Collection and Evaluation of Forage Germplasm Indigenous to Mongolia

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Abstract—*Mongolian rangelands are biologically diverse and productive, and are ecologically similar to rangelands in the western U.S. Plant communities in Mongolia have evolved and adapted to sustained grazing pressure from wild and domesticated animals. Changing economic and social conditions in Mongolia and overgrazing are threatening plant diversity and range condition. Joint U.S./Mongolia plant collection trips were conducted in Mongolia during 1994, 1996, and 1998 to collect seeds of important forage species. The collecting teams traveled about 20,000 km and made more than 1,300 seed collections of grasses and forbs across the major ecological zones of Mongolia. These collections were equally shared, and the U.S. portion of the seed was incorporated into the U.S. National Plant Germplasm System. Subsequent projects funded through the Food For Progress (PL-480) Program and the U.S. Department of Agriculture's Foreign Agricultural Service allowed evaluations of the seed collections for forage and conservation use at three sites in Mongolia. These evaluations identified the most promising indigenous forage species, which included: Agropyron cristatum, Allium species, Astragalus adsurgens, Bromus inermis, Elymus dahuricus, Elymus gmelini, Elymus sibiricus, Festuca lenensis, Hordeum bogdanii, Medicago falcata, Poa pratensis, Polygonum divaricatum, Psathyrostachys juncea, Puccinellia macranthera, Puccinellia tenuiflora, Stipa capillata, and Stipa krylovii. These species appear to have the greatest potential for use in Mongolia to revegetate abandoned wheat fields, restore deteriorated areas around villages, and rehabilitate areas disturbed by mining. A project through the U.S. Embassy in Mongolia is providing funding to increase seed of the most promising collections and make seed available for use by Mongolian herders and land managers. Besides the direct benefit of providing seeds for restoration and conservation efforts in Mongolia, knowledge gained from this work will be applicable to the possible use of these species for livestock and conservation purposes in the western U.S.*

Keywords: *Mongolia, forage, grazing animals, plant materials, revegetation, restoration, reseeding, conservation*

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Introduction

Because much of the original literature on Mongolia is published in Russian or Mongolian languages, references are almost impossible to obtain, read, and cite for most English speakers. In this publication, background information on Mongolia was obtained from Jigjidsuren and Johnson (2003) who cite the original sources of information.

Mongolia is a country without a seaport in Central Asia that is located between about 42 ° to 52 °N latitude and 88 ° to 120 °E longitude. Mongolia is situated south of Siberia and north of the People's Republic of China, and equal in size to Alaska (>1.56 million ha[2]). Mongolia extends for 2,400 km from the Altai Mountain Range in the west to the Great Khyangan Mountains in the east, and for 1,260 km from the Great Sayan Mountains in the north to Orvog Gashuun Hill in the South Gobi.

Mongolia is a climatic analog of the Intermountain, Northern Rocky Mountain, and Great Plains Regions of the western U.S. January is the coldest month of the year with a mean temperature of –35 °C in the northern parts (with the lowest temperature of –50 °C at the Great Lake Depression and mouth of the Tes River) and –10 °C in the Southern Gobi. Summers are short, and mean July temperatures range from 18 to 26 °C with a maximum of 40 °C. Mean annual precipitation is 200 to 300 mm in north Mongolia, 400 to 500 mm in the high mountains, and less than 100 mm in south Mongolia. Most of the precipitation in Mongolia is received between mid-June and the end of August. Variations in temperature and precipitation in Mongolia create seasonally harsh conditions. Winters are generally long, cold, and dry, whereas the spring season is cold, dry, and windy. Extended drought periods and severe winter snowstorms are common in Mongolia. These dry, temperate climatic conditions have favored the development of extensive grass and shrub steppe grazing lands.

Small and large lakes, streams, and rivers are abundant in northern Mongolia. Major rivers originating from the Altai, Khangai, Khentii, and Khuvsgul Mountains drain into the Pacific Ocean Basin, while small ones flow into small lakes. Of the more than 3,800 streams and rivers in Mongolia, the Selenge River is the largest with a total length of 600 km. The Selenge River is fed by converging tributary rivers such as the Tamir, Khanui, Tuul, Orkhon, Delger, and Egii Rivers with a water collection area of about 400,000 km^2. The Kharaa and Eroo Rivers converge with the Tuul River that originates on the southern slopes of the Khentii Mountains.

The topography of Mongolia is similar to that of the western U.S. Mongolia has deserts, high mountains, saline soils and lakes, fertile valleys, forests, and vast expanses of steppe. These lands have supported grazing animals for thousands of years, cover an area of 1.26 million km^2, and have the capacity to support large numbers of grazing animals. These natural pastures are grazed yearlong by pastoral livestock and wild herbivores. Higher-yielding natural pastures are harvested as hay for winter supplemental feed. Mongolian grasses and legumes evolved under sustained grazing pressure and are well adapted to grazing.

Because of their adaptation to grazing and the climatic and topographic similarities between Mongolia and western North America, many of the grasses and legumes found in Mongolia hold potential for use as forage species in pastures and rangelands of the Intermountain, Northern Rocky Mountain, and Northern Great Plains Regions of the western U.S. Prior to 1994, forage germplasm from northern Mongolia was poorly represented in the collections of the U.S. National Plant Germplasm System. Because of changing economic and social conditions in Mongolia at that time, rangeland areas in Mongolia were being threatened by overgrazing. Large herd size, uncoordinated herding patterns, and the development of mineral resources were beginning to threaten species diversity and were leading to increased soil erosion and weed infestation in Mongolia. Consequently, it was important that Mongolia's unique forage grass and legume germplasm be collected while the natural grazing lands in northern Mongolia remained in relatively high ecological condition. As a result, three joint U.S./Mongolia forage germplasm collection expeditions were conducted during 1994, 1996, and 1998. These collections were subsequently evaluated in trials at three locations in Mongolia.

This paper gives general background information concerning the vegetation zones of Mongolia, summarizes the results of the three U.S./Mongolia forage germplasm collection trips made in Mongolia during 1994 to 1998, highlights the subsequent evaluations of these collections, and describes recently initiated efforts to increase seed of the promising collections.

