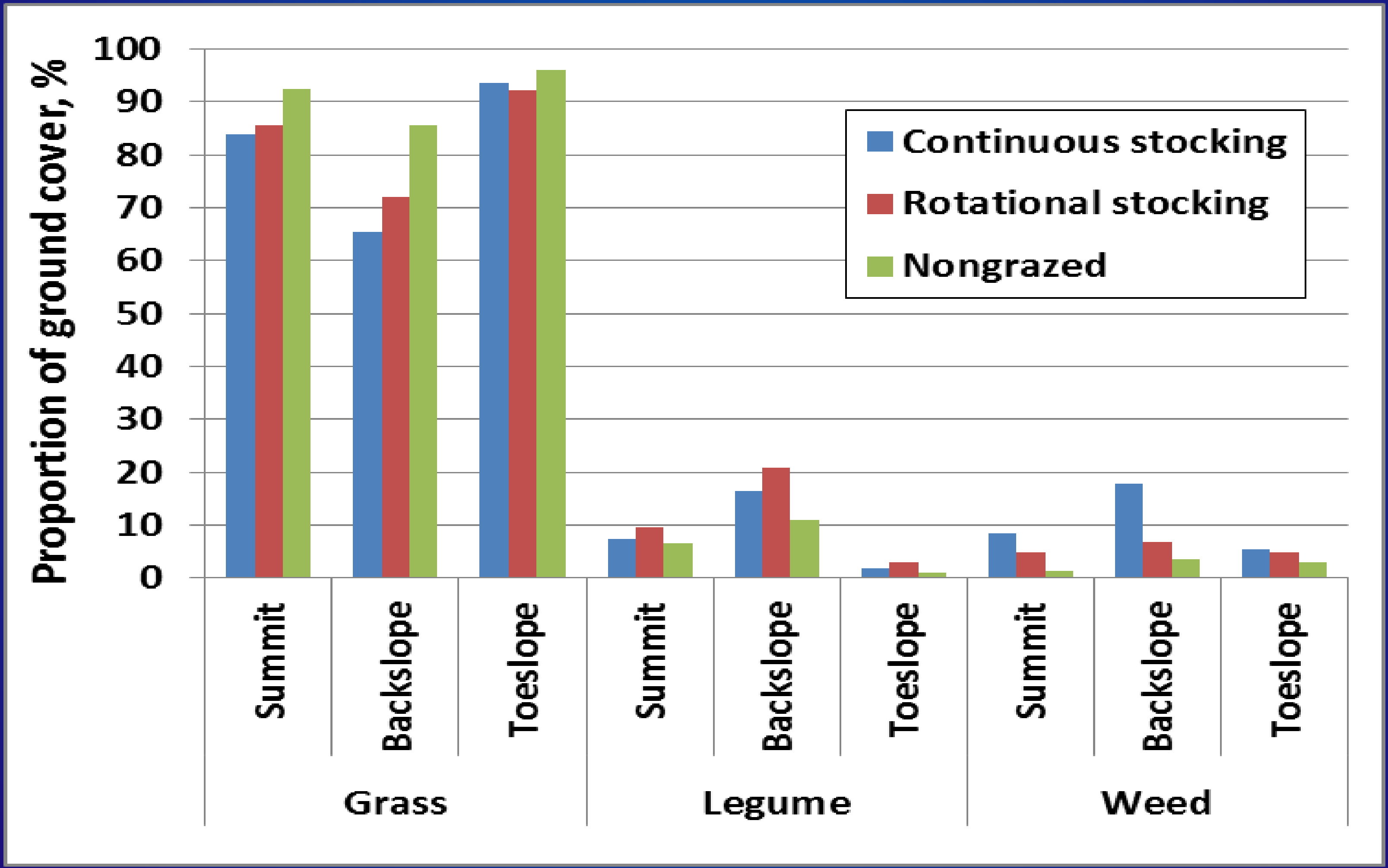


STOCKING MANAGEMENT EFFECTS ON THE PROPORTION OF GROUND COVER FROM COOL SEASON GRASS, LEGUME, OR WEED SPECIES



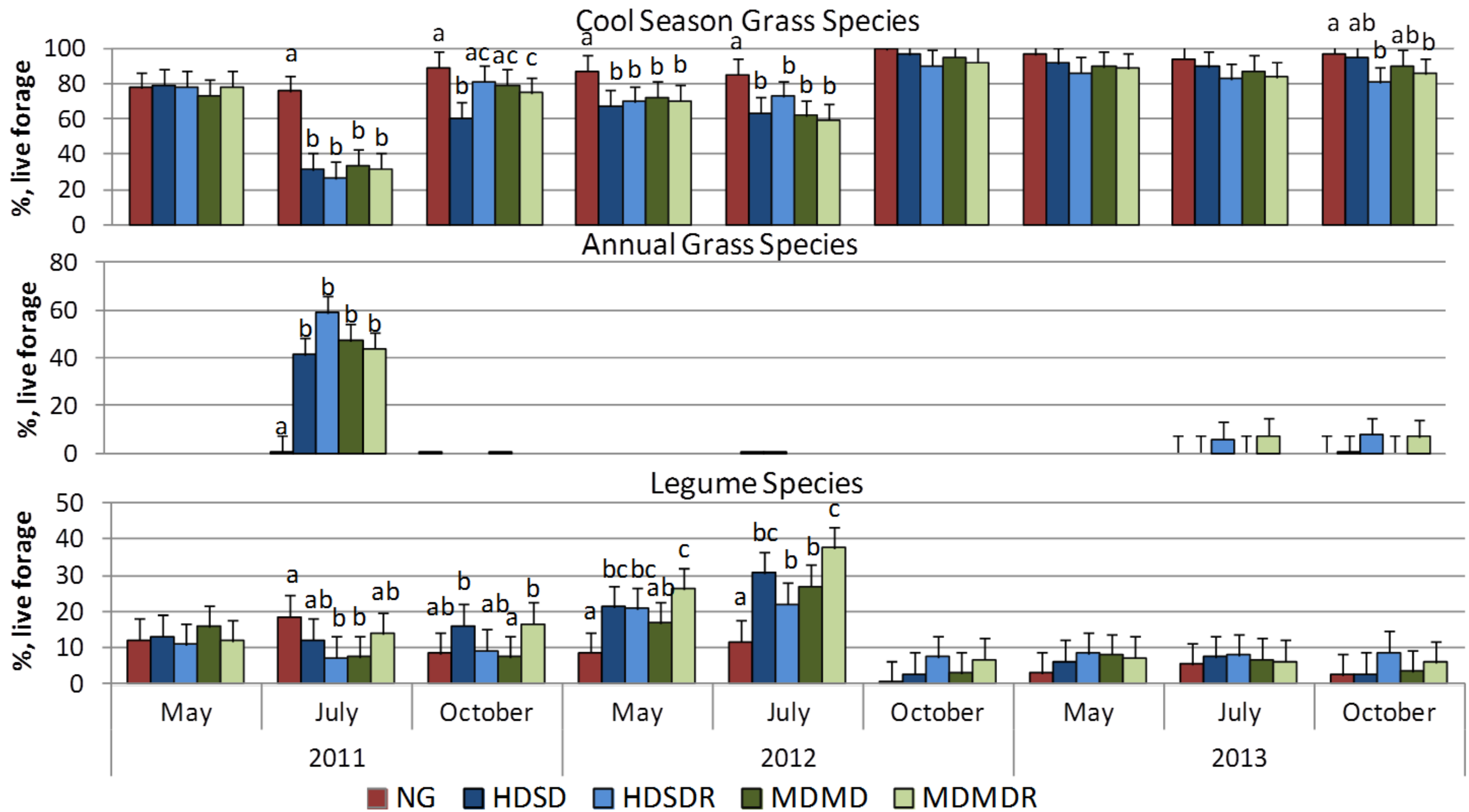
(Guretzky et al., 2004)

EFFECTS OF LANDSCAPE POSITION ON STOCKING SYSTEM IMPACTS ON THE BOTANICAL COMPOSITION OF PASTURES



(Guretzky et al., 2004)

EFFECTS OF A SINGLE SPRING GRAZING EVENT AT A HIGH OR MODERATE STOCKING DENSITY WITH OR WITHOUT SUBSEQUENT ROTATIONAL GRAZING ON THE BOTANICAL COMPOSITION OF GRASSLANDS (Precipitation during event = 6.7 mm d^{-1})



[a-c] Differences between treatment means within month with different superscripts are significant (P<0.05).

