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DISCUSSION PAPERS

MONGOLIA

Livestock and Wildlife in the Southern Gobi Region, with Special Attention to Wild Ass

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Cover image: Horses drinking from a shallow lake formed by migrating sand dunes. Photographer: Cody Sheehy 2009

Table of Contents

Foreword vii

Acronyms and Abbreviations ix

Acknowledgements xi

Executive Summary xiii
- Economic Development xiii
- Livestock and the Livestock Production System xiv
- Wildlife: Status and Trends xv
- Water Availability and Well Development xvi
- Development Impacts on Wildlife and Livestock xvi
- Overgrazing Impacts xvii
- Climate Change Impacts xvii
- Conclusion xviii

1. Introduction: Scope and Objective 1

2. Environment and Natural Resources 3
- Regional Features and Populations Trends 3
- Land and Water Resources 4
  - *Geology and Topography* 4
  - *Water Resources* 5
- Vegetation Resources 7
  - *Land Vegetation Cover* 8
  - *Natural Rangeland Ecosystems* 8
- Livestock Resources 9
  - *Livestock Production System* 10
  - *Natural Versus Industrial Livestock Economies* 10
  - *Livestock and Wild Herbivore Adaptability* 11
  - *Overgrazing Impacts on Rangeland Ecosystems* 13
- Weather and Climate Change 14
  - *Precipitation* 15
  - *Climate Impacts* 16

3. Development of the Southern Gobi Region 19
Regional Development 19
Transportation 19
Communication 19
Mining 19
Energy Generation 21
Water 21
Livestock Production 22
Tourism 22
Impact of Development 23
Development Perspectives 23
SGR Development Scenario 27
Degradation in the Southern Gobi Region 29
Livestock-Related Degradation 29
Degradation from Economic Development 29
Impacts on Wildlife 30
Climate Change Impacts 30

4. Wild Ass in the Context of SGR Development 35
Environment and Natural Resources 36
Land Form and Topography 36
Vegetation 36
Methodology 37
Herder Engagement 37
Wild Ass Local Pasture Use 38
Wild Ass Regional Pasture Use 39
Large Herbivore Distribution 39
Vegetation Community Selection 39
Large Herbivore Dietary Quality 39
Study Results 39
Seasonal Precipitation 40
Wild Ass Distribution 41
Preferred Vegetation Communities and Habitat 44
Livestock Distribution 48
Herbivore Diet Quality 49
Herder and Wild Ass Interaction 49
Conclusions 50
Precipitation Has a Marked Influence on Herbivore Distributions 51
Wild Ass Diet Changes with the Seasons 51
Wild Ass Tolerance of Humans Has Its Limits 51
Herders Can Be Excellent Collaborators 52
The Wild Ass's Future Is Tied to the Circumstances of the Herders 52

5. A Vision for Sustainable Resources Management 55
Developing a SGR Natural Resources Management Plan 55
Improving Environmental Assessments 58
Strengthening Policy and Regulations of Rangeland 59
Monitoring Trends 59
Monitoring Economic Development 62

Mitigating Risk to Livestock Herders ... 62
Facilitating Herder Participation ... 62
Coordinating With Other Projects ... 63
Conclusion ... 63

Annexes

Annex A. Plant Community Composition in SE Gobi ... 65
Annex B. Regional Differences Affecting Mongolian Livestock Production ... 69
Annex C. Pastoral Livestock Economies ... 75
Annex D. Current Population Status of Selected Wild Herbivore and Predator Species in Mongolia .. 79
Annex E. Vulnerability of Mongolia to Climate Change ... 85
Annex F. Tavan Tolgoi Mining and Electrical Power Generation Complex Implementation Plan ... 91
Annex G. Monitoring of Mongolian Rangeland ... 95

References ... 103

List of Tables

Table 2.1. Partial Census of Large Wild Herbivore Populations in SGR ... 12
Table 2.2. Livestock Mortalities during Mongolian Drought/Dzud Years ... 17
Table 3.1. Development Impact on Wild Herbivores and Pastoral Livestock Production in SGR ... 24
Table 3.2. Water Source Availability and Grazable Pasture ... 28
Table 3.3. Main Constraints Affecting Large Herbivore Wildlife and Predators in the SGR ... 31
Table 3.4. Potential Vulnerabilities of Rangeland Ecosystems to Climate Change Impacts ... 33
Table 4.1. Wild Ass Preference for Vegetation Communities in the SGR ... 46
Table 4.2. Ulaanhukhun Herd Movements 16 July 2005 to 27 August 2005 ... 47
Table A.1. Dominant Vegetation Types Found in the SGR ... 65
Table C.1. Livestock Production in a Natural Economy Versus an Industrial Economy ... 75
Table D.1. Estimated Current Large Wildlife Populations in Mongolia ... 80

List of Figures

Figure 2.1. Dundgov, Dornogov, and Omnogov Provinces Comprise the Southern Gobi Region ... 3
Figure 2.2. Human Population Trend in Mongolia 1950–2005 ... 4
Figure 2.3. Human Population Increase in Sainshand and Dalanzadgad Provincial Centers ... 4
Figure 2.4. Landsat Image of Basin and Range Topography of the SGR ... 5
Figure 2.5. Location of Lakes, Springs, and Rivers throughout Mongolia ... 6
Figure 2.6. Location and Dispersal of Small, Hand-draft Wells in Southwestern Dornogov Province ... 7
Figure 2.7. Location of Shallow Aquifers in the SGR ... 7
Figure 2.8. Land Cover in Mongolia ... 8
Figure 2.9. Estimated Livestock Numbers in Mongolia, 1961–2003 ... 9
Figure 2.10. Number and Trend of Livestock Species in the National Herd Before and After the 2001/02 Drought/Dzud ... 9
Figure 2.11. Regional Distribution of Mongolian Livestock Species ... 11
Figure 2.12. Population Development (since 1985) and Livestock Numbers (since 1970) ... 12
Figure 2.13. Changes In Desert Zone (DZ) and Forest Steppe Zone (FS) Ecological Condition during the 11 Year Interval between Macroplot Measurements in 1997 and 2008 ... 14
Figure 2.14. Cumulative Centimeters of Annual Precipitation by Season in Southwest Dornogov Province ... 15
Figure 2.15. Seasonal Precipitation in the Southeast Gobi during 2005 ... 15
Figure 2.16. Annual Differences in Vegetation Growth Related to the Amount of Precipitation ... 16

Figure 3.1. Unimproved Road Network in Western Dornogov Province, Characteristic of SGR.........20
Figure 3.2. LANDSAT View of Trans-Mongolia Railroad and Road Traffic Impacts at Sainshand in Dornogov Province 20
Figure 3.3. Coal Mine Tailing Piles in Dundgov Province 21
Figure 3.4. Small Lakes and Ponds in Eastern SGR Used Extensively by Livestock and Wild Herbivores to Obtain Drinking Water (LANDSAT Image) 21
Figure 3.5. Concentrated Livestock Use of Rangeland Near a Functioning Production Well 22
Figure 3.6. An Abandoned Production Well in the Eastern SGR...23
Figure 4.1. LANDSAT Topographic Relief Map of Part of the SGR Extensively Used by Wild Ass 36
Figure 4.2. Vegetation Map of the Southeast Gobi 37
Figure 4.3. Minimum Convex Polygon of Wild Ass Home Range Derived from Collared Wild Ass Locations during the 2005 Study. The Green Polygon Includes All the Tracked Points from the Wild Ass GPS Tracking Units 38
Figure 4.4. Annual Precipitation by Season in the Southeast Gobi..40
Figure 4.5 (a), (b), and (c). Regional Precipitation in the Southeast Gobi in 2005 and 2006 in Southern, Central, and North Study Areas Respectively 41
Figure 4.6. Seasonal MCPs of Rangeland Area with Observed Use by Collared Wild Ass during 2005 and Early 2006 42
Figure 4.7 (a) and (b). Vegetation Types at Different Elevations..43
Figure 4.8. Seasonal MCPs of Rangeland Area with Observed Wild Ass Use along North to South Vehicular Transects during 2006 and 2007..43
Figure 4.9. Seasonal MCPs of Rangeland Area with Collared and Observed Wild Ass Use between 2005 and 2007...44
Figure 4.10. Location of Collared Wild Ass Relative to Vegetation Types and Topography in 2005 and 2006...45
Figure 4.11. MCPs of Wild Ass Observed in 2006 and 2007 along a Vehicular Transect Relative to Vegetation Communities 45
Figure 4.12. Location of Collared Wild Ass (Colored Points) and Cooperating Herder's Pastureland (Grey Areas) in the Study Area during the Summer of 2005..................................48
Figure 4.13. Summer Dietary Quality of Five Large Herbivores Co-Grazing Pastureland in the Southeast Gobi...49
Figure 4.14. Recorded Observation of Wild Ass on Ulaanhukhun's Pastureland between 6/1/2006 and 7/1/2007 49
Figure 4.15. Recorded Observation of Wild Ass on Yubba's Pastureland between 6/1/2006 and to 7/1/2007 50
Figure 4.16. Recorded Observation of Wild Ass on Namsarai's Pastureland between 6/1/2006 and 7/1/2007 51
Figure A.1. The Juxtaposition of Plant Communities (Color-coded in Reference to Table A.1) and Livestock Used by Two Herders in the Southeast Gobi 67
Figure E.1. Sensitivity Analysis of Biomass in the Gobi 88
Figure E.2. Predicted above Ground Biomass in the Desert Steppe in Mongolia...............................88
Figure E.3. Changes in River Flow Predicted by the Computer Model CCCM 89
Figure E.4. Change in Ewe Weight Relative to Changes in Temperature and Pasture Biomass 90
Figure E.5. Map of Dzud Frequency in Mongolia 90

List of Boxes

Box 5.1. Models of Natural Resources Management Agencies 58
Box 5.2. PHYGROW Forage Growth Model 60

Foreword

This purpose of this report is to examine development trends in the Southern Gobi Region (SGR) as they affect livestock and wildlife. It provides an overview of the environment and natural resources of the region, discusses existing relationships and interactions among humans, livestock, large herbivore wildlife, and the natural resources on which they are dependent. It then explores the impact that economic development of the region is likely to have if that development does not consider the needs of the current users.

It is important to remember that there have been balanced interactions among these co-users of the SGR for millennia. During the socialist period, populations of large herbivore wildlife remained at relatively high numbers even though livestock production was highly organized and vegetation resources were systematically and heavily utilized throughout the region. It is only since 1990, with the transition to free-market economics, that large wild herbivores have been over-hunted and that conflict between wildlife and livestock is perceived as normal.

Even though the region is large and not densely populated, the control of the limited rangeland and water resources has been, and will remain, the key SGR issue as the economic development accelerates. Mining, energy, and transportation will substantially affect rangeland and water to the likely detriment of herders, livestock and wildlife.

The importance of rangeland and water resources in this region is illustrated by the case study of herder interactions with the Wild Ass or *Khulan*. This study found that Mongolians in the SGR, especially pastoralists, are interested in wildlife and can be willing cooperators in conservation, especially if they receive some compensation for their efforts. It was also observed during the study that the very presence of local people engaged in field work on Wild Ass was beneficial to improving regard for the well-being of wildlife and natural resources.

This current planning and preparation period represents a window of opportunity to engage local Mongolian pastoralists and others in activities that will provide long-term benefits to Wild Ass and other large herbivore wildlife in the SGR. This opportunity should not be squandered because there may not be many future opportunities to develop concern and appreciation for sustainable use of natural resources and the wildlife and pastoral livestock herders that are co-dependent on these resources. It is even more critical to engage local people at this time within a natural resource management program that also provides benefits to ensure their continued presence on the Gobi landscape.

The general conclusion reached by this report is that direct competition for resources is not now the primary issue affecting the relationship between humans, pastoral livestock and large herbivore wildlife; rather it is the lack or loss of a conservation ethic that provides protection for traditional users of natural resources, enforcement of hunting regulations, and prevents illegal sport hunting that is rapidly reducing populations of large wild herbivores in the region. Although economic development of the region will undoubtedly proceed, having in place an effective and functional natural resource management program is critical.

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Acronyms and Abbreviations

Aimags	Province in Mongolia
ARIMA	Autoregressive Integrated Moving Average (forecasting model)
AVHRR	Advanced Very High Resolution Radiometer
CP	Crude Protein
DOM	Digestible Organic Matter
DSS	Decision Support System
GANL	Texas A&M Grazing Animal Nutrition Laboratory
Ger	Traditional Felt Tent
GHG	Greenhouse gas
GIS	Geographic Information System
GLA	Grazing Land Applications
GPS	Global Positioning System
IPCC	Intergovernmental Panel on Climate Change
IUCN	The International Union for Conservation of Nature
KRESS	Kinetic Resource and Environmental Spatial System
kV	Kilovolt
kW	Kilowatt
LANDSAT	Earth-Observing Satellite Missions
MCP	Minimum Convex Polygon
MNET	Ministry of Nature, Environment and Tourism
MW	Megawatt
NDVI	Normalized Difference Vegetation Index
NIRS	Near Infrared Reflectance Spectroscopy
NOAA	National Oceanic and Atmospheric Administration
NRM	Natural Resources Management
PFRA	Prairie Farm Rehabilitation Administration (Canada)
PHYGROW	Rangeland Forage Growth Model
Red List	The IUCN List of Threatened Species
RIAH	Research Institute of Animal Husbandry
SGR	Southern Gobi Region
Soum	Mongolian County
SPA	Strictly Protected Area
UB	Ulaanbaatar, Capital of Mongolia
UNEP	United Nations Environment Program
USDA	United States Department of Agriculture

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Executive Summary

The Southern Gobi Region (SGR) is enormous, richly endowed with mineral wealth and home to many wide-ranging threatened species. Served by few transport links, the SGR is one of the last relatively natural, great landscapes on Earth: It has relatively intact grassland and desert ecosystems and retains a culture and history of pastoral livestock production that has changed very little over the centuries. The present livestock system has proven itself to be an efficient and sustainable means of utilizing available resources within the severe constraints of climate and limited natural productivity of the region. It is, however, suffering from decreases in both rainfall and water availability.

The SGR supports a sparse but growing human population, including livestock herders, who maintain a difficult grip on their livelihood after enduring the upheavals wrought by the collapse of the Socialist-command economy, and the recent multi-year period of severe drought and winter weather. Mongolia's transition to a privatized market economy, and the development of active and proposed mines, together with their associated infrastructure needs and human population change, could cause significant and varied impacts on the SGR environment. These new dynamics in current Mongolian society and economy have already started to appear as the traditional 'conservation ethic' of the Mongolian people is rapidly changing to an 'exploitation ethic' that is threatening rangeland capacity to support livestock and wildlife populations that share these resources.

In this light, the objective of this report is to describe for the SGR the status, trends, and likely development paths for pastoral livestock herding and populations of large herbivore wildlife relative to development of mechanical wells, exploitation of shallow groundwater, economic development, and the impact from climate change on these issues. The report was commissioned by the World Bank as part of the Southern Gobi Regional Environmental Assessment (Walton, 2010) that assesses the potential for and constraints facing economic development across all relevant sectors including transport, rural development, mining, energy, water, and natural resources management.

Economic Development

The SGR borders China, which is actively seeking access to the largely undeveloped deposits of precious metals, minerals, coal, petroleum, and livestock products found in the region. Development and sale of these deposits will improve Mongolia's national wealth and help satisfy global demand for these commodities but will also increase tension and conflict between current and future users of natural resources in the SGR.

The SGR is especially sensitive to human intrusion and economic development. It is also a region important to conservation of natural ecosystems, wildlife, pastoral livestock production, and traditional lifestyles. Most importantly, the SGR has:

- Desert and desert steppe land cover highly sensitive to drought and severe winter weather (i.e., *dzud*), which makes the region susceptible to degradation;
- Importance as the regional center of high-value cashmere wool production;
- A developing eco-tourism industry; and
- Habitats critical for globally significant populations of threatened and endangered wildlife.

Development of the SGR is ongoing and expected to accelerate in the near future. Several types of development are anticipated. The drivers of this development include:

- Mongolia's primary transportation corridor (rail and highway) linking Ulaanbaatar with China crosses the eastern section of the SGR;
- Ongoing or planned development of mineral, coal, and oil industries;
- Planned large-scale infrastructure construction, including i) development of a support and service infrastructure to facilitate exploitation of minerals, coal, and oil; ii) enhancement and expansion of the existing transportation network (roads, rail lines, air service, and ancillary industries); and iii) further development of water resource access, especially water from underground shallow aquifers;
- Development of oasis and deep-well agriculture to produce specialty crops and animal feed for more intensive, small-scale livestock production near the larger towns;
- An expanding tourism industry, including eco-tourism, that will require infrastructure development; and
- Commercialization of the livestock industry accompanied by increasing demand for meat and livestock products throughout the Asia Region, especially from China.

Livestock and the Livestock Production System

Livestock production remains the dominant economic activity for a majority of residents in the SGR, the center of Mongolian cashmere wool production. About 80 percent of Mongolia's total land area is comprised of natural rangeland ecosystems that have provided food for domestic herbivores for more than 4,000 years and for wild herbivores for millennia. The livestock species present in an area reflect differences in rangeland capacity and species adaptability to the different land cover types. The natural rangeland types occurring in the SGR are *grass steppe*, *desert steppe*, and *desert*, the latter two providing most suitable habitat for camel, sheep and goats, whereas grass steppe rangeland in the northern part of the SGR and along the Chinese border also provides suitable habitat for horses and cattle.

Livestock production is still the dominant economic activity for a majority of residents in the SGR. Following the breakdown of the Socialist (collective) system, livestock numbers in the SGR increased from about 762,000 to more than 5 million head. The increase corresponded to a change in livestock composition, with the most dramatic shift occurring in the number of goats and camels. Goats, which now dominate the national and SGR herds, increased from 30 to 57% of the SGR herd between 1970 and 2009. During the same period, the percentage of camels in the SGR herd decreased from 18 to 2.6%.

The extensively managed livestock production system as practiced by herders in the SGR is a viable system, well adapted to local conditions. It also presents both advantages and disadvantages relative to economic development and conservation of wildlife and natural ecosystems. The major advantages are:

- The existing livestock system is low-input and low-cost based on using renewable and monetary-free resources.
- It is a production system that has adapted itself to the SGR environmental conditions.
- It has the capacity to supply meat and off-take products desired by the Mongolian population.
- It is relatively self-sufficient in meeting consumption needs and producing marketable products.
- Under normal production conditions, it has few negative impacts on the natural environment or wildlife habitat.

The major disadvantages of the SGR livestock production system are:

- It is a forage supply-driven livestock production system where temperature and moisture conditions determine, during a short period of forage growth, the supply of animal feed for the entire year irrespective of animal needs.
- It has always been subject to natural climate-related catastrophe that can cause widespread livestock mortality in the short term, and reduce animal and pasture productivity in the long term.
- Almost no support (feed, veterinary care, marketing opportunities, etc.) is available for extensively managed livestock production and to relieve livestock pressure on regional rangeland.
- Herders are responding to market incentives by increasing livestock numbers and changing herd structure to cashmere goats. The change in numbers and herd structure can lead to catastrophic losses among herd populations in the event of natural and commonly occurring weather events; and to decreased opportunities for the conservation of wildlife and natural ecosystems.

Furthermore, privatization of livestock ownership and production has increased the level of uncertainty and risk to which herders must respond. This is further being compounded by new factors including:

- The concentration and expansion of livestock numbers,
- A decrease in the number of herding families,
- Changes in customary herder institutions,
- Uncertainties from the marketplace and government, and
- Increased potential for conflict over use of pasture resources.

Wildlife: Status and Trends

Despite the harsh conditions, the SGR provides important habitat for a number of wildlife species. The desert steppe provides habitat for the following large wild herbivores: Wild Ass (*Equus hemionus*), Argali bighorn sheep (*Ovis ammon*), and wild camel (*Camelus bactrianus ferus*). In the grass steppe areas, gazelle (*Procapra gutturosa*) and the Wild Ass are the most common wild herbivore grazers. The desert areas also provide habitat for some of these large wild herbivores.

Prior to the end of the Socialist period in 1990, most wildlife species found in Mongolia were relatively healthy, given the tightly controlled off-take of fish and wildlife. With the transition to a market economy, however, the situation has changed; populations of many wildlife species are in decline due to human-induced changes in their habitat as well as legal and illegal over-hunting, both for sport and as a source of income. The pressure on wild herbivores is further intensified as numbers of livestock increase, with which wild herbivores are competing for space and food. Hunting is also a primary threat to the population of the black tailed gazelle (*Gazella subgutturosa*), Argali bighorn sheep, Ibex goat (*Capra sibirica*), and snow leopards (*Panthera uncia*). Habitat degradation and human intrusions have contributed to population declines of snow leopards, Wild Ass, white tailed gazelle, and Ibex goat. These and other factors are threatening local species; many of these species are listed as Endangered in the Regional Red List, including the white tailed gazelle, Wild Ass, Argali bighorn sheep (critically endangered globally), wild camel (critically endangered globally) and snow leopard. The black tailed gazelle is listed as "Vulnerable" in the regional assessment.

The world's population of the Wild Ass (*Equus hemionus)* or *Khulan* as it is called in Mongolian (and pronounced "hoo lan"), has shrunk to a single sustainable population in the Gobi Region of Mongolia, with only vestigial populations in Iran, Turkmenistan, and India. The Mongolian population of Wild Ass, which is centered in the SGR, is expected to decline rapidly during the next 10 years as a result of illegal hunting and deterioration of their habitat. While Wild Ass and livestock have high potential to compete for forage and water, recent studies of Wild Ass in the SGR has shown that the high mobility and capacity to travel limit the potential for forage competition between Wild Ass and livestock of individual herders, but a high density of herders throughout the Wild Ass range increases competition for forage, especially during drought years. This is especially the case for herders dependent on surface water for their livestock. Economic development or more intensive livestock use of Wild Ass winter range habitat would be especially harmful to sustainability of the current Wild Ass population because the area of winter range habitat is substantially less than summer range habitat. In the longer term, habitat fragmentation caused by unregulated economic development will be the most important factor influencing the Wild Ass's survival.

Water Availability and Well Development

Water availability is the single most important factor influencing distribution of humans, livestock and wildlife, as well as production activities in the SGR. In this respect, precipitation has a major influence on the development of habitats and the distribution of animals within habitats since it influences both the amount and timing of annual forage growth. Very localized or lower forage and/or water availability can both directly and indirectly increase potential conflict between domestic livestock and wildlife that co-use the same rangeland.

Within the SGR, there is very little surface water; the largest water resources are underground water stored in shallow and deep aquifers. Most humans and domestic livestock rely on small, hand-drawn wells to meet water requirements. Large wild herbivores however rely almost exclusively on surface or near-surface water sources. Processes to extract minerals, precious metal, and coal also require substantial and reliable sources of water. Hence, infrastructure development at the scale anticipated will need access to large quantities of water and will require additional infrastructure development to extract water from aquifers.

It is reported that approximately 30,000 small wells exist in the desert and desert steppe regions. Many of the mechanical wells developed during the Socialist period are no longer functioning. As a result, considerably less rangeland area is actually accessible and being used during the seasons when livestock cannot drink from ephemeral rainfall sources or consume surface snow thus making access to potable water the most limiting factor for livestock production in the SGR. Since 2000, a key focus of government and certain donor projects in the region has therefore been rehabilitating existing mechanical wells and expanding well coverage to rangeland without drinking water for livestock. However, the development of wells and water systems is likely to have both positive and negative environmental impacts on rangeland ecosystems, livestock, and wildlife. Potential positive impacts from more wells and water sources include:

- Improved distribution of livestock thereby potentially reducing grazing pressure on local rangeland ecosystems near existing wells;
- Improved living conditions for herders and rural residents; and
- Potentially providing wildlife with access to water if water distribution systems are implemented and managed for wildlife as well as livestock.

Potential negative impacts include:

- Increased competition between livestock and wildlife for forage and habitat in rangeland areas formerly without water if livestock numbers increase in conjunction with water development;
- Degradation by livestock of native vegetation and soils in surrounding rangeland as they graze back and forth from newly developed mechanical wells; and
- Increased grazing pressure from livestock on newly accessible rangeland that provide critical security and habitat to wildlife, especially large herbivores.

Development Impacts on Wildlife and Livestock

Livestock production is likely to be affected both positively and negatively by the expected development in the SGR. It could improve marketing of livestock and products as well as increase access to resources and services such as water, electricity, non-livestock economic opportunity, information, health care, and education. However, development is also likely to result in loss of access to natural resources in general and to rangeland in particular, which could also result in increased conflict.

Although the anticipated development might result in increased potential for ecotourism and wildlife viewing, the impacts are likely to compound the threats facing wildlife. The impacts include: i) interference with wildlife mobility; ii) increased pressure from and access for hunting and poaching; iii) loss, degradation, and fragmentation of habitat; iv) increased competition for rangeland resources with livestock; and v) increased rate of human intrusion. Further anticipated economic development and human intrusion is therefore expected to increase pressure on livestock and wildlife unless appropriate safeguards to protect natural ecosystems, wildlife, and pastoral livestock production are in place and functional prior to the development. Unconstrained economic development without prior functional regulatory mechanisms will be a major cause of natural rangeland degradation.

Overgrazing Impacts

There seems to be a general consensus among herders, government officials, donor institutions, and the public that Mongolian rangeland has, and is, degrading from a combination of livestock overuse and increasing aridity throughout Mongolia. Although empirical data to support this consensus is limited in the SGR, a 2008 re-survey of 27 ecological monitoring plots in Gobi-Altai province that were established in the Desert ecological zone in 1997 supports this contention. The re-survey indicated that: i) plant species present in 1997 had declined by 33%, ii) grasses and forbs had highest loss of presence on winter and summer pastures, iii) ground surface cover of bare soil and rock had increased while cover of vegetation and plant litter had decreased, and iv) livestock preferred and desirable plant species had high loss of presence on all seasonal pastures. Ecological trend of Desert ecosystems had declined from good and fair condition to poor and very poor ecological condition and heavily grazed rangeland was becoming increasingly degraded. Unless changes in management relative to herd structure and stocking rate are implemented soon, and other issues contributing to degradation are addressed, the rate at which rangeland is being degraded will accelerate.

Climate Change Impacts

The added variable of climate change may increase pressure on humans, livestock, and wildlife. Although the debate on climate change and how to respond continues, there is little doubt that a warming trend accompanied by increasing aridity is occurring. In Mongolia during the previous 60 years, mean annual air temperature reportedly has increased by 1.6° C. If this pattern of change continues, by 2040 mean summer temperatures are predicted to increase by 1.0 to 3.0° C and mean winter temperatures by 1.4 to 3.6° C. Further, potential vulnerabilities of rangeland and natural ecosystems to climate change impacts include: i) increased frequency of extreme weather events, including drought; ii) increased water stress and heat stress, resulting in decreasing vegetation productivity; iii) reduced soil cover in arid land vegetation due to wind erosion; and iv) potential for increase in non-native invasive species caused by reduced ground cover and increased soil disturbance.

Projections of climate change impacts by the Intergovernmental Panel on Climate Change (IPCC) for the regional area that includes the SGR are: i) increased annual temperatures of 2.5–5.0° C during both winter and summer months; ii) an increase in annual precipitation during the winter; and iii) a slight decrease or increase in summer precipitation depending on sub-region location. Higher temperature and precipitation are predicted to result in a 25–75 percent increase of Net Primary Productivity in Mongolia’s desert steppe zones. However, there is concern that desert land cover types are gradually expanding their area northward into desert steppe and grass steppe, at least partially due to higher temperatures and less annual moisture accumulation.

Conclusion

The SGR is doubtless entering a period of significant change. It is important that the local inhabitants, civil society groups, and the government recognize the implications so that planning, avoidance, mitigation, and adaptation—as appropriate—are started early. There will be hard decisions to make: none less than whether or to what degree the wide-ranging wild herbivores should be constrained in their movements and subjected to poaching, together leading to their eventual extinction. Action in the form of a SGR Natural Resource Management Program is needed to: i) improve regional government capacity to enforce existing laws and regulations, ii) ensure application of environmental remediation measures as an essential component of economic development and infrastructure construction, iii) encourage and support regional rangeland management and sustainable use of resources by livestock and wildlife, and iv) provide meaningful and realistic information on wildlife needs to government planning and management agencies.

Ensuring sustainable wildlife populations as economic development rapidly changes the SGR requires an immediate need for pragmatic management recommendations to protect important wildlife habitat, mitigate wildlife/human conflicts, and guarantee the long-term survival of wildlife species in Mongolia. Although laws exist to protect wildlife species, the illegal take of these species continues, at least partially because of the poorly informed urban public and inadequate law enforcement. Although preventing change or stopping economic development of the SGR is unwarranted, a conservation management program that monitors and regulates economic development, detects changes in wild and domestic herbivore relationships and habitat degradation, and monitors the impact of climate change on the SGR environment is sorely needed. Environmental and land use legislation is required to regulate use of critical areas and prevent degradation of natural ecosystems.

Since economic development and infrastructure construction is on-going, these activities should be implemented as soon as possible with widespread commitment from national and international organizations. Given the urgency of the situation, a Natural Resource Management (NRM) Program can be established from a number of existing tools and intersected with on-going national and international projects that already have a presence in the SGR. Fortunately, many of the monitoring and management technologies are already available in Mongolia; and many activities already being undertaken by national and international projects are consistent with institutionalizing a NRM program in the SGR.

Successfully implementing a NRM program in the SGR will require real and direct involvement of local people, especially herders engaged in pastoral livestock production. Firstly, the recent Wild Ass study supports the position that the future of the Wild Ass, and many other animals, is tied to the circumstances of the Mongolian herder in the Gobi. If the herders are displaced, maintain or further develop negative attitudes towards the Wild Ass, or engage in free market practices that encourage hunting of wildlife or development of land resources, then the Wild Ass population will continue to decline rapidly. Findings from this study also clearly indicated that Wild Ass are the key wildlife species to monitor the status of resource needs for all large wild herbivores and pastorally managed livestock. Wild Ass need large tracts of land, especially during the summer. When/if these resources and movement opportunities are not available to large wild herbivores such as the Wild Ass because of fencing, railroads, mineral exploitation, or other human intrusion, then landscape fragmentation may be the final causative factor in the demise of the pastoral livestock system and large herbivore wildlife.

Secondly, the involvement of herders in collection of data during the Wild Ass study was more than just an efficient way to employ year-round researchers in a remote area; it also initiated the critical process of instilling a conservation ethic in the local people who were usually the only authority at present on the landscapes beyond aimag and soum centers. Perhaps the most important piece of this puzzle was finding a way to place a monetary value on living Wild Ass. These impromptu field technicians intentionally or unintentionally became a major factor to dissuade poaching in their pastures. Lastly, just by virtue of having the research connected to the local population, awareness of the Wild Ass's dire situation can effectively reach the people who are most able to make a difference.

1. Introduction: Scope and Objective

Mongolia's Gobi is a region of contrasts: it is enormous but served by few transport links; it is richly endowed with mineral wealth and wide-ranging wildlife and domestic animal species but suffers from low rainfall and decreasing water availability. The Southern Gobi Region (SGR) also supports a sparse but growing human population, among them are livestock herders who maintain a difficult grip on a livelihood after having endured the upheavals wrought by the collapse of the Socialist-command economy. Mongolia's transition to a privatized market economy and proposed development of mines in the region, together with their associated infrastructure needs and human population movement, could cause significant and varied impacts on the region's environment.

This report provides background to the Southern Gobi Regional Environmental Assessment (Walton, 2010) by addressing the current status; recent trends; and likely development paths for livestock, herding, large wildlife, wells, and shallow groundwater. And it looks at the impacts of climate change on these issues. The background report, while applicable to livestock issues throughout Mongolia, focuses on the Southern Gobi Region formed by Dundgov, Omnogov, and Dornogov Provinces. The report is issue specific and relates to technical and policy considerations. The Regional Environmental Assessment evaluates the potential for and constraints to development across all relevant sectors—transport, rural development, mining, energy, water, and natural resources management—and supports efforts of the Government of Mongolia and local communities to expand, deepen, and improve existing capacity for environmentally sustainable and integrated regional development planning.

The methodology for this background report employed the following steps to report on livestock-related issues in the SGR Regional Environmental Assessment:

- Define the region,
- Identify development scenarios,
- Summarize demands and impacts of the scenarios on natural systems,
- Describe relevant, regional environment and natural resources,
- Examine vulnerability of the region and of potential developments relevant to effects of climate change,
- Identify an applied interactive tool that is available to produce a synthesis of information that users can also apply to additional scenarios,
- Identify gaps and needs for capacity strengthening in the regulatory framework and institutional structure that exists to manage the impacts of development,
- Develop a process for stakeholder consultation,

Following this introductory chapter, the report has four main sections. Chapter 2, *Environment and Natural Resources*, defines natural resources and predominant uses and users of natural resources. Chapter 3, *Development of the Southern Gobi Region*, projects the impact of economic development on natural rangeland ecosystems, large herbivore wildlife, and pastoral livestock production systems. Chapter 4, *Wild Ass in the Context of SGR Development* is a case study which focuses on ongoing livestock and wildlife issues and how economic development will influence pastoral livestock production, large herbivore wildlife such as the Wild Ass, and the natural resources on which they are dependent. Chapter 5, *A Vision for Sustainable Resources Management*, lays out potential strategies to mitigate impacts and sustain desirable attributes through a resources management program. Ultimately, information obtained by this and other studies will contribute to developing a strategy for environmental and natural resources management in the SGR.

2. Environment and Natural Resources

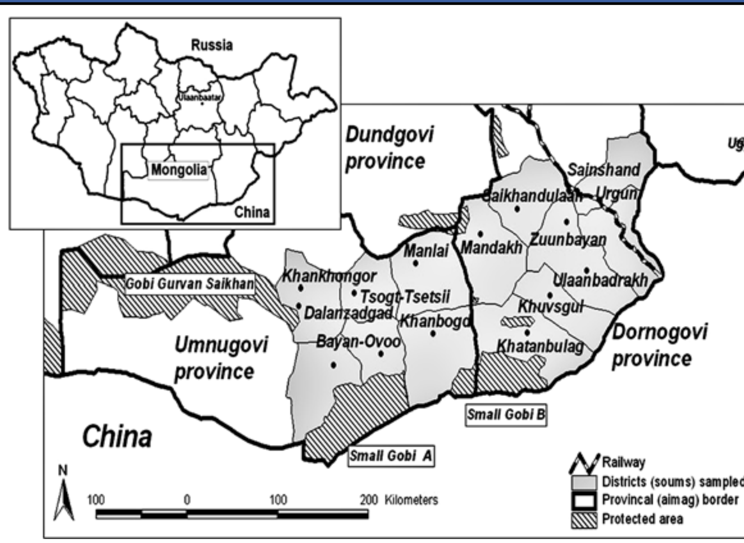
While this background report focuses on the Southern Gobi Region of Mongolia, defining the region separately from the rest of Mongolia is difficult. Most issues (i.e., economic infrastructure development, wildlife population decline, human population growth, and climate change) are national and international in context. The following sections will define the SGR relative to economic development within Mongolia, as a border region with China, and as one of the world's relatively undeveloped places with largely intact populations of native wild herbivores in native habitats and a functioning pastoral livestock production system.

The background report brings focus to a place on the verge of accelerated economic and environmental change that will alter the landscape, the people, and the animals that live there.

Regional Features and Populations Trends

Mongolia, which forms the transition zone between the Siberian taiga and the Central Asian desert, is in the center of Central Asia. Within Mongolia, the provinces of Dundgov, Dornogov, and Omnogov comprise the SGR (Figure 2.1).

Figure 2.1. Dundgov, Dornogov, and Omnogov Provinces Comprise the Southern Gobi Region

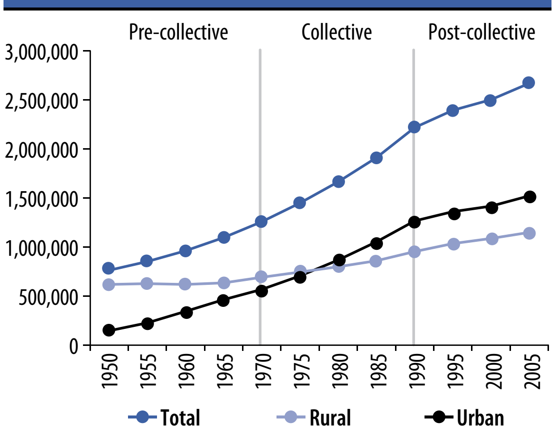


Source: Dornogov Office of Statistics (2005).

