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THE ROLE OF MONGOLIAN NOMADIC PASTORALISTS' ECOLOGICAL KNOWLEDGE IN RANGELAND MANAGEMENT

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Abstract. Past stereotypes of indigenous pastoralists as ignorant and environmentally destructive are being revised as ecological and social science research advances. As yet, little documentation of pastoralists' ecological knowledge exists, and even less is known about how this knowledge is, or can be, applied to resource management. This paper outlines the ecological knowledge of Mongolian nomadic pastoralists and its role in rangeland management, showing how herders' knowledge is reflected in pasture use norms and attitudes toward pasture privatization, as well as herding practices. The paper explores the potentially contradictory roles of pastoralists' ecological knowledge and perceptions in the current management context.

Key words: grazing management; livestock; Mongolia; nomadic herders; pastoralists; pasture privatization; rangelands; Traditional Ecological Knowledge.

INTRODUCTION

Range and livestock development projects implemented over the past half century were frequently based on flawed ecological and economic assumptions, reinforcing the existing stereotype that indigenous pastoralists were destructive of the resources they relied upon and unconcerned about, or ignorant of, the ecological consequences of their actions. The failure of many such projects (Sandford 1983), coupled with recent advances in ecological and social science research, challenge these assumptions and indicate that pastoralists' behavior is often ecologically and economically appropriate. The assumption of closely linked plant–herbivore dynamics that underlies conventional range management practices has been called into question by research demonstrating that abiotic factors may play a more important role in limiting herbivore populations (Ellis and Swift 1988, Scoones 1993) and in determining plant productivity and species composition (Westoby et al. 1989, Milchunas and Lauenroth 1993), than do plant abundance and herbivory, respectively, particularly in marginal environments such as arid and semiarid rangelands. The assumption that individuals who exploit a jointly used resource (such as a common grazing area) will inevitably act in a rationally self-interested manner to maximize individual benefits at the expense of group welfare and the health of the resource (Hardin 1968) has been undermined by empirical evidence (McCay and Acheson 1987, Feeny et al. 1990) and improved theory (Ostrom 1990, Bromley 1992).

As it becomes clear that pastoralists are often knowledgeable about their environments and capable of regulating resource use among themselves (Niamir 1995), examining the role that pastoralists' ecological knowledge plays in resource management becomes increasingly important in understanding the conditions necessary for the success of traditional resource management institutions and the development of viable new institutions. Traditional ecological knowledge (TEK) consists of biophysical observations, skills, and technologies, as well as social relationships, such as norms and institutions, that structure human–environmental interactions. TEK is transferred from one generation to the next, representing cumulative local knowledge, but is modified and amended as a result of new experiences and observations. TEK is specific to particular places and groups of people. Although the distribution and quality of specialized knowledge varies among individuals and groups within any community, a common denominator of ecological knowledge often underlies community resource management institutions. Common property theorists have suggested that shared beliefs and preferences within a community (Taylor and Singleton 1993) and the shared belief that users will be harmed if mutual agreement about the use of a resource is not reached (Ostrom 1990) are among the criteria that facilitate the successful development of common property resource management institutions. Common property resource management institutions regulate the use of resources from which it is difficult

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to exclude potential users, but where use by one person reduces the amount of resource remaining for others, such as extensive rangelands. This paper examines the role of ecological knowledge in the rangeland management practices of Mongolian nomads in light of these assertions from common property theory. Specifically, it shows how broadly shared ecological knowledge is reflected in traditional rangeland management institutions in Mongolia, and demonstrates that herders clearly articulate the relationship between local environmental conditions and their nomadic resource management strategy. However, it also suggests that herders lack a shared perception that their rangelands will be degraded to the point of threatening their livelihoods if they do not reestablish strong resource management institutions. Thus, in the current context, local ecological perceptions may impede herders from rebuilding strong regulatory institutions to manage their rangelands.