Major Vegetation Zones of Mongolia

Mongolia has six major vegetation zones, each having different topography, elevation, temperature, rainfall distribution, soils, and vegetation (fig. 1). Mongolia's major vegetation zones and the percentages of land area occupied by each are: alpine tundra (4.5 percent), mountain taiga (3.8 percent), mountain steppe and forest (23.3 percent), grass steppe (25.9 percent), desert steppe (21.5 percent), and desert (15.4 percent). The vegetation zones and the general descriptions of their topography, climate, flora, and fauna are as follows:

Alpine

The alpine zone is located at different elevations depending upon the mountain ranges. The lowest elevation of the alpine zone in the Khuvsgul and Khentii Mountains ranges between 2,000 to 2,200 m above sea level, in the Mongol Altai Mountain Range between 2,300 to 2,400 m, in the Gobi-Altai Mountains between 2,700 to 2,900 m, in the northern Khangai Mountains between 2,300 to 2,500 m, and in the southern Khangai Mountains between 2,700 to 2,800 m. This zone receives an annual precipitation of 400 to 500 mm, and the soils are clumpy tundra soil. Xerophytic and mesophytic cold-tolerant plants are predominant in this zone. The Mongolian alpine vegetation is markedly different from European and Middle Asian alpine vegetation. The Mongolian alpine zone has few herbaceous plants, but is abundant in species from Poaceae, Kobresia, and Cyperaceae, which are suitable for transhumant grazing during the summer.

Taiga

The taiga zone spans across a small territory covered with ashy, meadow, and turf permafrost soil. This zone occupies 3.9 percent of the total land area of Mongolia and is scattered throughout the Khuvsgul, Khentii, and Khangai Mountain Ranges. Mean annual precipitation in the taiga is 300 to 500 mm with a minimum of 250 mm. Taiga is rich in forage plants suitable for reindeer. Steppe vegetation can be found in mountain valleys within the taiga zone.

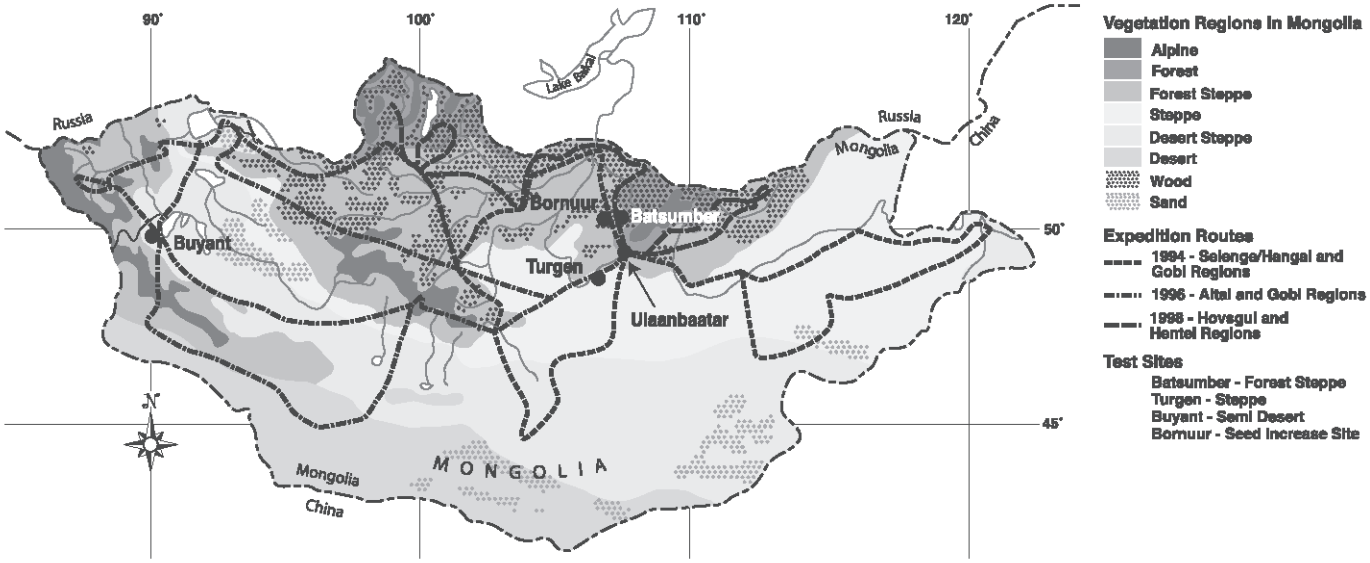

Figure 1—Map of Mongolia showing the major vegetion zones of Mongolia, germplasm collection routes (1994, 1996, and 1998), germplasm evaluation sites (Batsumber, Turgen, and Buyant), and location for the seed increase project (Bornuur).

Forest Steppe

The forest steppe zone stretches from the lower slopes of the Altai, Khuvsgul, Khangai, and Khentii Mountains to the steppe zone. This zone occurs at an elevation of 850 to 1,400 m above sea level in the Khentii Mountains, 1,000 to 12,000 m in the Northern Khangai, 1,400 to 1,500 m in the Eastern Khangai, and 1,800 to 2,000 m in the Mongol Altai. Zonal variations are pronounced especially in the Mongol Altai where the steppe zone spans beyond the forest steppe, and along the southern slopes of the mountain desert-steppe that joins the forest steppe. Average annual precipitation in the forest steppe is 300 to 400 mm. The growing season (frost-free period) lasts from 112 to 125 days, and spring and autumn periods are arid. Carbonated and non-carbonated fine black-brown soil is widespread in this zone. The Altai Mountain Range is covered with carbonated fine brown soil. The forest steppe is dominated by perennial grasses (*Stipa, Cleistogenes,* and *Festuca*), forbs, and shrubs (*Artemisia*). Fertile riparian meadows are located along the rivers. Forest steppe is highly suitable for farming and intensive livestock production.

Steppe

Xerophytic vegetation is a characteristic feature of the steppe zone. The Mongolian steppe stretches from the so-called "pushti" steppe of the Hungarian Danube to the Manchurian steppe of East Asia. The Mongolian steppe is different from other steppe zones in that it is dominated by shrubs and sub-shrubs such as *Caragana* and *Artemisia*. Fertile carbonated and non-carbonated black and sandy soil prevails in this zone. Saline soil is found along depressions and channels as well. Mean annual precipitation in this zone is 125 to 250 mm. The northern portions of the Mongolian steppe and Khalkh River Basin are highly suitable for cultivation.

Desert-Steppe

The desert steppe was formed at the junction of Mongolian steppe and Central Asian desert. Brown soil of steppe-like desert prevails in the desert-steppe zone, and only the northern edges are covered with carbonated fine soil. Salt marshes are common. Mean annual precipitation is 100 to 125 mm. Non-irrigated areas are not suitable for cultivation.

Desert

The northern edge of the Central Asian Desert passes through the territory of Mongolia. Gray desert soil prevails with alabaster covering the southern Gobi-Altai. Sand dunes, drifting sand, and salt marshes are common. Mean annual precipitation is less than 100 mm; however, sometimes there is no precipitation for the entire year. Vegetation is scarce in this zone. Shrubs grow intensively during the rainy seasons. Mongolian deserts can be divided into sandy and stony desert types, and oases occur occasionally in this zone.