EFFECTS OF GRAZING MANAGEMENT ON PLANT DIVERSITY ARE DEPENDENT ON SOIL PROPERTIES, TOPOGRAPHY, AND CLIMATE

Immediately following grazing at elevated stocking densities

Block 1 2011

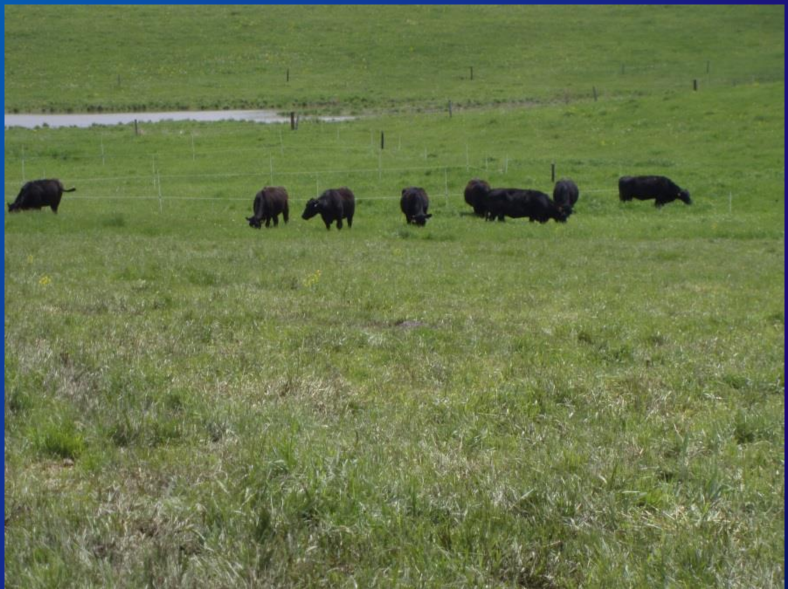
Block 2 2012

Block 1 2013

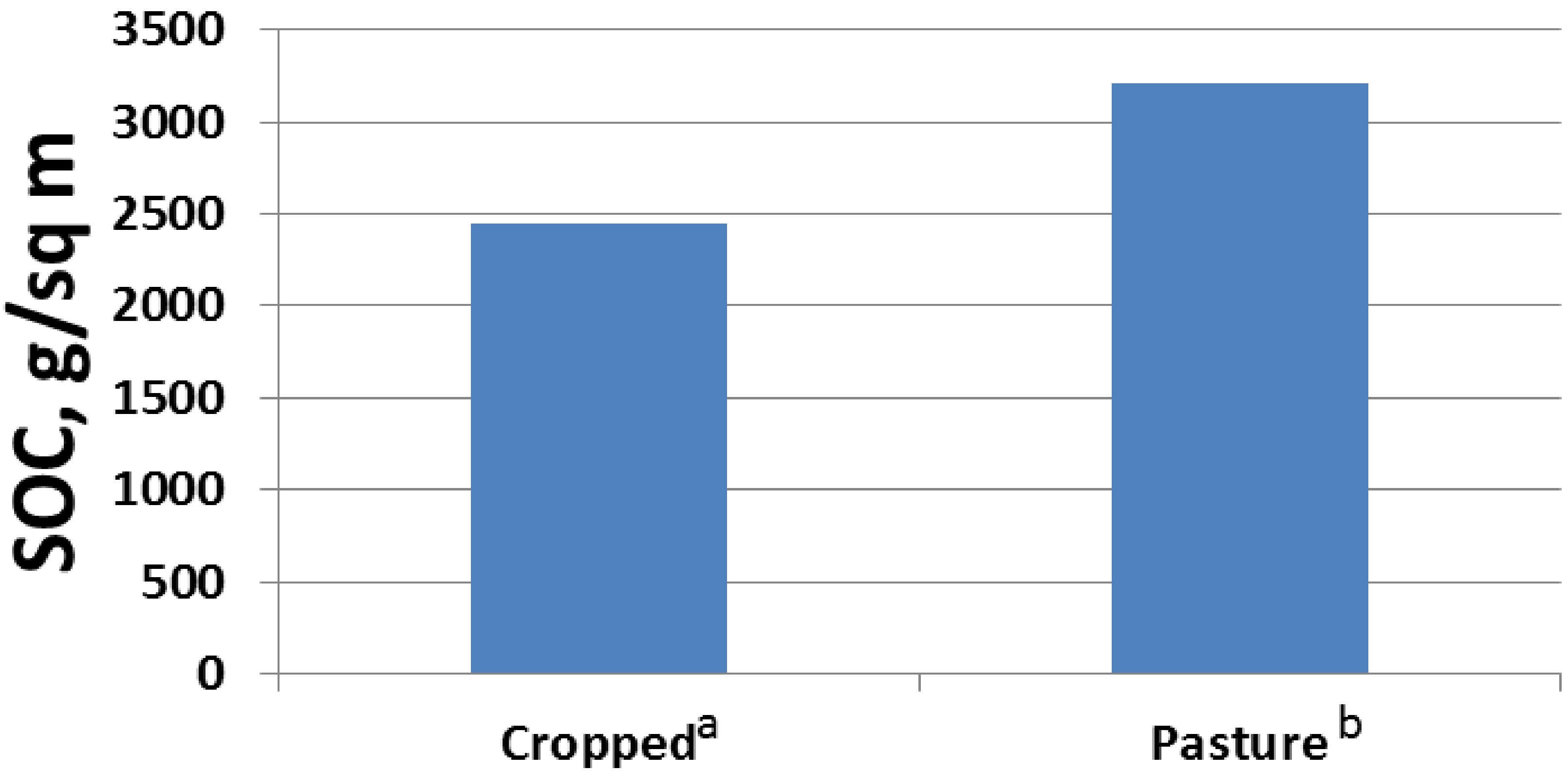
Block 2 2013

BENEFITS OF SOIL ORGANIC MATTER

- Sequestration of carbon and nutrients
- Water infiltration and holding capacity
- Soil aggregation and cation exchange



ORGANIC CARBON CONTENTS OF SOILS IN CROPPED FIELDS OR BERMUDAGRASS/TALL FESCUE PASTURES TO 20 CM DEPTH

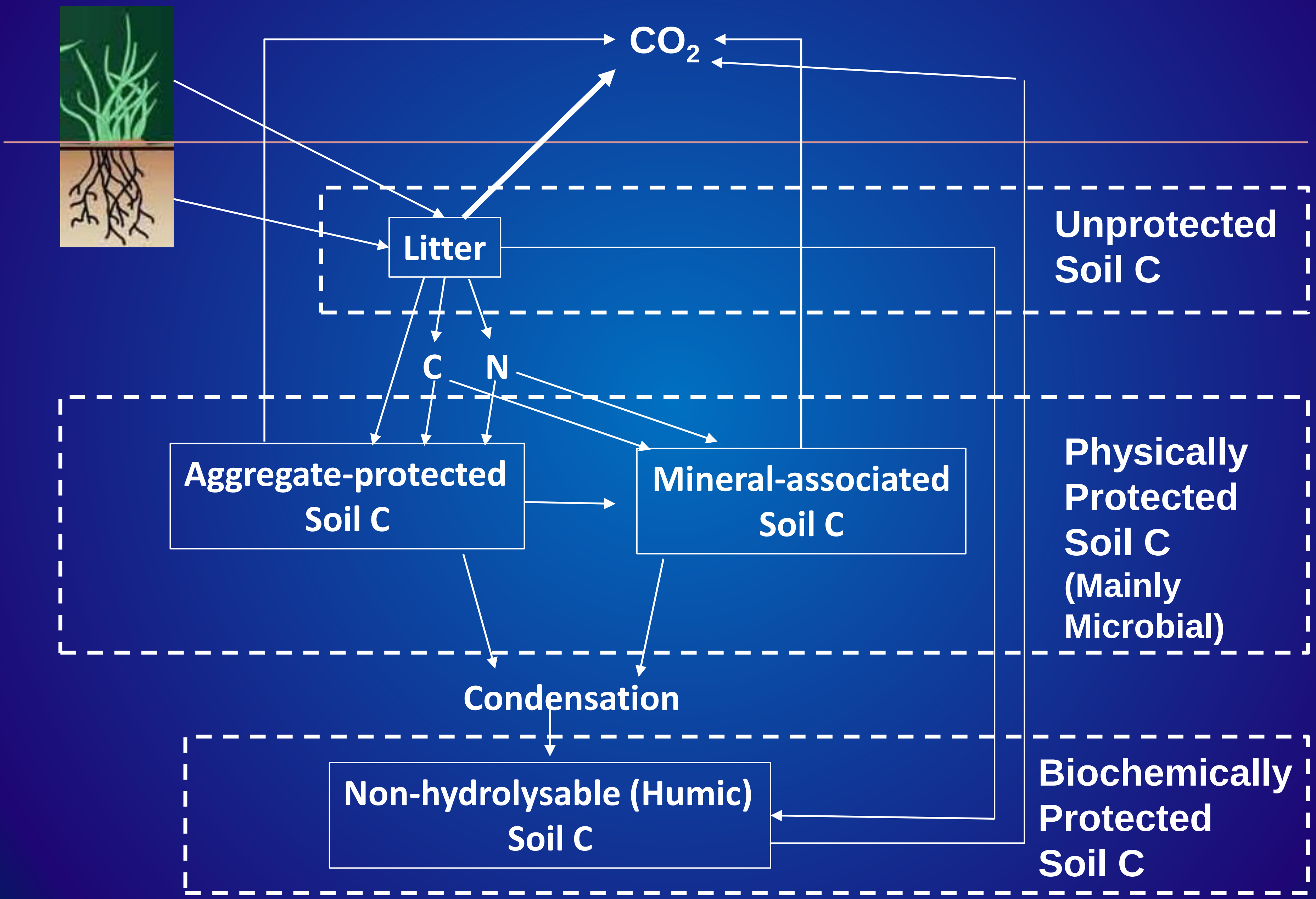


[a]24 yr conservation tillage after conventional tillage
[b]20 yr pasture after conventional tillage

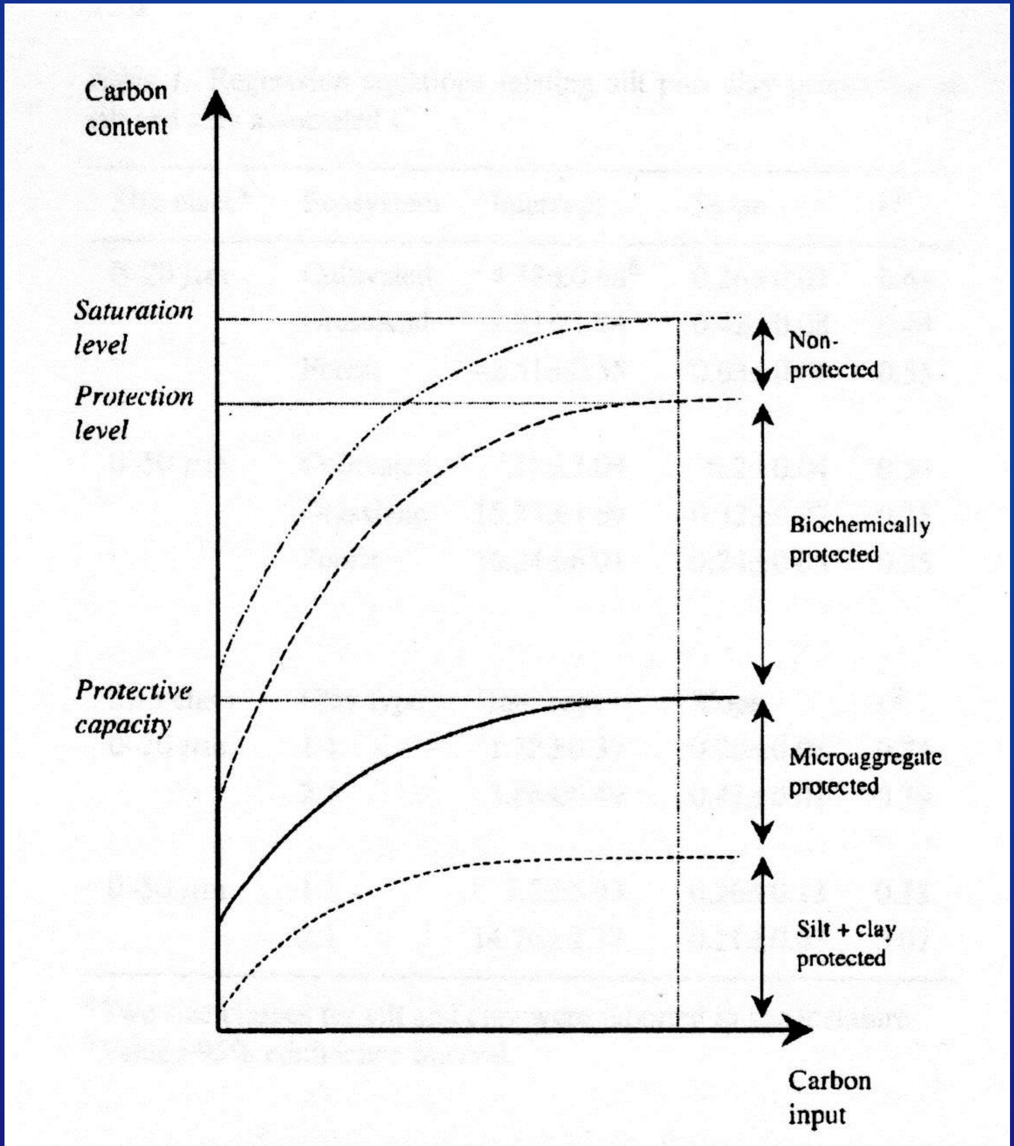
(Franzluebbers et al., 2000b)

WILL GRAZING MANAGEMENT INCREASE SOIL ORGANIC MATTER?

WHAT IS SOIL ORGANIC MATTER?

