The Grazing Implementation Index: Quantitatively Integrating Management Factors That Influence Grazing Intensity Across Spatiotemporal Scales

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GRAZING INTENSITY

- Defined as cumulative effects of grazing animals on rangelands or pastures during a given time-period
- Alternative management practices differ in approaches used to regulate grazing intensity to avoid overgrazing
- The primary focus has been on stocking rate OR stocking rate + distribution of livestock across the landscape
- Percent forage utilization is used as a proxy for grazing intensity and is operationalized by adjusting stocking rate
- ***Complexity of grazing management strategies has rendered percent forage utilization as the sole measure of grazing intensity insufficient***

METHOD FOR DEVELOPING A NOVEL INDEX

- Literature review to identify indicators of grazing intensity
- Developed two novel indicators to address gaps in traditional indicators
  - *Effective Stocking Rate / Stocking Rate (ESR/SR) – Stock days per unit land area currently being grazed relative to the overall stocking rate*
  - *Effective Resting Rate / Effective Stocking Rate (ERR/ESR) – Rest days per stock day that each paddock receives per grazing cycle*
- Surveyed 870 producers in ND, SD, TX (47% response rate)
- Calculated grazing intensity metrics
- Derived a weighted geometric mean to aggregate indicators into the GII

INDICATORS

Indicator	Abbreviation	Definition
Grazing Event Length	GEL	Number of days that animals spend grazing in one paddock before being moved to the next
Rest Period Length	RPL	Number of days each paddock is allowed to rest before being re-grazed
Re-grazing Frequency	RGF	Number of grazing events that occur per paddock per year
Paddock:Herd Ratio	PHR	Proportion of land area that is resting at any given time
Stock Density	SD	Number of animal units per unit land area currently being grazed
Stocking Rate/Carrying Capacity	SR/CC	Forage demand to forage supply ratio. CC calculated based on 25% harvest efficiency.
Effective Stocking Rate/ Stocking Rate	**ESR/SR**	**Stock days per unit land area currently being grazed relative to the overall stocking rate**
Effective Resting Rate/Effective Stocking Rate	**ERR/ESR**	**Number of rest days per stock day that each paddock receives per grazing cycle**

RESULTS OF FACTOR ANALYSIS (PCA WITH VARIMAX ROTATION)

The eight grazing intensity indicators resulted in three factors that explain 89.1% of the variance in grazing systems

- Factor 1 ***Rest Effect***: includes PHR, RPL, and ***ERR/ESR***
- Factor 2 ***Grazing Effect***: includes GEL, RGF, and ***ESR/SR***
- Factor 3 ***Animal/Land association***: includes SR/CC and SD
- Factor weight = normalized sum of squared loadings

Factor	Eigenvalue	% of Variance	Cumulative %
1	2.900	36.2	36.2
2	2.413	30.2	66.4
3	1.813	22.7	89.1

Indicator	Factor 1 Rest Effect		Factor 2 Grazing Effect		Factor 3 Animal/Land	
	Loading	Weight	Loading	Weight	Loading	Weight
PHR	0.950	0.311	0.091	0.003	-0.174	0.017
ERR/ESR	0.906	0.283	0.151	0.010	-0.004	0.000
RPL	0.763	0.201	-0.550	0.125	0.038	0.001
GEL	0.597	0.123	0.697	0.201	-0.287	0.045
RGF	0.113	0.004	-0.931	0.359	0.164	0.015
ESR/SR	0.125	0.005	0.849	0.299	0.164	0.015
SR/CC	0.122	0.005	-0.006	0.000	0.952	0.500
SD	-0.441	0.067	-0.075	0.002	0.860	0.408
Factor weight	0.407		0.339		0.254	

- Indicators were ***aggregated into factors*** using first equation: iw = weight associated with each indicator
- Factors were ***aggregated into the GII*** using second equation: fw + weight associated with each factor

$$Factor_x = \left(Indicator_1^{iw1}\right) \cdot \left(Indicator_2^{iw2}\right) \ldots \left(Indicator_j^{iwj}\right)$$

$$GII = \left(Factor_1^{fw1}\right) \cdot \left(Factor_2^{fw2}\right) \ldots \left(Factor_j^{fwj}\right)$$

RESULTS OF CLUSTER ANALYSIS

Mean values of individual grazing indicators, Rest Effect, Grazing Effect, Animal/Land Association Effect, and the GII, and number of cases in each cluster.

