



# M O N G O L I A

## Lessons from Tree Planting Initiatives

September 2006



THE WORLD BANK

**MONGOLIA**

**Lessons from  
Tree Planting Initiatives**

September 2006



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# Contents

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FOREWORD	v
ACRONYMS	vii
ACKNOWLEDGMENTS	ix
EXECUTIVE SUMMARY	xi
INTRODUCTION	i
Mongolia's Forest Resources	1
Depletion and Degradation of Forest Resources	2
Planting Initiatives in Mongolia	4
Study Site Selection	7
CHAPTER 1: TREE PLANTING IN NORTHERN MONGOLIA	7
Methods	7
Results	7
Discussion	17
CHAPTER 2: TREE PLANTING IN SOUTHERN MONGOLIA	21
Methods	21
Results	23
Discussion	29
CHAPTER 3: RECOMMENDATIONS	33
Planning	33
Site Preparation	33
Research	33
Partnerships	34
Financial Management	35
Alternatives	35

**BIBLIOGRAPHY** 37

**FIGURES**

- 1 Area of Mongolia's Territory Planted With Trees, 1980–2004 5
- 2 Map of Mongolia With Locations of the Tree Planting Sites Studied 8
- 3 Length of Shoots of Planted Pine Trees 16
- 4 Length of Shoots of Planted Larch Trees 16
- 5 Proportions of Different Tree Species Naturally Regenerating on the Planting Sites 17
- 6 Direct comparison Between the Height of the Tallest Planted and Naturally Regenerated Trees on each Study Plot 18
- 7 Comparison of Saxaul Survival Rates One Year After Planting and in 2005 25
- 8 Comparison of the Average Planting Density of Three Different Types of Planting Project and the Seedling Density in Natural Forest 26
- 9 Comparison of the Amount of Water Added Annually per ha by Precipitation and by Irrigation in the Green Wall Program (Juilchin Gobi) 27
- 10 Comparison of the Mean Implementation Costs (Tg) of the Different Projects in Southern Mongolia 29
- 11 Mean Basal Area per ha and the Maximum Amount of Harvestable Dry Saxaul at Utilized and Pristine Locations 29

**TABLES**

- 1 Biogeoclimatic Zones of Mongolia 2
- 2 Climate Characteristics of Mongolian Arid Regions 3
- 3 Fee Schedule for Planting Activities Financed by the State 6
- 4 Tree Planting Sites (declared and measured), and Details of Ownership 9
- 5 Ecological and Physical Characteristics of Tree Planting Sites 11
- 6 Planted Tree Survival Rates, Density, Percentage of Sites with Living Planted Trees, and Maximum Planted Tree Density 12
- 7 Planting Activity Visible on the 30 Sample Plots of Each Surveyed Site 13
- 8 Fire and Grazing in Planting Sites 15
- 9 Number of Planted Trees in Comparison with Natural Regeneration 18
- 10 Overview of the Saxaul Planting Sites 24
- 11 Overview of Green Wall Planting Sites 25
- 12 Comparison of Cost Factors in Southern Planting Programs 27
- 13 Inventory Data of Natural Saxaul Forests at Eight Different Locations (focusing on regeneration) 28

**Box**

- 1 Natural Regeneration of Forest Landscapes 34



## Foreword

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Mongolia's forests are of vital importance, both to the citizens and businesses that rely on timber and other forest products, and for the protection of Mongolia's fragile environment. Forested landscapes can maintain a high quality water supply, stabilize soils, and provide habitat for wildlife, and if managed effectively can also provide a secure supply of forest products to meet the needs of Mongolia's growing population. Promoting the recovery of forest landscapes has been identified as a key priority by the Government of Mongolia.

This report on tree planting initiatives in Mongolia is one of the many activities carried out under the Netherlands-Mongolia Environment Trust Fund for Environmental Reform (NEMO), which has touched on several aspects of environmental management in Mongolia in 2005/6. It responds to a request from the Ministry of Nature and Environment to the World Bank for support for the Green Wall program and for other planting initiatives in northern Mongolia.

The report finds that the best, most lasting means of restoring forest landscapes for the lowest cost is to

encourage natural regeneration, not investing in costly planting programs. Where planting is undertaken, however, sensitive planting site selection, strong technical assistance, training for workers, and care of the seedlings for a number of years after planting are all crucial if the seedlings are to survive. It was also found that programs for planting in remote areas are vulnerable to corruption, especially if inspections cannot be carried out regularly.

We hope this report provides a basis for continuing dialogue on how to care for and support—whether through policies or programs—one Mongolia's most precious resources; its forests and trees.

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East Asia and Pacific Region  
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# Acronyms

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AAC	Annual Allowable Cut
GPS	Geographic Positioning System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation)
MNE	Ministry of Nature and Environment
NFP	National Programme on Forestry
NGO	Nongovernmental organization
NSO	National Statistical Office of Mongolia
Tg	Tugrug, the national currency. \$1 = 1,100 Tg (2006)
UNEP	United Nations Environment Program
USSR	Union of Soviet Socialist Republics

*Notes:* All dollars are U.S. dollars; all tons are metric tons.

*Aimags* (= province) is the largest sub-national administrative unit; below the aimag is the *soum* (= district), which is divided into *bag* (= sub-district). In the capital city districts are called *duureg* and sub-districts *khoroos*.

*Dzud* is the collective term for a range of winter weather-related conditions that prevent domestic animals from foraging in open grazing. Dzud is a fact of life for Mongolian herders, who have developed strategies for coping with and adapting to their harsh environment. Heavy accumulations of snow or ice crusts covering pastures are the most common form of dzud (white dzud). In situations where this precipitation is the primary source of drinking water for livestock, the absence of snow or ice at winter pastures is also a type of dzud (black dzud). Since forage production on natural pastures is almost entirely dependent on rainfall during the short summer growing period, dzud conditions are exacerbated by drought in the preceding summer, so that there is less forage available for over-wintering animals. Historically, major dzud have occurred roughly every seven years, but more experienced herders are not surprised when they occur in consecutive years as has happened recently.



# Acknowledgments

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In Ulaanbaatar, the logistics of the fieldwork were coordinated by Hans Hoffman of GTZ.

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The work was managed by Tony Whitten, Environment Sector Coordinator (Mongolia), East Asia and Pacific Region of the World Bank.



# Executive Summary

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Mongolia's forestry sector is in disarray, with illegal and unsustainable logging depleting and degrading resources in accessible areas of forest, particularly those near urban areas. Despite Mongolia's low population density, there is increasingly high demand for timber, both for use in construction and manufacturing, as well as for fuelwood to support a growing population. Both the forests of the north of the country and the saxaul shrub forests of the south are under pressure; the former for commercial timber and construction of houses and fuelwood, and the latter predominantly for fuelwood and some construction. There are concerns that the depletion and degradation of the southern forests may be contributing to desertification. The timing of this study is relevant, as the Government of Mongolia has responded to concerns over the state of forest resources by funding and encouraging others to support planting initiatives, both in the northern forests and in the desert steppe region. In 2005, the government decided to direct considerable investment into a large-scale planting scheme in the Gobi—the "Green Wall" project—to reduce soil erosion and dust storms, and mitigate what is perceived as desertification. In this context, it is important to evaluate the success of past efforts and identify the elements needed for a successful program.

In the predominantly coniferous forests of northern Mongolia, the success of planting programs<sup>1</sup> at 23 planting sites was examined. Three of these could not be located by their owners, suggesting that they had never been planted despite funding being

provided. In most planting sites, few of the trees survived; the mean survival rate was just 12 percent. Survival rates were above 50 percent in only two sites. Fire damage, cattle grazing and water stress were the main stress factors identified. Some 30 percent of the trees in the planting sites studied were damaged by grazing—predominantly by large animals, rather than hares or rodents, suggesting that this could be greatly reduced with basic fencing. The siting of the projects may also have been a factor affecting survival, with the majority of the planting sites located on flat, easily accessible planting sites, rather than on the northern slopes where forested areas are generally found.

In future tree planting initiatives in northern areas, the use of fencing and fire protection strips would greatly improve survival rates, but the utility of natural regeneration should not be underestimated. In at least one case, natural regeneration had been removed to plant seedlings—with subsequent low survival rates. Natural regeneration of deciduous trees (birch and poplar) can shelter under-planted conifers, accelerate natural succession, and then be harvested after 50 years. In sustainable forestry programs, maintaining continuous forest cover will allow faster regeneration by sheltering the seedlings that replace the harvested trees. To design such programs, it is necessary to

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<sup>1</sup> Planting in this context may include both reforestation (the replanting of areas that are known to have been forested within the last 20 years) and afforestation (the planting of areas that were either deforested many decades ago, or in extreme cases, have never supported forest communities).

determine the maximum rate of tree removal in old-growth forest that will still allow reliable regeneration.

In southern Mongolia, seven tree planting sites were examined in desert steppe and true desert regions, where water availability limits tree growth. Planting sites included those with pure saxaul (a well-adapted, characteristic tree of the region), and those with mixed plantings with seedlings imported from China. In the first year after planting, all sites had a high survival rate. However, of the four planting sites where survival in the longer term could be evaluated, success was minimal. Two planting sites had no trees alive after one and three years, respectively. The highest seedling survival rate at a site was only 8 percent. Reasons for failure were insufficient or no irrigation, and browsing by livestock. The three Green Wall planting sites reported high success rates in the first year of planting; long-term success has not yet been determined.

A comparison of the Green Wall planting sites and the pure saxaul planting projects shows that much larger amounts of funding and resource inputs are being provided in the Green Wall sites. The Green Wall planting sites are estimated to cost over 2 million Tg / ha, more than thirty times as much as the pure saxaul projects. The very limited success of the previous projects makes it hard to justify this expenditure. Although the Green Wall planting sites are conducted with greater professionalism, this input must be maintained in the long-term, and there are many risks. An irrigation pump malfunctioning for a week will cause total failure. Well-maintained fences are also vital, and are required for years—almost impossible to assure for large planting sites. It is crucial to base planting site selection on ecological grounds, as trees need sufficient water resources; neither the saxaul nor the Green Wall planting sites were in the natural tree-growing zone. Transplanted seedlings require large amounts of irrigation; the Green Wall planting site at Dalanzadgad consumes 1.3 million liters of water per year, around 1.5 times the amount of natural rainfall. Removal of groundwater to meet these needs can contradict the aims of the program by further lowering the groundwater table, and the transpiration

of the trees will further increase water stress in the area—potentially negatively affecting livelihoods.

If planting projects are necessary in southern Mongolia, it is best to support small projects at specific locations close to groundwater. They will require a long-term budget that finances the salary of reliable people to care for the seedlings after planting. Prior to starting these projects, the availability of seed and seedlings of locally adapted trees such as saxaul should be increased. In addition, experience with planting projects in Mongolia must be improved through research programs and collection of data from other countries. It would be more appropriate to support regeneration and protection of the 2.02 million hectares of natural saxaul forest *before* embarking on any planting programs. Naturally regenerating planting sites have a denser distribution of seedlings than are planted on planting programs, are more vigorous than seedlings in planting efforts, and require less resources. Projects with the support and involvement of the local community should be supported for the greatest long-term sustainability.

The maximum success in restoring forest landscapes for the lowest cost would be obtained by designing programs that promote natural regeneration of degraded forest landscapes, rather than investing in costly planting programs, which have met with little success to date. When programs are designed, several factors are critical for positive results, including planting site selection on ecological grounds, technical assistance and training for workers, and care of the seedlings for a number of years after planting. In several cases, planting sites that had been reportedly planted could not be found; others were smaller than reported, or suffered from poor quality workmanship. This suggests that planting programs are providing an easy opportunity for stealing funds. Increased attention needs to be given to protection of the existing forest resources from illegal and unsustainable harvesting. In areas characterized by heavy harvesting pressure on limited forest resources, programs to promote sustainable alternative fuel sources would be beneficial.

# Introduction

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Mongolia's geographic location as a landlocked Central Asian country results in a harsh continental climate, characterized by sunny days, long and cold winters, low precipitation and large annual, seasonal, monthly, and diurnal fluctuations in air temperature. Temperatures may reach highs of 40°C (104°F) in summer and lows of -45°C (-50°F) in winter. Mongolia is also one of the world's highest countries, with over half of the territory more than 1,400 meters above sea level. Although population size has increased rapidly over the last century, human population density is still very low—with a land area of approximately 1.56 million square kilometers, and a population of 2.3 million people, density is approximately 0.6 people per square kilometer (Dore and Nagpal, 2006). The rate of population growth, which varied during the 20<sup>th</sup> century, has slowed since 1989. In 2000, around 57 percent of the population lived in urban areas. The vast majority of these are in the capital city of Ulaanbaatar, where currently 38 percent of the entire population officially resides, although the true figure may be much higher due to the large numbers of unregistered migrants.