Grazing in Mongolia's Vegetation Zones

High mountain grazing land (alpine tundra) has an annual standing crop yield (dry weight) that ranges between 100 to 850 kg/ha. Lichen grazing land at the highest altitude is used for summer grazing of reindeer. Lichen-*Carex* grazing land

is used for summer grazing of yak. *Caligonum* shrub and *Kobresia* meadows are used for summer and autumn grazing of yak and cattle. Alpine shrub and meadow grazing land is used for summer and autumn grazing of yak and cattle; swamp grazing land is used for summer grazing of cattle. *Poa* grazing land is used yearlong by all livestock.

Grazing lands in forest steppe and grass steppe zones predominate in Mongolia and exhibit the highest forage yields. Forest grazing land has annual standing crop yields ranging from 400 to 600 kg/ha. *Betula-Pinus* forest, *Larix* forest, and *Betula-Populus* forest grazing lands are used primarily for summer grazing by horses, cattle, and large wild herbivores. Forest with an extensive shrub understory is grazed during the summer by all livestock except camels. Swamp steppe grazing land is dominated by grasses (*Koeleria, Carex, Poa, Agropyron,* and *Puccinellia*) and *Carex* species in association with forbs, and have annual standing crop yields ranging from 180 to 800 kg/ha. Swamp steppe grazing land is used yearlong and is generally most suited for horses and cattle.

Forest and grass steppe zones have the highest number of livestock and have annual standing crop yields ranging from 250 to 800 kg/ha. These regions are dominated by grasses including *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. Plant morphological characteristics such as awns on *Stipa* species may limit use of some grazing land by livestock to certain seasons. Most forest steppe and grass steppe grazing land is grazed yearlong by all livestock except camels. Red deer is the major wild herbivore grazing in forest steppe areas, while gazelles are the most common wild herbivores in grass steppe areas.

Desert steppe and deserts generally exhibit low standing crop yields, but provide a high diversity of vegetation communities, soils, and land forms. The effect of these specialized communities is to create "patch" grazing for livestock and wild herbivores. Desert steppe is dominated by grasses, herbs, and shrubs with annual standing crop yields ranging from 170 to 400 kg/ha and was the original habitat of the Mongolian wild horse (*Equus ferris*). Annual standing crop yield ranges from 100 to 330 kg/ha. Desert grazing lands are especially suited to grazing by camels, sheep, and goats and provide habitat for a number of wild herbivores.

U.S./Mongolia Forage Germplasm Collections in Mongolia

The overall objective of the three U.S./Mongolia germplasm collection expeditions in 1994, 1996, and 1998 was to collect forage germplasm in Mongolia that was tolerant to grazing, extreme dry and cold conditions, and salinity. There was interest in using these materials in ongoing plant breeding programs in both Mongolia and the U.S. for reclaiming deteriorated rangeland areas and providing improved pastures. The Mongolians hoped to identify promising germplasm for revegetating abandoned croplands and stabilizing sand dune areas.

A wide diversity of grasses, forbs, and shrubs with potential importance and adaptation to North America are present within the Mongolian flora. The main focus of the three germplasm collection trips was to collect grasses in the genera: *Agropyron, Agrostis, Alopecurus, Bromus, Elymus, Elytrigia, Festuca, Helictotrichon, Hordeum, Koeleria, Leymus, Poa, Psathyrostachys, Ptilagrostis, Stipa,* and *Trisetum* (table 1). Although collection of grasses was the primary focus of these collection trips, because of the scarcity of Mongolian collections in the U.S. National Plant Germplasm System, collections of other agriculturally important germplasm were made when opportunities arose. Collections of various leguminous forage species were made from the genera: *Astragalus, Hedysarum, Lathyrus, Medicago, Melilotus, Onobrychis, Trifolium,* and *Vicia* (table 1).

Because of the long distances involved and the generally poor road conditions throughout Mongolia, two teams were organized to make collections each year (fig. 1). The Research Institute of Animal Husbandry in Ulaanbaatar provided a taxonomist, agronomist, interpreter, and driver for each team during the collection period. Local Mongolian officials were contacted throughout the trip and provided specific information concerning preferred collecting areas. Voucher herbarium specimens were collected for taxonomic verification at the Research Institute of Animal Husbandry in Ulaanbaatar. After the field collection phase of the trip was completed, the teams returned to Ulaanbaatar where the collections were taxonomically verified, collections were cataloged, seed was rough cleaned and evenly divided, and export approvals obtained. All necessary procedures and requirements for collection documentation and inspection required by the Mongolian Government were followed.

The U.S. portion of the seed collections were labeled with a quarantine permit prior to returning to the U.S. Seed packages were carried back to the U.S. as luggage and given to USDA-APHIS officials at the U.S. port of entry airport who forwarded the seed to Plant Germplasm Quarantine Center in Beltsville, Maryland. Seed was inspected and fumigated as necessary, and then sent to the USDA-ARS Forage and Range Research Lab at Logan, Utah for final threshing, cleaning, and cataloging. Seed collections and accompanying passport data were sent to the Regional Plant Introduction Station at Pullman, Washington, for entry into the U.S. National Plant Germplasm System. The most promising collections are being evaluated at the USDA-ARS Forage and Range Research Laboratory to determine their adaptation and potential use in germplasm enhancement programs for the western U.S. Triticeae grass collections were examined by USDA-ARS cytogeneticists and taxonomists at Logan, UT to evaluate their genomic and taxonomic relationship to other Triticeae grasses.

Table 1—List of species and number of accessions collected in Mongolia (1994, 1996, 1998).