Indicator/Factor	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Paddock : Herd Ratio	150.00	10.73	3.19	2.01	25.00
Rest Period Length	149.00	158.74	94.56	98.30	72.00
ERR/ESR	0.37	0.12	0.02	0.01	0.03
Grazing Event Length	1.00	22.81	64.14	174.36	3.00
Re-grazing Frequency	2.43	2.95	3.69	1.78	2.40
ESR/SR	0.77	0.57	0.65	3.04	1.63
Stock Density	30.00	5.67	1.18	2.17	280.00
Stock Rate : Carrying Capacity	4.95	8.17	5.84	18.72	134.05
Rest Effect	*1.76*	*3.33*	*3.54*	*3.56*	*3.39*
Grazing Effect	*1.10*	*1.14*	*1.22*	*1.49*	*1.16*
Animal/Land	*1.23*	*1.14*	*1.08*	*1.23*	*4.31*
GII	**1.37**	**1.75**	**1.82**	**2.00**	**2.51**
N	1	63	138	33	1

Cluster 1: **high intensity rotational**;
150 paddocks; 1 day/paddock

Cluster 2: **moderate intensity rotational**;
~10 paddocks/herd; few weeks/paddock

Cluster 3: **low intensive rotational**;
3 paddocks/herd; ~2 months/paddock

Cluster 4: **season long continuous grazing**

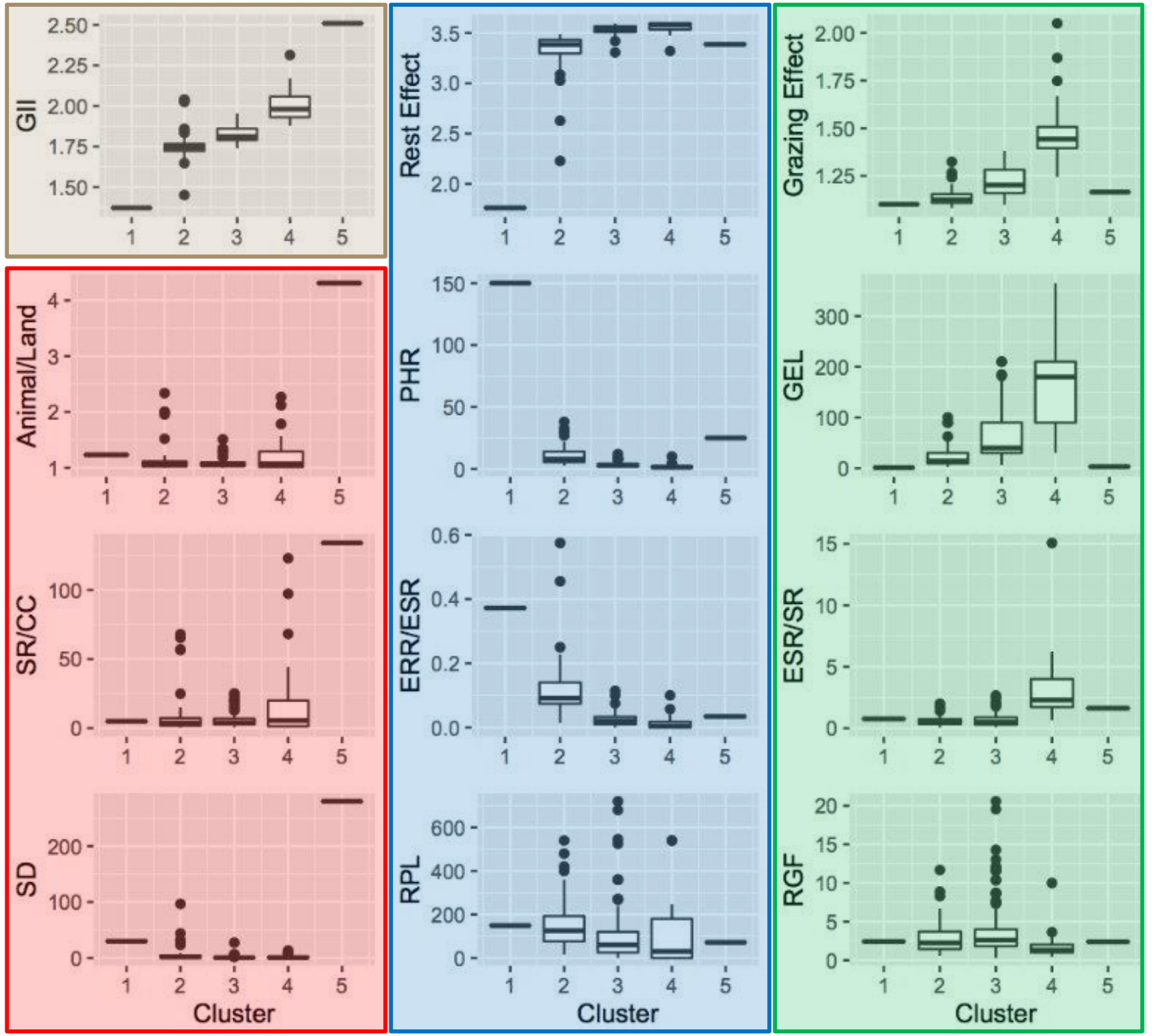
Cluster 5: **moderate intensity rotation**;
highest GII largely due to extremely high SR:CC ratio, and SD

