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For more information:

Global Fire Initiative
The Nature Conservancy
Tall Timbers Research Station
13093 Henry Beadel Drive
Tallahassee, FL 32312 USA
850-668-0827
fire@tnc.org

Cover Photo: Bogd khan Uul Strictly Protected Area, Töv province. Photo by Darren Johnson.

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contents

1 introduction

Purpose

The purposes of this assessment were threefold: 1) to gain some preliminary insights into the current status of fire management in the Eastern Steppe of Mongolia; 2) to assess the role of fire in the regeneration and maintenance of the dominant vegetative life forms present in the terrestrial ecosystems found there; and 3) to provide recommendations based on the collected information that will be useful in future conservation and fire management efforts in the Eastern Steppe region. The specific objectives of the assessment were to:

(1)Gather information on fire management needs and issues in the Eastern Steppe of Mongolia that may be important in biodiversity conservation and management in the region.

(2) Assess the extent to which fire plays a role in the regeneration and maintenance of the forest steppe and grassland ecosystems in northeastern Mongolia.

(3) Evaluate fire management planning, training, research and information needs in northeastern Mongolia, and gain some preliminary insights into the status of fire management and fire ecology in Mongolia as a whole.

(4) Provide The Nature Conservancy (TNC) in Mongolia with a conceptual framework for identifying and addressing fire-related threats to biodiversity conservation at their priority conservation areas.

(5) Provide fire managers and conservation management specialists with recommendations of long-term strategies and actions that reduce fire-related threats in the Eastern Steppe.

(6) Introduce ecological concepts related to fire that could be adapted to conservation management strategies in northeastern Mongolia.

Objectives and Focus

In July of 2008 a team of four fire ecologists visited the Eastern Steppe region of Mongolia including the provinces of Töv, Khentii and Dornod. The 12-day assessment took the team from the capital city of Ulaanbaatar east to Jargaltkhaan and then north Bayangol, Batshireet and Binder. From Binder the team continued

Team Members

— **Darren Johnson**, Fire Ecologist, Global Fire Team, The Nature Conservancy, USA

— **Oyunsanaa Byambasuren**, Ph.D. Student, Georg-August-Universitaet, Goettingen, Germany

— **Ronald Myers**, Ph.D. Fire Director, Latin America and the Caribbean, Global Fire Team, The Nature Conservancy, USA

— **Michael Babler**, Fire Manager, Colorado Field Office, The Nature Conservancy, USA west to Dadal and then south to Norovlin. Crossing from Khentii into Dornod province the assessment team first made its way to Bayan-Uul and then traveled south to Tsagaan-Ovoo. Just south of Tsagaan-Ovoo the team visited the Toson Hulstay Nature Reserve and concluded the field portion of the assessment in Choybalsan (Fig. 1). The four-person team, representing the United States, Canada and Mongolia, was assembled by the Conservancy's Global Fire Initiative.

The information in this report is based on observations by, and discussions among, the members of the Assessment Team and their Mongolian hosts during two days of meetings in Ulaanbaatar and nine days in the field in the Eastern Steppe. This assessment builds on and draws information in part from North American vegetation descriptions developed by the Conservancy and its partners in the U.S. LANDFIRE national mapping project (www.landfire.gov). Many of the LANDFIRE vegetation descriptions developed in the United States are analogous to systems that were observed in Mongolia. The northern and central Rocky Mountain region (Idaho, Montana), and the northern part of the Great Basin (Idaho, Wyoming) have a great deal in common with Mongolia (Gray 2006). For example the lodgepole pine (*Pinus contorta*) ecosystems of western Wyoming and Montana, and ponderosa pine (*Pinus ponderosa*) systems of Utah are ecologically similar in terms of vegetation structure and fire regimes to the boreal and sub-boreal coniferous forest ecosystems found in northeastern Mongolia. Similarly, Colorado's Front Range ecosystem bears some distinct similarities to Mongolia's Eastern Steppe grasslands which possess commonalities in both the structure of the landscape geology and plant vegetation. The Mongolian steppe grasslands also have structural and functional similarities with the steppe grasslands of Patagonia in southern Argentina.

Background on Mongolia

Mongolia is located in central Asia, bordered by Russia to the north and by China to the south, east and west. The climate can be categorized by short dry summers and long cold winters, with temperatures ranging from -15° and -30°C (-5° and -22°F) in winter to 10° and 27°C (50° and 80°F) in summer. The country has an area of approximately 1,564,116 km^2 (604,250 square miles) and a population of 2,951,786, of whom 812,000 reside in the capital city Ulaanbaatar. Forests cover 10 percent or about 13 million hectares (ha); grasslands cover about 70–80 percent of all of Mongolia.

The terrain in Mongolia consists primarily of mountains and rolling plateaus. Overall, the land slopes from the high Altai Mountains of the west and the north, to plains and depressions in the east and the south. The highest point (4,374 meters [m]), Khuiten Orgil (Mount Friendship), is located in western Mongolia, where the Mongolian, Russian and Chinese borders meet. The lowest point is 560 meters in the eastern Mongolian plain. The country's average elevation is 1,580 m (Worden and Savada 1989).

Mongolia has three major mountain ranges. The highest is the Altai Mountains, stretching across the western and the southwestern regions of the country. The Khangayn Nuruu range is older and more eroded than the Altai and occupies much of central and north-central Mongolia. The Khentiin Nuruu range, near the Soviet border to the northeast of

Ulaanbaatar, has the lowest elevation of the three ranges. Much of eastern Mongolia is occupied by a plain known as the Mongolian steppe grasslands. The rivers drain in three directions: north to the Arctic Ocean, east to the Pacific and south to the deserts and the depressions of Inner Asia. Rivers are most extensively developed in the north; the country's major river system is the Selenge-Moron, which drains into Lake Baykal. Rivers in northeastern Mongolia drain into the Pacific through the Argun and Amur (Heilong Jiang) rivers, while the few streams of southern and southwestern Mongolia run into salt lakes or deserts (Worden and Savada 1989).

General Ecology of the Eastern Steppe

The Eastern Steppe region of northeastern Mongolia is bordered by Russia to the north and China to the south and east and encompasses the provinces (*aymags*) of Khentii, Dornod and Sukhbaatar (Fig. 1).

The region covers almost 280,000 km² (108,109 square miles) and represents three distinct ecoregions: the Trans-Baikal conifer forest, the Daurian forest steppe and the Mongolian-Manchurian grassland zone. The following ecological system descriptions are based in large part on Ferree's (2008) classification and ecosystem mapping work for northeastern Mongolia.

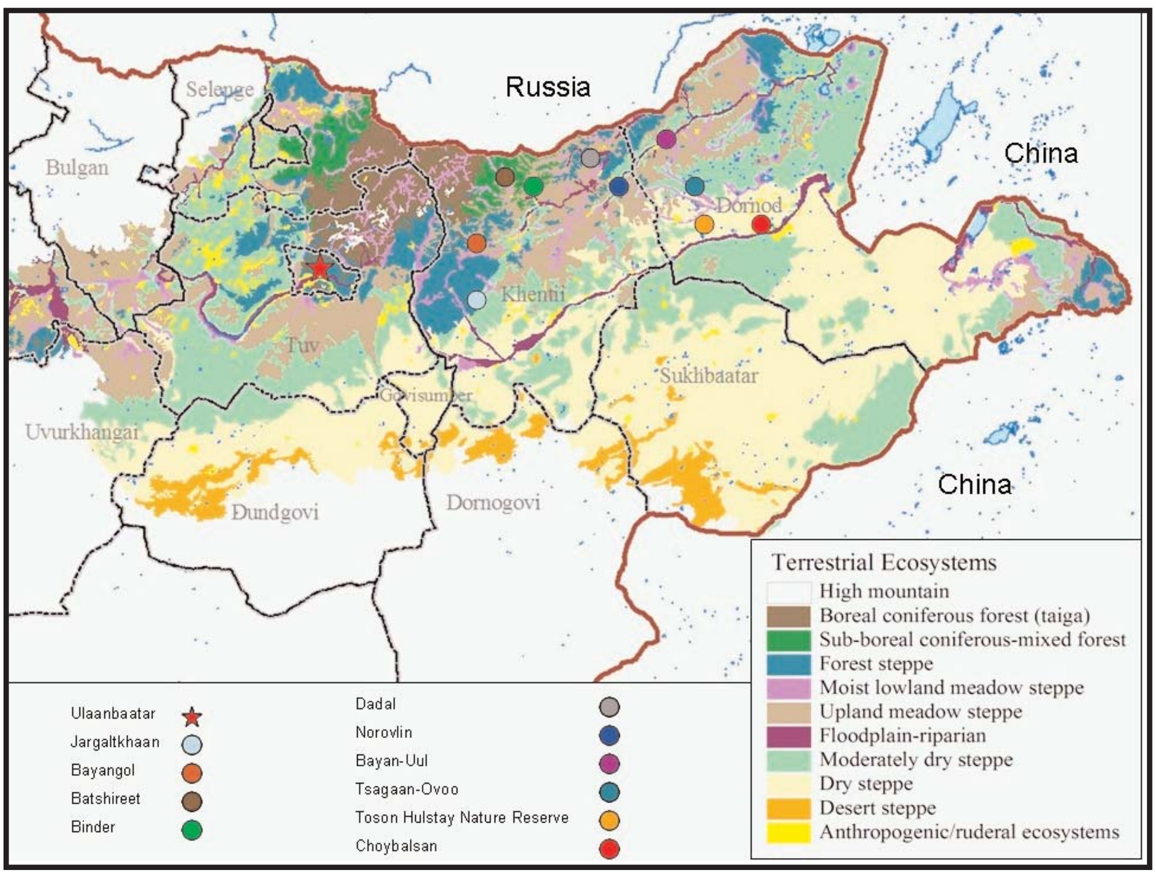

Figure 1. A map of northeastern Mongolia illustrating the locations visited by the assessment team and the terrestrial ecosystems associated with that portion of Mongolia. The Eastern Steppe region of Northeastern Mongolia is bordered by Russia to the north and China to the south and east. The Eastern Steppe includes the provinces of Khentii, Dornod and Sukhbaatar, which collectively cover an area of approximately 286,208 km² (Ferree 2008).