Human population in Mongolia is approaching 2.4 million people. Between 1950 and 2005, Mongolia's population more than tripled as diagrammed in Figure 2.2. A consistent demographic trend is the shift from a predominantly rural to an urban population base as herders move out of livestock production and become residents of urban areas (i.e., county and provincial centers and the three major urban areas of Erdenent, Darhan, and Ulaanbaatar). The demographic shift is on-going and will continue due to the growing desire of rural residents to participate more effectively in the developing market economy, among other reasons. For many herding families, production of livestock is no longer a desirable occupation in a changing socio-economic system where wealth and benefits are more attainable in urban areas.

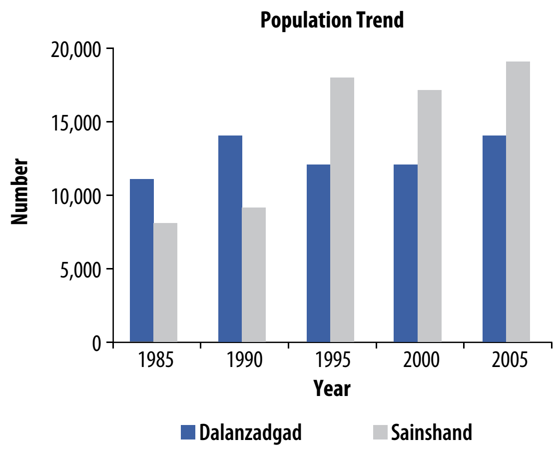
In the Southern Gobi Region, human population in Dornogov and Omnogov Provinces has followed the national trend. Between 1985 and 2004, the human population in 13 *soums* of the two provinces increased from 41,072 to 62,735 persons (53 percent). As noted in Figure 2.3, the most dramatic increase in human population occurred from 1985 to 1995, and was mostly due to population increases in Sainshand (Dornogov provincial center) and Dalanzadgad (Omnogov provincial center). The current population of Dundogov Province is more dynamic as many herders have moved their livestock to other provinces to escape a prevailing drought. The rapid population increase in Dalangazdad and Sainshand primarily reflects movement by younger persons seeking jobs and opportunities.

Figure 2.2. Human Population Trend in Mongolia 1950–2005



Source: FAOSTAT (2005).

Figure 2.3. Human Population Increase in Sainshand and Dalanzadgad Provincial Centers



Source: NSO (2005).

Land and Water Resources

Total SGR land area is 349.6 square kilometers, which is approximately 22 percent of Mongolia's land area, and approximately 50 percent of the entire Gobi Region. The southern SGR border forms part of the international boundary with China. The presence and location of the border will be a major factor influencing economic development and conservation of natural resources in the region. China will be a major driver of economic development because of its need to obtain access to the unexploited mineral wealth of the region. Inner Mongolia is already the primary destination of livestock products, especially cashmere wool, produced by livestock in the SGR.

Geology and Topography

The geology of the SGR is highly variable and important as geology is a substrate layer from which other layers develop and is closely correlated with underground and surface water. Geological features affect animal behavior and security and are linked to minerals and precious metals, which potentially lead to mining and other forms of resource exploitation.

While most of Mongolia lies at elevations above 1,500 meters, the SGR is characterized by lower elevation basins and ranges. The major topographic difference between the eastern and western portions of the SGR is increasing elevation and broader desert basins as the eastern extension of the Altai Mountains are encountered. Mongolia's lowest elevation occurs in the eastern part of the SGR and the terrain gains in elevation toward the western portion. In the eastern portion, SGR topography consists of low elevation ranges of the Gobi Mountains, which are separated by broad, shrub-dominated desert basins (Figure 2.4). In the western portion of the region, the eastward extension of the Altai Mountains and westward extension of the desert valleys creates a topography with higher, more rugged mountains and broader gravel plains.

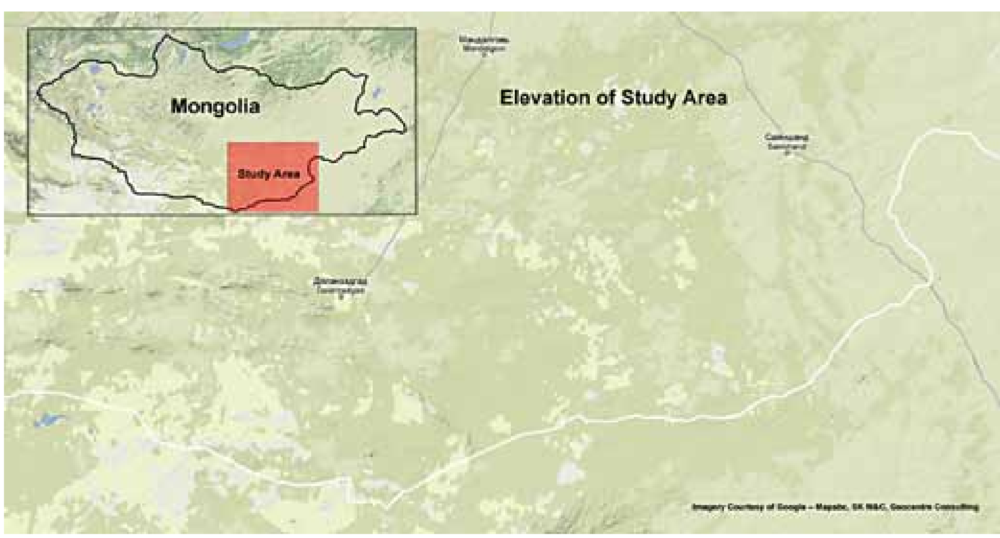
The Gobi Desert, directly south of the border between Mongolia and China, has even lower elevation that gradually grades to the higher elevation highlands and plateaus forming the boundary between Inner Mongolia and traditional China. If viewed from a land form and topographic perspective without regard for artificially imposed boundaries, the SGR is in the northeastern corner of the Gobi Desert Basin.

Water Resources

Mongolia has abundant water resources in the northern portion of the country (Johnson and others 2006a). In addition to natural springs, streams, and rivers, Mongolia has more than 3,000 lakes and ponds, of which 80 percent are saline. Almost 65 percent of Mongolia has no open water sources. In these areas, humans and livestock depend on wells for drinking water. About 32 percent of exploitable underground water resources occur in the Gobi Desert, especially in the SGR (Figure 2.5).

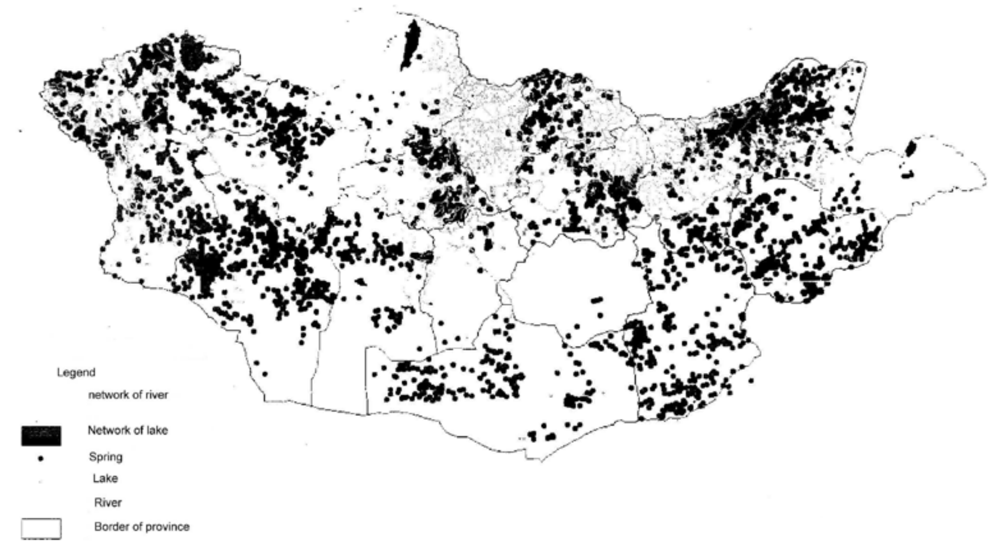
Water in the SGR is a critical resource for human occupation, livestock production, and wildlife habitat. Comparatively, the SGR has very little surface water. Dundgov Province has few natural springs or surface water. Most springs in Dornogov and Omnogov Provinces are concentrated in

Figure 2.4. Landsat Image of Basin and Range Topography of the SGR



Source: Johnson (2005).

Figure 2.5. Location of Lakes, Springs, and Rivers throughout Mongolia



Source: JICA (2003).

a few areas, leaving large expanses of the region without substantial surface water.

Throughout the SGR, most water for humans and livestock must be obtained from small, hand-drawn wells. Reportedly, approximately 30,000 small wells exist in the desert and desert steppe regions (Kaczensky and others 2006; Figure 2.6). During the Socialist period, numerous mechanical wells were built and maintained by the Government, which greatly expanded both the temporal and spatial scale of human and livestock use. Most mechanical wells (i.e., engine and pump or Archimedes screw wells) have fallen into disrepair, or the underground water source has failed.

The largest water resource in the SGR is underground water stored in shallow and deep aquifers. Accessible groundwater in the SGR is estimated to be 666.4 million cubic meters per year, with 408.1 million cubic meters per year available during the summer and 204.1 million cubic meters per year available during the winter (JICA 2003). Depth of the aquifer relates closely to accessibility. If water is close to the surface, less costly hand-drawn and screw-type wells are possible, but water withdrawal is less efficient. If water is in a deep aquifer (i.e., greater than 30 meters depth), withdrawal requires pump and engine (Sheehy and Byambadorj 2001). Materials for drilled mechanical wells are costly but wells are more efficient, and allow more livestock to be watered from a single well with essentially no additional labor costs.

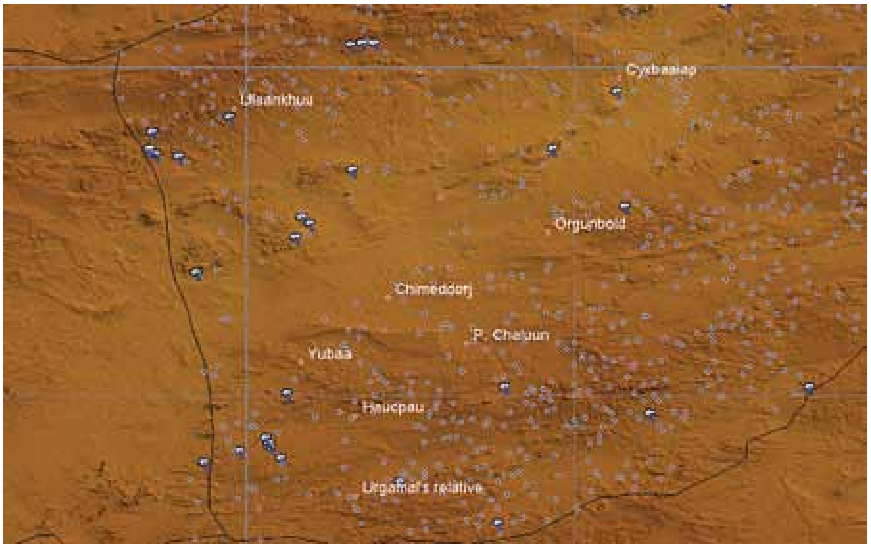
Within the SGR, most shallow water aquifers are located in east-central Dornogov Province and eastern Omnogov Province (Figure 2.7). Water users in areas with shallow aquifers, including herders and livestock, miners, urban residents, and wildlife (i.e., the Wild Ass has an innate capacity to use its hoofs to dig water holes) have much higher potential access to water compared to regions with water in deep aquifers (JICA 2003).

Since surface water is limited in the SGR, the presence of aquifers, especially shallow aquifers, will be a major factor influencing mining and mineral exploitation, infrastructure development, and expansion of a commercialized livestock industry.

Vegetation Resources

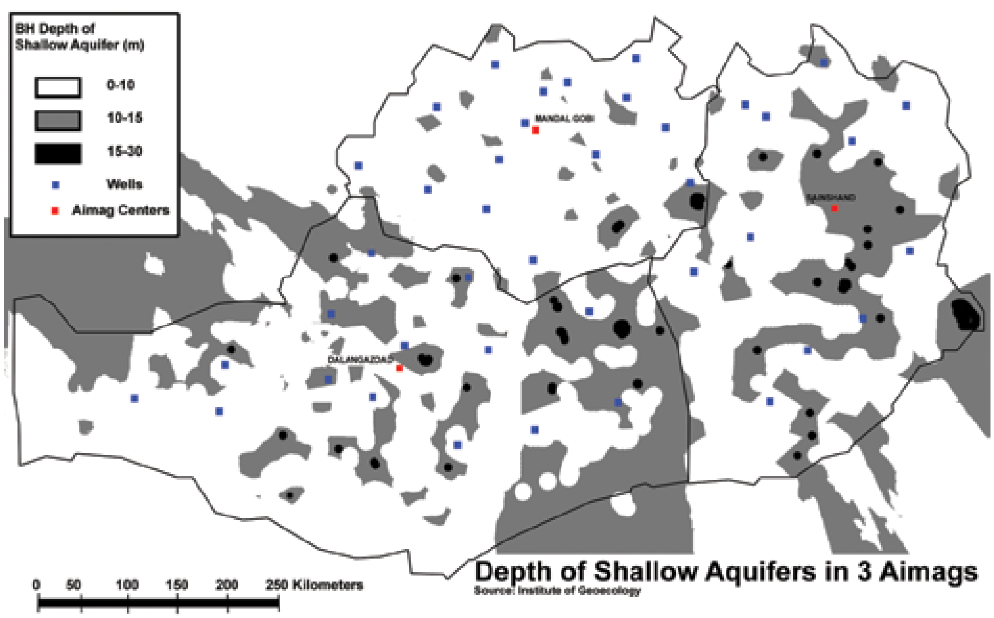
Mongolia, because of its location in Central Asia, has a high diversity of flora and fauna. Gubanov (1999) reported 2,823 species of vascular plants in Mongolia, including 662 genera and 128 families. Of these species, a relatively large number are recognized as valuable forage plants for large

Figure 2.6. Location and Dispersal of Small, Hand-draft Wells in Southwestern Dornogov Province



Source: JICA (2003).

Figure 2.7. Location of Shallow Aquifers in the SGR



Source: JICA (2003).

domestic and wild herbivores (Johnson and others 2006b, Damiran 2005). Many forage species retain relatively high nutritive values after growth stops, which is important to livestock and wild herbivores that must rely on senescent vegetation for more than 200 days of the year. Mongolia and the SGR have a rich diversity of plant species comprising rangeland-type vegetation that is well adapted to the short growing season (60 to 120 days) and to being grazed by large herbivores.

Land Vegetation Cover

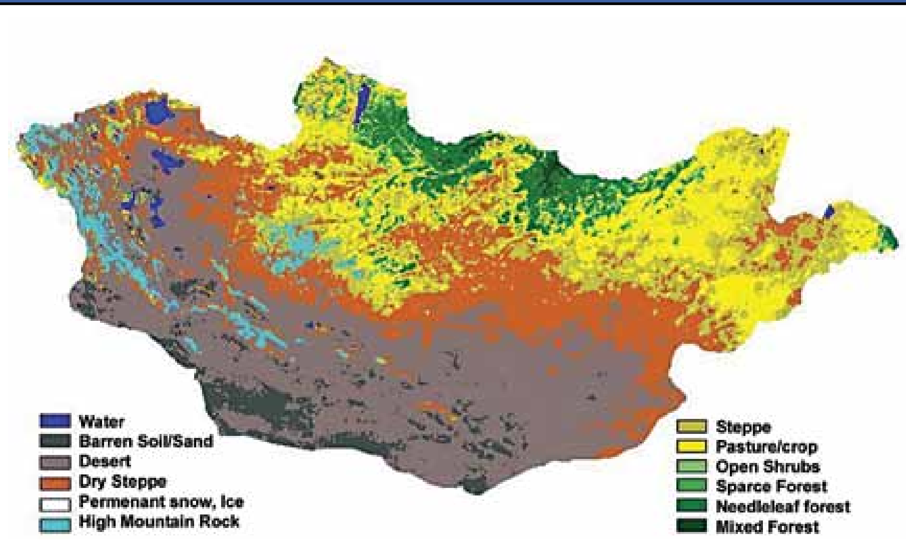
Land vegetation cover of Mongolia changes along a north-south axis (Figure 2.8). The two primary land cover types in the SGR are dry steppe and desert. The dry steppe occurs along the northern edge of Dundgov Province and the northern and eastern edge of Dornogov Province. Omnogov Province is primarily a desert, although dry steppe land cover occurs at higher elevation in the eastward extension of the Altai Mountains. Omnogov Province has relatively large areas of the barren soil/sand cover types.

Land cover classifications, which reflect a synthesis of abiotic and biotic factors, correlate closely with agro-ecological zones and natural rangeland ecosystems (Annex A). The two agro-ecological zones in the SGR are the central and eastern steppe region, which is the essentially treeless grass steppe region in central and eastern Mongolia, and the Gobi Region, which is the semi-arid and desert section of Mongolia (Annex B).

Natural Rangeland Ecosystems

About 80 percent of Mongolia's total land area (128.9 million hectares) is comprised of natural rangeland ecosystems that have provided food for domestic herbivores for more than 4,000 years and wild herbivores for millennia. Primary rangeland ecosystems occurring in the SGR are grass steppe, desert steppe, and desert (Johnson and others 2006a). Grass steppe has annual standing crop yield ranging from 650 to 1,300 kilograms per hectare. These areas are dominated by grasses in the *Genera Cleistogenes, Stipa, Aneurolepidium, Elytrigia, Festuca, Helictotrichon, and Koeleria*; various *Carex* species; and forbs including *Artemisia, Filifolium,* and *Allium*. The shrub *Caragana* is often present in the community as a co-dominant. Most grass steppe is grazed throughout the year by all livestock except camel. Gazelle and the Wild

Figure 2.8. Land Cover in Mongolia



Source: MNE (2008).

Ass are the most common wild herbivore grazers in grass steppe areas.

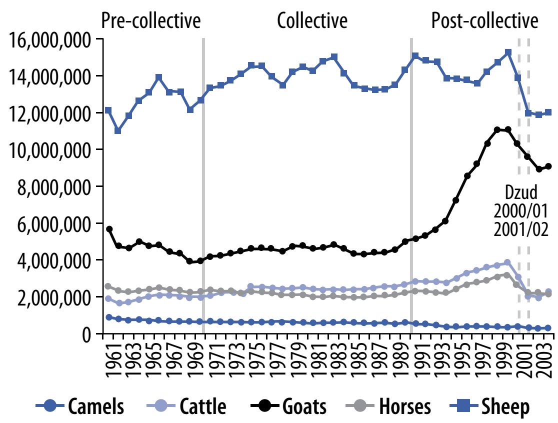
Desert steppes and deserts generally have standing crop yields between 290–380 kilograms per hectare and a high diversity of vegetation communities, soils, and topography that create forage-patch grazing opportunities for livestock and wild herbivores. Desert steppe is dominated by grasses, herbs, and shrubs. Desert steppe was formerly the habitat of the Mongolian wild horse (*Equus ferris*) and the current habitat of the Wild Ass (*Equus hemionus*), Argali bighorn sheep (*Ovis ammon*), and Saiga antelope (*Saiga tatarica*). Deserts are dominated by shrubs and perennial forbs and are especially suited to grazing by domestic camels, sheep, and goats. Deserts provide habitat for a number of large, wild herbivores. The few remaining wild camel (*Camelus bactrianus ferus*) are found in Desert habitat in southwest Omnigov province.

Livestock Resources

Mongolian livestock numbers remained rather constant from the 1960s to the late 1980s; but with the breakdown of the rural collective system (i.e., *Mon. negdel*), subsequent privatization of the livestock herd and movement of unemployed urban residents to rural areas to engage in livestock production, the livestock numbers increased dramatically. Prior to the 2000/01 and 2001/02 drought and *dzud* period that induced high mortality in the national herd, livestock numbers reached 33.5 million animals (Figure 2.9). During the drought/dzud period, summer drought followed by harsh winters killed approximately 9.0 million head of livestock throughout Mongolia. Since 2002, livestock numbers again began to rise, reaching approximately 36 million head in 2006 and 37 million head in 2008. Livestock numbers are projected to reach 40 million head by 2010. The increase is mainly due to higher goat, cattle, and horse numbers, whereas camel numbers have steadily decreased. Sheep numbers have also decreased as herders have replaced sheep in the herd with goats.

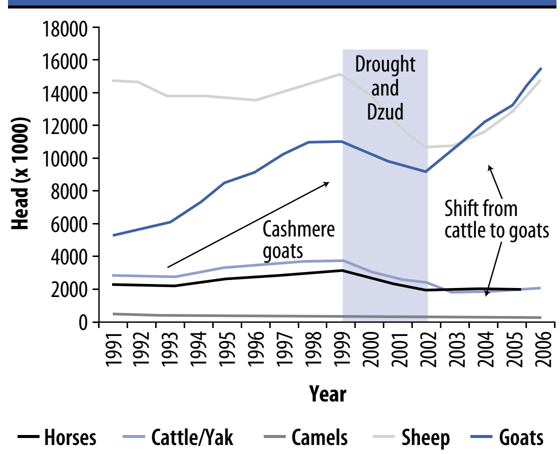
The trend toward goats dominating the national herd has resumed since the large-scale die-off caused by the 2000/02 drought/dzud period (Figure 2.10). Not only have goats replaced sheep as the dominant livestock species but cattle that died during the period have also been replaced in the national herd by goats. Goats also continue to dominate the SGR livestock herd as they had done so prior to the transition to a market economy. During the collective era, provinces forming the SGR were noted for cashmere wool production.

Figure 2.9. Estimated Livestock Numbers in Mongolia, 1961–2003



Source: FAOSTAT (2005).

Figure 2.10. Number and Trend of Livestock Species in the National Herd Before and After the 2001/02 Drought/Dzud



Source: Angerer (2007).

Livestock Production System

Extensively managed livestock production in Mongolia is a viable system and one that is well adapted to Mongolian conditions. In one form or another, it has been the dominant livestock production system for millennia. As practiced by herders in the SGR, managed livestock production is low-cost in terms of inputs; it uses an almost free, renewable resource (i.e., native forage produced on natural rangeland) and provides food, fiber, and fuel to the Mongolian people through family relationships or the marketplace. By providing products for domestic and international trade, it is a major component of the developing market-based economic system (Nixson and Walters 2006; Sheehy 1996).

Privatization of livestock ownership and production for a market economy have increased the level of uncertainty and amount of risk to which individual or groups of herders must respond in making decisions relative to livestock production and use of natural resources. The risk and uncertainty normally associated with livestock production itself is being compounded by new factors including (a) the concentration and expansion of livestock numbers, (b) decrease in the number of herding families, (c) changes in customary herder institutions, (d) uncertainties from the marketplace and government, and (e) increased potential for conflict over use of pasture resources.

In the SGR, the extensively managed, pastoral livestock production system as it now exists presents a number of advantages and disadvantages relative to economic development and conservation of wildlife and natural ecosystems.

The major advantages of the SGR livestock production system are:

a. It is a low input, low cost system based on using renewable and monetarily free resources;
b. The production system has adapted itself to the Gobi Region's environmental conditions;
c. It continues to supply meat and off-take products desired by the Mongolian population;
d. It is relatively self-sufficient in meeting self-consumption needs and producing a marketable product, and
e. Under normal production conditions, it has few negative impacts on the natural environment or wildlife habitat (Details in Annex C).

The major disadvantages of the SGR livestock production system are:

a. It is a forage supply-driven livestock production system in which temperature and moisture conditions determines, during a short period of forage growth, the supply of animal feed for the entire year irrespective of animal needs.
b. It is subject to natural climate-related catastrophe that can cause widespread livestock mortality in the short term and reduce animal and pasture productivity in the long term.
c. Almost no inputs (feed, veterinary care, marketing opportunities) are available to support extensively managed livestock production and relieve livestock pressure on regional rangeland.
d. Herders tend to respond to market incentives by increasing livestock numbers and changing herd structure to cashmere goats. The change in numbers and herd structure can lead to catastrophic losses among the herd population in the event of natural and commonly occurring weather events and as livestock numbers increase and herd structure changes, opportunities for conservation of wildlife and natural ecosystems decrease.

Natural Versus Industrial Livestock Economies

Further examination of the Mongolian livestock production system in the context of *natural economies* and *industrial economies* is a useful mechanism for relating livestock production in the Southern Gobi Region (SGR) to issues of sustainable economic development (Annex C). In an industrial economy: i) the natural resource base is overlaid and artificially divided by political and administrative hierarchies, ii) competition exists among the artificial divisions for purposes of economic gain, iii) a well-developed production infrastructure exists and is driven by fossil fuels and capital inputs, iv) large-scale and vertically integrated production facilities favoring monoculture production exist, and v) spheres of competing but independent economic interests develop. Conversely, in a natural economy: i) organization is by natural units of the landscape with boundaries imposed by natural constraints, ii) the largest part of the production infrastructure is invisible, iii) production activities are driven by solar energy and the need to reproduce, iv) production is dispersed among small units, v) production activities are circular and renewable, vi) consumptive use and recycling of production prevails, and vii) natural resources are viewed as connected habitats for use rather than exploitation.

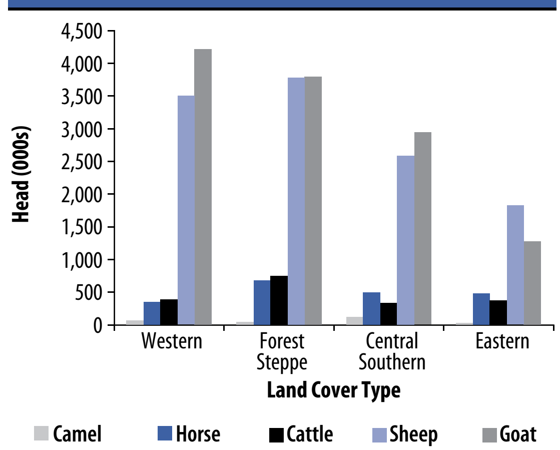
The pastoral livestock production system in the Southern Gobi Region presently continues to respond to constraints and opportunities of a natural economy relative to animal production and use of resources but is beginning to acquire characteristics of an industrial economy relative to product marketing. For example, the shift in herd structure to Cashmere goats is more characteristic of an industrial economy than a natural economy because the shift occurred for economic reasons rather than reasons related to environmental sustainability. The natural economies have considerable more potential to respond effectively to long-term climate change and other perturbations compared to industrial economies which are also a major factor inducing climate change. However, the partial adaption of the Mongolian pastoral livestock production system to the context of an industrial economy (i.e., overstocking and a herd structure dominated by goats) has also diminished the capacity of the livestock producer to respond to climate change.

Externally induced stimulants originating from new economic development and political paradigms will rapidly change the nature of the SGR pastoral livestock production system. Those herders that have the capacity to adapt livestock production to the industrial economy that results from economic development will survive and potentially prosper. However, herders that continue to operate within the natural economy will eventually fail or be forced out of livestock production as they lose capacity to respond to increasing financial and environmental risk imposed by economic development and the dominating industrial economy. The cumulative impact of disadvantages associated with industrial development will adversely affect sustainability of the livestock production system and rangeland resources.

Livestock and Wild Herbivore Adaptability

Livestock species present in the SGR herd reflect differences in rangeland capacity and species adaptability to the different land cover types (Figure 2.11). With the SGR, the environmental characteristics of the desert steppe and desert provide most suitable habitat for camel, sheep, and goats (Annex B). Although livestock herders in the SGR have followed the trend toward higher goat numbers as a percentage of the national herd, they have also retained relatively high numbers of horses and cattle in the regional herd. Dry steppe rangeland in the northern part of the Southern Gobi and along the Chinese border does provide suitable habitat for these livestock species (Authors personal observation 2005–2007).

Figure 2.11. Regional Distribution of Mongolian Livestock Species



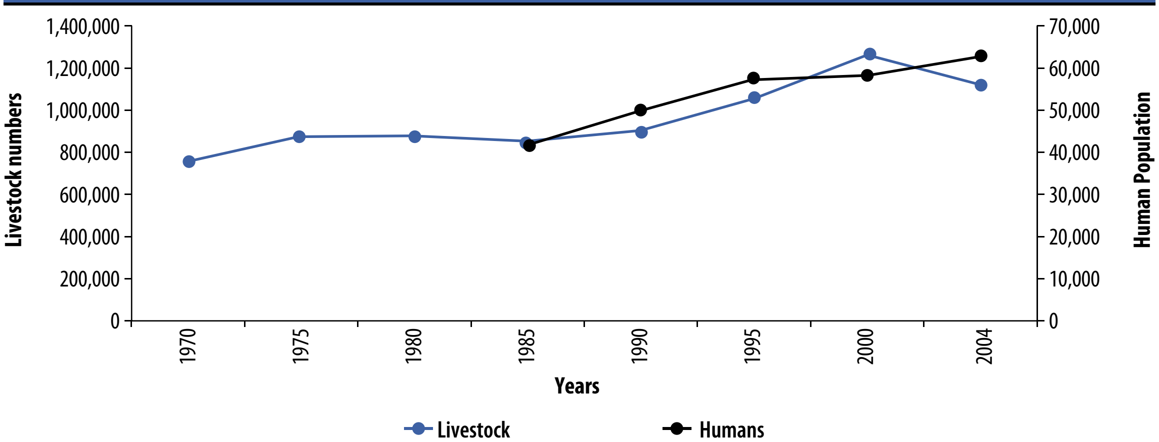
Source: NSO (2005) and ADB (2007).

Between 1990 and 2000, livestock numbers in the SGR increased from 761,973 to 1,121,095 head (47 percent increase) following the collapse of livestock collectives (Figure 2.12). Similar to the national situation, the increase in livestock numbers corresponded with a change in livestock composition. The most dramatic shift occurred in goats and camels with the percentage of goats increasing from 30 percent in 1970 to 58 percent in 2004, and the percentage of camels decreasing from 18 percent to 6 percent during the same period.

Large wild herbivores, which are most likely to compete for habitat and forage with domestic livestock, are commonly observed on rangelands of the SGR. A 2003 census of three large wild herbivore populations in southwestern Dornogov Province indicated the importance of the SGR as habitat for large wild herbivores (Table 2.1).

Prior to the end of the Socialist period in 1990, most populations of large wild herbivore species found in Mongolia were relatively healthy. Hunting and taking of fish and wildlife species was tightly controlled by the state; access to firearms was limited to herders who needed to protect livestock against large predators, especially wolves; and few people, whether urban or rural, had any

Figure 2.12. Population Development (since 1985) and Livestock Numbers (since 1970)



Source: NSO (2005).

Table 2.1. Partial Census of Large Wild Herbivore Populations in SGR

Soum	Wild Ass	Ibex	Argali
Mandakh	700	40	60
Saihandulaan	300		50
Ulaanbadrach	600		120
Khatanbulag	4,000	30	80
Khuvsgul	6,222		472
Erdene	550		78
Total	**12,372**	**70**	**860**

Source: Dornogov Office of Statistics (2005).

inclination to sport hunt or fish (Kaczensky and others 2006).

Over the past 17 years, with the transition to capitalism and a market economy, the situation has changed. Populations of large wild herbivore species are legally and illegally being over-hunted, or captured and sold; illicit export and sale of birds of prey is occurring; as well as illegal taking of rare fish species (Annex D). Although laws exist to protect fish and wildlife species, and provincial and county environmental inspectors are responsible for enforcing these regulations, the illegal take of these species continues (Kaczensky and others 2006).

Species that are currently experiencing major declines include the red deer, snow leopard, Wild Ass, Siberian musk deer and Argali bighorn sheep. The population declines have been extremely rapid, as is shown by the 92 percent decline of red deer (i.e., Mongolian elk) over an 18 year period (Wingard and Zahler, 2006). The prospects are even more alarming for other species. In the last five years, the Saiga antelope has declined from more than 5,000 to fewer than 800, and the Argali bighorn sheep population has declined by 75 percent in 16 years (Wingard and Zahler 2006)

Many species, such as the Mongolian Saiga antelope, wild camel and Gobi bear have been reduced to such small populations that they are highly threatened (Mech and Boitani 2008). It is estimated that there are only 460 wild camels in Mongolia and less than 1,000 globally. The Gobi bear is even more threatened with less than 50 remaining. Overall, 79 percent of large herbivores and 12 percent of carnivores in Mongolia are now threatened with extinction.

Large wild herbivore populations in the SGR are also in decline from legal and illegal over-hunting and changes affecting their habitat The population center of the Wild Ass is in the SGR but its population numbers during the next 10 years are expected to decline rapidly from illegal hunting and deterioration of their habitat (Kaczensky and others 2006). Argali bighorn sheep populations have been legally over-hunted to the extent that Mandalk county in west-central Dornogov Province has banned legal hunting to allow recovery of local populations (Personal communication with Mandalk County Environmental Inspector, 2007). The 2005–2007 study of the Wild Ass in the same area indicated that legal and illegal hunting is the main cause of declining large wild herbivore populations (Kaczensky and others 2006).

Overgrazing Impacts on Rangeland Ecosystems

There seems to be a general consensus among herders, government officials, donor institutions, and the public that Mongolian rangeland has, and is, degrading from a combination of livestock overuse and increasing aridity throughout Mongolia. Although empirical data to support this consensus is limited, a 2008 re-survey of 60 ecological monitoring plots established in Desert and Forest Steppe ecological zones in 1997 supports this contention (Sheehy and Damiran 2009).

In the Desert Zone, re-survey of 27 monitoring sites indicated that: i) plant species present in 1997 had declined by 33%, ii) grasses and forbs had highest loss of presence on winter and summer pastures, iii) ground surface cover of bare soil and rock had increased while cover of vegetation and plant litter had decreased, and iv) livestock preferred and desirable plant species had high loss of presence on all seasonal pastures.

In the Forest Steppe Zone, re-survey of 33 monitoring sites indicated that: i) plant species present in 1997 had declined by more than 33%, ii) forb plant species had highest loss of presence in all seasonal pastures, iii) ground surface cover of bare soil and rock had increased while cover of vegetation and plant litter had decreased, and iv) plants undesirable to livestock had highest loss of presence on all seasonal pastures but relative composition of preferred, desirable, undesirable and toxic plants comprising the forage base remained unchanged between 1997 and 2008.

Based on ecological trend at the two zonal study areas, both Desert and Forest Steppe rangeland had declined from good and fair condition to poor and very poor ecological condition (Figure 2.13). Rangeland in the two zones was becoming increasingly degraded and, unless changes in management relative to herd structure and stocking rate are implemented soon, the rate at which rangeland is being degraded will accelerate.

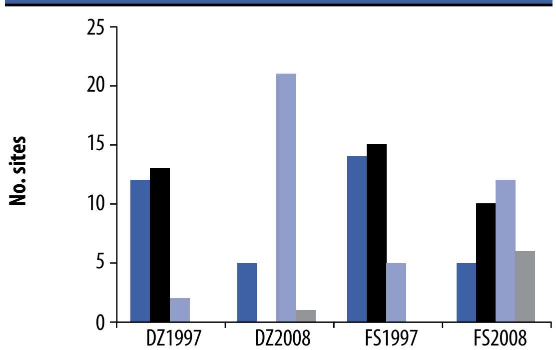
Two primary change factors caused rangeland degradation in Desert and Forest Steppe Zones between 1997 and 2008. One factor was the increase in total livestock numbers and dominance of herd structure by goats. Discussions with livestock herders and local government officials indicated that study areas were severely affected by the 2001/02 drought/dzud during which substantial numbers of livestock died. In addition to the direct impacts, officials in both study areas indicated that climate drying was affecting pasture ecological condition and livestock production in the sum. Changes included: i) insufficient precipitation or precipitation at inappropriate times, ii) a lack of adequate precipitation was causing streams, lakes and springs to dry-up, and iii) productivity of vegetation throughout the soum was declining. A second change factor was the gradual but persistent increase in aridity from insufficient precipitation during the 11 year interval between measurements. The primary impact of climate change relative to rangeland degradation in both the Desert and Forest Steppe study areas was increasing aridity.

Weather and Climate Change

Mongolia's climate is largely defined by its proximity to major mountain systems, and less so by its central continental position and far distance from oceans. Mountain ranges in the west and northwest portion of Mongolia intercept atmospheric flows carrying moisture from the Atlantic Ocean. Monsoonal storms from the Pacific Ocean fade rapidly and their influence is generally considered to be between 110° to 120° east latitude, which covers only the eastern portion of Mongolia (i.e., Mongolia lies between 87°41' and 119°56' east latitude). This exposes Mongolia to dry Central Asian desert winds from the south. As a result, Mongolia has extremely cold, dry winters and dry, cold, and windy springs. Most precipitation occurs during mid-June to the end of August. Mean annual precipitation decreases from north to south.

