Grazing Studies: What We've Learned

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During our careers in range management we've encountered few range professionals who have actually read any of the long-term stocking rate and grazing system studies that provide the scientific foundation for modern range management. Part of the problem is that many of these studies were published as United States Department of Agriculture reports or university experiment station bulletins that are buried in libraries or government archives. Generally they are lengthy, detailed documents that do not lend themselves to easy reading. However in our opinion knowledge of these studies is essential to anyone engaged in range management, ranching or range research. We believe less controversy would exist over approaches to grazing management, range condition, and range trend if teachers, scientists, and mangers had a more thorough understanding of the "classics."

Our objective is to identify these "classic" studies and provide a brief synopsis of their findings. We will focus on forage production, range condition, range trend, livestock production, and financial returns. Rather than attempting to discuss all the studies, we will concentrate on those involving native (non-seeded) rangelands that are most complete in terms of replication in time and space, collection of biological and financial data, and interpretation of results. A previous analysis of grazing studies is provided by Van Pollen and Lacey (1979). However their review focused only on herbage responses and much new information has become available over the past 20 years.

Description by Grazing Region

More scientific information is available on grazing management from the Great Plains and western coniferous forest types than from arid rangelands (Table 1). It is remarkable that although the sagebrush grassland is one of the largest range types, there have been no long term, replicated stocking rate studies with cattle in this type. Season of grazing use studies involving sheep are available from eastern Idaho (Laycock 1970). Frischknecht and Harris (1968) reported a thorough study of crested wheatgrass response to cattle grazing intensities and systems in Utah. It is also noteworthy that more information exists for cattle than for sheep. Stocking rates have been better evaluated than rotation grazing systems. Several scientific reports on specific aspects of the studies listed in Table 1 can be found in the *Journal of Range Management.*

Grazing Intensity: What is Moderate Stocking?

Nearly all stocking rate studies characterize grazing intensity treatments as heavy, moderate and light. However we have found in talking with students, range professionals and ranchers that considerable confusion exists over what these terms mean. The best explanation we've found was provided by Klipple and Bement (1961). They define heavy grazing as a degree of herbage utilization that does not permit desirable forage species to maintain themselves. Moderate grazing means a degree of herbage utilization that allows the palatable species to maintain themselves but usually does not permit them to improve in herbage producing ability. Light grazing means a degree of herbage utilization that allows palatable species to maximize their herbage producing ability.

The primary measure of grazing intensity used in long term grazing studies has been percent use of palatable forage species. Although it has limitations as a measure of grazing intensity, percent use is more easily understood by ranchers and non-range professionals than other measurements such as stubble heights, percentage of grazed plants, or minimum residues (Jasmer and Holechek 1984). When several years of data were collected, percent use of forage has been well related to changes in productivity of primary forage plants, livestock performance, and financial returns.

When all the stocking rate studies were averaged, heavy grazing averaged 57% use of primary forage species compared to 43% use for moderate and 32% use for light grazing (Table 2). Conventional wisdom has been that moderate stocking involves 50% use of forage. This guideline applies well in the southern pine forest, humid grasslands, and annual grasslands, but results in rangeland deterioration in the semi-arid grasslands, desert and coniferous forest rangelands. Here research was remarkably consistent in showing that moderate grazing involved about 35–45% use of forage (Johnson 1953, Klipple and Costello 1960, Beetle et at. 1961, Paulsen and Ares 1962, Houston and Woodward 1966, Launchbaugh 1967, Martin and Cable 1974, Skovlin et al. 1976, Sims et al. 1976).

Conservative stocking is a term commonly used by range researchers to define a level of grazing between light and moderate, generally involving about 35% use of forage. Several researchers recommended conservative stocking over either light or moderate stocking in their summaries.

Forage Production and Stocking Rate

Forage production across studies averaged 23% higher under moderate than heavy grazing and 36% higher under light than heavy grazing (Table 2). This analysis, however, is a bit misleading because in some studies the lightly stocked pastures were initially in lower or higher ecological condition that those heavily and/or moderately stocked. When changes in forage production through time were taken into account by averaging the first and last three

Table 1. Primary long term grazing management studies from various native rangeland types in North America.