BOX PLOTS

Boxplots for each grazing system cluster:

- Rest factor
- Grazing factor
- Animal/land association factor

- Each cluster has relatively distinct GII
- Considering GII holistically leads to different overall descriptions for grazing systems than individual indicators
- C1 vs C5: similar values for several indicators, but combination of all indicators produces starkly different GII
- Some clusters: wide range of values for individual indicators (e.g., C4 - grazing event; C3 - rest period), but combo of indicators produces similar GII



CONCLUSION

- Our results indicate the inadequacy of current broad definitions of various grazing strategies (e.g., rotational grazing) and point to the need to identify the combined effects of multiple management factors on ecological and economic outcomes
- Rather than comparing systems based on ill-defined grazing methods or grazing intensity based solely on forage utilization, studies should differentiate systems based on the GII to more comprehensively capture the management being applied
- The multi-dimensional GII metric provides a more comprehensive and objective measure for distinguishing grazing management practices than individual grazing indicators
- Evaluating changes in individual indicators over time may facilitate the identification of threshold values for overall grazing intensity and provide data for adapting to changing ecological or economic conditions

ABSTRACT

The debate about the ecological efficacy of alternative grazing management approaches has persisted since the 1950s. A primary reason for the disagreements is the inadequacy of parameters used to differentiate grazing impacts and the lack of a rigorous approach for quantifying grazing intensity. While this applies primarily to livestock production, the question of grazing intensity effects on the herbaceous layer is also relevant for wildlife management. This paper presents a composite index to serve as a standardized approach for more accurately quantifying grazing intensity. The Grazing Intensity Index (GII) is comprised of six traditional indicators and two novel indicators of grazing intensity that comprehensively account for the complex management parameters involved in grazing systems. Using data from a survey of 870 ranchers in North and South Dakota and in Texas, we applied a principal components analysis to converge the eight grazing intensity indicators into three factors that describe the effects of rest (*Paddock/Herd Ratio, Effective Resting Rate/Effective Stocking Rate, Rest Period Length*), grazing (*Grazing Event Length, Re-grazing Frequency, Effective Stocking Rate/Stocking Rate*), and the animal/land relationship (*Stocking Rate/Carrying Capacity, Stock Density*). The rest factor explained 36% of the variation across grazing systems, the grazing effect factor explained 30%, and animal/land relationship factor explained 23%. Application of the GII to previous grazing studies showed less disparity among systems where no ecological differences were reported than studies where significant ecological differences were found between grazing management practices. Importantly, these findings did not neatly align with traditionally defined continuous and rotational grazing systems.