Climatic attributes of the SGR include (a) mean annual temperature between 0.0 degrees and 2.5 degrees Centigrade (C) with minimum temperature in January (-20 degrees C) and maximum temperature (23 degrees C) in July; (b) between 110 and 140 frost-free days; (c) variable precipitation between 100 and 250 millimeters; (d) snow depth ranging between 5 and 10 millimeters; and (e) wind speed between 2 and 8 meters per second. Temperature and precipitation affect rangeland ecological condition and use of rangeland by large herbivores. Approximately 100–150 millimeters of annual precipitation occurs in the steppe desert; and 50–100 millimeters in the desert region. However, droughts induced by extended periods of low or no precipitation, often for several consecutive years, are common in the SGR.

Figure 2.13. Changes In Desert Zone (DZ) and Forest Steppe Zone (FS) Ecological Condition during the 11 Year Interval between Macroplot Measurements in 1997 and 2008



	DZ1997	DZ2008	FS1997	FS2008
Good	12	5	14	5
Fair	13	0	15	10
Poor	2	21	5	12
Very poor	0	1	0	6

Condition status

Source: Sheehy and Damiran 2009.

Precipitation

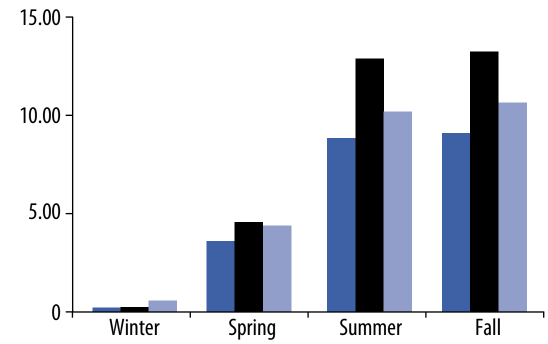
Precipitation has a major influence on the development of habitats and the distribution of animals within habitats. Although a number of abiotic and biotic factors intersect to form habitats and influence animal distribution, precipitation in the SGR is unquestionably the single most important climate factor influencing both domestic and wild herbivore distribution.

Precipitation influences both the amount and timing of annual forage growth. Without adequate amount and seasonal availability of precipitation in the form of rain or snow, inducement of drought may decrease forage growth across different habitats. Inadequate precipitation can also diminish the availability of surface water, which reduces the amount of drinking water available to both livestock and wild herbivores. Lower forage and water availability can both directly and indirectly increase potential conflict between domestic livestock and wildlife that co-use the same rangeland habitat (Kaczensky and others 2006).

The SGR has considerable annual and seasonal precipitation variation (Figure 2.14). Annual precipitation between 2005 and 2007 in the southeastern area of the SGR ranged from 7.29 to 10.60 centimeters (Figure 2.15). In each of the three years (2005–2007) measured, highest moisture accumulation occurred during the spring and summer seasons.

In 2005, considerable annual variation existed in the amount of seasonal precipitation occurring throughout the sub-region (Figure 2.15). The northern sub-region received more precipitation during spring, summer, and fall seasons than the central and southern portions. The latter two regions received approximately the same amount of precipitation (6 to 7 centimeters), and both regions had proportional accumulation of precipitation during each season. In 2005, accumulated precipitation at the end of each season was lower compared to accumulated precipitation in 2006 and 2007. The lack of precipitation during the spring and summer season of 2005 induced drought throughout much of the SGR.

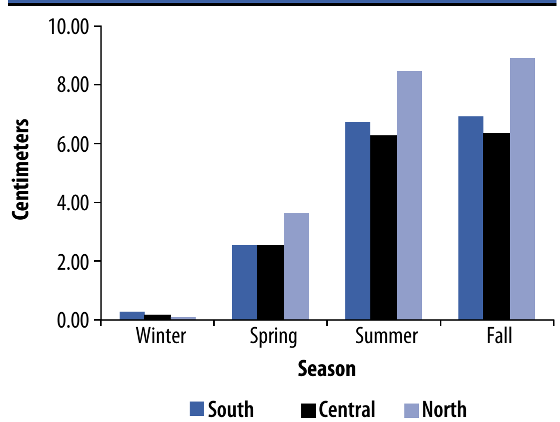
Figure 2.14. Cumulative Centimeters of Annual Precipitation by Season in Southwest Dornogov Province



	Winter	Spring	Summer	Fall
2005	0.19	2.89	7.07	7.29
2006	0.21	3.66	10.32	10.60
2007	0.46	3.51	8.15	8.53

Source: World Bank (2008).

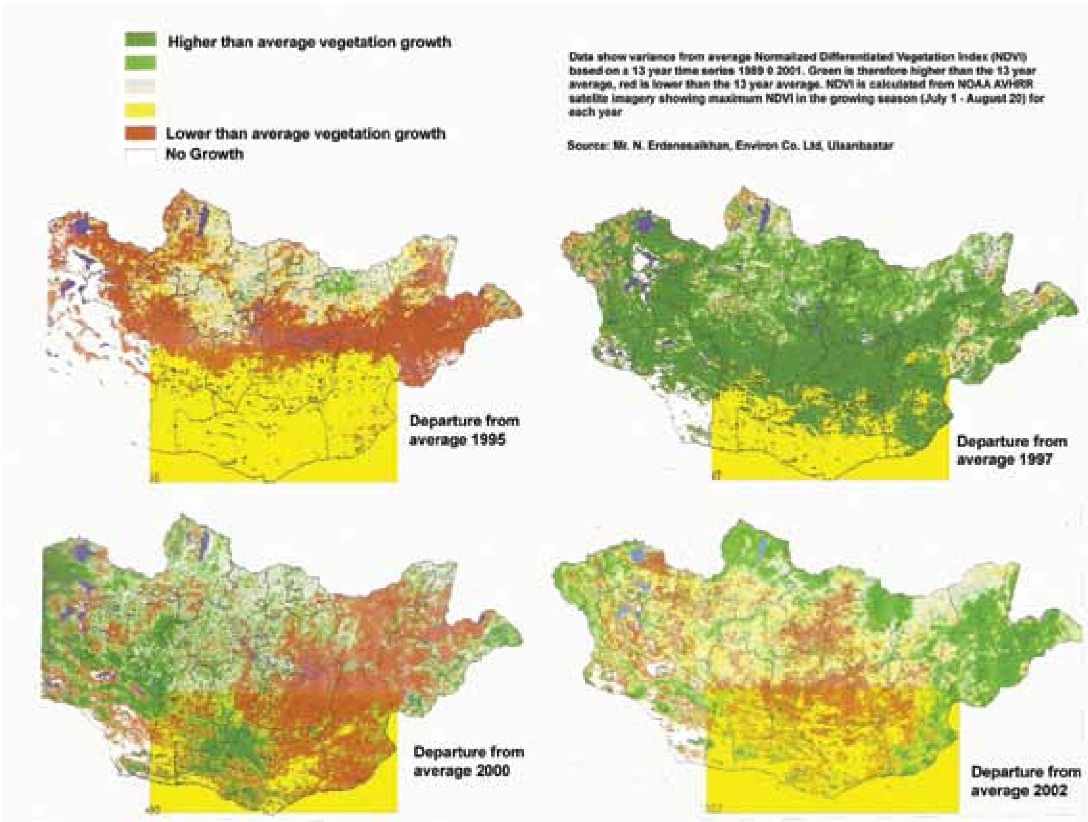
Figure 2.15. Seasonal Precipitation in the Southeast Gobi during 2005



Source: Compiled from C-Morph data collected by the Gobi Forage Project.

The variation in annual precipitation has implications in both local and regional areas (Figure 2.16). Most precipitation events during the summer season of highest moisture accumulation are the result of localized convection storms. Random distribution of precipitation tends to create extremely local areas of high vegetation growth and higher surface water availability. The annual variation in precipitation affects surface water and vegetation productivity throughout the SGR and influences wild herbivore and livestock

Figure 2.16. Annual Differences in Vegetation Growth Related to the Amount of Precipitation



Source: World Bank (2003).

productivity, distribution, and degree of potential conflict for habitat.

Climate Impacts

Although the debate on climate change and how to respond to climate change continues, there is little doubt that a warming trend is occurring. In Mongolia during the previous 60 years, mean annual air temperature reportedly has increased by 1.6 degrees C. If this pattern of change continues, by 2040 the mean summer temperatures are predicted to increase by 1.0 degrees to 3.0 degrees C, mean winter temperatures by 1.4 degrees to 3.6 degrees C, and mean annual temperatures by 1.8 degrees to 2.8 degrees C during the projected time period (Annex E). Relative to the SGR, there is some concern that desert land cover types are gradually expanding their area northward into dry steppe and grass steppe land cover types, at least partially due to higher temperatures and less annual moisture accumulation (World Bank 2003).

The short-term impact of climate on large herbivores is most often directly expressed through summer drought and severe winter weather. A drought summer followed by a severe winter is not uncommon, and both occurring sequentially can be extremely detrimental to livestock and large herbivore wildlife. Consecutive years of summer drought and severe winter weather can cause high mortality rates among populations of both large herbivore wildlife and livestock, as happened in the 2001–2002 drought/dzud years (Table 2.2) when over 9 million head of livestock and an unknown number of large herbivore wildlife died.

Table 2.2. Livestock Mortalities during Mongolian Drought/Dzud Years

			Animal mortality			
			Adult stock		Young stock	
Year	Type of disaster	Coverage (%)	Million	%	Million	%
44–45	Drought + dzud	9 aimags (65%)	8.1	33.2	1.1	17
54–55	Dzud	9 aimags	1.9	8.2	0.3	4
56–57	Dzud	11 aimags	1.5	6.2	0.9	12
67–68	Drought + dzud	13 aimags (80%)	2.7	11.9	1.7	21.6
76–77	Dzud	15 aimags, 116 soums (90%)	2	8.6	1.6	10.7
86–87	Dzud	11 aimags, 198 soums (80%)	0.8	3.6	0.9	9
93	Dzud	3 aimags, 30 soums	1.6	6.4	1.2	13
96–97	Dzud	11 aimags, 69 soums	0.6	2.1	0.5	5.4
99–2000	Drought + dzud	12 aimags, 157 soums	2.8	8.6	1.2	12.1
2000–01	Drought + dzud		4.1	13.8	—	—

The entire SGR is especially susceptible to drought and dzud. The northern part of Dundgov Province has had almost continuous drought since 1999. In this area, the combination of drought and high livestock numbers prior to and during the early drought period has affected ecological conditions of natural rangeland ecosystems in the area (Sheehy and Byambadorj 2001). Herbaceous grasses and forbs appear to be heavily over-grazed; shrubs over large areas of rangeland are over-browsed and in some areas dying; and rangeland in general appears to be degraded.

3. Development of the Southern Gobi Region

The sparsely populated SGR is enormous and richly endowed with mineral wealth. The SGR is served by few transport links and suffers from decreased rainfall and limited water availability. It also supports a growing human population that includes livestock herders who maintain a difficult grip on their livelihood after enduring a collapsed economy. Mongolia's transition to a privatized market economy and development of mines proposed in the region, together with their associated infrastructure needs and human population movement, could cause significant impacts on the regional environment and the many wide-ranging, threatened animal species. It is critical that economic development and infrastructure construction be sensitive to the needs of wildlife, pastoral herders and livestock, and sustainability of natural rangeland ecosystems in the SGR.

Regional Development

The types of development anticipated in the SGR include physical infrastructure (i.e., transportation and communication); resources (i.e., mining, energy generation, water use); and livestock production. These developments could potentially improve economic livelihoods of SGR residents, but they also have potential to degrade the environment. Unrestrained economic development without functioning regulatory mechanisms will be a major cause of the degradation of natural rangeland ecosystem. In the short term, economic development may induce site-specific degradation of natural ecosystems, but in the long term it could contribute to and accelerate climate change.

Transportation

Probable SGR transportation developments are expansion of the existing rail and road transportation corridor in Dornogov Province, construction of new railroads and hard-surfaced roads to support large-scale mineral exploitation, and improved region-wide air service (Figures 3.1 and 3.2).

Communication

Satellite-based communication systems are expected to provide cell phone coverage to all counties of Mongolia within two years. Satellite phone systems are already available but expensive, and provincial centers are connected to the Internet. Most rural residents already have satellite television and radio connections. Access by rural residents to real-time information will be a key element in SGR development.

Mining

Large-scale exploitation of minerals and coal is already occurring close to the major transportation corridor in Dornogov Province (Figure 3.3). Large projects to extract precious metals, high-value minerals, and coal for local energy generation and export have been proposed throughout the SGR.

Figure 3.1. Unimproved Road Network in Western Dornogov Province, Characteristic of SGR

Source: Johnson (2005).

Figure 3.2. LANDSAT View of Trans-Mongolia Railroad and Road Traffic Impacts at Sainshand in Dornogov Province

Source: Johnson (2005).

Figure 3.3. Coal Mine Tailing Piles in Dundgov Province

Source: C. M. Sheehy (2005).

Small-scale precious metal mining, usually illegal, is already occurring throughout the region.

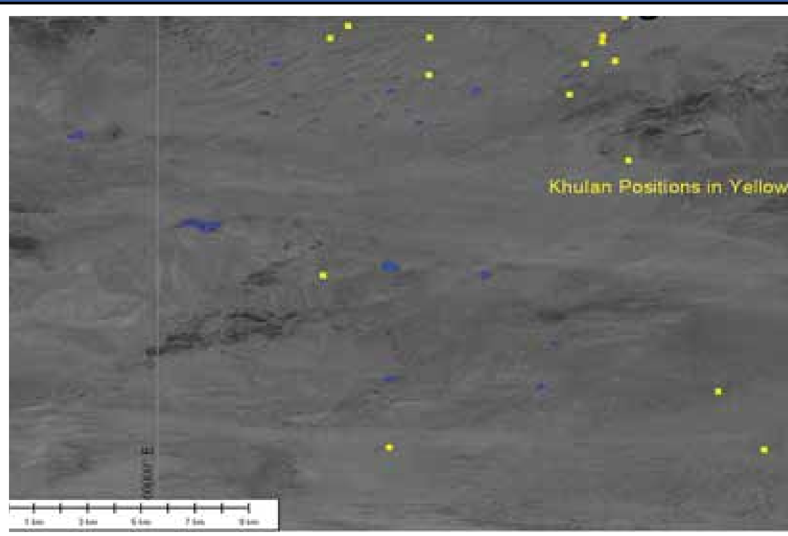
Energy Generation

Small-scale solar and wind power generation is well established in the SGR. Most rural households have either wind or solar power-generated electricity sufficient for their personal needs. Most counties in the region also have diesel-powered generation of electricity. Proposals to build large-scale wind and solar farms can be expected in the future. Large-scale energy generation proposed by Tavan Tolgoi mine complex development will focus on exportation of processed coal/coke or power directly to China and will require road and rail construction, power plants, and strip mining (Annex F). Geo-thermal power generation is possible in the SGR, and projects to tap underground water aquifers have been proposed (JICA 2003).

Water

Water is a critical resource for all forms of life and production activities in the SGR. Processes to extract minerals, precious metals, and coal require substantial and reliable sources of water. Humans and animals need reliable sources of fresh drinking water, usually on a daily basis, to live in the region. Currently, most humans and domestic livestock rely on wells to meet water requirements while large herbivore wildlife relies almost exclusively on surface or near-surface water sources (Figure 3.4). The anticipated scale of infrastructure

Figure 3.4. Small Lakes and Ponds in Eastern SGR Used Extensively by Livestock and Wild Herbivores to Obtain Drinking Water (LANDSAT Image)



Source: Johnson (2005).

development will require access to large quantities of water and will require additional infrastructure development to extract water from underground aquifers (JICA 2003).

Livestock Production

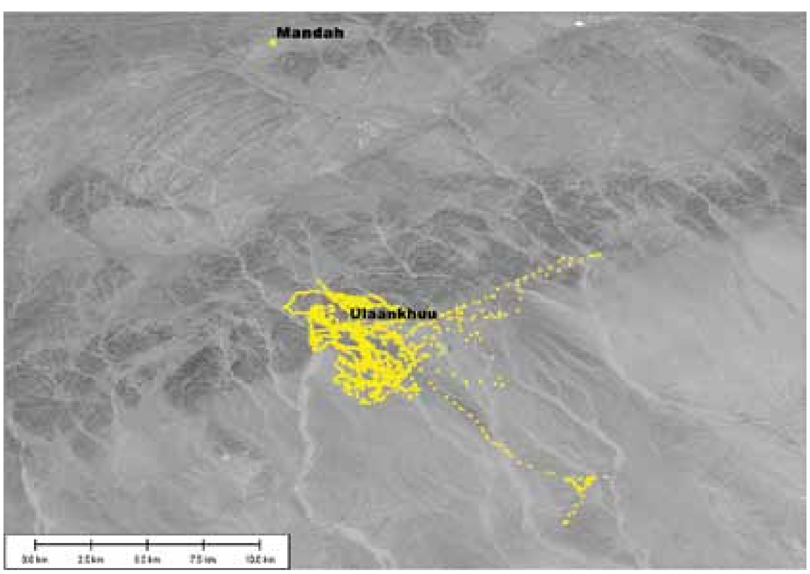
Livestock production remains the dominant economic activity for a majority of SGR residents (Figures 3.5 and 3.6). Access to potable water is the most significant limiting factor to livestock production in the region (Kaczensky and others 2006). Since 2000, a key focus of government and donor projects in the region has been rehabilitating existing mechanical wells and expanding well coverage to rangeland without livestock drinking water.

Other potential infrastructure needs of commercialized livestock production include fencing, permanent or modern mobile dwellings, livestock shelters, livestock health inputs, and supplementary animal feed. The livestock production system will also benefit from infrastructure development not directly related to livestock production, such as expanded transportation and communication facilities. As livestock production continues to change from subsistence based to commercialized, herders will by necessity embrace infrastructure developments that improve their competitiveness in the market place.

Tourism

Tourism is a fast-growing industry in the SGR, especially in Omnigov Province. The industry's need for infrastructure is minimal because the current clientele prefers the existing small hotels and tourist camps that are in or near provincial centers and engages in activities that have negligible impact on wildlife or natural resources. Tourism, especially as it becomes more commercially oriented and as the cliental diversity expands, will benefit from infrastructure development by other industries (i.e., transportation, communication, and electricity generation) and develop its own infrastructure to meet client needs (e.g., hotels, new and improved roads, golf courses). In the longer-term development, commercialized SGR tourism will require improved infrastructure and increasing use of water and other critical resources.

Figure 3.5. Concentrated Livestock Use of Rangeland Near a Functioning Production Well



Source: Johnson (2005).
Note: The yellow dots are GPS points indicating livestock movement and distribution around the well during the summer of 2005.

Figure 3.6. An Abandoned Production Well in the Eastern SGR

Source: C.M. Sheehy (2006).

Impact of Development

Four categories of impact on natural ecosystems associated with development in the SGR are:

- Direct impact from infrastructure establishment and operation,
- Direct impact that accelerates decline of large wild herbivore populations,
- Short-term, direct impact that deteriorates/degrades critical habitat components for pastoral livestock and wild herbivores, and
- Long-term, indirect impacts on natural systems from accelerated climate change.

It is also probable that impact will be synergistic and exponential in its effect on current uses and users of natural rangeland ecosystems. The impact of most anticipated development on natural ecosystems will be negative unless appropriate safeguards to protect natural ecosystems, wildlife, and pastoral livestock production are in place and functional prior to the development (Table 3.1).

Development Perspectives

Accelerated development has occurred in other regions globally that have a similar natural resource base, livestock production tradition, and large herbivore wildlife. Two areas which have been subject to accelerated development are the Intermountain Region of western North America and the Inner Mongolian Autonomous Region of China. Despite vastly different social, cultural, economic, and political histories, the 20th Century development path of the two regions has been similar, although under different timeframes and with potentially different outcomes since development continues to occur in both areas. A brief comparison of development pathways may provide valuable insights to the SGR.

Intermountain Region (North America). The Intermountain Region is a large, internally drained basin lying between the Sierra Nevada and Cascade Mountains to the west and the Rocky Mountains to the east. Native fauna and flora, including large herbivorous wildlife, is similar to the genus and species found in the SGR. Livestock production, based on cattle, sheep, and horses, is family based and pastoral in nature and remains a key industry in the region. A majority of the rangeland is public land managed and regulated by Federal Government agencies. Mining of precious metals from both public and private land is a major industry and a major contributor to the region's economy.

A select list of major events forming and motivating development in the Intermountain Region from the late 19th to the early 21st Century includes the following:

- Control and curtailment of indigenous peoples' activities (before 1900);
- Settlement of the region by non-native people (1850 to present);
- Over harvest of wildlife, especially large herbivore wildlife and large predators (1830–1920);
- Open access farming and large-scale stock growing (1850–1930);
- Government dispersal and fragmentation of land resources through privatization of public land (1870–1930);
- Degradation and abandonment of dispersed land by small-scale farmers and stockmen (1920-present);

Table 3.1. Development Impact on Wild Herbivores and Pastoral Livestock Production in SGR

Development	Type	Impact on large wild herbivores	Impact on pastoral livestock production
Transportation infrastructure	Hard surface roads and railroads to support industrial development, especially mining	• Interfere with mobility and decrease access to habitat, especially Wild Ass and gazelle which are highly mobile animals (negative). • Unfenced roads potentially will increase mortality of animals interacting with vehicles traveling at high speed (negative). • Improve human access to wildlife for legal and illegal hunting, wildlife viewing, and eco-tourism (negative/positive). • Degradation and fragmentation of wildlife habitat (negative).	• Improve herder access to inputs and services and improve direct marketing of livestock and products (positive). • Support commercialization of livestock production (positive/negative). • Improve livelihood sustainability of herders in a market economy (positive). • Justify need for vehicle acquisition and/or improvement of public transportation (negative). • Increase conflict over access to natural resources (negative).
	Air service in SGR	• Increase rate of human intrusion and development (negative). • Increase potential for eco-tourism and wildlife viewing (positive).	• Improve rural links with urban centers to access information, health care, and economic opportunities (positive).
Communication		• Increase rate of human intrusion and development (negative). • Increase potential for eco-tourism and wildlife viewing (positive).	• Improve herder access to inputs and services and improve direct marketing of livestock and products (positive).
Mining	Legal and illegal mineral exploitation at different scales	• Increase rate of human intrusion and development (negative). • Increase pressure on large herbivorous wildlife from poaching and illegal hunting (negative). • Loss of habitat dependent on scale and location of mineral extraction locations (negative).	• Improve herder potential for local marketing of livestock and livestock off-take products (positive). • Potential to improve herders' livelihood and access to health and education services (positive).
Energy generation	Solar power generation	Impact dependent on scale of solar power development as: • large-scale "solar farms" disrupting large areas (negative). • small-scale household solar (neutral/negative).	Impact dependent on scale of solar power development as: • large-scale "solar farms" disrupt activities of local livestock herders and cause loss of access to rangeland without gaining any direct benefits from the electricity generated (negative) • small-scale solar power could potentially benefit herder's livelihood by increasing access to electricity (positive/neutral/negative).
	Wind power generation.	Same as for solar power generation (neutral/negative).	Same as for solar power generation (positive/neutral/negative).

(*continued on next page*)

Table 3.1. Development Impact on Wild Herbivores and Pastoral Livestock Production in SGR *(continued)*

Development	Type	Impact on large wild herbivores	Impact on pastoral livestock production
Livestock Production	Development of livestock water sources	• Mechanical wells as a source of human and livestock water will potentially increase competition for rangeland resources between livestock and wild herbivores and result in conflict (negative).	• Mechanical wells will reduce labor associated with watering livestock and expand rangeland areas suitable for grazing by livestock (positive).
	Commercialization of production	• Potential for wildlife, especially highly mobile herbivores that form large herds, to be regarded as competing with livestock for scarce natural resources and decreasing profit potentials (negative/neutral).	• Many herders have already shifted from subsistence-based livestock production to commercial production (i.e., cashmere wool) (neutral). • The high value of cashmere is driving change herd structure and causing increased financial and environmental risk being assumed by herders (negative/neutral).
	Improved livestock health services and supplemental feeding.	• A further increase in livestock numbers beyond carrying capacity would (i) potentially increase competition between livestock and large wild herbivores for forage and habitat and (ii) increase degradation of rangeland quality (negative).	• Vaccines to prevent livestock diseases such as Foot & Mouth Disease (FMD), Brucellosis, and other contagious diseases will reduce animal mortalities; provision of supplemental feed to livestock during winter and spring seasons and availability of veterinary health services will improve survival and birth rates (positive).
Large herbivore population decline	Legal and illegal over-hunting by non-residents	• As population associated with new development increases, and with continued open access to firearms and vehicles, hunting of large wild herbivores is anticipated to further increase over current levels that are already having a negative impact on large herbivore wildlife in the SGR (negative).	• As populations of large herbivorous wildlife continue to decline, competition between livestock and wildlife for natural resources will decline (negative).

- National government-supported improvements to land and vegetation for economic uses (1950–1980);
- Ownership consolidation of privately owned dispersed land (1940 to present);
- Development, application, and enforcement of regulations on use of public lands and wildlife (1900 to present);
- Accelerated government and private infrastructure development (1950 to present);
- Public land change in emphasis from single economic use (i.e., stock growing, logging, recreation) to sustainable multiple uses (1970 to present);
- Public and private land use change in emphasis from economic purpose to environmental purpose, including restoration of wildlife populations and habitat (1980 to present);
- Failure of traditional, natural resource-dependent communities and family-based

agricultural production as a result of population demographic shifts, accumulation of wealth and political power in urban areas, and globalization of food production (1960 to present);
- Consolidation and ownership of the rural private land base by speculators, new forms of absentee owners, and corporate-industrialized agricultural production companies (1980 to present).

Inner Mongolian Autonomous Region (China). The Inner Mongolian Autonomous Region includes the southern portion of the desert basin that is dominated by the Gobi Desert. The southern boundaries of the three Mongolian provinces comprising the SGR form a portion of the international boundary between China and Mongolia. The physical boundary of the southern edge of the Gobi Basin in China is formed by the Qilien Mountains and Qinghai-Tibetan Plateau in Gansu Province, the Loess Plateau highlands, and the Khinggan Mountains in Inner Mongolia. The native fauna and flora, including large herbivorous wildlife, includes most of the same genus and species found in the SGR. Livestock production, based on cattle, sheep, goats, horses, and camel, has been family based and pastoral in nature except during the collective period. A majority of the rangeland is public land managed and regulated by agencies of the Chinese Government.

A select list of major events forming and motivating development in the Inner Mongolian Autonomous Region from the late 19th to the early 21st Century includes the following:

- Control and activity curtailment of the indigenous Mongolian people by foreign powers (before 1900 to present);
- Settlement of the region by Han farmers (before 1850 to present);
- Over-harvest and extirpation of wildlife, especially large herbivorous wildlife and large predators (before 1830 to present);
- Open access farming and large-scale stock growing via collectives and state farms (1950–1980);
- Government dispersal and fragmentation of land resources through quasi-privatization (household contracts) of public land (1990–2000);
- Degradation and abandonment of dispersed land by small-scale farmers and stockmen (1980 to present);
- National government-supported improvements to land and vegetation for economic uses (1950–1980);
- Consolidation of household contracted dispersed land (1990 to present);
- Development without application and enforcement of regulations on use of public lands and wildlife (1980–2000);
- Accelerated government and private infrastructure development (1990 to present);
- Public land change in emphasis from family-based, single economic use (i.e., stock growing and farming) to corporate single economic use (1990 to present);
- Public land use change in emphasis from strictly economic purpose to partial environmental purpose, including restoration of wildlife populations and habitat (2000 to present);
- Failure of traditional, natural resource-dependent communities and family-based agricultural production as a result of forced demographic shifts, accumulation of wealth and political power in urban areas, and globalization of food production (1980 to present);
- Consolidation and control of the rural land base by speculators, new forms of absentee owners, and corporate-industrialized production companies (2000 to present).

In both the Intermountain and Inner Mongolian Regions, economic development has taken precedence over environmental sustainability. In the Intermountain Region, efforts to restore a balance between economic development and environmental sustainability are on-going but have high social and economic costs to rural communities that formerly supported livestock production and exploitative industries in the region. The increasing global need for minerals and energy is again putting focus on economic development of the region but with strong environmental controls in place. In Inner Mongolia, environmental controls have been formulated but their application and enforcement is weak, and uncontrolled economic development continues to take precedence over environmental sustainability. In order to restore environmental stability to natural ecosystems, current Chinese policy is focused on moving rural residents to urban areas as a method of relieving human pressure on pasture and cropland (Sheehy and others 2006).

SGR Development Scenario

Both the Intermountain Region (North America) and the Inner Mongolian (China) development pathways suggest that current SGR development trends could have negative consequences for traditional use and users of the region's natural resources. Since establishment of rural livestock collectives occurred prior to the transition to a market economy, change is not new to the SGR; but the rate of change has begun to accelerate, especially since 2002.

The most obvious changes occurring in the SGR include:

- Physical changes to habitats of large herbivores as a result of mineral exploitation and increasing livestock numbers;
- Infrastructure development to support mining, livestock production, and rural populations;
- Decline in large wild herbivore populations from legal and illegal hunting and degradation of habitats;
- Demographic change in rural populations;
- Accumulation of wealth and political decision making in urban areas; and
- Application of broadly based projects to resolve Gobi-specific issues without accompanying safeguards or application of regulatory measures.

The two development activities having the most severe impact on SGR natural resources will be (a) exploitation of minerals through mining and (b) increased use of water resources stored in underground aquifers.

Mineral exploitation. The on-going, legal development of large-scale, regulated mines is expected to continue in the future (Annex F). Illegal development of small-scale, non-regulated mining is already occurring throughout the SGR. Although addressing Mongolia in general, Reading and others (2006) presented an overview of mining-related activities that have significance for the SGR:

- Mining activity has increased dramatically during the transition period.
- In 2004 both foreign and national companies already had licenses to explore 29.9 percent of Mongolian territory.
- Mining represented (in 2006) 15–20 percent of gross national product and 57 percent of exports.
- Laws relating to preparation of environmental impact assessments, reclamation activities, and establishing environmental protection funds with government oversight are not enforced.
- The largest threat to the protected area system from mining arises from government removal of land from a "protected" status to allow mineral exploration and extraction.

Both legal and illegal mining is a major economic activity generator in the SGR that can provide short- to medium-term solutions to rural poverty and unemployment; access investment funds to strengthen social, economic, and physical infrastructures; and strengthen economic activity in other sectors. Although social and economic outcomes may generally be positive, these impacts may be accompanied by negative environmental consequences, including residual open pit, strip and shaft mines; mine tailings and extensive degraded areas; air, water, and land pollution; human intrusion; and exploitation of local natural resources. Development of the physical infrastructure, especially roads and railroads, will negatively affect large migratory wild herbivores by creating barriers to movement, facilitating illegal hunting, and degrading large herbivore habitats (Kaczensky and others 2006).

Water exploitation. Water is the most important constraint to human and animal presence in the SGR. Without access to water, large areas of rangeland are not available for livestock grazing.

Without access to water, economic development at the scale proposed for the Tavan Tolgoi mining and energy generation complex will be unfeasible. Access to water is critical to economic development and successful livestock production.

In the desert steppe and desert regions, lack of water wells is a major limiting factor to successful livestock production and livelihood sustainability. Many of the wells developed during the collective era no longer function because pump and water delivery systems have been destroyed or gravel filters used in deep wells no longer function. Only 1,000 of the 1,800 wells established in Dorngobi, which has virtually no permanent surface water resources, were operable in 2003 (Sheehy and Byambadorj 2001). As a result, only 30 percent of the total pasture area was accessible to livestock compared to 60.7 percent during the collective period.

Shallow wells are a natural rationing system for livestock herd size, especially relative to the labor requirement needed to water large numbers of animals by hand-drawn water from shallow wells. Since most human and livestock populations are already dependent on water from shallow wells, and drought and lack of surface water are the common denominator in the Gobi even in normal years, developing new wells or rehabilitating old wells provides considerable benefit to livestock producers in the SGR relative to rangeland access (Table 3.2), and could be beneficial to wildlife if appropriate water distribution systems were implemented along with construction of new wells.

Environmental impacts of water system development. Development of wells and water systems can have both positive and negative environmental impacts on rangeland ecosystems (Sheehy and Byambadorj 2001).

Potential positive impacts:

- More wells and water sources could improve distribution of livestock and thereby reduce grazing pressure on local rangeland ecosystems.
- Living conditions could improve for herders and rural residents.
- Wildlife could have potential access to water if water distribution systems are implemented and managed for wildlife as well as livestock.

Potential negative impacts:

- Competition could increase between livestock and wildlife for foraging resources and habitat in areas formerly without water if livestock numbers increase in conjunction with water development.
- Livestock could degrade native vegetation and soils in surrounding rangeland if they graze back and forth from newly developed mechanical wells.
- Livestock could increase pressure on grazing newly accessible rangeland that provides criti-

Table 3.2. Water Source Availability and Grazable Pasture

Water source	Accessible area (km^2)	Accessible area gained (km^2)
Springs + lakes	55,903	
Springs + lakes + traditional wells	109,461	53,558
Springs + lakes + traditional wells + shaft wells	114,991	5,530
Springs + lakes + traditional wells + shaft wells + production wells	116,793	1,802
Total area gained when rehabilitating all broken wells	**60,890**	

Source: Kaczensky and others (2006).

cal security and habitat to wildlife, especially large herbivorous wildlife.

Government and donor projects to rehabilitate existing, non-functioning mechanical wells and drill new wells in waterless rangeland areas of the region are currently being implemented. Mapping of wells in 2003 by the Japan International Cooperation Agency and the Ministry of Nature, Environment and Tourism showed that in Dornogov Province alone there were over 1,200 deep, mechanical wells with an average of 1 well per 92 square kilometers (JICA 2003; and World Bank 2006). The development of new mechanical wells in waterless rangeland, while immediately beneficial to the pastoral livestock herder, should be evaluated in the context of reserving these newly accessible rangelands to mitigate drought impacts on livestock and wildlife. If used in this context, formerly waterless rangeland would improve sustainability of existing livestock rather than creating an opportunity to increase livestock numbers.

Degradation in the Southern Gobi Region

Rangeland degradation is influenced by the interaction of climate, geology, vegetation type, and disturbance caused by humans and animals. The degradation process reduces vegetation cover, yield, and usefulness for livestock and wild herbivores and exposes soils to wind and water erosion. In the short term, degradation causes natural ecosystems to become unstable; and in the long term, degradation will eventually impoverish people and animals dependent upon rangeland.

Three key indicators of rangeland degradation on a national/regional level are: i) a decrease in total area classified as rangeland (e.g., conversion of highest productivity rangeland to marginal cropland as has happened throughout Inner Mongolia) (Sheehy and others 2006); ii) a relative increase in rangeland area that is degraded, desertified, or salinized; and iii) the increase in degraded rangeland as a percentage of total rangeland. Four key indicators of rangeland degradation at the ecosystem level are: i) a decline in yield per rangeland unit; ii) a decrease in vegetation cover and height as well as increased exposure of the soil surface; iii) an increase in the percentage of invasive or non-selected plants in community species composition; and iv) a change in the structure of plant species (Sheehy and others 2006).

Livestock-Related Degradation

Degradation of SGR rangeland ecosystems is caused by a number of factors, including overuse by livestock and large wild herbivores, human intrusion, exploitation of natural resources, and climate and weather conditions. The two major types of degradation associated with livestock are grazing and small-scale infrastructure development (i.e., wells, fences, vehicle tracks, shelters, and feed or cropland production). Severely degraded rangeland is simple to detect. Degradation of rangeland surrounding a livestock water source is obviously caused by overgrazing and trampling but determining the cause of larger scale rangeland degradation can be more complicated as a number of interacting factors are usually involved. During the severe drought/dzud of 2000/01–2001/02, interacting factors were high livestock numbers, lack of drought/dzud preparation such as storage of animal feed, and the severity and length of the drought and dzud. These factors combined to cause overgrazing and rangeland degradation across the northern area of the SGR. The high livestock mortality directly associated with the drought/dzud and the degradation of highly productive rangeland affected the longer-term livelihood potential of rural residents (Sheehy and Byambadorj 2001).

Degradation from Economic Development

Economic development activities in the SGR that relate to rangeland degradation include: i) construction of asphalt and concrete hard-top roads, ii) strip and open-pit mines, iii) construction of new railroads, iv) various forms of air and water pollution including toxic chemicals from mining operations, and v) over-utilization of shallow underground aquifers. Many economic development activities destroy the natural ecosystem at the site rather than degrade it. Even though most economic development activities include plans and funds to restore the natural ecosystem after the life of the project, restoring those natural ecosystems to their prior state seems overwhelming.

