Research and education for managing resources within the Nebraska Sandhills: The Gudmundsen Sandhills Laboratory

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The Nebraska Sandhills which encompass about 12.75 million acres of rangeland are home for about 535,500 head of beef cows. Located in the heart of the Sandhills in Grant, Hooker and Cherry Counties is the University of Nebraska-Lincoln’s Gudmundsen Sandhills Laboratory (GSL) formerly known as the "Rafter 'C' Ranch" (Fig. 1). The "Rafter 'C' Ranch," a 12,817 acre working ranch, was given to the University of Nebraska Foundation in 1978 by Elmer "Pete" and Abbie Gudmundsen. Their desired purpose was stated, "to improve, advance and support agriculture in the state of Nebraska in ways that have relevance to the Sandhills area of the state through added research, improved teaching and continuing education and service to the agricultural industry." The University of Nebraska-Lincoln became the lessee of the Gudmundsen Sandhills Laboratory from the Foundation in 1981. The "Rafter 'C'" has made the transition from a commercial ranch to a multi-disciplinary research laboratory with additional fencing, water development, cattle handling facilities and roads. Research opportunity was enhanced with dormitory facilities for students and faculty, a meeting room, and a laboratory equipped for processing plant, insect, soil, water and livestock diet and extrusa samples.

The Gudmundsen Sandhills Laboratory contains about 1,200 acres of subirrigated and wetland meadows and 11,600 acres of upland sandhills range which include sands, sandy and choppy sands range sites. Approximate stocking rates for upland range and subirrigated meadow are 0.5 and 3.5 AUM/acre, respectively. Hay is harvested from meadows for winter feeding and to supplement dormant-season grazing on upland range sites. The dominant grass species on upland range sites are: little bluestem [Andropogon scoparius (Michx.) Nash], prairie sandreed [Calamovilfa longifolia (Hook.) Scribn.], sand bluestem [Andropogon hallii Hack.], switchgrass [Panicum virgatum L.], sand lovegrass [Eragrostis trichoides (Nutt.) Wood], and blue grama [Bouteloua gracilis (H.K.B.) Lag. Ex Griffiths]. Soils are predominantly Valentine fine sands (mixed, mesic Typic Ustipsamments). While forbs and shrubs generally account for less than 15% of the herbage, a great diversity of forb species are widely distributed on upland range sites. Meadow soils are primarily Gannett-Loup fine sandy loam (course-loamy mixed mesic Typic Haplollaquoll). At GSL, differences in depth to the water table and duration of standing water influence the degree of soil wetness and the distribution of plant communities on the meadow. Wetland sites have the longest duration of inun-

Fig 1. Map of the Nebraska Sandhills and location of the University of Nebraska-Lincoln Gudmundsen Sandhills Laboratory (GSL). Figure provided by the University of Nebraska-Lincoln Conservation and Survey Division.

Headquarters of the Gudmundsen Sandhills Laboratory.
dation and tend to be dominated by sedges and rushes. The water table may be as deep as 5 feet during the grazing season on subirrigated sites which are dominated by grasses. Wet subirrigated sites have a degree of wetness and species composition that is intermediate between the wetland and subirrigated sites. Common species found in most meadows include smooth bromegrass (*Bromus inermis* Leyss.), redtop bent (*Agrostis stolonifera* L.), timothy (*Phleum pratense* L.), slender wheatgrass (*Elymus trachycaulus* (Link) Gould ex Shinn.), quackgrass (*Elytrigia repens* (L.) Nevski.), Kentucky bluegrass (*Poa pratensis* L.), prairie cordgrass (*Spartina pectinata* Link), reedgrasses (*Calamagrostis* spp.), and numerous species of sedges (*Carex* spp. and *Cyperus* spp.), rushes (*Scirpus* spp.), and spikerushes (*Eleocharis* spp.). Big bluestem (*Andropogon gerardii* Vitman), indiangrass (*Sorghastrum nutans* (L.) Nash), and switchgrass (*Panicum virgatum* L.) are present on most of the meadows at GSL, but their relative abundance is low in areas that have historically been hayed each summer. Legumes and other forbs are generally minor components of meadow vegetation.

