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# Grazing management strategies as a factor influencing ecological stability of Mongolian grasslands

*Dennis P. Sheehy*

Mongolian pastoral ecosystems have been grazed by domestic livestock for centuries. During this long history, livestock grazing had minimal impact on long-term ecological stability of ecosystems. However, the relatively recent imposition of sedentary agricultural production systems and changes in livestock grazing management strategies have seriously impacted ecological stability of grazed ecosystems, especially in Inner Mongolia. Although ecosystem stability has been impacted in Mongolia, opportunities remain to implement grazing management strategies that support ecologically sustainable use by livestock. In Inner Mongolia, widespread ecological instability presents agricultural policy-makers and the livestock producer with little opportunity to use grazing management strategies in the livestock production system.

## Mongolian grazingland environment

Mongolian pastures have been grazed by large herbivores, including livestock, for centuries. Throughout this long history, long-term ecological stability of grazed ecosystems has been maintained even though livestock production was and remains the major agricultural production activity. Ecological instability that did occasionally affect grazingland usually was induced by natural causes such as drought, and had only relatively short term impacts on the 'steady state' ecological equilibrium of grazingland ecosystems. An important factor in maintaining this ecological stability was the use of adaptive rather than disruptive livestock grazing management strategies. Such strategies in the traditional Mongolian pastoral livestock production system were based on flexible and mobile use of grazinglands by environmentally adapted livestock (Purev 1990).

The most important factor influencing selection of such strategies is the nature of the Mongolian pastoral environment. Important environmental factors influencing stability and resilience of grazingland ecosystems are the amount and timing of precipitation, temperature, soils and livestock

grazing intensity. Mongolian grazingland is primarily arid or semi-arid steppe and is subject to drought, wind, variable temperatures and a short growing season. The geographic boundary between temperate agricultural China and steppe grazingland of the Mongolian Plateau is both a temperature and rainfall boundary with the southern limit of steppe and the northern limit of rainfall reliability (Murphey 1989).

Monsoon winds are a major climatic influence in the region (Nuttonson 1947). During May and June, winds shift from the Pacific Ocean to Central Asia and bring precipitation in the form of cyclonic and convection storms. Approximately two thirds of total precipitation and almost all growth of vegetation occurs during May to September. In September, winds shift to the northeast and bring cold temperatures, dust and little or no moisture from the dry and extremely cold regions of Siberia. Livestock production using non-adaptive grazing management strategies under these conditions increases the amount of risk and the potential that natural conditions will adversely affect livestock production activities and that livestock grazing, in turn, will adversely impact long-term ecological stability of pastoral ecosystems.

Composition of grazingland vegetation and the temporal and spatial distribution of annual forage standing crop are important factors regulating livestock production in the Mongolian environment. The Mongolian Plateau has been dry land since the Upper Palaeozoic, arid since the Cretaceous Age and increasingly arid since the Neocene (Walker 1982). Consequently, current grazingland vegetation and soils reflect the arid nature of the Mongolian environment. Natural communities encountered in the Mongolian Floristic Province are mesophytic or xerophytic, and include *Anabasis*, *Salsola*, *Kalidium*, *Haloxylon*, *Stipa*, *Laciagrostis*, *Allium*, *Reaumuria*, *Artemisia*, *Tanacetum*, *Ephedra*, *Zygophillum*, and *Nitraria* communities (Grubov 1969). These communities characteristically have seasonal vegetation growth, relatively low productivity and spatially dispersed annual forage standing crop. Consequently, harvest of vegetation is most efficiently accomplished using highly mobile livestock and flexible grazing management strategies.

The flora of Mongolian grazinglands has over 5000 species of plants, most of which are grasses (Grubov 1969). Grazingland species composition includes over 600 forage species, of which 200 are considered to be highly palatable to livestock. The major vegetation types characterising grazingland of the Mongolian Plateau are forest and meadow steppe with high annual standing crop (3500 to 4000 kg/ha), grass steppe with moderate annual standing crop (1500 to 3000 kg/ha), desert steppe with low annual standing crop (375 to 1500 kg/ha) and desert with low annual standing crop comprised primarily of browse from shrubs (Danagro 1992).

### Ecological stability of grazingland ecosystems

Mongolian desert and desert-steppe grazingland ecosystems exhibit 'patchy' vegetation, i.e., temporally and spatially diverse communities that occur because of differences in soil and environmental conditions

(Mearns 1991). Precipitation and temperature are temporally and spatially diverse and cause local and regional variation in vegetation composition and annual forage standing crop. These regional ecosystems should be classified as 'non-equilibrium environments' in which environmental factors influence ecological condition of plant communities equally or more than grazing by livestock (Behnke and Scoones 1992).

Grass-steppe and forest-steppe regional ecosystems have colder temperature and higher annual precipitation. Less temporal and spatial diversity of vegetation and soils occur in these ecosystems. Annual production of vegetation from plant communities is also less diverse. These regional ecosystems should be classified as generally more 'equilibrium environments' which have less spatially diverse but more temporally diverse annual forage standing crop.