First, I briefly outline the types of ecological knowledge that herders possess and show how this knowledge is embodied in pasture use norms and attitudes. Second, I illustrate how herders apply their knowledge to make herding decisions, including some of the socioeconomic constraints to the use of ecological knowledge. Finally, I consider how shared ecological knowledge facilitates or undermines the prospects for successful self-regulation of pasture use within groups of herders. The data presented are based on participant observation and interviews with 215 Mongolian herders, 67 government officials, and 12 professional researchers or scientists, conducted in 1993–1995 in west-central Mongolia, primarily in Jinst and Bayan-Ovoo Sums (districts), Bayankhongor Aimag (province), and Tariat and Ikh Tamir Sums, Arkhangai Aimag, Mongolia (Fig. 1).

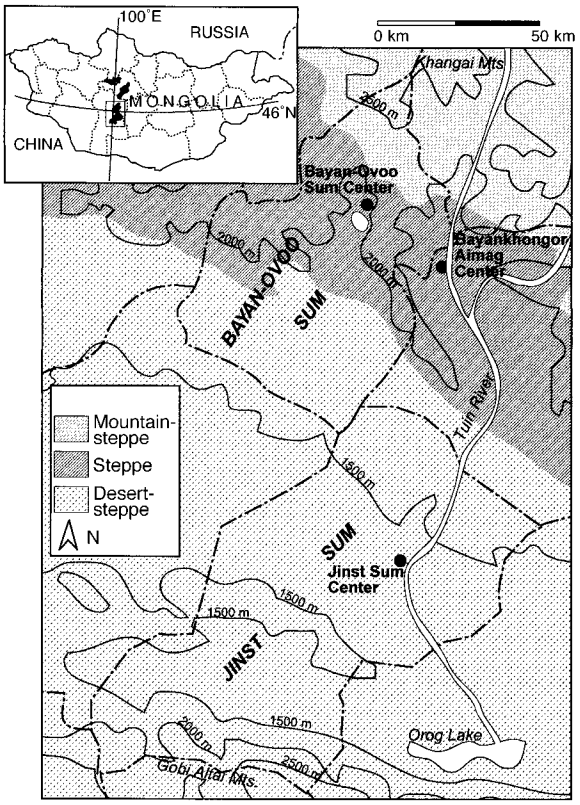

FIG. 1. Map of the study area. Data on herders' ecological knowledge were gathered in 1994 and 1995 in Bayan-Ovoo and Jinst Sums (districts), Bayankhongor Aimag (province) (area in the box on the inset map and shown on the large map). Additional interviews were conducted in 1993 in Tariat Sum and in 1995 in Ikh Tamir Sum, Arkhangai Aimag (shaded areas above the box on the inset).

BACKGROUND

Mongolia is a land-locked country 1.56×10^6 km^2 in size with a population of 2.5×10^6 people and $>30 \times 10^6$ head of livestock (camels, cattle, horses, sheep, and goats). Most of the country is steppe grassland, falling into three major ecological zones: the mountain-steppe, steppe, and desert-steppe. Roughly one-third of Mongolians are pastoralists, and at least half of the nation's population depends directly or indirectly on the pastoral economy for its livelihood. In addition to domestic herbivores, Mongolia's grasslands support important populations of wild herbivores, including two species of gazelle (*Gazella subgutturosa* and *Procarpa gutturosa*), argali (*Ovis ammon*), ibex (*Capra sibirica*), wild bactrian camel (*Camelus ferus*), wild ass (*Equus hemionus*), the saiga antelope (*Saiga tatarica*), and reintroduced populations of Przevalski's horse (*Equus przewalskii*). The highest concentrations of wild grazers are in the sparsely inhabited eastern steppes of Mongolia, where vast herds of gazelle migrate (Schaller 1998). Argali and ibex are found in rugged mountainous areas, which also experience less use by domestic livestock. Only one wild ungulate, *P. gutturosa*, the white-tailed gazelle, was observed in the study districts and no herders reported, or were observed, hunting wild ungulates, although mountain-steppe herders were often avid marmot hunters, and herders from both districts occasionally hunted wolves and foxes. The focus of this paper is herders' knowledge of domestic livestock–climate–vegetation interactions and its application to grazing management.