Achillea alpina
Achnatherum splendens (9)
Aconitum baicalense
Aconitum barbatum (2)
Aconitum septentrionale (2)
Acorus calamus
Adenophora stenanthina (2)
Agrimonia pilosa
Agriophyllum pungens
Agropyron cristatum (57)
Agropyron desertorum
Agropyron geniculatum
Agropyron krylovianum
Agropyron michnoi (5)
Agropyron pectinatum (2)
Agrostis clavata (7)
Agrostis mongolica (9)
Agrostis trinii (9)
Allium altaicum (4)
Allium anisopodium (6)
Allium bidentatum (8)
Allium clathratum
Allium leucocephalum (3)
Allium lineare
Allium maximowiczii
Allium mongolicum (3)
Allium odorum (10)
Allium polyrhizum (10)
Allium schoenoprasum (7)
Allium senescens (21)
Allium splendens (3)
Allium vodopjanovae
Alopecurus alpinus
Alopecurus arundinaceus (5)
Alopecurus brachystachyus (7)
Alopecurus pratensis (3)
Alopecurus ventricosus
Amaranthus retroflexus (2)
Amaranthus spp.
Amblynotus rupestris
Amethystea caerulea
Amygdalus pedunculata (2)
Androsace incana
Androsace septentrionalis
Anemone crinita
Arabis pendula
Arachis hypogaea
Arenaria capillaris (2)
Artemisia anethifolia
Artemisia commutata
Artemisia frigida (10)
Artemisia gmelinii
Artemisia laciniata
Artemisia santolinaefolia
Artemisia scoparia
Artemisia spp.
Asparagus dahuricus
Aster alpinus (2)
Aster tataricus (2)
Astragalus adsurgens (32)
Astragalus austrosibiricus (3)
Astragalus brevifolius (2)
Astragalus dahuricus (6)
Astragalus frigidus (2)
Astragalus inopinatus (3)
Astragalus melilotoides (4)
Astragalus minetus
Astragalus mongholicus (5)
Astragalus oroboides (2)
Astragalus patenti-pilosus (3)
Astragalus propinquus (5)
Astragalus scoberianus
Astragalus spp. (4)
Astragalus tenuis (9)
Astragalus tibetanus (2)
Atragene tangutica
Atriplex fera
Beckmannia syzigachne (7)
Betula fruticosa
Betula fusca (2)
Brassica juncea
Brassica spp.
Bromus inermis (24)
Bromus ircutensis
Bromus japonicus
Bromus pumpellianus (8)
Bromus squarrosus
Bupleurum bicaule (4)
Bupleurum sibiricum
Cacalia hastata
Calamagrostis epigea (4)
Calamagrostis langsdorffi (2)
Calamagrostis macrolepis
Calamagrostis purpurea (4)
Caragana bungei
Caragana jubata
Caragana leucophylla (4)
Caragana microphylla (7)
Caragana spinosa
Caragana stenophylla (3)
Carex duriuscula (3)
Carex enervis
Carex karoi
Carex korshinskii
Carex pediformis (2)
Carex pseudofoetida
Carex spp.
Carex stenocarpa (3)
Carthamnus tinctorius
Carum buriaticum
Carum carvi (4)
Ceratoides papposa (2)
Chamaenerion angustifolium (2)
Chenopodium aristatum
Chloris virgata (3)
Cirsium esculentum
Cleistogenes songorica (7)
Cleistogenes squarrosa (8)
Clematis hexapetala
Convolvulus arvensis
Convolvulus gortschakovii
Corispermum declinatum
Cotoneaster melanocarpa (4)
Dasiphora fruticosa
Delphinium grandiflorum (2)
Deschampsia sukatschewii
Dianthus versicolor (3)
Dontostemon integrifolius
Draba nemorosa
Echinops dahuricus
Elaeagnus moorcroftii
Eleocharis intersita
Elymus angustus (2)
Elymus brachypodioides (3)
Elymus chinensis (12)
Elymus confusus (2)
Elymus dahuricus (27)
Elymus excelsus (4)
Elymus gmelinii (11)
Elymus komarovii
Elymus ovatus (3)
Elymus paboanus (4)
Elymus racemosus (2)
Elymus secalinus (7)
Elymus sibiricus (31)
Elymus spp.
Elymus strigosus
Elymus transbaicalensis
Elytrigia aegilopoides (4)
Elytrigia nevskii (2)
Elytrigia repens (2)
Eragrostis minor (5)
Erigeron acer
Eriogonum mongolicum
Erodium stephanianum
Erysimum flavum
Festuca altaica (4)
Festuca dahurica
Festuca komarovii
Festuca lenensis (15)
Festuca litvinovii
Festuca ovina (6)
Festuca rubra (2)
Festuca sibirica (6)
Festuca venusta (2)
Filifolium sibiricum (2)
Galium vaillantii
Galium verum (2)
Gentiana barbata (2)
Gentiana decumbens (2)
Geranium pseudosibiricum
Geranium vlassovianum
Geum aleppicum
Glycine hispida
Glycyrrhiza uralensis (6)
Goniolimon speciosum
Gypsophyla dahurica
Halenia corniculata
Halerpestes salsuginosa (2)
Halimodendron halodendron
Haloxylon ammodendron
Haplophyllum dauricum (3)
Hedysarum alpinum (11)
Hedysarum collinum
Hedysarum fruticosum (5)
Hedysarum inundatum (2)
Hedysarum sangilense
Helictotrichon mongolicum (4)
Helictotrichon pubescens
Helictotrichon schellianum (11)
Hemerocallis minor (2)
Heracleum dissectum (3)
Heteropappus hispidus (3)
Hierochloe glabra (2)
Hierochloe odorata
Hordeum bogdani (4)
Hordeum brevisubulatum (11)
Iris bungei (3)

Table 1 (Continued)