## Mongolia's Forest Resources

Despite the low population density, demand for timber in Mongolia is relatively high and growing (Crisp et al., 2004; Erdenechuluun, 2006). It is estimated that less than 12.4 million ha of Mongolia's forest can be classed as intact today, with a further 3.6 million ha of

degraded forest and 1.8 million ha of non-forest land. The forested regions within this estate can be broadly divided into the predominantly coniferous forests of the north (boreal, montane, and mixed-forest steppe), and the saxaul (*Haloxylon ammodendron*) shrub forests of the southern desert and desert steppe.

Mongolia spans the transition zone between the deserts of Central Asia and the boreal taiga of Siberia, and no less than six major biogeoclimatic zones can be found within the country. These zones reflect a general trend from drier and warmer at lower elevations in the south to moister and colder in the north and at higher elevations. Annual precipitation ranges from an average of 400 mm in mountainous regions, to less than 100 mm in desert steppe; about 75 to 85 percent of the precipitation falls during the three summer months. The six zones, from lower latitudes and elevation to higher latitudes and elevations, are listed in Table 1.

The northern forests are found in the last three of these zones, all of which exhibit varying depths and distributions (from continuous to sporadic) of permafrost. The boreal forest and forest steppe zones contain a coniferous component; Siberian larch (*Larix siberica*) is the predominant species, followed by Scots pine (*Pinus sylvestris*) and Siberian pine (*Pinus sibirica*). In addition to the conifers, there is a smaller broad-leaved component composed primarily of birch (*Betula platyphylla*), aspen (*Populus tremula*), and poplar (*Populus diversifolia*). On average, the coniferous and broad-leaved northern forests are comprised of 72 percent larch, 11.1 percent birch, 9.5 percent Siberian

**Table 1: Biogeoclimatic Zones of Mongolia**

Zone	Vegetation type	Area (million km <sup>2</sup> )	Percent of total area
Desert	Largely unvegetated.	0.297	19
Desert Steppe	Short-grass prairie with sparse shrubs and scattered small trees.	0.329	21
Steppe	Tall-grass prairie with a significant forb component.	0.407	26
Forest Steppe	Mixed forests on northerly slopes and grasslands on southerly slopes.	0.125	8
Boreal Forest	Coniferous forests with a variable broad-leaved component.	0.063	4
Montane	Mixed sub-alpine coniferous forests, krummholz <sup>2</sup> , alpine meadows and tundra.	0.344	22

Source: Crisp et al., 2004

pine, and 6.3 percent Scots pine, with a variety of species accounting for the remainder (Dorjsuren and Sainbayar, 2004). However, this varies throughout the region, with broadleaf species virtually absent in the higher elevations of western Mongolia. The montane forest is a zone in which the larch and Siberian pine of the boreal and steppe forest gradually give way to sub-alpine forests of Siberian spruce (*Picea obovata*) and Siberian fir (*Abies siberica*). Over 90 percent of northern forests are contained in seven aimags—Khuvsgul (29 percent), Selenge (16 percent), Bulgan (14 percent), Khentii (11 percent), Tuv (10 percent), Arkhanghai (8.5 percent), and Zavkhan (5 percent) (NSO & MNE, 2000, in Crisp et al., 2004).

Desert and desert steppe regions (Table 2) are generally tree-less, because the low precipitation, high evaporation, critical groundwater depth, and low water storage capacity of the soil prevent tree growth. A few tree species can be found, however, where conditions are appropriate—namely in association with moist ephemeral depressions and stream courses. Availability of water is the major factor limiting distribution. The most characteristic is the saxaul, which is still found in a belt across the southern Gobi, though only a shadow of its former glory in terms of height, density, and extent. Secondary species such as tamarix (*Tamarix* spp.) and peashrub (*Caragana* spp.), are also present, to a much lesser extent. The southern forest resources are significant—saxaul comprises some 16 percent of the total area of Mongolia’s intact forest, although less than one percent in terms of volume (Forest

Management Project Centre, 1997, in Crisp et al., 2004). Almost all of the saxaul forests are contained in five aimags—Umnugovi (46 percent), Govi-Altai (27 percent) Khovd (12 percent), Bayankhongor (8 percent), and Dornogovi (6 percent) (NSO & MNE, 2000, in Crisp et al., 2004).

## Depletion and Degradation of Forest Resources

Statistics on forest loss are confusing, but it is estimated that Mongolia lost approximately 4 million ha of forest in the last century, an average of 40,000 ha annually. Deforestation rates increased to 60,000 ha annually in the 1990s, when the collapse of the Soviet state resulted in loosening of controls over the forestry sector (World Bank, 2003). The vast majority of the forested land is in the north of the country, and is under increasing pressure from unsustainable and widespread illegal commercial logging, as well as use as domestic construction timber and fuelwood for local residents—collection of which is not in accordance with any long-term strategy. The saxaul forests of the south—which protect the land against erosion and desertification—are not at risk from commercial logging, but are under pressure as a source of seasonal livestock fodder and fuelwood. In addition to direct exploitation of Mongolia’s forest resources, a long-term

<sup>2</sup> Low, dense trees stunted by wind.

Table 2: Climate Characteristics of Mongolian Arid Regions

	Average air temperature (°C)		Sum of temperatures above 10°C	Precipitation (mm/yr)	Evaporation (mm/yr)	Dryness index	Critical depth of ground water (cm)
	January	July					
Steppe Desert	-18.7	23.1	2763	112	707	5.8	209
True Desert	-18.2	24.0	2996	90	761	7.1	217
Arid Desert	-17.0	28.0	3648	43	911	18.6	249

Source: Adapted from Pankova, 1998

and cyclic drying of the climate is causing a slow northerly retreat of its forests (World Bank, 2003). Other factors that can negatively affect forest health are grazing of young trees by livestock, forest fires, and disease and insect infestations—although fire, disease, and insect pests also are important natural influences in forest renewal and regeneration.

Estimates of the sustainable annual allowable cut (AAC) in Mongolia, and also annual wood consump-

tion, vary widely due to lack of reliable data. All available evidence indicates that the volume of timber currently being extracted from the forest estate (for both industrial use, and for domestic construction and firewood) cannot be maintained in the long term, especially as forest use concentrates on mostly accessible areas of forest (Erdenechuluun, 2006). Central blocks of forest often do not have access roads, and are largely legally protected; an example is the interior



Transport of illegally felled timber.

of the Khentii Mountains in northern Mongolia. The past mismanagement of the forest estate may mean that—in the short to medium term—large amounts of timber can be harvested through thinning exercises, which are necessary to fireproof the northern forests. However, the slow growth rate of trees and unpredictability of future timber demands mean that serious thought should now be given to forest regeneration and planting activities in order to maintain the forest resources in this region for the long term.

In the south, heavy pressure on the limited resources from grazing and timber collection is leading to severe depletion of the shrub forests in many accessible regions. Land degradation and soil erosion are a major concern of the Government of Mongolia, leading to priority being placed on schemes to combat desertification in this area. The concept of desertification is a controversial one, and there are conflicting opinions over the extent to which this is occurring in Mongolia. The extent of Mongolian territory covered by sand (including dunes) appears to have been remarkably stable over the last 40 years, having increased by just 0.02 percent (World Bank, 2003). If this narrow interpretation of desertification is used, then the area said to be desertified in Mongolia is in fact very limited indeed. Estimates of the extent and degree of land degradation in Mongolia vary widely according to the criteria used by different agencies, which are in turn often not clearly defined, and therefore these estimates must be interpreted skeptically.<sup>3</sup> It is generally accepted that human activities, both from human-induced climate change and also from overgrazing, loss of saxaul-tree cover, and breaking of soil surface through ploughing, mining, and sharp animal hooves, are contributing to the worsening of sand storms. These are natural in origin, and can have major negative impacts in local regions and even in neighboring countries, although the situation is complex as the sand is also a source of nutrient input to the seas east of Mongolia, can neutralize the local effects of acid rain, and can have a cooling effect on the climate (World Bank, 2003).

<sup>3</sup> It is not clear, for example, whether the definitions refer to changes in range vegetation cover or species composition; whether they are based on field observations, and if so, from how many experimental plots; and whether or not the processes of vegetation change are thought to be irreversible (World Bank, 2003).

## Planting Initiatives in Mongolia

Forest management is the responsibility of the Ministry of Nature and Environment, while the industrial aspects of the sector are the responsibility of the Ministry of Trade and Industry. A National Forest Policy was prepared in 1998 that focused on forest utilization, forestry resources, conservation, and social welfare concerns. Three of the seven principle objectives of the document dealt with exploitation and utilization of forest resources, illustrating the preoccupation of the government at that time. With the revision of the forest policy in 2001 into the National Programme on Forestry (NFP), government priorities shifted away from utilization and toward conservation and protection. Reforestation is one of several key objectives under the NFP. The others are institutional restructuring, forest fire and pest management, and enhancing the quality and efficiency of timber processing (The key threat to Mongolia's forests, unsustainable and illegal exploitation, is in fact not emphasized as a key priority.) Under this program, aims include increasing seed collection from both trees and shrubs; developing seed storage and seedling nurseries; increasing reforestation and afforestation efforts to cover at least 10,000 hectares of land annually; and building shelter belts and windbreaks for the purpose of combating desertification and soil protection of agricultural lands.



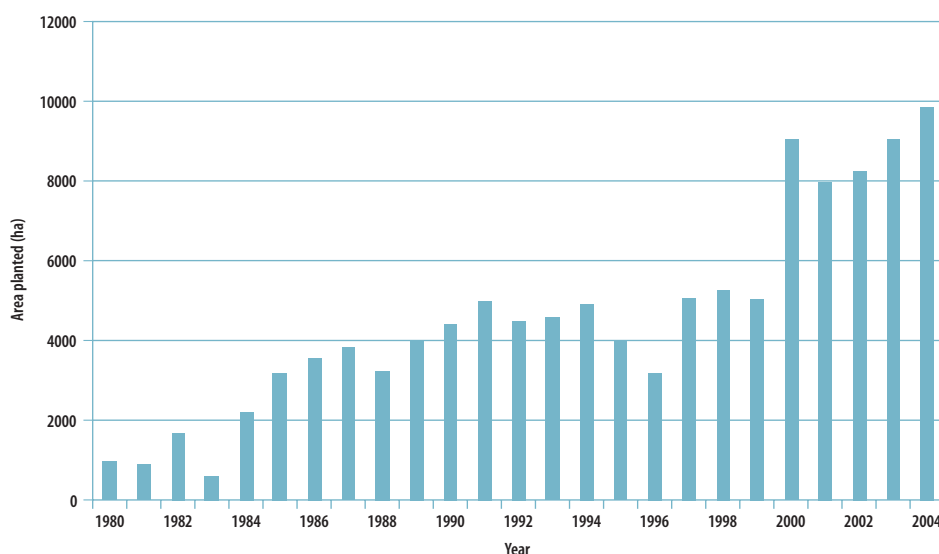
A small nursery producing larch and pine seedlings for central aimags.

The Government of Mongolia has had a planting program for over 30 years, and has established nurseries around 10–15 ha in size, with a capacity of around 80–100,000 seedlings, in Arkhangai, Bulgan, Dornod, Zavkhan, Zuunharaa, Uvs, Selenge, and Uverkhangai aimags and also in the capital city of Ulaanbaatar (Dorjsuren and Sainbayar, 2004). Forestry offices have also been established in aimags of the Gobi, in order to expand efforts in the southern region. The level of investment is currently around \$400,000–600,000 per year (Crisp et al., 2004), with 516.1 million Tg provided from the state budget in 2004 (Dorjsuren and Sainbayar, 2004). Additional financing is provided from local budgets, the organizations conducting the planting, and national and international donors. The state budget is controlled by MNE and shared with aimags according to approved plans; implementation is by environmental protection agencies at the aimag level, which can contract with individuals, businesses, and other organizations such as NGOs to carry out the activities. The area of land planted has steadily increased (Figure 1). In 2004, approximately 9,861 ha were planted, using 33 million seedlings (Dorjsuren and Sainbayar, 2004). Of this area, 585 ha were seeded, 5,300 ha were planted with seedlings, and a further 3,976 ha were prepared for natural regeneration.