Before 1924, Mongolia was divided into ~100 hereditary territorial units held by secular or religious nobles. In this study area, the powerful lama (religious leader) who controlled the territory allocated pasture and regulated the seasonal migrations of his subjects. Informal, customary institutions of pasture use enforced by herders themselves coexisted with this formal regulatory system. From 1924–1990, Mongolia operated under a Soviet-influenced socialist government with a centrally planned socialist economy. By 1960, all herders had joined livestock collectives, where they

herded state-owned animals for a regular salary under the close supervision of the collective administration, which took over the role of allocating pasture and regulating pasture use. Although some traditional knowledge and skills were probably lost and customary institutions undermined (Mearns 1996), herders maintained much of their specific animal husbandry knowledge and skills during this era. Even though the scope of nomadic migrations was curtailed during the collective era, the basic tenets of seasonal mobility were upheld and enforced, supported by subsidized transportation, auxiliary labor, and water developments. In 1992, following Mongolia's first democratic elections in 1990 and the liberalization of the pastoral economy, herding collectives were dismantled and most state owned livestock was privatized. Pasture land remained state-owned, to be used in common by the herders of defined districts (*sums*) and subdistricts (*bags*). Herders became, once again, entirely responsible for their own herd management decisions, as well as all production risks and inputs. Once the collectives were dismantled, there was no longer a formal regulatory institution to govern pasture use. The infrastructure that collectives had provided (e.g., transportation for nomadic movements and auxiliary herding labor) also vanished. The number of herding households increased as economic conditions in settlements declined and town dwellers acquired livestock and moved to the countryside to become herders. The lack of formal regulatory institutions, coupled with the weakening (during the collective era) of customary institutions for allocating pasture and enforcing pasture use norms, and the problem of obtaining transportation and labor to make seasonal moves, resulted in a change from coordinated seasonal movements among well-defined areas to increasing year-round grazing of desert riparian areas and winter and spring reserve pastures. There was also an increase in uninvited herders camping on other groups' customary campsites or grazing their customary reserve pastures, a form of trespassing. Significantly, livestock numbers in the study areas in 1994 remained at or well below their peaks over the past 40 years, and remote parts of the districts were underused. The spatial and temporal distributions of livestock, not overall stocking densities, were altered as a result of changing institutions of resource access and regulation of resource of use.

Although these trends in land-use patterns have been documented, the current ecological conditions and trends of Mongolian rangelands are disputed; no reliable estimates of the extent of degradation exist. It is generally agreed by international experts that the condition of Mongolia's rangelands is superior to that of rangelands in adjacent Russia and China, perhaps, because of the persistence of mobile resource management strategies during the socialist era (Sneath 1998). In 1994, the Mongolian legislature passed a national land use law that provides for the leasing of pasture to individuals and groups of herders in accordance with traditional patterns of seasonal nomadic movements and subject to monitoring using ''Western'' scientific criteria. At this writing (September 1998), the leasing provisions of the law had not yet been implemented.

Ecological Knowledge of Mongolian Herders

The classification of pasture resources.—Herders' knowledge of plant–animal–environment relationships, and the management practices based on this knowledge, are embedded in their classification of pasture resources. Herders classify pasture areas using a number of different criteria, including the season in which they are grazed, their nutritional quality and suitability for different types of livestock, topography and elevation, aspect, ecological zone and plant community, color, soil characteristics, water quality and quantity, distance from camp, and degree of utilization by livestock. Herders' classifications reflect both ecological reality and their use of different landscape components. For example, pastures in the mountain-steppe, near rivers and on mountaintops and north-facing slopes are classified as ''cool'' grazing territories (*seruun nutag*), whereas the desert-steppe, waterless steppe pastures, and south-facing slopes are ''hot'' grazing territories (*khaluun nutag*). The five types of Mongolian livestock are similarly classified as cool-muzzle (*seruun khamar*), hot-muzzle (*khaluun khamar*), or intermediate animals. Cool-muzzled animals (camels and goats), must graze in ''hot'' territories, whereas hot-muzzled animals (yaks and horses) are best suited to ''cool'' territories. Sheep, traditionally the backbone of the Mongolian pastoral economy, are adaptable to both types of habitats. This classification of livestock and their foraging habits corresponds closely with the Western classification of range animals as grazers (warm-muzzled animals), browsers (cool-muzzled animals), and intermediate feeders (Holechek et al. 1989).