Iris dichotoma
Iris lactea (4)
Iris ruthenica
Iris tigridia
Isatis costata
Juncus filiformus
Juncus gerardii (2)
Juncus leucochlamus
Juncus salsuginosus (2)
Jungia fleuxosa (2)
Kalidium foliatum
Klion tatarskii
Kobresia bellardii (2)
Kobresia prostrata (6)
Kobresia sibirica
Kochia prostrata (2)
Kochia scoparia
Koeleria alpina
Koeleria altaica (2)
Koeleria cristata (2)
Koeleria glauca (2)
Koeleria gracilis (2)
Koeleria macrantha (12)
Koeleria mukdenensis (3)
Larix sibirica
Lathryus pratensis
Lathyrus quinquenervius
Leibnitzia anandria
Leontopodium leontopodioides (2)
Lepidium apetalum
Lespedeza daurica (10)
Lespedeza hedysaroides (2)
Leymus chinensis (20)
Leymus paboanus
Leymus secalinus
Lilium martagon (3)
Lilium tenuifolium (6)
Linaria buriatica
Linum baicalense (5)
Lotus corniculatus
Malba trionum
Medicago falcata (41)
Medicago lupulina (5)
Medicago platycarpos (6)
Medicago ruthenica (9)
Medicago sativa
Medicago varia (3)
Melandrium brachypetalum (2)
Melica turczaninowiana (2)
Melica virgata (6)
Melilotus alba (1)
Melilotus dentata (18)
Nitraria sibirica (4)
Olgaea lomonossowii
Onobrychis sibirica (7)
Orobanche cumana
Oxytropis ambigua
Oxytropis ampullata
Oxytropis deflexa (2)
Oxytropis eriocarpa
Oxytropis microphylla (4)
Oxytropis nitens
Oxytropis oxyphylla
Oxytropis prostrata
Oxytropis pseudoglandulosa
Oxytropis spp. (2)
Oxytropis strobilacea (2)
Oxytropis tragacanthoides
Papaver nudicaule (4)
Parnassia palustris
Patrinia dahurica
Patrinia rupestris (5)
Pedicularis flava (3)
Pedicularis microphylla
Pedicularis resupinata
Pedicularis uliginosa (2)
Peganum harmala (2)
Peganum nigellastrum
Peucedanum baicalense
Phalaris arundinacea (2)
Phaseolus vulgaris
Phleum phleoides (10)
Phlomis tuberosa (4)
Phragmites communis (3)
Plantago depressa (2)
Plantago major
Plantago salsa
Pleurospermum altaica
Pleurospermum uralense
Poa argunensis (3)
Poa attenuata (4)
Poa botryoides (10)
Poa nemoralis
Poa palustris
Poa pratensis (25)
Poa sibirica
Poa stepposa (4)
Poa subfastigiata (7)
Polygonatum odoratum (2)
Polygonum aviculare
Polygonum divaricatum (5)
Polygonum lapathifolium
Polygonum viviparum (2)
Potentilla fragarioides
Potentilla gelida
Potentilla multifida (2)
Potentilla strigosa
Potentilla tanacetifolia (5)
Potentilla viscosa
Psathyrostachys juncea (7)
Ptilagrostis mongholica (5)
Ptilotrichum canescens
Puccinellia tenuiflora (7)
Pulsatilla bungeana (2)
Pulsatilla dahurica
Reaumuria soongarica (4)
Rhaponticum uniflorum (2)
Rhinanthus songaricus (2)
Rhodiola rosea
Ribes pulchellum (3)
Ricinus spp.
Rosa acicularis (2)
Rosa dahurica (2)
Rosa laxa (2)
Rubia cordifolia (2)
Rumex acetosella (3)
Rumex gmelinii
Rumex thyrsiflorus (4)
Salsola collina (3)
Salsola ruthenica
Sanguisorba officinalis (12)
Saposhnikovia divaricata (2)
Saussurea salicifolia (2)
Scabiosa comosa
Schizonepeta annua (2)
Schizonepeta multifida (3)
Scirpus orientalis (2)
Scorzonera divaricata
Scutellaria baicalensis
Sedum aizoon (3)
Serratula centauroides (3)
Serratula marginata
Setaria viridis (4)
Silene jenisseensis
Silene parviflora
Siliena crissentis
Solanum depilatum
Spaeropyra salsola
Spiraea flexuosa
Spiraea rubescens
Spiraea salicifolia
Stellaria dichotoma
Stipa baicalensis (5)
Stipa capillata (12)
Stipa glareosa (4)
Stipa grandis
Stipa krylovii (3)
Stipa sibirica (17)
Stipa spp.
Suaeda corniculata
Tamarix gracilis
Taraxacum collinum
Taraxacum officinale (2)
Thalictrum minus (2)
Thalictrum petaloideum (2)
Thalictrum simplex (4)
Thermopsis dahurica (4)
Thermopsis lanceolata (2)
Thermopsis schischkinii (4)
Thymus mongolicus
Trifolium lupinaster (15)
Trifolium repens (2)
Triglochin maritima
Triglochin palustris (2)
Tripogon pupurscens
Trisetum sibircum (12)
Trisetum spicatum
Urtica cannabina (2)
Valeriana officinalis
Veronica incana (3)
Veronica longifolia (2)
Vicia amoena (18)
Vicia baicalensis
Vicia costata (3)
Vicia cracca (17)
Vicia multicaulis (2)
Vicia nervata (2)
Vicia unijuga (5)
Vincetoxicum sibiricum (2)
Zea mays
Zygophyllum potanini
Zygophyllum xanthoxylum

Total = 1,373

1994 Germplasm Collection (21 Aug. to 26 Sept. 1994)

Two collection teams were organized with one going east and south to the Eastern Steppe and Gobi Desert Regions of Mongolia, and the other team going to the north and west to the Selenge-Onon and Hungai Regions (fig. 1). The two teams traveled more than 5,500 km (3,300 miles) and made a total of 412 collections, which represented 97 genera and 152 species. Mongolian scientists indicated this was the best year for seed availability in the last 20 years.

Collections were made in the mountain steppe region located in the Hentii Mountains north of Ulaanbaatar, an area of gently rolling hills dominated by grasslands interspersed with patchy woodlands occurring mainly on north-facing slopes. This mountain steppe area is picturesque and is valued for its wildlife habitat and livestock grazing (mainly sheep and horses with a few cattle). The major grass genera included: *Stipa, Poa, Festuca, Koeleria, and Trisetum,* whereas the dominant tree genera included: *Pinus, Larix, Picea, Abies, Betula,* and *Populus*. The lush, productive grasslands had a wide diversity of legumes including *Vicia amoena*, *Thermompsis lanceolata*, *Melilotus dentatus*, and *Medicago falcata*. Some of the broader, flatter areas were being cut for hay for winter feeding of livestock.

Near Bayangol the elevation drops into a broad, flat area along the Haraa River and north of Darhan along the Orhon River, where herders graze their animals in rangeland areas surrounding the grain fields. The Selenge River is one of the largest rivers in Mongolia and carries a large flow of water. The Selenge-Onon Region is a broad, flat basin area draining to the north and is the principal cropping region in Mongolia. Cattle and sheep grazed extensively in the Selenge and Hentei Mountain forest and steppe areas as well as the Onon and Ulz-Tuul steppe and arid-steppe areas. Collections were made along the broad, flat valley bottom of the Selenge River, and in moist meadow and riparian areas located along creek tributaries of the Selenge River. Main genera collected in this area included *Elymus, Leymus, Agropyron, Calamagrostis, Melilotus,* and *Medicago*. As the team proceeded up in elevation from the moist meadow areas in the broad valley along the Selenge River into mountain steppe areas, promising collections were made of *Onobrychis sibirica* and *Medicago falcata*. Large areas of abandoned croplands infested with annual weeds were noted in this area. As is typical near population centers throughout Mongolia, overgrazing became a prominent feature of the landscape near Bulgan.

As the team proceeded up in elevation into the Hangai Mountains, yak and yak-cattle hybrids became the dominant grazing animals. A diversity of important forage grass genera including *Poa, Elymus, Festuca, Bromus, Koeleria,* and *Helictotrichon* were collected in the high alpine areas of the Hangai Mountains. Lower elevation areas in the Hangai Mountains are used for overwintering sheep herds with stone and wood shelters on south-facing slopes used to protect livestock from severe winter weather. Many of the more productive meadow areas were cut for hay and stored in piles on top of the shelters for winter forage. Promising collections of *Astragalus adsurgens* and *Onobrychis sibirica* were made in these lower elevation areas.

The team traveled south of Arvayheer and descended in elevation (with associated declines in precipitation) into the expansive grass steppe area of Mongolia. This flat, treeless area had reduced species diversity (dominants included *Stipa capillata, Cleistogenes songorica, Agropyron cristatum*, and numerous *Allium* species) compared to the mountain steppe region.

As the team proceeded further south, the areas became gradually more arid and eventually graded into the northern reaches of the Gobi Desert. The dominant vegetation in this desert steppe area included low caespitose grasses (*Stipa gobica* and *Cleistogenes songorica*) and shrub species (*Anabasis, Artemisia, Eurotia, Kochia,* and *Salsola). Allium* species were abundant in the desert steppe and provide an abundant, reliable forage for sheep, goats, and camels. From Erdenedalay towards Ulaanbaatar the plant community changed to grass steppe where collections were made of *Medicago ruthenica*, a procumbent perennial legume that is closely related to alfalfa and has potential for a leguminous forage in semiarid areas.