Trans-Baikal Conifer Forest Ecoregion

The Trans-Baikal conifer forest ecoregion occupies a relatively small area of the Eastern Steppe and is composed primarily of three terrestrial ecosystems: boreal coniferous forest (taiga), sub-boreal coniferous forest and moist lowland meadow steppe. The latter is usually found in the bottoms of narrow high-elevation valleys.

The boreal coniferous forest ecosystem is located almost entirely within the Trans-Baikal Conifer Forest Ecoregion where it occurs in the Eastern Steppe. It occurs on summits, upper and lower slopes and in narrow valleys from elevations of 1,300 m to about 2,000 m. The tree layer is either monospecific or a mix of several coniferous species that include Siberian pine (*Pinus sibirica*), Siberian larch (*Larix sibirica*), Siberian spruce (*Picea obovata*) and Siberian fir (*Abies sibirica*) (Fig. 2). The understory is typified by a shrub layer that includes blueberries (*Vaccinium* spp.), round-leaved dwarf birch (*Betula rotundifolia*) and a variety of grasses, perennial forbs and mosses. Fire, insect outbreaks and wind are the primary disturbances in these forests.

The sub-boreal conifer forest or "light taiga" ecosystem consists of pure or mixed stands of Siberian larch (*Larix sibirica*) and/or Scotch pine (*Pinus sylvestris*) in the foothills of Khentii and east Khentii province, at elevations 300 to 400 m lower than the boreal coniferous forest.

Figure 2. Dense, even-aged stand of *Pinus sibirica* on lower slope of Bogd Khan Uul Protected Area south of Ulaanbaatar. Though dominated by *Pinus sibirica*, this forest has scattered stands of *Pinus sylvestris* and a few scattered individuals of *Picea obovata*. Fire scars on the trees are common throughout; recently burned patches of several hectares are scattered throughout. As adult trees the three species seem to be able to tolerate low-intensity surface fires. In more severely burned areas, bark beetle infestations were evident. Photo by Darren Johnson.

They occur on soils with permafrost. The stand density of sub-boreal coniferous forest is more open than boreal forest and it may be more fire-prone due to the abundance of fine fuels in the understory. South of the town of Batshireet in Khentii province the assessment team observed that north- and east-facing slopes are dominated by larch on the flats and lower slopes, mixing with Scotch pine and birch (*Betula platyphylla*) and/or aspen on the mid-slopes. The ground cover under the larches and pines consisted of a wide diversity of grasses and forbs along with scattered shrubs like *Rhododendron* sp. and *Salix* spp. (Fig. 3). These observations were consistent with Ferree's (2008) description of the species composition and structure for sub-boreal coniferous forest ecosystems in northeastern Mongolia.

Moist Lowland Meadow Steppe Ecosystem

The moist lowland meadow steppe ecosystem most often occurs in narrow bands in the bottoms of the narrow high-elevation valleys, in the riparian zones of small streams at lower elevations and in the drier steppe landscapes in areas adjacent to lakes and ponds. Vegetation consists of a variety of graminoids, and forbs (Fig. 4).

Daurian Forest Steppe Ecoregion

The Daurian forest steppe, also known as the mountain forest steppe zone, consists of forest steppe, upland meadow steppe and moist lowland meadow steppe; the latter occurs in the riparian zones of small streams at lower elevations. This ecoregion is dissected by large rivers such as the Onon, which drains east to the Amur River, and the Ulz.

The forest steppe can be typified as a savanna-type system, largely composed of open grasslands and meadows with intermittent patches of forest and woodland. The forest predominates on north- and east-facing slopes; the grassland predominates on south- and west-facing slopes.

Figure 3. Sub-boreal coniferous forest (Scotch pine, larch, birch) southeast of Batshireet, Khentii province. Past fires are evident throughout as fire scars, charred stumps and trunks and fire-killed stands. Photo by Ronald Myers.

The wooded patches and savanna consist primarily of Siberian larch (*Larix sibirica*) and Scotch pine (*Pinus sylvestris*) (Fig. 5). Tree densities vary widely: *Betula* spp. and *Ulmus sibirica* woodlands occur on stonier sites such as rocky outcrops; willow (*Salix* spp.) and aspen (*Populus tremula*) occur along the shores of lakes and rivers. Annual rainfall of about 350 mm provides adequate moisture for a forb-rich herb layer and a well-represented sedge and grass component. The forest steppe has a broad elevation range occurring from about 750 m to 2,000 m. In his description of the northeastern Mongolian forest steppe ecosystem, Ferree (2008) suggests that the woodland patches typical of this type may well be relics of contiguous forest (sub-boreal coniferous) that historically dominated this landscape. He goes on to state that changes in large-scale processes over the last 1,000 years such as fire, drought, grazing and logging may have resulted in a gradual change from dense forest to the forest steppe that now occurs.

Upland meadow steppe, as the name suggests, is found in hilly landscapes at elevations just below the forest steppe. This ecosystem occupies approximately 15 percent of the Eastern Steppe and represents a transition zone between forest and forest steppe to its north and the steppe ecosystems to the south. Annual precipitation amounts of 300 mm are less than in areas dominated by forest steppe. This low rainfall likely accounts for the sporadic occurrence of trees across the system. Like the forest steppe, there is enough moisture to support a variety of forbs, sedges grasses and shrubs (Fig. 6). Many of the forbs and low shrubs that occur in this system, such as *Artemisia*, *Thalictrum*, *Aster*, *Polygonum*, *Potentilla*, *Carex* and *Galium*, are also characteristic of larch-dominated forest ecosystems classified as forest steppe. This species association may be an indication of an ecosystem in flux due to changing disturbance regimes that have included excessive grazing, logging and/or fire over many hundreds of years.

Figure 4. A moist lowland meadow steppe system adjacent to the Onon River in Dornod province. Willow (*Salix* spp.) shrubs are evident closer to the river. Photo by Oyunsanaa Byambasuren.

Figure 5. Mixed pine and larch forest steppe ecosystem west of Dadal, Khentii province. Bark char on trees was pervasive. Lack of regeneration may indicate that seedling establishment is episodic, occurring in occasional fire-free periods. Photo by Ronald Myers.

Figure 6. Upland meadow steppe north of Batshireet, Khentii province. In addition to grasses such as *Festuca lenesis, Festuca sibirica, Poa attenuate* and *Helictotrichon schellianum*, a wide variety of forbs make this a botanically diverse system. Photo by Oyunsanaa Byambasuren.

Figure 7. Moderately dry steppe between Dadal and Norovlin, Khentii province. The gently rolling topography is typical of this ecosystem, which occurs at slightly higher elevations than dominant dry steppe ecosystem. This photo shows the dry steppe vegetation several weeks after rains ended a protracted seasonal drought. Photo by Ronald Myers.

Mongolian-Manchurian Grassland Ecoregion

The third and largest ecoregion of the Eastern Steppe, the Mongolian-Manchurian grassland, is composed of moderately dry steppe, dry steppe and moist lowland meadow steppe. The latter occurs adjacent to ponds and lakes in the drier steppe landscapes. Dry and moderately dry steppe ecosystems make up the majority of the grasslands of the Eastern Steppe of Mongolia, covering nearly 250,000 km^2 (96,525 square miles). These grasslands have been subject to extensive grazing by domesticated livestock for millennia. Over time, disturbances such as fire and drought could result in a significant change in vegetation structure and composition, particularly the relative abundance of grass and forb species.

The moderately dry steppe occupies about 26 percent of the Eastern Steppe, occurring between 550 and 1,600 meters elevation with average 250 mm annual precipitation. This type is characterized by rolling grasslands that occur at lower elevations and receive significantly less moisture than the upland meadow steppe (Fig. 7). Predominant vegetation consists of *Stipa, Festuca, Agropyron, Cleistogenes, Poa, Elymus* and *Koelaria*. Biophysical characteristics, such as soil moisture and topography, combined with grazing and other disturbances, including fire, determine the species composition across this ecosystem type.