Knowledge and use of plants.—A herder's knowledge about a particular plant may include the ability to recognize and distinguish it from other taxa, knowledge of the conditions in which it grows, specific locations where it can be found locally, other plants found in association with it, its palatability for different species of livestock (including the edibility of different plant parts in different seasons), its phenology and life history, its root system, its resistance to grazing, and its value for other human uses such as fuel, medicine, or food. Knowledge of specific species is quite variable among herders of differing experience, geographical location, and gender. However, forage preference ranking exercises conducted independently with male and female herders suggest that herders agree on the value of major forage species, as well as the undesirability of potentially toxic species (Table 1).

Perceptions of ecological processes and changes.—

TABLE 1. Results of a forage ranking exercise conducted independently with four desert-steppe herders (three men and one woman). Herders were asked to rank common pasture plants as desirable, acceptable, or undesirable.

Rank 1 (most desirable)	Rank 2	Rank 3	Rank 4	Undesirable (toxic to livestock)
Khyalgana	Kharagana	Bajoon	Shireg	Chotangar
Stipa spp.	*Caragana* spp.	*Rheum nanum*	*Carex* spp.	*Apocynum* spp.?
Taana	Ulaan bodargana	Nokhoin shiir	Ders	Khers
Allium polyrrhizum	*Reumuria soongorica*	*Zygophyllum xanthoxylon*	*Achnatherum splendens*	*Salicornia europea*?
	Khumuul	Tsagaan bodargana	Khiag	
	Allium mongolicum	*Salsola passerina*	*Elymus* spp.	
	Sazag	Builis	Kharmag	
	Ptilotrichum canescens	*Amygdalus mongolica*	*Nitraria* spp.	
	Bagluur		Arts	
	Anabasis brevifolia		*Juniperus* spp.	
	Ayg		Tsolkhir	
	Artemisia xerophytica		*Agriophyllum pungens*	
	Tsagaan deseg		Khazar Uvs	
	Eurotia ceratoides		*Cleistogenes songorica*	
	Yerkhog		Suutei Nogoo	
	Agropyron cristatum		*Scorzonera* spp.	
			Zeergene	
			Ephedra spp.	
			Shavag	
			Artemisia (*schischkini*?)	

Notes: Plants that were ranked desirable by all four informants are classified Rank 1, plants that were desirable to three informants are classified Rank 2, etc. The most desirable plants are highly palatable to a wide range of livestock. Many of the Rank 2 and Rank 3 species are excellent forage species for camels and/or goats, important animals in the desert-steppe region. Some of the desirable plants are also used for human food or medicine (*Allium, Rheum, Agriophyllum, Nitraria*), firewood (*Caragana, Artemisia, Amygdalus*), camel nosepieces (*Amygdalus*), or ceremonial purposes (*Juniperus*).

Herders' often detailed knowledge of the growth habits of plants suggests a strong understanding of ecological relationships and processes. Changes in pasture conditions across space and over time were attributed to climatic differences at regional spatial and long-term time scales, and to local variations in edaphic factors, rainfall patterns, and livestock and human land use at smaller spatial and/or shorter time scales. The amount and timing of precipitation were the most important determinants of short- and long-term productivity, according to herders. A desert-steppe herder described the situation in his region as follows. ''The grass will grow as much as it snows in the winter. And the rain. The grass will grow as much as it rains. For instance, do you remember, I've shown you the plant *bagluur* [*Anabasis brevifolia*]. It has eight joints at its peak of blooming. And the top joint when the plant has completely grown up has a big yellow flower, an excellent forage for livestock. . . . If it's not humid enough, the plants don't grow well. For example, *bagluur*, if this plant has only two or three joints, the herdsman will move to another place . . . The herdsman can't predict where the good growth will be. Before moving he must see it with his own eyes. If he is satisfied after the inspection, if the family is able to move there, they will move'' (Sonam, Jinst Sum 1995).