In both equilibrium and non-equilibrium Mongolian environments, grazingland ecosystems tend to be ecologically stable if livestock production is based on extensive grazing management strategies similar to the strategy used in the traditional Mongolian pastoral livestock production system. Grazingland ecosystems can be maintained in a 'steady state' equilibrium that is not readily changed by livestock grazing impacts (Archer and Smeins 1992). Although livestock grazing intensity on annual forage standing crop can be high during portions of the annual production cycle, especially near winter camps, evidence indicates that most forage plants comprising Mongolian pastoral communities are highly tolerant or resistant to grazing. Consequently, the focus of livestock management is on maintaining pastoral resources within the bounds of the current steady state equilibrium to prevent creation of a new steady state that is less favourable to extensive livestock production.

Management of livestock grazing to maintain ecological stability of Mongolian ecosystems is feasible because: (a) the long history of livestock grazing precludes the identification of non-grazed climax plant communities in most regional ecosystems; (b) the long history of pastoral livestock

grazing indicates close evolution of plant species and grazing herbivores, with plant communities either adapted physiologically to being heavily grazed seasonally or having evolved characteristics that enable them to resist grazing by herbivores (spines, toxins, etc.); (c) evidence that at least the majority of regional ecosystems potentially have 'multiple steady states' whereby if factors causing loss of ecological stability are severe and of sufficient duration, the threshold between the current steady state equilibrium will be surpassed and the grazingland ecosystem will enter a new and different 'steady state equilibrium'.

The loss of ecological stability and ecosystem movement towards a 'steady state threshold' is generally indicated by soil erosion and changes in vegetation composition and structure. Consequently, management of livestock using an extensive grazing management strategy should focus on maintaining the current ecological stability of regional and local ecosystems. Grazing management rather than costly inputs and activities designed to increase livestock off-take and exploit pasture resources is the objective of grazing management strategies. In the Mongolian environment, intensive grazing management strategies are usually the cause of and the response to exploitative livestock management in the production system.

### Grazing management for livestock production

Grazing management involves human regulation of herbivore consumption, primarily through strategies of livestock manipulation to meet specific, predetermined production goals. As the grazing process and associated managerial activities occur within ecological systems, both activities are subject to an identical set of ecological principles that govern ecosystem function. These ecological principles impose an upper limit on animal production which cannot be overcome by management (Briske and Heitschmidt 1991).

Grazing management strategies can be classified as extensive, i.e., improving the temporal and spatial distribution of grazing herbivores, or intensive, i.e., direct incorporation of energy inputs into the production system (Briske and Heitschmidt 1991). The effectiveness of grazing management strategies is therefore necessarily constrained by such factors as energy capture by plants, harvest by herbivores, and energy conversion by herbivores into meat, fibre and other off-take products. The principal factor affecting ecological stability is grazing intensity which is a function of temporal and spatial distribution of various kinds, classes and number of herbivore grazers using an available set of grazingland resources.

For these reasons, growth of vegetation and nutrient availability from vegetation is a primary consideration in selection of livestock grazing management strategies (Figure 1). Both vegetation growth and nutrient content of annual forage standing crop are constrained by climate and environment. In general terms, growth of annual forage standing crop begins in March but is slow until May. Nutrient availability in old forage (standing crop from the previous year) during this period is low but is high in new forage (standing crop from the current year). Between May and August, growth rate, total biomass and total nutrients of annual forage standing crop are at high levels. In September, growth of most grazingland plants ceases and, as plants mature and perennial plants enter senescence, annual forage standing crop becomes old forage. During the September to May period, total biomass of old forage standing crop declines as a result of grazing and environmental factors such as wind shattering. Nutrient availability, which reached highest levels prior to highest levels of annual forage standing crop, continues to decline to minimal levels until the advent of new forage growth in March.

It is during the May to August period as indicated by A and B on the new forage growth curve in figure 1 that energy capture by plants, harvest by herbivores and energy conversion by herbivores is high-

est. However, it is during late summer and autumn that high grazing intensity by herbivores on Mongolian grazingland has least impact on ecological stability of grazingland communities. Livestock grazing management strategies that are adapted to taking advantage of annual standing crop and nutrient availability during periods of maximum availability in the late summer and early autumn increase sustainable livestock production and promote long-term ecological stability.

### Mongolian grazing management strategies

Three basic grazing management strategies are currently used in livestock production on Mongolian grazinglands. These are an 'extensive grazing management strategy' which formed the basis of the traditional pastoral livestock production system, a 'semi-extensive grazing management strategy' employed by the collective livestock production system and an 'intensive grazing management strategy' or 'village strategy' employed by state farm and sedentary agricultural production centres. These three strategies or modifications of the basic strategies are commonly used in extensive livestock production systems throughout the world.