Figure 8. Dry steppe located on the northern side of Toson Hulstay National Reserve, Dornod province. The dominant grass, *Stipa krylovii*, is in bloom. Photo by Ronald Myers.

The dry steppe is the most widespread ecosystem in the Eastern Steppe, occupying approximately 33 percent of that area. It occurs at elevations that are slightly lower than the moderately dry steppe. As its name suggests, the dry steppe also receives less annual precipitation than the moderately dry steppe. The average annual rainfall is between 130 and 270 mm. The dominant species in the eastern extent of this ecosystem is *Stipa krylovii*. An increased presence of *Artemisia adamsii, Caragana microphylla, Cleistogenes squarrosa, Artemisia frigida* and *Agropyron cristatum* are often indicators of overgrazing (Fig. 8).

2 fire and fire management in Mongolia

Fire Management History and Structure in Mongolia

There is no information available on fire management and the use of fire in Mongolia prior to Soviet control of the country which began in the early 1920s. Under Soviet domination, the military (Civil Defense Branch) maintained exclusive authority to manage wildfires, coordinate fire training and maintain equipment. Fire suppression and prevention were the rule. We speculate that during this period any fire culture that may have existed was lost. The faltering of the Mongolian Soviet-era regime in the mid 1980s brought a significant decline in resources to support national fire suppression efforts that, among other things, required rural inhabitants to fight fires. Today, most rural inhabitants fight fires only when their property or pastures are directly threatened.

The loss of a centrally controlled fire management apparatus has had a direct effect on the ability of the government to effectively suppress many of the fires. It may also be a factor in an increased number of larger fires being reported, although the recent advent of Moderate Resolution Imaging Spectroradiometer (MODIS) and National Oceanic and Atmospheric Administration (NOAA) satellite imagery may have simply increased the capacity of Mongolian authorities to detect and report fires.

The fire management infrastructure in Mongolia has changed significantly since the Soviet regime began to falter in the early 1980s. Existing government departments have been restructured and new ones created at all levels—national, provincial and district—with responsibility for disaster management, including fire suppression. Resources, in terms of capital, equipment and trained personnel, have diminished, increasing the reliability on affordable technology to detect and monitor fire location and size. Figure 9 illustrates the current Mongolian fire management hierarchy.

National Level

The National Emergency Management Agency (NEMA) is responsible for fire fighting at the national level and was created in 2004. Before 1996 NEMA had a large smokejumper program that was established in 1968 with assistance from the former Soviet Union. The program was officially known as the Mongolian Protection and Aerial Patrol Service. Its primary function was to provide early detection and response to fires. At that time, there were eight aircraft in use and 200 trained smokejumpers located in seven provinces; however, due to the high cost, the program has been reduced to 40 people based in Ulaanbaatar. MODIS satellite imagery, obtained under contract from the Information and Computer Centre, National Remote Sensing Centre, is now used to detect fires.

The MODIS data are received on-line at the central offices in Ulaanbaatar and then distributed to the provinces. The Meteorological Agency also provides precipitation and temperature data used to determine a fire danger rating and then

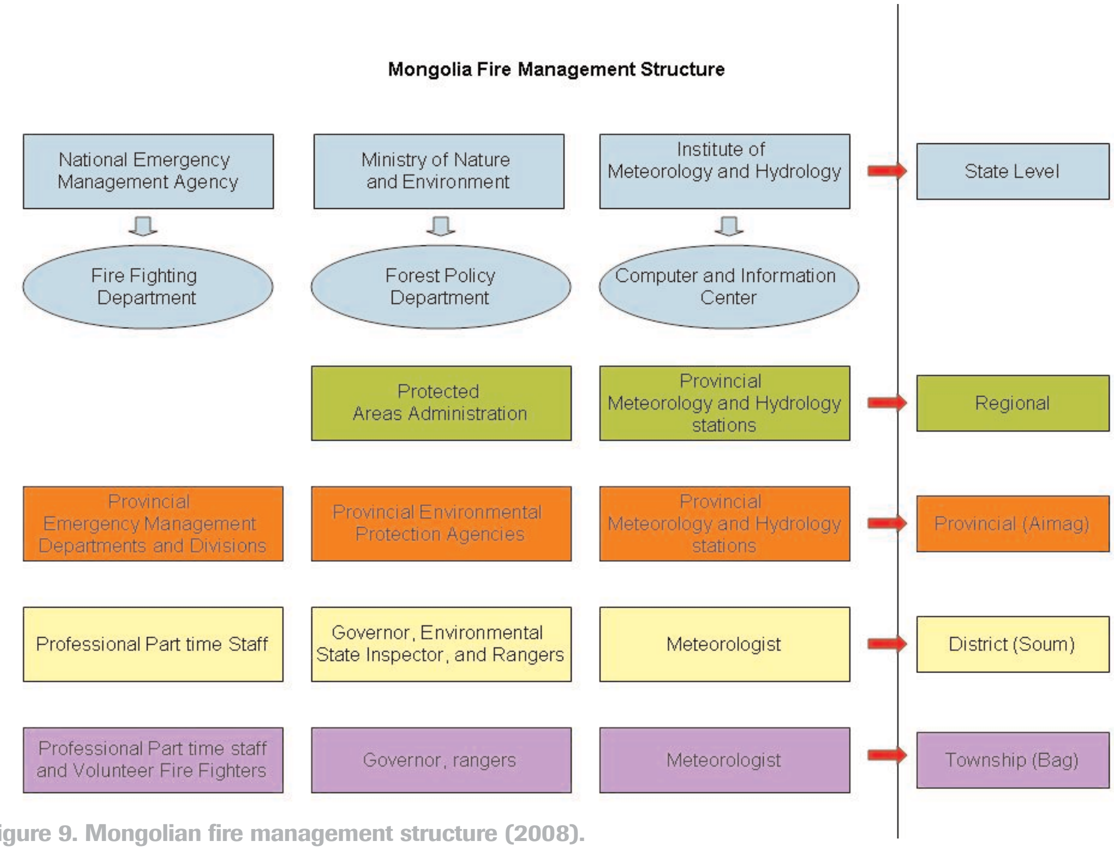

Figure 9. Mongolian fire management structure (2008).

predict red flag days. On average, about 10 lightning fires are reported annually, but recently the number has jumped to 20 per year and the distribution seems to be changing. This is most likely due to improved fire detection techniques such as MODIS that have become available in the last several years. Smokejumpers are dispatched to large fires via a privately contracted helicopter. Smokejumpers also serve as ground crews in fire fighting efforts. There are currently more than 2,000 firefighters, both structural and wildland, in Mongolia.

The Fire Prevention Department exists within NEMA and is primarily responsible for forest and steppe fires. It is headed by a forest fire specialist and a structural fire specialist.

The Ministry of Nature and Environment is responsible for disseminating fire occurrence information, laws/policy and other administrative issues but does not actively participate in suppression-related activities. The Forest Policy Department within this ministry is primarily responsible for forest protection and fire policy, except within protected areas. Another department within the Ministry of Nature and Environment has jurisdiction over protected area policy. During and after fires the Forest Policy Department calculates and produces reports regarding the cost of lost livestock, burnt pasture land and other agricultural losses resulting from fire. The districts, called *soums*, and provinces are responsible for providing the Department with all necessary information for the compilation of these reports.

The Forest Policy Department also issues permission for salvage logging or "cleaning" in burned areas. Two types of permits are available: commercial and fire wood.

The commercial permits cost 1,000 Tugriks/m^3; the fire wood permits cost 700 Tugriks/m^3. The Center for Water and Forestry Inventory monitors salvage logging and forest inventory activities and reports its findings to the Forest Policy Department. The Forest Policy Department is being re-structured; therefore, titles and positions will change in the near future. Currently there is little or no coordination within multi-lateral projects in terms of fire-related policy issues. However, the Forest Policy Department does coordinate with NEMA and the Institute of Botany on fire-related issues.

Regional Level

The Dornod Provincial Environmental Protection Agency lies within the Eastern Mongolia Protected Areas Administration and has jurisdiction over five parks. The agency employs four specialists for 1) conservation, 2) foreign affairs and tourism, 3) research, monitoring and buffer zones and 4) public affairs. Seven rangers are assigned to the five parks. The Administration has been collecting fire information since 1996, using information gathered from reports written by the rangers. The reports contain information such as the location and size of each fire. The assessment team was told that rangers often have difficulty estimating the size of fires; this was apparent when comparing fire size data from ranger reports to NOAA spatial data. The problem is most likely due to the fact that rangers make ocular assessments of fires from horseback. The fires may cover many hundreds and in some cases thousands of hectares in relatively flat terrain. In general terms, the reports provided by the rangers are not accurate, so data are now being compiled from provincial and state emergency agency reports. These agencies have in-house specialists (semi-army level) who create fire reports.