Long-term changes in productivity in both the mountain-steppe and desert-steppe were usually explained as the result of changing climate (fewer rains) and declines in soil fertility (the soil getting ''old''). Many herders made the analogy between an aging earth and an aging person. ''Everything in the world is changing except the sun and the moon. All over the world is changing, becoming worse. The planet is getting older. The rain doesn't fall, so the ground is going bad from the bottom up. Because it is less rainy, it is more sandy. Sand is eating the grasses. When it does rain, it rains too much and floods the pasture'' (Piljee, Jinst Sum 1994).

''Nature seems to be getting older and older, almost dying. . . . It's similar to human beings, when they get old and die. . . . Look at me know. How do I look? But how did I look when I was young? I think it's the same way. . . . On the one hand people do destroy nature. On the other hand, nature itself is getting older, the growth of plants is getting worse. Their roots are disappearing.'' (Byamba, Jinst Sum 1994).

''When I was a child, the plants were much better. Some of them are disappearing, some have already disappeared. The growth is not comparable to that in my childhood. They are shorter and grow [widely spaced]'' (Sangiseree, Jinst Sum 1994). Climate records for the past 30–40 years in the area indicate that mean annual rainfall has remained constant or declined slightly and mean annual temperature has risen, suggesting an empirical basis for herders' observations.

Although many changes in species composition were attributed to long-term climate changes, herders also linked shifts in species composition to human activities. In addition to livestock grazing, activities such as

improper harvesting of fuelwood and building materials by pulling plants up by the roots; roads and vehicle tracks; development of permanent settlements; and abandonment of cultivated fields following the collapse of the collectives were cited by herders as reasons for species changes.

Intermediate-term changes (5–15 years) in pasture productivity and species composition were attributed to human, livestock and rodent activities, as well as multiyear droughts. A mountain-steppe herder gave a detailed explanation of the sequence of plants found on an animal bedding ground. According to this account, the intense disturbance of continuously bedding animals in one place over a season leads to the ''death of the soil.'' Complete recovery takes about 10 years. In the first year, disturbance-related forb species unpalatable to livestock colonize the site (*Artemisia glauca, A. adamsii*). After a period of years, these are slowly replaced by ''hard grasses,'' such as *Elymus* species and *Agropyron cristatum.* After many years, thin, tender grasses (*Festuca* spp., *Poa* spp., *Koelaria macrantha*) and palatable forbs reestablish.

Short-term interannual changes in pasture conditions were perceived to be caused by weather and livestock, and were viewed as temporary and reversible, particularly if weather conditions were favorable. Similarly, seasonal changes in pasture conditions and species composition were perceived as natural and cyclical.

Most herders, as well as local officials, recognized that some areas in their territories show signs of overuse or improper use, usually near settled centers, roads, trekking routes, and rivers or wells. Herders relied heavily on soil conditions and vegetation cover when assessing pasture conditions, in addition to accounting for species composition and plant (or stubble) height. Severely or permanently damaged pastures were referred to as weedy or waste lands (*khog gazar*), black or bald pasture (*khar* or *khadsgay belcheer*), or places where the ''soil has died'' (*khurs ukhsen gazar*). *Artemisia glauca,* in the mountain-steppe, and *A. adamsii,* in the steppe, were the most widely recognized indicator species for overused pasture. However, other plants that Western-trained range managers might consider to be undesirable weeds (*Chenopodium* spp., *Plantago* spp., *Urtica* spp.), were valued by herders for food or medicinal uses, or as emergency forage. *Artemisia frigida,* which increased with moderate grazing, was a highly valued forage species. Ungrazed mountain pastures, on the other hand, were considered to be poor forage by herders because the heavy thatch of litter limits growth to coarse, tall grasses that they consider undesirable.