The cow herd at GSL consists of about 360 March-calving and 200 June-calving cows. Cows are MARC II composites (1/4 Hereford, 1/4 Angus, 1/4 Simmental, and 1/4 Gelbvieh). The herd was developed from 450 Angus × Hereford heifers which were purchased in the spring of 1981 and 200 Angus × Simmental cows transferred from the Sandhills Ag Lab (closed in 1981) near Tryon, Nebraska. Bulls are obtained from the USDA-ARS Meat Animal Research Center (MARC) near Clay Center, Nebraska. Fall pregnancy rate for March and June calving cows has generally been about 93% and calving rate has generally been about 98%. The culling rate of the cow herd has been highly variable to accommodate various heifer development studies. Heifers selected to replace cull cows are developed at GSL. Surplus heifer calves have been used in studies at other research locations in the University of Nebraska system or sold at weaning if they are not needed. Steer calves may be wintered and summer grazed at GSL as yearlings, fed in University of Nebraska-Lincoln feedlots at Mead or Scottsbluff, or sold at weaning if they are not needed for research.

A resident manager supervises 3 full-time technicians and directs day-to-day operations at GSL. Planning and coordination of research and education activities at GSL is done by a faculty planning committee comprised of all faculty with research at GSL, an extension educator, and the director of the University of Nebraska-Lincoln West Central Research and Extension Center in North Platte. One of the faculty researchers serves as the coordinator between the planning committee and the resident manager and supervises the resident manager. An industry advisory committee was formed in February 1996. The committee reviews research and education programming at GSL and identifies research and education needs for the beef cattle industry in the Nebraska Sandhills. Nominations for the committee were made by the Nebraska Cattlemen Association, Sandhills Cattlemen Association, the Nebraska Section of the Society for Range Management, the Nebraska Branch of Holistic Management, and University of Nebraska faculty. The advisory committee represents an array of ranch sizes and the full geographic region of the Sandhills. All advisory committee members help with technology transfer to the industry.

### Research and Education Objectives

Our research and educational objectives focus on beef production systems from conception to slaughter. This focus on systems allows us to identify necessary component research and then incorporate results into systems analysis. Research objectives are to develop plant/animal systems that are economically and environmentally sustainable. Our educational objective is to provide knowledge and decision support systems including monitoring techniques for optimal and sustainable use of Sandhills rangeland resources. Since the inception of GSL, research and educational programs have become more ecologically diverse and team oriented. Joint projects with animal, range, veterinary, economics, entomology, geology, hydrology, forestry and wildlife have increased our understanding of the Sandhills ecosystem. Facility development, increasing diversity of faculty expertise, cooperative efforts with other University of Nebraska centers and strong support of the beef cattle industry have all contributed to the research and educational efforts.

### Past Research at GSL

A number of studies at GSL have tested concepts which have contributed to the development and evaluation of livestock production systems for the Sandhills (Ward 1997). Protein and energy supplements have been studied for dry-gestation cows and lactating cows grazing dormant-season
forage on upland range sites. Cows have generally responded more favorably to supplemental protein than energy during fall-winter grazing. Dry-gestating cows grazing winter range generally loose body condition without supplemental protein. Gestating cows grazing winter range will maintain body condition with a small amount of supplemental degraded intake protein (DIP, i.e. rumen degradable protein). The requirement for supplemental rumen degradable protein is likely between 0.31 and 0.37 lb/day (Hollingsworth-Jenkins et al. 1996). Lactating cows grazing fall-winter range have responded to both degraded intake protein and undegraded intake protein (UIP, escape protein). Second-cutting hay, harvested on subirrigated meadows in August after a first cutting in June, contained about 15% crude protein and was as effective as more expensive soybean meal supplements in maintaining body condition of dry-gestating cows grazing winter range. Weaning March-born calves in early September improved condition score of cows in November over cows that suckled calves until November. Gain of calves weaned in September and placed on subirrigated meadow regrowth after a first cutting of hay in July was equal to calves suckling cows on upland range during the September to November period (Lamb et al. 1997). March- and April-born calves, suckling cows on upland range during summer (Hollingsworth-Jenkins 1994) or on subirrigated meadow regrowth in the fall (Lardy 1997), have increased gains when supplemented with UIP over non-supplemented calves, suggesting that protein available for growth is limiting calf gain.