Provincial Level (Aymag)

Each province has a Provincial Emergency Unit that consists of 10-person crews whose members receive formal fire management training when they join a team. Ongoing training occurs in the provinces during the winter months prior to the fire season. The provinces cooperate with each other when fires burn across provincial boundaries by sharing resources, personnel and equipment. In addition to having a specific budget for fire fighting activities, all fire-related costs within the provinces, including at the soum and township (*bag*) level, are dealt with by the Provincial Emergency Units. The Units are responsible for coordinating fire fighting efforts in protected areas where they also have jurisdiction.

District Level (Soum)

Agreements are in place to facilitate and coordinate fire fighting activities between soums. In each soum, the governor, state inspector and chief of police are responsible for coordinating fire fighting efforts and collectively make up what is known as

The Administration has been collecting fire information since 1996, using information gathered from reports written by the rangers.

a soum Commission. One of the tasks of the Commission, which is headed up by the governor, is to ensure that volunteer firefighters from each bag are local and have fire fighting experience. The money to pay for fire fighting expenses, such as food and fuel for volunteers, is allocated by the governor from emergency funds; however, funding is usually insufficient to cover all fire fighting costs. The governor's office submits detailed invoices to the province for reimbursement.

The soums request "expert" fire fighting crews from the province in the event of severe fires. In such instances the province seeks approval for the request from the Fire Prevention Department of NEMA. The budget for disaster management—including fire, flooding and *zud* (a combination of blizzard and bitter cold, preceded by drought)—is obtained from the province and distributed to the soum. Generally, the budget is not sufficient to support all disaster management activities. In terms of fire prevention, official letters indicating how people can prevent fires are sent out to all families in the soum. Upon receipt of the letter, each family is required to sign a document stating that they have read, understood and will comply with the recommendations; the signed letters are kept on file in the governor's office. The result from this approach has been a marked decrease in local accidental fires.

Township Level (Bag)

Each small town (bag) must provide at least 10 people when there is a fire in the soum; however, it is difficult to find them because neither incentive (pay) nor prestige is associated with fire fighting. Firefighters from the bag are usually volunteers who are provided with food and, in most cases, fuel for equipment while fighting the fire. Bayan-Uul was the only exception noted by the assessment team. There the governor pays firefighters 300 Tugriks a day along with food and fuel. In most instances volunteers lack any type of formal training; rather, they draw on their many years of fire fighting experience. Equipment used by volunteer firefighters consists of fire swatters fashioned from old tires and wire, Chinese-made leaf blowers, and water-soaked, felt saddle blankets.

Fire Environment and Fire Effects

Between 1981 and 1999, an average of 160 fires per year were recorded in Mongolia, each burning an average of 2,933,659 ha (7,249,229 acres) (Goldammer 1999). In the eight years between 2000 and 2008, an average of 188 fires per year were recorded in Mongolia, each burning an average of 3,253,000 ha (8,038,338 acres) (NEMA 2008). The increased occurrence of fires in the last decade can be attributed in part to an increase in dependency by local populations on natural resources both for local consumption as well as for sale. Their activities include logging, fuel wood collection, collection of non-timber forest products (NTFPs) and hunting. The cessation of Soviet-era, state-subsidized social services in Mongolia, combined with opening of formerly restricted markets, has made natural resource utilization, including wildlife trade, extremely lucrative (Brunn 1996).

The fire season in Mongolia begins in February and continues through most of June. This is followed by a second, short fire season in September and October. The majority of fires that start during the two fire seasons (spring and fall) are human-caused (Valendik et al. 1998). With the exception of 2002 and 2008, many areas in the Eastern Steppe have experienced drought conditions over the last 10 years, manifested in an average reduction in annual winter and summer precipitation. Fire and drought are strongly and positively correlated over short periods of time; fires generally will not occur in fully hydrated vegetation (Brown et al. 2005). This relationship makes it difficult to separate the independent contributions or effects that both fire and drought have on ecosystems in this region. The assessment team, therefore, did not attempt to draw any conclusions based on annual fire frequency and climactic variations in the Eastern Steppe.

Boreal Coniferous Forest

The mature Siberian pine- (*Pinus siberica*) and Siberian larch- (*Larix sibirica*) dominated stands of the boreal coniferous forest exhibit a closed canopy structure. As a result grass is less abundant in the understory and fires are less frequent than in the less dense stands of the sub-boreal coniferous forest and forest-steppe (Goldammer 2002). Average fire return interval is greater than 100 years and is of mixed severity, with climate playing an important role in dictating the flammability of these systems (Gray 2006).

The Rocky Mountain lodgepole pine forest ecological system of western North America is analogous to the Mongolian boreal coniferous forest ecosystem with respect to its overstory structure, silvicultural traits and relationship with fire. The North American system is typified by an overstory dominated by *Pinus contorta* and a shrub and grass understory (Kramer et al. 2007). This type encompasses mid- and upper-elevations of west-central Wyoming in the western United States. Lodgepole pine is an early successional, shade-intolerant species that typically colonizes areas following large-scale disturbances (Schmidt and Alexander 1985). In this forest type the primary large-scale disturbance is a stand-replacing crown fire with an average fire return interval of 175 years (Heavilin and Powell 2007; Kramer et al. 2007). Both the physiological characteristics and fire regime of this ecosystem are comparable with the Siberian pine-dominated Mongolian boreal coniferous forests. In the Rocky Mountain lodgepole pine forest, stand-replacing fires are the most important in shaping stand structures, with surface fires playing a minimal role. These large, stand replacement fires create a coarse-grained landscape pattern, while mortality from bark beetles creates a finer-grained landscape pattern. Over much of its range, lodgepole pine would be replaced by spruce/fir forests without periodic major disturbance events. Where aspen is present, lodgepole pine mortality from bark beetles favors aspen spread through suckering. Longer periods between fires favor spruce and fir regeneration (Kramer et al. 2007). As with Siberian pine, a proportion of cones produced by lodgepole pine are serotinous and release seeds only in the presence of high heat produced by intense fires. In addition, seed establishment is closely linked to conditions created by stand-replacing fires such as exposed mineral soil (Muir and Loan 1985).

Sub-Boreal Coniferous Forest

The subtaiga ecosystem, characterized by stands of Siberian larch (*Larix sibirica*) and Scotch pine (*Pinus sylvestris*), tends to grow on seasonally freezing soils and is more fire prone than the boreal coniferous forest due to its more open, grassy understory. The fire return interval in this forest type averages once every 30 years on warmer aspects and every 50 years on sites located on cooler aspects (Gray 2006). Fire effects tend to range from mixed-severity to low-severity surface fires, often resulting in patchy ground fires. The overstory is left relatively intact. Fires in this forest type may burn down into the organic litter layer, i.e. duff, and smolder for months. The consumption of the duff by smoldering combustion may promote early post-fire seedling recruitment of sexually reproducing tree species of pine and larch (St. Pierre et al. 1992; Duschesne and Sirois 1995; Charron and Greene 2002). Often the most favorable seedbeds for pine and larch seed germination are thin humus or exposed mineral soil resulting from these smoldering ground fires.

In North America, the northern Rocky Mountain dry-mesic montane mixed conifer forest-ponderosa pine (*Pinus ponderosa*)-Douglas-fir (*Pseudotsuga menziesii*) ecological system (Rust et al. 2005a) is very similar in its overstory structure, life history traits and relationship with fire to the Mongolian sub-boreal coniferous forest type. The ponderosa pine ecosystem is found in the northern Rocky Mountains of western Montana, eastern Washington and northern Idaho at elevations between 760 m (2,500 ft) and 1,200 m (4,000 ft). This system extends south to the Great Basin. Ponderosa pine is generally the dominant species on southerly aspects and drier sites, with Douglas-fir dominating on northerly aspects. Southerly aspects support relatively open stands while northerly aspects support more closed stands. On mesic sites with longer fire return intervals, Douglas-fir often co-dominates the upper canopy layers. The understory can be dominated by shrubs such as *Ceanothus sanguineus*, *Physocarpus malvaceus* and *Spiraea* spp., or open grass dominated by *Carex* spp. and *Calamagrostis rubescens*. However, in the absence of fire, Douglas-fir and grand fir tend to dominate stand understories. Surface- and mixed-severity fires occur at varying intervals ranging from between 35 and 60 years (Brown and Smith 2000; Crane 1986; Bradley et al. 1992a; Bradley et al. 1992b; Barrett 1988; Morgan et al. 1996; Brown et al. 1994). Occasional replacement fires may also occur with a mean return interval of approximately 300 years. Mixed-severity fire increases and surface fires decrease further north and at higher elevations as canopy closure increases and the grassy understory decreases. This is similar to the change in fire regime exhibited as the Mongolian sub-boreal coniferous forest type transitions to boreal coniferous forest. Insects and disease play an important role, especially in the absence of fire. Bark beetles such as mountain pine beetle, western pine beetle and Douglas-fir beetle are active in the mid- and late-structural stages, particularly in closed canopies (Ager et al. 1995).