Proposed infrastructure development during construction of the Tavan Tolgoi mine and power generation complex in Omnogov Province provides an example of impending economic development in the SGR and throughout the Gobi Desert (Ivanhoe Mines Mongolia 2005). Planned development at the complex includes: i) high–voltage power generation from diesel powered generators, ii) thermal power plants supplying electricity to China, iii) power transmission lines, iv) exploitation of water aquifers to supply water to coal mining activities, and v) improved earth and paved roads between the mine and Dalanzadgad. Although the impact of mining related activities at the Tavan Tolgoi site on rangeland condition, large wild herbivores, and pastoral livestock production may seem minor given the scale of the Gobi Desert, there are numerous plans for mineral exploitation and economic development. As the scale of unregulated economic development and infrastructure construction expands, cumulative degradation impacts on natural rangeland ecosystems will be more severe and permanent

Impacts on Wildlife

Many species of wildlife and all livestock species are classified as herbivores. At the larger scale of comparison, wild and domestic herbivores have ruminant or caecal digestion systems, many are ungulates, and some wild and domestic herbivores have overlapping diet and habitat needs. In the SGR, wild and domestic large herbivore equivalents are the domestic horse and the Wild Ass, the domestic goat and the Ibex, the domestic sheep and the Argali bighorn sheep, and the domestic camel and the wild camel. In general, wild and domestic herbivore equivalents have similar diets and prefer similar habitat compared to non-equivalents regardless of their domestic or wild herbivore status.

In the SGR, the major difference between wild and domestic large herbivore use of natural rangeland ecosystems is the management and security provided to domestic livestock by the herder. Management of domestic livestock in the pastoral production system retains many attributes of natural system. Large domestic livestock (i.e., camel, horse, and cattle) are free-roaming grazers except when being ridden, used as draft animals, or milked. Livestock continue to be moved between seasonal pastures and naturally seek out best foraging opportunities to maintain and improve body condition. Both wild and domestic herbivores are subject to, and similarly affected by, weather and prevailing climate; and the major constraint for both wild and domestic herbivores in the SGR is access to drinking water.

The SGR provides habitat for extensively managed pastoral livestock and populations of large herbivore wildlife that are already threatened or endangered. Further economic development and human intrusion is expected to increase pressures on their existence. Additionally, loss of large herbivore habitat through economic development will potentially increase pressure to eliminate large carnivore predators that may increase predation on livestock as an alternative to dwindling wildlife prey. Although the snow leopard may be adequately protected, no protection is currently provided to the wolf. The added variable of climate change may cause species survival to be increasingly problematic (Table 3.3).

Climate Change Impacts

Since the SGR is separated from Inner Mongolia only by an artificial boundary, comparison of expected climate change impacts could provide useful insights. Climate change impacts on Inner Mongolian rangeland ecosystems adjacent to the border with the SGR could be indicative of future impacts during and after economic development. Rangelands in Inner Mongolia have been subject to higher densities of livestock, rangeland is frag-

Table 3.3. Main Constraints Affecting Large Herbivore Wildlife and Predators in the SGR (*Summarized from Annex D*)

Wildlife species	Current factors affecting populations	Potential factors affecting populations
Black tailed gazelle (*Gazella subgutturosa*)	• Hunting • Increasing number of livestock compete for use of oases and cause degradation of surrounding rangeland	• Mining • Human disturbance
White tailed gazelle (*Procapra gutturosa*)	• Drought and dzud conditions • Infectious epizootic diseases • Steppe wildfires • Human and livestock intrusion • Predation by wolves and raptors	• Mining industry • Barrier construction that affects distribution and migration (e.g., the Trans-Mongolian railway) • Dietary overlap competition with domestic sheep and goats for forage-plant species
Wild Ass (*Equus hemionus*)	• Illegal hunting for meat and skins for commercial use • Habitat degradation due to human intrusion • Resource extraction (mining) • Increasing numbers of livestock	• Habitat fragmentation • Barrier construction that affects distribution and migration (e.g., the Mongolian railway)
Saiga antelope (*Saiga tatarica*)	• Drought and dzud conditions • Illegal hunting for meat and skins for commercial use	• Low population numbers
Argali bighorn sheep (*Ovis ammon*)	• Overharvest caused by hunting and poaching for trophy horns	• Habitat loss from mining • Increased competition with livestock
Ibex goat (*Capra sibirica*)	• Overharvest caused by hunting • Habitat degradation • Competition for resources	• Habitat loss from mining • Increased competition with livestock
Bactrian camels (*Camelus bactrianus ferus*)	• Decline in population numbers • Low reproductive success • Hybridization with domestic camels	• Low population numbers • Mining
Wolf (*Canis lupus*)		• Over-hunting
Snow leopards (*Panthera uncia*)	• Exploitation by poaching for pelts and bones • Loss of prey species as a result of (illegal) over-hunting of ibex, argali and marmots. • Loss and fragmentation of habitat. • Indirect competition with livestock for habitat	• Mining and infrastructure development

mented by fencing, and herders and livestock are more sedentary (Angerer and others 2008).

Inner Mongolia climate change. The projected change in natural ecosystem boundaries include i) a disappearance or decrease in area of more mesic rangeland types, increase in area of arid rangeland types, and/or replacement of existing rangeland types by extreme desert and warm temperate shrub rangeland types; ii) net primary productivity decreases in desert steppe (17 percent) and steppe (9 percent) rangeland productivity caused by higher temperatures and lower precipitation during the summer months; iii) water-use efficiency could increase throughout the region if higher seasonal precipitation and temperatures are realized in conjunction with higher carbon dioxide availability; iv) a reduction of soil cover in arid land vegetation due to wind erosion; and v) potential increase in non-native invasive species caused by reducing the amount of ground cover, increasing soil disturbance, and providing new invasive species seed dispersal vectors.

Mongolia climate change. The following changes in Mongolian natural ecosystem boundaries are projected: i) current desert, desert steppe, and dry steppe natural ecosystem zones will move northward; ii) mountain taiga and forest steppe zones will be replaced by steppe ecosystem zones by the end of the 21st Century; iii) net primary productivity will decrease 5–30 percent in the forest steppe and steppe zones and increase 25–75 percent in the high mountain and desert steppe zones due to higher temperatures or higher precipitation; iv) water-use efficiency could increase throughout the region if increased seasonal precipitation and temperatures are realized in conjunction with higher carbon dioxide availability; v) soil cover will be reduced in arid land vegetation cover due to wind erosion; and vi) potential for increase in non-native invasive species could result from reducing the amount of ground cover, increasing soil disturbance, and providing opportunities for new invasive species seed dispersal vectors.

Global and regional impacts. The longer-term effect of climate change on natural ecosystems, pastoral livestock production, and populations of large herbivore wildlife is uncertain (Annex E). Global projections of climate change impacts by the Intergovernmental Panel on Climate Change (IPCC) indicate the following (Brown and Thorpe 2008):

- Warming will be greatest over land and at high northern latitudes.
- Snow cover will contract, and thaw depth will increase.
- Frequency of hot extremes, heat waves, and heavy precipitation events is likely to increase.
- Tropical cyclone intensity will very likely increase.
- Extra tropical storm tracks will shift poleward.
- Precipitation will likely increase in high latitudes and likely decrease in most sub-tropical regions.
- River runoff and water availability will increase at high latitudes and decrease in dry regions at mid-latitudes and tropics.
- Many semi-arid regions will experience decreases in water availability.

At regional levels, changes in precipitation and temperature patterns are expected to jeopardize current agricultural practices. This action would necessitate changes in technology, management, species, or breeds (or all of these), as well as modifying animal productivity expectations and changing animal requirements to overcome climate-imposed production constraints (Table 3.4).

The IPCC projections of climate change impacts for the regional area that includes the SGR are increased annual temperatures of 2.5–5.0 degrees C during both winter and summer months; an increase in annual precipitation during the winter, and a slight decrease or increase in summer precipitation depending on sub-region location.

Sheehy and Damiran (2009) found that data collected from two Mongolian eco-zones (i.e., Desert and Forest Steppe) supported Angerer et al. (2008). On both zonal study areas there was: i) a reduction in Net Primary Productivity (NPP), ii) water deficiencies in the Desert Zone, iii) reduced ground cover and expansion of native increaser plants such as fringed sagebrush, and iv) less resiliency of rangeland to withstand drought (Annex 2). Although the data does not specifically verify that the drought/dzud of 2001/02 accelerated rangeland degradation, the severity of the drought/dzud, combined with increasing aridity and overgrazing, may have been sufficient to suppress the natural resilience of rangeland vegetation communities and induce accelerated degradation.

Table 3.4. Potential Vulnerabilities of Rangeland Ecosystems to Climate Change Impacts

Vulnerabilities	Factor
Climate	• Temperature – warming above global mean. • Precipitation – increase or decrease, uncertain changes in established patterns. • Extreme events – increase in frequency and/or intensity of droughts, storm intensities, winds, rainfalls, landslides, floods, lengthy hot spells, as well as events occurring in new areas.
Large herbivores	• Water stress – compromised runoff and water supply that affect livestock, wildlife, and humans through decreased water quality, decreased river flows and surface water points, and flooding. • Decreases in vegetation productivity and large herbivore yields from reduced soil moisture and evapo-transpiration; and rangeland, agricultural or grazing lands subjected to increased desertification, salinization, and erosion and degradation. • Heat stress and changing patterns in the occurrence of disease vectors, which increases risk to endemic morbidity and mortality for human and livestock health due to alteration of spatial and temporal transmission of disease vectors and changes in ways humans manage livestock.
Livestock, wildlife, and habitat	• Changes in species, functions and/or transitions from non-food to food functions (e.g., conversion of rangeland to crop production), multi-purpose to single-purpose livestock production (e.g., from multiple species to one species only), ruminants to non-ruminants (e.g. cattle or small ruminants to pigs and poultry). • Geographical shifts from marginal areas to humid and sub-humid zones, marginal areas to rural or urban areas, rural areas to urban areas. • Structural and technological shifts from resource-driven to demand-driven livestock production, small scale to large scale (economies of scale and industrial production), horizontal to vertical integration, and low input to high input livestock production.

Source: Tolleson and others (2008).

4. Wild Ass in the Context of SGR Development

In the SGR, the Wild Ass (*Equus hemionus)* or *Khulan* exemplifies the declining populations of large wild herbivore species that is occurring throughout Mongolia. This equine's range historically extended across much of Asia, but has now been reduced to one sustainable but shrinking population in the Gobi Desert of Mongolia with the population centered in the SGR (Feh et al. 2002). In Mongolia, aerial and vehicle surveys in 1997 estimated a Wild Ass population between 63,000 to 33,000 individuals (Reading 2001). By 2003, the number was estimated at 20,000 individuals, with approximately 12,000 individuals currently in the SGR population (Kaczensky and others 2006).

Relatively little is known about the Wild Ass, but researchers recently have begun to examine habitat needs and threats facing the species. In 2005 and 2006, Wild Ass were studied in the Southern Gobi Region of Mongolia to determine the impact of well rehabilitation and human intrusion (Kaczensky and others 2006). Results of this study indicated that:

- Home ranges were large (> 90,000 km^2) as a result of the need to move between spatially distinct high forage productivity zones that occur immediately following a precipitation event.
- Infrastructure development such as railroads, roads, fencing, and mining, which is anticipated to expand greatly over the next two decades, could have a very deleterious impact on migratory Wild Ass unless conservation strategies are firmly in place and infrastructure development accounts for needs of the Wild Ass and other large herbivores.
- Herders' natural tendency towards conservation, especially towards the Wild Ass, has been eroded by the market economy.
- There is virtually no enforcement of wildlife laws in the SGR region, and herders remain the single most important factor determining the fate of many species of wild animals.
- Wild Ass conservation should be approached at both local and landscape scale as both livestock and Wild Ass in the region require large areas of rangeland to mitigate the considerable seasonal and annual variability in rangeland productivity and water availability.
- The introduction of a market economy in Mongolia over the last two decades has created opportunities for organized poaching rings and probable distribution of Wild Ass meat as a low cost substitute for horse meat, especially as sausage.
- Habitat fragmentation and economic development that limits Wild Ass mobility will be the forces most influencing the Wild Ass's long-term survival.
- Perceptions that herders may harbor toward Wild Ass are crucial; if negative, herders will allow poachers free rein to hunt, and in some cases, provide valuable information about Wild Ass locations; if positive, herders will better understand the tenuous situation of Wild Ass and will be in a position to assist Wild Ass and wildlife conservation programs.

One of the less understood aspects of Wild Ass ecology is the relationship between livestock and Wild Ass that co-use natural resources in the SGR. Even less understood is the impact of regional economic development on the complex relationship that exists between herders, livestock, rangeland and the Wild Ass. The key factors in this relationship are derived from the co-use of natural resources by livestock and Wild Ass, and how that co-use was perceived by the livestock herder. Therefore, a study of the existing relationship between herders, livestock, and the Wild Ass was undertaken during 2006/07 as a follow-up to the Kaczensky and others (2006) study. The objectives of this study were: i) improve our understanding of the degree of competition between pastoral livestock and the Wild Ass, ii) determine herders understanding of, and willingness to use, new technologies such as the GPS and digital camera to collect habitat information about rangeland co-used by Wild Ass and livestock, and iii) develop a suitable incentive for local herders who actively participate in Wild Ass conservation programs and protect Wild Ass from illegal hunting and other types of detrimental human intrusion.

Environment and Natural Resources

The highest population density of Wild Ass in Mongolia occurs in portions of the three Mongolian provinces that comprise the SGR (i.e., Dundgov, Dornogov, and Omnigov provinces). Terrain in these provinces is typical of the eastern Gobi. Two low-elevation desert mountain ranges separated by a wide, low-elevation valley provide topographic relief. The Wild Ass Strictly Protected Area (SPA) is located primarily in the southernmost mountain range close to the border with China. The human population of the study area is low, and mainly consists of livestock herding families and residents of small soum centers.

Land Form and Topography

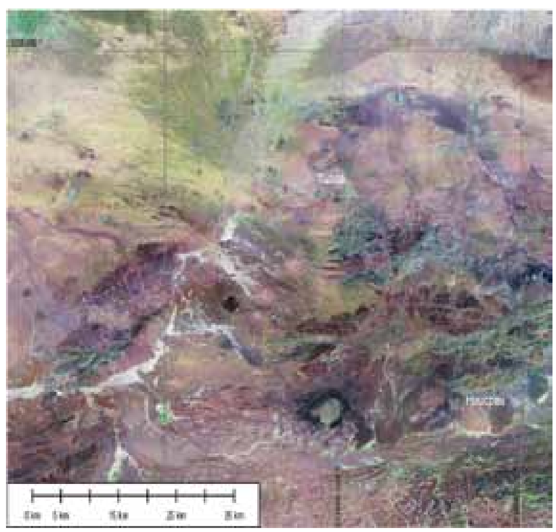
In the SGR, attributes of Wild Ass habitat include topography with variable aspects, elevation, and slopes; plant communities associated with different land forms and soils; sources of drinking water; and the presence of humans and livestock. These attributes are discernible in LANDSAT images of the southeast Gobi (Figure 4.1).

Although these and other attributes together comprise Wild Ass habitat, the two key factors determining whether habitat is viable for Wild Ass grazing is the availability of water, especially during the summer and fall seasons, and the type and availability of vegetation. Vegetation communities highly influence Wild Ass selection of habitat in the SGR.

Vegetation

Composition of rangeland vegetation and the temporal and spatial distribution of annual forage

Figure 4.1. LANDSAT Topographic Relief Map of Part of the SGR Extensively Used by Wild Ass



Source: Oregon State University 2005. (Note: Ephemeral water courses (i.e., white) cross the study area and small freshwater ponds are present (i.e., light blue). The darker colors of the dissected, rocky hill ranges contrast with the lighter shrub steppe plains. Relief energy is low and only a few small mountain ranges are found. Elevations in the area range from 750m to 1,900m. Superimposed on the mosaic are named herder camp locations and the colored dots represent GPS positions of collared Wild Ass in the 2006 study. There is a freshwater lake associated with the summer camp location of the herder Yubba near the center of the mosaic) standing crop are important factors regulating large herbivore distribution in the SGR. Extreme and unpredictable fluctuation in forage quantity and quality between seasons, years, and places (often on a very local scale) is a characteristic of forage growth. Although growth of forage standing crop may be initiated for some plant species by April, both quantity and quality of forage is insufficient to meet large herbivore needs until the rise in ambient temperature and precipitation create conditions suitable for a high rate of forage growth in late May and early June.

Vegetation types occurring in the Wild Ass study area range from gravel plains dominated by onion communities (*Allium* sp.) to large-stature Saxual (*Haloxylon* sp.) dominated shrub communities in desert valleys (Annex A). At least 26 different vegetation types occurred in rangeland habitat used by Wild Ass in the southeast Gobi between 2005 and 2007 (Figure 4.2).

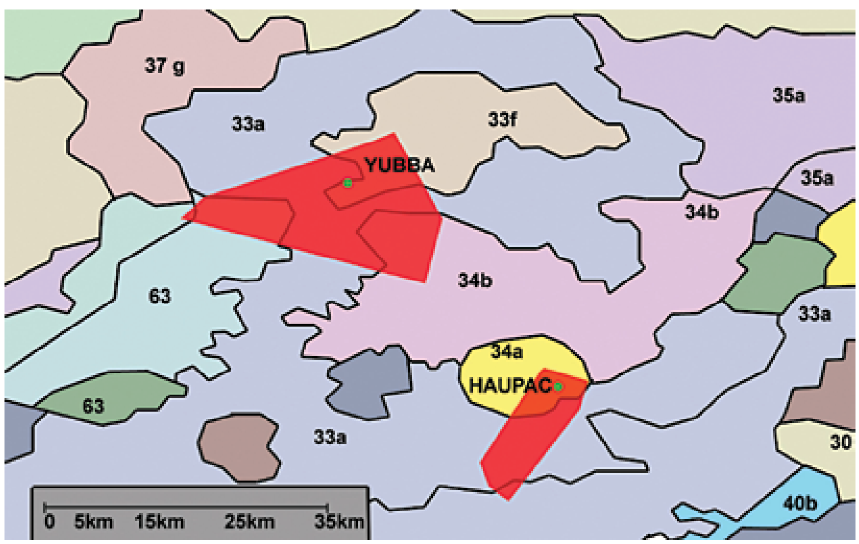
The area selected for the 2006/07 study of Wild Ass interactions with herders was the Minimum Convex Polygon (MCP) derived from locations of collared Wild Ass during the 2005/06 study (Kaczensky et al. 2006; Figure 4.3). This area lies wholly within the SGR and includes the southwest portion of Dornogov Aimag and the southeastern portions of Omnigov and Dundgov provinces.

Methodology

Herder Engagement

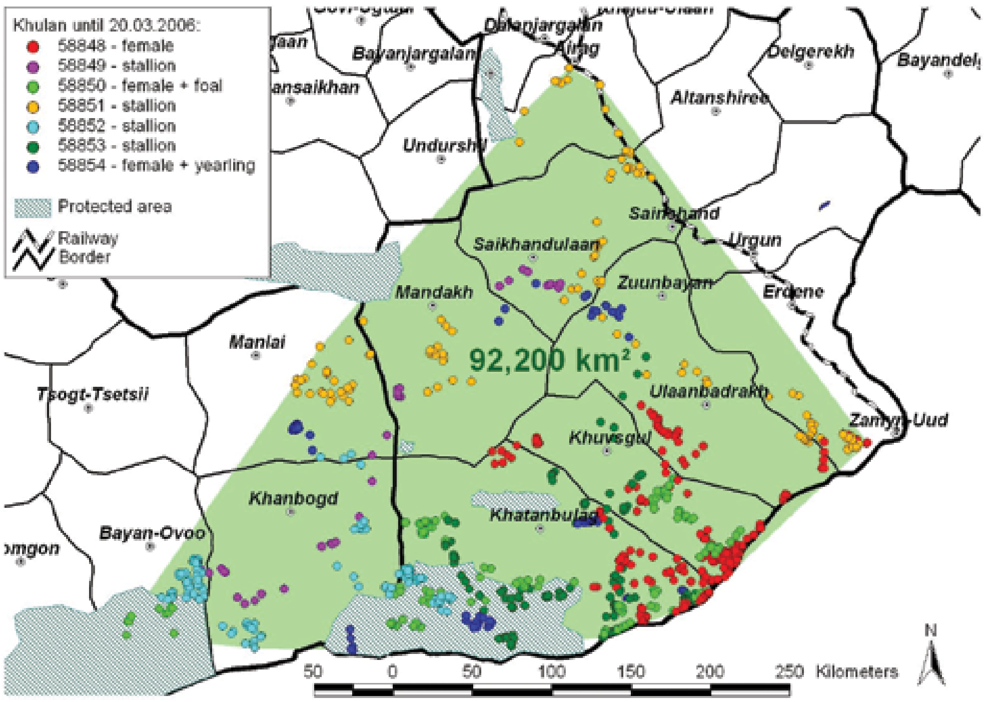
The study explored the interaction of Wild Ass with herders in the SGR during 2006/07. Three

Figure 4.2. Vegetation Map of the Southeast Gobi



Note: Examples of vegetation types grazed by studied livestock herds. The polygons represent the minimum convex polygons generated from GPS units carried by herders. Each dominate vegetation type contains a letter to denote a slight variation from the major type. The major types are as follows:
37 - Anabasis, Nanophyton, Sympegma, Ephedra, low Haloxylon stands on grey-brown desert, locally solonetz soils, often in combination with Sympegma-Potaninia or Artemisia terrae-abbae-Ceratoides papposa communities on sands
33 - Anabasis brevifolia with Stipa gobica, Stipa glareosa, Allium; Nanophyton erinaceum with Stipa, Artemisia, Ajania with Stipa deserts on pale-brown locally weakly solonetz soils
34 - Petrophytic Anabasis brevifolia, Sympegma, Ajania, Salsola laricifolia with Stipa glareosa deserts on pale-brown soils.
35 - Psammophytic Artemisia with grasses, Ceratoides papposa, Caragana, Potaninia deserts on pale-brown sandy soils
40 - Halophytic, Reamuria, Salsola passerina, Anabasis brevifolia, Brachanthemum deserts on grey-brown solonetz soils and solon-chak soils
63 - Combinations of halophitic (perennial saltwort Reaumuria, Kalidum, Nitraria, Haloxylon) communities on meadow and fluffy solonchaks

Figure 4.3. Minimum Convex Polygon of Wild Ass Home Range Derived from Collared Wild Ass Locations during the 2005 Study. The Green Polygon Includes All the Tracked Points from the Wild Ass GPS Tracking Units



Source: Kaczensky et al. 2006.

herder families who contributed information and assistance during the 2006 study were engaged to participate in the latter study. They were: i) Namsarai in Khatenbulag Soum, whose pastureland is located within the Wild Ass Strictly Protected Area (SPA). Namsarai's livestock, mainly sheep, goats, and camels, were dependent on shallow wells for drinking water; ii) Yubba in Khatenbulag Soum, whose pastureland is located outside of the Wild Ass SPA. Yubba's livestock, also mainly sheep, goats and camel, were dependent on fresh water ponds for drinking water; and iii) Ulaankhukhen in Mandalk Soum, whose pastureland is located on the northern edge of the Wild Ass range. Ulaankhukhen's livestock, primarily goats and sheep, were dependent on a deep mechanical well for drinking water.

The study evaluated Wild Ass interaction with the three herders at three scales: i) Wild Ass use of habitat in the study area (i.e., the Minimum Convex Polygon established in the 2006 study); ii) Wild Ass use of regional habitat as observed through vehicular transects; and iii) Wild Ass use of the herder's pastureland.

Wild Ass Local Pasture Use

The three herder families were provided with a digital camera, a GPS unit, LANDSAT derived grid maps of their pastureland, and data forms. They were provided with training and instruction in the use of the equipment and data collection procedures. Herders were asked to record information about Wild Ass use of pastureland grazed by their livestock. In return, herders were paid a stipend equivalent to about $8 and an additional amount (about $0.10) for each Wild Ass sighted and verified by a digital photo. The interaction of herders and Wild Ass was determined using data collected by the three herders located near three distinctly different kinds of water sources.

Wild Ass Regional Pasture Use

Between June 2005 and June 2007, Wild Ass and other large wild herbivore locations were observed and recorded along vehicular transects in the Wild Ass MCP range. On sighting of a Wild Ass or other large wild herbivore, their number in the group and the GPS position of the vehicle were recorded. The number and location of Wild Ass observed along the vehicular transects were used to derive summer and winter season MCPs of Wild Ass range areas during the second phase study. These MCPs were compared to summer and winter season MCP's derived from collared Wild Ass positions obtained in the 2005/06 study.

Wild herbivore GPS positions and numbers observed along vehicular transects were aggregated by season. Locations of Wild Ass during summer and winter seasons were overlaid onto plant community and topographic maps covering the MCP to determine selection of topographic parameters and plant community.

Large Herbivore Distribution

NDVI and C-Morph precipitation databases in the PHYGROW Forage Growth Model (Stuth and others 2003) that were derived at forage monitoring points established in the Wild Ass study area were compared with Wild Ass distribution. Accumulated precipitation in 2005 and 2006 was compared seasonally. Wild Ass use of habitat was compared on a seasonal basis throughout the study area to obtain indication of seasonal use during a drought year (2005) and a wet year (2006). The number and location of Wild Ass observed along the vehicular transect in 2006 were used to determine additional minimum convex polygons (MCP) of Wild Ass use during winter and summer seasons. These polygons are smaller than the MCP defining the study area and fall within its bounds.

Vegetation Community Selection

A preference index was used to determine selection of vegetation communities by Wild Ass. Such a preference index refers to the ratio between the percent of time an animal spends in a particular vegetation type divided by the percent of the total area that the vegetation type occupies. For the purposes of this study, the percent of time spent in an area was estimated by tallying the number of observation points that placed Wild Ass within the bounds of a community. The percent available area was found by determining the area of that vegetation community relative to other communities visited by the Wild Ass. For example, if 10 GPS points of the total 100 GPS points collected were located in "vegetation community number 1," then the percent of time in "vegetation community 1" would be 10%. If that community comprises 8% of the total area of all vegetation communities visited, than the preference value for "vegetation community 1" would be 10 divided by 8, or an index value of 1.25. Since this preference value is greater than one, it would be considered a 'preferred' community.

Large Herbivore Dietary Quality

During 2005, fecal samples of wild and domestic herbivores were obtained from herder pasturelands that overlapped with Wild Ass grazing areas in the Wild Ass SPA. Fecal profiling using Near Infrared Spectroscopy (NIRS) technique was used to determine dietary intake nutrition, represented as percentages of Crude Protein (CP) and Digestible Organic Matter (DOM) of large herbivores co-using the same pastureland (Lyons and Stuth 1992).

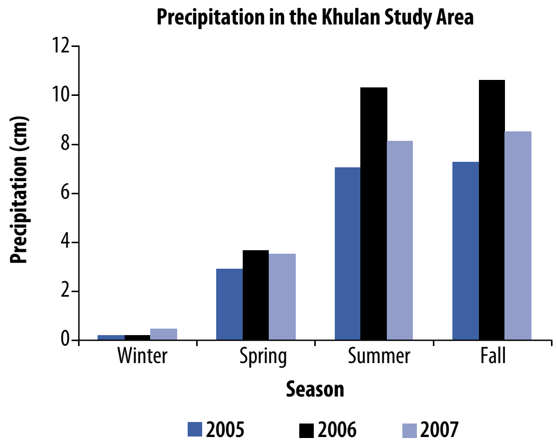
Study Results

Climatic factors have a major influence on habitat and distribution of animals within habitat in the SGR. Although a number of climatic factors interact to influence animal distribution, precipitation in the SGR is unquestionably the single most important climate factor influencing both large domestic and wild herbivore distribution. Precipitation influences both the amount and timing of annual forage growth. Without adequate seasonal precipitation in the form of rain or snowfall, drought is induced and forage growth in various habitats is reduced. Inadequate precipitation can also diminish the availability of surface water, which reduces the amount of drinking water available to both livestock and wild herbivores. Reduced availability of forage and drinking water can both directly and indirectly increase potential conflict between domestic livestock and wildlife that co-use the same rangeland habitat.

Seasonal Precipitation

Annual precipitation between 2005 and 2007 in the SGR Wild Ass study area had significant variation between years and between seasons (Figure 4.4).

Figure 4.4. Annual Precipitation by Season in the Southeast Gobi



Source: Gobi Forage Project 2007.

Using January 1 as the first calendar day to begin measuring annual precipitation, approximately the same amount of moisture from snow and rain (<0.5 cm as liquid) accumulated on the study area during winter seasons (i.e., winter season is arbitrarily defined as 1 January to 31 March). During spring seasons (i.e., spring season is arbitrarily defined as 1 April to 30 June), between 2.5 and 4.0 centimeters accumulated each year, indicating the SGR usually receives a relatively high amount of total annual precipitation during spring, but very little during winter.

However, the greatest amount of moisture in the SGR study area occurs during the summer season (i.e., summer season is arbitrarily defined as 1 July to 30 September). Each year during this season, accumulated precipitation in the study area increased between 4 and 7 centimeters. During the fall season (i.e., fall season was arbitrarily defined as 1 October to 31 December) the amount of accumulated precipitation only incrementally increased during each year.

Comparison of accumulated precipitation between years indicated that 2005 was a drought year in the SGR study area. During that year, accumulated precipitation at the end of each season was lower compared to accumulated precipitation in 2006 and 2007. The inadequate precipitation during the spring and summer season of 2005 induced drought. Long distance movements of collared Wild Ass during the 2005/06 study (Kaczensky and others 2006) appear to have been in response to the drought conditions of 2005.

In 2006, the relatively high amount of precipitation during the spring and summer seasons improved forage condition and drinking water availability for both domestic livestock and Wild Ass. During 2006, observations of Wild Ass indicated less movement and more concentrated habitat use in a much reduced area. In 2007, accumulated precipitation in the SGR study area was higher but more similar to 2005 than 2006 during the winter and spring seasons. Although Wild Ass were not observed in 2007 during summer and fall seasons, winter and spring observations of Wild Ass were consistent with 2006 observations during the same seasons.

Considerable annual variation existed in the amount of regional seasonal precipitation occurring throughout the SGR study area (Figure 4.5). In 2005, the northern portion of the MCP study area received more precipitation during spring, summer, and fall seasons than the central and southern portions of the study area. The latter two regions received approximately the same amount of precipitation (6 to 7 cm) and both regions had proportional accumulation of precipitation during each season.

Seasonal accumulated precipitation in the study area during 2006 was higher in all three regions compared to 2005, both relative to total annual accumulation and seasonal accumulation by study area region. During winter and spring seasons, the three regions accumulated approximately the same amount of precipitation but during summer, the southern region accumulated two to three centimeters more precipitation compared to the northern and central regions.

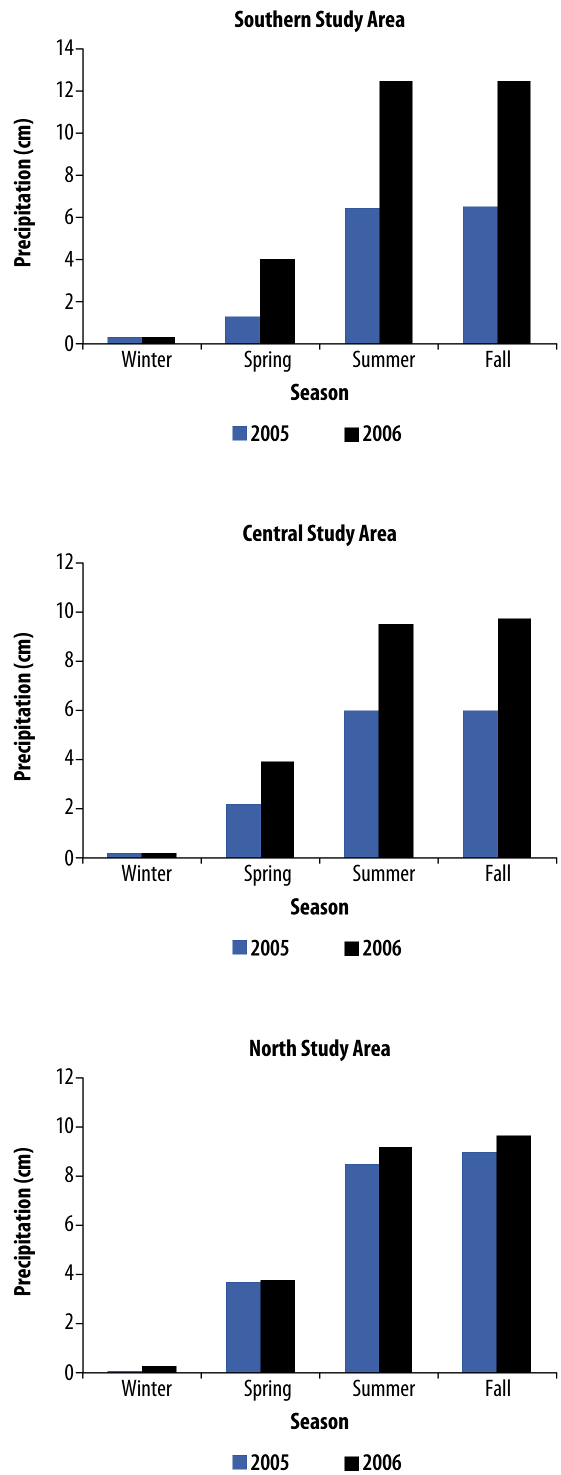
In 2007, annual precipitation appeared to be more uniformly distributed throughout the study area. The three study area regions appeared to accumulate precipitation at approximately the same rate during spring and summer. All three regions had received most of their annual precipitation by the end of the summer season, and precipitation accumulated equally in the three regions during spring and summer. Compared to 2005 and 2006, the study area in 2007 appeared to have average accumulated precipitation that was distributed evenly throughout the study area.

Wild Ass Distribution

The location of collared Wild Ass during summer and winter (i.e. 463 observations during 2005 and early 2006) and uncollared Wild Ass observed along vehicular transects (i.e. 51 observations during 2006 and 2007) provided an indication of Wild Ass distribution in the SGR. Locations were used to establish MCP of Wild Ass use of habitats during the period of observations. Location of Wild Ass in different vegetation types within the MCP also indicated trends in Wild Ass preference for habitat in the SGR.

Positions of the eight collared Wild Ass during the drought summer of 2005 indicated that Wild Ass in the SGR study area were widely dispersed. Habitat used by Wild Ass during the summer season was spatially large (67,248 km^2)

Figure 4.5 (a), (b), and (c). Regional Precipitation in the Southeast Gobi in 2005 and 2006 in Southern, Central, and North Study Areas Respectively



Source: D.P. Sheehy (2007).

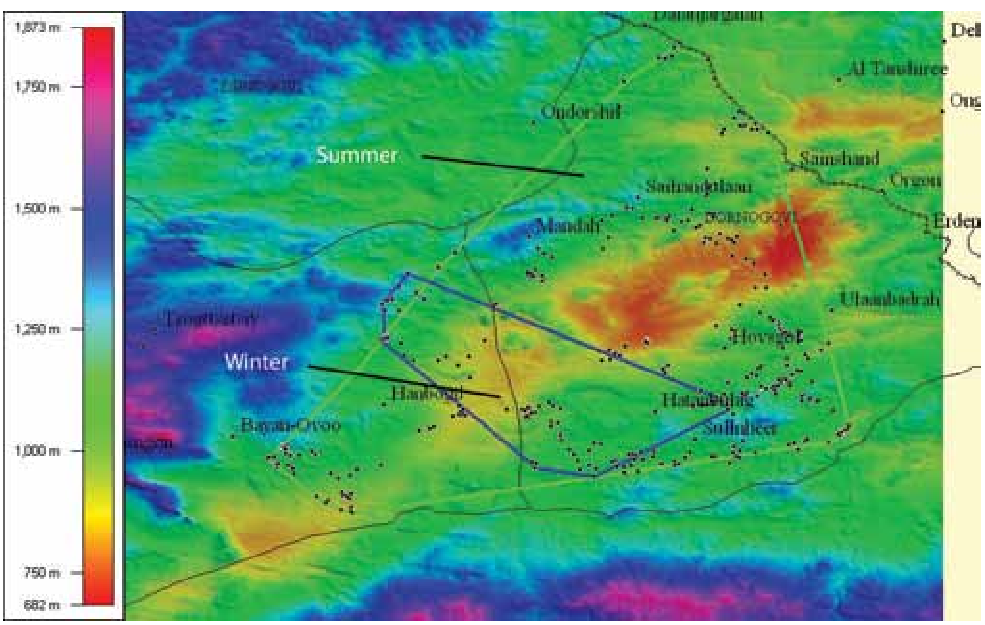
and included all or part of ten soums in southwest Dornogov province and southeast Omnigov and Dundgov aimags (Figure 4.6). During the winter, rangeland habitat used by Wild Ass was more concentrated (15,546 km^2) and was located in and around the Special Protected Area in southwest Dornogov province and southeast Omnigov province. During 2005 and early 2006, the ratio of winter range area to summer range area was 1:4.3, indicating the apparent need of Wild Ass to have access to an extensive range during summers experiencing drought.

