GOVERNMENT OF MONGOLIA,
GOVERNMENT OF THE NETHERLANDS
AND THE WORLD BANK

THE IMPLICATIONS OF
NATURAL DISTURBANCE REGIMES
FOR FOREST MANAGEMENT
IN MONGOLIA

Prepared by

Mike A. Fenger
Forestry Policy and Disturbance Ecology Specialist
mfenger@pacificcoast.net
Professional Forester
Registered with Association of British Columbia Forestry Professionals

A report prepared for

The Ministry of Nature and Environment
Government of Mongolia
May 24, 2006

Executive Summary

This report contains a review of forest law and current forest practices in Mongolia. The analysis focuses on how to achieve forest restoration using an ecosystem-based forest management approach. Forest restoration is needed to improve forest health (insects and disease) and reduce impacts from fire in forests that lie outside the natural range of variation. The recent trend to larger more intense fires and increasing forest damage from insects can be mitigated through restoration. Restoration can provide considerable benefit to the rural poor and add to the state economy.

Major conclusions of the report are:

- The word restoration is specifically included in Article 1 of the Forest Law of Mongolia (FLOM). Therefore, the law intended this activity in Mongolia's forests. Restoration is implied in Mongolian Law on Special Protected Areas (MLSPA), since forests in these areas are to be conserved in their natural condition.
- Forest restoration requires changing stand structure and managing fuel levels to those similar to historic conditions. This requires cutting of small trees. FLOM did not contemplate how to carry out restoration, and there is a prohibition on cutting of smaller trees. Specific minor wording changes in the legislation are provided that will enable cutting of smaller trees for the purpose of restoration.
- Damage from forest fires and insects today is unnaturally high. This is linked to the unnaturally high density of smaller trees and unnaturally high levels of forest fuels. This unnatural stand structure is attributed to the cumulative effects of fire suppression, grazing and agriculture that have reduced frequency of low intensity fires. Today, forests contain unnaturally densely-spaced young trees in poor condition, due to stress from competition for moisture and growing space. Restoration is in order in many stands.
- Ecosystem-based forest management (EBFM) mimics historic stand structures, with an emphasis on leaving trees that more closely approximate historic density and fuel levels. Fire and insect impacts are reduced in restored stands. There are considerable benefits to local economy from restoration and removal of smaller trees. An increase in posts, rails, timber and fuel wood will become available from small trees thinned from the forests.
- Forest restoration can be applied to more area than the current utilization zone (7%) identified in the FLOM. Restoration will help Mongolia to meet its goal of self sufficiency in timber. New opportunities for fuel wood and small wood will result from restoration and fuel management.
- Current high-grading harvest (mostly illegal) removes the largest, oldest trees, a practice which is adding to the "unnatural state of forests", as dominant trees are best able to resist insect and fire disturbance. Unnaturally-high levels of large fuel wood are left after high grading (tops and large branches). When this large woody debris burns, the high temperatures damage forest soils and reduce site productivity.

The report recommends the following:

- Make changes to legislation and forest policy to enable forest restoration.

- Adopt an ecosystem-based approach to forest management (EBFM), and develop operational, landscape and stand level components needed to support restoration decisions by Soum and Aimag staff.
- Create a map of Natural Disturbance Regimes (NDRs) based on existing, ecological vegetation classification and maps. Map forested NDRs at an operational scale (1:50,000), suitable for restoration planning, and in a Geographic Information System (GIS) format. Refine NDRs maps using a digital terrain model for slope, and aspect. Verify GIS created map by checking NDRs in the field.
- Refine stand structure classes proposed by (Gray 2006) and map stand structures at an operational scale with maps available in GIS environment suitable for restoration planning. Verify in the field that structural classes mapped from digital remote sensed data are suitably accurate to support restoration planning decisions.
- Map administrative zones identified in FLOM and Mongolian Law on Special Protected Areas (MSLPA), as well as any buffer zones established under Mongolian Law on Buffer Zones (MLBZ). The delineation and mapping of these administrative zones is needed to support restoration planning and must also be available in a GIS format.
- Develop a number of restoration templates at the landscape and stand levels, in order to provide the ecological rational to guide planning decisions that will be made by Aimag and Soum staff.
- Train Aimag and Soum staff in practical aspects of restoration planning and implementation.
- Increase awareness of the need for, and the benefit of, restoration. Search for archival photographs and compare these photographs to the same forest stand taken today. Interview elders on forest conditions, fires and non-timber products. Most Mongolians and many foreign advisors do not understand that the forests in Mongolia are in an unnatural condition, and that the solution to healthy disturbance-adapted systems lies in mimicking NDRs and adapting an ecosystem-based forest management approach. Programs that attempt to eliminate disturbances have not been, and will not be, successful.
- Conduct, in a GIS environment, an analysis of Forest Types to determine the amount each type within the zones identified by FLOM and MLSPA. When verifying NDRs and refining Forest Types identify examples of each type that are within the range of natural variation. Advocate that representative examples of forest types in a natural condition be included in conservation designations such as the Ecological Reserve designation in MLSPA. Representative ecosystems within the range of natural variability are critical as benchmarks from which to compare and adapt forest management policy and practices.

Acknowledgments

This project would not have been possible without funding from the Government of the Netherlands. Thanks are due to many who helped with this report. Ongonsara Purev ably arranged contracts and team logistics. Dr. C. Dugargav arranged for interviews with government staff and identified indicator plants while in the field. Dr. Dashneyan supplied translations during interviews and accompanied presentations made to the students and faculty at the University of Mongolia and the project team. Ehkhtur D and Hans Hoffman of the German Technical Cooperation Program (GTZ) provided helpful insights into the Mongolian forest situation. I also appreciate Dr. B. Enkhmandakh, Vice Minister of Nature and Environment, for his interest in the project.

John Dick, the National Advisor to the Government of Mongolia made useful insights in the larger context for this proposed project. Robert W. Gray, Fire Specialist, shared the interview process and collaborated with me on presentations. I value the fact that Colonel Batchuluun Chimeddorji, from the National Emergency Management Agency (NEMA), and his staff are willing to take NEMA forward, towards a role in fire prevention. Jambalragchaa Byambajav, Forest and Water Research Centre updated me on the forest inventory situation and supplied digital files. The Ministry of Nature and Environment staff briefed us on National Forest Policy and provided their thoughts for improvements to the current situation. Tony Whitten of the World Bank conveyed the lead on this project. I will take responsibility for errors and omissions, and trust this advice moves the project forward towards acceptance.

Executive Summary
Acknowledgements
Acronyms and Definitions

1. Introduction 1
2. Background on natural disturbance in Mongolia 2
3. Approach 3
4. Elements of Ecosystem-Based Forest Management (EBFM) 3
5. Review of Legislation and Policy 14
  5.1 Mongolian Forest Law (FLOM) 16
  5.2 Fire Management Legislation 24
    Mongolian Law on Prevention of Steppe and Forest Fires 24
    Law on State Emergency 24
    Law on Buffer Zones 24
  5.3 National Program on Forestry (NPOF) 25
6. Silviculture Systems 29
  6.1 Current Silviculture System 30
  6.2 EBFM Silviculture System 35
  6.3 Silviculture Systems Appropriate to NDRs 37
  6.4 Silviculture Trials 40

List of Tables

Table 1. Historic Range of Natural Variability (HRNV) 5
Table 2. Applying Historic Range of Natural Variability (HRNV) to forest management 5
Table 3. Historic Natural Fire Regimes of Mongolia (Gray 2006) 6
Table 4. Elements for Landscape-Level Planning for EBFM 12
Table 5. Elements of Stand Level Planning for EBFM 13
Table 6. Strategic, Tactical and Operational Planning Levels to Support EBFM. 14
Table 7. Summary of Mongolian Law and Policy Governing Forest Management. 16
Table 8. Summary of recommended amendments to FLOM. 20
Table 9. Forest Zones Administered under Forest Law of Mongolia (FLOM) 22
Table 10. Zones with Forests Administered under Mongolian Law on Special Protected Areas. 23
Table 11. National Program on Forests Activities and Clarification of EBFM Activities to Achieve Program Goals 27

List of Figures

Figure 1. Separation of Powers of Government.. 15

List of Photographs

Photo 1. Occluded Steppe HNFR 3: MCSS. Siberian Larch (*Larix sibirica*) stand. 9
Photo 2. HNFR 5: MCMS. Moist Montane Forest – Mixed *Larix siberica/Pinus sibirica* 10
Photo 3. HNFR 3: SCSS Pinus Sylvestris 10
Photo 4. HNFR 3: MCMS. Occluded Steppe - Pinus sylvestris with a deciduous understory. 11
Photo 5. High grading and abandonment HNFR 5. 33
Photo 6. Pine nut harvest Montane Moist Fire Regime.HNFR 5. 33
Photo 7. Current unsustainable pine nut harvest in HNFR 5. 34
Photo 8. Higher grading HNFR 3. 34
Photo 9. Pinus sylvestris tap root HNFR 3. 35

Acronyms and Definitions.

AAC — Allowable Annual Cut. A maximum volume (cubic meters) set by MNE.

EBFM — Ecosystem-Based Approach to Forest Management. EBFM is forest management that maintains and protects ecosystem functions as a first priority in order to sustain a diversity of human uses within ecological limits. The emphasis is on which forest stands, and which stand structures, are left behind (retained) rather than the traditional forestry approach with a focus on what to take (remove) from the forest.

FLOM — Forest Law of Mongolia

gap replacement. Describes patches or openings in the forest where young forest establishes. Gaps may be small, created when a sign tree dies, or larger, where disturbance creates an opening in the forest of several hectares.

HNFR — Historic Natural Fire Regime. The frequency and intensity of forest and grassland fires that alter forest regeneration and determine plant survival. HNFR is strongly correlated to regional climate and site factors (slope and aspect) which affect site moisture.

HRNV — Historic Range of Natural Variability refers to long-term variations in the frequency and intensity of all disturbance agents, such as fire, insects, storms, etc.

MCMS — Multi-Cohort Multi-Story. A forest that has trees of different ages and different heights within the same stand. A cohort refers to trees of the same age. A stratum refers to trees of similar height. A stand can be single or multi strata. Trees in a single strata may or may not be from the same cohort.

MCSS — Multi-Cohort Single-Story. A forest that has trees of different ages and the same height within the same stand. A cohort refers to trees of the same age. A stratum refers to trees of similar height. A stand can be single or multi strata. Trees in a single strata may or may not be from the same cohort.

MLBZ — Mongolian Law on Buffer Zones

MLSPA — Mongolian Law on Special Protected Areas

NDR — Natural Disturbance Regime. Terms that refers of a variety of disturbances that affect forest structure and establishment. Fire, insects, storms (wind, snow, ice) and flooding are natural disturbances which collectively change forest stands, thereby creating the diversity of forest structures across the landscape. Differences in disturbance frequency, intensity and size enable classification of forests into different natural regimes, such as stand-replacement and gap-replacement disturbance regimes. NDR classification is based on HRNV, which considers all disturbance factors acting on a landscape. Fire is the dominant disturbance agent in Mongolia. NDR classification in this report therefore is synonymous with HNFR.