Rangeland Type	Location	Annual Precipitation	Type of Animal Studied	Duration of Study	Primary References	Treatments Studied
		(Inches)		(Years)		
Southern Pine Forest	Georgia	48	cattle	4	Halls et al. 1956	Stocking rates
	Louisiana	58	cattle	10	Pearson & Whitaker 1974	Stocking rates
Tall Grass Prairie	Kansas	38	cattle	7	Herbel & Anderson 1959	Stocking rates & grazing systems
	Texas	37	cattle	6	Drawe 1988	Grazing systems
Southern Great Plains	Texas	19	sheep	10	Taylor & Garza 1986	Grazing systems
	Texas	27	cattle	6	Heitschmidt et al. 1990	Stocking rates & grazing systems
	Texas	17	cattle/sheep/goats	13	Taylor et al. 1993	Stocking rates & grazing systems
	Oklahoma	23	cattle	9	Shoop & McIlvain 1971	Stocking rates
Central Great Plains	Kansas	23	cattle	20	Launchbaugh 1957, 1967	Stocking rates
	Colorado	15	cattle	12	Sims et al. 1976	Stocking rates
	Colorado	12	cattle	13	Klipple & Costello 1960	Stocking rates
	Nebraska	13	cattle	10	Burzlaff & Harris 1969	Stocking rates
	Wyoming	15	cattle	13	Manley et al. 1997	Stocking rates & grazing systems
Northern Great Plains	South Dakota	15	cattle	9	Johnson et al. 1951	Stocking rates
	Montana	13	cattle	10	Houston & Woodward 1966	Stocking rates
	Alberta	12	sheep	19/9	Smoliak 1960, 1974	Stocking rates & grazing systems
	Alberta	15	cattle	5	Willms et al. 1986	Stocking rates
Annual Grassland	California	20	cattle	14	Bentley & Talbot 1951	Stocking rates
	California	35	sheep	5	Rosiere 1987	Stocking rates
Palouse Prairie	Oregon	20	cattle	12	Skovlin et al. 1976	Stocking rates & grazing systems
Western Coniferous Forest	Colorado	15	cattle	16	Johnson 1953, Smith 1967	Stocking rates
	Wyoming	24	cattle	8	Beetle et al. 1961	Stocking rates
	Oregon	20	cattle	12	Skovlin et al. 1976	Stocking rates & grazing systems
	Oregon	21	cattle	5	Holechek et al. 1987	Grazing systems
Pinyon-Juniper	New Mexico	15	cattle	10	Pieper et al. 1991, Holechek 1994	Stocking rates & grazing systems
Chihuahuan Desert	New Mexico	9	cattle	37	Paulsen & Ares 1962	Stocking rates
Sonoran Desert	Arizona	10	cattle	13	Martin & Cable 1974	Stocking rates & grazing systems
	Arizona	14	cattle	10	Martin & Severson 1988	Grazing systems
Salt Desert	Utah	7	sheep	13	Hutchings & Stewart 1953	Stocking rates

years of study for each stocking rate, heavy stocking overall resulted in a 20% decline in forage production, moderate stocking had no change, and light stocking resulted in an 8% increase. In drought years moderately stocked pastures produced 20% more forage than those heavily stocked. Forage production was 49% higher under light than heavy grazing and 24% higher under light than moderate grazing. These studies consistently showed that the greatest benefit of light or conservative stocking in terms of forage production occurred in the dry years.

Range Trend and Stocking Rate

Heavy stocking consistently caused a downward trend in ecological condition, light stocking caused an upward trend, and slight improvement occurred under moderate stocking (Table 2). Invariably the decreasers (most productive and palatable forage species) showed a decline in cover under heavy stocking while they tended to increase under light stocking. The longer the time the study involved, the more divergence there was between heavy and light stocking in terms of vegetation composition (Houston and Woodward 1966, Launchbaugh 1967, Smith 1967, Smoliak 1974, Martin and Cable 1974, Skovlin et al. 1976). Generally

Table 2. Summary of 25 studies on effects of grazing intensity on native vegetation and livestock production in North America.