The summer-season MCP derived from collared Wild Ass locations indicated that Wild Ass use their mobility and capacity to travel long distances to seek out favorable habitat. During the summer, Wild Ass locations relative to topography indicated Wild Ass sought moderate to higher elevation positions on the hill ranges and plateaus (i.e., green to blue color in figure 4.6). Conversely, Wild Ass locations also indicated avoidance of wide, low elevation desert valleys between east-west lying hill ranges. The location of collared Wild Ass during the winter season indicated Wild Ass sought out higher elevation hills and plateaus dominated by more preferred low-stature shrubs and grasses (Figure 4.7a) and avoided high stature shrub dominated valleys that considerably reduced the capacity of Wild Ass to detect approaching danger (Figure 4.7b).

During the summer and winter seasons of 2006 and 2007, Wild Ass were observed along vehicular transects extending from Mandalk soum in west-central Dorngov province to the SPA in Khatenbulag soum (Figure 4.8). Although the MCP defined from vehicular observations tends to be linear (since it is an artifact of the general north-south linear transect followed by the vehicle), the summer and winter range MCPs indicates a southern shift in range by Wild Ass during the 2006/07 winter similar to the shift observed during the 2005/06 winter with the collared observations.

The MCP defined by collar observations of Wild Ass during the summer of 2005 indicated the much larger area of summer rangeland habitat used by the Wild Ass. The MCP defined by collar

Figure 4.6. Seasonal MCPs of Rangeland Area with Observed Use by Collared Wild Ass during 2005 and Early 2006



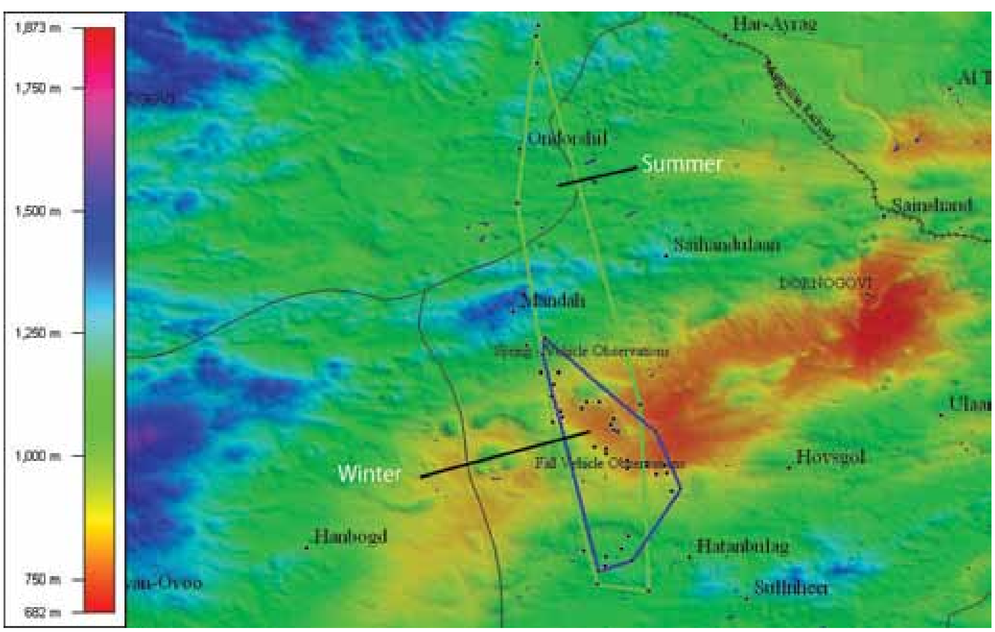
Source: C.M. Sheehy (2007).

Figure 4.7 (a) and (b). Vegetation Types at Different Elevations

Source: D. P. Sheehy (2007).
Left figure (a) shows small stature shrub/bunchgrass habitat found on higher elevation plateaus and hill ranges. Right figure (b) shows tall shrub habitat found in low elevation valleys and depressions.

observations of Wild Ass during the winter indicated they again concentrated their use of habitat in and around the SPA. The MCPs for 2006–2007 indicated that Wild Ass have an expansive summer range (8,063 km^2) but concentrate their use during the winter in a relatively small area of winter rangeland habitat (4,405 km^2). In 2006–2007, the ratio of winter range to summer range was 1:1.8.

Figure 4.8. Seasonal MCPs of Rangeland Area with Observed Wild Ass Use along North to South Vehicular Transects during 2006 and 2007



Source: C.M. Sheehy (2007).

Although the ratio of winter to summer range area is not directly comparable between years because of the different methodologies used to obtain MCPs, both ratios support the apparent need of Wild Ass to have access to larger areas of summer rangeland habitat compared to winter rangeland habitat (Figure 4.9). The need for a large summer range is apparent even though 2006 had higher accumulated precipitation compared to 2005.

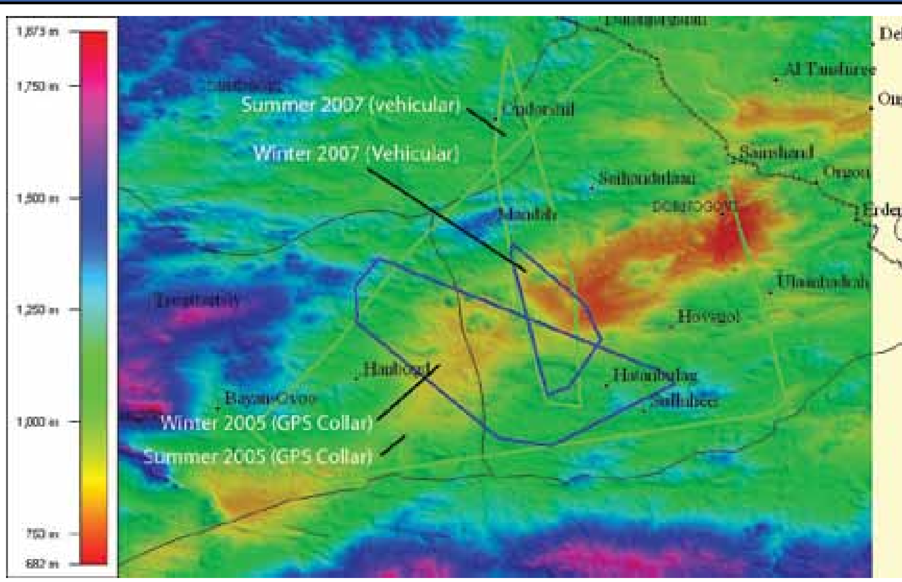
The overlap of winter range MCPs, although established using different methods and data sets from different years, suggests that Wild Ass select specific land forms that provide optimal conditions for winter survival and security. Relative to topography, Wild Ass appeared to utilize habitat associated with moderate elevation hill ranges and plateaus found in the southeast Gobi. The lower elevation desert valleys, while used, appeared to provide less optimal habitat for Wild Ass in either winter or summer. These landforms appeared to be in or near the SPA and were centered on the east-west range of moderate elevation hills and plateaus in the southeast Gobi. The much larger summer rangeland MCPs indicated the mobility and capacity of Wild Ass to travel long distances to access a variety of habitats that provided optimal foraging conditions and access to drinking water

Preferred Vegetation Communities and Habitat

Different vegetation communities and diverse topography were contained within rangeland areas used by Wild Ass between 2005 and 2007. During the summer of 2005, collared Wild Ass used 15 different vegetation communities but only five during the winter season. In the following topographical overlay, colored dots representing collared Wild Ass positions are paired with narrow black lines indicating different vegetation types (Figure 4.10).

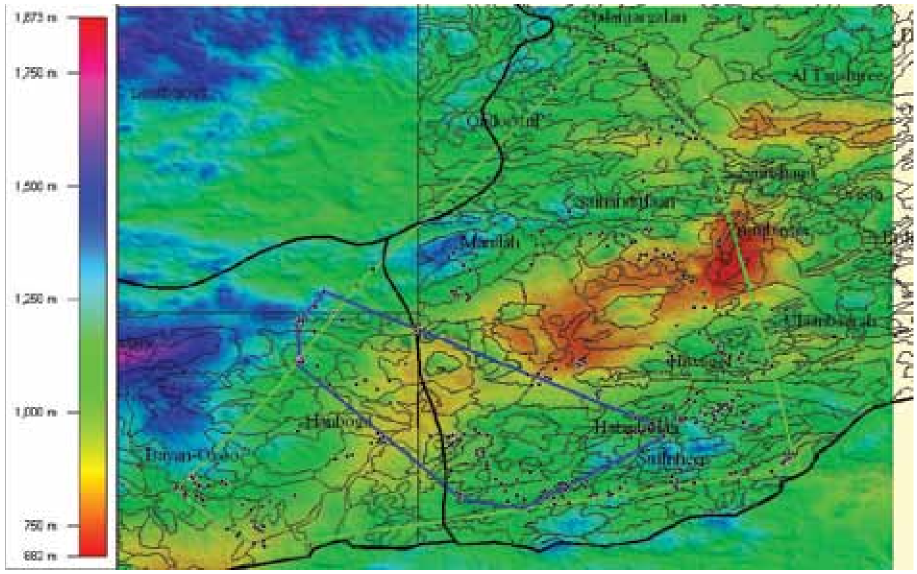
Between June 2006 and June 2007, seasonal observations of Wild Ass along north-south vehicular transects indicated animals used five different vegetation communities during the summer season and six during the winter season (Figure 4.11).

Figure 4.9. Seasonal MCPs of Rangeland Area with Collared and Observed Wild Ass Use between 2005 and 2007



Source: C.M. Sheehy (2007).

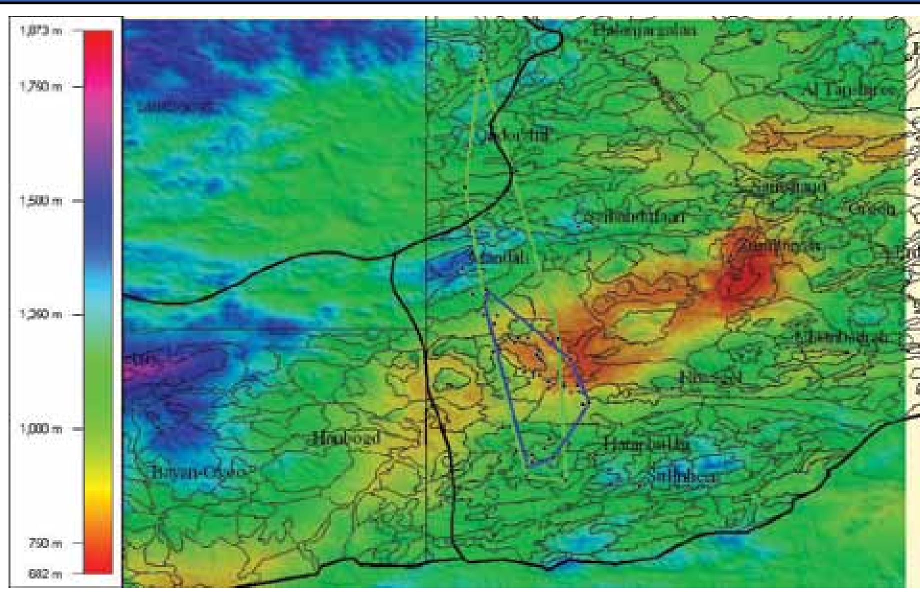
Figure 4.10. Location of Collared Wild Ass Relative to Vegetation Types and Topography in 2005 and 2006



Source: C.M. Sheehy (2007).

Both of the above figures indicate that Wild Ass need access to a diversity of vegetation communities and topography, especially during the summer. During the summer of 2005, collared Wild Ass were also observed in the highest number of communities. This would be expected to

Figure 4.11. MCPs of Wild Ass Observed in 2006 and 2007 along a Vehicular Transect Relative to Vegetation Communities



Source: C.M. Sheehy (2007).
The summer MCP boundary is defined by the green line, while the winter boundary is defined by the blue MCP.

Table 4.1. Wild Ass Preference for Vegetation Communities in the SGR

Community labels	Collared obs. 2005 Summer	Collared obs. 2005 Winter	Vehicle obs. 2006 Summer	Vehicle obs. 2006 Winter	Community description
Semi-Desert Steppe					
25					*Artemisia*[2]-bunchgrass, bunchgrass (*Stipa, Cleistogenes, Agropyron*) steppes with *Caragana* on light chestnut soils
26	3.3[1]			1.6	Forbs-*Artemisia*-bunchgrass (*Agropyron, Stipa*) steppes on the light chestnut and mountain chestnut soils.
27	0.1			6.2	Bunchgrass steppes (*Agropyron,Stipa/S,glareosa and S. gobica, Cleistogenes*) with shrubs on light chestnut sandy loamy and sandy soils.
28					*Nanophyton-Artemisia*-bunchgrass, *Allium-Stipa glareosa* steppes on light chestnut soils.
North Desert Semi-Desert Steppe					
29	1.5			0.7	Bunchgrass (*Stipa gobica, S.,glareosa*) with *Anabasis, Allium, Ajania, Artemisia, Nanophyton* on brown desert-steppe soils with locally Calcareous soils.
30	0.7				Bunchgrass (*Stipa gobica, S. glareousa), Ajania, Salsola laricifolia, Ceratoides papposa,* with *Caragana* on brown soils locally in combination with perennial saltworts and brown soils.
31	2.1				Bunchgrass (*Stipa gobica, S.glareosa) with Caragana, Ceratoides papposa, and Stipa-Cleistogenes* communities on brown loose-sandy soils and sands.
32	0.8				Bunchgrass (*Stipa gobica, S. glareousa*) with perennial saltworts, *Salsola passerine* with *Stipa* and *Allium; Reaumuria songarica* with *Stipa* and *Allium* communities on brown soils and their complexes..
Middle Desert Steppificated Desert					
33	1.3	0.7	0.5	1.1	*Anabasis brevifolia* with *Stipa gobica, S. glareosa, Allium; Nanophyton erinaceum* with *Stipa, Artemisia, Ajania* with *Stipa in* deserts with pale-brown locally weak soils.
34	0.6	5	2.9	1.1	*Anabasis brevifolia, Sympegma, Ajania, Salsola, laricifolia* with *Stipa* glareosa on stony deserts with pale-brown soils.
35	1.9	0.4	1		*Artemisia* with grasses, *Ceratoides papposa,Caragana, Potaninia* in deserts with pale-brown sandy soils.
36	0.4			1.0	Perennial saltworts with *Stipa glareosa* in combination with *Kaldium* and *Haloxylon* stands in deserts with pale soils.

(*continued on next page*)

Table 4.1. Wild Ass Preference for Vegetation Communities in the SGR *(continued)*

Community labels	Collared obs. 2005		Vehicle obs. 2006		
	Summer	Winter	Summer	Winter	Community description
38	0.8				*Anabasis, Salsola laricifolia, Sympegma, Amygdalus*, perennial saltwort in deserts with grey-brown poorly developed soils.
39	0.7	0.4			*Psammochloa, Artemisia, Caragana, Potaninia,,Zygophyllum*, and *Haloxylon* stands in deserts on grey-brown, locally gypsic, sandy, weakly differentiated soils and sands.
40	0.9		1.3	3.8	*Reamuria, Salsola passerina, Anabasis brevifolia,Brachanthemum* in deserts on grey-brown soils.
41	1.2				*Nitraria, Haloxylon* with *Nitraria* on perennial saltworts deserts with grey-brown strongly gypsic soils.
63	0.1	1.1			Combinations of perennial saltwort (*Reaumuria, Kalidum, Nitraria, Haloxylon*) communities on meadow and fluffy.

[1] Values in table 4.1 indicate Wild Ass preference for the vegetation community. Values >1 signify the ratio of the time spent in the community was larger than its area relative to other communities and are highlighted in yellow. Values <1 signify that the amount of time spent in the community was less than its area relative to other communities.
[2] Italicized words reflect names of plant communities as defined by dominant plant species and/or the genus and species names of co-dominant plants in the community.

some degree as the highest number of Wild Ass points were recorded from the newly placed collars that enjoyed a high rate of function. However, when compared to winter samples for 2006, data collection was still consistently high and the analysis shows that spatial area, topography, and the number of vegetation communities used by the Wild Ass is substantially reduced in the winter.

A general idea of Wild Ass preference for habitat was obtained from the 463 GPS collar locations and the 51 vehicular observations. A preference analysis of Wild Ass location relative to vegetation community suggested that Wild Ass selectively used specific vegetation communities during summer and winter seasons (Table 4.1). Many communities in the area did not have any observations of Wild Ass and were not included in table 2. Of the Wild Ass-used vegetation communities, the ones with a value >1 were considered preferred.

Table 4.2. Ulaanhukhun Herd Movements 16 July 2005 to 27 August 2005

Ulaankhukhun Herd Movements	
Distance from Ger/water	Time spent
< 500 m	85.94%
501–1000 m	1.54%
1001–1500 m	4.16%
1501–2000 m	1.79%
> 2001 m	6.57%

Ger is located near water source for convenience of the herder in providing livestock with drinking water.

Wild Ass appeared to select the Petrophytic Forb/Artemisia bunchgrass steppe community #26 (preference value 3.3) and the Psammophytic bunchgrass/shrub community #31 (preference value 2.1), both of which are semi-desert communities with relatively high grass components. During the winters of 2005/06, Wild Ass appeared to select the Petrophytic shrub-bunchgrass community #34 (preference value 5). During the winter of 2006 only, Wild Ass appeared to strongly select the Psammophytic and Hemipsammophytic bunchgrass community #27 (preference value 6). During the 2006 summer season, Wild Ass selected the Petrophytic shrub/bunchgrass community #34 (preference value 2.9), although not as strongly as the previous winter.

During the two years that Wild Ass were observed in the Southeast Gobi, highest Wild Ass use occurred in vegetation communities classified as belonging to the Middle Desert-Steppe Desert vegetation type. The exception to this general statement was the drought summer of 2005 and the winter of 2006 when Wild Ass selected small stature shrub and bunchgrass communities (#26 and #27) in the middle region of the study area belonging to the Semi-Desert Steppe vegetation type. Although the reason Wild Ass selected these vegetation communities is not certain, plant species comprising these communities, especially grasses, are known to be selected by Equines. In addition, it is generally believed that Wild Ass travel to and reside in areas of recent precipitation. Consequently, Wild Ass use of vegetation communities during the summer season may be related to recent weather in the area as it affects forage growth.

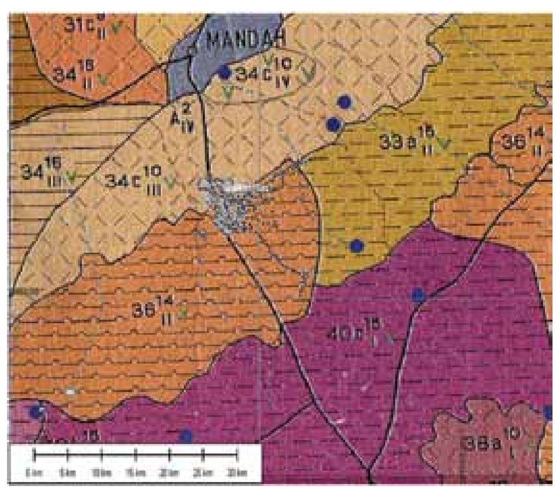
Livestock Distribution

Although livestock are distributed widely across the region, individual herders and their livestock use southeastern Gobi habitat at a smaller scale than Wild Ass (Table 4.2). For both Wild Ass and livestock, access to water was the most important constraint influencing rangeland habitat use.

Wild Ass overcame water limitations during the 2005 drought summer by moving to better forage habitat while herders' livestock were limited to movement around a known water source (Figure 4.12). Although the different scale of livestock and Wild Ass habitat use persisted in 2006, the scale of conflict for forage resources decreased because of the presence of many more water sources for Wild Ass. In 2006, the relatively high spring and summer precipitation that occurred throughout the SGR substantially reduced drinking water and forage availability as limiting factors for both Wild Ass and livestock use of habitat.

Lack of access to drinking water is the most important constraint to livestock use of rangeland in the southeast Gobi. Dependence by herders on wells for drinking water for personal and livestock use also limits livestock access to vegetation communities. Although access of herders' livestock to vegetation communities was obtained only for three herders, researchers have observed many herders and their livestock concentrated around available drinking water sources in the SGR. Especially during drought summers such as occurred in 2005, livestock dominated use of much of the

Figure 4.12. Location of Collared Wild Ass (Colored Points) and Cooperating Herder's Pastureland (Grey Areas) in the Study Area during the Summer of 2005



Source: (Johnson 2005)

southeast Gobi rangeland communities adjacent to sources of drinking water.

Herbivore Diet Quality

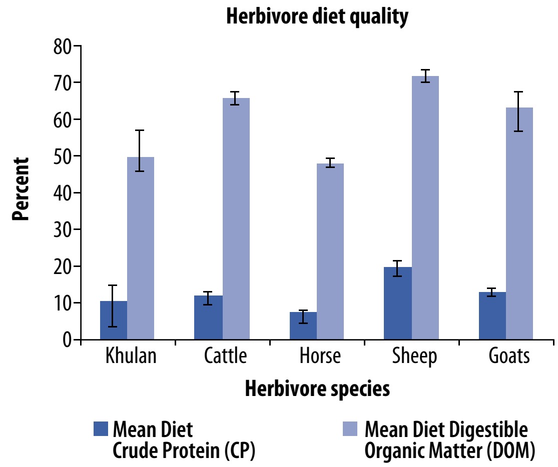
During the summer of 2005, herders who had agreed to collect field information on Wild Ass were also asked to collect fecal samples of Wild Ass and livestock from their co-grazed pastureland. Only one herder, Namsarai, actually complied with the request, collecting samples from Wild Ass, cattle, horses, sheep and goats. Samples were analyzed by the Texas A&M Grazing Animal Nutrition Laboratory (GANL) using NIRS fecal profiling techniques (Lyons and Stuth 1992). Although the number of samples collected was inadequate to test statistically, the results present an opportunity to gain insight into dietary relationships among large herbivores co-grazing the same pastureland during a drought year in the southeastern Gobi.

Both horses and Wild Ass had similar dietary Crude Protein (CP) and Digestible Organic Matter (DOM) in their diet, even though these dietary levels are slightly higher for Wild Ass (Figure 4.13). Both equine species have lower dietary CP and DOM levels compared to ruminant livestock species. Sheep, among the ruminant livestock, had the highest dietary levels among the herbivores. A possible explanation for the higher CP and DOM in the diets of sheep and cattle compared to goats is that the sheep and cattle are bulk roughage foragers while the goat is a selective feeder. If this assumption is correct, then sheep and cattle have access to sufficient herbaceous plant material to allow them to optimize quantity of forage intake from higher quality grasses and forbs. Goats, as selective feeders, are less able to optimize forage intake during the summer season.

Herder and Wild Ass Interaction

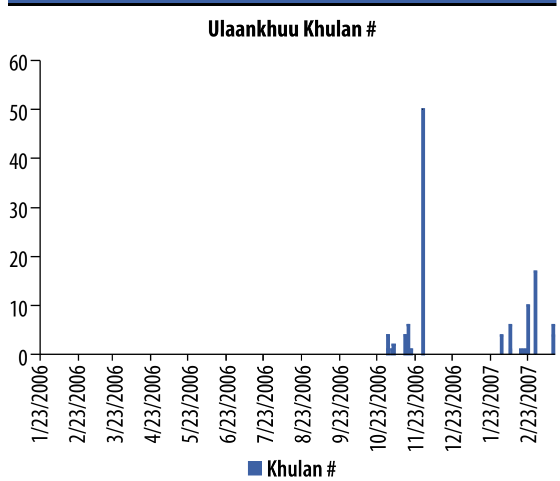
In 2006, the three herders actively monitored Wild Ass use of their pastureland. Since they were paid a fee for each Wild Ass observed, the numbers were verified through photographs taken by the herder with a digital camera. At the time of observation, herders recorded the date and the number of Wild Ass that were observed. The digital timestamp on the photograph verified the written record

Figure 4.13. Summer Dietary Quality of Five Large Herbivores Co-Grazing Pastureland in the Southeast Gobi



Source: C.M. Sheehy (2007)
The whiskers represent the largest and smallest sample.

Figure 4.14. Recorded Observation of Wild Ass on Ulaanhukhun's Pastureland between 6/1/2006 and 7/1/2007

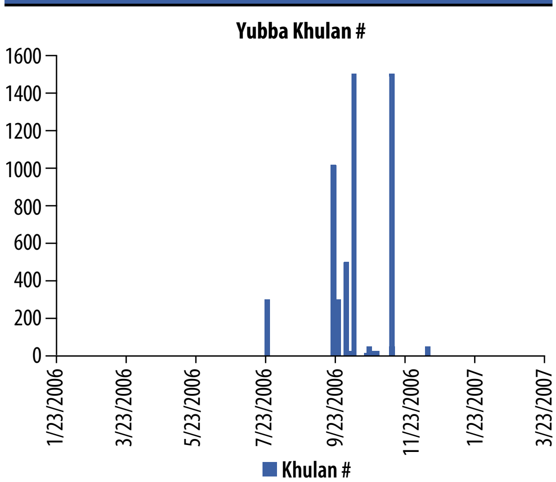


Source: D.P. Sheehy (2007)

In Mandalkh soum of west-central Dornogov province, the herder Ulaanhukhun recorded Wild Ass observed on her pastureland between June 2006 and June 2007 (Figure 4.14). Based on the number of Wild Ass recorded, only a few Wild Ass used the northern portion of the Wild Ass study area in 2006. The total Wild Ass recorded during the fall season was 21, and these Wild Ass were all recorded between 31 October and 29 November, 2006. During the winter season, the herder recorded a total of 101 Wild Ass between 1 February and 31 March, 2007. The largest group recorded during the observation period was 50.

The second herder recording Wild Ass use of pastureland during the same period was Yubaa. His camp and pastureland was located due west of the Khatanbulag soum center and north of the Wild Ass Special Protected Area (Figure 4.15). Several fresh water ponds provided drinking water for livestock in the area. During the summer of 2006, the herder had only one recorded observation of 300 Wild Ass. Other than this solitary summer observation, all others were recorded in late fall when Wild Ass were using fresh water ponds to obtain drinking water. Between 9 October and 12 December, 7,645 Wild Ass in 273 groups were observed using Yubaa's pastureland.

Figure 4.15. Recorded Observation of Wild Ass on Yubba's Pastureland between 6/1/2006 and to 7/1/2007



Source: D.P. Sheehy (2007)

Many of the Wild Ass were observed drinking from the fresh water ponds, including two herds of 1500 migrating Wild Ass.

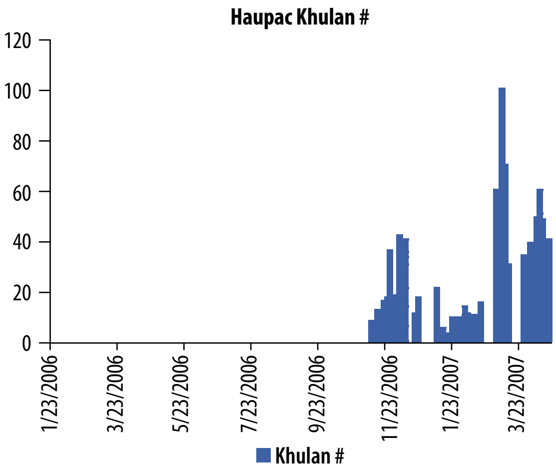
Namsarai was the third herder to record observations of Wild Ass during the same period. Namsarai's pastureland and camp was located close to the boundary of the Wild Ass SPA southwest of the Khatanbulag soum center. Most of Namsarai's recorded observations occurred during the winter of 2006 and the winter and spring of 2007 (Figure 4.16). During the winter of 2006, total observed Wild Ass was 1,319 in 71 different groups ranging in size from 3 to 42 Wild Ass. During the winter of 2007, Namsarai recorded 21 observations of 198 Wild Ass with herd size ranging from 3 to 21 Wild Ass. The largest total number of Wild Ass recorded occurred during the spring of 2007 when Namsarai recorded observing 1,798 Wild Ass in 82 herds. The largest number of recorded Wild Ass in one herd during the spring season was 100.

Although it is unknown if all Wild Ass using the three herders' pastureland were recorded, the three herders were enthusiastic about both recording Wild Ass use of their pastureland and verifying their number with digital photos. At the end of the study, the herders expressed disappointment that the study was ending along with their supplementary source of income. They also expressed enthusiasm to participate in any future studies even though they had encountered some resentment from neighboring herders relative to their windfall income or suspicion that the herders were "spying for the government."

Conclusions

The study was completed in the summer of 2007, approximately three years after the initial World Bank-supported Wild Ass work began. During the course of the study, it was the opinion of the researchers that Wild Ass were noticeably scarcer in many areas of the Gobi than in 2004/05. In the earlier study by Kaczensky and others (2006), the combined effects of poaching, habitat change, human conflict for resources, and landscape fragmentation were believed to collectively reduce the

Figure 4.16. Recorded Observation of Wild Ass on Namsarai's Pastureland between 6/1/2006 and 7/1/2007



Source: D.P. Sheehy (2007)

population of Wild Ass by 10% annually. If correct, this precipitous decline would have reduced the 2003 population of 20,000 animals to less than 11,800 in 2007. Another population census is urgently needed in order to validate this rate of reduction and the growing scarcity of Wild Ass in the area at this time. During the course of this study, we were able to draw several conclusions important to future research and conservation efforts of Wild Ass. These are discussed below.

Precipitation Has a Marked Influence on Herbivore Distributions

Evaluation of annual and seasonal precipitation over three years in the southeastern Gobi indicated the following:

- Precipitation is very variable between years, seasons, and regions.
- Most precipitation occurs during the spring and summer seasons.
- Fall and winter seasons usually lack substantial precipitation events.

With the onset of summer drought in the southeastern Gobi, the competition between livestock and Wild Ass for available water sources increases. Wild Ass avoid mingling with herded livestock and are forced to range further in search of unoccupied water sources. The data from both collared Wild Ass and those observed from vehicles indicate that they were distributed over a wider range of habitats during the summer and fall seasons, with an even wider range of habitats covered during periods of drought. Summer MCPs are larger than winter, even in years with high accumulated precipitation. Ranges tend to be concentrated during the winter and localized around the Wild Ass SPA because of the quality of habitat.

Wild Ass Diet Changes with the Seasons

As a corollary to the range patterns exhibited in summer and winter months, the Wild Ass diet is much more diverse during the summer than in winter. Specifically, GPS data points confirm grazing in 16 different types of plant communities during the summers, but only five communities during the winter. However, when looking at vegetation community preference shifts, there may be more changes in community selections between years than season. In large part this is probably due to rainfall patterns between years. No general observations were made in this study to discount the assumption that Wild Ass prefer vegetation communities consistent with expectations developed from observing domestic equines.

During the summer of 2005, fecal samples from one location were collected and analyzed but little difference was observed in crude protein (CP) and digestible organic matter (DOM) in the diets of domestic horses and Wild Ass. There does however appear to be a large difference in dietary quality between Wild Ass and other kind of livestock. Further research could verify this relationship across the Gobi region.

Wild Ass Tolerance of Humans Has Its Limits

Herders and Wild Ass in the southeastern Gobi interact continuously throughout annual cycles, but not necessarily on a daily or even a seasonal basis. Information obtained during Phase II of the Wild Ass study supported the Kaczensky and others (2006) findings and further explained interactions between Wild Ass and herders and livestock. Findings of this study indicated that:

- Wild Ass quite readily use surface water even if herder camps and livestock are in the immediate vicinity. This indicates that Wild Ass are tolerant of humans and livestock that maintain established, non-harassment patterns.
- The high mobility and capacity to travel limits potential for forage competition between Wild Ass and individual herders, but high density of herders throughout the Wild Ass range increases competition for forage, especially during drought years, and especially for herders dependent on surface water for livestock as Wild Ass also require water from these same sources.
- Economic development or more intensive livestock use of winter range habitat would be especially harmful to the current Wild Ass population because their winter habitat range is substantially lower compared to summer habitat range.
- Wild Ass need access to a greater variety of habitats and water sources during the summer to meet physiological and lactation needs; there is a preliminary indication that Wild Ass do have a preference for certain vegetation communities and land forms, and that their access to nutrients in rangeland vegetation communities is similar to that of domestic horses.

Herders Can Be Excellent Collaborators

One of the more enthusiastic persons involved in this study was an older herder who lived several kilometers west of Khatanbulag Soum. When trying to locate him for data retrieval, it was common for the research team to ask other herders about the location of his camp. By the end of the study, his neighbors referred to him as “the herder with the camera.” A local story had been circulating, unbeknownst to the researchers, that this herder’s black GPS tracking unit was actually monitoring Wild Ass, and that if the herder was nearby, any poached Wild Ass would be detected and reported by satellite communication to the authorities.

Another herder was fortunate enough be camped near a lake that turned out to be a popular Wild Ass watering hole. After being paid substantial sums of money to photograph and record hundreds of Wild Ass near his camp, the word began to spread that Wild Ass were a lucrative source of income. On subsequent trips to the herders’ camp, research team members were approached earnestly by other would-be Mongolian collaborators.

In these cases and others, the involvement of herders in collection of the data was more than just an efficient way to employ year-round researchers in a remote area. It also began the critical process of instilling a conservation ethic in the local people who were usually the only authority at present on the landscapes beyond Ulaanbaatar. Perhaps the most important piece of this puzzle was finding a way to place a monetary value on living Wild Ass. Secondly, these impromptu field technicians intentionally or unintentionally became a major factor to dissuade poaching in their pastures. Lastly, just by virtue of having the research connected to local populations, awareness of the Wild Ass’s dire situation can effectively reach the people who are most able to make a difference.

The Wild Ass’s Future Is Tied to the Circumstances of the Herders

As in the Kaczensky and others (2006) study, this study continues to support the position that the future of the Wild Ass, and many other wild animals, is tied to the circumstances of the Gobi herder. If the herders are displaced, experience compromised livelihoods, maintain negative attitudes towards the Wild Ass, or engage in free market practices that encourage hunting of wildlife or development of land resources, then the Wild Ass population will continue to decline rapidly.

The main threats currently facing the Wild Ass are:

1. Illegal poaching
2. Habitat change (desertification)
3. Landscape fragmentation (fences and infrastructure)
4. Livestock competition with Wild Ass for water and forage

Findings of this study clearly indicated that Wild Ass need large tracts of land, especially during the summer. When/if these resources and movement opportunities are not available to wild herbivore such as the Wild Ass because of fencing, railroads, mineral exploitation, or other human intrusion, then landscape fragmentation may be the final causative factor in the demise of the Wild Ass.

5. A Vision for Sustainable Resources Management

The Southern Gobi Region is an interesting part of the world. Although an arid landscape, it has a relatively intact natural biodiversity, the vegetation and topography provide habitat for several threatened wildlife species, and the pastoral livestock production system that has co-existed with wildlife and natural ecosystems for millennia remains the dominant form of agricultural production. The largest population of the Wild Ass is located within the boundaries of the SGR, as is significant number of Ibex, Marco Polo sheep, and gazelle. The location of six Special Protected Areas within the SGR indicates the importance of the region to wildlife.

The ongoing transformation of Mongolia into a modern nation has significant implications for the conservation of wildlife and natural ecosystems, pastoral livestock production systems, and traditional lifestyles. The SGR is especially sensitive to human intrusion and economic development even though these are not entirely new to the region. In the eastern part of the region, the Trans-Mongolia railroad corridor has influenced the region for over half a century, while the proximity of the international boundary between Mongolia and the Inner Mongolian Autonomous Region of China has influenced the southern part of the region.

While prior human intrusion undoubtedly had some impact on habitat and large herbivore wildlife, the human intrusion that has occurred since the democratic transition to capitalism and the market economy, and the accelerated rate of economic development and infrastructure construction that is just now beginning will have much greater impact on the region's wildlife, natural ecosystems, and traditional pastoral livestock production. Unless there are major changes, both types of intrusion will probably be exploitative, weakly regulated, and purely profit driven, especially where related to mineral extraction, development of energy reserves and commercialization of livestock production. Economic development without parallel safeguards to ensure protection of wildlife, natural rangeland ecosystems, and traditional lifestyles will foster conflict over use of the region's natural resources.

Developing a SGR Natural Resources Management Plan

It is important that local inhabitants, civil society, and the government recognize the implications of change so that planning, avoidance, mitigation, and adaptation—as appropriate—can be initiated early in the change process. To successfully respond to the impending challenges, Mongolia needs to develop and implement a SGR Natural Resources Management (NRM) program. A NRM program should be developed and implemented through the Ministry of Nature, Environment and Tourism, which already has some of the authority and the capacity. The program would require broad-based support from a diversity of stakeholders in both the public and the private sectors, such as the Environment Office of the State Specialized Inspection Agency; Ministry of Food, Agriculture, and Light Industry (pasture and livestock divisions); Land Management Agency in the Ministry of Construction and Urban Development; provincial and county governments; law enforcement agencies; and natural resource user entities.