We recognized that if we were to be effective in development and evaluation of livestock production systems we needed a greater understanding of seasonal patterns in diet quality and composition on meadows and upland range, particularly when reducing fed forages and relying more extensively on grazed forages. Nutrient content of hay, individual plant species, and livestock diets from both meadows and upland range have been described in relationship to plant maturity in agronomic meadow studies, tiller staging and grazing preference studies on upland sites, and by diets from fistulated cows and calves. Agronomic studies on subirrigated and wetland meadows have evaluated harvest date, fertilizer, and harvest date by date of fertilization interaction effects on yield and quality of hay and regrowth after haying, plant recovery of applied nutrients, and species composition. Economic analysis of the yield and forage quality of hay showed that application of nitrogen, sulphur, and phosphorus to subirrigated meadows can be profitable practices, especially when accounting for forage quality. When forage quality was valued as part of this economic analysis of meadow forage, optimal harvest time was earlier than traditional haying dates in the area (Norton et al. 1997). Nutritional knowledge gained from meadow research at GSL has been critical for extending the length of grazing seasons, consistently producing high quality forages for supplements and heifer development, and increasing flexibility in calf and yearling grazing programs.

In order to utilize the metabolizable protein system adopted by the National Research Council (NRC 1996), degraded intake protein (DIP), undegraded intake protein (UIP) and forage digestibility have been determined on diet samples collected throughout the year from upland range and subirrigated meadows (Lardy et al. 1998). Nutrient intake is the product of concentration of a nutrient in a forage and the amount of forage consumed. Considerable efforts were made to build a base of forage intake data for cows throughout the year at all stages of pregnancy and lactation, and for weaned and suckling calves and yearlings. With regression models (Lardy et al. 1998) of annual pro-

The first systems research at GSL addressed winter and post-calving grazing and feeding within year-long production cycles for March-calving cows (Adams et al. 1994). This work showed that extending winter grazing and grazing cool-season forages on subirrigated meadows in early spring, in lieu of feeding hay, increased returns per calf up to $90/head. Systems which fed the least hay were consistently most profitable.
tein and digestibility patterns and reliable estimates of forage intake components, the metabolizable protein system and energy can be evaluated for a variety of animal requirements to determine first limiting nutrients or deficiencies. These evaluations can then be the basis for nutrition and management research needed for developing and refining livestock production systems.

A forage yield and quality plot on a subirrigated meadow at GSL.

The large geographic area of the Sandhills and the diversity of enterprises and managerial thought processes have resulted in a wide variety of grazing strategies. It became evident that in the Nebraska Sandhills, testimonials and not reliable data were generally the norm for evaluating impacts of proposed grazing schemes on meadows and upland range. Resources were not available at GSL for comparative studies of all possible grazing schemes on upland range and/or meadows. Additionally, we found considerable controversy among ranchers and conservationists about impacts and interpretation of studies and grazing systems implemented in other geographic locations. The approach conceived for studying grazing effects on upland range and subirrigated and wetland meadows needed to be well controlled, replicated and have broad application. These needs led to the development of a series of grazing studies designed to provide a broad ecological data base for the development of grazing systems that are designed to achieve specific resource management and livestock production objectives.