Figure 1. Seasonal relationships between annual forage standing crop and nutrient availability on Mongolian grazinglands

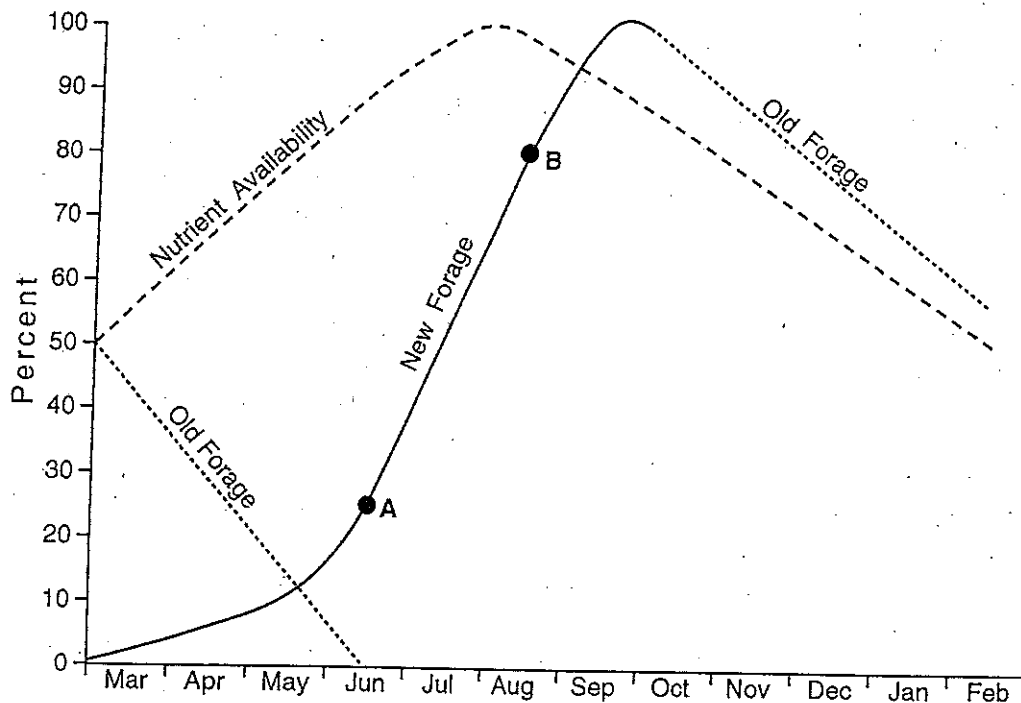
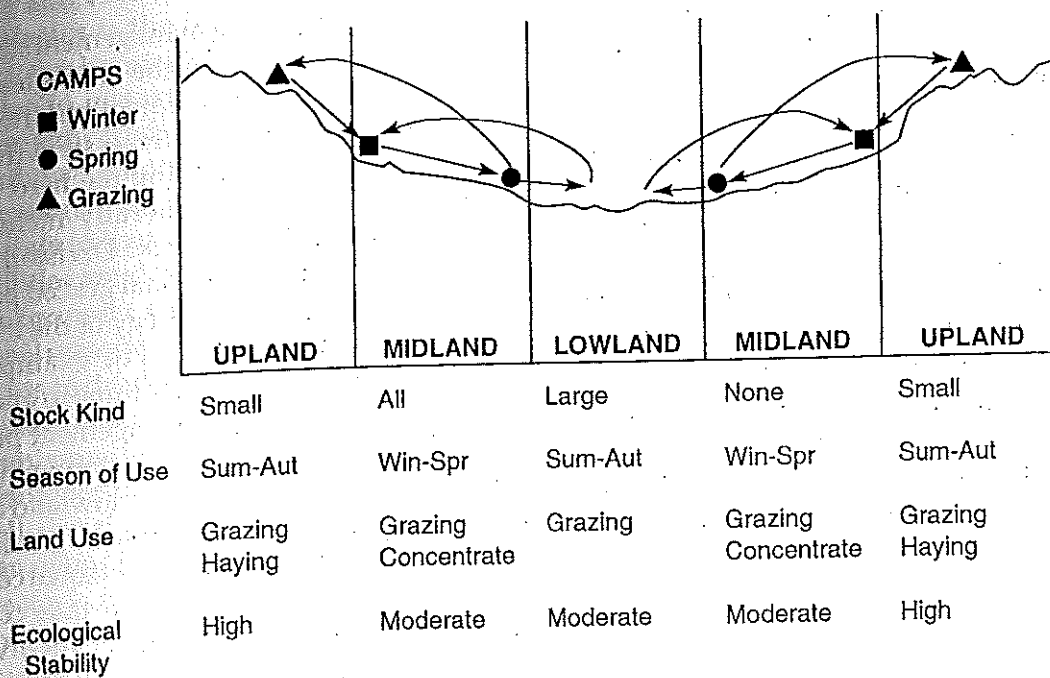


Figure 2. Extensive grazing management strategy



### Extensive grazing management

The extensive management strategy is adaptive to natural conditions encountered in the grazing environment (Figure 2). The herd is mixed and includes small stock such as sheep and goats, i.e., intermediate feeders with high dietary plasticity (Huston and Pinchak 1991) and large stock such as camel (intermediate feeder) or horse, cattle and yak (bulk roughage feeders) in various combinations according to animal adaptability to vegetation, terrain and environmental conditions. Grazingland is separated into seasonal pastures and grazed according to managerial and production objectives of the livestock producer. For example, small stock graze upland areas of rough terrain during the summer to restore body condition and build body reserves of fat on specific upland plant communities during the autumn. Large stock from which milk products are obtained are kept on lowland areas close to water sources and rapidly growing mesophytic vegetation most suited to large animal bulk roughage feeders. The mini-

mal amount of vegetation harvested as hay from grazingland designated as hayland is used to supplement weaker livestock and alleviate nutritional stress during critical winter and spring production events such as parturition.