The other team initiated germplasm collections in Hentii Aimag along the Herlen River, which is the major river in eastern Mongolia and the only river in Mongolia that drains into the Pacific Ocean. Collections were made in the typical grass steppe as well as marsh and meadow communities along the main channel of the Herlen River and associated tributaries. Livestock use was most heavily associated with riparian zones along river and stream tributaries and adjacent to villages. From Onderkhan City, germplasm collections followed the general ecological transition from typical grass steppe to desert steppe. Collection sites were located in increasingly drier grass steppe in Hentii Aimag and the northern portion of Dorngov Aimag. Collections were made in the northern portion of Sukhbaatar Aimag and through Dornod Aimag to the Mongolian border with Inner Mongolia in the People's Republic of China. This area is a vast, treeless plain in the grass steppe with generally low human and animal populations, except for areas adjacent to the Herlen River and Khalka River in extreme eastern Mongolia. The typical grass steppe is uniform in its limited plant species diversity. Soils are brown chestnut soils developed under grass steppe conditions and have not been cultivated. Collections were made in a moderate elevation hill range that parallels and is located south of the Herlen River between Choibalson and Onderkhan cities. Both human and livestock populations were high in this area because of summer grazing areas, water, and meadow/marshland associated with the Herlen River. Meadows and marshlands are used extensively as summer grazing land for livestock, whereas the higher elevation hills are used for winter grazing. Collections were made in the area north of the Herlen River between Onderkhan City and the Tariat Research Station, which was in the transition zone between the mountain steppe of the Hentii Mountains and the grass steppe of eastern Mongolia. This higher rainfall area yielded a large diversity of species, and elk and wolves were observed in the area.

1996 Germplasm Collection (13 Aug. to 18 Sept. 1996)

The two collection teams in 1996 (fig. 1) traveled about 10,000 km (6,000 miles) and made a total of 387 collections, which represented 94 genera and 176 species. Collections were made in the Gobi, Altai, and Hangai-Hovsgol Ecological Regions of Mongolia.

The Gobi Region includes the semi-arid, southern portion of Mongolia. In this region, moisture availability and arable soils are the major limiting factors to agricultural production. Except in irrigated oases suitable for the production of vegetables and melons, agriculture is limited primarily to the grazing of sheep, goats, and camels. The Gobi Region is the center of a cashmere goat industry. A major limiting factor to livestock production in the Gobi Region is the need for winter supplemental feed for livestock, which this region has little inherent capability to produce. Aimags forming the Gobi Region include Gobi-Altai, Bayanhongor, Oborhangai, Dundgov, Omnogov, and Dorngov. General climatic and physical factors of the Gobi Region include: elevations ranging from 700 to 1,400 m; mean annual temperatures ranging from 0.0 °C to >2.5 °C with a low temperature of –20 °C in January and a high temperature of 23 °C in July; mean wind velocity of 2 to 8 m/sec; from 90 to >130 frost-free days; and precipitation of about 100 mm. Lack of snow, which is used as a water source by grazing animals, limits livestock production in the Gobi Region.

The Altai Region is the high mountain region in western Mongolia. Agricultural production in the northern and central part of the region is limited to using cattle, sheep, goats and yaks to harvest grazing land forage with pastoral grazing management strategies. In the southern Altai Region irrigated fruits, berries, and melons are produced and limited fodder production is possible. Aimags forming the Altai Region include Ubs, Bayan-Olgii, Hovd, Zavhan, and Gobi-Altai. Climatic and physical factors influencing biological systems in the Altai Region include elevations between 1,500 and 4,000 m; mean annual temperature between –2.5 °C and 5.0 °C with a low temperature of –24 °C in January and a high temperature of 22 °C in July; 60 to 120 frost-free days; between 400 to 500 mm of annual precipitation; snow depths that range between 5 to >15 mm; and an average wind speed of between 2 to 6 m/sec.

The Hangai-Hovsgol Region is located in northwest Mongolia. This mountainous region has a high elevation and deep valleys with some forest and arid steppe, which limits agricultural production to the grazing of animals including yaks, cattle, sheep, and reindeer. Agricultural activities other than pastoral grazing include a limited amount of fodder harvest and grain production in the steppe areas of the region. Aimags in this region include Arhangai, Hovsgol, Bulgan, and Zavhan. Climatic and physical factors influencing biological systems in the Hangai-Hovsgol Region include elevations between 2,000 and 3,000 m; mean annual temperatures between –2.5 °C and 7.5 °C with a low temperature of –24 °C in January and a high temperature of 19 °C in July; from 60 to 100 frost-free days; and an annual precipitation of 200 to >400 mm; wind speed that averages from 2 to 4 m/sec; and snow cover that often exceeds 15 mm in depth.

1998 Germplasm Collection (21 Aug. to 20 Sept. 1998)

The 1998 germplasm collection in Mongolia was centered in north-central Mongolia, primarily in the Hovsgol and Hentii Aimags, with additional collections made in the Selenge and Bulgan Aimags (fig. 1). Specific areas within these regions include the Hovsgul and Mongolian-Daguur forest steppe areas within the Hangai-Hovsgul Region and the Hentei Mountain area within the Selenge-Onon Region. These collection areas are floristically representative of the Inner Baikal Province of Russia. In 1998, the two collection teams traveled about 5,000 km (3,000 miles) and made a total of 574 collections, which represented 132 genera and 253 species.

The Hangai-Hovsgol Region was described in the previous section. The Selenge-Onon Region is located in north-central Mongolia and includes the principle cropping area for Mongolia as well as the extensive Hentii Mountains located in Selenge, Tov, and Hentii Aimags. Although considerable cropping is done in this region, livestock grazing is still the main agricultural activity. Native or hybrid cattle and sheep are the primary grazing animals as well as large wild herbivores such as elk, deer, and moose. The mountain portion of this region is comprised of relatively low mountain ranges with *Larix* forests typically occurring on north slopes. The Onon River Basin, which enters Mongolia from Siberia and loops back to Siberia in the eastern portion of Hentii Aimag, drains the northwestern portion of Hentii Aimag. Although climatic and physical factors limit crop and livestock production, conditions are less severe than those in the Hovsgol-Hangai Ecological Region. Average elevation in this region is between 1,500 and 2,000 m. Mean annual temperature is between 0.0 °C and 2.5 °C with cold temperature in January to –20 °C and warm temperature in July to 19 °C. The region averages between 70 and 120 frost-free days and has annual precipitation between 250 and 400 mm. Snow cover averages between 5 to 10 mm in depth, except in the center of this region, which includes the Hentii Mountains. Average wind speed is between 4 to 6 m/sec.