	Grazing intensity		
	Heavy	Moderate	Light
Average use of forage (%)	57	43	32
Average forage production (lbs./acre)	1,175[1] (1,065)[2]	1,473[1] (1,308)[2]	1,597[1]
Forage production drought years (lbs./acre)	820[1]	986[1]	1,219[1]
Range trend in ecological condition	down (92%)[3]	up (52%)4	up (78%)[4]
Average calf crop (%)	72[1](77)[2]	79[1](84)[2]	82[1]
Average lamb crop (%)	78	82	87
Calf weaning wt (lbs.)	381[1](422)[2]	415[1](454)[2]	431[1]
Lamb weaning wt (lbs.)	57	63	---
Gain per steer (lbs.)	158	203	227
Steer/calf gain per day (lbs.)	1.83	2.15	2.30
Steer/calf gain per acre (lbs.)	40.0	33.8	22.4
Lamb gain per acre (lbs.)	26.0	20.4	13.8
Net returns per animal ($)	38.06[1] (29.00)[2]	51.57[1] (39.71)[2]	58.89[1]
Net returns per acre ($)	1.29[1] (1.72)[2]	2.61[1] (2.24)[2]	2.37[1]

[1]Average for those studies comparing heavy, moderate, and light grazing (studies comparing only heavy and moderate grazing excluded).
[2]Average for all studies
[3]Percentage of studies with downward trend.
[4]Percentage of studies with upward trend.

these studies provide support for Dyksterhuis (1949) theories of plant responses to grazing management. However different stocking rates generally had more impact on forage production than plant composition.

Livestock Production and Stocking Rate

Heavy stocking consistently lowered calf and lamb crops, animal weight gains, and fleece production compared to moderate stocking (Table 2). Livestock death losses were higher under heavy compared to moderate stocking. However per acre gains were consistently higher under heavy than moderate stocking. Generally the researchers believed this would change if the study was carried out 20–40 years because of soil erosion and large scale replacement of palatable forage species with those that are unpalatable, low in productivity, or poisonous (Houston and Woodard 1966, Launchbaugh 1967, Shoop and McIlvain 1971). Because plant composition change and soil erosion are slow, non-linear processes, the adverse impacts of heavy grazing on livestock production cannot be well quantified with 10–15 year studies (Shoop and McIlvain 1971).

Financial Returns and Stocking Rate

When all studies were averaged, moderate stocking rates gave 31% higher net financial returns per acre than heavy stocking and 11% higher financial returns than light stocking. In 4 of the 20 studies, heavy stocking gave higher net returns per acre than moderate stocking. These studies were all in humid grassland or forest areas, where heavy stocking involved 45–60% use of palatable forage species. With the exception of Pearson and Whitaker (1974) in the southern pine forest, the authors expressed considerable doubt about continued financial advantage of heavy stocking. This doubt centered around the gradual loss of grazing capacity that was occurring under heavy stocking.

Several studies have demonstrated that ruinous financial losses can occur under heavy stocking and drought (Launchbaugh 1957, Shoop and McIlvain 1971, Whitson et al. 1982). In contrast conservative stocking is one of the surest ways to minimize financial loss from drought (Boykin et al. 1962). Our analysis of the various stocking rate studies indicates on a short term basis (1–5 years), a rancher using conservative stocking will forego at worst only 10–25% of the profits possible with moderate stocking. However when severe drought occurs conservative stocking will give 30–60% higher net returns than moderate stocking. Conservative stocking also has the benefit of increasing grazing capacity through time on degraded rangelands. This benefit was not financially quantified in the various stocking rate studies. After taking these factors into account, Martin (1975) concluded that conservative stocking (35% use of forage) would give the highest long term financial returns on semi-desert rangelands in southern Arizona.

Grazing Systems

Range Vegetation

Unlike stocking rate studies, research comparing continuous or season-long and rotation grazing systems has shown much inconsistency regarding influences on rangeland vegetation (Table 3). Across all studies forage production was 7% higher under rotation compared to continuous grazing. In the semi-arid and desert range types, rotation grazing systems generally showed no advantage over continuous or season-long grazing. However in the more

Table 3. Summary of 15 studies on effects of rotation grazing systems on native rangeland vegetation and livestock production in North America.