> … the northern Rocky Mountain… ecological system is very similar… to the Mongolian sub-boreal coniferous forest type.

Forest Steppe

Annually, the grassy understory of the forest steppe and the adjacent steppe grasslands become very flammable at about the same time and historically could have burned with similar frequency

(Goldammer 2002; Schulman 1996). The forest steppe is thought to have exhibited a mixed-severity fire regime, with an average frequency of less than 10 years. However, in the last century, intense grazing, which removes much of the understory fine fuels, combined with fire suppression, may have altered the historical fire regime of this ecosystem (Gray 2006). The results are less frequent low- and mixed-severity fires and more frequent, severe stand-replacing fires. This shift in fire regime severity has significantly altered the vegetation structure and composition.

The Northern Rocky Mountain ponderosa pine (*Pinus ponderosa*) woodland and savanna ecological system (Rust et al. 2005b) is a close analog to the Mongolian forest steppe ecosystem. In particular, the systems share a characteristic grass-dominated understory, low tree density, and open canopy. This ecosystem is located throughout the northern and central Rocky Mountains in Montana, central Idaho and northeastern Washington. In Idaho, the distribution is limited to lower slope positions in the Boise, Payette and Salmon river drainages. In northeastern Washington, it is found on sites with elevations of less than 1,300 m (4,500 ft), particularly along the Columbia and Kettle rivers and in the Okanogan Highlands. A healthy savanna often consists of open and park-like stands dominated by *Pinus ponderosa*. Frequent fires promote a grass-dominated understory with sparse shrubs and a ponderosa pine overstory. Understory vegetation consists predominantly of grasses such as Idaho fescue (*Festuca idahoensis*), rough fescue (*Festuca campestris*), *Carex* spp. and forbs that re-sprout following surface fires (Fischer and Bradley 1987). The *Festuca* and *Carex* representation in the understory is a characteristic that is also shared with this system's Mongolian forest steppe analog. Prior to European settlement, frequent, non-lethal surface fires were the dominant disturbance, occurring every three to 30 years (Arno and Petersen 1983; Arno 1980; Fischer and Bradley 1987). Mean fire return interval for this type ranges from 10 to 15 years, which is roughly equivalent to the historical fire return interval of the Mongolian forest steppe ecosystem. Mixed-severity fire has a mean fire return interval of about every 50 years; stand-replacement fire is rare but will occur where there are closed stands. In those instances the fire return interval is approximately 300 to 700 years. Where stands are open, stand-replacement fires are uncommon.

Steppe Grasslands

The steppe grasslands are considered to be both fire-prone and fire-dependent. Fire-dependent ecosystems are defined as those where fire is essential and the species have evolved adaptations to respond positively to fire and to facilitate fire's spread (Myers 2006). Fire return intervals in this ecosystem type average about 10 years and can be characterized as being low-severity as the majority of the biomass is unaffected by these fires and remains alive below ground. As fire-dependent grasslands, many of the species have developed physiological properties and morphological features to store large amounts of resources in their below-ground structures. This enables them to re-sprout following burning and/or grazing. In addition, because of the short duration of many grassland fires and the fact that much of the available fuel is above ground, temperatures tend to peak rapidly. This means that soil heating into the range where roots and subterranean buds can be damaged (>60°C) is minimal (Zedler 2007).

The western Great Plains shortgrass prairie system (Milchunnas et al. 2007) is similar to the dry and moderately dry steppe grassland systems observed in northeastern Mongolia. Most notable are similarities in fire regimes, species composition and biophysical conditions, i.e. geology, topography and precipitation levels. The North American shortgrass prairie ecosystem occurs in the Great Plains from northeastern Colorado to eastern Wyoming and Montana and into southern Alberta, Canada. It occurs primarily on flat to rolling uplands with loamy soils ranging from sandy to clayey. There are north-south bands of productivity within this shortgrass vegetation type, corresponding to increased precipitation going east due to the rain shadow of the Rocky Mountains. Mean annual precipitation is approximately 300–500 mm, with most precipitation occurring in the summer months (Lauenroth and Milchunas 1991). Historically, vegetation was dominated by short grass, and to a lesser extent midgrasses and shrubs. Dominant species include *Bouteloua gracilis, Pascopyrum smithii, Stipa krylovii*, shrub species such as *Artemisia frigida* and *Gutierrezia sarothrae*, which is cyclical and often abundant following drought or heavy grazing. *Chrysothamnus* spp. may also be present. Large-scale processes such as climate, fire and grazing influence this system. The often dry, semi-arid conditions can decrease the fuel load and thus the relative fire frequency. Historically, however, fires that did occur were often expansive. There is a wide variability of mean fire return interval across this system, based on precipitation and fuel. It is thought that the average fire return interval in shortgrass prairie ranges between five and 20 years. This is dependent on the precipitation gradient east to west within the system. Both lightning-induced fire and spring fires set by Native Americans are recognized as important pre-European components of the fire regime (Williams 2003).

Large-scale processes such as climate, fire and grazing influence this system.

Brown et al. (2005) suggest that protracted drought (lower than average rainfall for several years) in North American steppe grasslands reduces the amount of fine fuel, resulting in fewer and smaller fires. The same scenario seems to take place in the Mongolian steppe. The removal of fine fuels or mulch in grassland ecosystems by periodic fire can be an important influence on ecosystem function. Fires often have the effect of enhancing productivity by minimizing self-shading and opening the habitat for regeneration in many grassland systems (Launchbaugh 1973; Oesterheld et al. 1999; Lunt and Morgan 2002). It might be expected that a lack of fire would result in a grassland community that exhibits reduced biodiversity due to limited opportunities for the establishment of smaller and shorter-lived species. However, large grazing animals such as horses, cows, sheep, camels and, more recently, goats have over several hundred years also played an important role in shaping the grassland ecology of the Eastern Steppe and western United States. The grasses that dominate the western Great Plains shortgrass prairie system are extremely drought- and grazing-tolerant. These species evolved with drought and large herbivores and, because of their stature, are relatively resistant to overgrazing. It is thought that the shortgrass system adapted evolutionarily with heavy grazing and, therefore, represents a highly co-evolved system (Milchunas et al. 1988; McNaughton 1985). The degree to which grasslands and large mammalian grazers form a type of mutual co-evolutionary ecological system is, however, debated as these grasslands are also heavily utilized by small mammals such as the Mongolian marmot (*Marmota sibirica*) or *tarvaga* (Bonham and Lerwick 1976; Stromberg and Griffin 1996). The same is true of the shortgrass prairie systems in the western United States where black-tailed prairie dogs (*Cynomys ludovicianus*) are an ecologically important component of the grazing regime (Gober 2000).

There is no doubt that the impact of heavy grazing in natural grasslands can be significant and that grazing by domesticated animals can alter fire regimes by reducing fuel amounts and fuel bed connectivity (Savage and Swetnam 1990). Heavy grazing of the Mongolian steppe combined with altered fire regimes and drought may over time result in degradation of these grassland systems. A grass-free, shrub-dominated type may result as these two life forms seem to overlap broadly and coexist (Woodward et al. 2004).

3 observations and interpretations

Protected Areas

Protected areas in Mongolia fall into two categories: Strictly Protected Areas (SPAs) and Nature Reserves. These are areas of land dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources. SPAs are generally delineated into three zones: pristine, conservation and limited use.

Pristine zones are areas in which only protection activities are permitted and in which only observation-based research or research activities that do not create disturbance can be done.

Conservation zones have similar restrictions as those associated with pristine zones with the addition of permitting activities that support indigenous plant and animal populations. Disaster prevention activities are also allowable as long as there is minimal environmental impact.

Restrictions that apply to limited use zones are the same as those for pristine and conservation zones, with the following exceptions:

(1) Additional restrictions are in place to improve soil and plant cover condition.

(2) Forest thinning and sanitary logging are permitted activities.

(3) Utilization of natural springs for medical purposes is permitted.

(4) Limited ecotourism via predetermined routes is permitted.

(5) With permission, tourists are allowed to camp.

(6) Photographing and audio or video recording for scientific purposes are permitted.

(7) Traditional ceremonies such as *ovoo* (mountain ceremony) are permitted.

(8) Local people can utilize medicinal plants, traditional food sources and other non-timber products with permission.

The Department of SPA Administration is responsible for implementation of laws and regulations concerning Special Protected Areas. Its functions include coordinating activities related to expansion of the Special Protected Areas network and implementation of associated programs, projects and actions, as well as providing professional and practical assistance to the administrative authorities of SPAs. It focuses on assuring an integration of policies and actions promoting sustainable natural resource use and ecological balance. These responsibilities are carried out by developing partnerships with all organizations engaged in policy implementation, ensuring the effective allocation of resources and organizing and coordinating their activities in line with government policy, programs and plans.