Short-duration grazing treatments were used to simulate arrays of grazing strategies in large sets of small upland range pastures. The treatments evaluated resource responses to date and frequency of grazing, date by stocking rate interactions, and grazing pressure (Ward 1997). Prairie sandreed was more susceptible to heavy grazing during June–August than sand bluestem. Cattle selectively grazed both species all summer (Reece et al. 1996). Reductions in total organic reserves of grazed sand bluestem populations corresponded to similar percentage reductions in root length in plants clipped to simulate grazing (Engel et al. 1997). Root response to grazing has become an important area of our research. Infiltration rates are high and water holding capacity is low in the sandy soils of this ecosystem.

Utilization of prairie sandreed during early summer is highly correlated with grazing pressure and percent of prairie sandreed tillers grazed is highly correlated with use. Grazing pressures can be calculated for many grazing schemes, based on our documentation of seasonal distribution of current-year herbage, and used to predict use of this key forage species.

Four years of heavy summer stocking rates on sands range sites increased the species composition of cool-season grasses by 10 percentage points, from 5% to 15%. Heavy grazing also caused measurable increases in western ragweed (Ambrosia psilostachya Dc.) which declined to pretreatment levels after 1 year of rest. Grazing treatments in several studies at GSL have caused measurable changes in foliar architecture and insect populations that affect distribution and decomposition of litter. Changes in foliar architecture also affect wildlife habitat. Grazing pastures only in June or July at light stocking rates resulted in adequate cover for prairie grouse nesting sites in the following year. Moderate stocking in June frequently provided adequate cover while heavy grazing in either month resulted in poor cover for sharp-tailed grouse (Pedioecetes phasianellus) or prairie chickens (Tympanuchus cupido).

Present and Future Research

At GSL we are trying to determine effects of cattle on rangeland resources and vice versa over full production cycles. Profitability and sustainability of the resource rather than selected production outputs will be the criteria for evaluating systems. Key to our present work is a high degree of cooperation among faculty from Animal Science, Range Science, Agricultural Economics, Entomology, Veterinary Science, Water Conservation, and Nebraska forestry and input from the beef industry, the primary user of Sandhills forage resources.

Based on our work with March-calving cows we hypothesized that if the cows' lactation and calving date were matched with nutrients available in upland range and meadow forages, that fed hay could be reduced by a ton or more. We further hypothesized that the improved match would enhance profitability of Sandhills ranches by reducing the amount of hay fed and labor and equipment associated with feeding. Simple descriptive models of the nutrients in range and meadow forages provided the basis to conceptually match the cows' nutrient requirements with nutrients in grazed forages. To test our hypothesis, we selected a mid-June calving date as a means to match the nutrient requirements of late gestation and lactation with a high concentration of protein and digestibility in range forages. In this study, the endpoints for evaluation

A steer fit with a fecal collection bag for intake studies.
are returns per cow exposed to the bull at weaning, and the returns on the calf through to slaughter. All production outputs and costs are recorded for the traditional March-calving cow herd and the June-calving herd. All marketing opportunities will be evaluated. A progress evaluation after 3 years (Clark et al. 1997) showed that annual fed forage has been reduced by over 3,000 lb/cow with the June-calving system and returns per calf are about $50 greater for June-born than March-born steer calves.

Replacing days on harvested feed with grazing days will require knowledge of how combined seasons of grazing during spring, summer, and/or dormant seasons affect range-land resources compared to single seasons of use. We hypothesize that sustainable stocking rates on upland range sites will increase as the percentage of annual stocking rate is shifted from summer to dormant-season grazing. Recently initiated studies will focus on different systems of managing growing cattle from weaning to finishing with different schemes for backgrounding weaned calves and summer grazing yearly on different combinations of meadow and upland range before shipment to feedlots. These studies will involve detailed ecological and economic assessment.

**Literature Cited**