Characteristic	Season-Long or continuous grazing	Rotation Grazing
Average use of forage (%)	41.8	42.4
Average forage production (lbs./acre)		+7%
Range Trend	up=61%, stable-31%, down=8%	up=69%, stable =8%, down = 23%
Average calf crop (%)	89.4	85.9
Calf weaning wt. (lbs.)	504.6	494.1
Net returns ($/acre)	6.60	6.37

humid range types, forage production averaged 20–30% higher under rotation grazing. Generally rotation grazing has been more beneficial to desirable forage species in the humid types than continuous grazing. However in semi-arid and arid areas, rotation has had no definite advantage. In mountainous areas rotation grazing systems give convenient areas (riparian zones) opportunity for recovery, and can be advantageous over season-long grazing.

Livestock Performance

In most studies, continuous or season-long grazing has given higher calf crops and animal weight gains than rotation grazing when stocking rates were the same (Table 3). A notable exception has been the Merrill 3 herd/4pasture system developed for Texas rangelands (Taylor and Garza 1986, Drawe 1988, Heitschmidt et al. 1990). We believe the reason the Merrill system has given equal or superior livestock performance to continuous grazing is that it uses 75% of the range at all times and livestock movements are minimal.

Financial Returns

Financial returns per acre average about 4% higher under continuous or season-long grazing than rotation grazing systems. The only grazing system showing a consistent financial advantage over continuous grazing was the Merrill 3 herd/4 pasture system. This advantage was due to increased grazing capacity through time, higher overall livestock performance, and better performance by vegetation and livestock during drought.

Some Conclusions and Thoughts for Future Research

Heavy grazing continues to be an important problem on rangelands in the United States and other parts of the world. This is somewhat puzzling in view of the fact that 25 long term grazing studies are consistent in showing it to be a losing proposition, financially, as well as biologically. Torell et al. (1991) using a Colorado prairie study (Sims et al. 1976), found profit-maximizing stocking rates were well below those that would deteriorate the rangeland resource. Workman (1986), as well as several studies we reviewed, drew the same conclusion. Therefore we believe ignorance, rather than monetary incentive, is the main reason why overgrazing is still such a serious problem.

Rotation grazing systems have been widely recommended by various government agencies concerned with range management. However research shows stocking rate reductions from heavy to conservative, have much higher probability of increasing grazing capacity, reducing risk, increasing financial returns, and reducing erosion. The United States Department of Agriculture, Natural Resources Conservation Service continues to recommend 50% use of forage resources. However the research convincingly shows 40–45% use is moderate on most rangelands and 30–35% use is needed for improvement in rangeland vegetation.

Many of the rotation grazing systems were studied using heavy stocking rates. Moderate continuous grazing typically gave better vegetation, livestock, and financial performance than rotation grazing at heavy stocking rates. However under moderate stocking rates there is evidence that some rotation grazing systems give equal or superior vegetation, livestock, and financial performance to continuous grazing (Holechek et al. 1987, Heitschmidt et al. 1990, Taylor et al. 1993).

The Merrill 3 herd/4 pasture system has proven superior to continuous grazing on Texas rangelands. The Merrill 3 herd/4 pasture system differs from all others in that it involves multiple herds and only 25% of the rangeland receives non-use at any time. This system has been studied using moderate to conservative stocking rates. This allows sensitive areas and decreaser plants opportunity for recovery without placing stress on plants and livestock in grazed areas. Livestock with greatest nutritional requirements, such as replacement heifers, can be rotated into the non-use pasture. The multi-herd approach also accommodates common-use grazing. The Merrill system can be modified for areas with seasonal precipitation, such as New Mexico, by dividing the ranch into 4 pastures and providing each pasture with growing season non-use once every 4 years. We have talked to many ranchers outside of Texas who have had considerable success with the Merrill multi-herd approach. We believe this approach should receive experimental evaluation in other range types.

As a final word, we express tremendous gratitude to the many great range people involved in conducting the classic studies. They involved much effort, time, creativity, and cost. In these studies a wealth of information remains to be discovered by those willing to do some reading and thinking.

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