Livestock mobility, flexible use of land, and low off-take from environmentally adapted livestock are key elements of the extensive grazing management strategy. Consequently, specific areas receive concentrated grazing use by livestock but only for relatively short time periods. Areas receiving longer periods of concentrated livestock use, such as mesic lowlands, have plants adapted to livestock grazing and moisture conditions promoting rapid growth of grazed vegetation.

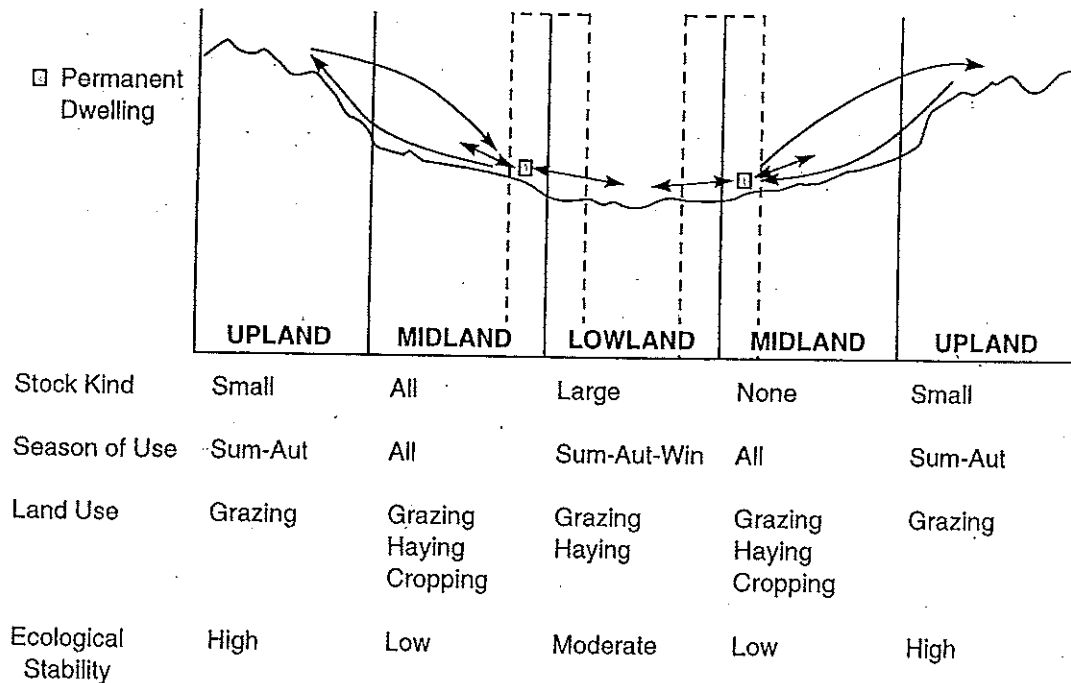
Winter and spring grazingland is most susceptible to grazing induced ecological instability. Animals are concentrated on these areas as a result of environmental conditions and the need for close human supervision during the important livestock production events that occur during these seasons. Usually the low livestock density

associated with extensive grazing management strategies presents opportunities to rest and defer grazing of vegetation on winter and spring pastures. Less resilient vegetation of the more xeric midlands and uplands has opportunity to escape grazing during and between grazing events. If livestock numbers and density increase to levels sufficient to cause ecological instability, adverse climatic events coupled with the resultant increase in animal nutritional stress usually increases livestock mortality. Ultimately, a balance between livestock numbers and carrying capacity is restored. Consequently, land managed with extensive livestock grazing management strategies usually has moderate to high ecological stability.

*Semi-extensive grazing management*

Semi-extensive grazing management strategies continue to rely on the strategies of extensive grazing management but incorporate energy inputs into the system (Figure 3). Livestock comprising the herd remain diversified and generally include small stock and large stock. Division of grazingland area into seasonal grazed pastures is a fundamental strategy of the livestock production system. For example, small stock such as sheep continue to graze upland vegetation with management provided through camps. Large lactating livestock continue to utilise mesic lowland areas during summer and autumn grazing seasons. Animal products for personal consumption and sale of excess off-take continues to be the primary goal of the livestock production system.

Figure 3. *Semi-extensive grazing management strategy*



A major difference between semi-extensive and extensive grazing management strategies is the increase in energy input into the livestock production system. In order to increase the amount of off-take from either individual animals or from the herd, an attempt is made to overcome environmental or seasonal vegetation constraints to livestock production. Watering facilities are developed or improved in areas formerly receiving specific and occasional seasonal use because livestock lacked access to drinking water. Greater amounts of vegetation are harvested to be used as supplementary feed during winter and spring periods of forage deficiencies. The well developed semi-extensive grazing management strategy trades high levels of livestock mobility and flexibility against more reliance on inputs to overcome constraints. The impetus for the livestock production system becomes higher numbers and higher off-take rates achieved by improving access to grazingland vegetation and providing more stored forage for the winter and spring seasons.