To date, efforts have mostly focused on the northern aimags, where commercial logging contractors are required to replant as part of their permits, although they often get paid (for reasons that are not clear) and continue to be issued with cutting permits even when they do not plant. Payments are also made to contractors for the afforestation of areas that have not supported forest in the recent past. Funding is also available for activities to “facilitate natural regeneration.” Detailed guidelines appear to be lacking, but this generally involves soil cultivation by hand or by tractor. The fee schedule was set in 1999, and has not been revised since despite high rates of inflation and increasing costs (Table 3). Fifty percent of the fee is advanced and the rest paid after survival surveys. Payment of the remaining fee is based on the following formula: if survival is greater than 40 percent the whole balance is paid; if survival is 25 to 40 percent, 50 to 100 percent of the balance is paid; and if survival is below 25 percent, the advance must be returned.

Although payments for planting activities are supposedly connected to seedling survival, no clear procedures for survival surveys (particularly where seeding is employed) have been established, and it is apparent that authorities often just take the contractors’ word for both the area planted and the survival

**Figure 1: Area of Mongolia’s Territory Planted with Trees, 1980–2004**



Source: Dorjsuren and Sainbayar, 2004

rates. Moreover, regeneration surveys (if done) and final payment are completed in the fall, though in a summer-wet climate such as Mongolia’s the main planting mortality is likely to occur in the dry period from late fall to early spring. It does not appear that natural regeneration surveys precede a decision to plant a site, and there are examples of advanced natural regeneration being either destroyed by planting operations, or even dug up to provide the bulk of the planting materials for the tree-planting sites (Bretenoux, 2001). Even if survival rates were found to be high, the ecological and economic rationale for the reforestation program is in serious doubt. Many of the planting sites are chosen for accessibility in order to limit costs. This often means that they are on forest edges and in drier, more open sites where survival, let alone growth, would be expected to be poor, particularly at a time of long-term, cyclical climatic drying (World Bank, 2003). In addition, it has been

suggested that no economic or financial methodology (such as net present value) justifies planting commercial tree species in a climate where they are not expected to become merchantable for 130 to 150 years (Crisp et al., 2004).

However, tree planting programs in Mongolia remain popular and are set to expand. In 2005, a major new national initiative—the “Green Wall”—was launched in the south. The objective of this program is to create a belt of planted trees in the transitional zone of the Gobi and steppe regions in an attempt to reduce the “present intensification of loss of forest reserves, desertification, sand movement and dust and sand storms, caused by climate change and inappropriate anthropogenic activities” (MNE, 2005). The Green Wall will extend for 2,500 kilometers from the east to the west of the country, with a width of at least 600 meters, covering 90,000 ha, and will be planted with a mixture of saxaul and other species such as elm (*Ulmus* sp.), poplar, willow, and tamarix. In this context of increasing interest in, and funding for, planting initiatives, this study evaluated the success of planting sites planted in recent years.

**Table 3: Fee Schedule for Planting Activities Financed by the State.**

Activity	Maximum payment per ha
Planting with coniferous seedlings in forest steppe zone	100,000 Tg
Planting with deciduous seedlings such as saxaul and elm in steppe, gobi zones	104,000 Tg
Planting with deciduous seedlings in forest steppe	135,000 Tg
Planting with seeds	
• Coniferous trees	91,000 Tg
• Saxaul	66,000 Tg
Facilitating natural regeneration	57,000 Tg

Source: Dorjsuren and Sainbayar, 2004

## Study Site Selection

This study conducted separate evaluations of planting sites in the north and in the south of Mongolia. Fieldwork was limited by the short duration of the study period available—two months—and the difficulties of working in remote locations with poor transport links. The maximum number of possible sites were surveyed, working within these limitations. Survey methodology differed between the sites in the north and the south, due to the very different ecological characteristics of the forest types, and the differences in extent of the planting programs in the two areas.

# 1. Tree Planting in Northern Mongolia

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In the north, planting activities to date have been primarily concentrated in the Khangai and Khentii mountains. The latter was chosen as a representative area to survey sites established during the last decade. The survey was carried out in the Selenge, Khentii, and Tuv aimags, where the Khentii Mountains extend over 200 km northeast from Ulaanbaatar toward the Russian border.

## Methods

Tree planting initiatives in the Khentii Mountains (Figure 2) took place in two periods, 1995–99 and 2004–05. The study evaluated a stratified random sample of 23 tree planting sites from the 177 sites in the region listed by government agencies, aiming to sample each of the three aimags equally.

The sample planting sites were located and the area measured using GPS. Thirty sample plots (15 x 15 m) were systematically distributed throughout each site by calculating coordinates for the center of the sample plots and locating them using GPS. Within the sample plots, each tree was recorded and its species determined, differentiating between planted trees and naturally regenerated trees. All naturally regenerated trees, regardless of size, were recorded. Survival of planted trees was calculated by comparing living trees with planted tree density, which according to the information supplied by planters was the government-specified density of 2,500 stems/ha. In each sample plot, height and yearly sprout shoots of the tallest

planted and the tallest naturally regenerated tree were measured. Vitality was determined in three classes (-, 0, +). Damage by grazing or by rodents and strong competition with grass were also recorded for the tallest individual trees.

The soil of each planting site was also classified. Using questionnaires, owners were asked about the planting method, the fire history, and the source and amount of money invested.

## Results

### *Planting Site Descriptions*

Three of the 23 planting sites could not be found. In one of these cases, a responsible person in MNE did not want his own site to be studied. Thus the number of ecologically surveyed planting areas was reduced to 20, of which two were planted as a joint venture and treated as one (Site 3/4). Therefore, detailed observations were made for 19 planting sites: 11 with pine, and eight with larch.

In addition to the three sites that could not be found and are assumed not to have been planted, seven of the measured areas were smaller than declared in official documents (Table 4). In total, the real reforested area amounted to 86 percent of the declared area. Sometimes sites were planted communally by several companies (Sites 1, 3, and 4). Small companies planted areas together with former state forest companies,



Table 4: Tree Planting Sites (Declared and Measured), and Details of Ownership

Site no.	Year established	Name of owner	Size declared (ha)	Size measured (ha)	Site owned by	Responsible person	Logging company
<b>Selenge Aimag</b>							
1	1998	Narsan Togol Chamtlag	10	(160)	Company and state administration	State forester	No
2	2004	Zuun Choid Asiin Oin Chuulgan	150	170	Company and state administration	State forester	No
3	2005	Oi Bajasach	15	(155)	Several companies, and state administration	State forester	No
4	2005	Monstend	10	(155)	Several companies, and state administration	State forester	No
5	1999	Dulaan Khaan	10	10	Company and state administration	State forester	No
6	2004	Norgon Alt Chamtlag	10	20	Company	Private forester	Yes
7	1996	Zuunchara Prison	100	80	Prison	Private forester	No
<b>Tuv Aimag</b>							
8	1997	Shagdarjav	20	Could not find			No
9	1998	Mongol Algii Chuulgan	12	12	University	State forester	No
10	2005	Titim Oi	20	10	Company	Private forester	Yes
11	1996	Batsumber Oin Angi	15	11	Company	Private forester	Yes
12	2004	Titim Oi	20	17	Company	Private forester	Yes
13	2004	Butimsh Uul	10	10	Company	Private forester	No
14	2005	Ikh Ailchin	10	Could not find			Yes
15	1995	Mjandas	10	Could not find			No
<b>Khentii Aimag</b>							
16	2004	B. O. Ch. Cholboo	10	10	Company	Private individual	No
17	2004	Bajan Adarga Soum	10	10	Company	Private forester	Yes
18	1998	Balschhan	10	10	Company	Private individual	Yes
19	1997	Chuw Chumuus	35	25	Company	Private forester	No
20	1995	Taiga Chortscho	8	5	Company	Private individual	Yes
21	2004	Binder Oi	20	20	Company	Private individual	Yes
22	2004	Bold	30	15	Company	Private individual	Yes
23	1995	Ganbat	8	8	Company	Private individual	No

Values in brackets are joint ventures, where the declared site was part of a larger one and could not be distinguished from it.

because the state companies own tractors. Sites varied in size but most were fairly small (5–20 ha). This is typical of the projects in Mongolia—in fact, there are fewer sites over 100 ha in area than might be suggested by the proportion surveyed within this study. Smaller sites are more common due to the poor organization within the forestry sector, and the risks involved for companies that may have to wait to be paid, or receive only a proportion of the expected fee. Seedlings were generally planted at two years old, supplied from the state nurseries in the region. They were planted in May, and were not watered at the time of planting—neither was there any after-care, apart from in Tuijin Nars, where the ranger attempted to keep cattle out of the area for two years following the planting.

Planting sites 1–5 were located within the Tuijin Nars Nature Reserve, and were organized by the state nature conservation administration in partnership with private companies. Such an active degree of involvement by the state in planting projects is relatively unusual; the majority are privately owned with little advice available from the government. In a number of the sites, the planting was organized by a logging company. In the majority of cases, the key person responsible for the site was a trained forester; however, most of the sites surveyed in Khentii aimag were established by citizens with no formal training in forestry. The people who worked on the sites were from the local areas—seasonally unemployed people, families, students—and mostly

had no prior training or experience in planting, the team being established solely for the purposes of the planting project. In all cases, funds were paid according to the set fee schedule and were paid by the aimag administration, with the exception of one planting site (Site 16, four poor families) where no money was given to the people by the aimag administration due to a mistake in MNE. The soum administration finally gave each person \$7 for 2 weeks' work.

Table 5 shows slope gradient, aspect, mean annual precipitation, and soil types. In most years, annual precipitation is below 300 mm, with the majority of the rain falling in July and August. All of the cambisol soil types encountered can be classified as “permafrost soils of forest-steppe in mountains” after Ogorodnikov (1981), and do not exclude forest cover. All sites were established close to existing forest stands. On sandy soils, less nutrients are available than on clayey soils, and parachernozems have the best nutrient availability. The majority of the sites were established on relatively flat slopes, with only five on a gradient of more than 10°. The aspect of the sites covered a broad range of directions—although as most were not on steep slopes, they often did not face a particular direction.

### *Tree Survival*

Tree survival rates in a planting site were calculated by dividing mean density of living planted trees by the density of trees planted. The latter figure was taken as the government-specified density of 2,500 trees per hectare for all sites, as this was the information provided by planters and it was not possible to confirm or refute this figure based on the surveys. The mean survival rate for all 19 sites was 12 percent. The survey showed that the survival of planted trees was less than 10 percent in 12 of the 19 cases. The trees in these areas are unlikely to survive in the long term. In the remaining seven cases, the mean survival rate amounted to 29 percent, and there is a chance that these areas will become forested.



This tree planting site in Selenge had a seedling survival rate of around 15 percent.

**Table 5: Ecological and Physical Characteristics of Tree Planting Sites**

Site no.	Site type (species planted and elevation)	Slope gradient	Aspect	Mean annual precipitation at nearest meteorological station (mm)	Soil type	Affected by fire
1	Pine (lower elevation)	0°		225	Sandy podsolized cambisol	2005
2	Pine (lower elevation)	3°	NW	225	Sandy podsolized cambisol	
3/4	Pine (lower elevation)	1°	W	225	Sandy podsolized cambisol	
5	Pine (lower elevation)	3°	WNW	225	Sandy podsolized cambisol	
6	Pine (lower elevation)	5°	SE	320	Clayey podsolized cambisol	
7	Pine (higher elevation)	4°	SE	320	Clayey podsolized cambisol	
9	Pine (lower elevation)	5°	NW	240	Clayey podsolized cambisol	2000
10	Larch (higher elevation)	15°	SW	240	Clayey podsolized cambisol	
11	Larch (higher elevation)	13°	SSW	240	Podsolized cambisol	2001
12	Larch (higher elevation)	10°	W	240	Clayey podsolized cambisol	
13	Larch (higher elevation)	23°	S	260	Parachernozem	
16	Pine (higher elevation)	4°	NNW	250	Podsolized cambisol	
17	Pine (higher elevation)	7°	NW	250	Sandy podsolized cambisol	
18	Pine (higher elevation)	8°	SW	250	Sandy podsolized cambisol	
19	Pine (higher elevation)	14°	NE	250	Podsolized cambisol	
20	Larch (higher elevation)	2°	SW	250	Podsolized cambisol	
21	Larch (higher elevation)	9°	N	250	Podsolized cambisol	
22	Larch (higher elevation)	18°	NW	250	Parachernozem	
23	Larch (higher elevation)	5°	ESE	250	Podsolized cambisol	

Higher elevation refers to sites more than 1000 m above sea level.