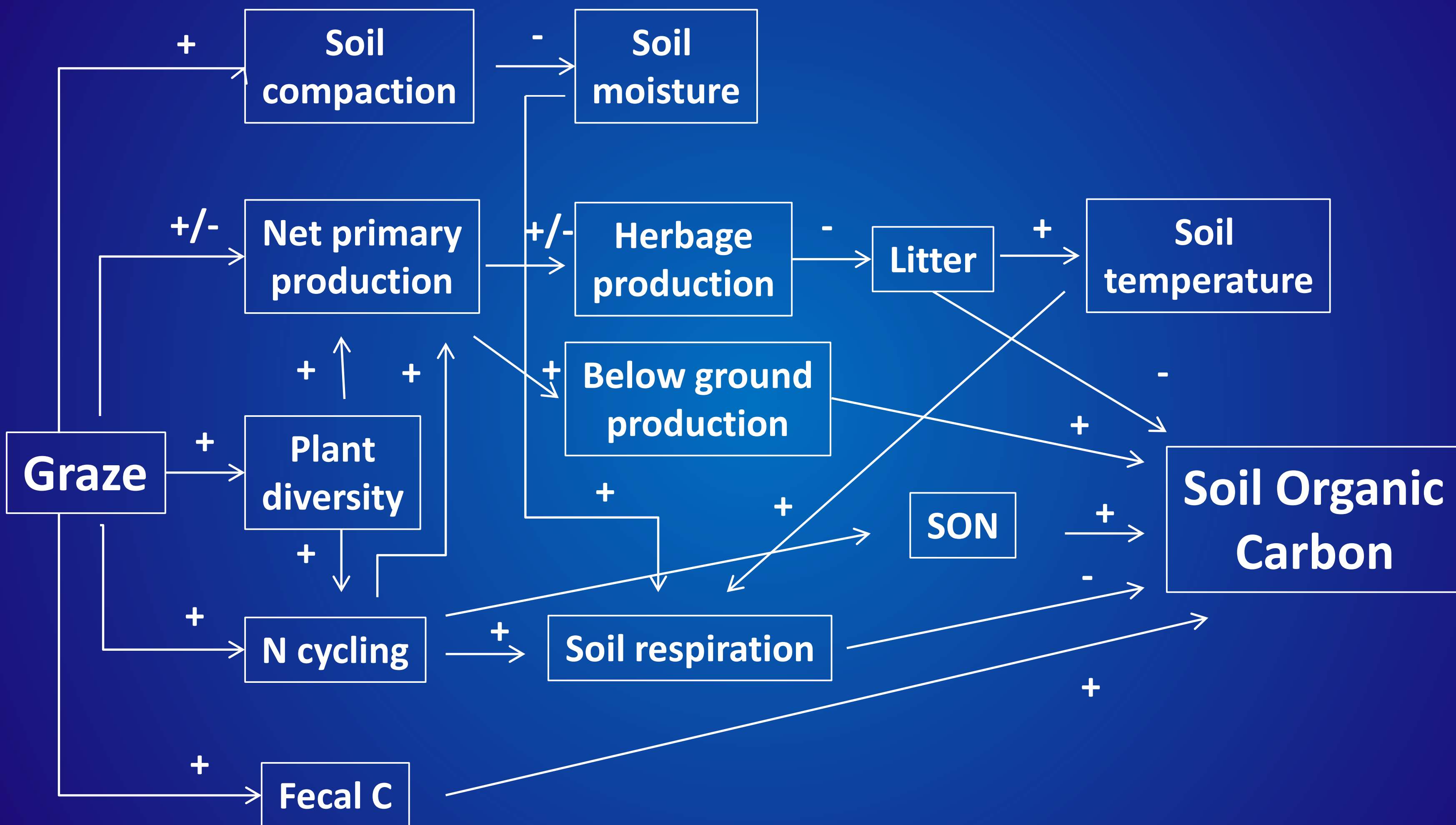


HOW MUCH ORGANIC MATTER CAN BE STORED IN THE SOIL?



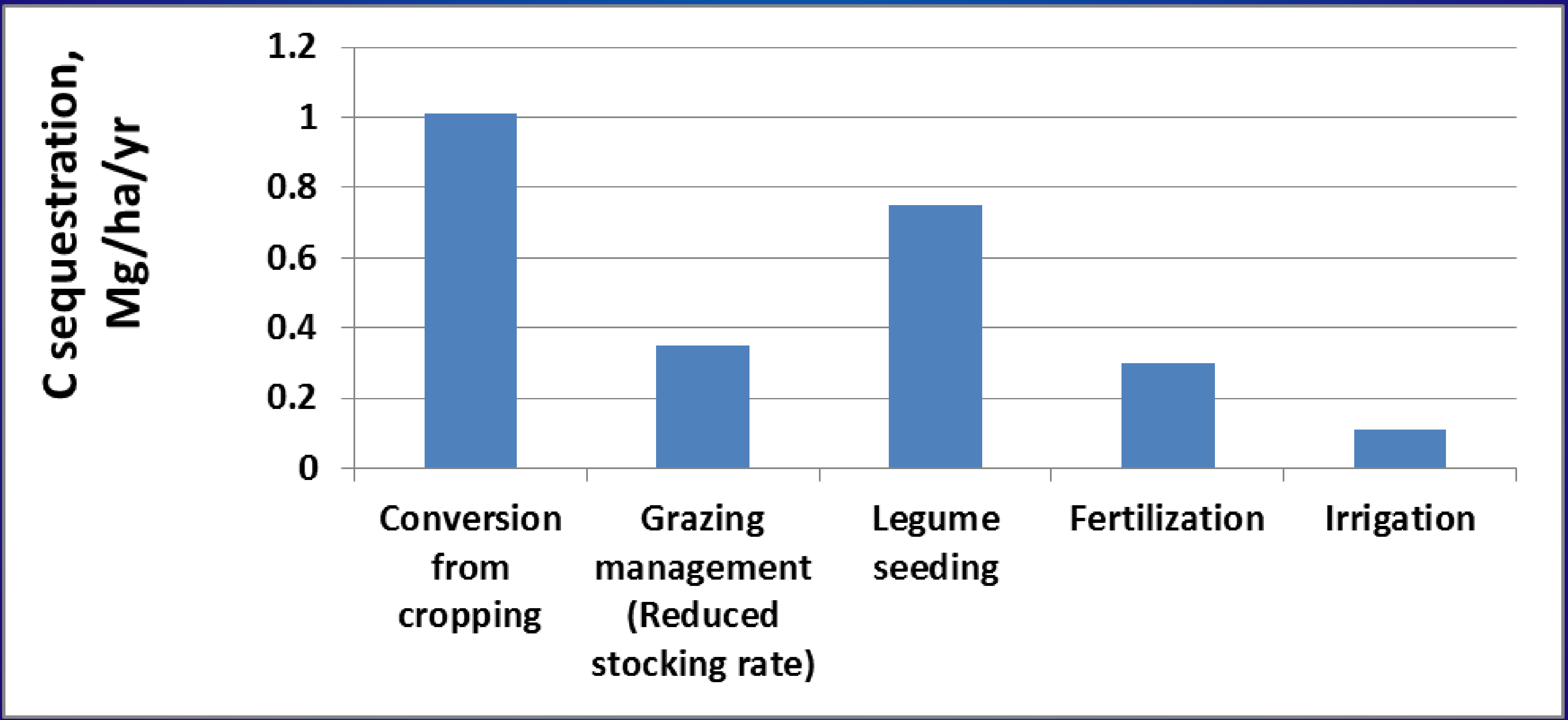
(Six et al., 2002)

EFFECTS OF GRAZING ON SOIL ORGANIC CARBON COMPARED TO UNGRAZED GRASSLANDS



Adapted from (Piñeiro et al., 2010)

META-ANALYSIS OF C SEQUESTRATION RESULTING FROM GRASSLAND MANAGEMENT IMPROVEMENTS IN 115 STUDIES FROM 17 COUNTRIES

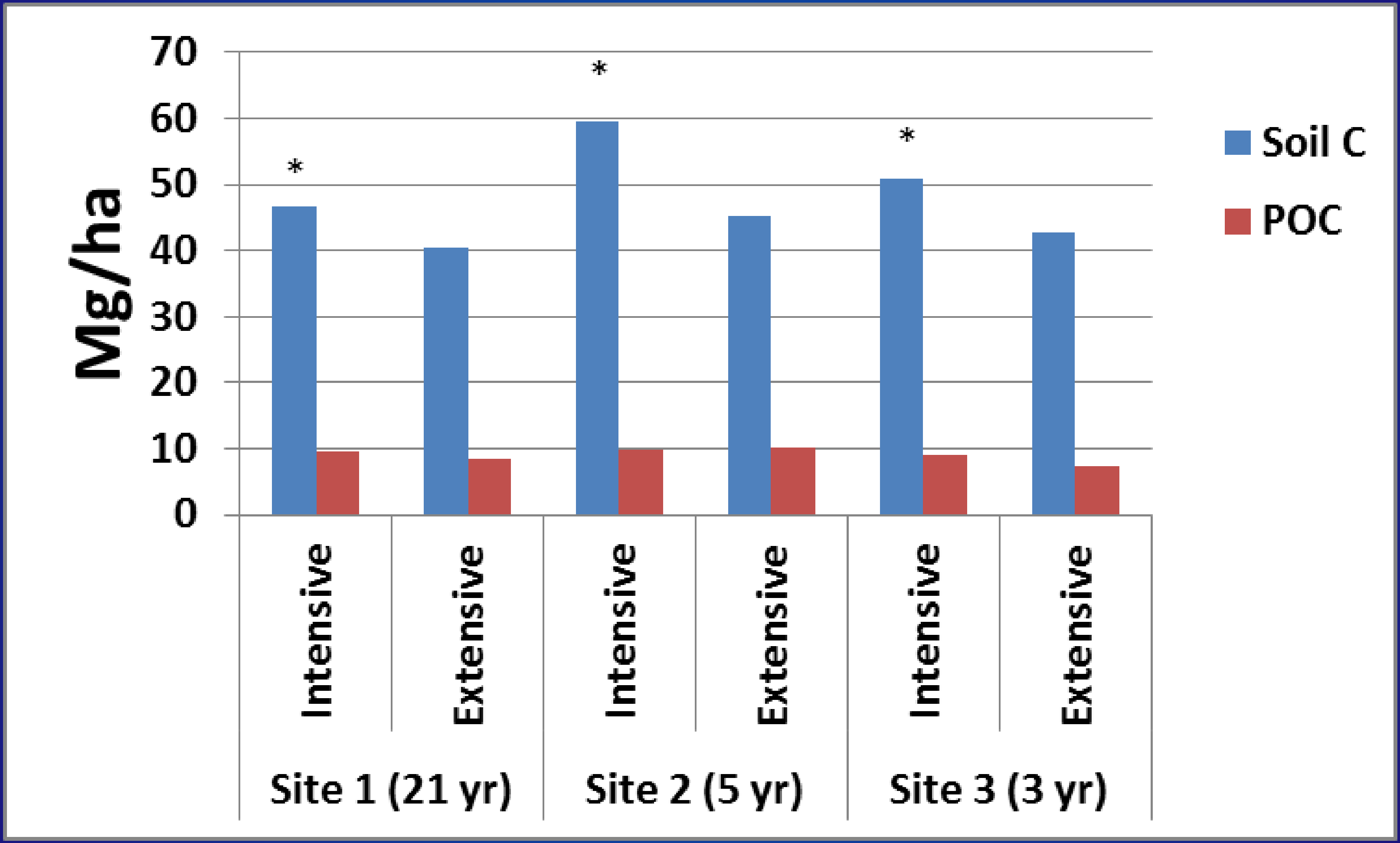


(Conant et al., 2001)

FACTORS AFFECTING RESPONSES OF SOIL CARBON TO MANAGEMENT IN GRASSLANDS

- Soil depth
- Duration of treatments
- Climate
- Soil
- Landscape position
- Plant community

SOIL C AND PARTICULATE ORGANIC MATTER C FROM COOL SEASON GRASS-LEGUME PASTURES GRAZED BY MANAGEMENT INTENSIVE OR EXTENSIVE GRAZING