Areas of former grazingland used as hayland need protection from grazing animals, usually requiring fences to be constructed. More of the livestock producers' time is required to implement improvements which means less time is available for managing livestock grazing. Managed livestock movements are reduced, causing a reduction in animal distribution. A tendency of the livestock producer is to introduce livestock with higher genetic potential to the production system and to specialise in one kind of livestock to reduce labour demands and increase returns from livestock.

Ultimately, movement of camps to provide optimal management of livestock will be deemed to be an inefficient use of scarce labour and time. Tending and protecting hayland and crops grown to produce concentrate feeds will require the livestock producer to have a fixed residence. The pattern of livestock production then becomes one of large livestock grazing lowland and midland pastures and small livestock grazing uplands during summer and

autumn. During winter and spring, all livestock graze midland and lowland grazing areas close to cropland and hayland. Daily rations of supplementary feed are provided during at least part of the year. Under semi-extensive grazing management strategies, ecological stability of upland pasture is high, lowland pasture stability is moderate and midland pasture is low because of the impact of year-long livestock grazing and increased density of animals.

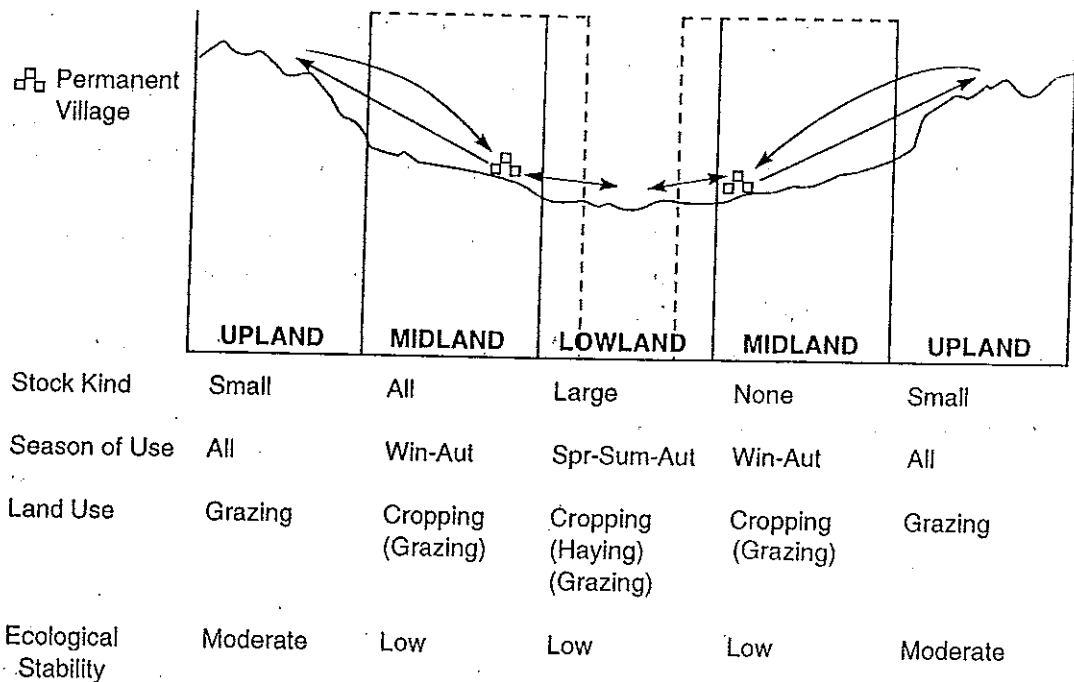
#### *Intensive grazing management*

Intensive grazing management strategies rely on maximum inputs into the livestock production system to maximise off-take from livestock (Figure 4). Specialisation of livestock with higher genetic potential rather than diversity of environmentally adapted livestock is a major objective of the livestock production system. The management objective is to obtain maximum grazing value from grazingland without due regard to maintaining long-term ecological stability of the grazingland ecosystem. High grazing intensity, over time, changes grazingland plant composition to grazing-resistant plants. Incidence of wind and water erosion increase as a result of animal grazing impacts on vegetation and soils. Adverse impacts from grazing such as the forming of a surface compaction layer increase in occurrence and duration (Sheehy 1993). Land that has highest yield of annual forage standing crop when used for grazing will invariably be converted to marginal rain-fed cropland.

If production remains focused on livestock as the primary production enterprise, cropland will be used to provide high energy supplements to livestock. Grazingland will be intensely used in periods of maximum vegetation growth during summer and autumn. Cropland will be used to produce harvested fodder for livestock during other seasons of the year with grazing of crop aftermath permitted only after crop harvest. In order to improve grazing efficiencies, the livestock producer may seek to increase productivity of grazingland by seeding improved pasture species to



Figure 4. *Intensive grazing management strategy*



allow high intensity grazing by livestock on artificial pastures. Maintaining artificial pastures requires an almost continuous stream of energy inputs such as fertiliser, water for irrigation, periodic re-establishment of pasture stands, and intense livestock management. Grazing management strategies focus on short duration, high intensity grazing. Only minimal use of livestock off-take products will be made directly by the producer.