Both the Hentii Mountains and Hovsgol areas are protected as national parks because of the unique composition of their flora and fauna and their scenic beauty. Both collection areas can be generally categorized as cold temperate. The most common vegetation type encountered during the 1998 collection was forest steppe. Many of the forests had been burned by wildfires during the previous one to three years, creating many early successional communities. High mountain and swamp steppe were encountered in the upper reaches of streams and passes both in the Hovsgol and Hentii Mountain areas. Other communities encountered were birch, river and stream riparian, and pine forest. The steppe vegetation type was also present in these areas as ecotonal communities intergrading with forest steppe vegetation. Overall, human population in both the Hentii

Mountain and Hovsgol collection areas is low. The northern boundary of Hentii Aimag with Siberia, Russia has mainly Buriat Mongols, who are few in number and primarily live in log cabins rather than the Mongolian ger (yurt). Because the human population is low, livestock numbers are also low, creating large areas of almost unused vegetation. Except for areas adjacent to villages and along main roads, most plant communities appear to be in almost pristine ecological condition, except where disturbed by fire or other natural forces.

Hovsgul Lake, which is the main physiognomic feature of the Hovsgul area, is famous as one of the largest, cleanest freshwater sources in the world. The lake is located at an elevation of 1,624 m and is 238 m deep. To the west of Hovsgul Lake is Darkhand in Hotgor Valley, which was originally the old lakebed of a large prehistoric lake. The mountains in this area have permanent snowfields, and there are active glaciers in the area. This unique area represents about 5 percent of the total area of Mongolia. Of the 768 plant species in the flora of this area, 118 are forest species, 205 are stone-rock species, and 242 are cold-resistant plants. This area has 11 endemic plant species including *Equisetum variegatum, Ptilagrostis junatovii, Poa trivialis, Festuca huvsgulica, Festuca komarovii, Elymus excelsus, Elymus kronokensis, Elymus praecaespitosus, Elymus sajanensis, Allium victorialis,* and *Lathyrus gmelinii*.

The Mongolian-Daguur Forest Steppe area represents 6.6 percent of the total area of Mongolia. It has an average elevation of 800 to 1,500 m with a maximum elevation of 1,800 m. This area contains mainly graminaceous species. Endemic plant species in this region include *Stipa pennata, Koeleria glauca, Poa supina, Elytrigia geniculatum, Elymus brachypodiodes, Allium nerinifolium, Allium victorialis, Trigonella canceolata, Melilotus albus, Trifolium pratense, Astragalus chinensis, Astragalus membranaceus, Astragalus uliginosus, Onobrychis arenaria,* and *Vicia trydenii*.

The Hentei Mountain area is the longest province in Mongolia being 250 km long. This region has an average elevation of 1,600 to 2,000 m. The Hentei Mountains are located on the continental divide and represent the main water source for Mongolia and a substantial part of Russia. This area is the headwaters for the Herlen, Onan, and Ulz Rivers (which flow to the Pacific Ocean) and the Tuul Haraa, Eroo and Minj Rivers (which flow to the north). This particular region represents about 3 percent of the total area of Mongolia. There are 844 graminaceous species and 132 forest species in this region. The flora of the region is dominated by the east Siberian flora and has a number of endemic species including *Equisetum sylvaticum, Stipa confusa, Calamagrostis turczaninovii, Poa kenteica, Poa nemoralis, Festuca komarovii, Allium maximowiozii, Thermopsis alpina, Trifloium repens,* and *Pedicularis sceptrum-carolinum.*

Forage Evaluation Trials in Mongolia

A forage germplasm evaluation project was initiated to evaluate the Mongolian seed collections made during 1994, 1996, and 1998. Funding for this effort was provided through the Food For Progress (PL-480) Program and an associated grant from the USDA's Foreign Agricultural Service during 2000-2003. The field evaluations were designed to identify promising forage collections for improving degraded rangelands in Mongolia. Three sites were selected to represent the major vegetation zones of Mongolia (fig. 1). These included: (1) forest steppe zone–located at the experimental plots of the Research Institute of Animal Husbandry in Batsumber Sum, Tuv Aimag, (2) steppe zone–located in the Turgen Gol area, near the city of Ulaanbaatar, and (3) semi-desert zone–located at the experimental plots of the Agricultural Department in Buyant Sum, Khovd Aimag. The general features of the three sites are as follows:

Batsumber Site (Forest Steppe Zone)

This site is located in Batsumber Sum in Tuv Aimag about 80 km from Ulaanbaatar, near the railway station "Mandal." The site is in an open, long valley and has an elevation of 1,100 m above sea level. Soils at the site are dark brown, and the soil texture is light sandy. The A soil horizon ranges from 0 to 40 cm. The B soil horizon ranges from 40 to 80 cm and is light dark brown with a light soil texture with few plant roots. The C soil horizon ranges from 15 to 20 cm, is gray with yellowish color, and is light sandy. The organic matter content of the top soil layer is 1.7 to 3.2 percent. The sum of absorbed alkaline per 100 g of soils is 17 to 25 g-equivalent, and for K is 4 to 9 mg with a pH of 7.1 to 7.5. Salinity increases with soil depth.

The main climatic characteristics of the Batsumber site are presented in table 2. Mean annual air temperature at the site is 1.2 °C with a mean January temperature of –21.8 °C and mean July temperature of 17.0 °C. Daily average temperature reaches 0 °C on about 13 April in the spring and 11 October

Table 2—Long-term climatic data for the Batsumber site.

Climate Variable	Month												Annual Mean
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Air temp, °C	–21.8	–18.2	–9.4	0.6	9.8	14.8	17.0	15.0	8.5	–0.3	–11.4	–19.0	–1.2
Soil temp, °C	–23.7	–18.8	–7.9	5.5	14.7	19.7	21.3	17.9	11	1.0	–12.6	–21.1	0.6
Rainfall, mm	22	1.6	3.8	8.0	14.9	54.8	59.4	80.8	22.3	10.2	3.6	2.7	264.0
Humidity, %	78	75	64	52	48	58	62	64	61	63	72	77	64

in the autumn. There are about 180 days with temperatures above 0 °C. Latest spring frost occurs near 20 June, and the earliest autumn frost occurs near 30 August. There are usually 130 to 140 days above 5 °C and 70 to 80 days with temperatures above 10 °C.

Mean annual precipitation is 264 mm, and 81 to 93 percent of this amount is received during June to October. There are 31 to 48 days of rain and 20 days of snow, and continuous snow cover occurs during 136 to 157 days. The depth of permanent snow cover usually does not exceed 10 cm. Mean maximum wind speed occurs in April and May with a mean of 4.1 to 4.4 m per sec. The driest period of the year occurs during April to May.