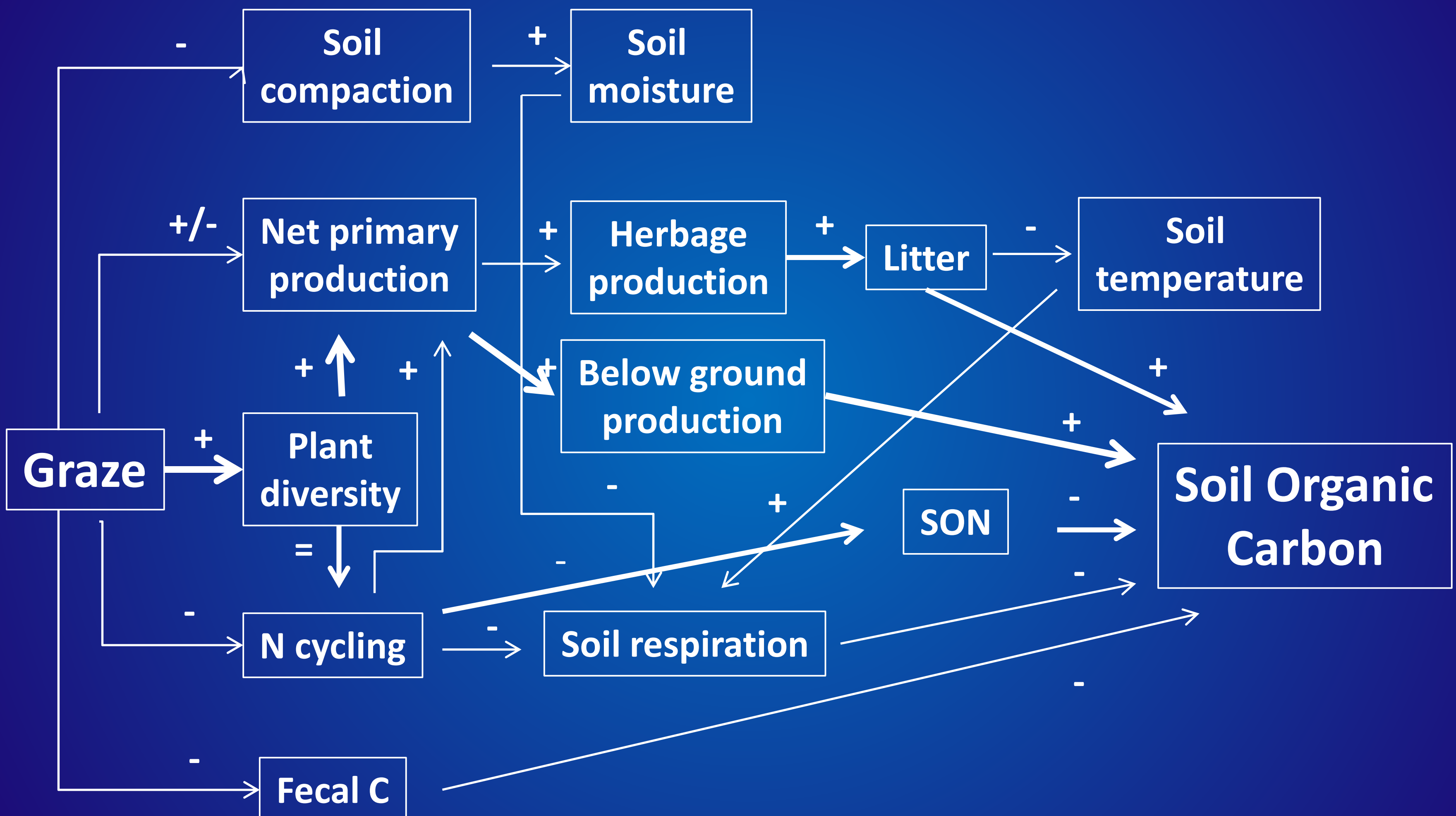


- Difference between systems at site was significant., P < 0.05.
- Intensive=short rotational grazing
- Extensive=extensively grazed or harvested as hay

(Conant et al., 2003)

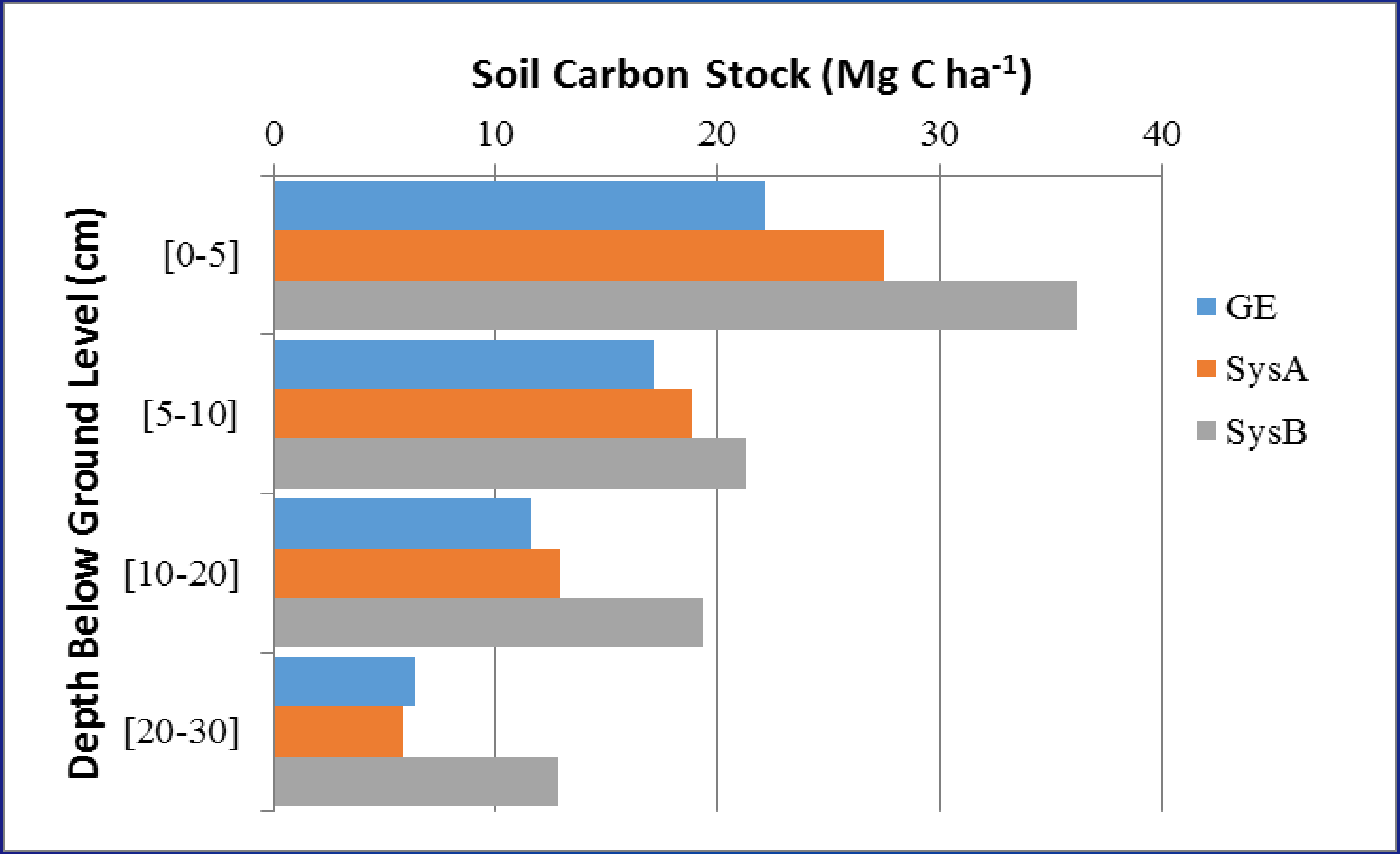
WILL HIGH DENSITY GRAZING INCREASE SOIL ORGANIC MATTER IN THE EASTERN U.S.?

EFFECTS OF MOB GRAZING ON SOIL ORGANIC CARBON IN COMPARISON TO EXTENSIVE GRAZING



Key management: Long rest periods

EFFECTS OF GRAZING MANAGEMENT ON SOIL CARBON CONTENT AT DIFFERENT DEPTHS OVER 3 YEARS



GE = Grazing exclusion

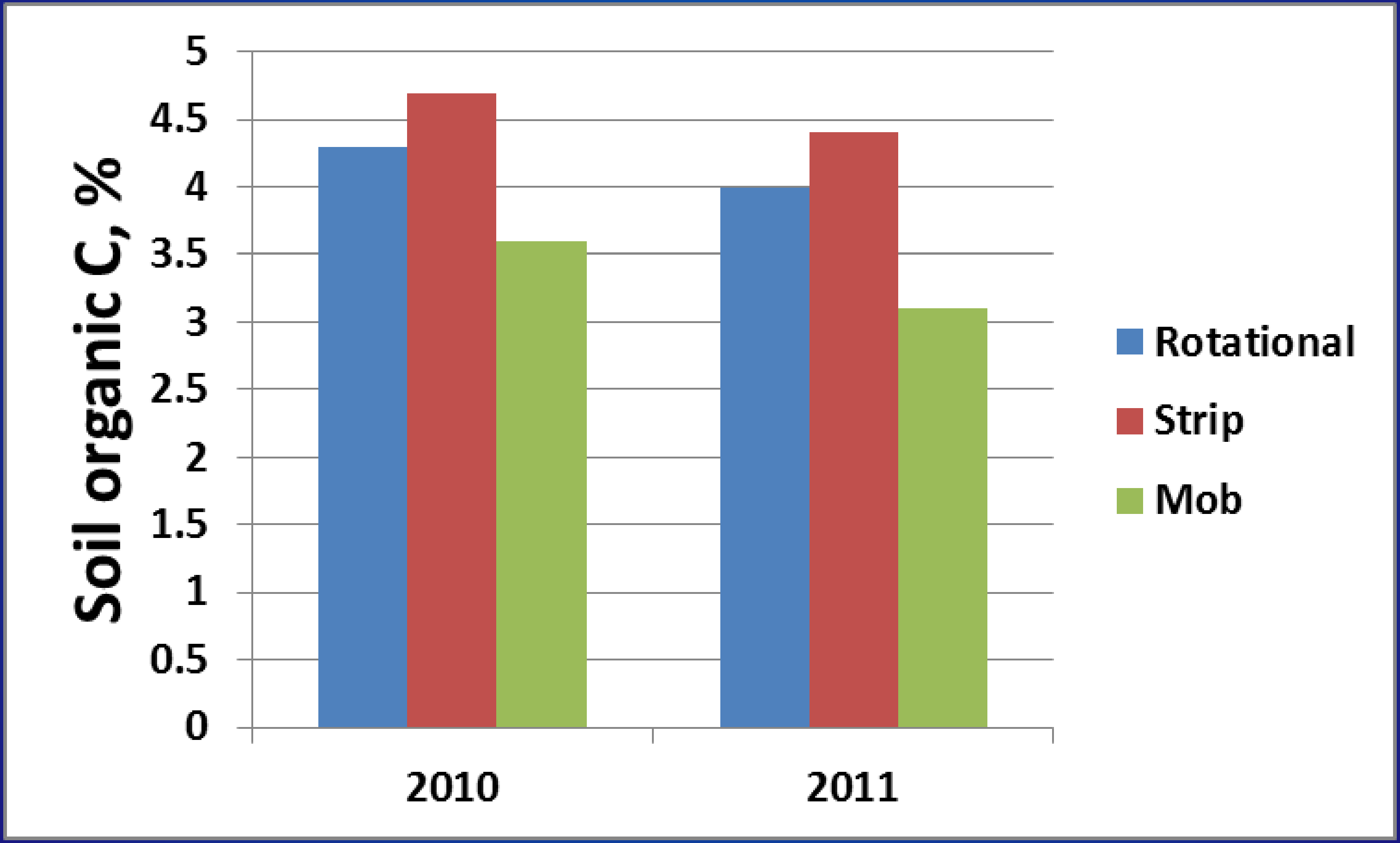
SysA = Low stocking rate (1 cow/ha)-High stocking density (100,000 kg BW/ha)