Conversely, if the production focus changes to crop production as the primary agricultural activity with livestock considered a secondary production activity, livestock production will receive only incidental energy inputs. Management of livestock grazing is minimal and under-supervised with the grazing management strategy being protection of crops until harvest and high intensity grazing of natural ecosystems. The supplementary feed provided for livestock is usually low energy crop by-products such as straw and stems. Livestock are viewed as supplementary to the primary agricultural cropping activity. The contribution of livestock to the economic

well-being of the farm enterprise, while welcome, is not considered to be essential.

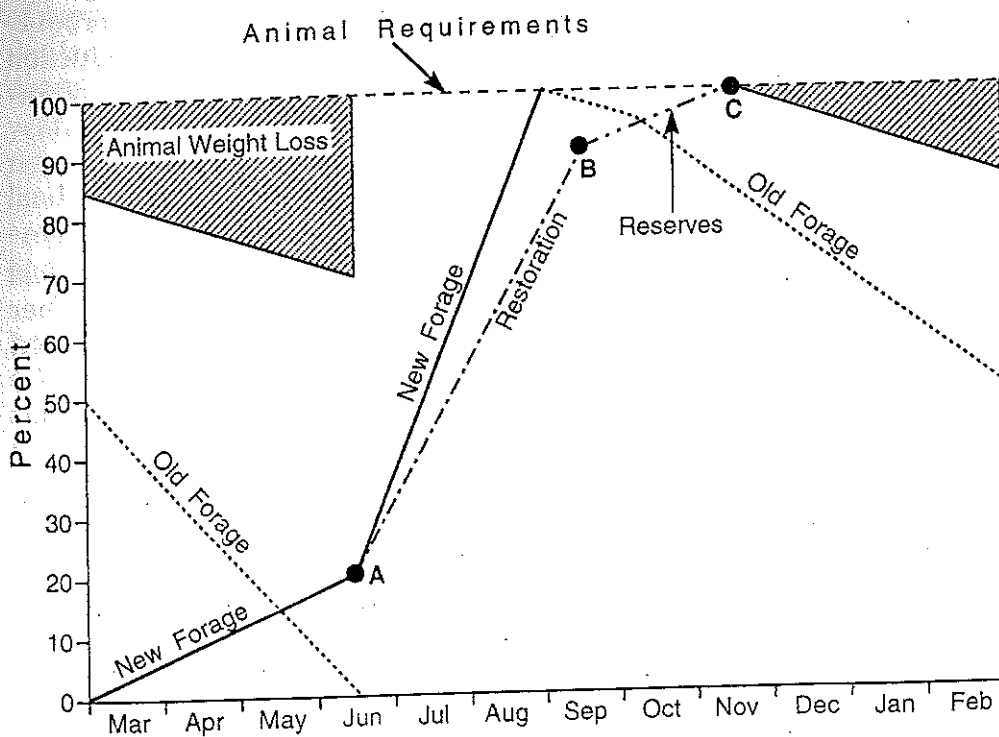
An intensive grazing management strategy is used either when livestock are viewed as primary producers or when livestock are viewed as being a supplementary agricultural production activity. In either situation, livestock grazing intensity is high and the primary cause of ecological instability. Lowland and midland pastures that are too marginal to be converted to cropland will be intensely grazed by all kinds of livestock during all seasons. Uplands that received only summer and autumn grazing by small stock in the extensive and semi-extensive grazing management strategies are grazed year-long by all stock. In the intensive grazing management strategy, all pasture vegetation is grazed by livestock during all seasons. Uplands may retain moderate ecological stability because of the distance from villages or agricultural production centres but natural midland and lowland pasture will invariably have low ecological stability as a result of high intensity grazing and impacts from concentrated livestock use.

## Impact of grazing management strategies on livestock production and ecosystem stability

The adaptive, extensive grazing management strategy used in the traditional pastoral livestock production system used environmentally adapted livestock that were capable of adjusting to environmental and production constraints (Figure 5). Livestock used the annual forage standing crop produced during the short growing season between June and August to restore body condition (A to B on the restore curve in Figure 5). In autumn, between September and December, adapted livestock were able to replenish body reserves of energy (B to C on the restore curve in Figure 5) even though total forage standing crop and nutrient levels available from grazingland were generally declining. Body reserves and remaining old forage standing crop were used during winter and spring to maintain livestock and complete animal physiological processes.

Parturition was timed to occur between March and May when usually some amount of new forage with high nutrient content was available to grazing livestock. Breeding of large stock was timed to occur during the period of maximum growth rate of new forage when body condition of livestock had been restored. Breeding of small stock was timed to occur on autumn pastures when the cooler weather and high energy forage presented optimal conditions. If summer and autumn conditions were optimal for restoring body condition and replenishing energy reserves, environmentally adapted livestock were able to survive the winter and spring periods of feed deficiencies and still be relatively productive. With minimal feed supplementation, the remaining old forage, the availability of early new forage with high crude protein and energy levels, and animal body reserves were able to carry livestock until new forage was available to restore body condition and body reserves. Animal weight loss to 35 percent of body weight

Figure 5. Seasonal relationship between annual forage standing crop and environmentally adapted Mongolian livestock



between December and June was an expected constraint of livestock production with extensive grazing management strategies (Purev 1990).