Pine trees demonstrated better survival rates than larch trees; pine trees had a mean survival rate of 19 percent, as opposed to only 3 percent of larch trees. There was considerable variation in survival rates among the two types of sites. Seven of the eight larch sites had a survival rate of 2 percent or less, but the eighth was relatively successful with 19 percent. The most successful pine sites were the four surveyed in the Tujiiin Nars Nature Reserve (Sites 1–5), where on average 37 percent of trees survived.<sup>4</sup> This figure may well have been higher, had many trees not been killed by a fire in Site 1 in 2004. In the other pine sites, mean survival rates were 9 percent.

Even within individual sites, tree survival varied greatly. In one case (Site 16), there were no trees—dead

or alive—over half of the area, but one quarter was well stocked. This site was a cooperative effort between four families, but only one family had planted successfully. Table 6 shows the estimated percentage area of the site without living planted trees (calculated as the percentage of sample plots with no living planted trees), as well as the maximum tree density found on the sample plots within the planting site.

#### *Evidence of Planting Activity*

In Table 7, planting activities are summarized. Where a tractor had been used to plough, stripes were still easily visible after ten years. Manual planting by spade leaves no sign two years after planting.

There was no sign of any planting activity in 30 percent of the surveyed area, but there was great variation within single sites. In almost half the cases, lack

<sup>4</sup> Planting activities are not conducted in accordance with the protection status of an area.

Table 6: Planted Tree Survival Rates, Density, Percentage of Sites with Living Planted Trees, and Maximum Planted Tree Density

Site no.	Year established	Species planted	Survival declared one year after planting	Survival measured in 2005	Mean tree density (planted trees / ha)	Percentage of site with no living planted trees	Maximum measured tree density (planted stems/ha) within site	Mean number of planted and regenerated trees/ha (only including species planted)
1	1998	Pine	76.0	6.0	151	53	755	160
2	2004	Pine	n.i.	50.5	1264	3	2844	1469
3/4	2005	Pine	—	66.5	1664	0	2755	1708
5	1999	Pine	85.0	23.5	588	0	1467	596
6	2004	Pine	n.i.	10.3	256	50	1378	484
7	1996	Pine	57.0	0.1	3	77	89	13
8	1997	Could not find	n.i.	—	—	—	—	—
9	1998	Pine	55.0	9.2	230	37	844	244
10	2005	Larch	—	2.0	50	43	222	77
11	1996	Larch	n.i.	0.1	1	97	44	1
12	2004	Larch	"well done"	0.0	0	63	667	19
13	2004	Larch	70.0	0.4	9	80	44	9
14	2005	Could not find	—	—	—	—	—	—
15	1995	Could not find	65.0	—	—	—	—	—
16	2004	Pine	42.0	6.8	170	57	667	175
17	2004	Pine	41.5	1.5	37	70	222	107
18	1998	Pine	42.7	18.6	465	0	1067	465
19	1997	Pine	n.i.	14.2	356	10	1644	433
20	1995	Larch	51.0	1.2	30	57	133	31
21	2004	Larch	62.0	0.3	7	97	222	19
22	2004	Larch	59.0	0.1	1	77	89	19
23	1995	Larch	41.0	18.9	473	0	1200	533

In 2005 survival rates were not yet determined by official inspection. n.i. = no information available. Natural regeneration in this context refers only to the same species as was planted.

Table 7: Planting Activity Visible on the 30 Sample Plots of each Surveyed Site

Site no.	Year established	Method of planting	Plots without visible forestry activity	Plots without visible forestry activity, but silviculturally justified	Plots with no obvious explanation for lack of forestry activity	Planted twice	Time without forest cover before planting (years)
1	1998	Plowed by tractor	0				14
2	2004	Plowed by tractor	2	2			9
3/4	2005	Plowed by tractor	6	5	1		9
5	1999	Plowed by tractor	4	4			4
6	2004	Plowed by tractor	15	12	3	Yes	15-20
7	1996	Plowed by tractor	11	8	3	Yes	Unknown
9	1998	Plowed by tractor	1		1		No forest before
10	2005	Manual	8	6	2		7
11	1996	Manual	29 (fire)				20
12	2004	Plowed by tractor	6	2	4	Yes	> 10
13	2004	Manual	4		4		No forest before
16	2004	Manual	10	7	3		No forest before
17	2004	Manual	19	14	5	Yes	No forest before
18	1998	Manual	0				20-25
19	1997	Manual	2	2		Possible	10
20	1995	Plowed by tractor	1	1			> 10
21	2004	Manual	29	2	27		15
22	2004	Manual	26	8	18	Yes	> 20
23	1995	Manual	1	1			> 10
Total:			174	74	71		

"Silviculturally justified" in this context means that there was a potentially valid reason why the sample plot did not show signs of planting, such as natural regeneration, presence of seed trees, or more than 50 percent deadwood cover.

of planting could be justified by natural regeneration, presence of seed trees, or by more than 50 percent deadwood cover.

A high degree of planting was apparent at ten sites (1, 2, 3/4, 5, 9, 10, 13, 18, 20, 23). In two planting sites, activity was insignificant (22, 21) and, in one, forest cover had been destroyed by fire (Site 11). In another (Site 5), there were signs that natural regeneration had been destroyed in some parts by the planting activities, which were done using a tractor.

In total, there were no planting activities visible on 174 of the 570 surveyed sample plots, but in 74 cases the decision not to plant was silviculturally justifiable and a further 29 plots were destroyed by fire. Therefore, it is likely that planting activities had been neglected in at least 12 percent of the plots (71 of 570 surveyed plots).

This tree planting site was unsuccessful—the marks of the plough are visible, but the seedlings have died.

### *Factors Affecting Survival and Growth of Seedlings*

The main factors affecting survival and growth of seedlings appear to be neglect of seedlings, unskilled planting, fires, cattle grazing, and a government order to plant in spring (when there is low precipitation). Table 8 shows the occurrence of fire and grazing in different sites. Three of the 19 sites were affected by fire, and had a mean tree survival of about 5 percent. The study covered a total area of 758 ha, of which 183 ha were affected by fire.



Forest fire.



Site affected by fire (Site 1).

A distinction between damage by cattle and by deer is difficult, but in 13 sites a great deal of cattle excrement was found. In at least four cases (Sites 6, 9, 10 and 23), heavy damage by cattle was evident. In winter, hares can also damage young trees. There were few observations of damage by rodents. On average, 30 percent of recorded trees were damaged by grazing.

### *Growth and Competition*

To assess the growth of planted trees, the annual increase in shoot length was measured. Figure 3 shows that the mean length of new shoots one year after planting was 11 cm. After eight years, the mean length of shoots measured about 27 cm, but with great variation; the longest shoots reached 50 cm. The shoot length of larch trees differed even more strongly, but on average the length of shoots in the first year after planting was less than 6 cm (Figure 4). After 10 years, the mean length was less than 15 cm.

The height of the tallest planted tree was also compared with the height of herb vegetation. Seventy-three percent of the planted trees were taller than grass. Those trees surrounded by tall grass did not seem to suffer from competition, and in fact, the grass cover seemed in some cases to shelter the planted trees.

Table 8: Fire and Grazing in Planting Sites

Site no.	Information from planters				Damage from grazing observed (percent)	Survival of planted trees (2005)
	Fire before planting	Fire after planting	Cattle grazing	Game grazing		
1	1991	2005	Yes	No	14	6.0
2	1997	No	No	No	31	50.5
3/4	1997	No	No	No	3	66.5
5	1995	No	Yes	Hare	17	23.5
6	ca. 1985	No	Yes	No	10	10.3
7	n.i.	No	Yes	No	43	0.1
9	Repeatedly	2000	Yes	Hare	58	9.2
10	1995	No	Yes	No	35	2.0
11	1976	2001	Yes	Hare	100	0.1
12	1988	No	Yes	Hare	82	0.0
13	No	No	Yes	No	33	0.4
16	2001	No	Yes	Yes	15	6.8
17	1998	No	No	Hare	33	1.5
18	1996	No	Yes	Hare	27	18.6
19	1978	No	Yes	Hare	11	14.2
20	No	No	No	Mouse	100	1.2
21	1998	No	No	No	0	0.3
22	1998	No	No	No	0	0.1
23	1993	No	Yes	No	60	18.9

### Natural Regeneration

Planted trees were found on half of the 570 sample plots, and two-thirds of the surveyed sample plots also had natural regeneration. The natural regeneration comprised nine species (*Populus tremula*, *P. diversifolia*, *P. laurifolia*, *Salix caprea*, *Betula platyphylla*, *Pinus sylvestris*, *P. sibirica*, *Larix sibirica*, *Picea obovata*). The most common were poplar/aspen (72 percent), willow (12 percent) and birch (11 percent), with conifers accounting for only 5 percent (Figure 5). In 10 sites, the number of naturally regenerated trees was higher than the number of planted trees (Table 9).

In Figure 6, the heights of the tallest planted and naturally regenerated trees are compared for each sample plot. The dotted red line shows equal heights for planted and naturally regenerated trees. This figure clearly shows that in 90 percent of the sample plots the largest naturally regenerated tree is taller than the largest planted tree. The tallest naturally regenerated tree was selected for measurement regardless of age or species; the two trees are therefore not directly comparable in terms of growth vigor, but the results do illustrate the degree of competition faced by the planted trees.

Figure 3: Length of Shoots of Planted Scots Pine Trees

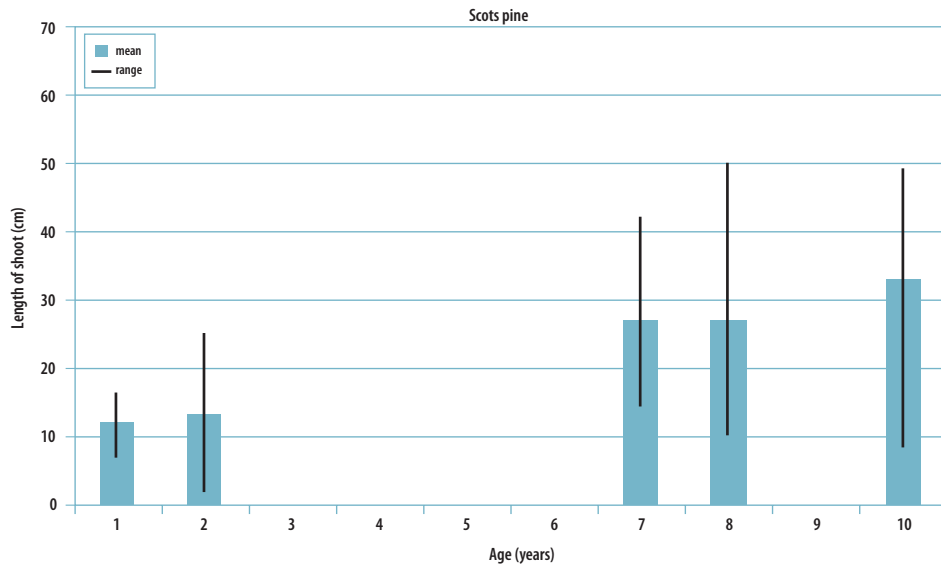


Figure 4: Length of Shoots of Planted Larch Trees

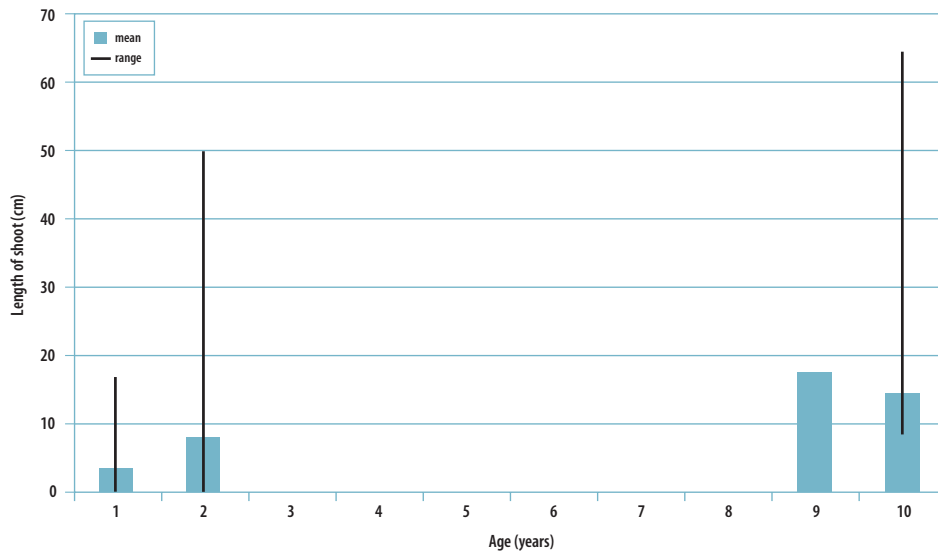


Figure 5: Proportions of Different Tree Species Naturally Regenerating on the Planting Sites