SysB = High stocking rate (2.5 cow/ha) – Low stocking density (28,000 kg BW/ha)

SysB fertilized with 60 lb N/ac in yr 1 and irrigated each year

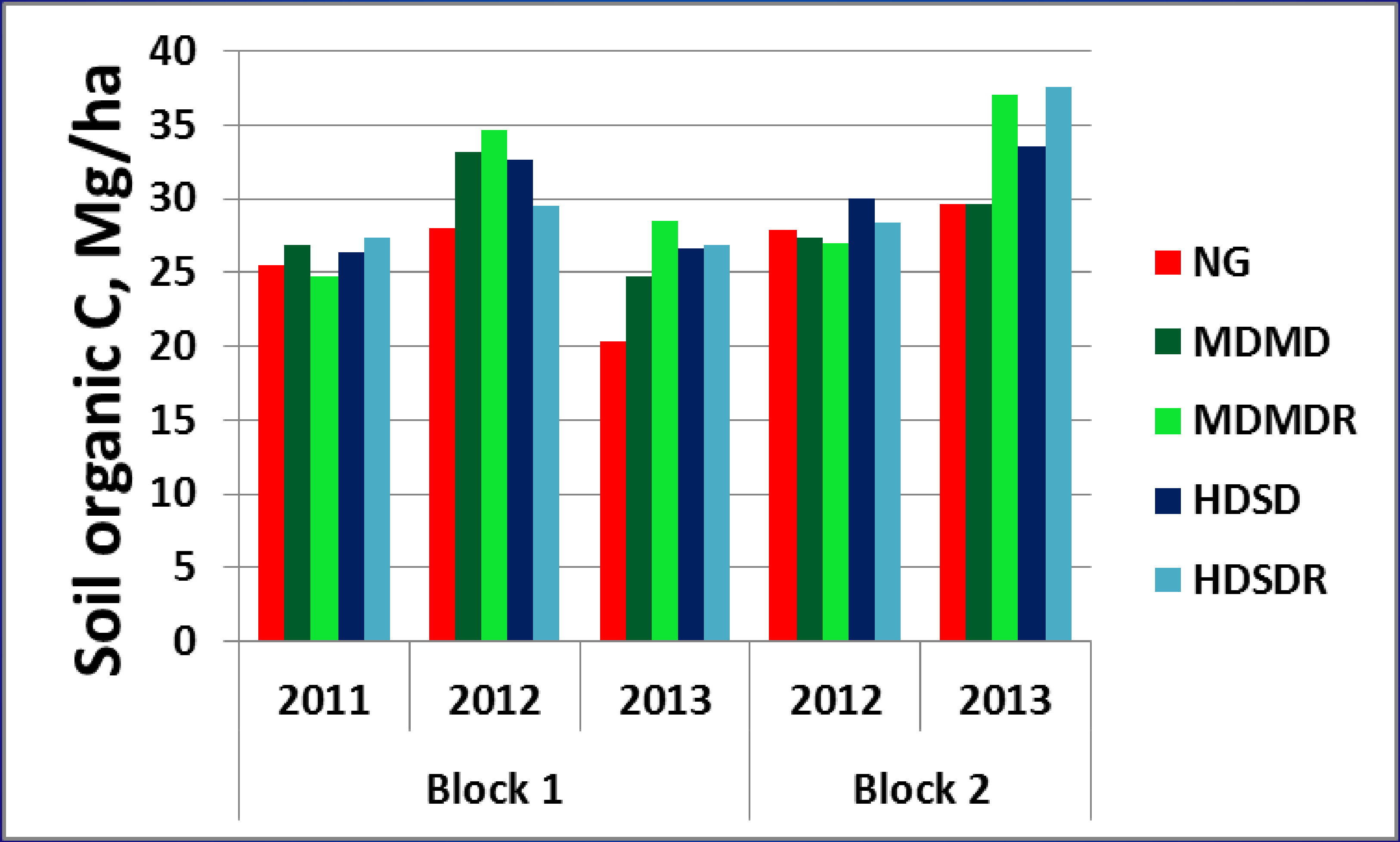
(Chiavegato, 2014)

EFFECTS OF SEASON-LONG STOCKING SYSTEM ON SOIL ORGANIC CARBON TO 7.5 CM DEPTH OVER 2 YEARS IN CENTRAL IOWA



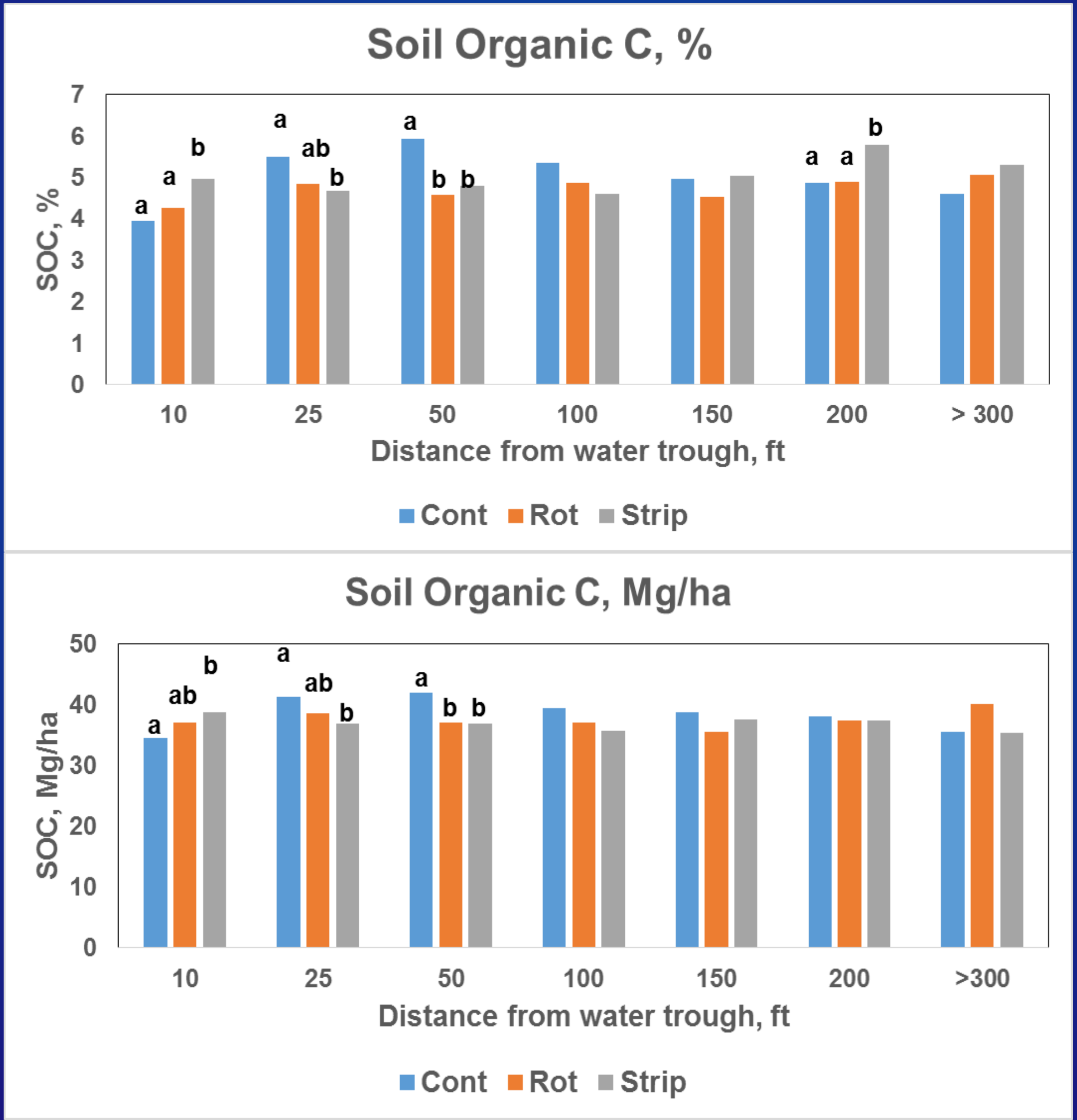
(Dunn, 2012)

EFFECTS OF A SINGLE SPRING GRAZING EVENT AT DIFFERENT DENSITIES WITH OR WITHOUT SUBSEQUENT ROTATIONAL STOCKING ON SOIL CARBON CONTENT TO 7.5 CM DEPTH



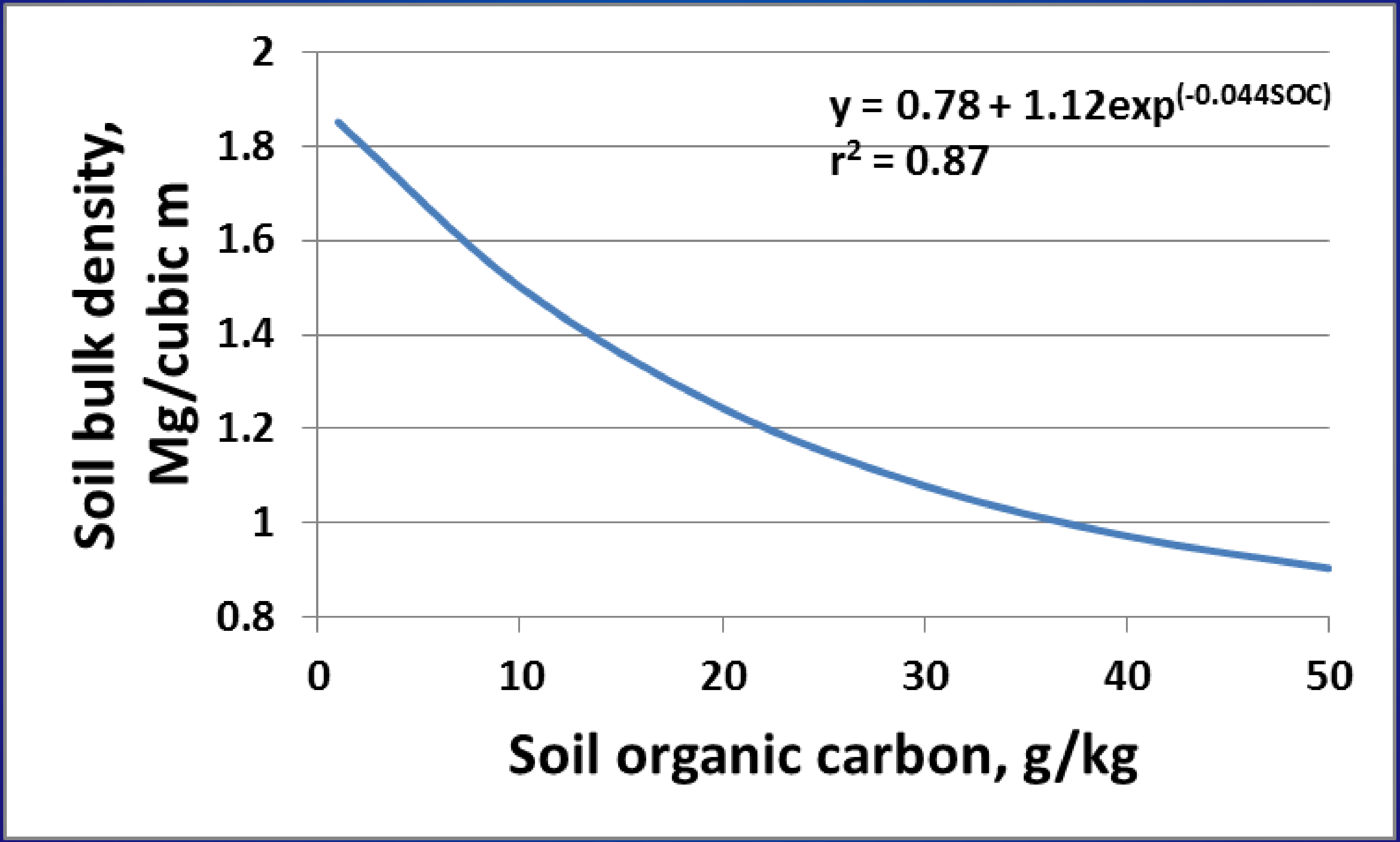
MDMD grazed once at 132,000 lb/acre with movement 1 time/day (Bisinger, 2014)
HDSD grazed once at 471,000 lb/acre with movement 4 times/day