NPOF — National Policy on Forests

SCSS — Single-Cohort Single-Story. A forest that has trees of the same age and same height. A cohort refers to trees of the same age. A stratum refers to trees of similar height. A stand can be single or multi strata. Trees in a single strata may or may not be from the same cohort.

UD — Understory dominant. Stand structure that lacks trees.

1. Introduction

This is the second of two reports in a study of disturbance ecology and forest management in Mongolia. This study, in turn, is one of five short-term investigations intended to advise The World Bank and the Government of Mongolia and other donors on a proposed forest resource management project called the Forest Landscape Recovery and Sustainable Livelihoods Project. These five studies have been carried out with grant funding from the Government of the Netherlands (NEMO TF 54417).

The focuses of this study are to define the range of natural disturbance regimes (NDRs) in Mongolia's northern forests and to use the concept of NDRs as a framework for recommendations on comprehensive, ecologically-based forest management and forest fire management prescriptions. The first report under this study defines historic natural fire regimes and associated stand structures in Mongolia, describes current stand structures and their inherent risks, and proposes wildland fire management strategies to reduce ecological risk (Gray 2006). This report builds on the concept of NDRs and defines the silvicultural management activities that will be required to restore quality and resilience to Mongolia's northern forests.

An understanding of natural disturbance ecology is fundamental to programs of forest landscape recovery and to the application of an "ecosystem-based approach to forest management" (EBFM). This report begins by defining EBFM and describing the principle characteristics of the concept. In Mongolia, natural disturbances, predominantly fire, have shaped the forests over thousands of years and so many plant and animal species and communities exhibit both structural and ecological adaptations to fire. Recent large-scale fires have resulted in recommendations for programs to prevent steppe fires from reaching the forest (Valendik *et al* 1998). It is the opinion of the consultants involved in this study that such recommendations, if adopted, will only increase fire proneness and risk in steppe and "pseudo-taiga" forests. EBFM takes a different, pro-active, approach that accepts fire as a natural influence in many forest ecosystems. Suppression can delay fire in such systems, resulting in significant fuel accumulation, so that when fires inevitably do occur, they are much more severe. This is the case in Mongolia, where there has been a long period of fire exclusion (due to a combination of fire prevention, fire suppression and over-grazing), resulting in recent, unnaturally severe fires due to higher fuel loadings. Rather than pursue fire exclusion, EBFM accepts fire as a recurring reality for forests. This shifts forest management to improving forest resilience to disturbance through managing forest stand structure (density and composition). The result is similar to that developed under historic natural fire regimes (HNFR).

Only 11.2% of Mongolia is forested. Enkhbat and Tosgtbaatar (1997) estimated this to be 17.2 million (ha). Crisp *et al* (2004) provide a profile of the dominant trees by area and volume. Siberian Larch (*Larix sibirica)* is the most abundant tree species; 61% by area and 75% by volume. Deciduous trees are the second most widespread; 10 % by area and

6% by volume in trembling aspen *(Populous tremula)* and Siberian birch (*Betula platyphylla).* Siberian pine (*Pinus sibirica)* is the next most widespread with 8% by area and 12% by volume, followed by Scots pine (*Pinus sylvestris)* at 5% by area and 5.7 % by volume. *Picea obvata* and *Abies sibirica* are each less than 1% in area and volume. Saxual forests (*Haloxylon ammodendron*) occur in locations in the steppe, desert steppe and desert zones. Saxual is the second most abundant tree species by area (16%) but accounts for less than 1% of wood volume. Saxual forests are not considered in this project, since their protection and management is very closely associated with the activities of pastoral herders in the steppe and desert steppe.

2. Background on natural disturbance in Mongolia

The average annual area burned over the last 37 years is 1.88 million ha (Wingard 2001). This increased in the 1990s, averaging 4.64 million ha per year. Average size of individual fires went from 14,000 ha in the 1990s to 30,000 ha in 2000. Gray (2006) provides additional fire disturbance information.

Dendrochrononlogy studies are an aid to defining HNFR as well as tracing historic climate fluctuation. D'Arrigo *et al* (2001) inferred temperature variability over 1738 years based on analysis of Siberian pine (*Pinus sibirica*) sampled from trees in the subalpine zone. D'Arrigo *et al* conclude the warmest temperatures over this period have occurred in the last century, with 1999 as the warmest year. Davi *et al* (2005) examined tree rings from five trees in the Selenge valley and linked this to precipitation models to reconstruct climatic moisture fluctuations. This study was done to improve quantitative forecasts of precipitation in order to assist agriculture and forest management and improve our understanding of Historic Natural Fires Regimes. Applied ecological studies will help to predict wet and dry growing seasons and improve forest fire management, as well as reduce agriculture uncertainty. Mongolia experienced a four-year drought from 1999 to 2002. The average mean monthly precipitation from the three stations in the Selenge watershed indicated that 72% of the annual 252.3 mm of precipitation falls in June, July and August, with the average monthly temperature above freezing starting in May and ending in October.

Valendik *et al* (1998), in a study on fires in forest ecosystems, concludes that lightning fires are common in the taiga belt of Mongolia, with storm intensity highest in May and early June. Extreme fire seasons occur every three years in Mongolia. Fires during these extreme periods account for almost half the number of fires and 1/3 of the area burned in the last decade. The mean fire interval in the forests varies between 9 and 22 years, depending on forest type, slope, aspect and human factors. Ing (1999) concluded that most of the 239 fires in 1997 and the 3.1 million ha burned in 1999 originated from human sources.

3. Approach

This report first defines EBFM and describes the major guiding principles A major principle of ecosystem based forest management is to manage in such a way as to mimic the natural disturbance regime. The major natural disturbance regimes for Mongolia and the associated historic stand structures are described by Gray (2006). These are used to develop plans and stand level prescriptions to restore stands. The report then reviews Mongolian laws and policy, and recommends changes to enable restoration of forests. Finally, the report reviews the current silviculture system (high grading) and recommends a system appropriate to restore forests by thinning of smaller trees to lower more natural condition. The field work and review was conducted between May 1 and May 22, 2006 together with R.W Gray.

4. Elements of Ecosystem-Based Forest Management (EBFM)

Ecosystem-based forest management defined by Grumbine (1994) incorporated these aspects:

- maintain viable populations of all species representative of the range of native ecosystems,
- represent all native ecosystem types across their natural range within a combination of ecologically-managed forests and protected areas,
- maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes and nutrient cycles, etc.) and
- manage over long enough periods of time to maintain the evolutionary potential of species and ecosystems.

A more concise definition of EBFM is forest management that maintains and protects ecosystem functions as a first priority, in order to sustain a diversity of human uses within the limits of ecological sustainability. EBFM emphasizes what forest stand structures to leave, in contrast to the more traditional approach to forestry, which focuses on what trees to take from the forest.

A thorough understanding of the role of natural disturbance in forest ecosystems is a key requirement for recovery and silvicultural programs.

Natural disturbances have shaped Mongolia's forest species, plants and animals for thousands of years. Forest communities have developed adaptations that increase their resilience to natural disturbances such as frequent fire, and the continued existence of many of these species is dependent on periodic fire. Over their long history, Mongolia's nomadic pastoralists also adapted to natural fire disturbance. They used fire to shape the forest and steppe ecosystems to their benefit and are considered an intrinsic part or the NDR. EBFM considers humans, particularly indigenous peoples, part of the natural processes that have shaped ecosystems.

We cannot prevent natural disturbances such as fire and insects from influencing forests. A central tenant of EBFM is to create, through forest management, forests that resemble those established through natural disturbances (Andison 2004). When we do so, there is greater probability that all native species and ecological processes will be maintained. As well, humans will have a high probability of receiving a sustainable supply of goods and services from forests (British Columbia Government 1995). Forests management, including fire management, means that forests will be more resilient to disturbances when they do occur.

EBFM uses knowledge of a historic range of natural variability (HRNV) to guide forest planning and practices. Ecosystems may change gradually over decades as a result of human interventions. Human activities, such as forest harvesting, grazing and fire suppression cumulatively change forests. Duration and magnitude have impacts on cumulative changes, which are reflected in changes in forest composition, structure and natural disturbances. Gradual cumulative changes in forests also cause humans to believe that the current situation may be "natural" even when the forests have significantly departed from HRNV.

Historic photographs of forests are a valuable way to demonstrate changes in forest stand structure and density over time. Compared to trees, humans have short life spans, so most people are not aware of forest changes that take place over the span of a human life time. A comparison of two photos of the same forest taken at different times show changes in the amount of forest and stand structures. The older the archival photos, the greater the change when compared to the same site today. It is recommended that a search of archival photographs of Mongolian forests be undertaken, as the current Mongolian population, its advisors and even non-government organizations focused on conservation still consider the forests "natural". Information and knowledge based on the recollections of elders can also provide evidence about historic conditions. Elder recollection of their access to forest plants for domestic and medicinal purposes, former attitudes to use of fire, and availability of wildlife also provide evidence that forests have changed significantly. Historic photo comparisons, together with interviews of elders, will improve understanding of the need for, and benefit of, restoration. These types of studies, possibly by university and college students, are recommended because the stronger the evidence that the current forests are in a departed state, the more acceptable it will be to move forest management to an EBFM approach.

Field visits confirmed the need for landscape-level forest restoration. Field visits provided information on stand structure, stand density, and time since the last disturbance. Most forests visited are considered to be outside of HRNV. This assessment is based on fire frequency from observations of fire scars, the historic fire return intervals and high density of small trees under a sparse, widely-spaced overstory. Other evidence indicating departure from natural conditions is the amount of area in the young forest (less than 60 years) lacking older trees. This indicates that forests have encroached on former grasslands over the last 60 years. Gray (2006) provides additional evidence based on fire return intervals and on fire scars and increment borings.

When systems are significantly departed from HRNV, they are at high risk of intense fires. Restoration means returning the forest to a condition within the HRNV, thereby reducing the risk of catastrophic fire. When an ecosystem is within the HRNV, it is more resilient to disturbance. Forest management decisions under EBFM are guided by questioning whether practices cause the forest to further depart from HRNV or whether practices maintain the forests within the HRNV (Table 1).

Table 1. Historic Range of Natural Variability (HRNV)

Ecosystem condition	**Ecosystem Risk**	**Management Direction**
Outside HRNV	**High**	**Restore historic natural stand structures**
Within HRNV	**Low**	**Maintain historic natural stand structures**

Under historic conditions, the range of natural diversity of stand structures fluctuates over large areas, depending on disturbance frequency and extent of natural disturbances, such as wildfire, windstorms and insects. Measuring this historic forest stand diversity provides EBFM an operational planning context. This context, when measured over thousands of hectares, is appropriate for landscape-level planning. It is recommended that a template of historic range of natural variability be used as a guide for restoration. Current stand structures can be compared to historic natural stand structures and where there is a significant deviation, restoration is warranted.

Table 2 shows the relationship between landscape and stand planning levels. Table 4 describes major stand structure classes recommended for Mongolia. These classes need to be mapped to support operational landscape planning decisions. Stand-level planning allows forest stands in need of restoration to be identified and Soum and Aimag staff to confirm conditions and prescribe treatments for these stands.