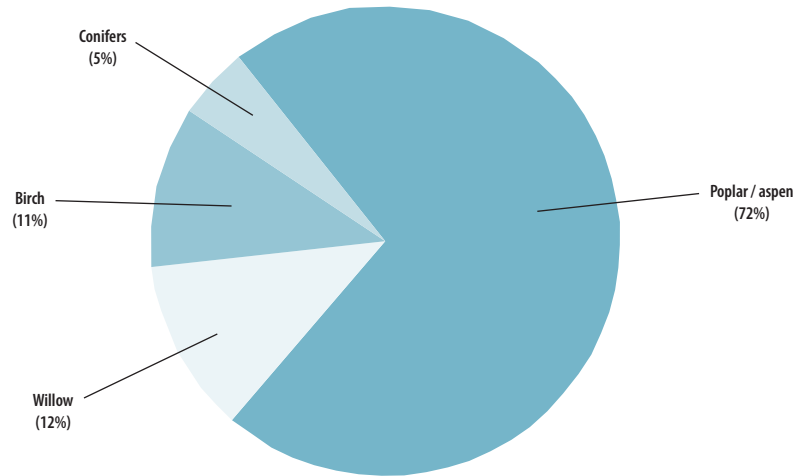
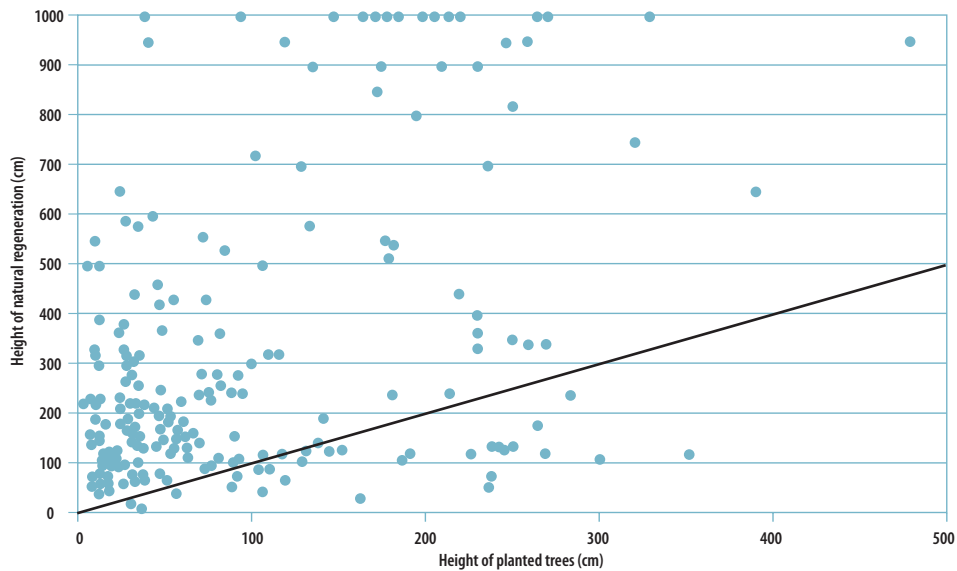


Table 9: Number of Planted Trees in Comparison with Natural Regeneration (NR)

Site no.	Planted trees / ha	Natural regeneration trees / ha	Poplar / aspen		Birch		Willow		Conifers	
			NR	RA	NR	RA	NR	RA	NR	RA
1	151	5000	4482	631	496	40	22			
2	1264	3563	3011	947	365	4	187	102		
3/4	1664	653	373	16			280	203		
5	588	212	203	29			9	2		
6	256	489	254		191		44			
7	3	113			94	66	19	7	21	15
9	230	0								
10	50	402			379		23		7	
11	1	6			1		5			
12	0	61			51		10			
13	9	5					5			
16	170	1173	1117		2		54			
17	37	693	564		35		94			
18	465	1765	1577		124		64			
19	356	727	333		352		42		815	
20	30	1			1					
21	7	5093	4398		564		131			
22	1	1811	705		117		989		9	
23	473	3			1		2			

NR is the figure for natural regeneration in parts of the sites without evidence of forestry activity. RA is the natural regeneration in areas where there had been forestry activity (planting or uncovering of mineral soil).

Figure 6: Direct Comparison Between the Heights of the Tallest Planted and Naturally Regenerated Trees on each Study Plot



## Discussion

The main disturbance factors in the planting sites were fire and grazing by livestock. The hare has been described as a major driving force in boreal forest dynamics (Krebs et al., 2001). Damage by hares does sometimes occur in the Khentii Mountains in winter, but the extent was low compared to cattle grazing. Fencing to exclude large animals is vital, while more expensive fencing to exclude small animals is less important. Pitterle (2003) also saw fencing as being crucial to increase survival.

Grass fires are also a major destroyer of young trees (Hilbig, 1987; Sommer, 2003). A ground fire can be stopped by a 3m-width strip cleared of vegetation. This method is successfully applied in European pine stands, but requires intensive management.

Careful, ecologically based site selection is important to increase the chances of success for planted areas. Most of the planting sites were located on more or less flat sites. Only Tujiin Nars (Sites 2 and 3) had relatively high success for pine seedlings in these



Naturally regenerated pine in Tujiin Nars, approximately seven years old.

conditions. Survival rates might increase if northern slopes were used; in the transition zone between forest and steppe, conifer forests exist naturally only on the northern slopes and at higher altitudes. Southern slopes and valleys are generally covered by steppe vegetation (Walter and Breckle 1986; Hilbig, 1987; Dulamsuren, 2004). Treter (1996) compared the relative radiation of northern and southern slopes with flat areas. On 40° northerly slopes, the relative radiation amounts to 37 percent of radiation on flat areas. On 40° southerly slopes, the radiation amounts to 140 percent. Use of slopes for pine trees is limited, however, by tractor accessibility. According to Zhou (2000), the uncovering of mineral soil—for example, by ploughing—greatly improves growing conditions.

Success of planting initiatives might be improved by timing planting to coincide with a period of high precipitation, but the law currently requires planting to be done in May, which is a time of very low precipitation. Some ecologists suggest planting in August, when rainfall is double that in May (Savin et al., 1988). These authors also report high water stress resistance for larch trees located close to steppe, which was not apparent from the results of this research. Nevertheless, in one case a responsible forester in Tuijin Nars

planted larch trees instead of pine, with greater success than other pine sites studied. Usually pine trees grow well on poor planting sites, while larch should be planted on parachernozems at higher altitudes. The annual shoot length of larch trees demonstrates slow average growth rates. The annual shoot length of pine trees demonstrates a good growth in height once trees are well-established. The great variation in shoot length for both species indicates that some trees are not growing to their full physiological potential. The highest risk of failure due to physiological stress factors (excluding fire and grazing) occurs during the first three years after planting.

Most of the sites investigated showed signs of natural regeneration—often at higher densities than the planted species. The main stress factors identified for planted seedlings (water stress, grazing and fire damage) can also be expected to apply to natural regeneration. However, naturally regenerating seedlings are likely to have considerable advantages over planted stock, as a naturally placed seed will germinate when conditions are favorable, and can “grow into” the local conditions as the root will find available water and grow at a rate dictated by water supply. Planting a seedling with established water



Ten years after a fire on this planting site, there are a variety of pioneer species but few planted trees remain.

requirements and an unnaturally shaped root system into the ground is likely not to work, especially if the timing does not coincide with the period of maximum water availability. Also, a seedling growing naturally will be protected from grazing in the initial stages as the surrounding ground vegetation will make it less conspicuous, whereas a seedling planted in cleared ground will be readily visible. Incorporating management practices to promote natural regeneration of Mongolia's forests may be of great benefit, requiring a lower initial investment than tree planting programs, and potentially less opportunity for corruption.

The natural process of succession for southern taiga forests as starting after fire or clear-cutting has been described by Krauklis (1987). If this process is not interrupted by cattle grazing, the herb vegetation will be replaced by deciduous trees after several years. Birch trees and poplar will dominate the composition of forest during the next 100–150 years. Under the canopy pine, larch and fir conifers will grow and slowly replace the deciduous trees. In the surveyed sites, which were up to 11 years old, about half of the area was already covered by young deciduous trees. At this stage, the admixture of conifers may not be optimal, because the evapotranspiration of the existing young trees is probably greater than for the herbaceous vegetation, so any planted seedlings suffer a shortage of water. In these cases, the silvicultural recommendation is to wait 30 to 50 years, then remove utilizable birch trees and underplant small

openings with larch trees by hand. This underplanting imitates the natural process (Kuper, 1994). The removal of natural regeneration in favor of planting conifers should be avoided at all costs; maximum efficiency would be obtained by using planting capacity in areas without natural regeneration.

Another option to enhance forest regeneration is to avoid clear-cutting. Pitterle (2003) stressed the importance of avoiding clear-cuts in order to ensure a sustainable use of forest resources in Mongolia if for no other reason than the harsh climatic conditions. Unfortunately, it is not known how much shelter is necessary for reliable regeneration in these “pseudo-taiga” forests (Korotkow, 1976). Walter and Breckle (1986) observed that pine seedlings in Siberia show the best growth rates under canopy, if the relative radiation amounts to 63 to 71 percent compared to conditions without forest cover. A good long-term investment to support forest regeneration would be research into the comparison of shelterwood cuttings with different radiation regimes on the forest floor. A study could be made of five stands, for example, where 50, 60, 70, 80, and 90 percent of stocking timber volume is removed, with the remaining seed trees equally distributed in the stand. Over the next five to ten years, the survival of seedlings and their growth rates could be observed. This would enable determination of the maximum rate at which trees could be removed from old-growth forest that would still allow reliable regeneration.



Ten years after a fire on this planting site, there are a variety of pioneer species but few planted trees remain.

## 2. Tree Planting in Southern Mongolia

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All the southern planting sites investigated were located in steppe desert and true desert regions. The choice of sites was much more limited than for the northern regions, as few planting initiatives have taken place in this region in recent years. The first research on the possibility of using saxaul in planting programs in southern Mongolia was carried out in the 1960s and 1970s, but was found to be of limited use and ceased soon after. Only five saxaul planting projects in Mongolia have been established in recent years (Tsogtbaatar, *pers. comm.* 2006), although the number is set to expand with the implementation of the Green Wall program.

### Methods

Seven planting sites were sampled in three southern aimags—Gov-Altai, Ömnögov, and Dundgov (Figure 2 p.8). At the four pure saxaul sites, survival rates of planted trees were assessed. At the three Green Wall sites, it was too early in the project to determine survival. A systematic sampling method was used, counting the surviving trees of every fourth planting row to give a sampling intensity of 25 percent. Due to the extremely small size of many of the surviving trees, height measurements were taken only at Site 3 which had the highest survival rates. At all planting sites, information was collected on the time of planting, cost of planting, tree species used, density of planting or seed sowing, use of irrigation after planting, and survival rates in the first year after planting. Observa-

tions were made of evidence of planting activity and the condition of any fences present.

In addition, eight areas of natural saxaul forest were investigated, by establishing four 900 m<sup>2</sup> (30 × 30 m) rectangular sample plots at every study site. Some of these study sites were utilized by the local population for fuelwood, while others were inaccessible and classified as pristine. At each site, the soil type was determined. The stem diameter and height of the saxaul trees were measured. Young trees less than 30 cm in height and 1 cm in stem diameter were classified as regeneration. For an approximation of a possible non-destructive fuelwood harvest, the weight of dead trees and wooden debris on the ground was estimated.

### *Saxaul Planting Site Descriptions*

**Sites 1–3:** These were all planned and conducted by the same dedicated professional forester, Ms. Byambaa. All the planting was done with 3–4 year-old seedlings taken from the nursery and experimental planting site at the aimag center of Mandal Gobi. This is currently the only saxaul nursery in Mongolia. The saxaul seeds were harvested in October of the year before planting and originate from the northernmost population of saxaul in Mongolia, about 170 km south of the aimag centre at Ulaat. The seed collection is no longer organized by the state, as it was in the 1970s and 1980s, resulting in a shortfall of seedlings for the nursery. The planting sites examined were dictated by the government, and seem not to have taken into

account conditions like good water access and distance from permanent livestock. Prior to planting, the site was prepared by digging planting trenches with a tractor and by building a fenced enclosure. Fences for Sites 1 and 2 were constructed from pine poles, which were transported from northern Mongolia, with two strands of barbed wire, at heights of 1 m and 1.5 m. These were not an effective barrier against livestock, and camels especially were easily able to get over the fence to browse the seedlings. In addition, parts of the fences were stolen and not replaced. Site 3 had no fencing at all, probably because of its large area. On all three planting sites, the seedlings were watered by hand in the year of planting, with the water transported to the sites by tractor. All the work was undertaken by 20 workers who were all seasonal employees of the tree nursery.