Semi-extensive and intensive grazing management strategies try to prevent the animal weight loss associated with the extensive grazing management strategy, instead focusing on converting that weight loss into higher animal off-take (Figure 5). Livestock whose body condition is maintained at a higher level in the December through May period through feed supplementation should produce higher off-take than animals that are nutritionally stressed for the greater part of each annual production cycle. Higher conception and birth rates, higher survival rates among progeny, lower adult mortality and greater off-take of meat and fibre are expected.

However, preventing animal weight loss associated with the extensive grazing management strategy in the severe Mongolian environment requires that costly inputs be used. Hay and concentrate feeds have to be produced on a scale sufficient to meet feed intake and nutritional requirements of livestock for six to seven months of each annual production cycle. European breeds of livestock that are introduced with the expectation of having higher off-take rates generally do not have the expected response in the Mongolian environment.

Grazing management strategies in both Inner Mongolia and Mongolia have been altered from the traditional adaptive strategies, most often in response to political and socio-economic factors separate from considerations of maintaining ecosystem stability. Livestock numbers are at high levels and semi-extensive and intensive grazing management strategies form the basis for grazingland based livestock production systems. The goal of livestock production in both regions has been to increase livestock off-take from such ecosystems. In doing so, ecological stability and the potential for sustainable livestock production that was the primary attribute of the adaptive, extensive grazing management strategies have been discounted as factors constraining livestock production.

## Mongolia

Mongolia attempted to alter traditional grazing management strategies to meet political and social objectives in the 1940s (Bazargür *et al.* 1992, Mearns 1993). In the 1960s, collective livestock production implemented exploitative grazing management strategies in response to the political and economic objectives of the socialist command economy. State farms were established to develop an intensive agricultural production system that required intensive grazing management strategies. State agricultural institutions promoted grazing management strategies that focused on increasing livestock off-take, livestock development and grazingland use.

The state farm system emphasised intensive, year-long dairy production using Friesian and dual-purpose dairy cattle while the *negdel* collective system attempted to increase livestock off-take in the traditional pastoral production system by using livestock grazing management strategies that benefited from inputs. Grazing management strategies emphasised developments such as watering facilities, provision of supplementary feed and specialised livestock breeds. Both institutions regarded livestock as the primary level of production rather than a secondary production level based on sustainable harvest of forage or fodder from grazingland.

## Inner Mongolia

Factors leading to diminished ecological stability in steppe grazingland in Inner Mongolia in the historical era originated from attempts to increase productivity through more intensive agricultural production (Sheehy 1992). The process and pattern of instability in grazingland ecosystems was expansion of sedentary agriculture from temperate agricultural regions, especially China during periods of dynastic strength, into semi-arid and arid steppe areas grazinglands of the Mongolian Plateau. Conversion of pasture to cropland and concentration of livestock near cultivated areas disrupted traditional

extensive livestock grazing management strategies that were adapted to maintaining long-term ecological balance. Over relatively short time periods and for a variety of reasons, the shift from extensive to intensive grazing management strategies caused both ecological and economic instability. As ecological thresholds were reached and crossed, pastoral ecosystems entered a new steady state equilibrium that was unable to support sedentary agriculture. Ultimately, the attempt to move sedentary agriculture and intensive grazing management strategies into the Mongolian environment collapsed, allowing the gradual re-establishment of stable grazingland environments in the affected area.

Currently, pastoral ecosystems in Inner Mongolia are being subjected to another period of sedentary agricultural expansion and imposition of intensive grazing management strategies. The latest attempt to increase productivity of semi-arid and arid steppe by increasing livestock off-take and by using fallow farming techniques is increasingly affecting long-term ecological stability. According to recent reports, a total of 35.6 percent, or 213,000 km<sup>2</sup> of grazingland is ecologically unstable (Neimenggu Ribao 1993). Pasture capable of supporting optimum livestock production is declining by over 60,000 ha/year and desertification is expanding by 340,000 ha/year. In east-central Inner Mongolia, deterioration of formerly productive grazingland is widespread and the result of both environmental and socio-economic influences (Sheehy 1993).

Agricultural development in the region has focused on conversion of steppe areas adapted to supporting extensively managed livestock to marginal rain-fed cropland. Conversion of the most productive grazingland to cropland has been accompanied by large increases in the number of livestock, the introduction of European breeds as a replacement for less productive but adapted native Mongolian livestock, and specialisation in livestock kind (Sheehy 1992). As part of this process, the Mongolian minority engaged strictly in animal husbandry has been overwhelmed by the

Han majority engaged in sedentary agricultural activities and intensive livestock production. The reduction in grazingland area and productivity, and the increase in livestock numbers has forced adoption of intensive grazing management strategies for livestock production.

The rate and extent of ecological instability affecting grazingland ecosystems in Inner Mongolia and Mongolia have differed considerably even though environmental and climatic conditions and the traditional pastoral livestock production system were relatively homogeneous. In Mongolia, grazingland ecosystems are generally intact and ecologically stable except in specific areas. In Inner Mongolia, grazingland ecosystems are generally becoming ecologically unstable except in specific areas; pastoral ecosystems over a wide area are experiencing soil loss from wind and water erosion, annual forage standing crop is declining and livestock productivity is declining.