Nature Reserves are protected areas that are considered important for wildlife, flora and fauna or for features of geological or other special interest. These areas are reserved and managed for conservation

Figure 10. A pair of Mongolian gazelle in Toson Hulstay nature reserve, Dornod province. In recent years the steppe grasslands have been under increasing threat from development such as oil and mineral exploration, which would disrupt gazelle migration. Changing land use patterns, including agricultural expansion, fencing of land, overgrazing and altered fire regimes, also affect gazelle habitat in the area. Photo by Ronald Myers.

and to provide special opportunities for scientific study and research.

Eighteen of Mongolia's SPAs are classified as "Nature Reserves"; six more are classified as "Monuments" (natural or mixed natural-cultural heritage sites). Such areas account for only 0.38 percent of SPAs. Based on their respective site conservation objectives, Nature Reserves are divided into four sub-categories: complex, historical artifacts, biological and geological nature reserves. Monuments are divided into two sub-categories: natural and historical-cultural.

Toson Hulstay Nature Reserve

Toson Hulstay Nature Reserve was established in 1998 and covers an area of nearly 470,000 ha (1,161,395 acres) in northeastern Mongolia. Vegetation in the reserve is a dry to moderately dry steppe grassland ecosystem which provides critical habitat for a number of species including the Mongolian gazelle (*Procapra gutturosa*) or *zeer* (Fig. 10). Toson Hulstay is the focus of much of TNC's Mongolia program conservation effort in the Eastern Steppe. The future staffing plan includes up to 10 rangers for the park. According to the chief ranger of the reserve, most fires in the reserve start in the spring after snow melt or in late June prior to the summer rainy season. The ranger suggested the majority are caused by lightning; few are started by people. Of particular concern is the fact that when fires do occur they tend to burn the vast majority of the area within the reserve boundaries. This results in significant short-term loss of habitat for species such as the Mongolian gazelle that inhabit the area. Gazelle will graze burned areas if there is enough rainfall to produce new grass growth; however, if it is dry following a fire they will move to unburned areas to graze. Additionally, fires reduce suitable gazelle breeding areas that have grass that is two years or older, causing the animals to seek habitat outside of the protected area.

The chief ranger stated that late-June fires are not good for the pastures/grasses due to the lack of precipitation. This contradicts comments we received from at least one herder who stated that June fires were better than fall fires because of the rapid green-up with the coming of the rains. Conversely, fires that occur earlier in the year during the wet season have better regrowth of grass due to the availability of moisture. Mid-March is generally the earliest that fires occur as there is still snow cover prior to that.

Toson Hulstay straddles both Dornod and Khentii provinces and contains five soums, each of which is responsible for fighting fires in the area, both inside and outside the park. According to Mr. Amar, this is a source of conflict as the soums feel that the park personnel should be responsible for the fires that occur there, and little to no coordination between the soums exists when it comes to fighting fire in the park.

In 2007 park personnel began to manage buffer zones around the perimeter of the park. Problems exist within the park when the area within the buffer zones becomes over-grazed or burned and herders move livestock into the park to graze. The government has allowed livestock into the park during the winter months; however, many remain year round. Under Mongolian law, people can move freely, even though protected area laws restrict use and movement.

Fire data were obtained from the Eastern Mongolia Protected Area Administration in Choybalsan for the period from 1996 to 2008 for Toson Hulstay Nature Reserve According to the data, over the last 13 years this landscape had an average fire return interval of between four and five years (Table 1). This level of fire frequency is supported by research conducted by Daubenmire (1968) for similar grassland ecosystems in North America which found that about three to five years is required for grassland litter biomass to accumulate to pre-fire levels. However, it is more frequent than the 10-year average fire return interval for similar grassland ecosystems in Mongolia cited by Gray (2006). This discrepancy is most likely due to the relatively short duration (13 years) of fire occurrence record-keeping in the Nature Reserve. Analogous grassland systems in parts of the North America, such as in eastern Colorado, exhibit fire return intervals of between five and 20 years (Milchunnas et al. 2007).

Bogd khan Uul Strictly Protected Area

In 1996, Bogd khan Uul was designated as a UNESCO World Biosphere Reserve in large part due to the fact that in the 12th and 13th centuries the khan of Khereid Aimag banned logging on the mountain and declared it a holy site. Bogd Khan Mountain is classified as a Strictly Protected Area whose boundaries encompass approximately 42,000 ha (103,784 acres), with an additional 26,000 ha (62,247 acres) in buffer and transition zones. The reserve is located in Töv province just a few kilometers south of the Mongolian capital city Ulaanbaatar. The

Table 1. Fire data for Toson Hulstay Nature Reserve (1996–2008). (Source: Eastern Mongolia Protected Area Adminstration)

Total Area (ha)	Year	Area Burned/Year (ha)	Area Burned/Year (%)
462,070	1996	397,381	86
462,070	1997	365,054	79
462,070	1998	0	0
462,070	1999	3,601	1
462,070	2000	130,562	28
462,070	2001	0	0
462,070	2002	0	0
462,070	2003	0	0
462,070	2004	162,800	35
462,070	2005	277,242	60
462,070	2006	0	0
462,070	2007	0	0
462,070	2008	0	0

Figure 11. A stand of Siberian pine on a north-facing slope in Bogd khan Uul Strictly Protected Area that exhibited evidence of beetle infestation and fire damage, including scorched foliage and charred bark. It was not apparent which disturbance event occurred first in this stand—beetle infestation or fire. Photo by Darren Johnson.

highest point on the mountain reserve is the summit of Tsetseegun Uul, at 2,256 meters above sea level. Bogd Khan occupies a transition zone between boreal coniferous forest and forest steppe, and eventually grades into dry steppe grasslands. Much of the mountain is vegetated by dense stands of Siberian pine (*Pinus sibirica*) and Scotch pine and occasional Siberian spruce. Scotch pine tends to be on upper slopes, Siberian pine on lower slopes and the majority of the spruce scattered with the Siberian pine. Trees grow primarily on north-facing slopes; southern slopes are covered in steppe grass and rocky outcrops.

The assessment team observed areas that were burned as recently as two years ago on the north-facing mid-slope and on the ridge tops. There was evidence of bark beetle infestation in a stand of Siberian pine in and around one of the mid-slope burn sites (Fig. 11). Large patches of standing dead trees are visible on the north-facing slope of the reserve from nearby Ulaanbaatar. Based on its observations, the assessment team speculate that mortality is due to a combination of beetle kill and fire. However it is not clear which disturbance event occurred first. A similar mountain pine beetle (*Dendroctonus ponderosae* Hopkins) disturbance occurs in the pine forests of western North America. These beetles are one of a small number of bark beetles that kill their host in order to reproduce. The beetles spend most of their lifecycle feeding on the inner bark or phloem of living trees (Heavilin and Powell 2007). Tree mortality caused by these beetles creates the fuel conditions that predispose a stand to fire (Peterman 1978).

Ignition Sources and Suppression Responses

Lightning was cited as an important source of ignitions. Other commonly cited ignition sources are Russian farmers burning their fields, hunters using tracer bullets and general carelessness with cooking fires. Hunting roe deer for the blood and antler trade has significantly increased over the last decade and is an important source of support for many low income families in the Eastern Steppe forests. Many individuals interviewed during this assessment believe the majority of fires occurring in northeastern Mongolia originate just north of the border in Siberia, usually between March and early June. Locals stated that since the early 1990s, fires started on the Mongolian side of the border have decreased, while fires originating in Russia have been more common. In Tsagaan Ovoo, for example, there were reports of large fires occurring in 1993, 1995, 1998, 2007 and 2008, with all but the 1993 fire originating further north in Siberia. In 2007 a large fire was thought to have originated on the Russian side of the border, 40 km north of Dadal, burned to Dadal and continued 150 km south to Norovlin before being extinguished. Satellite imagery (NOAA) from August 5, 2007 indicates that the fire originated near Mogoyt, Siberia just north of the Mongolian border. The prevailing north/northwest winds in this region may be a factor in pushing most of these fires south from Siberia into Mongolia.

In 2006, in an effort to mitigate the problem of cross-border fires, a blackline was created along a section of the Mongolian Russian border north of Dadal. The blackline was created by 20 fire technicians from the Khentii provincial capital and 30 locals from the Dadal area. This 140-km-long, 10-m-wide blackline significantly reduced the amount of fire coming into Mongolia from Russia. Individuals involved in constructing the blackline were initially paid by the Mongolian government; however, there have not been funds available to maintain this fire break. As a result, the blackline has fallen into disrepair and fire coming from Siberia into Mongolia is again perceived as a problem. The general belief of locals is that the majority of fires start in Siberia. Satellite imagery shows that fires often originate in Mongolia. In 2006, two fires occurred in the forests a few kilometers north of Norovlin. Locals stated that one of them was started by someone smoking and the other from people logging in the forest. Both fires started in the springtime; one of them burned into the peat and re-ignited in the autumn. In 2004, a particularly dry year, there were seven documented fires in the area surrounding Norovlin that were started by lightning in mid-summer.