Site 1 is located 24 km southeast of Mandal Gobi at an elevation of 1,100 m. The planting of 2,500 saxaul, 2,500 elm, and 2,500 willow (2–3 years old) seedlings began in 2004. The land is flat and shows apparent signs of overgrazing, as there is only a very sparse grass cover. The fence enclosing the plantation is partly missing and in poor condition. The planting trenches are about 15 cm deep and show signs of erosion. Site 2 comprises pure saxaul and is located 17 km away from Mandal Gobi. It was started in 2002 when, according to the local forester, about 9,000 2–3 year-old saxaul seedlings were planted on 60 ha. The land slopes slightly to the south. The ground is covered by medium-sized gravel and has patches of grass. The trees were planted 3 m apart, in rows 20 m apart. Some of the area was planted using seeding. Site 3 is the oldest existing saxaul site and was established in 1989 and extended in 1996. It covers 120 ha and is located 130 km southwest of Mandal Gobi. A water pump in the center of the site stopped working in 1995. It is located on flat land on the bottom of a valley. School children helped with the first project, which covered 20 ha and was part of a government-funded community development program. The second project, covering 100 ha, was initiated by the local forester using 2–3 year-old seedlings.

**Site 4:** This 4-ha site was initiated in 2003 by a local bag governor in Erdene soum, Gobi-Altai, in 2003. It is located 100 m north of the bag settlement close to a small oasis. Intensively utilized saxaul forests grow

nearby, but according to the bag governor, the planting site itself was always free of saxaul. Seeds were buried 10 cm deep into the sandy soil, with 1 m between seeds and 2 m between the lines. The work was done by the local community without expert advice. The seeds were collected in October and planted in May. No fence was built and emerging seedlings were not watered.

### Green Wall Planting Site Descriptions

**Site 5:** This is part of the Green Wall program and is located near the bag center of Gurvansaikhan. It is divided into two planting areas of 0.5 ha with a pump station in the center and a fence enclosing both areas. Four tree/bush species were planted—sea buckthorn (*Hippophae rhamnoides*), silverberry (*Eleagnus mucroftii*), poplar, and Siberian elm, all planted as 2-year-old seedlings, 2 m apart, with 4 m between the rows.

**Site 6:** This is also part of the Green Wall program, and is located just 500 m west of Dalanzadgad. The reason for planting so close to the town was to create a barrier against dust storms. It is an 80-ha site bordering a state tree nursery established in 1980. The nursery grows poplar, Siberian elm, silverberry, and tamarix. The planting site has been planted with Siberian elm, most of which originated from the nursery or elsewhere in Mongolia, but many of the seedlings were imported from China.<sup>5</sup> The fence construction, well drilling, irrigation system, and planting



Green Wall planting sites are funded by the Mongolian government and Korean NGOs.

were supported by Korean NGOs. At the start of the project, in 2003–04, 5,300 seedlings were planted. In the following year, another 20,000 trees were planted. The planting distance is 2 m between seedlings and 3 m between rows. Groundwater is pumped up from a depth of 30 m and stored in a large tank.

**Site 7:** This Green Wall site is located 35 km southwest of Dalanzadgad and is named Juulchin Gobi. About 60 ha have been fenced, and up to August 2005 about 8,000 trees, mostly Siberian elm from China, had been planted. It is intended to plant 30,000 more trees on the same site. An irrigation system, which provides a water tap every 50 m, is supplied by a 90 m well. All work was assisted by Korean Rotarians, and was executed by local citizens.

Sites 5–7 are all part of the Green Wall program and are managed with expert advice from the Institute of Geocology (Mongolian Academy of Sciences). Not surprisingly, they were all well prepared for planting. The young trees were transplanted from the nursery at 2–3 years of age at a height of about 60 cm, and



Green Wall sites are generally well prepared, and have wire fencing.

planted in separate holes together with the original soil and manure. The holes, 30 cm deep and 80 cm across, were dug with a plough. The depth of the hole provides enough shading for the saplings and allows effective irrigation. All these sites had fences that were adequate to exclude livestock; the wire stretched from ground level to about 1.5 m and was in good condition. They also have permanent wells, which pump groundwater from 50 to 100 m to water taps every 50 m. Irrigation ranges from 40 to 100 liters per week per seedling. To avoid water loss due to evaporation, the watering usually takes place in the evening or at night. Full-time workers are responsible for watering the trees and the practical management of the site. If trees die, they are replaced the following year. It is planned to reduce the volume of water used over the years to encourage the trees to adapt to the arid conditions.

## Results

The results of the site assessments are shown in Table 10 and Table 11. Survival rates were assessed only for the saxaul planting sites; the long-term success rates of the Green Wall planting sites are not yet known.

### *Survival Rates*

In the first year after planting, the success rate of all the projects was very high, with a minimum reported survival rate of 70 percent. These figures were evaluated by a governmental working group six months after the planting and determined the payment of the second half of the allocated budget. In the case of Site 4, the survival numbers were evaluated by the initiator of the project (the local bag governor).

In Sites 2 and 4, no trees were alive after one and three years respectively. Site 1 had a survival rate of 0 percent for the planted elm and willow seedlings. The 2,500 saxaul trees at this site showed no above-ground biomass, but 100 of the roots (4 percent) had shoots and could develop into trees again if protected from grazing (Figure 7).

<sup>5</sup> The Chinese seedlings (used in the Korean-financed sites) are less expensive than seedlings from native trees but are less adapted to the arid local environment. This is especially true for species of elm and poplar.

Table 10: Overview of the Saxaul Planting Sites

Site no.	Location	Trees	Authority	Time of planting	Size of the project	Financing institution	Costs at time of planting	Cost per ha	Supervision	Success in first year (reported rate)	Success in 2005	Reasons for failure
1	Mandal Gobi	Saxaul, elm, willow	Aimag	May 2004	15 ha	Government	1 million Tg in the year 2004	66,700 Tg	Local forester	60 percent growing success (elm, saxaul)	0 percent survival of elm and willow. 4 percent of saxaul trees survived.	Livestock and limited irrigation
2	Mandal Gobi	Saxaul	Aimag	May 2002	60 ha	Government	no data	No data	Local forester	70 percent	0 percent, no trees visible	no irrigation
3	Mandal Gobi	Saxaul	Aimag (trial project)	First planting April 1989, second planting in May 1996	120 ha	Government for 100 ha in the year 1996	6 million Tg	50,000 Tg	Local forester	75 percent	On the 100 ha planted in 1996, 8 percent survived, mean height 43 cm.	Livestock and limited irrigation
4	Gobi Altai	Saxaul	Bag governor	May 2004	4 ha	Local community	no direct costs	no direct costs	Bag governor	unknown	0 percent, no seedlings visible.	Livestock and no irrigation

Table 11: Overview of Green Wall Planting Sites

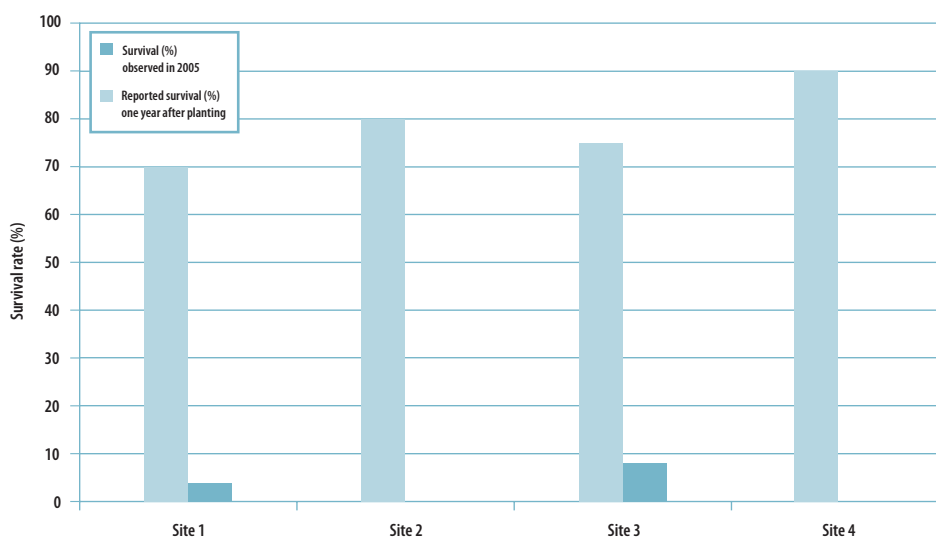
Site no.	Location	Trees	Authority	Time of planting	Size of the project	Financing institution	Costs at time of planting	Cost per ha	Supervision	Success in the first year (reported rate)
5	Mandal Gobi coordinate 45°32'965" N 107° 04'811" S	Sea buckthorn, silverberry, poplar, elm	Green Wall Program	May 2005	1 ha	Mongolian Government with Korean NGOs	No data	No data	2 full-time employees	95 percent
6	South Gobi, next to Dalanzadgad	Elm	Green Wall Program	2003	80 ha	Mongolian Government with Korean NGOs	120 million Tg	1.5 million Tg	7 full-time employees	70 percent
7	South Gobi 35 km south of Dalanzadgad	Elm	Green Wall Program	2005	60 ha	Mongolian Government with help from Korean Rotarians	160 million Tg (not complete)	2.6 million Tg	6 full-time employees	77 percent

The highest survival rate, 8 percent, was found at Site 3. The surviving seedlings were all part of the latest planting in the year 1996; no seedlings have survived from the 1989 planting. Compared with seedlings of the same diameter class (1–3 cm) at the home nursery and in natural forests, the surviving ones at the saxaul sites are much shorter, with an average height of 43 cm compared to 58 cm in natural forests,<sup>6</sup> and 71 cm at the nursery (where the trees were irrigated). About 80 percent of

the surviving trees were found within 150 m of the access point. This might be caused by poor irrigation or by incomplete planting further away from the access point.

<sup>6</sup> The data of the natural forests is derived from eight locations with very different site conditions, and hence great variability. The numbers are an indication of the importance of irrigation and site selection if saxaul is planted.

Figure 7: Comparison of Saxaul Survival Rates One Year after Planting and in 2005



### Number of Trees Planted

A comparison of the number of trees planted per ha at the saxaul sites in Mandal Gobi and at the Green Wall sites shows that the tree density is about 137 trees per ha higher in the latter (Figure 8). At the tree-planting site in Gobi Altai, 1,250 seeds were sown per ha, but according to the bag governor only a small percentage germinated. The estimated number of natural regeneration (seedlings up to 30 cm height) per ha in natural saxaul forests is approximately 845 (mean density value of seven inventoried sites, excluding one site with extremely high density, Table 13).

### Irrigation

Saxaul trees need sufficient water in the juvenile phase of their development, requiring a great deal of irrigation. The Green Wall program sites at Dalanzadgad consume about 1.3 million liters of irrigation water per ha annually. This is about 1.5 times the amount of natural precipitation, assuming annual rainfall of 100 mm (Figure 9).