Table 2. Applying Historic Range of Natural Variability (HRNV) to forest management

What was present	**What is present today**	**What could be present (Future Desired Condition)**
Historic Range of Natural Variability (Planning scales)	**Current condition**	**Management Options Based on deviation from HRNV (risk)**
Landscape-Level **(Template)**	Assessment of numerous stands in a landscape	Selecting stands for treatment **Priorities**
Stand-level **(Template)**	Assessment of individual trees in a stand	Selecting types of trees for treatment (thinning)

To understand historic natural disturbance regimes that have shaped the vegetation communities, a review of available vegetation zones was undertaken.

Natural zones of Mongolia appear in a general map (scale 1:10, 000,000) in Enkhbat and Tsogtbaatar, 1997. There are six zones: 1) high mountain, 2) taiga forest, 3) mountain forest steppe, 4) steppe, 5) desert steppe and 6) desert. These zones present a very high level of generalization. These zones are referred to as biogeoclimatic zones in Crisp, et al, 2004**.** The Forest Steppe biogeoclimatic zone covers 8% of the country; the Boreal Forest biogeoclimatic zone covers 4% of the country and Montane Zone biogeoclimatic zone 22%. These zones provide a good overview, but were considered too general to build NDRs for forest management.

A more detailed map of vegetation (scale 1:1,500,000) was made available by Dr. C. Dugargav, Institute of Botany. This map was the result of a 10 year joint Russian-Mongolian Project undertaken through the Institute of Botany and completed in 1983. This map is in Russian and supported by 4 volumes detailing plants. Inclusion of indicator species for each of the 40 types enables classification to HNFR shown in table 3. It is recommended that the 1983 Botany Institute Forest type map and classification be used as the basis on which to extend and refine the six Historic Natural Fire Regimes described in Table 3.

Table 3. Historic Natural Fire Regimes of Mongolia (Gray 2006)

1.	Non-Fire	Deserts and high elevation plant communities.
2.	Frequent (<10 years)	Non-forested steppe fire regime.
3.	Frequent (<10 years)	Occluded steppe fire regime.
4.	Frequent (<30 years)	Montane dry fire regime.
5.	Frequent (<50 years)	Montane moist fire regime.
6.	Infrequent (>100 years)	Subalpine/alpine fire regime.

More detailed (scale 1:50,000) maps of forest cover showing the dominant trees, the size of the stand and the productivity class were made available for viewing through Jambalragchaa Byambaja, Director of the Forest and Water Research Centre Ministry of Nature and Environment. The stand types are coloured and mounted on canvas, with adequate room for folding to approximately 20 cm by 20 cm for storage and transportation. These maps were made using aerial photographs with field sampling for ground-truthing. The forest cover maps are made for each Soum, with one copy kept by the Ministry of Nature and Environment and another copy kept at the Aimag centres. These maps are being digitized at the rate of one million hectares per year at a cost of approximately a million Tureg/year (USD 100,000.00). At the current digitizing rate, it is estimated that it will take over a decade to finish. Review of Ministry of Nature and Environment forest inventory methods and standards is recommended, with a goal to integrate forest types and stand structures into a forest inventory classification system.

O’Hara and Latham (1996) proposed a structural classification system for dry continental forests of United States, forests that historically have been frequently fire disturbed Forests of Mongolia are similar in structure to dry portions of the western central United States and the dry interior of British Columbia, Canada. Table 4 provides an overview of these structural classes developed by O’Hara and Latham (1996). These are considered similar to the low rainfall, highly fire disturbed forests in Mongolia.

Table 4 .Structure Classes Suited to Dry Inland Forests of British Columbia and the North West United States.

Based on O’Hara and Latham (1996)		
Structural Class Name	Definition	Description
A. Stand initiation	Growing space is re-occupied following a stand replacement disturbance	1 canopy stratum (may be broken or continuous) 1 cohort of seedling or saplings grass, forbs, shrubs may be present.
B. Open Stem Exclusion	Underground competition limits the establishment of new individuals	1 broken canopy stratum which includes poles or smaller trees, grasses, shrubs or forbs may be present.
C. Closed Stem Exclusion	New individuals are excluded through light or underground competition	Continuous closed canopy usually more than 1 cohort, poles, small and medium tress present. Suppressed trees, grasses and forbs may be absent in some cover types.
D. Under-story Re-initiation	Initiation of a new cohort as older cohort occupies less than full growing space	Broken overstory canopy with formation of understory stratum, two or more cohorts. Overstory may be poles or large trees; understory is seedlings, saplings, grasses, forbs or shrubs.
E. Young Multi-strata	Two or more cohorts present through establishment after periodic disturbance	Multi-aged multi cohort with assortment of tree sizes and canopy strata present.
F. Old forest Multi-strata	Two or more cohorts and strata present including large older trees	Multi-aged stand with assortment of tree sizes, and canopy strata present including large, older trees. Grasses, forbs, and shrubs may be present
G. Old Forest Single-Stratum	Single stratum of medium to large, old trees of one of more cohorts. Structure maintained through non lethal burning.	Broken or continuous canopy of medium to large older trees. Single or multi-cohort. Understory absent or consisting of some seedlings saplings, grasses, forbs or shrubs.

Table 5 shows the four structural classes proposed by Gray (2006). Further development of the structure classes is needed. Mapping stand structures using remote sensed images is considered a practical approach to assessing current stand conditions.

Table 5. Proposed Stand Structure Classes for Mongolia (Gray 2006)

1. Understory Dominant (UD) **–** No overstory trees **2. Multi-Cohort, Single Stratum (MCSS) (photo 1)** – Widely spaced, old and young trees occupying a single canopy stratum 3. **Single-Cohort, Single Stratum (SCSS) (photo 3)** **–** moderately dense patches of single age cohort, with a single canopy stratum 4. **Multi-Cohort, Multi-Stratum (MCMS) (photos 2 and 4)** **–** multiple age cohorts, multiple canopy stratum
Classification terms • A cohort refers to trees of the same age. • A stratum refers to trees of similar height. A stand can be single or multi strata. • Trees in a single strata may or may not be from the same cohort.

Photo 1. Occluded Steppe HNFR 3: MCSS. Siberian Larch (*Larix sibirica*) stand.

The stocking density in this stand is unnaturally high in terms of historic levels. This stand is close to Ulaanbataar in the Historic Natural Fire Regime (HNFR) 3 the Occluded Steppe. Fires burned with mixed severity < than every ten years. This site has likely missed 5 burn intervals which would have eliminated some of the Larch regeneration. Multi-cohort means that the stand has trees of many ages as a result of natural regeneration. Tree growth is limited by above ground competition for light, and by below ground competition for moisture and nutrients. The dominant trees will win this competition. The subdominant trees are severely moisture stressed. Ibis beetle (a bark beetle) is successfully killing the subdominant trees. The stand is in the process of self thinning and will, in time, achieve a lower, more natural stocking density.

A restoration silviculture system, when applied to this stand, would remove a significant number of the smaller subdominant trees. This thinning from below may need two entries to ensure the retained trees are wind firm. Larch are well adapted to wind as they lack foliage for much of the year when winds are the strongest. A thinning from below restoration treatment will release the dominant Larch trees and create understory regeneration and in time a second cohort of smaller trees. Thinnings are to be removed from the site, likely to provide posts and rails, while some of the larger subdominant thinned trees will be suitable for sawn timber products. The restoration goal is to manage the stand to be more fire and insect resilient. To ensure that when fires occur, they do not burn at a high intensity and degrade soils, larger woody materials on site needs to be removed. If small limbs and branches cannot be transported and used for fuel, they can be piled and burned when safe to do so.

Photo 2. HNFR 5: MCMS. Moist Montane Forest – Mixed *Larix siberica/Pinus sibirica*

Larix sibirica and *Pinus sibirica* dominated forest. Canopy closure under natural condition is between 50-60%.

Photo 3. HNFR 3: SCSS Pinus Sylvestris
This single cohort single strata Pinus Sylvestris stands established north of Binder approximately 40 years ago.

Photo 4. HNFR 3: MCMS. Occluded Steppe - Pinus sylvestris with a deciduous understory.

Occluded Steppe is the largest forested Historic Natural Fire Regime. Fire severity is mixed and frequency is estimated at less than 10 years. *Pinus sylvestris, Larix sibrica, Betula platyphyla* and *Populus tremula* are the dominant trees. In this photo, stand structure is Multi Strata Multi-Cohort. After fire aspen and birch recolonize the site from below ground. Aspen suckers from the root system, whereas birch re-sprouts from the basal portion of the older tree. Any smaller pine regeneration present before the fire has been killed. When fire severity is mixed, some pine and larch will survive and achieve sufficient height to survive the next fire. Note the height of the scorch zone that has killed the lower branch foliage below 5 meters.

Pine in this stand is less than 40 years. Trees have encroached on former grasslands. Under natural fire regimes, birch and aspen may never achieve greater density and height than that shown. Historically the density of trees was much lower than shown. Restoration thinning would determine the spacing of the older stems and would thin to this density. Some or all of the young trees may be thinned to achieve restoration condition. The degree to which trees are removed depends on site inspection and a clear understanding of the historic natural fire stand structures.

Operational planning needs to be done at two levels to support restoration.

1) Landscape-level planning

   Guides staff preparing Soum level plans and provides criteria to help prioritize and schedule stands for treatment. Planning at this level integrates social objectives with technical, science-based information to achieve restoration objectives. Mapping of forest types, stand structures and forest zones are needed. (see Table 6)

2) Stand-level planning

   Guides field staff who need direction when prescribing stand level recovery treatments. This will clarify stand structure objectives and ensure which structure will be retained post treatment. (see Table 7)

Landscape and stand level operational planning guidelines and policy provide the framework for management control and decisions, technical direction, information and communications decisions. Trained Ministry of Nature and Environment staff will develop and approve operational plans on behalf of the government of Mongolia. Ministry of Nature and Environment staff with delegated responsibility will be guided by policy and guidelines. A clearly identified framework enables MNE staff to be held to account. A precise framework with well-defined policy and specific guidelines also enable MNE staff to maintain a degree of independence from elected and appointed officials.

Table 6 and 7 are examples of criteria to be developed within the landscape and stand level planning framework.

In order to develop and implement restoration plans at the landscape and stand level, MNE staff also need to acquire technical restoration information about the past appearance of the forests, and determine their future desired condition. These are referred to as restoration templates. A restoration template provides clarity on future desired stand density, decides fuel levels and chooses trees to retain, based on their ability to withstand fire, wind, and insects.

A landscape-level restoration template is based on HFRI classes and stand conditions for forest types. Landscape level templates provide information on spatial structure and stand type composition. A stand level restoration template provides guidance on vertical and horizontal structure as well as species composition. These templates provide technical underpinning for restoration and provide the ecological rational for restoration decisions.

Table 4. Elements for Landscape-Level Planning for EBFM.

1. Landscape-level restoration template.
2. Current condition, types of stands.
3. Location of stands where restoration is most needed, ie high population density areas. Settlement areas are considered priority if fuel conditions pose a high risk

to human safety from fire.