Each year the Russians and Mongolians hold a regional meeting in order to discuss the number and causes of large fires in the cross-border region and to develop corresponding fire management strategies. One strategy was the development of an agreement between the two countries that allows resources to cross back and forth across the border. The Mongolian border army is responsible for performing many of the fire suppression activities along the Russian border, a task often done in collaboration with the Russian military.

Several herders with pastures located in the upland meadow steppe between Batshireet and Dadal indicated that there had been more rain in 2008 than in the previous eight years. This was evidenced by the abundance of green grass in the area in early July, which in this part of Mongolia is late in the dry season and just prior to the onset of the rainy season. The herders added that the winter of 2007/2008 had very little snow, resulting in a very dry early spring. This initial lack of moisture combined with heavy grazing from livestock resulted in few grassland fires due to the lack of fuel. Fires tended to be restricted to the surrounding forest and forest steppe where grazing pressure was less intense and higher moisture levels maintained higher fine fuel loadings.

Fires in the forest and forest steppe started in early spring and burned until June when rain eventually extinguished them. Some ignited peat or duff and continued to smolder through the summer; a few re-ignited as surface fires in the fall. Fires that occur in forested vegetation are generally left to burn, as they typically prove too difficult to suppress by locals with limited resources.

A list of the primary terrestrial ecosystems found in the Eastern Steppe, fire management needs and issues and a brief description of the fire ecology of the region are summarized in Box 1.

Box 1: Summary

Primary Ecosystems
- Boreal coniferous forest
- Sub-boreal coniferous forest
- Upland meadow steppe
- Moist lowland meadow steppe
- Moderately dry steppe
- Dry steppe

Fire Management Needs
- Formal training in fire suppression techniques that take into consideration minimal resources and technical capability.
- Education and awareness programs that focus on prevention and suppression.
- Increased understanding by locals and conservation managers of the ecological role that fire plays these grassland ecosystems.

Issues
- Cross-border fires between Mongolia and Russia.
- Climate change effects on fire regimes and regional weather trends.
- Increasing land use pressure from increasing rural population, intensive grazing and mining interests.
- Dwindling critical habitat for key species such as the Mongolian gazelle.
- Minimal available resources, including funding, equipment and trained personnel.

Fire Ecology
The majority of the terrestrial ecosystems found in this region can be broadly classified as fire dependent, where fire is essential and species have evolved adaptations both to respond positively to fire and to facilitate its spread (Myers 2006). Fire regimes vary considerably from the forested ecosystems to the grassland steppe systems in this region of Mongolia. Current average fire return intervals range from 10 to 175 years in the forested systems to an average of every 10 years in the grasslands.

4 proposed fire management conceptual framework

Integrated Fire Management

Integrated Fire Management (IFM) is the conceptual framework that the Conservancy proposes to use to identify and address fire-related threats to biodiversity conservation at priority conservation areas. The term refers to various aspects of fire management. TNC's definition includes the combination of science and society with fire management technologies at multiple levels. It implies a comprehensive approach to address fire issues that integrates biological, environmental, cultural, social, economic and political issues. Furthermore, IFM addresses problems and issues posed both by damaging and beneficial fires within the context of the natural environments and socio-economic systems in which they occur (Myers 2006).

IFM helps communities find cost-effective approaches to preventing damaging fires while maintaining ecologically appropriate and socially acceptable fire regimes. When fires do occur, IFM provides a framework to:

(1) evaluate whether the effects will be detrimental, beneficial or benign;

(2) weigh relative benefits and risks; and

(3) respond appropriately and effectively based on stated objectives for the area in question.

IFM takes into account fire ecology, socio-economic issues and fire management technology to generate practical solutions to fire-related threats to biodiversity. This concept can be visualized as a triangle with three sides: 1) fire management, 2) fire sciences, and 3) communities (Fig. 12).

The Conservancy's approach to IFM includes eight fundamental steps that can be adapted and incorporated into conservation management planning efforts in Mongolia. They are designed to develop and implement IFM approaches in ecosystems that are fire-dependent as well as those that are fire-sensitive (defined as ecosystems largely composed of species which have not evolved with fire as a significant recurring process). Species in fire-dependent areas lack adaptations to respond to fire, and mortality can be high even when fire intensity is low. Vegetation structure and composition tend to inhibit ignition and fire spread. Under natural,

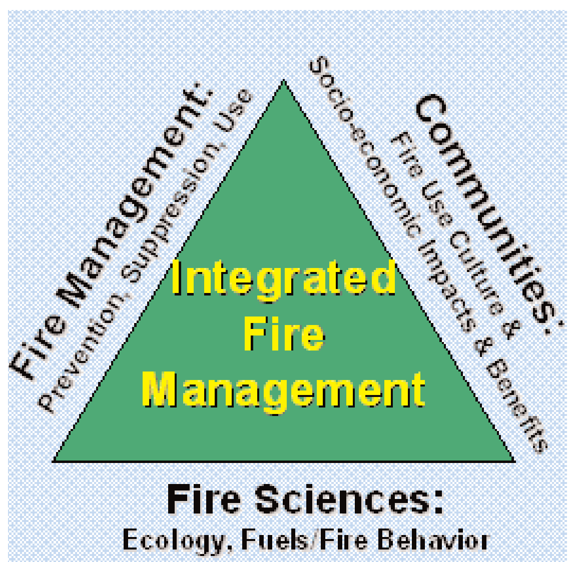

Figure 12. The Integrated Fire Management triangle illustrates a conceptual framework that integrates basic perceptions of fire and the need to use fire by local communities with the beneficial and detrimental role that fire may play in ecosystems, coupled with all the technical aspects of fire management.

undisturbed conditions, fire may be such a rare event that some of these ecosystems could be considered fire-independent.

Step 1: Assessment and Situation Analysis

Effective analysis of a given situation is key to integrating ecology, social issues and appropriate fire management technologies successfully. Identifying the role that fire plays in the cultural, economic and social context of various stakeholders is critical in developing this understanding. Questions that should be asked when conducting such an analysis include:

- What is the ecological role and impact of fire in a given area?
- What is the social, cultural and economic context in which fires are occurring?
- Who is doing the burning and why?
- How are they burning?
- What are the characteristics of the fuels in the area and how does fire behave in them under different burning conditions?
- What other factors or threats are exacerbating the fire problem, such as land tenure issues, illegal logging, invasive species or climate change?

Step 2: Fire Management Goals and Desired Ecosystem Condition

Identify desired future conditions and establish fire management goals that will achieve and maintain those conditions. Key questions are:

- What role should fire be allowed to play in the landscape?
- Are there land uses or other constraints that limit fire from playing an ecologically appropriate role?
- How and where should fires be constrained?
- Should some fires be purposely ignited and who should do that?
- What mix of fire use, prevention and suppression strategies should be utilized?
- How will local communities be involved?

Step 3: Laws, Policy and Institutional Framework

In addition to an institutional framework that embraces the concept of IFM, supportive laws and policies must be in place. To ensure adequate dissemination and implementation, ecological and social information must be incorporated into fire management curricula at universities, technical schools and professional training programs.

Step 4: Prevention and Education

This step aims at gathering and disseminating information so that fire managers and communities can make informed decisions about on-the-ground fire management. It is necessary to understand the ecology of fire in a particular landscape in order to make assessments as to whether people are burning too much, too little or inappropriately to meet both conservation goals and to maintain the ecosystems on which communities depend. The information gained from these assessments can be used in developing appropriate and effective fire prevention programs and educational curricula and supporting materials. Identifying and understanding local needs as well as the ecological constraints of an area will lead to the design and application of more effective fire management and outreach programs.

Step 5: Fire Use

Fires can be both beneficial and/or detrimental depending on how, where, when and why they are burning. In order to make decisions that maximize potential benefits and minimize damages, a good understanding of local ecology, fire behavior and the variables that determine that behavior is essential. When fire is determined to be beneficial, either as a tool to combat detrimental fire or to maintain the natural role of fire in a particular ecosystem, it can then be applied judiciously with minimal risk.

Step 6: Preparedness and Response
Effective fire management invariably involves preparedness and response capability to deal with emergency situations. Fire events can be better anticipated, and better decisions made when fires do occur, if managers know about past fires, ignition sources and the need and propensity of certain vegetation types to burn.

Step 7: Restoration, Recovery, and Maintenance
The objective of this step is to gather information needed to deal with a post-fire environment. Post-fire recovery and restoration efforts are frequently poorly designed, ineffective and costly. They can be better designed by incorporating ecological knowledge of the burned vegetation and its recovery potential.

Step 8: Adaptive Management, Research and Information Transfer
This final step ensures that active learning will constantly occur and will refine the management of fire. This is extremely important because many IFM decisions will be made with incomplete knowledge and limited experience. It is important that an adaptive management framework exists, through which continual improvement and adjustments can be made. Current plans and actions should be based on existing knowledge and inferences derived from the initial situation analysis (Step 1). The effects of those decisions must be monitored, and it is those monitored trends along with the incorporation of new knowledge that will inform future management actions. Effective mechanisms need to be in place that will facilitate review of implementation strategies, and translation and dissemination of technology, information and new knowledge.