### Costs

The higher costs (about 30 times) of the Green Wall program compared to the earlier saxaul plantings

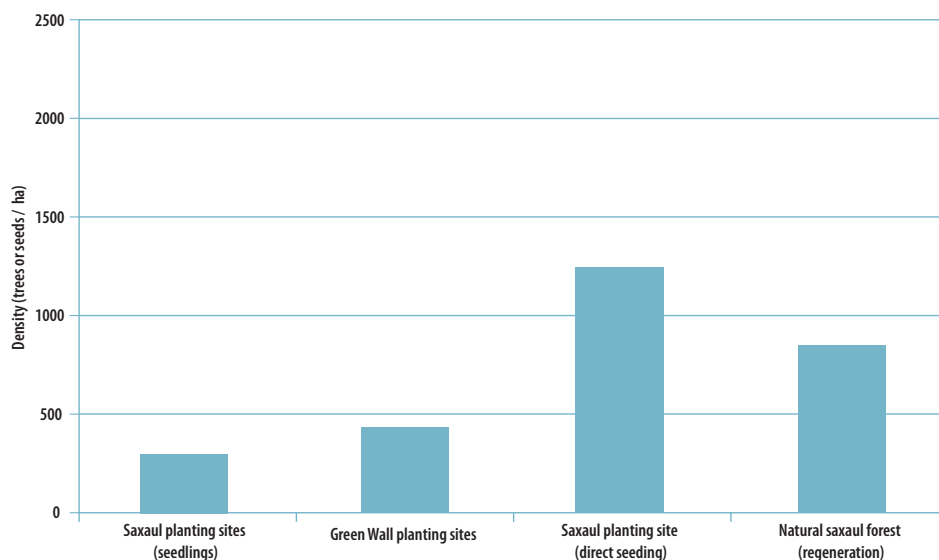
are a result of the higher professionalism and a much greater resource input (Figure 10; Table 12). Irrigation systems and fences at the Green Wall planting sites together with the salaries of the permanent workers (about 40,000 Tg each per month) were important contributing factors. The water used for the irrigation is free, so only the cost of pumps (or manual distribution) is included. The cost for manual distribution of water differs according to distance and frequency of irrigation, as they are mainly transportation costs. The imported seedlings are less cost-intensive, as they are mass-produced in China.

### Natural Regeneration

The results of the inventory of eight natural saxaul planting sites (Figure 2) are shown in Table 13.

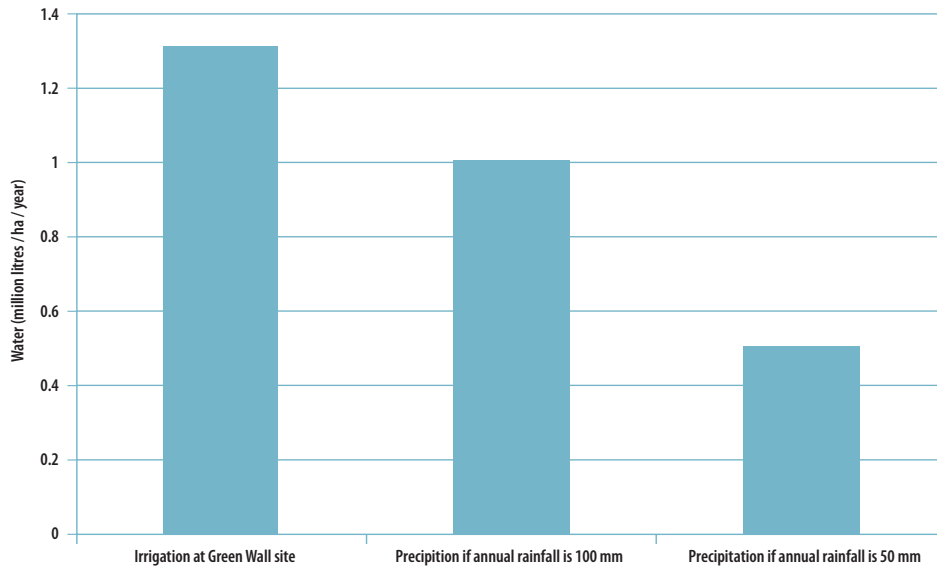
It was not possible to derive even qualitative data on the impact of fuelwood harvesting on the ecology of saxaul forests from this inventory, as the different site factors and the limited extent of the study made a direct comparison between the different forests very difficult. Differing parameters like basal area and the number of stems / ha vary with site conditions and cannot be causatively linked to the harvesting of saxaul.

**Figure 8: Comparison of the Average Planting Density of Three Different Types of Planting Project and the Seedling Density in Natural Forest**



The figures for the saxaul and the Green Wall sites are mean values. The numbers for the natural forest are mean values from the natural regeneration plots.

**Figure 9: Comparison of the Amount of Water Added Annually per ha by Precipitation and by Irrigation in the Green Wall Program (Juulchin Gobi)**



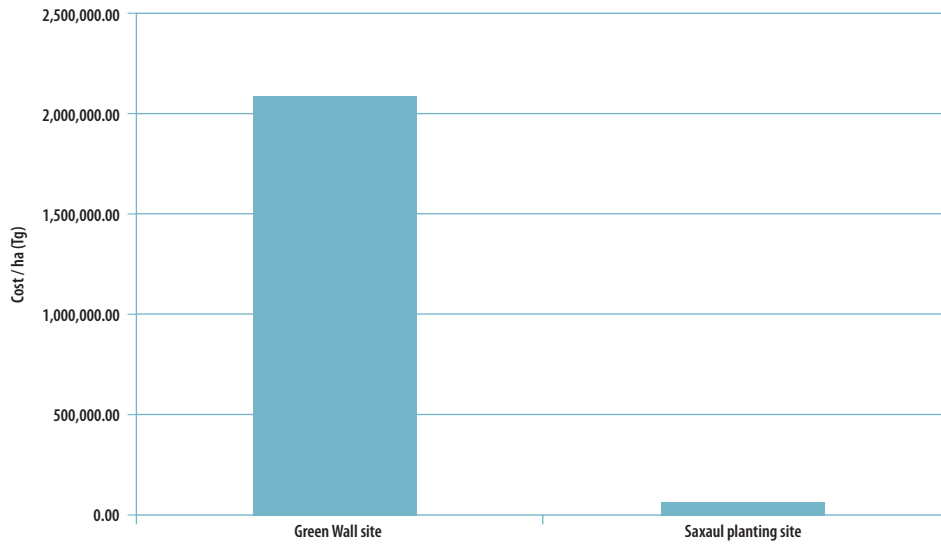
Tree planting schemes in arid areas require vast amounts of irrigation if they are to successfully establish.

**Table 12: Comparison of Cost Factors in Southern Planting Programs**

Higher cost	Lower cost
Permanent water pump	Water brought out manually = no investment costs
High quality fencing (wire fence from China)	Poor quality fencing
Permanent workers	No workers
Mechanized implementation	Planting by hand
Locally grown seedlings	Imported seedlings

According to the observations made, people harvest mainly dry, dead saxaul trees for fuelwood. The forest locations where people harvest fuelwood showed a much lower amount of harvestable saxaul than pristine forests, indicating the large amount of biomass that is extracted from the ecosystem by the harvesting operations (Figure 11).

**Figure 10: Comparison of the Mean Implementation Costs (Tg) of the Different Projects in Southern Mongolia**



The costs are total, not per year. Some of the figures were not derived from official sources and may be inaccurate, but any inaccuracies are not expected to significantly impact the enormous cost differential.

**Figure 11: Mean Basal Area per ha and the Maximum Amount of Harvestable Dry Saxaul at Utilized and Pristine Locations**

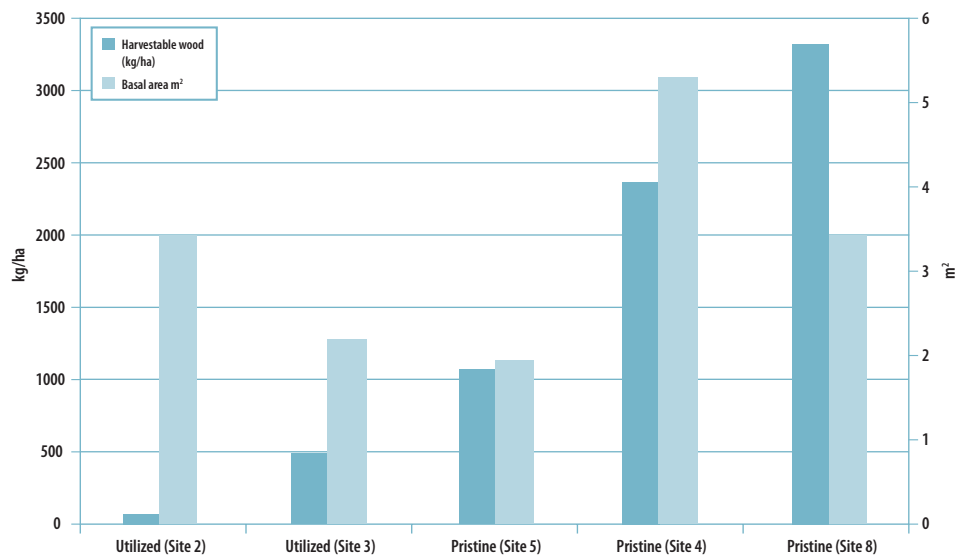


Table 13: Inventory Data of Natural Saxaul Forests At Eight Different Locations (Focusing on Regeneration)

Site no.	Location	Soil	Basal area		Total number of stems / ha		Regenerating seedlings / ha (root collar class <1 cm)		Harvestable dead wood kg / ha		Mean height of regenerating seedlings (root collar class <1 cm)		Seed trees / ha		Stump germination / ha	
			Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
<b>1</b>	N:44°41'302" E:103°41'882"	Sand /Brown Desert Soil	<b>1.33</b>	(0.63)	<b>6321</b>	(4488)	<b>1828</b>	(3374)	<b>n.d.</b>	n.d.	<b>35</b>	(24)	<b>n.d.</b>	(n.d.)	<b>n.d.</b>	(n.d.)
<b>2</b>	N:44°37'247" E:97°21'574"	Sand	<b>3.42</b>	(2.44)	<b>3227</b>	(1664)	<b>678</b>	(1289)	<b>74.5</b>	(2.36)	<b>54.61</b>	(8.92)	<b>36.08</b>	(57.59)	<b>130</b>	(21)
<b>3</b>	N:44°49'071" E:97°20'579"	Gray Brown Desert Soil	<b>2.18</b>	(0.35)	<b>882</b>	(353)	<b>593</b>	(304)	<b>489.5</b>	(17.6)	<b>43.81</b>	(15.71)	<b>55.50</b>	(28.66)	<b>22.2</b>	(9.06)
<b>4</b>	N:44°18'696" E:97°00'154"	Gray Brown Desert Soil	<b>5.3</b>	(5.33)	<b>2464</b>	(601)	<b>1190</b>	(659)	<b>2369</b>	(69.33)	<b>59.53</b>	(34.76)	<b>8.33</b>	(16.65)	<b>2.75</b>	(5.5)
<b>5</b>	N:44°23'262" E:97°03'789"	Gray Brown Desert Soil	<b>1.93</b>	(0.52)	<b>688</b>	(171)	<b>155</b>	(60)	<b>1072.5</b>	(36.7)	<b>35.65</b>	(3.66)	<b>0</b>	(0)	<b>0</b>	(0)
<b>6</b>	N:44°23'964" E:101°15'711"	Solonchak	<b>0.72</b>	(0.35)	<b>840</b>	(429)	<b>352</b>	(241)	<b>n.d.</b>	n.d.	<b>24.71</b>	(3.54)	<b>24.71</b>	(1.71)	<b>58.28</b>	(18.96)
<b>7</b>	N:44°23'978" E:101°15'834"	Sand	<b>3.17</b>	(0.75)	<b>18159</b>	(8913)	<b>13891</b>	(7914)	<b>n.d.</b>	n.d.	<b>94.10</b>	(38.28)	<b>0</b>	(0)	<b>0</b>	(0)
<b>8</b>	N:44°07'381" E:101°43'095"	Sandy Clay	<b>3.4</b>	(3.0)	<b>1332</b>	(454)	<b>1118</b>	(756)	<b>3324.75</b>	(153.93)	<b>98.22</b>	(31.14)	<b>230</b>	(65.59)	<b>13.88</b>	(5.55)
<b>All</b>			<b>2.68</b>	(1.67)	<b>2251*</b>		<b>845*</b>		<b>1466</b>	(55.9)	<b>43.5</b>	(17)	<b>71</b>	(21.2)	<b>45.3</b>	(12.0)

\* Mean value excluding Site 7, which had extremely high density.



Planted seedlings can survive, but only if irrigation is sufficient and they are protected from livestock.

## Discussion

A major reason for the high mortality rates of the saxaul seedlings is that the growth of a normal taproot may be inhibited by the shape of the nursery seedling container. Consequently, the seedlings easily dry out shortly after planting. Most of the remaining saxaul seedlings which survived planting died after the watering stopped. At the three planting sites at Mandal Gobi, the seedlings were only watered twice after planting. According to the supervisor, the small budget restricted irrigation, as the transport of water to the planting sites was difficult and expensive. In natural forests, regeneration is most frequent after a winter with greater-than-average snow (white dzud) or with rain early in the year. The survival of container-transplanted saxaul seedlings can be increased by 33 percent if post-planting irrigation with five liters is applied three times (Lalymenko, 1998). After the trees have established a sufficiently extended root system, they are extremely drought-resistant and can survive without precipitation for more than a year (Walter and Breckle, 1986). Species like Siberian elm and poplar, which are planted in the Green Wall program, need to be hardened off in their juvenile growth stages in order to adapt to the arid conditions, meaning that the amount of water supplied at least twice a week is slowly reduced. But

irrigation is required for at least three years (Odsurin, nursery manager, *pers. comm.*, 2005). The removal of groundwater in large quantities can be contradictory to the initial aims of the Green Wall program, thus accelerating the already observed lowering of the groundwater table in southern Mongolia (UN Report, 2005). The transpiration of the trees will lead to a further lowering of groundwater.