The Role of Herders' Ecological Knowledge in Rangeland Management

The rationale for a nomadic strategy.—Herders' perceptions of spatial and temporal variability in their environment are reflected in their nomadic herding strategy. A good herder is said to constantly monitor both his herds and his pastures, seeking to ''harmonize'' the needs of his stock with daily, seasonal, and interannual changes in plants, weather, and water availability. The repeated patterns of seasonal movements among customary winter, spring, summer, and autumn pastures are a means of meeting the changing physiological demands of the five Mongolian species of livestock (camels, cattle, horses, sheep, and goats) throughout the year with the most suitable available resources. These cyclical changes in livestock and pasture conditions are predictable, and the location of basic pasture types remains constant between years. Interannual variation in the pattern of precipitation, and thus the location of productive pasture in any given year, leads to local adjustments in seasonal movement patterns and the use of alternative customary grazing grounds and campsites. Climatic disasters are unpredictable in the timing of their occurrence, but the probability of their occurrence at some time is 100%. Severe winter storms occur every 5–8 years and result in high rates of density-independent livestock mortality. The need to avoid or escape these disasters, and to minimize their impact on pastures and herds, accounts for occasional large between-year variations in pasture use.

Herders articulate clearly these ecological reasons for their mobile and flexible lifestyle, past and present. ''There in the Gobi [desert-steppe] it is very hot in the summer. When the sun is shining, plants such as *taana* [*Allium polyrrhizum*] are extremely rich for livestock and the animals won't fatten. They could even die if they ate too much of these plants. Therefore, herders nomadized to the Khangai [mountain-steppe] region for two to three months. But when autumn begins, and the *taana* is half dried, we nomadized back to the Gobi. Thus we nomadized three times a year between the [desert-steppe] and the [mountain-steppe]. This is why our livestock fattened by the winter without any special fodder. Because of this fatness, they could survive the harshness of the winter and spring seasons. This is not my method [only]. All the herders of the Bayankhongor region did like this'' (Baramsai, Bayan-Ovoo Sum 1995).

''Why don't we stay in the same place all the time? Because if we stay in the same place, the livestock stops getting fat. And also there are many flies in the summer and the water is too salty and not suitable for livestock. If the water is too salty the animals will get diarrhea and lose weight. Warm water also causes an increase in worms in animals. Every disease is abetted by warm water. That's why I'm . . . looking for clear water and good grass'' (Sangiseree, Jinst Sum 1994).

''We don't know how to combat droughts and we have no special equipment. The only way is to find good pasture where the grass is growing and follow the livestock'' (Sangiseree, Jinst Sum 1994).

''We lived on the boundary of two *sums.* But in some very cold and snowy winters we moved to better places, even to other *aimags* or *sums.* In summer, if the grass did not grow, we moved to places where the pasture was better. . . . If it was a good autumn, we nomadized to our native territory, but some autumns we passed on the other side, because of the bad condition of pastures in our native land. Thus, where the pasture was good, we nomadized to this land and spent the season there. Sometimes it occurred that we spent the whole year far from our native territory.'' (Sharav, Bayan-Ovoo Sum 1995).

Norms of pasture use and attitudes towards land tenure reform.—Herders' ecological perceptions of temporal and spatial variability in forage availability give rise to two important norms of pasture use. First, herders must collectively refrain from grazing common winter and spring pastures during the summer and autumn, so that those pastures will be available during the harsh non-growing seasons. The second is a norm of reciprocity that prevents herders of one community from denying access to their pastures to herders from another area seeking refuge from a climatic disaster (drought or winter storm). The implicit understanding is that the other community would offer the same reciprocal hospitality if circumstances were reversed.

A corollary to these norms is the herders' nearly universal conviction that individual private ownership of pastureland in their semiarid and variable environment would lead to disaster. Many herders articulated the need to keep access to pastureland unrestricted by a one person, one piece of land system of tenure. ''The reason why the land is not [privately] owned is that we are a nomadic people. If a winter storm or drought happens and there is a lack of pasture, we move to Khar Us or even to the *sum* center. If the land were private, we would have no rights to move somewhere else. Then the livestock would suffer. That's why there are no private lands and we have rights to move to where the pasture is good'' (Sangiseree, Jinst Sum 1994).