4. Access (summer or winter operability) and proximity to local wood yards.
5. Local processing capacity, ability to use thinning material for fuel or products.
6. Forest Zones from MLSPA and FLOM (see Tables 10 and 11).
7. Location and condition of non-timber forest product areas, such as wildlife habitat, pine nut forests.
8. Local community vision for use of thinning. Local capacity to use thinning materials and need for fuel.

Stand level planning guides MNE staff when prescribing thinning and guides those doing stand treatments. Site treatments will be focused on restoration and fuel management objectives.

Table 5. Elements of Stand Level Planning for EBFM

1. Location map, treatment area boundaries, and area sizes.
2. Stand level restoration template on the selection of trees to mark-to-leave and selection of trees with best resistance to fire, insect and storms, as well as fuel levels.
3. Forest Type.
4. Stand Type.
5. Current condition.
6. Nature and volume of thinning material to be removed.
7. Appropriate fuel loadings for the site. Whether and when to burn piles.

Chapter 5 of FLOM enables cleaning forests so that they are protected and achieve normal forest growth. Restoration and EBFM are considered fundamental to meeting these protection and normal growth provisions.

Refinement of the information which supports restoration planning needs to be further developed. Table 6 and 7 focused on operational Planning levels. Table 8 shows Strategic, Tactical and Operational planning levels along with the types of decision and support each level needs. It is recommended that that the restoration project build greater capacity within the existing MNE planning framework.

Integration of information requires coordination and cooperation between State, Aimag, Soum and Bag levels. There must also be a clear understanding of roles and responsibilities between planning levels within an organization as well as between different institutions. These can be developed at the local level with technical mapping support from MNE. Restoration targets based on Soum level assessment can then be sanctioned by the State for approval by Aimag and Soum levels. A bottom-up synthesis of treatable areas is recommended in a pilot Soum or other area.

Table 6. Strategic, Tactical and Operational Planning Levels to Support EBFM.

STRATEGIC PLANNING		
	Role	Tasks
State *	Responsible for approval and changes in policy and legislation to enable EBFM. (see section 5 for needed amendments) Program definition, scope and approval, commitment, budget revenue/cost structure	Principally MNE staff responsible for project development, implementation and coordination. Policy development done in cooperation with other levels. Delegation of authority and responsibility. Coordination of information (Forest Type, HFRI and forest zone mapping, (GIS format). Development of restoration templates. Leadership, training and collaboration with Aimag and Soum staff. Practices, planning and audit function done to a set standard.
TACTICAL PLANNING		
Aimag	Implementation of EBFM	Regional priorities. Leadership and collaboration with State and Soum staff
OPERATIONAL PLANNING		
Soum/Bag	Community Forest capacity building to develop and implement landscape level plans. Managing site treatments. Managing sale of thinning materials.	Implementation/development of plan and priorities. Access (Summer/winter). Community involvement. Processing capacity. Revenue/cost structures. Stand-level treatments . Monitor results.

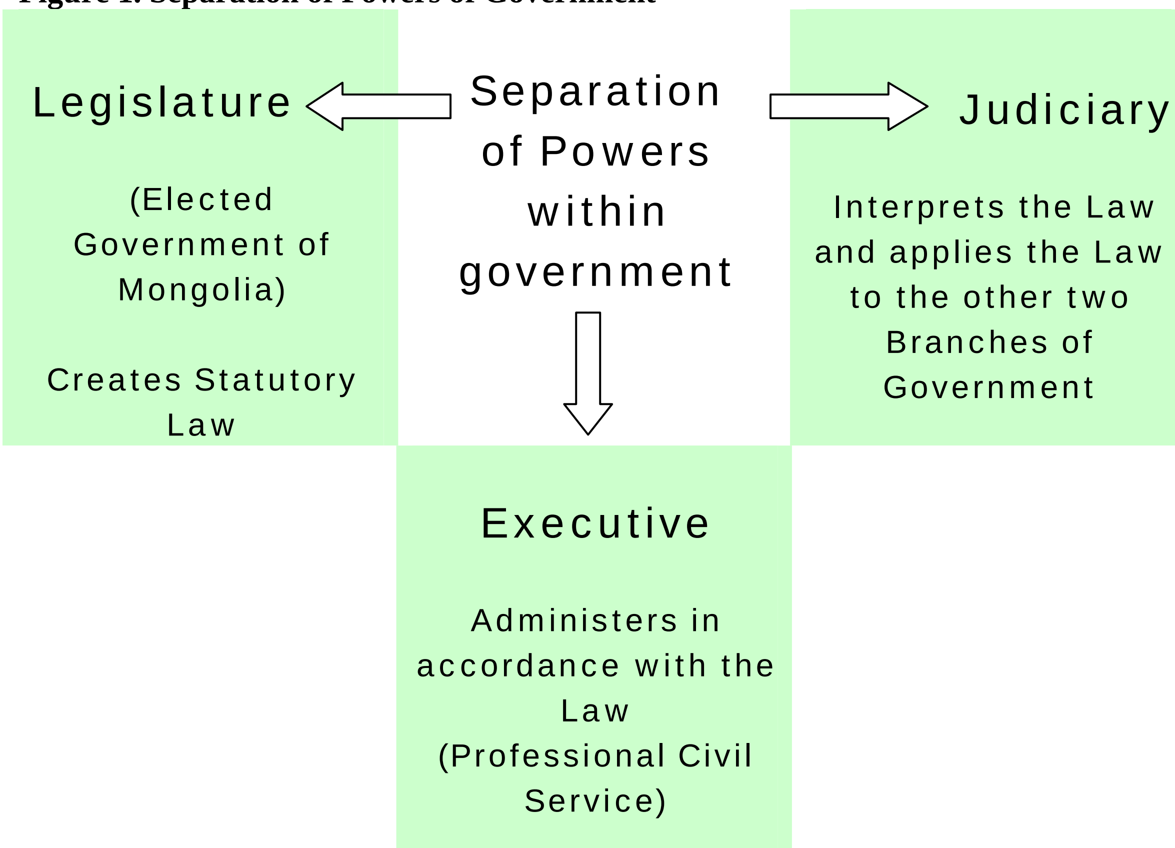
5. Review of Legislation and Policy

Based on interviews with government staff at the State and Soum level, there is frustration with the current forest management situation. Interviewees noted a need for a professional civil service as part of a solution to improved forestry. It was also noted that there was very restricted access to wood for fuel and commercial purposes. However, high levels of illegal use of forests was seen in part as a response to lack of legal access to forests combined with high dependence by local citizens on fuel wood. People simply help themselves outside the law as there are no consequences and no alternative fuel wood options.

A landscape recovery program, if accepted, will greatly increase the local access to timber products through thinning material generated as forest density is reduced to HRNV levels. The success of the program in part depends on a professional civil service with clearly delegated responsibility and accountability. Many civil service positions appear to be “at pleasure appointments”, creating a lack of stability, program continuity and loss of expertise as governments change. Competition from other sectors for skilled workers also contributes to high staff turn over, again reducing program continuity.

Figure 1 shows three independent but related elements of government. When all three function in harmony, there is “A government of Laws and Not of Men", Aristotle. [1]

Figure 1. Separation of Powers of Government



This preamble is included because discretion is exercised with regard to how much direction and detail need to be in legislation and what can be done through policy. Legislation normally clarifies the purpose of a law and enables activities directed to that purpose. The details on how to achieve activities are left to policy. Changing legislation involves elected government members and is a more arduous task than changes in policy, which can be undertaken by the Executive within the confines of the Law.

---

[1] From Risk Management and Statutory Decision Making Handbook
Chapter 05: Assessing and Managing Risk within a Statutory Forest Management Regime - The Rule of Law Part One: The Role of the Civil Servant.
http://www.for.gov.bc.ca/hen/publications/risk_manage/risk_manage_chapter05.html

Crisp et al (2001) identified the most important laws with implications for forest management as: Forest Law of Mongolia (FLOM), Mongolian Law of Environmental Protection (MLEP), Law of Mongolia on Land (LML), Mongolian Law on Special Protected Areas (MLSPA). Mongolian Law on Buffer Zones (MLBZ), and Mongolia Law on Natural Plants (MLNP). Wingard (2001) in his review of Environmental Law and Practices, noted that there are more than 50 pieces of forest legislation (laws, resolutions, orders, rules, etc.) Forest legislation is considered the most detailed and complete of all the legislation governing the environment in Mongolia. Table 9 provides a listing of some of the major pieces of legislation governing the forest environment.

The Forest Law of Mongolia (FLOM) provides the basic framework for protection and forest use. Together with the Mongolian Law on Special Protected Areas (MLSPA), it establishes zones as the primary basis for management. The National Policy on Forests (NPOF) is also a key element, as it sets out the focus for MNE staff on forestry. The Ministry of Nature and Environment staff provided available English translations. The Open Government Site (English translation) was consulted http://www.open-government.mn/ but found to have little information posted. The compendium compiled by Wingard (2001) was a valuable asset for this review.

Table 7. Summary of Mongolian Law and Policy Governing Forest Management.

Name of Legislative Documents	**Date Enacted**
Law of Mongolia on Land (LMOL)	Nov 11, 1994
Mongolian Law on Special Protected Areas (MLSPA)	Nov 15, 1994
Mongolian Law of Environmental Protection (MLEP)	March 30, 1995 Amended, 2005
The Mongolian Law on Natural Plants (MLNP)	April 11, 1995
Forest Law of Mongolia (FLOM)	March 31, 1995
Law of Mongolia on Water (LMW)	April 13, 1995
Mongolian Law on Prevention of Steppe and Forest Fires (MLPSFF)	1996
Mongolian Law on Buffer Zones (MLBZ)	Oct. 23 1997
The Mongolian Law on Environmental Impact Assessments (MLEIA)	January 22 1998
Name of Policy	
National Program on Forestry (NPOF) Resolution Attached to Government Resolution 248	2001

5.1 Mongolian Forest Law (FLOM)

The purpose of FLOM is the "protection, restoration and proper use of forests" (Article 1). Restoration, therefore, is a fundamental goal set in legislation and thus provides a context in law for a Forest Landscape Recovery Program. Although restoration is a stated goal, Article 22 prohibits needed restoration activities from occurring as it is *"prohibited to cut or violate forests up to the 5th age class and it is prohibited to cut or violate all species of young trees*". Considering that density management and thinning of smaller trees is the primary tool to achieve restoration, this prohibition prevents a forest restoration program.

The ban on cutting young trees will need an exemption for restoration purposes. This could be done by making the following change (added in bold).

> *Article 22/1/ Prohibited to cut or violate forest* ***older*** *than the fifth age class and all species of* ***older*** *trees* ***where retention is identified to achieve forest restoration*** *as well as rare species such as: Siberian fir, rhamnus, Asiatic poplar, elaeagnus, cornel, tamarisk, Siberian alder, mountain ash, sea-buckthorn, fruit bearing trees and certain shrubs.*

Although restoration is mentioned in Article 1 of FLOM, it is not mentioned in other portions of FLOM. It is recommended that the words 'restoration' and 'thinning' be explicitly included in section Chapter 5 (change in bold):

> Article 18 *Measures for Forest Protection shall include care-taking, cleaning of forests,* ***restoration*** *of forests through* ***thinning to natural stand structures, restoration of forest through fuel management to natural levels,*** *maintaining normal growth and regeneration of forest and a positive genobank ...*

Policy then can be developed to address restoration by thinning, fuel management and definition of natural levels. These proposed amendments will also enable prescribed fire.