EFFECTS OF STOCKING SYSTEM ON SOIL ORGANIC CARBON AT DIFFERENT DISTANCES FROM THE WATER TROUGH OVER 3 YEARS



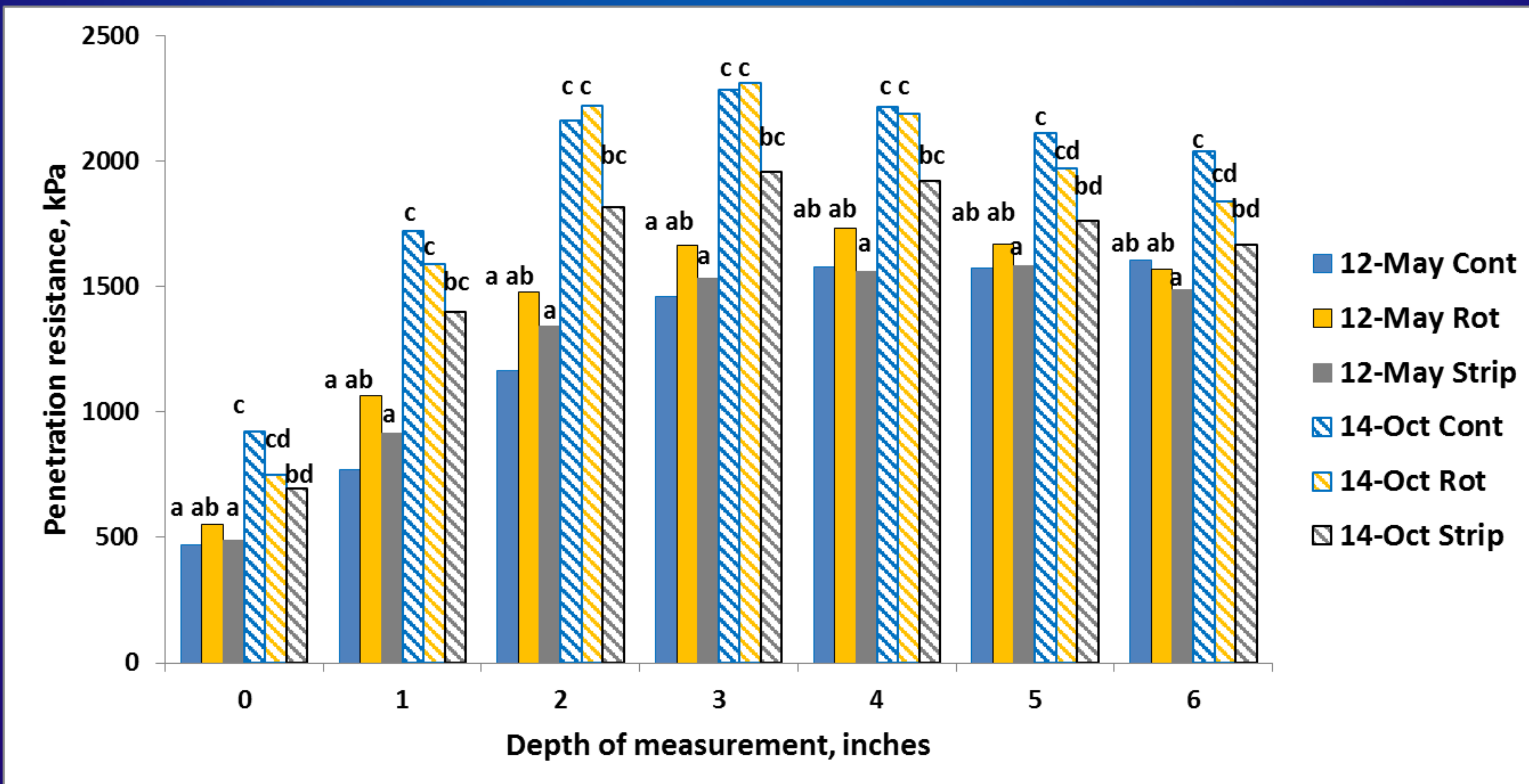
CAN GRAZING MANAGEMENT AFFECT SOIL PHYSICAL PROPERTIES?

RELATIONSHIP OF SOIL BULK DENSITY AND SOIL ORGANIC CARBON BETWEEN LAND USED FOR CROPLAND AND LAND IN TALL FESCUE PASTURE FOR 20 YEARS

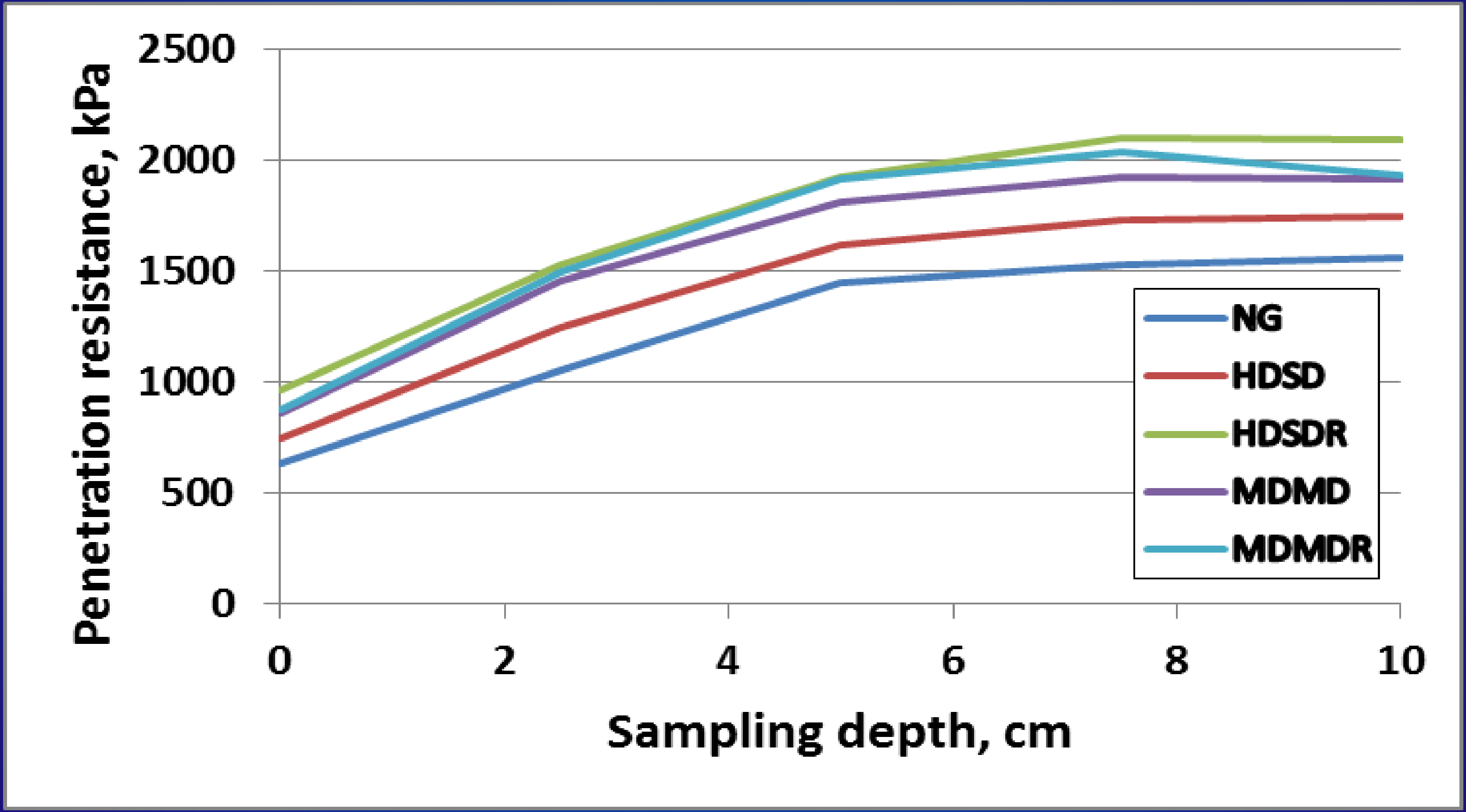


(Franzluebbers et al., 2000b)

EFFECTS OF GRAZING MANAGEMENT ON SOIL PENETRATION RESISTANCE AT DIFFERENT DEPTHS FROM 10 TO 300 FEET FROM WATER SOURCE



EFFECTS OF A SINGLE SPRING GRAZING EVENT AT DIFFERENT DENSITIES WITH OR WITHOUT SUBSEQUENT ROTATIONAL STOCKING ON SOIL PENETRATION RESISTANCE TO 10 CM DEPTH



(Bisinger, 2014)

EFFECTS OF GRAZING MANAGEMENT ON WATER QUALITY OF PASTURE STREAMS

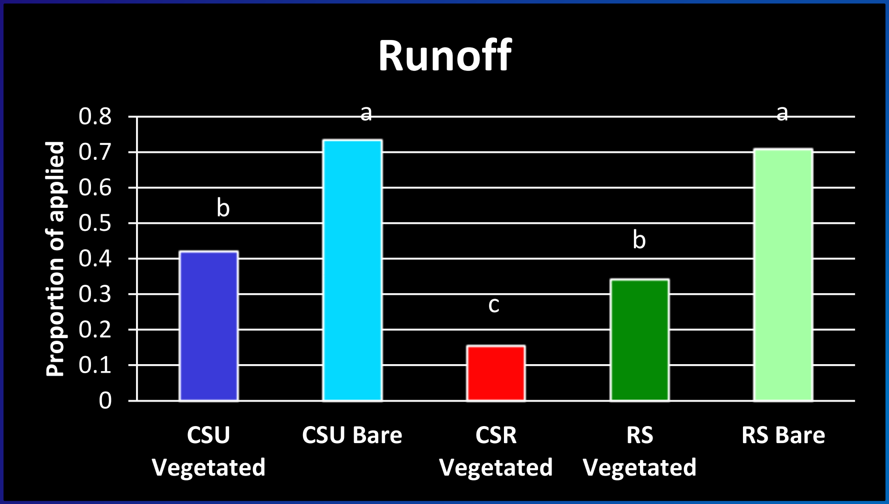
EFFECTS OF GRAZING MANAGEMENT ON SOIL AND FORAGE CHARACTERISTICS AND PRECIPITATION RUNOFF FROM HILLS OVER 3 YEARS*