Grazing management strategies in Inner Mongolia have been influenced more by the sedentary agricultural production system characteristic of temperate China. Comparison between Mongolia and Inner Mongolia suggests that external factors stimulating exploitative grazing management strategies are more influential in Inner Mongolia than in the Mongolian Republic. These factors included: (a) higher human population; (b) dominance over the animal husbandry minority by sedentary agriculturalists with a different perspective on acceptable exploitation of grazingland ecosystems; (c) an environment with higher, albeit marginal, potential for successful sedentary agricultural production; (d) a large population with high demand for food and fibre in relatively close proximity; and (e) little or no influence by the animal husbandry minority in influencing agricultural policy and decision-making.

## Future management strategies for Mongolian grazingland

In both Inner Mongolia and Mongolia, off-take from livestock using forage produced on grazingland provides a major source of food and fibre for rural and urban populations. Sustainable use of pastoral ecosystems by livestock to satisfy social, economic and dietary needs of the human population of these two regions is both necessary and desirable.

### *Inner Mongolia*

The traditional pastoral livestock production system based on an extensive grazing management strategy is no longer a viable option for most of Inner Mongolia (Sheehy 1992). In some areas, even the semi-extensive grazing management strategy is no longer capable of supporting livestock production because of the current widespread ecological instability resulting from conversion of grazingland to cropland and increases in livestock numbers. Intensive grazing management strategies that are employed as stratagems to increase livestock off-take in a declining production environment are contributing to the widespread ecological instability.

In Inner Mongolia, agricultural policy-makers can either continue policies that reduce the amount and quality of pasture available for the high number of livestock and that increase ecological instability, or alternatively livestock numbers can be brought into balance with carrying capacity at levels sufficient to allow ecological stability to be re-established. The latter option, which would permit resumption of a semi-extensive livestock grazing management strategy, is unlikely to be selected by the agricultural administration because of its social and political ramifications. It is more likely that the pattern established by previous expansionary periods of sedentary agriculture into arid and semi-arid steppe grazinglands will be completed. However, the scale at which grazinglands will lose ecological stability will be much greater than during the historical period.

### *Mongolia*

Extensive and semi-extensive livestock grazing management strategies remain feasible strategies for livestock production in Mongolia because pastoral ecosystems are more ecologically stable. However, re-establishing a pastoral livestock production system based solely on an extensive livestock grazing management strategy is a doubtful option (Bazargür *et al.* 1992). The collective and state farm systems generated social and economic changes and fostered agricultural development that will be difficult to change. A livestock production system based solely on a producer-regulated, extensive grazing management strategy, while a necessary component, is not likely to be the livestock production option leading to ecological stability.

Agricultural policy-makers in Mongolia, because grazinglands remain more ecologically stable, still have the opportunity to select a viable management strategy. Although undefined at the present time, the grazing management strategy should incorporate an integrated, systematic approach in which the environmental as well as the economic and social parameters influencing livestock production are considered in planning and management decisions. In the dynamic Mongolian ecosystems, it is necessary to delineate multi-dimensional, dynamic relationships between (a) grazingland ecosystems, (b) livestock production levels and (c) the various goals of the resource manager and/or the livestock producer.

### **An approach to successful grazing management**

Transferring Western semi-extensive livestock grazing management strategies to Mongolian grazinglands will probably fail and cause greater ecological instability to Mongolian grazinglands (Vavra and Raleigh 1982). Likewise, grazing management strategies using criteria derived solely from environmental and ecological principles that are unrelated to economic and

social factors influencing livestock use is both undesirable and unrealistic.

An integrated, systematic approach to grazing management has met with limited success in other developing countries. Major impediments to success have been using short-term economic criteria as the sole basis for organising livestock production and the inability to obtain, access, organise and integrate information about pastoral grazing resources and the livestock production system. Lack of information, especially ecological information, is an impediment to making informed planning and management decisions concerning livestock production in the grazingland environment (Sheehy *et al.* 1991).

Successfully integrating ecological information and livestock production decisions into a grazing management strategy leading to long-term ecosystem stability requires an awareness by both the livestock producer and the agricultural policy-maker that environmental limitations and ecological principles impose an upper limit on livestock production that cannot be overcome by management alone. Grazingland-based production systems function under ecological principles and environmental constraints which limit the products and the production levels that can be supported. Integrating ecological considerations into planning and management decisions involves relating products and production levels to human social and economic goals. Production goals for livestock and livestock products must be based on limits imposed by an ecologically based livestock stocking rate that ensures that the pursuit of social and economic goals does not result in irreversible deterioration of the pastoral resource.

During the current transition to a market based economy, there are opportunities to develop an institutional capacity to administer and use grazingland in a sustainable manner. It is of great importance to future livestock production that traditional livestock rearing practices that evolved in accordance with environmental limitations be maintained and that practices that are being promoted to increase pro-

ductivity be realistic with regard to those same limitations.

Mongolia, because of its unique past and current status as a mainly pastoral livestock society, appears to have an overriding land conservation ethic that acknowledges sustainable use, not maximum exploitation, as the goal of grazingland use. Mongolian agricultural policy-makers and producers acknowledge that the livestock production system should be based on livestock off-take at a conservative rate sufficient to maintain ecological stability. Agricultural policy-makers in Inner Mongolia do not appear to have reached a similar conclusion regarding the necessity for sustainable livestock production systems and ecological stability.

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