FLOM establishes forests as the property of the state which can grant forest use for a fee through a contract or a license for a specified period. After fee payments, citizens and economic entities have the right to timber, other forest products and ownership of any trees planted with their own money.

Direction for forest management in FLOM is primarily accomplished through zones, with boundaries to be established based on their "ecological and economic importance": These zones are: 1) Special Forest Zone (also referred to as Strict Zone Forests, 2) Protected Zone, and 3) Industrial Forest Zone (also referred to as the Utilization Zone Forests). All zones require implementation of fire, pest and management protection programs. Understanding Mongolia's system of zones, their purpose and restrictions is central to forest restoration. Table 9 provides a summary of the main differences and permitted forestry activities under FLOM. Table 10 provides a summary of zones managed under the MLSPA that contain some forests.

1) Special Forest Zone. This zone is the most administratively complex. It is divided into two zones: zone a) the subalpine, is administered under FLOM and zone b) managed under the Mongolian Law on Special Protected Areas (MLSPA).

Subzone a) The Subapline Forest Type falls under FLOM. Management allows the use of forest fuel and non-timber forest products under permit. The emphasis is on protection. This is the zone in which forests are multi-aged and natural regeneration occurs in forest gaps where fires are less frequent. *Pinus siberica* is a major species in the subalpine and is considered to be a large, unrealized, local economic opportunity. *Pinus siberica* trees are being felled for one time collection of pine nuts, prohibiting sustainable annual harvest. There is urgency to get this situation under control. Licensing to local interests with a vested interest in the long-term maintenance of pine nuts is considered prudent.

Suzone b) This subzone is administered under MLSPA which does not explicitly mention "restoration". It is assumed that there is no overlap between MLSPA and FLOM regarding this zone. The MLSPA intent is on "maintenance of natural features" and "environmental balance". Natural disturbance and restoring forests towards a HRNV can legitimately be considered "environmental balance". The wording of the Forest Landscape Restoration Program will need to use "environmental balance" as a program objective for restoration within SFZ forests. The intent and restrictions of MLSPA are shown in Table 10. As well as environmental balance, the legislation states that restorations of plants, forest maintenance and protection from natural disasters are legitimate activities in the 1.5 million ha of forests administered under the MLSPA. Wingard (2001) indicates that harvesting may be permitted in the Tourist and Travel Zone, as well as in the Limited Use Zones of both the Strictly Prohibited Zone, and the National Conservation Parks. A more complete description of Special Protected Areas is provided by Mayagmarsuren, 2000.

The type and area of forests within MLSPA-defined Forest Zones, Subzones, classes and subclasses was not readily available. Therefore, it is not clear to what extent the diversity of Mongolia's forest ecosystems is represented within different classes and subclasses in Tables 9 and 10. Natural benchmarks and representation of forest types is consistent with an EBFM restoration program. Benchmarks must be selected from areas considered to be either within, or capable of easy return to, the historic range of variability. They would also be adequately protected in the long term, to act as monitoring and benchmark areas. The resulting comparison between managed and benchmark forests would more effectively inform forest management. Since there is discussion on expansion of Mongolia's protected area beyond the current 13.1%, it is recommended that there be a gap assessment done using the 1983 Botany Institute forest types map. The forest types and extent would be compared to the protected zones shown in Tables 9 and 10. An assessment of forest types within administrative protective forest zones will identify gaps in protection of forest types. The goal is to ensure that all forest types are represented within a strong conservation designation, such as the Ecological Reserves designation. Protected forests will serve as long term forest management practices benchmarks. Ideally, areas in Ecological Reserves are within, or can be managed to stand structures within the HRNV.

2. The Protected Forest Zone includes 46% of Mongolia's forests, or 8.22 million ha. It is administered under FLOM. In general, the intent is protection. See Table 9 for subzones and intent. Forests in the Protected Forest Zone can be "cleaned and cared for their

protection, normal growth and regeneration”. In this zone, there is a prohibition on commercial forest use. Fuel wood and sideline forest products, such as collection of pine nuts or antler pick-up, is permitted. The phrase “cleaned and care for to provide for normal growth” is interpreted as consistent with the aims of a restoration program. A restoration program will clean the forest through thinning of small trees. As tree canopies will more quickly attain a height where scorch from ground fire no longer kills them, this will release trees to normal growth, providing ongoing fire protection. As they are at lower stress levels due to reduced between-tree competition, this will also allow the released trees to be less susceptible to insects.

3. Industrial Forest Zone.

Wingard (2001) describes the Utilization Zone as a default zone for forests which did not fall into the first two categories. There is a top-down process to set an allowable cut calculation for commercial timber harvest, with volume made available through contracts. MNE calculates the maximum harvest allowed for each Aimag and the Capital City. Then Aimag and the Capital City Khurals decide on the harvest, based on MNE recommendations. The Soum Khurals use this same basis for the permissible cut within their own territories. Bag and Kharoo governments are not included in the process. The allowable annual cut includes the volumes available for fuel wood. It is estimated that 75% of the harvest goes to fuel wood of which a family uses 8 cubic meters per year. Current harvest practices and law require the volume to come from cutting trees above age class 5 or from salvage of dead trees. This approach is inconsistent with restoration. When commercial harvest rights are granted, there are obligations for planting and fire prevention. Three to five trees must be planted after each older tree is harvested. The regeneration success is evaluated in the fall of the year. The emphasis is on regenerating a new forest solely through planting. Field observation indicated a low level of planting success. Harvesting older trees, high grading for volume, and planting do not create forests that have stand structures that are resilient to disturbances, nor do they create forests that are healthy and achieve normal growth.

Article 23/2/ removes the reforestation liability after an appropriate percentage of seedling survival is confirmed in the fall of the year. Planting potentially increases the stocking density significantly. The current approach is described as “high grading” with emphasis on volume removal. Forest restoration has a focus on structure retention, with volume coming from thinning stands and use of smaller diameter wood. Currently, a very limited volume is provided by MNE from a very restricted area of a small zone. In reality, there is no enforcement and the cut is coming from a large area, irrespective of zoning, many times over the MNE-allowable volume. Forests are left with stand structures opposite to those left after natural disturbance. Current practices are counter to the intent of FLOM. Forest stands are less resilient to disturbance and seedling survival is very low. The current approach is not considered good forestry.

The current allowable annual harvest, estimated to be 600,000 cubic meters, can only be met from the utilization zone. Restoration greatly expands the amount of wood available from the Protection zone and also the Limited Use Zone of the Special Protected Areas.

The reforestation obligation needs to shift from planting to release of existing regeneration and creating a site suitable for natural regeneration. Stocking densities need to approximate those of the HRNV. It is recommended that Article 23/1/ read something like:

Article 23/1/ Regeneration of Forests. *In order to enrich forest resources, to protect the genobank of the forests, and to ameliorate the climate* ***after a period of time sufficient to allow for establishment of natural regeneration,*** *trees* ***may*** *be planted* ***to a density and stand structure similar to natural disturbance density and stand structure*** *in area damaged by fire, diseases and harmful insects and in deforested areas. These measures shall be financed by local budgets, citizens, economic entities and organization on their initiative.*

Table 8 summarizes the changes considered necessary to support restoration.

Table 8. Summary of recommended amendments to FLOM.

Article	Current Wording	Proposed wording
Article 18 Measures for Forest Protection	*Forest Protection Measures shall include care-taking, cleaning of forests, of forests through**,** maintaining normal growth and regeneration of forest and a positive genobank, as well as protection of forests from fire, disease and harmful insects, and from the negative impacts of human activity.*	*Forest Protection Measures shall include care-taking, cleaning of forests,* ***restoration*** *of forests through* ***thinning to natural stand structures, restoration of forest through fuel management to natural levels,*** *maintaining normal growth and regeneration of forest and a positive genobank, as well as protection of forests from fire, disease and harmful insects, and from the negative impacts of human activity*
Article 22/1 Activities Prohibited in the Forests	To provide for the normal growth and regeneration of the forest and to protect it from the negative impacts of human contact the following activities are prohibited.	
	to cut or violate forest up to the fifth age class and all species of young trees as well as rare species such as: Siberian fir, rhamnus, Asiatic poplar, elaeagnus, cornel, tamarisk, Siberian alder, mountain ash, sea-buckthorn, fruit bearing trees and certain shrubs.	*to cut or violate forest* ***older*** *than the fifth age class and all species of older trees* ***where retention is identified to achieve forest restoration*** *as well as rare species such as: Siberian fir, rhamnus, Asiatic poplar, elaeagnus, cornel, tamarisk, Siberian alder, mountain ash, sea-buckthorn, fruit bearing trees and certain shrubs.*
Article 23/1/ Regeneration	*In order to enrich forest resources, to protect the*	*In order to enrich forest resources, to protect the genobank of the forests, and to*

of Forests.	*genobank of the forests, and to ameliorate the climate, trees shall be planted in areas damaged by fire, diseases and harmful insects and in deforested areas. These measures shall be financed by local budgets, citizens, economic entities and organization on their initiative.*	*ameliorate the climate* ***after a period of time sufficient to allow for establishment of natural regeneration,*** *trees* ***may*** *be planted* ***to a density and stand structure similar to natural disturbance density and stand structure*** *in area damaged by fire, diseases and harmful insects and in deforested areas. These measures shall be financed by local budgets, citizens, economic entities and organization on their initiative.*

Table 9. Forest Zones Administered under Forest Law of Mongolia (FLOM)

<table>
<tr><td colspan="4">Intent of FLOM: Regulate the protection, the proper use and the restoration of forests.
Protect forests from fire and insects. Improve regeneration.</td></tr>
<tr><td colspan="2">Strict Forest Zone</td><td>Protected Forest Zone</td><td>Utilization Forest Zone</td></tr>
<tr><td colspan="2">47% of Forest Territory
8.4 million ha</td><td>46% of Forest Territory
8.22 million ha</td><td>7% of Forest Territory
1.2 million ha</td></tr>
<tr><td colspan="2">“maintain natural features” and “environmental balance”
“preservation and conservation of its original condition”</td><td>“cleaned and cared for, to maintain normal growth and improve regeneration”</td><td rowspan="2">Commercial Timber harvest
Fuel wood from local range estimated to be 75% of allowable harvest
Recent Allowable Annual Cut.
600,000 cubic meters</td></tr>
<tr><td colspan="3">No commercial timber production</td></tr>
<tr><td colspan="4">Protection from fires and pests
Fire management also addressed by Mongolian Law on Prevention of Steppe and Forest Fire, and Law on State Emergency, and Law on Fire Safety</td></tr>
<tr><td></td><td colspan="3">No cutting of trees less than the fifth age class</td></tr>
<tr><td colspan="2">2 zones</td><td>8 conservation focused zones/forest types</td><td>No zones</td></tr>
<tr><td rowspan="3">Defers to Mongolian Law on Specially Protected Areas

(see Table 11)</td><td>Subalpine Forest
(outside of SPA)
Above 1,700 to 2,500 m elevation
Mapped at 1:500,000</td><td rowspan="2">1. Green zone (areas up to 30 surrounding towns and cities, except the capital city)
2. Prohibited Strips (forests up to 5 km around lake and river sources and up to 3 km along river banks and springs and 1 km both side rail and national roads)
3. Saxual Forest (Gobi desert forests)
4. Forest Areas up to 100 ha
5. Small tree groups
6. Scrub
7. Sun-exposed forests
8. Forests on slopes >than 30 degrees</td><td rowspan="3">Residual forests not in other categories
Top down allowable harvest volume. Aimag and Soums decide on permissible cut.
Bids on available volume awarded by Soum and Capital City Governors based on
1. Economic activity
2. Harvest technique
3. Processing technology
4. Level of use
5. Funding for protection, planting and certified
3 to 5 seedlings for each tree planted
70% of fees will go to protection and regeneration
6. No clear cutting organization
Permissible cut
Reforestation cleaning and protection borne by those under license to cut.
Fines for harvest without license.</td></tr>
<tr><td>Ecological balance and Protection from soil erosion in watersheds</td></tr>
<tr><td>Gathering of fallen trees and branches permitted
Use of approved sideline products, such as pine nuts from Pinus Siberica
1 time harvest of 20 kilos per person under permit.</td><td>Fuel wood cutting for household consumption permitted under license from forest ranger, but within Allowable Cut limit set by MNE.