''In my opinion, there is no need to possess a fixed area to herd our stock. Today we must live according to the principle, 'occupy the land to the edges of your home and eat as much as the bridle allows.' It is a disaster if one herd limits another. . . . Privatization is a measure to restrict the freedom of both herd and herdsman. Privatizing land to individuals harms the right of the herd to move. Certainly, without private ownership of land in urban centers, it is impossible to expect effective and rational use of land. But ordinary herdsmen are not interested in staying in one place until a lot of dung collects there'' (Tsogdbadrakh, Bayan-Ovoo Sum 1995).

Herding practices and decision making.—The herd and resource management decisions that herders make each day, month, season, and year are the concrete manifestations of their nomadic strategy. Researchers who study the foraging behavior of large grazers use the term ''matching'' to denote foraging behavior in which the amount of time a grazer spends in a resource patch is proportional to the quality and quantity of forage in the patch (Senft et al. 1987). In the context of a pastoral ecosystem, where domestic livestock are closely herded by pastoralists, herders play a key role in determining foraging patterns. Within the constraints of access to resources and transportation, herders assist grazing animals in accomplishing optimal matching behavior across a range of scales. At any given spatiotemporal scale, various different factors (abiotic, biotic, and social) influence herder decisions and animal behavior (Table 2).

At the decision frequency of a season and the spatial scale of the landscape or ecological region, the major decisions include the choice of seasonal pastures and campsites, and whether and where to reserve pasture for winter and spring use. At this scale, social decision factors constrain the ability of herders to apply their ecological knowledge in an optimal fashion. A survey of a stratified random sample of households in Jinst and Bayan-Ovoo Sums conducted in 1995 revealed that, although herders of differing wealth and herding experience were similar in their use of traditional skills and in their norms of pasture use, poor herders were significantly less mobile, and both poor and new herders (those who became herders after privatization) were more likely to trespass on other herders' campsites and to be trespassed upon (Fernandez-Gimenez 1997). Access to labor and transportation (which differed between rich and poor herders), and the source of rights to pasture (which varied between rich and poor, and new and old herders) were the main determinants of mobility and trespass behavior. Access to transportation, labor and pasture rights were, in turn, linked to larger social and economic processes. The dismantling of collectives meant the end of state transportation assistance, as well as an end to state enforcement of seasonal movements and state allocation of pasture. Poor herders often did not own sufficient pack animals to make seasonal moves and lacked surplus to exchange for motorized transport. Similarly, poor and new herders were more likely to gain access to campsites and key pasture areas through alliances with wealthier kin or acquaintances rather than by direct inheritance, resulting in weaker rights. Less mobile households and those with less secure rights were more likely to graze reserve pastures out of season. Thus, large-scale processes such as declining economic conditions and lack of strong, formal regulatory institutions constrained resource use patterns at the regional/seasonal spatiotemporal scale.

Lessons from Mongolia

The Mongolian experience offers several potentially contradictory lessons about the role of TEK in resource management in traditional and contemporary contexts.

TABLE 2. Hierarchy of herding decisions, showing the abiotic, biotic, and social factors that influence specific decisions across a range of spatiotemporal scales. Some factors operate across a range of scales, whereas others are scale specific.

Hierarchy	Frequency and scale of decision		
	Day; patch or plant community	Week; plant community or landscape	Season; landscape or region
Decision	choose route of grazing path	choose grazing area	choose seasonal camp and pasture
Decisionmaker	herder for the day with household, or camp head	camp and/or household head	camp head
Decision factors			
Abiotic	temperature wind speed and direction rain, snow topography	weather trends topography	weather changes topography soil conditions mineral availability
Biotic	reproductive and nutritional status of animals animal behavior pasture utilization plant species present plant phenology	reproductive and nutritional status of animals animal behavior water availability forage quantity and quality herd size and composition predation poisonous plants disease outbreaks	reproductive and nutritional status of animals animal behavior water availability forage quantity and quality herd size and composition
Social	knowledge/skill/ability labor available other tasks (fuel and water collection)	knowledge/skill/ability labor available access to pasture and campsites number of other households information available seasonal productive activities (e.g., milking, combing cashmere) livestock theft	knowledge/skill/ability labor available access to pasture and campsites number of other households information available seasonal productive activities (e.g., milking, combing cashmere) transport available household size norms of pasture use social networks access to markets and services formal regulation, if present