Turgen Site (Steppe Zone)

The Turgen site is located in Tuv Aimag near Ulaanbaatar in the Turgen Gol River Basin. The site is a Dauhur Mongolian type of hill and hillock steppe, lying along a widely open hollow with no permanent water flows. The soils in this area have a sandy texture, medium fertility, and light brown soil color. Organic matter content for the 0 to 30 cm depth is 1.07 to 1.36 percent. Content of P in 100 g of soil is 2.9 to 4.2 mg, and K is 2.6 mg. Soil pH is 6.3 to 6.7.

There is no meteorological station at the site, but six months of data are available from a station in Ulziit District, located about 6 km from the site (table 3). Mean annual temperature at this site is –0.9 °C. Mean annual precipitation is 200 to 230 mm, and mean wind speed is 3.5 m per sec with the spring season being the most windy. The active vegetation period is about 110 to 120 days. Mean snow cover of 4 to 9 cm lasts for 120 to 150 days from November to mid-April.

Buyant Site (Semi-desert Ecological Zone)

The Buyant site is located in Buyant Sum in Khovd Aimag in far western Mongolia, and the area is classified as a semi-desert in the Great Lake Depression. The site has light, sandy Gobi brown soils. The depth of the plow layer is 18 to 20 cm, and the soil is poorly textured with an organic matter content of 0.9 percent. The soil at the test site is rich in Ca and poor in P and N. This area is characterized by hot summers, a small amount of snow, and cold winters. Temperature and precipitation characteristics of the Buyant site are presented in table 4. Annual precipitation in this area is 120 to 130 mm with nearly all of the precipitation coming during the summer months (79 percent of total rainfall comes from July to early September).

Results of Field Evaluation Studies

A large number of seed collections of various forage species were planted at the three study sites (table 5). The largest number of collections was evaluated at the Turgen site where experiments were conducted under both rainfed and irrigated conditions with direct seeding as well as transplants started in a greenhouse. Plots were established using randomized complete block designs with three or four replications. Characteristics evaluated included seedling vigor, seedling establishment, biomass production, crude energy, and digestible protein. Based on data collected during three years of study at the three Mongolian study sites, the following species appear to hold the most promise for seed production and subsequent use in reseeding efforts in Mongolia: *Agropyron cristatum,*

Table 3—Long-term meteorological data for Ulziit Station near the Turgen site.

	Month						
Climate Variable	**April**	**May**	**June**	**July**	**August**	**September**	**October**
Air temperature, °C	5.8	12.9	21.6	20.7	17.6	11.7	–2.2
Rainfall, mm	14.0	12.2	14.2	35.3	104.4	3.2	14.5

Table 4—Long-term monthly mean temperature, °C and rainfall, mm for the Buyant site.

	Month											
Climate Variable	**Jan**	**Feb**	**Mar**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Temperature (°C)	–24.5	–20.3	–7.6	3.5	12.0	17.3	18.6	16.9	10.7	1.6	–9.9	–20.1
Rainfall (mm)	1.5	0.9	2.4	6.1	10.0	26.6	38.0	23.1	10.8	4.7	1.8	1.8

Table 5—Number of seed collections tested at each of the evaluation sites.

Study sites	Collections tested
1. Batsumber site (forest steppe)	773
2. Turgen site (steppe)	
Rainfed	742
Irrigated	733
Transplants	758
3. Buyant site (semi-desert)	555
TOTAL	3,561

Allium species, *Astragalus adsurgens*, *Bromus inermis, Elymus dahuricus, Elymus gmelini, Elymus sibiricus, Festuca lenensis, Hordeum bogdanii, Medicago falcata*, *Poa pratensis, Polygonum divaricatum, Psathyrostachys juncea, Puccinellia macranthera, Puccinellia tenuiflora, Stipa capillata,* and *Stipa krylovii*.

Publication of Book "Forage Plants in Mongolia"

Based on results from the forage evaluation project, a 563-page book entitled "Forage Plants in Mongolia" was prepared and published that describes the botanical features of more than 300 forage species from the rich, diverse flora of Mongolia (Jigjidsuren and Johnson 2003). The text of the book is written in both English and Mongolian languages. The book contains plant species names in Latin and Mongolian, local Mongolian names, botanical and vegetation characteristics of each species, area of distribution within Mongolia, palatability and nutritional information, and their economic importance. Color photographs and/or line drawings for most of the forage species are included in the book and make it a resource for identifying Mongolia's main forage species. The inclusion of local Mongolian plant names in the book preserves traditional knowledge of Mongolian plants. This book will benefit a wide range of readers including amateur and professional botanists, scientists, students, tourists, and livestock herders. The book can be purchased by email (extension.publications@usu.edu) or phone (435-797-2251) at a cost of $15 plus shipping.

Project to Increase Seed of Most Promising Forage Species

A proposal for increasing seed of the most promising forage species was selected for funding through the U.S. Embassy in Mongolia. The seed increase project will be conducted at Bornuur Sum in Tuv Aimag, which is located about 110 km north of Ulaanbaatar (fig. 1). Prior to 1990, the area around Bornuur was known for its dairy production. Bornuur is recognized as one of the best areas in Mongolia for growing irrigated vegetables, grain and forage crops, sunflower, oats, and corn. Mongolian State University of Agriculture has an experimental station about 12 km from the center of Bornuur for testing of crop and forage varieties and seed multiplication. The Bornuur Experimental Station is located in the forest zone and has an annual precipitation of 300 to 350 mm. The minimum air temperature in January is –30 °C, maximum air temperature in July is 35°C, and annual mean temperature is about 1.2 °C. Soils at the Station are a sandy loam, and the elevation is about 1,200 m above sea level. The Bornuur Experimental Station has a dormitory for both students and researchers that can accommodate about 100 people. The Station is equipped with permanent electricity and water, and encompasses an area of 178 ha[2]. A series of water reservoirs, canals, pumps, sprinklers, and drip irrigation facilities on about 34 ha will be used to provide supplemental irrigation to maximize seed production of the most promising forage collections.

Summary

Three joint U.S./Mongolia germplasm collection expeditions were conducted in 1994, 1996, and 1998 to collect seed of important forage species in Mongolia. These expeditions resulted in the collection of a wide diversity of forage species from the major vegetation zones of Mongolia. These collections were equally shared between both countries, and the U.S. share of the seed was added to the U.S. National Plant Germplasm System where it is stored for use by scientists around the world. In subsequent years, collections from these expeditions were evaluated at three sites in Mongolia for forage production and conservation uses, and the most promising collections were identified. Results from these evaluation trials were used as a basis to publish a book describing the major forage plants of Mongolia. A project recently funded through the U.S. Embassy in Mongolia will provide funds to increase seed of the most promising forage species for use by herders and land managers in Mongolia.

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