Sideline non-timber products use is permitted, such as pine nut, mushroom and antler pick-up.</td></tr>
</table>

Table 10. Zones with Forests Administered under Mongolian Law on Special Protected Areas.

<table>
<tr><td colspan="10">Intent of Special Protected Areas Law
“conservation of original conditions” (lacks a reference to restoration)</td></tr>
<tr><td colspan="3">Special Protected Areas</td><td colspan="3">National Conservation Park</td><td colspan="4">Nature Reserves</td></tr>
<tr><td colspan="3">Prohibits all uses incompatible with the zone
3 subzones</td><td colspan="3">Relatively preserved areas with historic, cultural, scientific and ecological value of state importance
3 subzones</td><td colspan="4">“Conservation, restoration and preservation of certain features”
No commercial activities that change the character of the features”
4 types of reserves</td></tr>
<tr><td colspan="6">Estimated 1.5 million hectares of forest</td><td colspan="4">Forest Area within reserves not readily available.</td></tr>
<tr><td>Pristine Zone</td><td>Conservation Zone</td><td>Limited Use Zone</td><td>Special Zone</td><td>Tourism and Travel Zone</td><td>Limited Use Zone</td><td>Ecological Reserve</td><td>Bio-logical Reserve</td><td>Paleon-tological Reserve</td><td>Geo-logical Reserve</td></tr>
<tr><td>Protection only</td><td>“bio-technological measures to enhance flora and fauna reproduction and eliminate natural disasters”</td><td>Forest maintenance and cleaning
Approved wildlife management to regulate numbers.
Soil and plant restoration
Local collection of plants for local home use.</td><td>Protect only</td><td>“to restore soil and eliminate damages caused by natural disaster”</td><td>“to restore soil and eliminate damages caused by natural” disaster”</td><td>Preserving virgin ecosystems</td><td>Conserving rare and endangered plants and animals</td><td>Ancient animals and plants</td><td>Unique signs, formations and structures</td></tr>
<tr><td></td><td></td><td>Khan Khentii * 367,000 ha forested in limited use zone</td><td></td><td colspan="2">Gorkhi-Terelji * 41,000 ha forested in limited use and tourism zones.</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Gap analysis recommended for assessing what forest types are present in the current SPA system.
Where there are significant gaps in conservation, consideration needs to be given to include under-represented types within SPA.</td></tr>
</table>

* Identified by Wingard (2001)

5.2 Fire Management Legislation

Mongolian Law on Prevention of Steppe and Forest Fires

The purpose of the law is the coordination of forest and steppe fire prevention, suppression and restoration. It is the responsibility of every citizen to prevent and, where possible, suppress fire. Governors have the authority to mobilize anyone who is not exempted, such as the young, the old and women with responsibility for young children, including women in pregnancy. It is a criminal offense to cause a fire, with punishment up to ten years in jail. Costs for fire suppression are to be supported by the local budgets. This requires a suppression plan. There is reluctance by the local population to participate unless mobilized. Payments are set out in accompanying pieces of legislation. A restoration plan will be able to address some of the elements of a prevention plan, namely the management of fuel.

Law on State Emergency

This governs interagency cooperation during extreme suppression activities. The Act includes steppe fire prevention. During interviews with the National Emergency Management Agency (NEMA), staff were open to expand from suppression to role prevention. The role of prescribed fire as a management tool is considered some way off, but NEMA staff would be central to its use. They are the logical choice to assist and support the use of prescribed fire for fuel management. This will be possible when staff are properly trained, have appropriate equipment and possess a prescribed fire plan with clearly defined goals. It is recommended in areas where human safety is a concern, such as areas near settlements. These areas need to be mapped and given priority for restoration and fuel management.

Law on Buffer Zones

The purpose of this law is to set out procedures for establishing buffers around Special Protected areas (SPA) and National Parks (NP). Within established buffers, the purpose is to *"minimize, eliminate and prevent actual and potential adverse impact to the SPA and NP, to increase public participation, to secure their livelihood and to establish requirements for proper use of natural resources."* Resources use within the zones requires an automatic Detailed Environmental Impact assessment for certain uses. Wingard (2001) noted that 12 buffer zones had been established, covering 10.5 million ha, or an area one and a half times the size of the SPA and NP. The amount of forest within designated buffer zones is unclear, as is the extent to which the six provisions of Buffer Zone Management Plans address forests.

5.3 National Program on Forestry (NPOF)

The NPOF is the government's blueprint for forest management. The author considers that NPOF goals are achieved with greater certainty once an EBFM approach is adopted.

NPOF Goals are:

Objective 1. To apply modern, more effective techniques and technology for forest protection, and to urgently implement prevention measures for reducing the negative human impact of forest fire, harmful insects and diseases.
Objective 2 To meet domestic demand for wood products.
Objective 3 To promote export-oriented production of furniture and other value-added products.
Objective 4 To prevent desertification and deforestation.
Objective 5 To support improved living standards.

The National Program on Forestry describes "*forests of our country as hyper sensitive ecosystems which function to regulate river flow, to protect soil erosion and degradation, to ameliorate climate conditions. To mitigate green house gases, to create habitat for wildlife and to conserve perma frost distribution"*. This indicates understanding of the importance and need to manage the forests well to continue to receive these benefits.

The NPOF has an objective to *"hand over forest resources to economic entities who will log and reforest"*. This commercial, concession-based forest management approach makes social objectives for fire and insect management more difficult to achieve. Commercial concessions focus on removing as much high value volume as possible to maximize profit. Stand tending and reforestation are business expenses, and thus a liability at odds with profit generation. There is constant tension between social goals and private interests. EBFM focuses on removal of smaller trees, with thinning providing a source of timber which is able to sustain timber-products manufacturing. Operational costs, planning restoration, site treatment and transportation of thinning can be financed through the sale of thinning materials from wood yards. Auctions can be used to establish fair market value. Funds from sales can be applied to local community projects with an expectation that a portion will also support Aimag and State infra structure and general revenues.

The most significant benefit from a landscape restoration program is the size of the forest area to which restoration can be applied. Commercial forest harvest is limited to 7% of the forest territory (1.2 million ha) and a current AAC of 600,000; an approximation based on Table 6 Crisp et al 2001. There is a significant illegal harvest volume well above this estimated sustainable. Restoration can be applied to benefit the Protection Zone, making access to 46% of the forest territory adding (8.22 million ha). An EBFM approach will better meet domestic demand. In addition, restoration is suited to a portion of the limited use zone of the Strict Protected Areas, adding another potential 400,000 ha to the Special Protected Areas. Collectively, the thinning material from forests treated in these zones is expected to meet local timber requirements. Depending on the size of the restoration program, it may take twenty years to restore forests in these zones. Even after that time, there will need to be continued fuel management activities. While the program restores stand structures, the volume of thinning materials will significantly exceed the current 600,000 cubic meters AAC made available by MNE for commercial harvest.

Table 11 compares the actions implicit in the NPOF with the more desirable EBFM approach. This table illustrates the differences in approach that would need to be undertaken by MNE staff. EBFM is considered to support the intent of forest management in FLOM, but prescriptions necessary to achieve this volume would differ significantly between the two approaches

Table 11. National Program on Forests Activities and Clarification of EBFM Activities to Achieve Program Goals

Article	NPOF	EBFM	Benefit
1. Harvest calculation	Calculate annual increment and set AAC for commercial harvest and fuel wood. Volume based on access to 7% of the forest	Calculate restoration area. Greater usable volume expected from thinning Greater area available for restoration Possible 60% or more of all forests forest.	Area approach means much larger area application
2. Allocation to improve regeneration	Award cutting rights with reforestation obligations; concentrate on allocation of highest volume areas.	Plan thinning over stocked areas. Focus to reduce fire risk near settlements. Work awarded through bids. Leave stand naturally stocked, no reforestation obligations.	Higher likelihood of success
3. Hand over forest resources cutting rights and plant to protect the forest	Requires reforestation with cutting rights which means protecting the forest. Not deemed successful, as profit incentive is unsuited to achieving some social goals.	Finance thinning operations from sale of material through local auction at wood yards. Higher volumes of smaller wood are better able to meet sustainable domestic wood demands.	EBFM higher economic benefit
4. Cease cutting of young and pre-mature trees.	Prohibits thinning. Increases risk of loss of more trees to fire and insect. Reduces biological diversity. Inconsistent with FLOM intent.	Thin from below (mark trees to leave). Released trees are better fire adapted and less prone to insects. Current policy does not permit restoration.	EBFM more likely to achieve overall goals
5. Saxual Forests	Beyond project terms of reference		
6. Road access	Participate with assistance of foreign investment. Note that winter access provides low impact and is to be encouraged.	Forest restoration and transport of thinning is not considered limited over the next 20 years. Use of frozen ground encouraged.	Short term thinning can use existing access
7. Limitation of wood export and encouragement of import	Large-dimension, high-volume exports prohibited	Consistent with thinning from below	High EBFM compatibility
8. Railway sleepers replaced by non-wood	Support reduction of illegal harvest.	Consistent with moving to timber products from thinning.	High EBFM compatibility
9. Reduce waste from logging	Not apparent as the post-harvest obligation for planting. Enforcement of waste unclear.	Use of small thinning for fuel reduction is a major EBFM goal. Maximum use of fuels at the local level is an outcome. Chipping and burning where settlement has central heating infra structure.	EBFM is focused on fuel reduction