The second major cause of failure is due to grazing by livestock. As reported by other authors (e.g. Walter and Breckle, 1986) and also as indicated by the results of this study, saxaul grows easily from its stumps. This is probably an adaptation to browsing, as the tree is often the only source of green biomass in arid regions. However, seedlings are vulnerable and must be protected if the planting initiative is to be successful. At Sites 1 and 2, the last seedlings were browsed after the fencing was breached following lack of maintenance and theft. The relatively high survival rate of 8 percent at Site 3, despite the lack of fencing, is explained by the remoteness of the location, and because livestock herders had left after the well pump broke. However, even this minimal success cannot justify the investment in the project. In Gobi Altai (Site 4), there was no fencing or irrigation, and according to the bag governor the few seeds that germinated soon dried up and were browsed. Saxaul seedlings and

trees are especially favored by camels. Goats are more of a threat to species of elm, willow and tamarix.

Of the four saxaul sites investigated, none was chosen for its ecological suitability for tree growth. Water is the most important factor; the success of planting in arid lands depends largely on an adequate water supply (Lamprecht, 1990). The natural growing conditions of saxaul are determined by the availability of groundwater, the moisture content of the soil, and the soil salinity. That these conditions are not met everywhere in southern Mongolia is indicated by the disjunct distribution of saxaul. Only at planting sites close to groundwater with grey soils of loamy and sandy texture (grey desert soils) can the tree reach heights of 5 to 6 m (Walter and Breckle, 1986). The different densities at which saxaul occurs naturally in southern Mongolia (Table 13) is also an indication of how sensitive the trees are to local conditions. This has also been shown by investigations in natural saxaul forests in China, where differences in stand densities and regeneration of up to 90 percent were observed between different planting site conditions (Liang, 1999). The saxaul sites were located in areas 150 km from the nearest natural saxaul forest at Ulaat, which is very isolated from the main saxaul area in southern Mongolia (see Figure 2). The planting of saxaul or other trees in southern areas a long way from settlements is of very little ecological benefit, as the results are very likely to be the opposite of what is intended. For example, instead of reducing



Many of these planting projects meet with little success, and the considerable investment is not justified.

desertification, planting may actually *reduce* groundwater, causing a loss of agricultural production and the drying up of wells, which in turn leads to further concentration of livestock in certain areas and a further decline of the natural vegetation.

A comparison of the monetary and resource input of the saxaul plantings and the Green Wall program indicates that if a large-scale planting project in southern Mongolia is to be successful, a highly professional multiyear input is needed. It is very difficult to justify these projects, taking the high risk of failure into account; a water pump malfunctioning for just one week can cause the total failure of a project. The integrity of fencing is also vital. A large-scale tree-planting site of 10 ha, typically 100 m by 1,000 m, needs 2,200 m of fencing. It is nearly impossible to assure the integrity of such a fence for, say, up to five years. If saxaul planting projects are necessary, it is better to plan and support small projects at specific locations close to groundwater. They require a long-term budget that finances the salary of responsible persons to assure adequate post-planting management. Local initiatives, (e.g. at Site 4) that are not driven by the expectation of financial benefit should be supported technically. Small-scale planting projects could perhaps be integrated into agroforestry systems, where the trees can improve the growing conditions for agricultural crops.

The limited availability of seed is a major obstacle to saxaul planting projects in southern Mongolia. Site 4 used a direct seeding approach with a density of only 1250 seeds / ha—this is incredibly low given the expected high mortality of this approach. It is extremely difficult to obtain enough seeds for the production of seedlings, as the former government-organized collections no longer exist. At all four saxaul sites, the quality of the work and the indication of former planting activity decreased with the distance from the access point. This suggests that only part of the area was actually planted, which was probably because of a lack of seedlings. The existing nursery in Mandal Gobi should be supported and extended. In addition, there is really very little experience with saxaul planting projects in Mongolia (Tsogtbaatar, *pers. comm.*, 2006), so it is necessary to start research programs and collect data from other countries. China and countries of the former USSR have long and successful experience of conducting arid land planting, and specific knowledge of the saxaul



Seedling survival rates were poor at evaluated sites.

tree and its management. There are also examples from the desert regions of Turkmenistan, where recent successful saxaul planting projects have been conducted on sandy areas by the low-input method of seeding.

However, much better than investing in planting projects, it is more appropriate and effective to support the growth of trees growing naturally. The area of natural saxaul forest in Mongolia is more than 2 million ha. It is more reasonable to protect these resources

than to put much effort into the planting of naturally tree-free areas that will, even if successful, cover only a small part of the desert steppe. The reported lowering of the groundwater table and the decrease of precipitation in the context of climate change are probably one reason for the decline of natural saxaul forests. Another is the intensive utilization of the forests for fuelwood. Removal of dead wood for fuel severely interferes with the nutrient cycles, having a negative effect on the growth of the saxaul forests. Despite the increase of aridity, there is still natural regeneration of saxaul forests, and there is an indication that extreme climatic events like heavy snowfall enhance the regeneration of these forests. Areas of intense natural regeneration should be protected from browsing and fuelwood collection. Trial projects of this kind have been established by the New Zealand Nature Institute in the Bulgan region.

Harvest of saxaul could be reduced if there was an increased focus on using fuelwood efficiently, and if alternative energy resources were made available. Administrative buildings and schools that still rely on saxaul for their energy should be enabled to implement different heating systems. Several projects have focused on the manufacture of fuel briquettes, such as a project in Shinejjist which produced them from dung, clay, and coal fragments. These briquettes can decrease fuelwood harvests, facilitate income generation for local people, and in some cases have been shown to reduce indoor air pollution. However, it should be noticed that the use of dung in briquettes impacts carbon and nutrient cycling in the soil. Over the long term this can cause depletion of soil nutrients, and it must be ensured that fuel briquettes are made from sustainable sources.

## 3. Recommendations

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**T**he most effective means of restoring forest landscapes for the lowest cost would be through designing programs to promote natural regeneration of degraded forest landscapes, rather than investing in costly planting programs that have met with little success to date in either the northern or southern regions. For the planting sites studied in southern Mongolia, naturally regenerating sites had a denser distribution of seedlings than the planted sites, were more vigorous than planted seedlings, and required no intervention other than protection. However, if planting programs are regarded as a (political) necessity, then success can be increased and the wastage of state and other resources decreased if the following recommendations are adopted.

### Planning

Before embarking on a planting program, there must be sufficient supplies of locally adapted seeds and seedlings. In addition, planting sites must be selected on the basis of ecological considerations. Northern planting sites may be more successful on north-facing slopes in areas that have supported forests in the recent past. Southern planting sites should be located at locations close to groundwater and within the natural range of the vegetation.

### Site Preparation

Natural regeneration should never be removed when preparing a planting site. In the case of the northern forests, natural regeneration of deciduous trees (birch and poplar) can be utilized after approximately 50 years to shelter under-planted conifers and accelerate natural succession. Water supplies are crucial and should be maximized; the planting should be timed to take place during the season best-suited for planting, and sufficient water for irrigation must be available. Pumps must be well-maintained, as even short-term failure of a pump in southern planting sites would likely result in the complete failure of the project. Steps to minimize disturbance to the planting site should be taken—for example, in northern forests, fire protection strips would decrease fire damage, although this requires maintenance to be successful and hence is costly. In both northern and southern areas, protection from grazing is important, and well-maintained fences will greatly improve survival rates of the seedlings. Most vital, a secure budget should be provided for responsible people to care for the sites for several years after the planting.

### Research

Experience with planting projects in Mongolia should be increased through targeted research on long-term study plots, and the collation of data from comparable

sites outside Mongolia. In the northern forests, continuous-cover forestry is likely to be most appropriate, as the remaining trees will shelter seedlings for faster recovery of the forest. To design such programs, it will be necessary to determine the maximum rate of tree removal in old-growth forest that will still allow reliable regeneration. This should be studied in the context of the impacts of different intensities of fire,

which are part of the natural ecosystem dynamic and can be beneficial to the forest stand.

## Partnerships

Projects with the support and involvement of the local community should be supported for the greatest

### Box 1: Natural Regeneration of Forest Landscapes

#### Conifers

Initiatives for the restoration of forest landscapes in Mongolia would do well to take advantage of natural regeneration processes. In northern forests, it was clear from the study that many of the planted sites were already supporting young naturally regenerated trees, although broadleaf species were more common than conifers. This is the natural route succession on open sites, and it must be accepted that coniferous trees may not be the best suited to grow, at least initially, on many sites where mature forests were found previously, because site conditions may make it difficult for them to become established. To accelerate the recovery of the site to a conifer forest, it may be justified to underplant regenerated broadleaved trees (when they are 30 to 50 years old) with conifer seedlings, clearing openings to allow for their rapid growth. This would mimic the process of natural succession, with the broadleaved trees providing shelter for the conifer seedlings. However, human-assisted regeneration of this type would need careful supervision for quality of work and care after planting, for example clearing vegetation competing with the seedlings. There is also the risk that the activity of planting out seedlings will trample naturally-regenerated seedlings.

One of the key factors which prevents landscapes from becoming forested is the presence of grazing animals. Keeping livestock out of an area should enhance natural regeneration and therefore fencing—or strict and agreed grazing management—is vital. It is not really practical to fence large areas—and if fencing were done with timber, this could result in further pressure on forest resources. Fenced areas should concentrate on priority sites—for example, logged sites prone to erosion—and materials should be durable and re-useable where possible. Protection of regenerating sites from grass fires in their early years would also be of benefit, and fire protection stripes could be created. Both fencing and fire protection stripes would require ongoing maintenance, and the investment is likely to be worthwhile only in areas which are accessible for supervision, or in places where the local community have vested interests in the long-term outcome of the project.

Preparation of sites to enhance natural regeneration may also be a possibility—exposure of mineral soil through ploughing can enhance regrowth, as can the incorporation of forest litter (organic matter) into the soil. State programs in Mongolia already include payments for regeneration activities, but more specific research on which management regimes are most effective, and how a program could be supervised, is required. It may be that such activities are only cost-effective when as part of a legal logging operation. Ongoing logging operations can also be managed to ensure the best chances of successful natural regeneration. Clear-cutting should be avoided and is in fact no longer legal in Mongolia. Remaining trees can be used to provide shelter for seedlings, and are also a source of seed. Before logging, the strongest and healthiest ‘mother trees’ should be selected to remain. Logging of a site can also be timed to coincide with a year of high seed crop—it is possible to determine this earlier in the year by examining developing cones. Site preparation may also be of benefit, although the logging operation itself may disturb the soil enough to allow good seeding establishment and growth. Research is needed to identify the maximum rate at which trees could be removed from old-growth forest that would still allow reliable regeneration.

#### Saxaul

Saxaul forests are under pressure from harvesting and grazing from livestock, and for regeneration to succeed these pressures must be eased. Fencing areas to prevent livestock from entering, and developing agreements with local communities not to harvest from these areas would be necessary. Developing an agreement whereby local residents have the right to benefit from the regenerated forests, by sustainably using the resource for fuel or grazing in times of severe drought is key to such a program, as it will require long-term involvement of the communities in terms of keeping animals out of the area, respecting the agreement not to harvest, and being involved in the maintenance of fences.

long-term sustainability. In those areas where local community members are employed as a source of labor for the initial implementation of the project, but have no interest in the long-term outcome of the project, a valuable partnership is lost.

## **Financial Management**

In several cases in northern Mongolia, it appears that some sites that had been reportedly planted, had not. Others were smaller than reported, or had suffered from poor quality of workmanship. This suggests that planting programs are providing an easy opportunity for stealing funds. In future, financial support for any planting company should depend on the success

of their tree-planting sites and transparent financial reporting should be introduced.

## **Alternatives**

Most importantly, scarce financial and human resources need to be directed toward protecting and managing the forest resources that still exist in Mongolia. This requires increased attention to the prevention of illegal and unsustainable harvesting. In areas of heavy harvesting pressure on limited forest resources, programs to promote sustainable alternative fuel sources and increased efficiency of fuelwood use would be of great benefit.



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