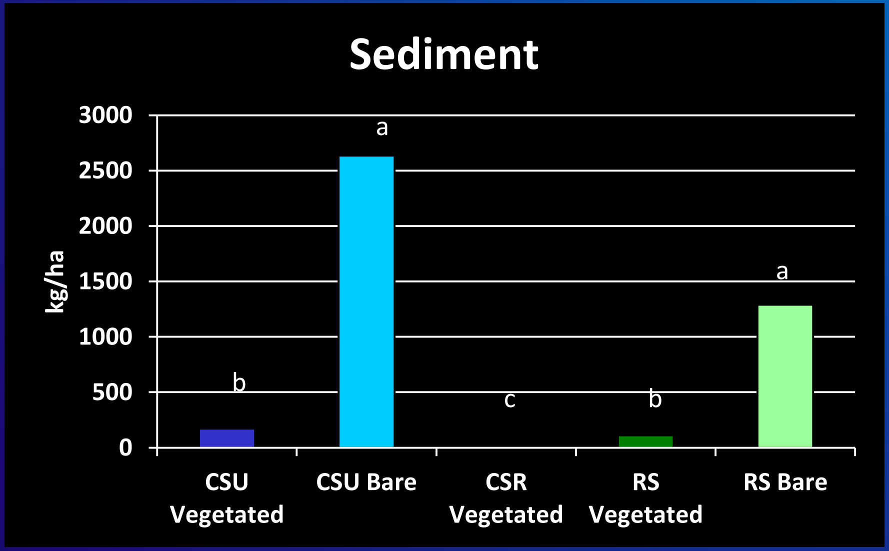
	Treatment				
			Rotational stocking		Continuous stocking
	Nongrazed	Hay-stockpile	4 in. residual	2 in. residual	2 in. residual
Soil					
Penetration resistance, kPa					
3.5 cm	1199[a]	1528[b]	1811[c]	1963[c]	1872[c]
10.5 cm	2101[a]	2590[b]	2697[b]	2598[b]	2781[b]
Forage					
Mass, kg/ha	4315[a]	1512[b]	2132[c]	1502[b]	1114[d]
Ground cover, %	99.2[a]	95.7[ab]	94.7[ab]	91.9[bc]	87.7[c]
Runoff, % rainfall	6.4[a]	16.4[bc]	12.7[ab]	20.7[c]	21.9[c]

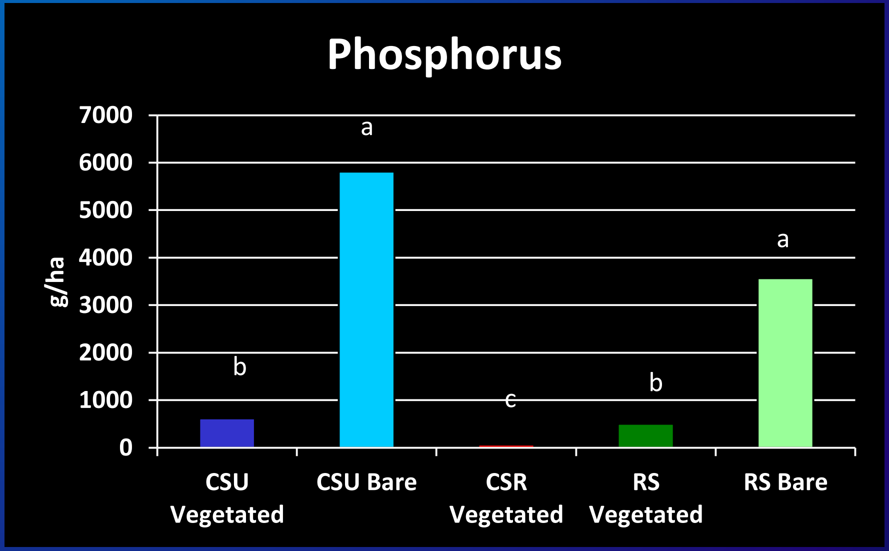
*April through October

(Haan et al., 2006)

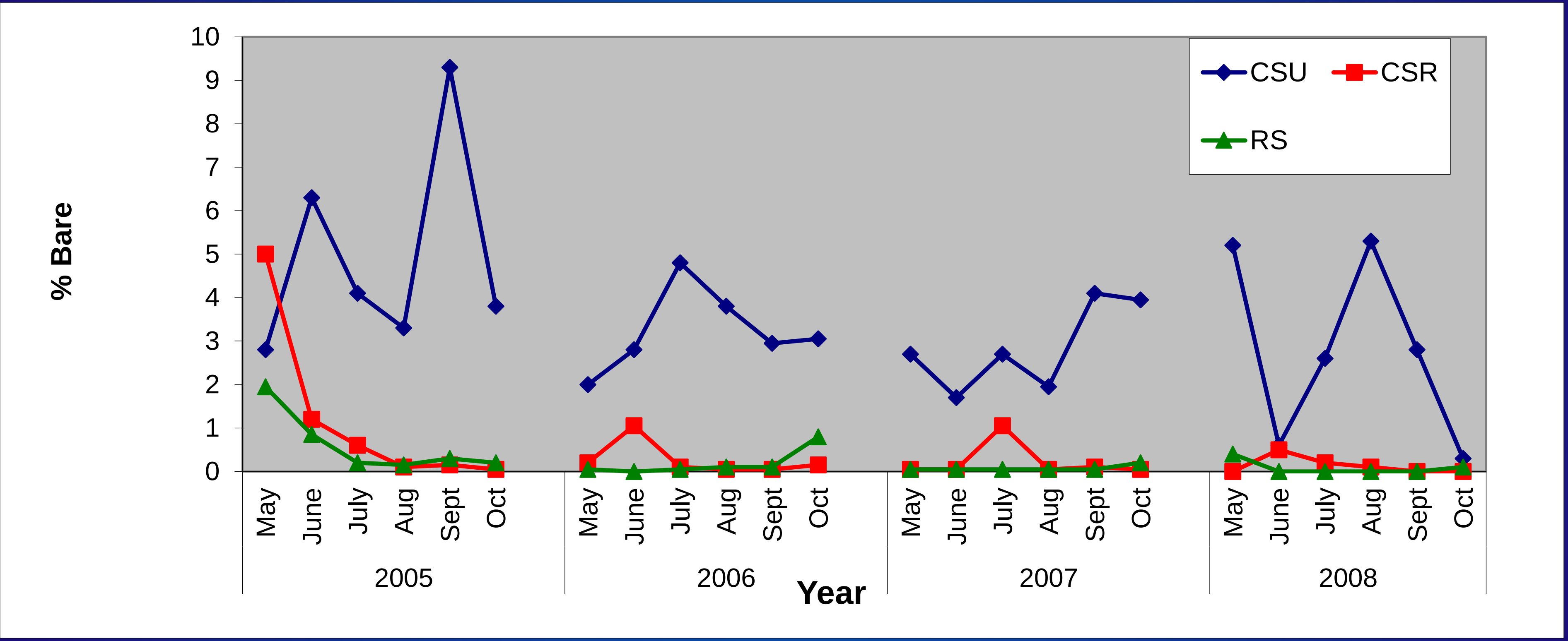
GRAZING SYSTEM EFFECTS ON PROPORTIONS OF APPLIED PRECIPITATION AND AMOUNTS OF SEDIMENT AND P TRANSPORTED IN RUNOFF FROM SIMULATED RAIN APPLIED TO BARE AND VEGETATED SITES ON STREAMBANKS AT 3 inches/hr (P < 0.10)







GRAZING SYSTEM EFFECTS ON PROPORTIONS OF BARE GROUND WITHIN 15 TO 110 FT OF PASTURE STREAMS



CSU = Continuous stocking unrestricted
CSR = Continuous stocking restricted
RS = Rotational stocking

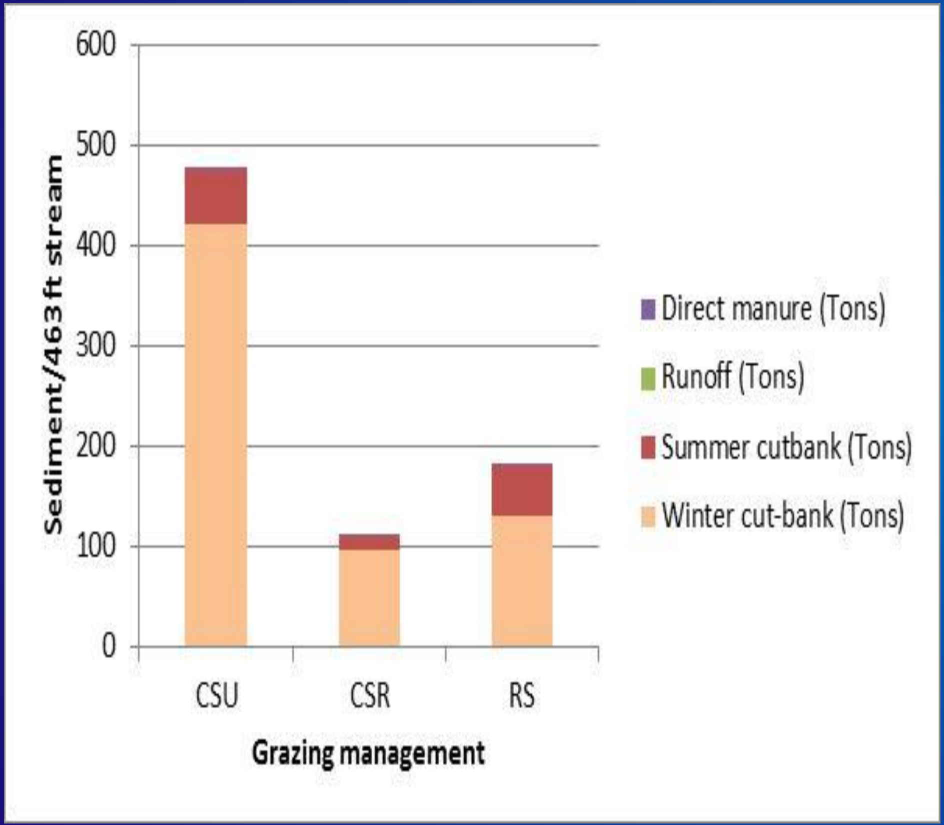
HYPOTHETICAL ROUTES OF NONPOINT SOURCE POLLUTION BY GRAZING CATTLE

Direct manure deposition

Cut bank erosion

Surface run-off

CONTRIBUTIONS OF PRECIPITATION RUNOFF, DIRECT FECAL DEPOSITION, AND CUT BANK EROSION TO ANNUAL SEDIMENT LOADING OF PASTURE STREAMS