10. Pine oil, larch oil and birch charcoal production	Develop additional forest products for market.	More potential small wood volume anticipated.	High EBFM compatibility
11. Increase birch products; e.g. flooring	Links to economic goals; post harvest fuels and desired future condition not addressed.	Consistent with EBFM, will require fuel management goals to be achieved.	High EBFM compatibility
12. Small and medium-sized timber goods industry: furniture, etc., for local and export sales	Concern that wood will come from high grading	Consistent with EBFM, will require fuel management goals to be achieved.	High EBFM compatibility
13. Conditions for factories for plywood, particle board, veneer.	Veneer and plywood require high quality large pieces, which means high grading.	Particle board construction is well suited to restoration thinning, as small diameter wood can be used. Veneer production relies on largest trees, and is not compatible with EBFM	High compatibility with particle board
14. Local processing for local use	Concern that wood will come from high grading	Develop greater local industry based on thinning, as there is greater7 access across forest zones.	High EBFM compatibility
15. Inventory of non-wood products by season and region.	Understory plants cannot be interpreted from current forest inventory.	Inventory supporting EBFM will provide a basis for inventory of forest stands and non-timber products, including wildlife.	High EBFM compatibility
16. Guidance on use of non-wood products.	Current practices are decreasing the supply of non-timber products, such as pine nuts, berries, mushrooms.	EBFM will increase availability of non-timber wood products as understory production will increase.	High EBFM compatibility
17. Increase household income from non-timber.	Current management is reducing the ability to supply non-timber products.	Restoration will speed recovery of forest and the supply of non-timber products.	High EBFM compatibility

Recommendations for additions to Mongolian NPOF

1. Include an article specific to Restoration and application of EBFM. Recognition and support of the Forest Landscape and Sustainable Forest Management Project.
2. Support ecosystem-based natural disturbance ecology training module for MNE Soum and Aimag staff at all levels, including professional organizations that may be engaged in restoration. Development of a standard curriculum and learning outcomes for institutions teaching forestry.
    a. Public outreach on natural disturbances and forest recovery.
    b. Review MNE Aimag and Soum staff qualifications and salary with an aim to maintaining a professional qualified staff and reducing turnover of trained staff at all levels.
3. Complete mapping of natural disturbance regimes using existing forest type classifications. Refine these using Digital terrain models. Support GIS system and define data layers needed to support Soum level planning. Provide easy access to forest ecosystem mapping and template type information for MNE, especially at all levels. Ensure all zones are mapped at an operational level.
4. Develop an integrated forest stand structure mapping standard that is able to use remote-sensed satellite data, so it can be quickly mapped and up-dated.
5. Concentrate cleaning of forests for the purposes of reducing fuels and fire intensity near infra structure, towns, human habitation, power lines, etc.
6. Eliminate planting trees in areas where there is no evidence of pre-existing established forests. These sites are fire-adapted grasslands.

6. Silviculture Systems

Forest Management can be defined as human intervention into the nature, extent and timing of disturbance to forest ecosystems for the purposes of obtaining desired goods and services. Harvesting is a disturbance over which we have the greatest control.

Silviculture is the art and science of controlling the establishment, growth, composition and quality of forest vegetation for the full range of forest resource objectives**.** Successful silviculture depends on clearly defined management objectives. Silviculture is often focused to managing stands and forests purely for timber. Silviculture practices can be applied to manage forest ecosystems for: resilience to disturbances such as fire and insects, production of non-timber forest products such as pine nuts, wildlife habitat, water yield and quality, etc.

Objectives, whether timber-focused or resilience-focused, must be consistent with the understanding of the tolerances in the ecosystem to be successful. Desirable objectives for Mongolia’s forested landscapes, consistent with the Forest Law of Mongolia, are:

- Resilience to fires and insects (increased certainty)
- Maintenance of long term site productivity
- Maintenance of biological diversity
- Ability to improve living standards in a sustainable manner by a flow of goods and services for Bag, Soum, Aimag and State economies.

6.1 Current Silviculture System

There has been a significant amount of forest harvest over the last 50 years in Mongolia. Much of the harvesting is believed to have been done by clear felling, with poor natural regeneration to conifers. This likely contributed to the 1995 ban on clear felling in the FLOM and mandatory planting. Harvest volume varied between 0.8 million cubic meters to 2.8 million cubic meters from the late 1970s to 1994. (Crisp et al. 2004)

The objectives of the current silviculture system are to sustainably manage stands and forests for timber and to improve living standards at Bag, Soum, Aimag and State levels through timber production.

Observation of logged areas in the field indicates that harvest practices increase the divergence from HRNV. In short, current practices are creating forests which are more susceptible to loss by fire and insects. Current commercial harvest, legal or otherwise, removes the largest older trees. This is also known as thinning from above or high grading. This commercial approach does not achieve the social goals in FLOM of "proper use and restoration", and is arguably counter to the intent of FLOM. EBFM takes a different approach from high grading: namely, thinning of smaller diameter trees. EBFM will provide greater volumes of smaller wood, thus leaving a forest more resilient to natural disturbances such as fire and insects. Once forests are restored and more resilient, they will be able to provide a more predictable supply of wood, but the need to thin in order to manage fuel and reduce competition is considered to be a long term activity. Large fires quickly change forest inventory. Staff at Soum confirmed the inaccuracy of the inventory despite legislated requirements for updates at least every 10 years.

The current silviculture system is a "selective cutting system" where the largest trees are harvested. This is also known as thinning from above or high grading. From field observation, there are high volumes of wood left on site. Large, older trees develop heart rot in the lower bole. After trees are felled, any butt rot found is cut off and left on site. Older trees also have large limbs, which decrease timber value and increase milling difficulty. Large limbed trees often have only a single log removed from the lower bole. The upper two-thirds of the tree is left, creating unnaturally high levels of large-diameter fuels on the site. Since decay rates are slow, due to low rainfall and cold temperatures, this fuel remains on site. When a fire occurs, it burns more intensely and the heat sterilizes the soil, thus reducing long-term site productivity. Timber contracts have provisions for "returning the deforested area to forest." Enforcement of utilization standards and post harvest fuel was not evident from field visits. Currently there is no management of stocking density during harvest as an alternative to planting, in order to achieve a new stand. The specifications for reforestation obligations could be expanded to include advanced regeneration, instead of relying on planting.

The high grading system moves the forest away from HRNV, increases fire and insect susceptibility and is counter to the intent of the FLOM. Most of the harvested areas visited were being cut illegally using the high grading system. The harvest disturbance leaves the forest in poor condition.

Post harvest, it is necessary to plant 3 to 5 trees for every tree harvested. Planting takes place in the spring and survival is confirmed in the fall. Reforestation obligations are extinguished in the second year after planting. Considerable effort and much of the forestry budget go to tree nurseries and planting. Planting by local residents is encouraged. Two payments are made: the first, when trees are planted in the spring and the second, when survival is confirmed in the fall. This provides local employment and a source of revenue for local residents, but does not meet the objectives of even the timber management, because the long term survival, when measured 5 to 10 years after planting, is so low. Discussion with staff indicated that plantation survival was less than 10% when measured a number of years after planting.

There are approximately 30 tree nurseries in Mongolia. There, many local people are employed planting trees; however, while in the field, regeneration success was observed to be low. Trees are planted in the late spring and survival is fairly good during the first growing season, as summer rains carry trees through to the fall. Half the money for planting is paid in the spring and the remainder in the fall, based on over-summer survival rates. However, a significant source of seedling mortality occurs in the following spring when the ground is frozen and the air is warm, so the evergreen conifers like *Pinus spp* transpire, but cannot access soil moisture, so they desiccate and die. Higher survival exists when there is some over-story shade to prevent desiccation while the ground is frozen. With too much over-story shade, the seedlings cannot compete. *Larix sibirica*, because it is deciduous, does not suffer transpiration mortality. The planting program appears to be a means of transferring money to local residents, with little or no long term forest benefit. Planting should be limited to productive sites where natural regeneration and spacing of established smaller trees do not create a new stand of trees similar in stand structure and composition to that developed through HFRI over a reasonable time period.

The Vice Minister, Dr. D. Enkhmandhakh, requested advice on current salvage policy. Currently, forest policy permits salvage of all dead trees, a blanket prescription that is not appropriate in all circumstances. A more ecologically based salvage policy would be appropriate A general observation on blanket forest policy such as the current salvage policy, is that they seldom provide the best long term results. Ecosystems and forests are diverse, so a single rule for every situation does not often satisfy. The alternative to a blanket approach is to develop a policy based on the understanding of natural systems. This requires knowledgeable, well-trained staff who have the authority to make decisions based on the site-specific circumstances. With flexibility for staff, controls in policy are a necessity for reasons of accountability.

An ecologically based salvage policy would protect some dead trees. Dead trees provide important habitat for some species and are thus part of the natural diversity of forests. Systematic removal of dead trees from the forest is not ecologically appropriate, as it leads to of the simplification forest stands and reduced biological diversity. Forests without a dead wood component are unnatural. From a practical point of view, local residents also find old trees more difficult to cut and less endowed with heat than green wood that has been dried.

Salvage of dead trees is appropriate after a major disturbance such as a wild fire, where many trees have been killed over a large area. Salvage can be beneficial for the forest when the forest stand structures are significantly departed from HRNV and there is a higher than appropriate level of tree biomass on the site. This is the case for many forests visited, where fire has been excluded and understory plants have decreased, allowing trees to dominate the site. Where there is a high volume of biomass accumulated in dead trees, the site contains a lot of fuel. After these trees fall and when the next fire occurs, the dead wood will burn more intensely, sterilizing the soil and reducing site productivity. Note the use of the word "when" the next fire occurs, as fires are part of the Mongolia forests and cannot be excluded. Removal of dead biomass from these sites is a form of restoration to a more normal mix of biomass in the trees and in understory grasses, forbs and shrubs. Salvage will reduce the intensity of the next fire. Salvage is ecologically appropriate for both fuel management and site productivity reasons.

However, after a fire, the highest tree mortality occurs in the shortest, small-diameter trees. These are the trees that lost their crowns because they had not grown out of the scorch zone. While in the field it was noted that salvage of dead trees was concentrated on larger trees. This is appropriate if the larger trees have truly been killed. It may not be readily apparent which trees survived, so the salvage may be taking live blackened trees, which have survived the fire. Marking of surviving trees for retention within fire-killed forests may be appropriate for staff, ahead of salvage operations. The remaining, large, older live trees are the very trees that will be able to provide the seed source for natural regeneration. These are the trees that are fire adapted. The practice of "high grading" in salvage therefore poses risk when live trees are also salvaged.

Photo 5. High grading and abandonment HNFR 5.

The largest fire resistant trees have been harvested. Only the clear lower boles are used: limby sections of the boles, and sections with butt rot, are left on site. When the next fire occurs, and burns these logs, it will create high temperatures, sterilize the soil and degrade the site, thus reducing productivity.

High grading has opened this to < 20% crown closure and created an unnatural amount of grass, *Calamagrostis sp* in the understory, that will carry wildfire into these forests. These forests are under natural disturbance conditions controlled by "gap" patterning.

Photo 6. Pine nut harvest Montane Moist Fire Regime.HNFR 5.

Research is needed to understand *Pinus sibirica* ecology, including frequency and predictability of cone crops, tree age when bearing crops and yield potential when managed correctly. Licensing to locals will establish a vested long term economic interest and increase the likelihood that the no-cutting prohibition on *Pinus sibirica* will be upheld. Without ownership, the current unsustainable illegal harvest is expected to continue.