An effective NRM program would have to overcome a number of challenges, including:

- Exploitative and unregulated economic development that is on-going and is expected to accelerate as development intensifies;
- Transition of the extensively managed pastoral livestock production system to a commercial, profit-driven production system that is more responsive to the market-based economic system and less responsive to maintaining natural ecosystems in good condition;
- Inadequate efforts to improve capacity of local and regional government to manage SGR's natural resources for sustainability;
- Climate change interacting with and exacerbating the negative impacts of human intrusion; and
- Solutions to critical social and economic problems in Mongolia already dependent on projected revenues from mineral exploitation.

The objectives of a NRM program would be to:

- Improve regional government capacity to enforce existing laws and regulations,
- Ensure application of environmental remediation measures as an essential component of economic development and infrastructure construction,
- Encourage and support regional rangeland management and research needed to foster sustainable use of resources by livestock and wildlife, and
- Provide meaningful and realistic information on wildlife needs to government planning and management agencies.

The following key activities of the NRM program would be required to realize the above listed objectives:

- Assist provincial and county governments with environmental impact assessment prior to implementation of any economic development activity;
- Ensure developer compliance with requirements of the assessment during construction and implementation and after the development activity is completed;
- Assist responsible entities to develop and enforce necessary regulatory measures that helps ensure natural rangeland ecosystems and wildlife, especially species on the IUCN Red List, are not subject to harm from economic development activities, livestock production-related activities, and other types of human intrusion (e.g. legal and illegal hunting);
- Monitor use of natural rangeland ecosystems to determine trends in system health related to livestock grazing pressure and weather events;
- Monitor the impact of climate change on the dynamics and stability of natural pasture ecosystems;
- Study the interactions between pastoral livestock, large herbivore wildlife, and sustainable use of natural rangeland ecosystems; and
- Improve capacity of local government and pastoral herders to mitigate environmental and financial risk in livestock production to reduce livestock caused degradation of natural resources.

During the collective era (<1990), Mongolia had a well-developed, functional, and effective rangeland research and management program. Since the transition to a market-based economic system and a more pluralistic form of government, resource management in general, and rangeland management specifically, has essentially failed. Although some pasture research has been undertaken by both national and international institutions, an organized and systematic pasture research program has not been re-established even though the need for such a system in a country dominated by extensively managed livestock production is obvious.

The Mongolian National Agriculture University has established a Research Center that may, in the future, have some capacity to address rangeland resource issues. Several donor projects (United Nations Development Program, International Fund for Agricultural Development, Swiss Development Corporation, Mercy Corps) with rangeland components have undertaken or supported adaptive research through their project but on a limited basis. Institutionalization of rangeland management and measures to mitigate pastoral risk has been a primary focus of the World Bank's Sustainable Livelihood Project. These efforts, while valuable, are too narrowly focused and, at the best, provide only short-term support to development of rangeland management. The failure of the national government and international donor agencies that have projects involving or related to livestock production or resource use to institutionalize and support a national rangeland research and management program will contribute to large-scale exploitation of natural resources and overgrazing of rangelands throughout much of Mongolia.

Developing a new SGR NRM program will be time consuming and complex since management should be inclusive of all resources and, by definition, should integrate knowledge and expertise from many disciplines and sources. The diversity of resources, which are both abiotic (i.e., solar radiation, water, minerals, soils, and air) and biotic (i.e., vegetation, fish and wildlife, livestock, and humans), increases the complexity of management as some resources will either need to be addressed singularly or comprehensively depending on the particular management situation. Resource management without a process to control or regulate use (i.e., in the SGR, primary users are wildlife, livestock, and humans) will guarantee the ineffectiveness and ultimate failure of any NRM program. Most importantly, human use, whether by herders or developers, needs to be controlled and regulated because human impact on natural resources is both indirect and direct. Humans indirectly use most of the abiotic and biotic resources by harvesting livestock and wildlife directly for food, shelter, and clothing or for sale within the market economy. Humans also have exploitative direct use of some of the natural resources through mining, pollution, etc.

Components of a SGR NRM program already exist and, with integration of purpose and adequate direction and national support, could be the basis for a relevant, practical, and accessible NRM agency. By constitutional decree, most natural resources are the property and responsibility of the state. Natural resource management should be a Government initiative; and given the importance of natural resources to Mongolia, the NRM agency needs to be strong and supported politically, financially, and philosophically by the Government. It should have a presence at national, regional, provincial (aimag), and county (soum) levels. An effective and functioning SGR NRM program should have at least four primary emphases: implementation, enforcement of compliance, policy and regulatory, and education.

The key implementation and management unit of the NRM agency should be formed from provincial and county government staff. The NRM staff will need to have:

- Technical capacity in resource management and planning, project implementation, and environmental assessment;
- Management capacity for pasture and habitat, fish and wildlife, and all aspects of livestock production.
- Direction from provincial and county natural resource advisory councils (i.e., similar to the resource management and planning councils currently being established in the second phase of the World Bank-financed Sustainable Livelihoods Project).
- Inputs into resource planning and management solicited from users such as herders and other rural citizens.
- NRM-trained representation from Law Enforcement and Environmental Inspection agencies.

Integrated provincial and regional offices with broader-scale NRM responsibility should be established to support county field offices. At the national level, a Natural Resources Management Coordinating Council should be established as an office directly responsible to the Prime Minister. New information obtained concerning any aspect of natural resource management and from many different sources, especially from the NRM planning program, should be funneled to the NRM unit.

If such a NRM program was initiated in the SGR, it will have far-reaching impacts on development strategy and resource conservation by improving understanding of the impact of various human development activities, providing national and local experience in conservation management, and focusing attention on problems associated with economic development. Institutional models used in other countries with similar environment and natural resource management problems may be applicable and should be evaluated (Box 5.1).

Improving Environmental Assessments

The capacity of the Mongolian private sector to conduct environmental assessment has made considerable progress during the transition period. Most economic development projects require an environmental assessment to identify and evaluate potential impacts of the proposed activity. The environmental impact assessment should evaluate impacts of development on water resources, air and climate, soils, vegetation and wildlife; and present guidelines for reclamation and environmental compliance activities. However, current capacity to enforce compliance with environmental guidelines and ensure reclamation of disturbed sites is weak (Reading and others 2006).

The NRM program could determine what reclamation and environmental compliance activities are required of a developer in relation to natural grassland ecosystems and wildlife, and

Box 5.1. Models of Natural Resources Management Agencies

In the United States, public agencies received their first mandate to regulate and manage use of public lands with the passage of the Taylor Grazing Act of 1934, leading to regulation and enforcement of rangeland use. Subsequent to this Act, various public agencies, which include the Department of Agriculture's Forest Service and Department of Interior's Bureau of Land Management, were funded and staffed to manage public lands that were under their jurisdiction. Although an imperfect system at the time, these agencies were able to manage public lands to the degree needed to reverse trends in ecological degradation and initiate ecological recovery. Mongolia should heed the example and develop similar rangeland monitoring and management capacity. Without this capacity, there is no reason to think that current trends of overuse, conflict over access to resources, and negative environmental impacts will be reversed.

Agencies of the United States Department of Agriculture (USDA)—Forest Service, Natural Resource Conservation Service, and Farm Service Agency—work directly with farmers, ranchers, and other resource users, including wildlife managers, to develop sustainable uses and conservation of natural resources. In Canada, the Prairie Farm Rehabilitation Administration (PFRA) manages public Crown lands and actively rehabilitates degraded and abandoned crop and pasture land. In both countries, these institutions work directly with individual and group users of natural resources to develop and implement conservation programs.

A major contributor to the effectiveness of state/province and national natural resource management agencies in the United States and Canada was the highly effective research and extension system of the western state/provincial universities, and in particular the successful development of good rangeland and livestock research and management practices, which were effectively transferred to livestock producers via linked extension services and experiment stations managed by those universities. Ideally, something similar will be developed in Mongolia as Mongolia has in place the components needed for rational natural resource management in the SGR. In 2006, a National Coordinating Council for Rangeland Management was established. Although established specifically to address the ministerial location of a rangeland management division, the inclusion of representatives from resource-oriented ministries and agencies would easily permit expansion of the Council's mandate to include all natural resources. The responsibilities of the expanded Council should, in due course, be similar to those of agencies/services in the USDA or PFRA, including development of management and standards criteria, policy development and implementation, coordination of national and international projects, oversight of NRM activities undertaken by ministries, etc. An NRM project in the SGR would also provide a format for determining the most suitable institutional structure to facilitate integrated natural resource management.

monitor compliance in undertaking required restoration activities. It would improve the capacity of provincial and county environmental inspectors to enforce mining companies' compliance with environmental regulations and safeguards as well as duties defined in the mining law and during the environmental assessment. It would also increase the effectiveness of environmental inspectors to prevent exploitation of large herbivore populations through illegal hunting and poaching.

Strengthening Policy and Regulations of Rangeland

Several laws that pertain to rangeland use and animal management need to be strengthened, revised, or redrafted. Especially pertinent to sustainable use of natural rangeland ecosystems is the new Rangeland Law, still in draft form since 2000. The draft law does have regulatory provisions relative to overstocking, degradation of rangeland, entities with access rights, prohibited activities, and rights of rangeland possession. However, the draft law lacks capacity to manage rangeland ecosystems. There is little or no capacity to implement and enforce provisions of the Rangeland Law and other appropriate regulatory mechanisms. A review by the United Nations Development Program (Hannam 2007) notes that effective application of tenants of the of the new Rangeland Law would require the addition of some 400 trained pasture management staff.

- Rangeland monitoring and management, including regulating use and making rangeland improvements, requires public sector involvement, based in part on the following rationale:
- Rangeland ecosystems occur across administrative boundaries and require centralized monitoring and management by a non-user entity.
- Rangeland ecosystems are of national importance and are critical to sustaining livestock production that continues to be a primary industry and livelihood support system in Mongolia.
- The managerial capacity of livestock production household/groups under environmental or financial risk is usually inadequate to avoid negative environmental impacts.
- By constitutional decree, rangeland ecosystems are controlled and managed by the state. As such, the state has a responsibility to monitor and manage rangeland ecosystems for the benefit of all citizens.

Monitoring Trends

Livestock and wild herbivores have similar habitat needs and often interact on a daily basis. Likewise, the land, vegetation, and water resources are also exploited for other uses that are often not compatible with either the needs of livestock or large wild herbivores. The SGR experiences extreme temperature and low, irregular precipitation. It is thus especially sensitive to climate change impacts on habitat used by both large wild and domestic herbivores. This must be factored into approaches taken to ensure conservation of wildlife, pastoral livestock production systems, and natural resources.

Long-term monitoring of economic development, livestock use of natural resources, and climate warming is possible if available monitoring tools are applied and used consistently. Annex G details various monitoring systems being used today for monitoring livestock and vegetation. Between 2003 and 2007, the USAID-supported Gobi Forage Project developed a Gobi-wide system capable of providing advanced warning of impending drought, dzud, and other weather- and climate-related catastrophes. The technologies used in the model allow the acquisition of satellite-based weather data from the National Oceanic and Atmospheric Administration (NOAA) to feed temperature, precipitation, and solar radiation values into a rangeland forage growth model (PHYGROW) to provide daily estimates of forage on offer to a mixed population of herbivores.

PHYGROW already has the capacity to operate in the SGR (Box 5.2). Employing it as a direct near-real time monitoring tool would provide a

Box 5.2. PHYGROW Forage Growth Model

Although developed as the primary component of a Mongolian Livestock Early Warning System (Sustainable Livelihood Project 2007), the PHYGROW technology and procedures provide a near-real time method of accurately monitoring rangeland ecological condition, degradation trends, and interactions between large wild and domestic herbivores in the SGR (Sheehy and others 2006).

- ***Vegetation monitoring.*** The PHYGROW technology relies on establishment of a series of carefully selected, random monitoring points. At these points, vegetation is measured and characterized by basal area of grass species, frequency of occurrence of herbaceous species, and effective canopy cover of the woody species. Data is input along with soil surface and horizon characteristics of the monitoring points and animal grazing rules derived from interviews with herders and specialists in the immediate area of the monitoring grid.
- ***Climate and weather monitoring.*** A climate map layer is developed from weather information obtained from reporting stations within the county and surrounding area. A matching technique is used to assign known historical weather data with the newly created climate map layer. The system produces a 50-year weather projection set that forms the foundation for comparing current forage conditions in terms of percent deviation and percentile ranking at selected grid locations. The key to success of this technique is to locate and properly match historical weather data with the selected grid in terms of behavior of events in a selected locale. A NOAA global weather-data satellite covers Mongolia each day showing daily rainfall, temperature, and solar radiation.
- ***Animal preference monitoring.*** PHYGROW accounts for differential preferences of mixed populations of large herbivores and models growth of individual plant species or functional groups of species competing for vegetation resources under selective grazing. Each monitoring site is then run for the 50-years and daily percent deviation, and percentile ranking is determined for each day based on a "day of year" average standing crop of forage usable by a target herbivore (e.g., cattle, sheep, goats, horses, Wild Ass, and gazelle). Associated soils, grazing rules, and satellite-based weather data is used to produce daily estimates of forage production, deviation from normal forage on offer, and associated percentile ranking. Advanced geo-statistics coupled with the Normalized Difference Vegetation Index (NDVI) greenness data are used to map areas of forage deficiencies and excesses, as well as provide 90-day forecasts.
- ***Forage monitoring and forecasting.*** To map forage on a regional basis, predetermined monitoring sites reflecting the variety of landscapes and climate conditions are established across the selected region. Monitoring sites provide information on current conditions, past conditions and their trends, likely emerging conditions with updates every 7 to 10 days, and new projections being made. The forecasting technique uses the ARIMA forecasting techniques. The resulting map of forage supply and deviation is a provided on 8x8 square-kilometer grids for the entire region. Timely issuance of reports on forage conditions relative to expected long-term averages updated every 7 to 10 days, with 90-day forage forecasts and projected probabilities of precipitation and temperature issued monthly provide a new dimension to monitoring rangeland and large herbivore use. Once analysis is completed, a website is updated automatically and all the data from 1998 to present are made available to the public, NGOs, and other interested organizations. The website is http://glews.tamu.edu/mongolia/. The Center for Natural Resource Information Technology at Texas A&M University provides the analysis hub.
- ***Current applications of the PHYGROW forage monitoring and forecasting technology.*** PHYGROW is currently used to monitor and forecast vegetation growth and changes in East Africa (Ethiopia, Kenya, Tanzania), the United States, and Mongolia. PHYGROW will also be an integral part of the Livestock Early Warning System currently being developed for Afghanistan. In East Africa, the status of vegetation quantity and quality derived from PHYGROW modeling is the basis for drought advisory bulletins distributed bi-weekly to agricultural community centers, government, and NGOs working in the four country region. In the United States, PHYGROW is used by government agencies to (a) determine the distribution and amount of understory vegetation on forested lands to assist fire managers in predicting wildfire events (USDA-Forest Service); (b) predict vegetation growth, amount, and distribution on rangeland to determine proper livestock stocking rates (USDA-Natural Resource Conservation Service); and (c) monitor vegetation changes at military training areas to regulate amount and duration of training impacts on natural resources (US Department of Defense). In Mongolia, PHYGROW monitoring and forage forecasting is established for 8 of the 21 provinces, including the 6 provinces in the Gobi Region. Bi-weekly reports on forage condition are compiled and distributed to soum government staff.

The PHYGROW technology and procedures can provide resource managers with near-real time information about rangeland ecological condition, forage quality and quantity, and rangeland degradation trends. With completion of the Mongolian nutritional balance equations, resource managers will be able to better understand interactions between large wild and domestic herbivores relative to impact of co-use on rangeland habitats (Sheehy and others 2006). Although output from the PHYGROW Forage Forecasting model is being used by resource managers, PHYGROW will have even more applicability if used in conjunction with other recent technological developments and within a nationwide Natural Resource Management program. However, PHYGROW has only limited potential as a grazing management tool for private producers. PHYGROW will have more applicability to private sector use when full coverage of Mongolia is obtained (i.e., in 2012). When completed, natural resource managers and the NRM program will have access to a functional natural resource monitoring tool adapted to Mongolian conditions.

truly interactive set of tools to evaluate impacts of economic and infrastructure development, livestock grazing interactions with large wild herbivores and natural rangeland ecosystems, and climate change in the SGR.

PHYGROW was not explicitly designed to monitor climate change, determine large herbivore wildlife and livestock interactions, or economic development impacts on wildlife habitat and pastoral livestock production. However, most of the databases and much of the output information has immediate application to monitoring natural resource use, natural rangeland ecosystems (including large wild herbivore habitat), degradation associated with economic development and livestock grazing, and the impacts of climate change on vegetation and water resources. Collected data is accessible by the public through a website (http://glews.tamu.edu/mongolia/) and can be used for analysis at county, provincial and other scales. The Center for Natural Resource Information Technology at Texas A&M University provides the analysis hub.

In addition to PHYGROW, the Kinetic Resource and Environmental Spatial System (KRESS), a large herbivore habitat model developed by Oregon State University, uses Global Positioning Systems (GPS) technology. It was tested during the initial work on Wild Ass supported by the World Bank/NEMO study (Kaczensky and others, 2006). It examined impacts of human intrusion on the Wild Ass and provided information on large herbivore rangeland use that was correlated with landscape information. Also, Near Infrared Reflectance Spectroscopy (NIRS) fecal profiling used to determine large herbivore dietary quality is being tested and adapted to Mongolian conditions by the USAID/Mercy Corps Gobi Forage Project. The availability of technologies such as Google Earth, which radically improves access to earth imagery on a global basis, will substantially improve capacity for planning use of natural resources.

Other applicable near-real time technologies have had several generations of use as resource management tools but have not been part of an integrated NRM program. Decision support systems that can assist managers and users to make appropriate decisions relative to sustainable use of natural resources, such as Grazing Land Applications and Nutritional Balance Analyzer (Texas A&M University), are available for use in a NRM program. Integrating such technologies into a NRM program will improve capacity to monitor SGR rangeland resources information on both a landscape and site-specific scale, develop and assess resource data, and generate near-real time output that can be immediately used by natural resource managers and users.

The Institute of Meteorology and Hydrology is a national level institution that employs a data collection system at local levels to determine pasture conditions. Although the data is used to determine pasture status relative to yield and drought, it does not appear to be used effectively to aid herder and local government decision-making. Combined with PHYGROW, the two systems might have improved functionality as an indicator of rangeland condition, capacity to support extensively managed livestock production and improved national and local capacity to react quickly to mitigate weather and other anomalies affecting the livestock production system. Most data is collected at county administrative units by local people.

In the current context of livestock and resource management, rural people and government in general have little capacity to advocate for government assistance to resolve issues that are affecting their livelihood or to effect meaningful change to management of natural resources, marketing of livestock, or protection of wildlife. Herders that lose their livestock to drought and/or dzud move to the urban areas and become the urban poor. Many of the so-called “Ninja” miners are rural people, including herders, who mine often illegally to generate income to supplement income from sale of livestock products. However, retaining herders with knowledge of natural resource use to support research and management initiatives not only provides the herder with a mechanism for local empowerment and livelihood support but also helps to resolve resource conflicts. For example, herders paid to gather data on Wild Ass use of pastures and water became advocates for the Wild Ass rather than supporters of illegal hunting.

Monitoring Economic Development

A similar but separate task of a SGR NRM program will be monitoring economic development and infrastructure construction activities. This can be achieved with high-resolution remotely sensed images. Use of spatial images, updated annually, perhaps through the National Geo-Informatics Centre, could be used to monitor infrastructure development and exploitative developments associated with natural resources. Fine-scale image cover of the SGR would allow an annual inventory of economic development activities and infrastructure construction; legal and illegal mine development, and rehabilitation of existing and development of new mechanical wells. The fine-scale images should also be tested as to their applicability for livestock and large wild herbivore census, tracking identified areas of degraded rangeland, and migrations of large wild herbivores (Annex G).

Mitigating Risk to Livestock Herders

A viable and functioning NRM program in the SGR should address pastoral risk assumed by livestock herders because herder response to risk often leads to ecological degradation of natural resources. Livestock production is highly susceptible to the natural conditions (i.e., weather and climate) and natural resource exploitation risks. Drought and severe winter storms cause losses in livestock productivity or abnormal livestock mortalities. In areas where drought and dzud persist for longer-than-normal periods, continued use of forage resources can induce degradation of rangeland resources or lead to conflict with wildlife over their use.

Herders are increasingly being subjected to a new type of environmental and financial risk. Both legal and illegal mining activities reduce herder access to rangeland and water resources needed for optimal livestock production. Licensed, large-scale, and often open-pit mining activities generally cause herders to lose water resources without adequate mitigation or compensation. Illegal, small-scale mining activities despoil rangeland and water resources and, over time; can degrade relatively large areas of highly productive resources critical to wildlife and livestock. Although direct loss of rangeland area from mining activities or infrastructure development is not currently substantial, indirect impacts such as loss of water quality caused by stream placer mining in the northern Gobi Region substantially reduce the value of rangeland habitat for wildlife and livestock. Large-scale extraction of water from underground aquifers to support mining and infrastructure development will, in the future, have a considerable but unknown impact on rangeland habitat and traditional users of natural resources in the SGR.

Facilitating Herder Participation

An important asset of a SGR NRM program will be pastoral herders who depend on the natural rangeland ecosystems for their livelihood. Most herders have a conservation ethic at heart: they are concerned about wildlife and sustainable rangeland use, and they generally have excellent knowledge about local rangeland conditions and local events. Gaining herder participation in a NRM program is critical to successful natural resource management, and their concern was evident during the recently completed case study of the Wild Ass in the SGR.

During the second phase of the World Bank/NEMO-supported study (presented in detail in Section IV above), local herders were engaged and given digital cameras to monitor Wild Ass use of their rangeland. Each herder was trained to use the camera and record desired information relative to Wild Ass numbers and activity. Project staff visited each herder at scheduled times to download photographs and collect data sheets. Herders were paid an agreed upon fee for each recorded and photo verified Wild Ass using the herder's rangeland Wild Ass. At the conclusion of this study, the herders' perception on the intrinsic value of the Wild Ass use of rangeland resources changed as they began to appreciate their positive value rather than regarding them as a threat. Also, the herders' financial status improved as they were compensated for their participation and cooperation in the study. Herders became advocates for protection of Wild Ass, as well as for other wildlife projects in the local area. Looking at the above outcomes, clearly, more work along the same lines needs to be instigated.

Coordinating With Other Projects

Coordination of NRM program activities in the SGR with on-going national and international projects will benefit both the NRM program and the project. For example, in the first phase of the now nationwide Sustainable Livelihoods Project, Omnigov and Dundgov were among the aimags chosen for piloting approaches. This included a pastoral risk management component set out to improve the disaster relief response capacity of local governments in the event of drought and dzud. The component also helped rural residents by providing low-interest loans to facilitate rehabilitation of non-operating mechanical wells and develop livelihood alternatives, and improved capacity of local government to manage rangeland by providing training in rangeland management and compiling county scale rangeland maps.

The new national phase of the project is continuing to work with rural residents of these two provinces as well as expand the project into Dornogov. The pastoral risk management component will support development of a Mongolian Livestock Early Warning System based on PHYGROW to provide drought and dzud warning to the three SGR provinces, continue to improve capacity of local government to manage and plan use of natural rangeland ecosystems, and provide grant support to help reduce livestock herder susceptibility to environmental and financial risk. The SGR NRM program would derive considerable benefit if a cooperative relationship exists with the Sustainable Livelihoods Project and similar development-oriented projects.

Mongolia at this time does not have an effective rangeland research and extension system. Although a previous Canadian project established the framework for a western-style extension system in the National Agriculture University, and the Research Institute of Animal Husbandry (RIAH) nominally became the University's research and experiment arm, neither were effectively integrated into the University or received sufficient support to truly function as a national research and extension service. The rangeland division in MOFALI, which was established only in 2008, does not have a research component or the capacity to do research. Several international donor projects, such as the Swiss "Green Gold" project, which is focused on developing herder grazing associations to enable better management and development of group rangelands, and the World Bank's "Sustainable Livelihood Project" which has a Pastoral Risk Management component focusing on reducing herder financial and environmental risk, are engaged in institutionalizing rangeland management and research. However, this is a slow process at best, and with the recent shrinking of the Mongolian economy, commitment by the government of the crucial, long-term financial support is uncertain.

Conclusion

There are numerous advantages to implementing a SGR NRM program at the present time. The technology platforms on which the program would operate are functional, and have been tested in other areas as resource conservation tools. Integration of natural resource information with information derived from other models and methodologies would substantially enhance natural resource management capabilities.

The SGR NRM program would recommend national policies and programs to mitigate the adverse impacts of economic development, privatization, exploitation, and human intrusion on natural resources with the expectation that national, regional and local agencies, NGOs, etc. will implement them. It should take advantage of ongoing work already supported by the national government and the international development community. Most of these national and international initiatives have a strong natural resource management component, even if the projects' primary purposes may not directly relate to management of natural resources or wildlife.

Expected outcomes from developing and implementing a NRM program in the SGR include:

- Improved natural resource monitoring throughout the region using near-real time technologies (e.g., PHYGROW, KRESS, etc.) that have been tested under Mongolian conditions and proven capable of monitoring natural resources on both a landscape- and site-specific scale;
- An effective NRM program officially sanctioned and supported by the government at national, regional/provincial, and county levels;
- Nationally coordinated management and development of natural resources by managers and users throughout Mongolia;
- A NRM program that resolves conflicts over regional natural resources; and
- Legislation defining natural resource management regulations and policies, and allocation of funding to implement conservation activities.

In the SGR, any NRM program should focus on ensuring herding families engaged in pastoral livestock production and populations of large herbivore wildlife are sustainable. It is suggested that the Wild Ass will be the key wildlife species on which successful application of natural resource management can be measured and on which a NRM program should be based. As indicated by the study of Wild Ass and livestock relations, the relationship between livestock and large wild herbivores is not always antagonistic, conservation of wildlife can generate supplemental income supporting herder livelihoods, and uncontrolled economic development will be equally detrimental to both pastoral livestock and large herbivore wildlife.

It is especially critical that a NRM program be in place and functioning prior to the anticipated acceleration of economic development in the SGR. Unfortunately, that will require immediate action to be taken in implementing the NRM program as the Mongolian government has agreed to allow large–scale mining and associated infrastructure development to proceed in the SGR. In addition, a severe winter is adversely impacting livestock and large herbivores wildlife throughout Mongolia. Although the degree to which livestock and large herbivore wildlife in the SGR will be affected is, at this time, unknown, high winter mortalities of both will further reduce sustainability and resilience of the pastoral livestock production system and large herbivore wildlife that are dependent on natural resources in the SGR. The NRM program will also support the position of those who view mining and economic development activities as taking precedent over natural resource conservation. Integration and coordination of national and international efforts to develop a NRM program is critical to the future of large herbivore wildlife and pastoral livestock production.

Annex A. Plant Community Composition in SE Gobi

Table A.1. Dominant Vegetation Types Found in the SGR

ID	Description
Semi-desert Steppe	
25	Artemisia-bunchgrass, bunchgrass (Stipa, Cleistogenes, Agropyron) steppes with Caragana on light chestnut soils
26	Petrophytic forbs-Artimisia-bunchgrass (Agropyron, Stipa) steppes on the light chestnut and mountain chestnut soils.
27	Psammophytic and hemipsammophitic bunchgrass (Agropyron, Stipa glareosa and Stipa gobica, Cleistogenes) steppes with shrubs on light chestnut sandy loamy and sandy soils
28	Hemihalophytic Nanophyton-Artemisia-bunchgrass, Allium-Stipa glareosa steppes on light chestnut solonetz soils and solonetzes
DESERT **North Desert (Semi-Desert)**	
29	Bunchgrass (Stipa gobica, Sipa glareosa) with Anabasis, Allium, Ajania, Artemisia Nanophyton on brown desert-steppe, locally calcareous soils
30	Petrophytic bunchgrass (Stipa gobica, Stipa glareousa) with Ajania, Salsola laricifolia, Ceratoides papposa, Caragana on brown soils, locally in combination with perennial soltworts on solonetz brown soils
31	Psammophytic bunchgrass (Stipa gobica, Stipa glareosa) with Caragana, Ceratoides papposa, and Stipa-Cleistogenes communities on brown loose-sandy soils and sands
32	Halophytic bunchgrass (Stipa gobica, Stipa glareousa) with perennial saltworts, Salsola passerina with Stipa and Allium; Reaumuria songarica with Stipa and Allium communities on solonetz brown soils and their complexes with solonetzes
Middle-Desert (Steppificated Desert)	
33	Anabasis brevifolia with Stipa gobica, Stipa glareosa, Allium; Nanophyton erinaceum with Stipa, Artemisia, Ajania with Stipa deserts on pale-brown locally weakly solonetz soils
34	Petrophytic Anabasis brevifolia, Sympegma, Ajania, Salsola laricifolia with Stipa glareosa deserts on pale-brown soils.
35	Psammophytic Artemisia with grasses, Ceratoides papposa, Caragana, Potaninia deserts on pale-brown sandy soils

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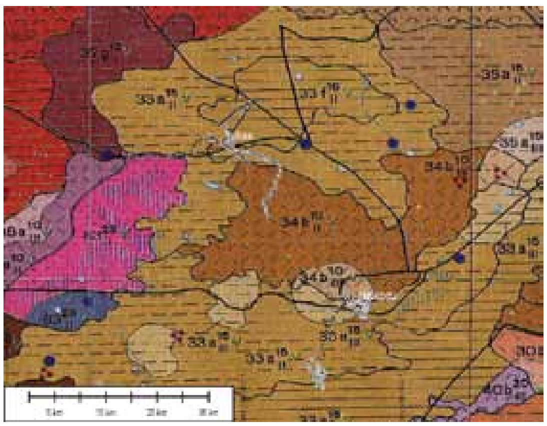
Table A.1. Dominant Vegetation Types Found in the SGR *(continued)*

ID	Description
36	Halophytic perennial saltworts with Stipa glareosa in combination with Kaldium deserts on solonchaks and Haloxylon stands on pale solonetz-solonchak
South-Desert (True)	
37	Anabasis, Nanophyton, Sympegma, Ephedra, low Haloxylon stands on grey-brown desert, locally solonetz soils, often in combination with Sympegma-Potaninia or Artemisia terrae-abbae-Ceratoides papposa communities on sands
38	Petrophytic Anabasis, Salsola laricifolia, Sympegma, Amygdalus, perennial saltwort deserts on grey-brown skeleton and grey brown raw soils
39	Psammophytic Psammochloa, Artemisia, Caragana, Potaninia, Zygophyllum deserts, high Haloxylon stands on grey-brown, locally gypsic, sandy, weakly differentiated soils and sands
40	Halophytic, Reamuria, Salsola passerina, Anabasis brevifolia, Brachanthemum deserts on grey-brown solonetz soils and solonchak soils
41	Gypsum-halophytic Nitraria, Haloxylon with Nitraria on perennial saltworts deserts on grey-brown solonchak strongly gypsic soils
Desert	
56	Sedge halophytic grass (Puccinellia, Hordeum) meadows on saline meadow soils, Iris-Carex duriuscula meadows on saline soddy soils, Puccinellia-Achnatherum and Suaeda Achnatherum meadows on meadow solonchacks and saline meadow-chestnut soils with participation of Trisetum-Carex meadows, locally with Phragmites, halophytic forb-grass, Puccinella-Achnatherum meadows on saline meadow-chestnut soils
57	Carex duriuscula-Iris and Anchnatherum communities on saline soddy soils, halophytic grass communities on saline meadow soils in combination with: a) Artemisia frigida-Cleistogenes communities on soddy and chestnut soils, b) Allium and Leymus communities on soddy desertificating calcareous soils
58	Puccenilia, Calamagrostis communities on saline meadow soils, Juncus, Eleocharis-Carex communities on swampy clay mucky-gley soils, Achnatherum and Iris communities with Caragana on soddy desertificating calcareous soils, locally with Phragmites on meadow-swampy soils in combination with: a) poplar stands with shrubs on soddy primitive soils
59	Combination of halophitic meadow communities (Phragmites, Carex, Achnatherum) and shrub tugals (Tamarix, Hallmodendron halodendron), locally with Populus on saline meadow and meadow-desert soils.
60	Shrub (Caragana, Halimodentron, Tamarix) Achnatherum splendens communities with Artemisia and halophytic forbs locally with Stipa on soddy desertificating calcareous soils
61	Phragmites, Eleocharis-Phragmites communities on meadow-swampy soils in combination with: a) Elymus-Carex communities on saline swampy clay-mucky gley soils and forb-Puccinella communities with Achnatherum on saline meadow soils; b) Eleocharis-Juncus communities on swampy peaty soils, Leymus communities with Limonium and Achnatherum, locally with shrubs (Tamarix, Caragana) on saline meadow soils; c) Phragmites, Carex-Phragmites communities, locally on peaty gley soils
62	Achnatherum communities (with Carex spp, Carex-Agropyron, Potentilla-Artemisia-Stipa krylovii, Allium-Carex-Stipa krylovii) on meadow-chestnut, locally solonetz soils
63	Combinations of halophitic (perennial saltwort Reaumuria, Kalidum, Nitraria, Haloxylon) communities on meadow and fluffy solonchaks
64	Haloxylon (Reaumuria, Nitraria) with shrubs, sometimes in combination with Tamarix tugals and psammophytic communities on primitive sair soils

Source: UNEP Vegetation Type Maps Compiled by the Russian-Mongolian Complex Ecological Study 1995.

Digitized plant communities of UNEP Vegetation Type Maps compiled by the Russian-Mongolian Complex Ecological Study of 1995 are available for Dornogov aimag and the eastern portion of Omnogov aimag (Oregon State University at www.Wild Ass.org).

Figure A.1. The Juxtaposition of Plant Communities (Color-coded in Reference to Table A.1) and Livestock Used by Two Herders in the Southeast Gobi



Source: C.M. Sheehy (2007).

Annex B. Regional Differences Affecting Mongolian Livestock Production

Eco-region	Environmental factors	Livestock production risk factors	Livestock suitability	Livestock production strengths	Suggestions to improve regional livestock production and mitigate risk
1. Hangai-Hovsgol Region (Aimags of Arhangai, Hovsgol, Bulgan and Zavhan). Mountainous region of high elevation and deep valleys with some forest and arid steppe.	• Elevation between 2000 and 3000 m; • Mean annual temperature between −2.5°C and 7.5°C with minimum (−24°C) in January and maximum (19°C) in July; • Between 60 and 100 frost-free days; annual precipitation between 200 and >400 mm; • Average wind speed between 2–4 m/sec; • Snow cover often greater than15 millimeters in depth.	• Winter cold and deep snow limit animal access to forage and nutrients and reduce efficient use of available nutrients; • Lack of access to water during cold periods can be major factor limiting animal production; • Equilibrium ecosystem function whereby over stocking of livestock can change species composition and induce soil, vegetation, and water degradation.	Native yak, native cattle, sheep and reindeer, hybridization with English breeds if winter and spring supplemental nutrients provided.	• Forage production on natural rangelands during summer and fall is high; • Harvesting forage with grazing animals during summer and fall is optimal; • Hay, fodder and grain production potential are relatively high.	• Increase animal access to nutrients during winter and spring by growing hay and fodder crops on abandoned or marginal cereal grain land; • Reduce animal stocking rate by shifting marginal livestock producers to alternative forms of livelihood including producing hay, fodder, and supplements for sale locally or to other nutrient deficient regions; • Change pastoral livestock production system from yearlong forage dependence to greater dependency on nutrient input during the winter and spring seasons; • Regulate animal numbers according to seasonal access to nutrients; • Limit goat and camel numbers in the livestock herd; • Improve herd genetics to meet developing market demand for quality meat by crossing native cattle with English breeds; • Improve livestock producer access to animal production inputs and competitive markets for off-take.