5 conclusions and recommendations

Socio-Economic Necessities and Perceptions Related to Fire

The Mongolian Eastern Steppe region exhibits a culture that does not use fire and in which fire is considered negatively. This seems at odds with the flammability of the vegetation and fire use in similar steppe environments elsewhere in the world. During informal interviews many of the pastoralists who reside in the Eastern Steppe indicated that they were unaware of any benefits resulting from either wild or controlled fire. For example, locals seemed to make no clear linkage between the use of fire and the stimulation of berries for food, or of fire and the improvement of pasture quality for livestock grazing. Fire, when it does occur in the Eastern Steppe, is fought quickly and aggressively, particularly when it threatens property and pastures. Due to the economic importance of steppe grasslands for livestock grazing, and the fact that much of this grazing is done at the subsistence level, the current focus on fire prevention and suppression as the sole fire management approach is understandable. However, recent conservation efforts in fire-dependent steppe ecosystems such as Toson Hulstay Nature Reserve may necessitate a shift in this suppression/prevention approach to fire management in areas of the Eastern Steppe. Coupled with an increasing pressure on regional land use by mining interests, an increasing rural population and more intensive grazing practices, effective conservation in the Eastern Steppe may well require a paradigm shift in the way fire is perceived and managed.

Fire Management Options and Strategies

Fire Management Options

Fire management encompasses all technical strategies, actions and decisions involving fire prevention, suppression and use.

Prevention

The prevention of unwanted or undesirable fires is the hallmark of fire management in both fire-dependent and fire-sensitive ecosystems, as it is considerably cheaper and more effective to prevent unwanted fires than to try to put them out after they are ignited. Prevention is an essential component of all fire management programs because of the risk of fires that threaten health, life and property, or which are ecologically and economically damaging. In many places, prevention campaigns and programs have been so successful that undesirable environmental changes result.

Existing fire prevention campaigns in Mongolia focus exclusively on the negative aspects of fire, e.g., it is assumed that all fires are bad and must be prevented. The campaigns ignore the ecological necessity of fire to maintain the health of conifer-dominated forest ecosystems and steppe grasslands. The assessment team recommends a more balanced approach that recognizes fire as an essential element of the environment.

Suppression

Control of unwanted fires is an expensive and logistically difficult part of the fire management equation. Suppression is particularly important when fires threaten life and property or could be ecologically damaging. Except for the limited suppression activities of the National Emergency Management Agency and the Provincial Emergency Management Departments and Divisions, suppression capacity in the Eastern Steppe is very limited. Suppression should be community-based with greater emphasis being placed on the training and coordination of organized local volunteer firefighters.

The assessment team noticed that equipment such as hand tools and tractors is scarce in many towns. A strategy to remedy this is needed.

The development of comprehensive community fire management plans supports effective decision-making regarding areas: 1) that need to be protected from fire for specific intervals, 2) that can be allowed to burn, 3) that need to burn either to stimulate regeneration or to protect them from intense wildfires and 4) where firebreaks, particularly blacklines would be effective. Such plans would likely improve the effectiveness of the limited fire suppression resources.

Fire Use

Fire use is the purposeful application of fire to meet specific economic or ecological objectives. Fires may be controlled or uncontrolled, and planned or unplanned. Prescribed burning is the controlled use of fire using a written plan designed to meet specific objectives. Controlled burning is essentially the same thing but without a written plan. Unplanned, uncontrolled fires also can be used or managed to meet specific objectives and resource management goals. Decisions are made regarding appropriate courses of action regarding fires that occur or which may occur in a given area. Decisions may involve aggressive suppression, monitoring or indirect management regarding locations where fire could be allowed to burn based on fuels, natural fire breaks, weather patterns and other factors.

Fire Management Strategies

In most instances, the prevailing attitude in the Eastern Steppe is that fire is a negative event. Therefore, a management strategy is needed that focuses on an integrated approach to fire prevention that includes suppression, training, education and outreach. For example, the use of fire breaks or blacklines, though currently practiced, could be expanded and more strategically utilized, particularly in protected natural areas. The Eastern Steppe is crisscrossed with two-track roads and trails whose width could be expanded using fire that is ignited off the existing tracks and ruts. Resulting blacklines could halt the spread of unwanted fires, assist in fire suppression efforts and facilitate controlled burning in protected areas where fire may be beneficial. Most burning could be done using existing knowledge of fuels, weather, topography and fire effects and by using locally available resources. Most burns need not be highly technical prescribed burns, though providing basic prescribed fire training to individuals responsible for the programs would be helpful.

The latter would be an appropriate strategy in Toson Hulstay Nature Preserve. A potential fire management approach in the park might be the use of extensive blacklines that are constructed along and use the existing two-track roads. These dirt roads tend to have multiple ruts that could serve as initial fire breaks or baselines for the blackline. The park, and perhaps some of the surrounding buffer grasslands, could be divided into a relatively small number of compartments that would be surrounded by blacklines, and thus potentially reduce the spread of fires that occur in and around the park. They would also prevent the entire protected area from burning in a single fire event. This strategy has been applied in Emas National Park, an extensive savanna in Brazil (Fig. 13). The theory behind using blacklines is that fires operate at a significantly larger scale than the park itself and there is a relatively high probability that the entire park will burn in any one year, eliminating forage for gazelles and other wildlife in the short term. As grazing pressures increase outside the park, the option of moving the gazelles outside the park, if it burns, may become less feasible. A system of compartments separated by blacklines would reduce the probability of the whole park (and more) burning in one season. At the same time, it allows fire to play its ecological role in those compartments that do burn. In effect, this strategy would make the park landscape a microcosm of what it used to be, with smaller patches burning each year.

Another useful fire management strategy for Toson Hulstay Nature Preserve might be the organization of Fire Councils or Commissions that consist of representatives from each of the five soums that encompass the preserve. Such a group might be able to make better decisions regarding fire management in the park. This strategy should be incorporated into the TNC Conservation Action Planning (CAP) process for the Eastern Steppe.

Education and outreach should always be a component of effective fire management planning. The development of fire prevention and safety brochures to distribute to local herders could provide a way to reach many of the people directly affected by fire. The brochures could be designed to include information on black lining and basic suppression techniques. (There is a 100 percent literacy rate in Mongolia even amongst pastoralists.) Similarly, fire season calendars and posters could be developed that depict local heroes such as wrestlers and horse riders that contain information regarding fire prevention and safety. The months when fire risk is high could be highlighted and offer important information regarding prevention and safety.

Figure 13. Blackline in the savannas of Emas National Park, Brazil used to prevent lightning fires from burning the entire park in a single season, while at the same time allowing fire to play its ecological role. Photo by Ary Soares.

Technology Transfer

Adopting and using technology that is affordable, useful and which requires minimal technical support would be of great value in Mongolia where current fire management resources and expertise are limited. There are some obvious opportunities to transfer existing modeling technology and methodology from the U.S. LANDFIRE National Mapping Project directly to fire management and conservation efforts in the Mongolian steppe grasslands.

The ecological models developed for the LANDFIRE project are useful tools in illustrating and summarizing current scientific and management knowledge as well as inferences and hypotheses about the dynamics of vegetation and fire regimes. Ecological models illustrate relationships between vegetation types and their disturbance regimes. In some cases LANDFIRE models developed in the U.S. can be "cross-walked" to corresponding analogs in the Eastern Steppe. These cross-walked models would need only slight modifications to more closely represent specific situations in Mongolia. The LANDFIRE vegetation models and their descriptions can be downloaded from the LANDFIRE Web site at http://www.landfire.gov/NationalProductDescriptions24.php.

6 next steps

(1) Disseminate report to TNC Mongolia for comment. Translate and disseminate in Mongolia.

(2) Discuss with TNC Mongolia the potential implementation of selected strategies and actions.

(3) Invite up to two key representatives from Mongolian agencies to attend the joint FAO-TNC CBFiM training workshop in Yunnan, China in March 2009.

(4) Identify and discuss training needs with TNC Mongolia and their partners.

(5) Promote IFM concepts within NEMA to better address and manage the large number of fires that occur in the forest steppe and steppe ecosystems of northeastern Mongolia.

(6) Promote the Two Faces of Fire as an alternative to existing prevention campaigns. The Two Faces of Fire is a learning approach being used by TNC's Global Fire Initiative in some areas to explain the dual role that fire may play in ecosystems and communities.

(7) Identify possible demonstration projects within the Eastern Steppe or elsewhere in Mongolia where IFM concepts can be applied through community-based programs. Seek funding for one or more programs.

(8) Discuss the value of a similar assessment and report for the Hulunbuir Grasslands in Inner Mongolia.

(9) Discuss who in TNC's Mongolia Program could take the lead on fire management issues and serve as liaison with the Global Fire Initiative.

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