In the ''traditional'' context, shared ecological knowledge and perceptions are strongly reflected in pasture use norms and herding practices, leading to a flexible, mobile system of pastoral land use that persisted, with modifications, over centuries. In this context, shared ecological knowledge was the foundation for biosocially sustainable resource management institutions. Despite the inevitable variability in the kind, quantity, and quality of ecological knowledge held by different members of a herding community, the majority of herders shared a base of knowledge, founded in empirical reality, that gave rise to a widely embraced set of norms, attitudes, and practices. This shared base of knowledge is largely intact, and most herders continue to articulate the norms and attitudes grounded in it. If shared beliefs and norms are essential to the success of common-property resource management institutions, then the persistence of widely and strongly held ecological beliefs and norms suggests that one cornerstone of the foundation for sustainable, locally based resource management institutions may exist in the study communities.

My research also suggests that the use of ecological knowledge is constrained by a variety of factors, which vary across scales. At regional/seasonal spatiotemporal scales, factors such as lack of access to transportation, campsites, and key pasture areas constrain herders' ability to apply their ecological knowledge, resulting in behaviors that violate widely held norms of pasture use. These factors are, in turn, linked to the larger social, economic, and political processes of decollectivization, livestock privatization, and the transition to a market economy. The resulting unsustainable grazing patterns suggest that there is a need to reestablish strong local institutions to regulate pasture use.

It is not clear that herders recognize a connection between recent changes in land use patterns and future pasture degradation and threats to their livelihoods. Because herders generally share the perception that degradation is either an inevitable process of earthly aging or a temporary and reversible phenomenon, many do not perceive an imminent threat to the resources they use or to their future livelihoods. Thus, herders may lack the necessary incentive to reorganize institutions to coordinate pasture use among themselves. This does not necessarily imply that their ecological observations to date are wrong or inaccurate; it is likely that climate change over long and short periods dominates ecolog-

ical relationships in much of Mongolia. Rather, herders' experience with climate-driven vegetation dynamics and relative lack of experience with high densities of livestock grazing year-round in concentrated areas may limit their ability to foresee potentially irreversible degradation.

Thus, the problem remains of how to develop or strengthen resource management institutions in a rapidly changing social and economic environment, in which it is unclear whether the conditions for locally generated solutions exist. In this contemporary context, what role can herders' TEK play in the monitoring and management of Mongolian pastureland? Several possibilities are outlined:

1) The national land use law passed in 1994 specifies that a pasture leasing system be implemented in accordance with traditional seasonal patterns of nomadic land use. Herders must be intimately involved in any local implementation of the law, especially local delineations of these patterns. In this process, particular attention should be given to who is consulted and who benefits and loses from the outcomes. In general, ''new'' resource management institutions, such as land leasing, should respect successful aspects of pre-existing institutions, incorporating or elaborating on them, rather than supplanting them. In the Mongolian context, coordinated seasonal movement was historically the key institution for sustainable land use. In situations where traditional institutions are no longer functioning successfully, the reasons for their decline must be thoroughly investigated rather than assumed.

2) The land use law also calls for a national land certification program, which would require the collection of baseline soil and vegetation data on all leased pasture land, as well as periodic monitoring. Given the lack of national resources for inventory and monitoring of this scope, herders' cooperation and assistance is essential to the program. Herders' ecological knowledge should be further investigated to help identify scientifically valid, but easily measured, monitoring criteria that are culturally appropriate. Wherever possible, herders should be trained and enlisted to carry out local monitoring, in coordination with their participation in local land use regulation.

3) Scientific research on the condition and dynamics of Mongolian rangelands should continue in concert with ethnoecological research on herders' knowledge and perceptions. One objective of such collaborative research is to identify and resolve conflicting perceptions of ecological conditions and dynamics held by some herders and researchers, such as the relative importance of variations in climate and grazing to pasture conditions. An assessment of the ecological status and trends on Mongolian rangelands based on mutual understanding among researchers, managers, and herders, and a shared knowledge base including both ''scientific'' and ''traditional'' contributions, should make a strong foundation on which to reconstruct ecologically sound and culturally appropriate pasture management institutions.

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