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Eco-region	Environmental factors	Livestock production risk factors	Livestock suitability	Livestock production strengths	Suggestions to improve regional livestock production and mitigate risk
2. Selenge-Onon Region (Aimags of Tov, Selenge and Bulgan). The region is a basin with drainage to the north.	• Elevation between 1500 and 2000 m; • Mean annual temperature between 0.0°C and 2.5°C with coldest temperature in January (−20°C) and warmest in July (19°C); • Between 70 and 120 frost free days; • Annual precipitation between 250 and 400 mm; • Snow cover averages 5–10 mm; • Wind speed averages between 4 to 6 m/sec.	• Winter cold and deep snow can limit animal access to forage and nutrients and reduce efficient use of available nutrients; • Lack of access to water during cold periods can be a major factor limiting animal production; • Equilibrium ecosystem function whereby over stocking of livestock can change species composition and induce soil, vegetation, and water degradation.	Native or hybrid cattle and sheep.	• Principle agricultural cropping area for Mongolia; • Rainfed & irrigated cultivation of cereal grains (wheat, barley, rye, oats) and hay is possible and creates opportunities to produce livestock feed grains and silage; • Forage production on natural rangelands during summer and fall is high, • Harvesting forage with grazing animals during summer and fall is optimal for rangeland use.	• Increase animal access to nutrients during winter and spring by growing hay and fodder crops on abandoned or marginal cereal grain land and improved hayland;* • Reduce animal stocking rate by shifting marginal livestock producers to alternative forms of livelihood including producing hay, fodder, and supplements for selling locally or to other nutrient deficient regions; • Regulate animal numbers according to seasonal access to nutrients • Limit goat and camel numbers in the livestock herd; • Change pastoral livestock production model primarily dependent on annual forage growth to "nutrient supply" model dependent on harvested feeds during winter and spring and forage during summer and fall; • Primary region suited to development of an integrated, semi-extensive livestock production system.

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Eco-region	Environmental factors	Livestock production risk factors	Livestock suitability	Livestock production strengths	Suggestions to improve regional livestock production and mitigate risk
3. Altai Region (Aimags of Uvs, Bayan-olgii, Hovd, Zavhan and Gobi-Altai). High mountain and desert valley region in western Mongolia.	• Elevation between 1500 and 4000 m; • Mean annual temperature between −2.5°C and 5.0°C with low temperature (−24°C) in January and high in July (22°C); • Between 60–120 frost free days; • Precipitation between 400 and 500 mm; • Snow depth ranges between 5 to >15 mm • Wind speed can occur between 2 and 6 m/sec.	• Winter cold and deep snow limit animal access to forage and nutrients and reduce efficient use of available nutrients; • Forage and browse production potential on natural shrub rangelands is low; • Lack of access to water during cold periods can be major factor limiting animal production; • Equilibrium ecosystem function in the north whereby over stocking of livestock can change species composition and induce soil, vegetation, and water degradation, non-equilibrium ecosystem in south whereby environmental influences such as drought and/or dzud in combination overstocking can change "steady state" conditions very quickly as well as decimate large herbivore populations.	Cattle, sheep, goats and horses in the north; sheep, goat, and camel in the south.	• Shrub-dominated rangeland are optimal winter and spring season rangelands for adapted livestock; • Harvesting forage and browse with adapted grazing animals during all seasons is optimal, • Hay, fodder and grain production potential is low except in a few oasis and developed irrigated areas.	• Increase animal access to nutrients during winter and spring by growing hay and fodder crops in oases, by rehabilitating abandoned irrigation developments as irrigated hayland (i.e., especially legumes such as alfalfa), and by importing animal feed from more efficient feed producing regions; • Reduce animal stocking rate by shifting marginal livestock producers to alternative forms of livelihood, by rationalizing livestock numbers and kind, and by obtaining higher annual livestock turnover; • Regulate animal numbers according to seasonal access to nutrients; • Limit Cashmere goat, cattle, and horse numbers as a proportion of herd; • Improve application of the pastoral, extensively managed livestock production model by developing and rehabilitating wells and by facilitating distribution of livestock and livestock producers.

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Eco-region	Environmental factors	Livestock production risk factors	Livestock suitability	Livestock production strengths	Suggestions to improve regional livestock production and mitigate risk
4. Central and Eastern Steppe Region. (Aimags of Dornod, Hentii, Sukhebaatar, Dornogov and Dundgov). Broad, essentially treeless grass steppe region in central and eastern Mongolia.	• Elevation between 900 and 2,000 m; • Mean annual temperature between 0.0°C and 2.5°C with low in January (−20°C) and high in July (22°C); • Between 110 and 140 frost free days; • Precipitation between 150 and 250 mm; • Snow depth ranges between 5 to 10 mm; • Wind speed can occur between 4 and 8 m/sec.	• Winter cold and deep snow can limit animal access to forage and nutrients and reduce efficient use of available nutrients; • Lack of access to water during all seasons except along major rivers is a major factor limiting animal production; • Equilibrium ecosystem function whereby over stocking of livestock can change species composition and induce soil, vegetation, and water degradation; • High winds during spring and lack of topographic animal shelter can limit livestock production efficiencies; • Difficulty of access to major markets and low human population is a major constraint except in the western portion of the region and along the rail corridor.	Sheep, goat, horse, and cattle	• Has potential as an area to produce hay and other livestock feeds (i.e., during the collective era, there were 20 state hay farms in the region). • Considerable unused rangeland exists in the eastern and northern part of the region, • Has potential to become an export region for livestock offtake because of close proximity to railroads, water transportation, and large population areas in China, • Forage production on natural rangelands during summer and fall is high, • Harvesting forage with grazing animals during summer and fall is optimal for rangeland use.	• Increase animal access to nutrients during winter and spring by developing improved hay and animal feed grains capacity on abandoned hay and crop farms for sale locally or to other nutrient deficient regions[1]; • Improve livestock production potential of the region by developing wells and livestock shelters; • Regulate animal numbers according to seasonal access to nutrients; • Limit goat and camel numbers in the livestock herd; • Change pastoral livestock production model primarily dependent on forage yearlong to "nutrient supply" model dependent on harvested feeds during winter and spring and forage during summer and fall; • Develop regional value-added facilities to improve export potential.

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Eco-region	Environmental factors	Livestock production risk factors	Livestock suitability	Livestock production strengths	Suggestions to improve regional livestock production and mitigate risk
5. Gobi Region (Aimags of Gob-altai, Bayan-hongor, Ovor-hangai, Dundgov, Om-nogov, Gobi-Sumbaer, and Dornogov). Semi-arid and arid southern section of Mongolia	• Elevation between 700 and 1400 m; • Mean annual temperature between 0.0°C and >2.5°C with a low (−20°C) in January and high of (23°C) in July; • Between 90 to > 130 frost free days; • Average precipitation of 100 mm. • Wind speed between 2 and 8 m/sec.	• Lack of snow water for grazing animals is a major factor limiting livestock distribution and production in the Gobi Region; • Non-equilibrium eco-system whereby envi-ronmental influences such as drought and/or dzud in combina-tion with overstocking can change "steady state" conditions very quickly and as well as decimate large herbi-vore populations; • Difficulty of access to major markets and low human population is a major constraint to sustain-able livelihoods; • Overbrowsing of shrubs which dominate vegetation communities cannot be easily mitigated; • Hay, fodder and grain production potential is low except in a few oasis and developed irrigated areas; • Arid ecosystems are prone to both environmental and anthropomorphic desertification.	Native sheep, goat, and camel.	• In winter and spring shrub dominated rangeland are optimal range-lands for adapted livestock; • During all seasons harvesting forage and browse with adapted grazing animals is optimal; • Region has highest potential to support Cashmere goat production.	• Increase animal access to nutrients during winter and spring by importing supplemental feeds; • Improve livestock distribu-tion and production potential of the region by developing wells and livestock shelters; • Regulate animal numbers according to seasonal access to nutrients; • Limit horse and cattle numbers in the livestock herd and maintain correct proportions of goats and sheep; • Maintain and improve pastoral livestock production whereby livestock are de-pendent on annual forage/browse by improving animal distribution capabilities of the livestock herder (i.e., ac-cess to water, transportation and supplemental feed); • Develop regional value-added facilities to improve export potential; • Develop cross border marketing linkages. • Encourage faster livestock turnover and initiate annual "severe culling" at the end of the fall grazing season; • Focus livestock production to take advantage of local, national, and international markets developing along the rail and road corridor.

Annex C. Pastoral Livestock Economies

Table C.1. Livestock Production in a Natural Economy Versus an Industrial Economy

Industrial economy	Natural economy	Mongolian livestock economy	Change factors
Livestock production in an industrial economy is organized into political hierarchies (countries, states, counties, cities, private homesteads).	Livestock production in a natural economy is organized into natural units (watershed, basins, mountains, and natural habitats defined by soils, vegetation, and topographic features, etc.) where use is defined by natural factors of the animal and the habitat.	Livestock production in the Mongolian economy is organized into political hierarchies (aimag, sum, & bag) but generally organizes actual livestock production according to natural units within the bag (watersheds, seasonal pastures, cooperative decision-making concerning access to forage).	Higher human population in the livestock economy is causing conflict over *de facto* possession of critical natural inputs (winter shelters, hay making areas, water sources, and access to markets).
Livestock production in an industrial economy has political divisions competing and often conflicting over the ownership, use, and distribution of resources. Livestock are mere tools used to exploit natural resources for economic benefit to the owner.	Livestock production in a natural economy views livestock and natural resources as part of a co-evolving relationship. Boundaries are imposed by biophysical constraints. Livestock are the basis of livelihoods.	Livestock and habitat are viewed as part of a co-evolving habitat with boundaries imposed by biophysical constraints (seasonal ranges determined by topographic, vegetative, and climatic attributes of the natural landscape, knowledge of the interaction between livestock and natural resources critical for livelihood sustainability)	Change in political and economic systems is creating situations analogous to an industrial economy (natural parks and reserve areas, movements to assign ownership to components of natural resources critical for livestock production, conflicts over access and use of natural resources increasing, regulations defining livestock use of natural resources being prepared)

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Table C.1. Livestock Production in a Natural Economy Versus an Industrial Economy *(continued)*

Industrial economy	Natural economy	Mongolian livestock economy	Change factors
Livestock production in an industrial economy has a production infrastructure which is visible and recognizable, and its function is generally understood as animal rearing areas, feedlots, slaughterhouses, feed production, market channels, wholesale and retail chains. Livestock production depends on provision of inputs obtained externally to the local production infrastructure.	Livestock production in a natural economy has a production infrastructure, which is only partially visible, and its function, while poorly understood, is the basis of sustainable livestock production. Livestock production is low input and dependent on local resources.	Livestock production in the current Mongolian economy currently has only a partially visible infrastructure. Inputs other than locally manufactured inputs are few (veterinary medicines, supplemental feeds, processing facilities, production to meet market needs). During the preceding collective era, livestock production on both state farms and rural collectives had a more visible infrastructure.	The change in political and economic systems is fostering infrastructure development (introduction of higher yielding livestock breeds, increase in Cashmere goats to meet international market demand, development of marketing centers). Development of a more visible production infrastructure will increasingly be driven by social and economic considerations affecting the rural human population rather than livestock production considerations.
Livestock production in the industrial economy is driven by fossil fuel and the need to accumulate capital.	Livestock production in the natural economy is driven by solar energy and the need to reproduce.	Livestock production in the Mongolian economy is currently almost entirely driven by solar energy and the need to reproduce. Forage is the basis of livestock production. Nutrients obtained from forage determine livestock production coefficients such as mortality, survival, estrous and birth rates, which affect livelihood sustainability of rural populations.	The need to market products over long distances and the transport of households between seasonal pastures is an impetuous for livestock producers to purchase vehicles dependent on fossil fuels. During the socialist era, rural livestock collectives provided transport for household movements and transfer of primary off-take products to urban distribution centers and value-added processing centers. Lack of cash and access to fuel are limiting factors retarding dependence of the livestock production system on fossil fuels.
Livestock production in the industrial economy favors large centralized production facilities (single livestock type and breed, feedlots, slaughterhouses, trading centers, etc.), which lead to biological and technological monocultures.	Livestock production in the natural economy favors dispersed production among small units.	Although livestock production is relatively dispersed, the trend is towards concentration of animals because of social and economic reasons	Concentration of animals introduces density-dependent feedback mechanisms. Unless more top-down interventions are added to the livestock production system, sustainability of livestock production and ecosystem stability can rapidly be negatively impacted.

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Table C.1. Livestock Production in a Natural Economy Versus an Industrial Economy *(continued)*

Industrial economy	Natural economy	Mongolian livestock economy	Change factors
Livestock production in the industrial economy is linear and extractive, emphasizing production.	Livestock production in the natural economy is circular and renewable, encouraging reproduction.	Most livestock production in Mongolia continues to be circular and renewable. An emphasis on production is developing in some areas (e.g., change in herd structure to favor Cashmere goats because of market demand for Cashmere, introduction of Suffolk sheep because of potentially higher meat yields).	Changes will diminish adaptability of livestock in the Mongolian herd to environmental constraints; The demand for top-down intervention to support livestock with costly inputs will increase.
Livestock production in the industrial economy creates waste and fails to fully recycle resources.	Livestock production in the natural economy has no waste, everything is recycled	Generally, the Mongolian pastoral livestock production system has no waste. In some areas, economic and social changes are creating waste (e.g., little demand for yak hair, oversupply of Cashmere wool on the world market, little market demand for sheep wool).	Waste is a characteristic of an industrial economy usually generated by supply and demand functions of a market economy.
Livestock production in the industrial economy partitions natural resources into discrete economic spheres that operate independently of each other.	Livestock production in the natural economy views natural resources as a maze of connected habitats.	Pastoral livestock production has always viewed natural resources as habitats connected through space and time. Indigenous knowledge of the livestock herder allowed optimal use of accessible habitats. In areas where livestock are being concentrated for economic and social reason, the connectivity between humans, livestock and habitats is being lost.	Pastoral livestock production views natural resources as a "continuum" with forage and nutrients and shelter as the critical elements of livestock production. Livestock production in an industrial economy operates within artificially defined discrete units that have little relationship to the natural environment or animal behavior.

Annex D. Current Population Status of Selected Wild Herbivore and Predator Species in Mongolia

Status of Mongolian Wildlife

Mongolia harbors a large diversity of wildlife. So far, scientists have identified 139 species of mammals; 450 species of birds; 22 species of reptiles; 6 species of amphibians; and 76 fish species (Clark et al. 2006). Scientists in Mongolia and abroad have been documenting the decline of these species over the last several decades, and most believe that this decline is intensifying (Table D.1). In 2006, the National University of Mongolia participated in a "red list" assessment of 128 species of mammals and 64 species of fish, which is the most comprehensive survey to date. Of the mammals, 16% were considered regionally threatened. More detailed classification results in 2% critically endangered, 11% endangered, and 3% vulnerable. The status of the fish species was grave with 23% regionally threatened. A more detailed classification indicated that 2% were critically endangered, 13% were endangered, and 8% were vulnerable (Red List of Mammals 2006).

Populations of herbivorous wildlife until recently have been relatively high but human intrusion in the form of legal and illegal hunting has substantially impacted most populations of large wild herbivores. Only the White Tailed gazelle and the tenuous population of Saiga antelope appear to have increasing population trends at present. The Marmot is a small herbivorous animal that has disappeared over much of its' range since 2000, even though hunting has been restricted or banned for several years. Among the two major predators, wolf populations, which are not protected, appear to be declining while snow leopards, which are strictly protected, have an increasing population.

The focus of this annex is on the population trend of mammals and fishes that are directly threatened by the activities of humans. The species are divided into groups of large herbivores and small herbivores, and main herbivore predators. The large herbivores are subdivided by the eco-regions tundra, boreal forest, forest, grass steppe, shrub steppe, desert steppe, and desert-mountain. Main threats for all species can be summarized by competition with livestock for forage and water, changing land uses such as habitat fragmentation or mining, and direct poaching for animal products.

Large Herbivores

Tundra/Boreal Forest/Forest

Moose (*Alces alces*). There are two subspecies of moose in Mongolia: the very small population

Table D.1. Estimated Current Large Wildlife Populations in Mongolia

Year	Marmot	Snow Leopard	Wolves	Wild Ass	Ibex	Gazelle (Black Tailed)	Argali	Gazelle (white tailed)	Saiga	Moose	Elk	Taimen (Numbers Unknown)
1940								4,500,000				
1960						90,000						
1975							50,000					
1978								260,000				
1979								250,000				
1980			30,000					165,000				
1981								350,000				
1985												100%
1986											130,000	
1987					8,000							
1989										14287		
1990	200,000					60,000						
1997									2,950			
2000		750							5,240			
2001	50,000						14,000		2,500			
2002								850,000	1,020			
2003				20,000					750			
2004			10,000						800		9,000	
2005									1,500			
2007		950										50%

Sources: Batbold 2002, Clark and others 2006, Dulamtseren 1989, Kaczensky and others 2006, Lkhagvasuren and others 2001, Mech and others 2008, Mc-Carthy and others 2003, Reading and others 1997, Shagdarsuren 1987, Winegard and Zahler 2006, and WWF website 2007]

of *A. a. cameloides* and the more abundant *A. A. pfi zenmayeri.* A 1989 survey estimated 10,000 individual *A. a. pfi zenmayeris* in the Hentii and Hangai Mountain Ranges, which represented 70 percent of the total population. However, populations are known to be declining due to exploitation, habitat loss, and pollution. Regional distribution: *A. a. cameloides* occur along the Halh River and in the Nömrög River Basin in Ikh Hyangan Mountain Range (Shagdarsuren and Stubbe 1974, Shiirevdamba and others 1997). *A. a. pfi zenmayeri* occur in taiga habitats, particularly along the Onon and Herlen Rivers in northeastern Hentii Mountain Range, and along the Eröö and

Minj Rivers in western Hentii Mountain Range (Clark and others 2006).

Elk (*Cervus elaphus*). In 1986, the estimated population of elk or "red deer" was 130,000 individuals across 115,000 square kilometers (Dulamtseren 1989). By 2004, only 8,000–10,000 individuals in 15 provinces were counted. This represents a 92 percent decline over the past 18 years (Zahler and others 2004). This species is primarily targeted for its antler velvet, which is highly valued for traditional medicines, with a current market value of US$60–100 per kilogram of antlers. Other antler products and body parts, including male genital organs, fetuses, and female tails are also valued for traditional medicines and have similar market values (Zahler and others 2004, Wingard and Zahler 2006). Habitat loss and fragmentation, and human disturbance resulting from resource extraction (mining) and infrastructure development, constitute threats to some extent (Clark and others 2006).

Grass Steppe

Black tailed gazelle (*Gazella subgutturosa*). Between the 1940s and 1960s, the range and population size of this species declined in Mongolia by 30 percent (Lkhagvasuren and others 2001: 159–167). In 1990, the population was estimated to be 60,000 animals (Amgalan 1995). Hunting is the primary cause for this population decline. This species requires very little water, but it is theorized that increasing numbers of livestock compete for use of oases, resulting in pasture degradation. Mining is not causing a substantial loss of habitat at present, but associated human disturbance is a threat in some areas (Clark and others 2006). Trophy hunters can purchase hunting licenses, from which US$450 is allocated to the government (MNE 2005).

White tailed gazelle (*Procapra gutturosa*). Population size has increased following the epizootic disease and extreme droughts in 1980 that reduced the population to approximately 150,000–180,000 individuals (Lushchekina and others 1983). Over 2 million Mongolian Gazelles now inhabit Mongolia's Eastern Steppe, but this number is thought to be declining again (Clark and others 2006). According to latest population census formula by Milner-Gulland and Lhagvasuren (1998) there were 4–5 million gazelles in the 1940 and 1950s. The population once roamed throughout the entire country but now occurs primarily in Eastern Mongolia (WWF 2007). Main threats include dzud conditions; several infectious diseases; steppe fires; human and livestock interference; predation by wolves and raptors; the mining industry; and the Trans-Siberian Railway, which affects the Mongolian Gazelle's distribution and migration (Clark and others 2006). Food overlap with sheep and goats appears to be very high as indicated by Pianka's index (0.977) but not with horses (Campos-Arceiz and others 2004).

Plans to reduce threats to the gazelle and its habitat's include (a) supporting anti-poaching initiatives; (b) introducing sustainable pasture management; (c) supporting alternative livelihood activities in order to reduce pressure on and competition for habitat; and (d) expanding habitat into areas formerly inhabited by Saiga (WWF 2007).

Shrub Steppe-Desert Steppe

Wild Ass (*Equus hemionus*). In 2003, the population was estimated to consist of 19,000–20,000 individuals (B. Lkhagvasuren, personal communication), but is declining at 5 percent per year. Dominant threats are illegal hunting for meat and skins for commercial use (Duncan 1992, Stubbe and others 2005), habitat degradation due to human intrusion, resource extraction (mining), and increasing numbers of livestock. Habitat fragmentation and restriction of long range migrations is a significant problem along the Ulaanbaatar-Beijing Railway and the China-Mongolia border (Kaczensky and others 2006), and is also caused by developing roads and railway lines associated with increasing resource extraction.

Conservation measures needed include enhanced enforcement of existing protective legislation, including strict control at border posts between Mongolia and China to prevent the illegal export of carcasses and control of meat markets to prevent illegal trade in carcasses within Mongolia. Maps of critical habitat and movement corridors should be considered when planning transportation routes and fences (Kaczensky and others 2006).

Saiga antelope (*Saiga tatarica*). This endemic species exists in two isolated populations in Mongolia; the Sharga and the Mankhan populations (Mallon and Kingswood 2001). Annual surveys by WWF Mongolia and the Mongolian Academy of Sciences estimated the total Mongolian population to consist of 2,950 individuals in 1998, rising to 5,240 in 2000 (Dulamtseren and Amgalan 1995). However, by 2005, the numbers had dropped to 1,500. This makes it the most threatened and endemic ungulate species (WWF 2007). The population is very small and therefore vulnerable to stochastic events such as severe winters (Lkhagvasuren and others 2001). Hunting levels in Mongolia may still be relatively low in comparison to other species (Lkhagvasuren and others 2001), but the horns of males, used in traditional medicines, still invokes hunting pressure and results in skewed sex ratios (Zevegmid and Dawaa 1973). This hunting is exasperated by economic collapse in the rural areas of Kazakhstan and Kalmykia (Milner-Gulland and others 2001).

The Saiga appears to be stabilized for the moment but is of concern because of the population's small size. Full aerial surveys are needed in the Betpak-dala (Kazakhstan) and Mongolian populations, and funding is urgently required for the control of poaching in all parts of the Saiga range (Milner-Gulland and others 2001)

Desert Mountain

Argali bighorn sheep (*Ovis ammon*). The Argali sheep population has plummeted by more than 70 percent over the past 50 years. Some 50,000 Argali were counted in 1975, whereas the census of 2001 and 2004 counted only 13,000 (WWF 2007). The main factors behind the decline are related to hunting and poaching for horns that are prized as trophies. Over harvesting has occurred in the absence of management plans and rural economies have not benefited. Thus, poaching of the animals for cash has occurred due to poverty in these areas. In addition, the Argali is experiencing habitat loss from mining and greater competition with livestock (Reading and others 1997, 2003, 2005; Wingard 2005).

Interviews with rural pastoralists in Siilkhemi-in Nuruu National Park in western Mongolia suggest positive attitudes toward the Argali. Herders are generally aware of and support government protection but may not be able or willing to reduce herd sizes or modify grazing regimes for the benefit of wildlife without compensation (Maroney 2005).

Ibex goat (*Capra sibirica*). In 1987, the first *Mongolian Red Book* estimated the total population in Mongolia to consist of around 80,000 individuals (Shagdarsuren and others 1987). Numbers are believed to have declined since this peak (Mallon and others 1997). As with other ungulates, causes are exploitation, habitat degradation, and competition for resources. Even so, trophy hunters can still purchase hunting licenses, which cost US$800 for Altai ibex and US$720 for Gobi ibex (Clark and others 2006).

Bactrian camels (*Camelus bactrianus ferus*). The wild Bactrian camel population has reached an extremely tenuous position due to declines in numbers and reproductive success. Estimates of the population have proved difficult to obtain and need to be more accurate. However, only 277 camels in 27 groups were observed in 1999 (Reading and others 1999) and 463 mature individuals were counted in 2005 (Adiya and Dovchindorj 2005). Perhaps the greatest threat facing an already tenuous population is hybridization with domestic camels. The extent to which this occurs remains unclear, but some scientists believe that herders breed their domestic camels with wild camels.

Small Herbivores

Marmot (*Marmota sibirica*). In 1990 the population was estimated to consist of 20 million individuals (Wingard and Zahler 2006), falling to 5 million by the 2001 assessment, indicating a 75 percent decline (Batbold 2002). Hunting was completely banned during 2005 and 2006 by the Ministry of Nature and Environment. Marmots inhabit steppe and grassland habitats across Mongolia and suffer from being hunted for skins, traditional medicines, and meat for local, national, and international trade. This species is conserved under Mongolian Protected Area Laws and Hunting Laws, but no conservation measures are specifically in place, and enforcement of existing protective legislation is weak (Clark and others 2006).

Predators

Wolf (*Canis lupus*). In 1980, the Mongolian Academy of Sciences estimated there were 30,000 wolves in Mongolia. More recent estimates are less precise, but the most recent results suggest 10,000 animals remain in Mongolia (Mech and Boitani 2008).

Brown bear (*Ursus arctos*). The brown bear has been added to the Government's official List of Rare Animals (WWF 2007) in large part because so little information about numbers and threats is known. What has been determined is that a human-caused change in the availability of habitat is the largest identifiable threat. Illegal and unsustainable hunting for international trade is also an issue since all body parts are used for traditional medicines. Within Mongolia, trade in gall bladders is the focus of illegal and unsustainable hunting (Wingard and Zahler 2006).

Snow Leopards (*Panthera uncia*). Snow leopard population in Mongolia varies from approximately 700 to 1,200 animals, with a low density of 1 to 1.5 leopards per 100 square kilometer (WWF 2007, McCarthy and Chapron 2003). The small population is predicted to decline by an additional 20 percent over the next two generations, primarily due to exploitation (Clark and others 2006), even though hunting has been illegal since 1972 (MNE 1996). Worldwide, populations are in peril; the Mongolian population represents 13 to 22 percent of the estimated global snow leopard population (WWF 2007). Decline in Mongolia is largely due to poaching for fur and bones and loss of prey species as a result of (illegal) over-hunting of ibex, argali, and marmots. In addition, loss and fragmentation of habitat and competition with livestock for remaining habitat is an issue. Some of the illegal killings are retaliation killings for loss of livestock (WWF 2007). In general, there is a lack of awareness and support of local people for the conservation of the snow leopard, its prey and habitat (Evans and others 2003).

Conservationists have turned to incentive programs to motivate local communities to protect carnivores. This has been promising in some areas. However, initiatives to offset the costs in terms of livestock and to make conservation beneficial have not been expanded beyond isolated experiments. Making these initiatives comprehensive is the best opportunity to conserve large carnivores such as the snow leopard (Mishra and others 2003).

Conservation measures must also investigate illegal hunting and enhance enforcement of existing protective legislation, including rigorous border checks to prevent illegal exports.

NOTE: Visit www.zuil.mn for more information.

Annex E. Vulnerability of Mongolia to Climate Change

Warming of the Earth's climate system is very hard to dismiss. Global observations of air and ocean temperatures are continuing to climb, as is the global average sea level due to thermal expansion (IPCC 2007). Perhaps the most visual evidence is the rapid disintegration of Arctic ice sheets and vanishing glaciers in central Asia, Western Mongolia, and North-West China (Pu and others 2004). Scientific observations in Asia include the migration of plant and animal species to higher elevations and cool temperate grassland species shifting northward (Sukumar and others 2003: 266–290; Christensen and others 2004; Tserendash and others 2005: 59–115).

Climate Models

Many scientists believe that carbon dioxide (CO_2) is the most important anthropogenic greenhouse gas. Worldwide emissions grew by 80 percent between 1970 and 2004. However, this growth did begin to slow in the early 1990s. The Intergovernmental Panel on Climate Change (IPCC) released a Special Report on Emissions Scenarios in 2000. They identified four world development scenarios that have become the basis for climate prediction models (A1, A2, B1, and B2):

- A1 – Rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies.
- B1 – Convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy.
- B2 – Intermediate population and economic growth, local solutions to economic, social, and environmental sustainability.
- A2 – Heterogeneous world with high population growth, slow economic development and slow technological change.

The IPCC has developed four potential future scenarios, of which scenarios B2 and A2 would lead to the warmest climate. Given these scenarios, climate centers around the world have developed computer models such as HADCM3, ECHAM, and CSERO to make global predictions.

In general, all computer climate models that simulate global climate predict an enhanced hydrological cycle and an increase in area-averaged annual mean rainfall over Asia (Murari and others 2001: 39–84)). However, difficulties arise in making predictions at smaller scales. Natural climate variability is relatively larger, making it harder to distinguish changes that may be brought about by the global climate influences (IPCC 2007).

Observed Climate Change

Mongolia's sensitivity to climate change. Mongolia has a livestock economy that is intimately linked to weather events. Mongolia's climate is characterized by long and cold winters, dry and hot summers, low precipitation, high temperature fluctuations, and on average 260 sunny days per year: 100–150 millimeters of precipitation falls in the steppe-desert; and 50–100 millimeters in the Gobi Region. Most precipitation occurs in late spring and summer, with 50–60 percent falling in July and August alone. Snow contributes less than 20 percent to total annual precipitation (Natsagdorj and others 2005: 39–84).

Mongolia's total land area is 156 million hectares (Cruz and others 2007: 469–506). Of this, 74.1 percent is rangeland and 1.6 percent is used to make hay to support livestock (MNE 2008). Livestock rely on naturally produced rangeland forage for over 90 percent of their total diets. In total, Mongolia produces 257,700 tons meat of which 3 percent is camel, 13 percent is horse, 17 percent is goat, 35 percent is beef, and 32 percent is mutton (Batima 2008).

This linkage makes Mongolia and the livestock economy very sensitive to climate change. For example, about 200,000 animals are lost every year because of heavy winter conditions (MNE 2008). In addition, many species of wildlife live in Mongolia and the Gobi Region. The South Gobi (Dundgov, Omnogov, and Dornogov) in particular has high populations of large herbivorous wildlife that are already threatened or endangered. Further development and human intrusion is expected to increase pressures on their existence. The added variable of climate change may cause species survival to be increasingly problematic.

Direct observations of climate change. In 2008, Batima conducted a survey of herders in Mongolia. Ninety-two percent thought climatic hazards were the only cause of worsening of their livelihood. Fifty-three percent had lost more than half of their animals. Like scientific communities worldwide, 77–92 percent of the herders felt that they were observing climatic change.

Meteorological records show that during the last 60 years, the annual mean air temperature for the country has increased by 3.61° C in the winter and 1.4° C in the spring and autumn. The average precipitation rate increased by 6 percent from 1940 to 1998 (MNE 2008). However, the peak of pasture biomass has declined by 20 percent to 30 percent over the past 40 years because of climate change (Batima 2008). This trend has been verified for the last two decades by the Normalized Difference Vegetation Index (NDVI), which measures the biomass of vegetation from remote sensing satellites.

Emissions

Development is responsible for much of the greenhouse gases emitted into the atmosphere, and many scientists argue that these gases are exacerbating climate change. On the other hand, development greatly insulates human from being severely affected by climate variability (Cruz and others 2007: 469–506). Development is taking place in Mongolia, but there is no regulatory mechanism that explicitly addresses climate change-related problems (MNE 2008).

In 1994, Mongolia's emission of CO_2 dropped to 9,064 tons of greenhouse gases but is projected to reach 40,571 tons by 2020. At this point in the future, coal will be the predominant source of CO_2 emissions. Currently, the single largest source of greenhouse gases is CH_4 from livestock herding, which accounts for 90–93 percent of Mongolia's total emission (MNE 2008). It is important to note that herded animals have a small relative carbon footprint compared to industrialized dairy, pig and poultry production in more developed countries.

Increased carbon dioxide in the atmosphere has many implications for evapo-transpiration, water balance, and runoff. Higher CO_2 leads to reduced evaporation in plants, but conversely causes increased plant growth. Overall, there is greater total evapo-transpiration from a given area (Kundzewicz and others 2007: 173–210). For example, it has been predicted that if CO_2 concentrations double, then global mean runoff will increase by

5 percent (Betts and others 2007, Leipprand and Gerten 2006).

Predictions of General Climate Change Impacts

Global. Climate change is projected to compound the pressures on natural resources from urbanization and economic development. The resilience of many ecosystems is likely to be exceeded by this combination of rising temperature, changing precipitation, ocean acidification, land use change, pollution, fragmentation of natural systems, and overexploitation of resources (IPCC 2007). Increased migration of human populations can be expected over the coming decades (Cruz and others 2007: 469–506).

In Asia, water and agriculture sectors are likely to be most sensitive to climate change-induced impacts because of high temperature, severe drought, flood conditions, and soil degradation (Cruz and others 2007: 469–506). About 1 billion people will face risks from reduced agricultural production potential, reduced water supplies or increases in extremes events (Schneider and others 2007). By the 2050s, freshwater availability in Central, South, East, and South-East Asia is projected to decrease (IPCC 2007). Most semiarid river basins in developing countries are more vulnerable than in developed countries because of rising populations paired with a low capacity to cope with change (WHO 2005).

Mongolia. Many of these issues could arise in Mongolia as its population is expected to approach 4.1 to 4.3 million between 2020 and 2025. Compared to 1993, energy used may be five times greater by 2020 and domestic animals may reach 41.7 million by 2010. The result will be increased pressure on a changing environment (MNE 2008).

South Gobi. Overall, there is conflicting predictions on what the Gobi Regions of Dundgov, Omnogov, and Dornogov can expect. Some estimates predict a marginal decrease in productivity by the end of this century (Tserendash and others 2005: 59–115) while others believe biomass will increase (Batima 2008). Most researchers predict that a gradual reduction in annual precipitation will likely contribute to ongoing desertification from livestock overuse. These areas are projected to increase to the north by 6.9–23.3 percent by 2040 and by 10.7–25.5 percent by 2070. In addition, desertification may lead to a soil carbon decline of 14.2–48.9 percent by 2040 (MNE 2008).

In combination with expected urbanization, there may be difficulties in provisioning safe, affordable, domestic water supply (Faruqui and others 2001). These changes are gradual but long term, and are often associated with increasing vulnerability to extreme weather events, particularly droughts and dzud (i.e., severe winter storms with very cold temperatures) (Batima 2008). The study of the impacts of climate change on wild animal life is in the initial stages. The location of wild animals strongly depends on natural zones (MNE 2008).

Potential Impacts of Climate Change on Livestock Production

Potential economic impacts. Global market fluctuations mask variations caused by climate change at regional scales (Schneider and others 2007). However, the market economy that was introduced to Mongolia in 1990 is focused primarily in the capital city of Ulaanbaatar (Batima 2008). Herders in Dundgov, Omnogov, and Dornogov Provinces must respond primarily to variables found in nature rather than market incentives. The largest impact on livelihoods is the drying up of water sources and declining forage resources for livestock (Natsagdorj and others 2005: 39–84).

Vulnerability is a function of the expected rate of climate change relative to the resilience of the system. However, the vulnerability of natural systems is also a function of human developments that block migration routes, fragment habitats, reduce animal populations, introduce invasive alien species, and pollution (Schneider and others 2007). Any changes in the natural systems will greatly affect the human populations that are dependent on them.

Herders could benefit economically from mild winters. However, some researchers believe that rapid warming in winter can create problems. For example, if there is sudden snow melt followed by freezing, then large ice sheets will interfere with pasture grazing (Natsagdorj and others 2005: 39–84). In general, climate change compounded with poverty could be a devastating arrangement. Gobi herders may have a very low adaptive capacity because of limited access to information, technology, capital, forage, and other agronomic inputs that will allow them to adjust their production strategy to match changing conditions (Cruz and others 2007: 469–506).

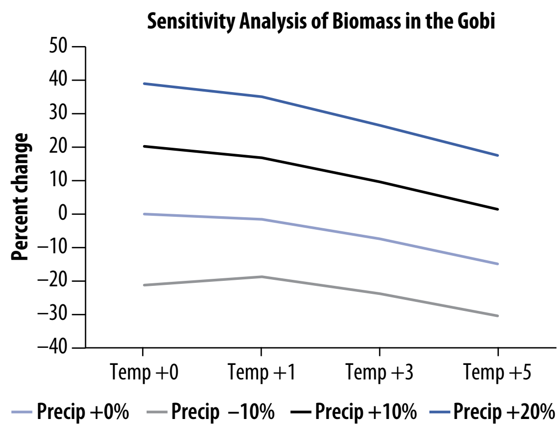
Fortunately, it is evident that current climate variability falls largely within the coping range of fodder production and it is not expected to be exceeded significantly because of predicted climate changes (Schneider and others 2007). This makes hay production, especially winter time forage, an important tool for any herder transitioning into predicted climate change scenarios and the very real emerging economy.

Potential impacts on rangeland. Pasture in the Gobi Regions of Dundgov, Omnogov, and Dornogov are controlled primarily by abiotic factors of temperature and precipitation, and the biotic factor of animal grazing. Sensitivity analysis of plant biomass examines the abiotic variables and shows that a plant aboveground biomass decreases with increased temperature. However, plant biomass increases with additional precipitation, and this effect dwarfs the temperature effect as can be seen in Figure E.1 (Batima 2008).

Relative to predictions of computer models, the HADCM3 and CSERO models agree that biomass will increase for the desert steppe region in both the A2 and B2 scenarios. The ECHAM model shows no change in biomass for the A2 scenario and decreasing biomass in the B2 scenario (Figure E.2).