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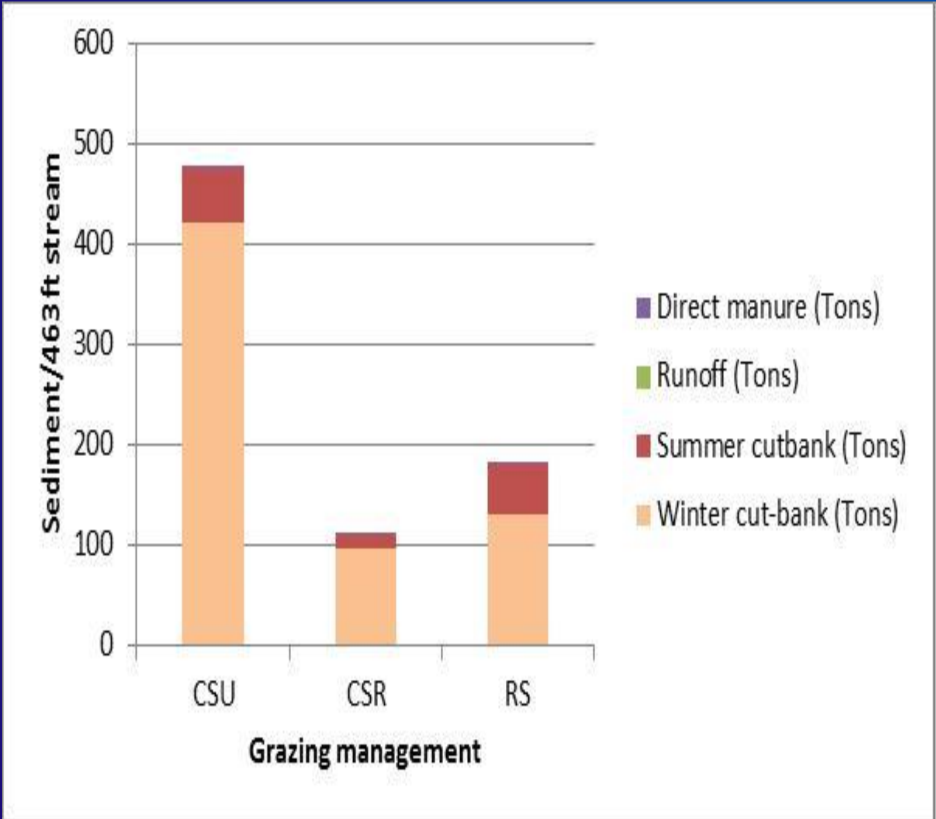
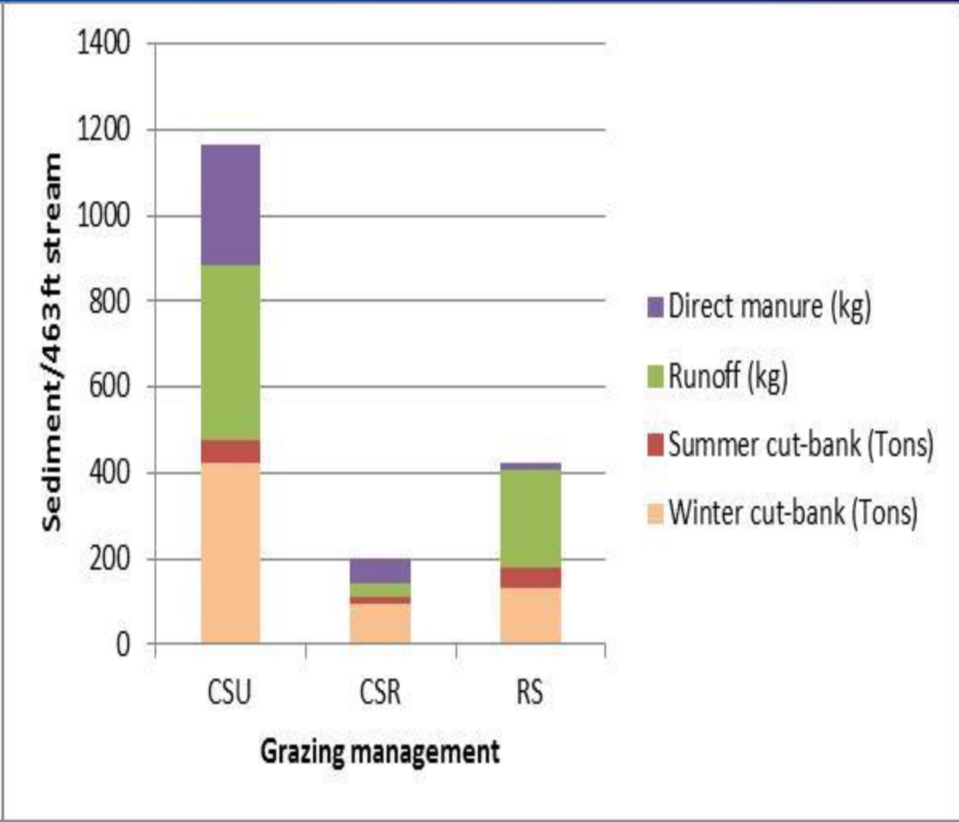
CONTRIBUTIONS OF PRECIPITATION RUNOFF, DIRECT FECAL DEPOSITION, AND CUT BANK EROSION TO ANNUAL SEDIMENT LOADING OF PASTURE STREAMS





CSU = Continuous stocking unrestricted

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RS = Rotational stocking

Can grazing management enhance:

- Plant communities?
  - Yes
  - But the response will depend on landscape position, soil fertility, and climate
- Soil OM?
  - Yes
  - If grazing management is defined as reduced stocking rate, legume incorporation, fertilization, or irrigation on soils that are not C-saturated
- Soil physical properties?
  - Yes
  - By reducing length of grazing periods and extending length of rest periods
- Water quality in streams?
  - Yes
  - If the residual forage height is managed to maintain a minimum of 4 inches near pasture streams

CAN YOU HAVE IT ALL?

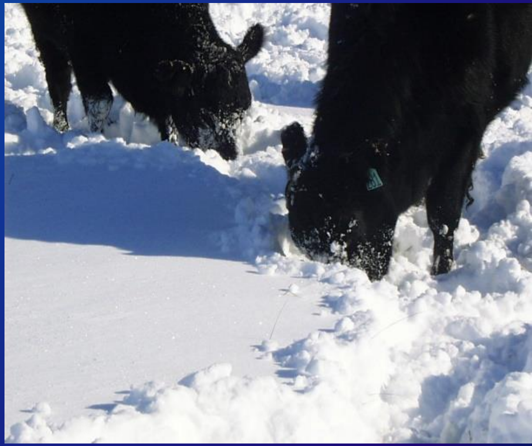
Positive	Management	Negative
Increase biodiversity	Mob-graze	Decrease stocking rate
Improved wildlife habitat	Mob-graze	Increase bare ground
Increase soil OM	N fertilization	Decrease biodiversity Increase N_2O emission
Reduce methane emissions	Strip-grazing (Limited forage intake)	Decrease cow body weights and condition
Reduce winter hay feeding	Fall forage stockpiling	Decrease animal production/acre

BOTTOM LINE

- **Grasslands provide many more services than row crop production**
- **Implementation of pasture and grazing management strategies can enhance both livestock production and environmental services**
  - **Dependent on numerous management and environmental factors**
  - **Optimal conditions differ**
- **The first step in utilizing grazing management to enhance environmental services is to prioritize the desired results**

As the world's attention focuses on the need for a safe, economical, and adequate food supply for a growing global population, there must be equal concern for the sustainability of that food production and the protection of our natural resources and environment. The grazing animal will likely play a key role in achieving these objectives and contributing to resilience of these ecosystems.

-Viven Allen, 06



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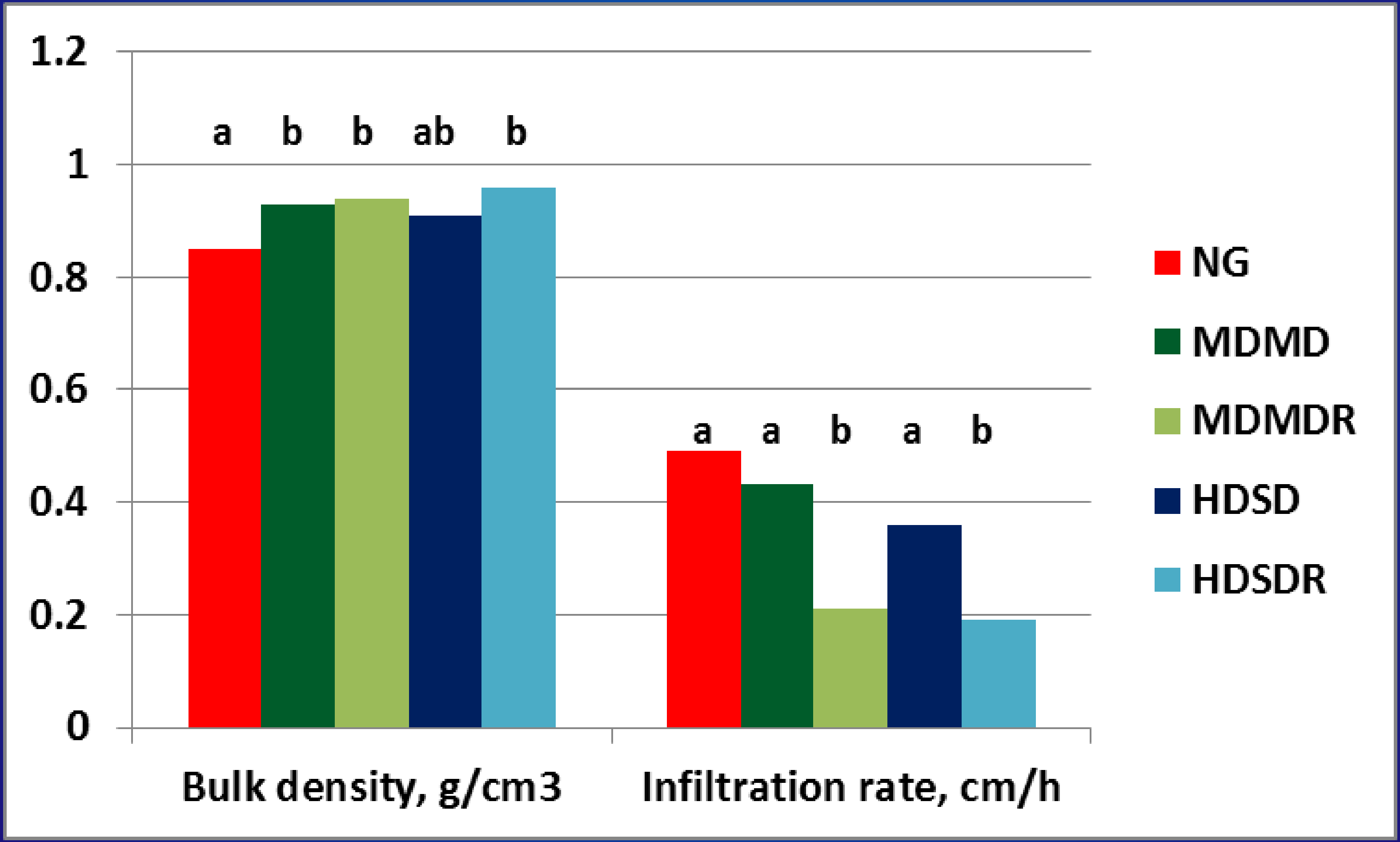
  - The Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Award No. 2006-51130-03700
  - The Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Award No. 2007-35102-18115
  - The Leopold Center for Sustainable Agriculture
  - Iowa Beef Center
  - Rathbun Land and Water Alliance

EFFECTS OF A SINGLE SPRING GRAZING EVENT AT DIFFERENT DENSITIES WITH OR WITHOUT SUBSEQUENT ROTATIONAL STOCKING ON SOIL BULK DENSITY TO 7.5 CM AND WATER INFILTRATION RATE OVER 3 YEARS



(Bisinger, 2014)