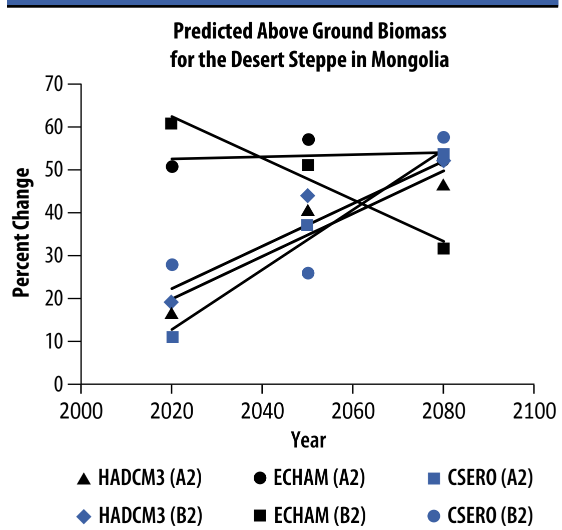
As projected by both the NPOESS Preparatory Project (NPP) and Aridity Index, eco-zones of Mongolia are expected to shift to the north due to increased dryness and higher air temperature. The results of the climate change models, the HADCM3, ECHAM3, and CSIRO all agree within the context of scenarios A2 and B2. This means the Gobi will shift north due to combined impacts of increased temperature and reduced precipitation

Figure E.1. Sensitivity Analysis of Biomass in the Gobi



Source: Batima (2008).
Note: In 2008, Batima shows that precipitation is a greater effect on aboveground biomass than temperature.

Figure E.2. Predicted above Ground Biomass in the Desert Steppe in Mongolia



Source: Batima (2008)
Note: In 2008 Batima shows that in both A2 and B2 the HADCM3 and CSERO models showed increased biomass.

while at the same time experiencing an increase in biomass (Batima 2008).

Implications for water resources. Mongolia's total water resource is estimated at 599 cubic kilometers of water (MNE 2008), and precipitation plays an enormous role in its recharge and cycling. Unfortunately, precipitation is not reliably simulated in present climate models and there are conflicting results, often because of the localized nature of precipitation. However, it is well established that precipitation variability increases due to climate change (Kundzewicz 2007: 173–210, MNE 2008, Natsagdorj and others 2005: 39–84, and Batima 2008).

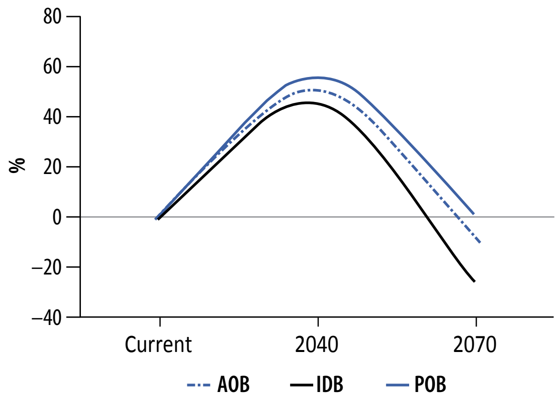
The Gobi desert and desert-steppe areas are expected to receive less rainfall. This will lead to reduced river runoff, lower water levels in the lakes basin, and cause drying-up of small lakes in the Gobi Region (MNE 2008).

In the last 60 years, annual precipitation has increased by 30–70 millimeters in the most south-eastern part of the country (Batima 2008). The findings of the 5 computer models (CCCM, CSERIO, ECHAM, GDFL, HADLEY) show that this trend will continue in the first quarter of the century and then decrease, returning close to current levels by the mid-21st Century as shown in Figure E.3 (MNE 2008).

If there is an increase of summer rainfall, there might be a much higher increase of evapotranspiration. Already, potential evapo-transpiration has increased by 7–12 percent over the previous 60 years (Batima 2008). The impact of precipitation change is predicted to be greater than that of temperature in relation to river flows. For example, Batima found in 2008 that if the annual precipitation drops by 10 percent while the temperature remains constant, the average river flow would reduce from 7.5 percent to 20.3 percent. For each degree C of temperature increase, there is an additional 2 percent decrease in flow.

Recent drought and growing water demands is already creating a need for both new infrastructure and rehabilitation of old infrastructure such as wells. Water use, and in particular irrigation water use, generally increases with temperature and decreases with precipitation (Kundzewicz 2007: 173–210). Coping capacity is particularly low in rural populations found in Dundgov, Omnogov, and Dornogov Provinces that are without access to reliable water supply from large reservoirs or deep wells. Even in semi-arid areas where water resources are not overused, increased climate variability may have a strong negative impact. For example, droughts in 1999 to 2002 affected 70 percent of grassland and killed 12 million livestock (Batima and others 2005, Natsagdorj and others 2005: 39–84). Adopting management measures that are flexible may be the best approach to dealing with a largely unpredictable climate (Stakhiv 1998).

Figure E.3. Changes in River Flow Predicted by the Computer Model CCCM



Potential impacts on temperature. The driver of global climate change is rising temperatures. Eleven of the last 12 years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature dating back to 1850 (IPCC 2007). In Mongolia, annual mean temperatures between 1940 and 2003 have risen by 1.8° C. Warming has been most pronounced in winter, with a mean temperature increase of 3.6° C, while spring, autumn, and summer mean temperatures have risen by 1.8° C, 1.3° C, and 0.5° C, respectively (Batima 2008). However, warming temperatures has been lowest in the Gobi desert (Natsagdorj and others 2005: 39–84). The cold wave duration has shortened by 13 days nationwide in the last 60 years, but again, it has not been as pronounced in the Gobi Desert (Batima 2008). Heat wave duration has increased by 8 to 18 days in last 40 years. One direct consequence of the warming is that frequency and aerial extent of the forest and steppe fires in Mongolia has significantly increased (Erdnethuya 2003).

In the future, all models predicted winter warming would be more pronounced than summer warming, especially after 2040 (MNE 2008). The rate of winter warming varies from 0.9° C to 8.7° C, while the summer temperature increase varies from 1.3° C to 8.6° C (Batima 2008). As winter temperatures have increased in the past, the occurrence of abnormal or unseasonable weather phenomenon such as windstorms in winter and rapid warming that causes ice sheets have increased. This trend of increasing dzud and associated domestic animal mortality can be expected to continue if climate scenarios are correct in their predictions (Batima 2008).

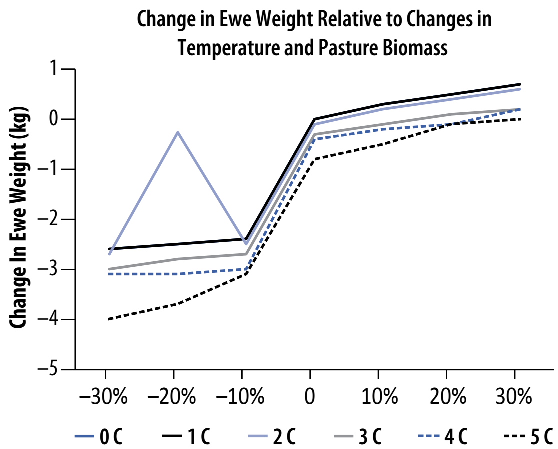
Impact on Livestock

How a changing climate affects the livestock industry in Dundgov, Omnogov, and Dornogov will ultimately be of greatest concern to herders who live in the region. This effect is a culmination of the economic, pasture, water, and temperature effects mentioned previously.

Some research points toward a small weight gain for animals in the Gobi Desert, if pasture biomass and temperature increases as seen in Figure E.4. For example, temperature rise has a dominant role in ewe weight gain (Batima 2008). Ewe weight changed relative to pasture biomass and temperature did not affect this change greatly.

However, there can be adverse affects as well. Indirectly, decreased animal grazing time can be a large factor in decreased weight gain. The threshold temperature above which animals cannot graze has been shown to be 26° C in the Gobi Desert. If animals cannot graze pasture because of excessive heat, their daily intake decreases, weight gain suffers; and it may impact their ability to survive a harsh winter (Batima 2008). However, warmer

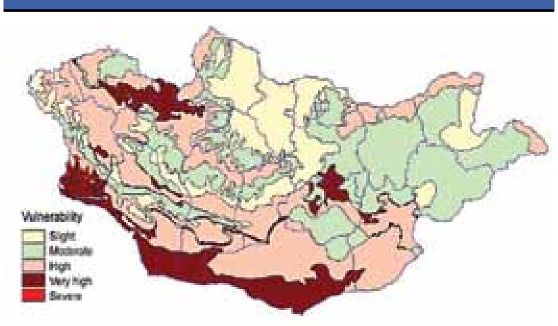
Figure E.4. Change in Ewe Weight Relative to Changes in Temperature and Pasture Biomass



temperature in the winter should provide more opportunity to graze and may more than offset any detriment of summertime heat.

The Mongolia word *dzud* describes weather events such as heavy snowfall, long-lasting or frequent snowfall, extremely low temperatures, or drifting windstorms that reduce grazing time and have caused serious animal mortality in recent years. Dzud also represents a high risk to humans in the affected areas (Batima 2008). As Figure E.5 shows, Omnogov and Dornogov provinces have both experienced extreme dzud events in the past. It is unknown but possible that greater climate variability associated with predicted climate change will increase the frequency or severity of these winter events.

Figure E.5. Map of Dzud Frequency in Mongolia



Annex F. Tavan Tolgoi Mining and Electrical Power Generation Complex Implementation Plan

This annex is an excerpt from the executive summary of the implementation plan to develop the Tavan Tolgoi Mining and Electrical Power Generation Complex in the SGR. It has been included as an annex in this discussion note to illustrate the scale of development that will potentially occur in the immediate future in the South Gobi. The electrical power generation complex development discussion does not include development of the mining operation itself.

Infrastructure

Power supply. The initial power for this project assumed to be supplied by 5 diesel stations of 900 kilowatt (kW) capacities each. Stations will be mounted in steel containers. The same time with project start up, following works should commence: extension of existing 110 kilo volt (kV sub-station at Mandalgobi; construction of 220 kV power transmission line to Tavan Tolgoi and 220 kV sub-station at Tavan Tolgoi. The line will be built as 220 kV line, however it will be in 110 kV operational regimes. This line can transmit about 20–25 megawatt (MW) of power from CES. After commissioning of this line, the diesel station will be reinstalled at major critical points of the Complex as a back-up power sources.

Thermal Power Plant of 2 x 50 MW and Power Plant of 2 x 300 MW capacities will be put into operation at this Complex. These plants assumed to be built and commissioned in 2.5–3 years. Both plants will be equipped with modern and efficient techniques and technology. Double circuit transmission line of 220 kV also will be built with construction of 2 x 300 MW Power Plant. The purpose of this line is power export to southern neighbor.

Another possibility of power supply is electricity import from Inner Mongolia located Bayannuur power system. In this case, 220 km-long double circuit transmission line of 220 kV voltages needs to be built within two years from the mine complex down to Gashuun Sukhait border station. The distance from state border to Khailutu—500 kV sub-station (China) is 150 km long.

Water supply. Water supply will be resolved through digging underground wells near coal mine during construction period. In future, water demand of the Complex will be supplied from reserve proved Balgasin Ulaan Nuur site.

Roads. Own auto road network will be developed at Tavan Tolgoi Complex. This network will consist of the following roads: improved earth road for the mine and concentrator's heavy-duty trucks and machinery; paved road between village and industrial area; paved roads inside of village. In future, paved road between Tavan Tolgoi and Dalanzadgad will be built.

Preliminary activity plan. Construction works will be planned with consideration of issues such as climatic features, frozen ground, ambient temperature of Mongolian climate. Construction works planned to be carried out mostly during warm seasons and procurement, commodity transportation will be done during cold season.

Environmental Assessment

General. The general environmental assessment for the Tavan Tolgoi project has been performed by the Ministry of Environment by the order of the "Energy Resource" LLC in accordance with the "Law of environmental impact assessment". This general environmental assessment concluded that a detailed environmental impact assessment shall be performed in accordance with the "Law of environmental impact assessment". The conclusions of the general assessment were based on the following:

The environmental impact during the Tavan Tolgoi coking coal mining project implementation shall be determined by performing the detailed environment impact assessment which will help to:

- Clarify the basic environmental evaluation of the area;
- Prepare the environmental protection plan and the area monitoring program, and to plan the expenses required for their implementation;
- Determine the soil erosion and fault conditions, to prepare a plan of erosion and damage prevention and reclamation, and to estimate the expenses for their implementation;
- Determine the methods to protect the clean water used for the project, and to safely retreat the polluted water and wastes; and
- Estimate the amount of water required for the project in detail and determine the reliable water supply and the method to keep the water balance.

Detailed environmental impact assessment. The general environmental impact assessment study, done by the Ministry of Environment, determined the directions and schedules for the detailed environmental impact assessment study.

Water:
- Obtain a professional conclusion based on determination of the ground and surface water conditions, and to estimate the required water demand with the available supply;
- Determine amount and content of the water, which will be wasted from production and other usages, and to plan the expenses required for its disposal safe to the environment;
- Estimate the water settling and recirculation tank capacities, the dam design and percolation/evaporation rates, and to construct them with material with least percolation;
- Not discard the technology waste water directly into soil;
- Determine the impact of mining operation to the water regime and to determine the monitoring period and related expenses;
- Determine the monitoring period and related expenses for the technology water reserve and quality, and to include it in the monitoring-analysis program;
- Select an optimal option to reduce water loss and to increase water conservation;
- Take measures for water conservation of the surrounding small rivers, creeks and lakes;
- Plan activities for ecologically safe removal of the soil and mine water and to plan the related expenses;

Soil:
- Determine and document the current soil erosion and damage conditions in mapping and video forms;
- Determine the project area soil structure and vegetation and to plan the reclamation accordingly;
- Determine the negative impact of the mining production to the soil and to plan measures to reduce it;
- Determine the mine internal and external transport routes, the main and auxiliary facility boundaries in order to prevent soil damage;

- Clearly define the waste and ore stockpile location in the reports;
- Use the stripped topsoil for reclamation as soon as possible, or to prevent it from erosion, and to take measures for surface plantation to keep microorganism alive;
- Prepare the reclamation program to store and prevent the stripped topsoil in normal conditions;

Air and climate:

- Determine the area's air pollution situation and to plan the air analysis period and related expenses;
- Determine the project area climate changes and determine the possible production impact on the climate, the measures to reduce the impact and related expenses;
- Take measures to spray water during soil stripping and ore haulage in case of dry and dusty conditions;

Vegetation and wildlife:

- Determine the mining impact on flora and fauna, take measures to reduce the impact, and the related expenses for activities;
- Determine the plant types and distribution at the project area, likely to impact during production, including existence of rare and very rare plants. If such rare plants do exist, to take measures and expenses to prevent them and relocate;
- Determine the project area's animal location, distribution and amount and to determine the possible impact of mining production on them;
- Prepare a environmental protection plan as well as the ecological analysis program;
- Evaluate the natural disaster and mining production related accident possibilities and to determine the prevention and extermination plans;
- Include opinions of the local community and administration into the detailed environmental impact assessment report;
- Organize transportation, storage and usage of the fuel, inflammables and combustibles in safe and environmentally non-hazardous manners.

Reclamation:

- Organize the reclamation of the area which sustained environmental degradation into natural state as much as possible;
- Prepare and implement a specific plan to clean up the environmentally degraded land;
- Implement the annual rehabilitation activities plan approved by the Ministry of Environment;
- Organize the reclamation activities along with mining operations and keep an optimal balance of the annual reclamation work load with the mining productivity;
- Prepare the environmental rehabilitation plan with assistance of a professional organization before any mining activity takes place;
- Recreate a condition for the degraded land to be safe, mechanically stable and for the future wildlife stable growth;
- Select and determine the optimal equipment for technical rehabilitation process;
- Prepare a detailed plan for biological rehabilitation process and plantation activities;
- Prepare the rehabilitation plan on annual basis and implement it as part of the annual mining plan;
- Prepare and implement ecologically safe methods to discard the mining hard wastes;
- Have the detailed environmental impact assessment study approved by the Ministry of Environment.

Environmental Rehabilitation Activities

Reclamation of the mine working shall be done during the mining process, and the mine workings to be used for the next year shall be fenced around and labeled and be agreed with the local officials and environmental inspectors in written form.

Any operator, participating in the Tavan Tolgoi deposit development, shall have extensive knowledge and experience in regards to the coal mining as well as power generation plant operations and shall implement international management standard as well as environmental protection and rehabilitation activities continuously. When the project is implemented, an optimal program for coordination of environmental and social aspects of the local community will be prepared and adopted, creative methods will be implemented to create a green area around the mine site, to develop the local culture and traditions, and to enhance healthy lifestyle and environment for the local community and employees.

The main constructions of the mining project such as the open pit, tailings, production facilities, living settlement, power station and water pool will change the land surface into a new condition even after the rehabilitation. These environmentally altered areas will be reclaimed in such way that will not have negative impacts to the local soil, aquifer, and air conditions.

The environmental rehabilitation process will go on continuously throughout the mining project development. The purpose of the environmental rehabilitation works is to restore the environmentally degraded land into the pre-mining state as much as possible and to keep the regional ecological stability.

Annex G. Monitoring of Mongolian Rangeland

Monitoring of rangeland can employ several different techniques and can be used to collect data at several different scales.

Remotely Sensed Information

Large-scale monitoring. Advanced Very High Resolution Radiometer (AVHRR) information is the commonly used data generated daily by NOAA Satellites. This information has the benefit of being close to "real time" in its collection and processing because it can be received directly from satellites and processed quickly by dedicated computer programs. The Mongolian National Remote Sensing Center analyzes AVHRR data which it receives daily and has the capability to provide the following output to Aimag government offices:

- Normalized Difference Vegetation Index (NDVI);
- Global Vegetation Index;
- Soil Moisture Maps which are produced in the spring and fall;
- Snow Coverage Maps;
- Meteorological Maps (such as cloud coverage)

Although AVHRR data is very useful, it has its limitations because the pixel size is large (1 km). Information derived from AVHRR data should be used at the national scale for rapid assessment of vegetation conditions so that governmental programs can react quickly to changing environmental conditions and inform local government and herders of developing conditions that will increase their exposure to environmental risk.

Intermediate-scale monitoring. Intermediate scale remotely sensed data (ground resolution of 15 to 50 m) is especially useful for rangeland monitoring. It is also very valuable for land and water resource analysis and land use planning. Detection of thermal pollution, degradation of land by moving sand, and geological studies are also common applications of this data. The most conventional data sources at this scale are Landsat MSS and Thematic Map data. The *Systeme probatoire de l'Observation de la Terre* or SPOT program conceived and designed by the French *Centre National d'Etudes Spatiales* (CNES) provides information at a slightly finer scale than Landsat.

Unfortunately, Landsat and SPOT data is expensive which has limited its use in Mongolia. Use in monitoring rangeland requires that the monitoring agency have access to Landsat Thematic Map data. Information at intermediate resolution requires relatively sophisticated hardware since data sets can consume 50 Mbytes or more of hard disk storage. Processor speed is also critical if tasks are to be done in a timely fashion. Equipment usually consists of a workstation with tape backup or tape reading capabilities. Currently, the National Remote Sensing Center is operating a Micro VAX 3400 computer and several Personal Computers (486 PC) are available.

Fine-scale monitoring. Fine-scale monitoring of rangeland is assisted by the availability of low level aerial photography coupled with ground measurements. Plant cover, usually expressed as percent, extent of bare soil, and standing crop estimates are the products of this work. Detailed ground monitoring of the sites at seasonal or yearly intervals is needed to reach the level of accuracy needed. Photographic and ground based inventories can indicate changes in plant species composition and provide explanation for the changes that are occurring. For example, if plants that are known to be preferred by livestock are disappearing from grazed areas and are present in adjacent ungrazed exclosures then grazing is the likely cause of degradation. If on the other hand, plants are disappearing from both areas then drought or climatic change is the probable cause. As only small areas can be sampled using this technique, sites should be established in critical or representative areas in the pasture resource area.

Vegetation dynamics can be ascertained from image data by using time series analysis. Subsequent geo-referenced images can be compared by setting a threshold and differencing or by regressing one image upon the other. In both techniques, points of change between the images are identified. Death of plants, degradation by livestock, livestock trails, vehicular trails and soil erosion can be effectively monitored and quantified using these techniques. Images can be overlain on digital elevation, slope and aspect models, which further enhance their usefulness for monitoring desertification/degradation.

A substantial library of high resolution air photos and COSMOS satellite data exists in the Mongolian Department of Geodesy and Cartography (this Department also has maps of all of Mongolia at 1:100,000 scale and of some regions at finer scale).

Animal population monitoring. Populations of grazing ungulates can also be assessed using air photos if proper preflight planning and statistical procedures are followed. Vertical aerial photography has been very effective for census-taking of populations, provided there is tonal contrast between animals and background. Scales employed are from 1:2,000 for small grazers to 1:8000 for large animals.

Reference data. Reference Data or ground data is extremely important in remote sensing at all scales. Referencing must be done to ensure data quality. Field measurements of plant cover, plant type, land use, soil type, etc. should be collected at established monitoring sites. Historical plant production data exists for 30 sites throughout Mongolia. Most of the sites are associated with Research Centers and *aimags*.

Geographic Information Systems

Information extracted from remote sensing sources is generally mapped and is often combined with ancillary information in order to increase its usefulness. For example, it may be necessary to relate remotely derived vegetational cover with factors such as land slope, aspect and soil type in order to determine erosion potential. Traditionally, the data would have been combined by creating a series of map overlays made on transparent map sheets and identified by visual inspection. The development of high speed computers presents the capability to create a spatially registered database in which a matrix of cells contains information about a specific area on the map.

Systems designed to store, manipulate, and display this information are called Geographic Information Systems (GIS). Numerous GIS software packages exist. The Ministry of Nature and Environment has selected and installed ARCINFO as their GIS package. The Academy of Science, Institute of Informatics employs ERDAS to process images. These systems operate on either workstations or personal computers. The power of a Geographic Information System is derived from its ability to model and manipulate geo-referenced data.

To support various modeling functions, a GIS must be able to handle both locational data and attribute or descriptive data about features. Several types of area, linear and point data can be encoded by digitization so that the full power of remotely sensed data can be realized. When each of these themes or map layers are created based on information obtained from remote sensing and actual site measurements, they can be combined using the GIS in various ways to yield new information about the rangeland use and the effect of this use on pasture sustainability.

Vegetation Growth Models

Mongolia has extremely dynamic and variable vegetation. Because summer rainfall is the result of convective storms, precipitation and its resultant vegetative growth is highly variable across the landscape. As aridity increases in the Gobi, so does climatic and vegetation variability.

Remotely sensed information can be used to help the Government of Mongolia set target numbers for livestock in each sum. Researchers in Mongolia have developed predictive growth equations for herbaceous vegetation which are based on information gathered at 30 research sites throughout the country. Statistical modeling of precipitation, temperature and other climatic variables do not provide accurate estimates of standing phytomass. If, however, AVHRR-derived NDVI were combined with climatic variables a substantially improved estimate was obtained. Data from the various aimag centers are being carefully collected and relayed to the National Remote Sensing Center. This information can be quickly processed and estimates of standing vegetation relayed back to the Regional Centers. This is the first step in balancing plant growth and grazing animal harvest of vegetation. The location of available forage and the comparison of forage patterns between years should facilitate the identification of rangeland being adversely impacted by current levels of livestock utilization.

Pasture Management Decision Support Systems

A rangeland monitoring system without a managerial component will not improve management of rangeland. Remotely sensed/GIS information must be combined with a management structure on Mongolian grazing lands. For this reason, an effective mechanism for balancing livestock numbers with available forage and distributing derived information is critical. This is the objective of rangeland management planning. Resource Based Decision Support Systems can be an effective tool for management planning providing that timely information is passed to herders and herders find the information accurate and reliable.

Extensively managed livestock production in Mongolia is dependent almost entirely on forage produced on 125 million ha of rangeland. Consequently, the livestock production system is regulated by forage supply rather than animal demand in that herders have traditionally tried to adapt livestock production (i.e., environmentally adapted livestock, multiple species grazing, minimal used of supplemental feeds, deferred pastures, using a diversity of pasture types and land forms to assist livestock production, etc.) to the pasture environment rather than adapt pastures to animal needs. The most important constraints affecting livestock production in forage supply systems is the amount and kind of forage produced annually and access of livestock to the forage produced. Both pasture management and livestock management traditions have developed in response to forage supply constraints.

Utilizing pasture areas to avert risk also resulted in de facto pasture management, i.e., the prevalence throughout Mongolia of deferred pasture rotation systems involving separate winter, spring-fall, and summer pasture management units. The traditional custom throughout Mongolia to graze multi-species of livestock together on the same pasture management unit was both pasture management and livestock management. Different kinds of livestock have different preferences for plant species forming the plant composition of different pastures. By grazing animals with different plant preferences on the same pasture types, the majority of plants in different pasture communities are subjected to similar grazing intensity which prevented non-grazed plants from establishing a competitive advantage over grazed plants. Multi-species grazing also benefited the herder by allowing better utilization of plant species forming pasture communities.

During the collective period, indigenous pasture management of this nature was supplanted by more specialized livestock management practices in which the soum-managed herds consisting often of one kind and one age class of livestock. Livestock collectives were directly involved with livestock management and, to a lesser extent, with pasture management. Also, pasture and livestock research institutes, as government supported institutions, were able to be more involved in obtaining and providing information on pasture and livestock production needs to assist collectives and state farms in managing their pasture resources.

The current inclination of herders to increase goat numbers in response to market incentives is not a good practice of pasture or livestock management. This is because the increasing grazing intensity on selected plants may lead to changes in competitive relationships among plant species and reduce both quantity and quality of forage available for livestock production; not because of the myth that goats are inherently destructive of rangeland. It is not good livestock management because the herder is increasing exposure to environmental risk and economic risk while reducing effective livestock utilization of available forage and pasture resources.

Developing Pasture Management Capabilities

Pastures are subject to changes that make them less able to meet nutrient and forage needs of extensively managed livestock. This necessitates the provision of pasture management which usually consists of a set of guidelines and applied practices that are oriented towards ensuring that productivity and other indicators of pasture condition, especially soil and vegetation attributes, are not being stressed beyond recovery by grazing and behavioral activities of animals.

Good livestock management does not directly correlate with good pasture management. Depending on the perception of the pasture user as to what constitutes the primary level of production (i.e., pastures or livestock) the level of applied pasture management can vary from little, if any, to pasture management being the primary focus of the production unit and livestock production being a secondary production focus.

At the present time, there is a need and opportunity to improve the capacity for pasture management among government agencies responsible for Mongolian rangeland. As indicated above, external and internal forces are changing the kind and degree of pasture and livestock management that was traditionally applied at the livestock-pasture interface. These include:

- Responsibility for livestock production and responsibility for pasture resources are vested in the same ministry, instead of two different ministries as formerly occurred.
- The debate between parliament and government over collection of fees for rangeland use and the development of a Pasture Law as a supplement to the Basic Land Law indicates the high level of interest in rangeland, the concern over pasture use, and the importance of rangeland and livestock production to Mongolia as a nation.
- There is a prevailing perception by much of the international community and among some elements of the Mongolian population that pasture degradation is widespread, increasing, results from over-utilization by livestock and, if left unchecked, will in the near future result in extensive desertification of Mongolian rangeland resources.
- By constitutional decree, rangeland will remain under state control, implying that the state through government institutions also has the responsibility to manage rangeland to ensure the availability of rangeland for future generations of Mongolians.
- Livestock numbers are increasing at the same time as the capabilities of indigenous herders and government institutions to effect proper and adequate pasture management are declining.

Concerns of Pasture Management

The three components of applied pasture management in Mongolia are monitoring, planning, and utilization of information. In the context of Mongolian rangeland and extensive livestock production, monitoring means establishing a program employing suitable methodology and the tools necessary to monitor change in pasture condition over time. That means measuring site indicators such as plant species composition and productivity to determine if ecological condition of pasture communities is being maintained or improved in accord with established goals under current levels of use. It also means monitoring to measure and evaluate livestock utilization to determine if adjustments are needed in the planned use of pasture resources.

Planning means to effectively plan the use of local rangeland ensuring impacts are not irreversible within management timeframes. It also means having an awareness of (a) the capacity of pasture to support livestock production activities; (b) the impact of livestock production activities, especially animal grazing impacts on plant species and soils that determine plant communities, livestock behavior and needs; and (c) the capacity of herders to manage livestock in accord with the limitations and advantages of the set of pasture resources accessible to the herder production unit.

Utilization of information derived from monitoring and planning means not only using that information to develop new plans of pasture management or to make adjustments to current plans at local administrative levels, it also means passing the information on in a timely manner to several categories of institutions that are interested in information on pasture and livestock.

Pasture Management Utilizing Decision Support Systems

Although information obtained by monitoring pasture conditions and assessing management is useful at all levels and among all Mongolian institutions involved in pasture management, actual monitoring and planning of rangeland use and development of pasture management plans should occur at the interface between government administration of rangeland (i.e., the soum and bag), the herder production unit, and the actual rangeland utilized for livestock production. A large amount of complex and interrelated information is needed to adequately monitor and manage rangeland at this level.

In the Mongolian traditional livestock production system, and even to some degree in the collective livestock production system, herders intuitively acquired and processed the information needed to make livestock production decisions that enhanced their access to the supply of forage produced on pastures. During the transition period, the influx of herders without the intuitive knowledge base about pasture management and the impact of new incentives originating from the market economy has changed and diminished the capacity to manage pasture. Accordingly, a new form of pasture management is needed to ensure that the capacity of rangeland to produce forage is not diminished by new social and economic considerations affecting livestock production.

A new concept and tool to enhance pasture management is the pasture-based Decision Support Systems (DSS). Pasture DSS allow resource information to be organized in a format that aids managers in selecting pasture management strategies, designing and implementing sustainable livestock production alternatives, and supporting the rehabilitation of degraded pasture. It can be used to assist the selection of alternatives for livestock production and grazing management systems that maintain or enhance use of pasture forage supplies while maintaining or improving the economic viability of the livestock production enterprise.

A DSS should have the capability to inventory and create informational databases about physical and biological resources (land, climate, vegetation, water, etc.); distribution of production resources (livestock, wildlife, and crops); and social, economic and technical coefficients of production (cost, income, markets, and human needs). Constraints or opportunities present in the production environment can be used to build information databases for the system. Management alternatives that minimize the impacts of grazing by livestock can be identified.

A DSS should be used to improve capabilities of the resource manager to develop ecologically based management systems and make appropriate decisions about stocking rate. A DSS technology provides a suitable format for developing resource management plans for ecological management of grazed ecosystems. Using DSS technology allows resource managers to record and analyze information obtained from monitoring in a timely manner to determine the ecological and economic impacts of introducing selected grazing and improvement practices. A DSS is a tool that can be used by rangeland administrative staff at different levels to assist herder groups to plan livestock use of rangeland.

Rangeland Management System

A critical element of rangeland management in Mongolia is determining how resource data will be identified, both in the field and subsequently as databases in the database management system. Unless all potential users agree on the "what, where, and when" of data to be collected; collection methods; and nomenclature used to identify databases constructed from the field information, the database management system will be subject to inter-institutional discord that delays or defeats the intended purpose of the database system (i.e., a tool that allows better management of grazing land resources).

Key elements of the database to be identified are:

- Administrative and resource use unit that collected data will represent (i.e., national, aimag, soum, or bag)
- Ecological unit that collected data will represent (plants, soils, plant communities, vegetation types, eco-regions, etc.)
- Resources for which databases will be constructed (soils, vegetation, livestock, climate, etc.) and,
- Institutions and personnel that will be responsible for constructing, maintaining, and using databases for monitoring, planning and formulating policies.

Administrative units, which are linked to a Resource Management Planning System, are aimag, soum, and bag. User defined units are Pasture Management Units and Pasture Response Units. The number of these units is variable, depending on terrain, topography and associated vegetation and soils interacting with climate. Pasture Management Units, which represent seasonal use areas, and Pasture Response Units, which represent areas of separate pasture communities, influence the kind and amount of use possible by grazing animals. They are the key identifiers for a database management system.

Pasture Resource Areas

The Pasture Resource Area defines the point at which markets, government decision-making staff, livestock production decisions by herder groups, and use of grazing land ecosystems intersect. The Pasture Resource Area is also the basis for relating resource use and livestock management to specific Pasture Management Units and Pasture Response Units. Pasture Response Units are the primary land units for monitoring and evaluating pasture condition.

Pasture Management Units

Pasture Management Units are areas of land with distinct boundaries that are managed separately from other types of Pasture Management Units (i.e., fields, paddocks, pastures, seasonal use areas, etc.). Generally, seasonally used pastures are Pasture Management Units. In the current Mongolian extensive livestock production system, terrain features, elevation along with slope and aspect, vegetation communities, and availability and location of water are among the major factors determining the type and number of Pasture Management Units in a Pasture Resource Area.

Pasture Response Units

Pasture Response Unit is an area of land that can be separated from other areas within the same Pasture Management Unit because of different inherent production potential, current ecological condition, response potential, planned treatment, or limitation to livestock use (i.e., the distribution constraints). The primary distinguishing characteristics of a Pasture Response Unit are the soils and associated plant community. Physical characteristics of the landscape are major long-term influences on soil development and the plant community that occupies a Pasture Response Unit. Because these characteristics are repeatable throughout a Pasture Management Unit, the same Pasture Response Unit may occur at several different times in the same or other Pasture Management Unit and Resource Area.

Rangeland Assessment

Resource Area Assessment

The GIS should be used to determine spatial area of the major plant community types comprising rangeland. Measurement of three categories of spatial area in each soum needs to be defined. The three categories of spatial area are (a) vegetation communities, (b) land form, and (c) land use. Bag and Resource Areas should be spatially defined as sub-units on the soum maps. This information is subsequently digitized into a GIS to determine area measurements of Pasture Response Units, Pasture Management Units, and Pasture Resource Areas.

A preliminary evaluation of Pasture Response Units comprising Pasture Resource Areas and Pasture Management Units should be made. Fixed points are selected to identify Pasture Response Units, evaluate ecological conditions, and measure attributes of Pasture Response Units. The establishment of fixed sites in Pasture Response Units had several purposes: (a) allowing resource response units comprising forage resources of case study areas to be adequately sampled, (b) allowing sites to be relocated and resampled, (c) initiating a pasture monitoring system that can be maintained, and (d) providing the model for establishing pasture databases for monitoring and management of resources.

Each fixed site consists of a randomly located central point fixed by GPS and 3 plots located 20 paces at 0, 120 and 240 degrees from the central point. Information collected at the site should consist of site coordinates, (i.e., latitude and longitude), aspect, slope, slope position, elevation and general appearance of the site relative to plant community and any obvious grazing caused impact on ecological condition. Information collected from each plot, which has an area of 0.5 square-meter on grass steppe sites and 1 square-meter on shrub steppe sites, includes (a) plant species composition in the plot; (b) basal cover (%) of grasses, forbs, and semi-shrubs, and density of shrubs; and (c) yield (kg/ha) of standing crop biomass.

Database parameters collected from Pasture Response Units are used to describe environmental conditions and ecological relationships prevailing in Pasture Management Areas as follows:

- Allows a preliminary identification of plant communities and soils comprising the resource response units of resource areas and resource management units in each of the four case studies;
- Identifies main plant species in the resource management area, plant communities during fall, winter, and early spring and which comprise available standing crop for grazing livestock during winter and early spring;
- Provides information on initiation of plant growth of species comprising vegetation of different Pasture Response Units;
- Allows an estimate of total biomass (kg/ha) available in each plant community at the end of the winter grazing period and prior to initiation of new growth forage during late spring and early summer;
- Allows an estimate to be made of the supply of forage available in the Resource Area during the critical spring season to meet intake and nutrient needs of livestock using the Pasture Management Unit;
- Initiates acquiring the necessary information to construct grazing land management databases.

Spatial Analysis of Resource Areas

Vegetation, land form and land use maps should be digitized and entered into a GIS to enable area measurements and spatial analysis of pasture communities in the study areas. Vegetation, land form, and land use maps are overlaid to define Pasture Management Units and Pasture Response Units in the study areas.

Database Construction

Information collected during field visits is analyzed by the ecological team and entered into spreadsheet databases describing the pasture, livestock, and user attributes of the rangeland Resource Areas. The databases finalized are (a) ecological databases that describe Pasture Response Units by plant species, animal preference for plants species, plant community composition and structure, and yield of forage standing crop; (b) Pasture Management Unit databases comprised of Pasture Response Units in each Resource Area; (c) animal databases that describe livestock using the Pasture Management Unit; and (d) socio-economic factors that affect decision-making by farm/ranch production units relative to livestock use strategies and livestock production. The databases are interactively analyzed to determine proper stocking rate of livestock for each Resource Area.

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