Photo 7. Current unsustainable pine nut harvest in HNFR 5.

.

Continued illegal felling of the *Pinus Sibirica* will soon produce an end to the annual harvest of pine nuts. This means the loss of an opportunity to develop a pine nut trade that could provide annual local benefit

Photo 8. Higher grading HNFR 3.

High grading, or thinning for above, removes the largest older trees. High grading often uses only a single portion of the lower bole, as this has the highest value and is easiest to mill, due to the absence of large limbs. Also note that a portion of the lower bole was found to have butt rot after the tree was felled. Leaving large pieces of wood on site provided a high level of fuel and intensified the next fire. Note the abundance of natural regeneration. Restoration thinning leaves these older fire resistant trees and removes smaller, more densely spaced trees.

Photo 9. Pinus sylvestris tap root HNFR 3.
Moisture is low, < 300mm per year in the Selenge valley, so pine succeeds by developing a significant tap root. Inter tree distances are great and grasslands dominant much of the Occluded Steppe.

6.2 EBFM Silviculture System

"In other parts of the world, under similar conditions differing widely from those prevailing in Europe, there is great scope not only for the intelligent application of existing systems but also for elaboration of new systems.." R.S Troupe.1928.

Based on field visits and samples, much of the forest area has significantly departed from stand structures able to withstand fires and insects. Based on field observations, forests have missed several fire disturbance intervals, and have therefore departed from natural stand structures. Fire return intervals have been skipped, due to sustained fire suppression coupled with increased grazing and expanded, mechanized dryland farming. When fires occur today, they are more intense and kill more mature trees as well as smaller, understory trees. Steppe fires, that once carried ground fire into forests, have decreased or been eliminated, while forest fuels have increased. In the absence of fire, the number of small trees surviving is high. In such heavily stocked sites, trees are in poor condition, due to below-ground competition. When forest fires occur now, they are larger and burn hotter for a longer period, causing greater mortality of older trees and leaving soils degraded. High stand densities and competition for moisture results in trees being under moisture stress for longer periods and being more susceptible to insects.

A number of silviculture systems were reviewed with an aim to finding an existing system appropriate to the dry forests found in Mongolia. The selection system in dry forests removes single trees of commercial value from a stand. The group selection systems focus on a number of trees of commercial value, and remove these from the stand. Sometimes, partial cutting systems use a fixed diameter above which all trees can be removed. This is referred to as diameter limit cutting. The shelter wood system is also a partial cutting system which focuses on conditions that ensure removal of volume, while creating conditions that provide shade and moisture for seedling survival. Where shade and moisture are not limiting the shelter wood system creates conditions for natural regeneration, mature seed trees may be left, while most of the volume is removed. (Lieffers et al., 2003)

After a review of existing silviculture systems it was concluded that none specifically addressed restoration and thinning of smaller trees to densities and structures within HFRI. Most of the reviewed silviculture systems focus on commercial harvest, followed by prompt regeneration, and set a goal of maximum site occupancy for commercial tree species. The variable retention system focuses on stand structure retention; however it also has commercial timber production as a primary goal. (Lindemeyer and Franklin 2002).

Though silviculture, by definition, is stand manipulation for a variety of objectives including non-timber; the non-timber objectives are not reflected in literature. Therefore, no text books on silviculture systems describe how to adopt an already-defined silviculture system that was explicitly developed for restoration of stand structure with primary goals to improve forest health and create a forest more resilient to disturbance. The restoration silviculture system considered appropriate to restore forests is a partial cutting system that cuts young trees and leaves larger, older ones. Removing young trees is managing for a lower stand density, with a fewer larger-stand structures. This silviculture system is also known as thinning from below. To distinguish this from commercially focused systems the term disturbance-based restoration silviculture system is proposed.

The objectives of disturbance-based restoration silviculture system are to create a forest that:

- Is resilient to fire and insects
- Maintains long term site productivity
- Maintains natural biological diversity
- Improves living standards through the flow of goods and services in a sustainable manner for the benefit of the local, regional and state economies

Disturbance-based restoration silviculture creates or maintains stand structure on the site most closely resembling structures developed from HFRIs. A guide to the former stand structure on site can be found by looking at older trees, stumps and decaying trees. There is a range of variability for each site. Time, fire frequency and chance determine what is present today, but this is simply one possible outcome. It is recommended that the development of a site’s potential range structure be undertaken to clarify the range of variability. This description of a restored stand structure has been referred to earlier as landscape and stand level templates.

When on site, it is practical to look at the evidence of the persistent stand structure. Persistent means the trees which survive post disturbances. This evidence can be found in live old trees, cut stumps or decaying tree stumps and in comparisons of whether trees are grouped or fairly evenly spaced. Older trees in the stand today indicate they are resilient to fire and wind. These trees can be marked to leave. Some smaller trees, where available, can also be marked to leave so that thinning from below does not homogenize stand structures, but instead allows variability within stands, similar to that of a mixed intensity fire.

It is expected that MNE staff will be trained to write silviculture restoration stand prescriptions. These stand prescriptions are similar to requirements now specified in FLOM Article 26 timber contracts. A stand prescription will provide the reason for restoration, the location and size of forest stand to be thinned, and a map of the treatment area. A prescription would also include a description of post treatment stand structure and estimates of thinning material, such as the likely volume of poles, rails, fencing, fuel wood and larger timber that need to be transported from the site. It is envisaged that thinning material will be sold and made available for local use or auction. On the ground, the boundaries of the stand would be marked. As well, trees that are to be retained would be marked at ground level. A prescription would also clarify how to manage fuel and the amount of woody material appropriate to leave on a site. Prescriptions may include piling of small wood and a schedule burning, where necessary and when safe to do so. On site chipping of some materials and transport from the site may be feasible. Cutting of larger trees (thinning from below) must be consistent with site recovery and not be driven by high grading, as is currently practiced. Training MNE staff to do treatment layout is considered an effective approach to restoration and allows local auction and bidding systems to build local processing.

6.3 Silviculture Systems Appropriate to NDRs

This is a brief description of the four, forested NDRs and a discussion of silviculture systems appropriate to match the natural disturbances structures. More field work and sampling are needed to clarify HRNV of stand structures and the future desired condition. These have been referred to earlier as landscape and stand level templates. See Gray (2006) for a more complete description of these HNFRs.

HNFR 3 Occluded steppe fire regime.

Description: Frequent (<10 years). Mixed severity. This fire regime contains a steppe grassland and forest. Forests occur on the cooler, northerly aspects where moisture is slightly higher and trees are able to survive. *Pinus sylvestris, Larix sibirica, Betula platyphylla, and Populus tremula* are the dominant forest trees.

This is the largest of the forested NDRs in Mongolia and the one most significantly affected by grazing and fire suppression. This NDR also has the highest density of settlements and the highest number of people. As well, this zone has the highest levels of access. The forest types in this fire regime have the least available moisture, so trees are most widely spaced and the understory species present are those adapted to frequent fire, such as *Poa sibrica*, *Bromopsis pumpeliana* , *Calamgoristis arundinacease.* Due to proximity to the open steppe, these forests historically could have burned as frequently as the open steppe.

Disturbance-based restoration silviculture system

Thinning from below is appropriate in order to move structure towards historic conditions. This disturbance type is considered to be most at risk, from a fire perspective, and most in need of restoration to reduce hazard to humans and property. There is significant opportunity to restore forests and use the thinning materials as a source of poles, rails, dimension lumber, fuel wood and energy (bio-fuel). Deciduous stands may have increased in areas where there was extensive clear cut logging.

HNFR 4 Montane dry fire regime.

Description: Frequent (<30 years), Mixed severity. These warm aspect *Pinus sylvestris* and *Larix sibirica* forests are open growth with heavy grass cover. Understory species, such as *Calamagrostis* spp., *Lonicera* spp., *Carex* spp. and *Geranium* spp., are well suited to low-severity fires. Historic fires appear also to have generated some small openings, and stands are considered to be somewhat "gap driven", with some opening of < 5 hectares (Gray 2006). When fuel levels are higher than historic levels, fire intensity is more severe, so without fuel reduction (restoration treatments) the trend is to increase the size of the gaps. These are productive ecosystems and much of the illegal logging was observed in this natural disturbance regime. Logging is removing the older trees, thereby adding to the fuel problem.

Disturbance-based restoration silviculture system. Thinning existing smaller diameter trees (thinning from below) to lower stocking densities is appropriate to restore stand structures and remove fuel from these sites. The variability of stand structures and historic levels of small forest gaps needs to be better understood. Deciduous trees are present in many portions of this disturbance type. Aspen and birch respond to thinning and will sucker and basal sprout when disturbed. In mixed stands, thinning can favour conifer or deciduous species. There is significant opportunity to restore forests and use the thinning materials as a source of poles, rails, dimension lumber, fuel wood and energy (bio-fuel).

HNFR 5 Montane moist fire regime.

Description: Frequent (<50 years) Mixed severity.

This NDR is associated with the cool aspects of *Larix sibirica* and *Pinus sibirica* forest with understory species of shrubs, mosses and herbs. Moisture availability is higher than in the adjacent, drier HNFR 4 where grasses dominate. This NDR type is more productive than HNFR 4. Stand structure is highly variable, with a wide range of cohorts present in a stand. The fire severity is mixed, and when severe, the gaps tend to be small in size (<1 ha). Understory species, such as *Vaccinium* spp., *Ledum palustre* and mosses, slow ground fire spread, while grass species such as *Calamagrotis* spp., which are more flammable, spread the ground fires. The stands are very heterogeneous.

Disturbance-based restoration silviculture system. These are gap driven forests. Regeneration of new trees occurs when gaps form in the forest. The flammability of understory species regulates the severity of fires when they occur. To emulate gaps, a better understanding of the current gap dynamics is needed. Single tree selection is the EBFM silviculture system that can best create gaps. It is recommended that only larch be thinned or harvested and that *Pinus sibirica* be maintained to sustain pine trees and pine nut harvest. Species such as *Vaccinium uliginosum* provide annual berry crops. Single tree selection needs to be light to maintain shrubs such as *Vaccinium uliginosum*, as these types of evergreen species are less flammable and slow the spread of ground fire. If removal of trees creates larger gaps, grass species increase, allowing ground fires to penetrate into this zone. The result is increased species mortality. Field observations showed natural regeneration to be vigorous. Some thinning, to release *Larix sibirica*, could increase growth of the remaining trees. Current illegal harvest practices are not consistent with maintaining gap dynamics, as logging is creating large openings and an increase of flammable grasses.

HNFR 6. Subalpine/alpine natural disturbance regime.

Description: Infrequent (> 100 years), Mixed-severity. Trees in this higher elevation NDR are *Larix Sibirica, Pinus siberica, Picea obvata* and *Abies sibirica.* Gray (2006) indicates that climate plays an important role in the subalpine, where fuel may only be dry enough to burn in fall and only during climatic drying cycles. The term 'mixed severity' is used, as fuel accumulations are high and fires are infrequent. When fires occur, they can be stand replacement disturbances, as trees such as *Abies sibirica* and *Picea obvata* are not adapted to fires. Understory plants are also not well adapted. The complex terrain also creates variability in fire intensity and skips added to the mixed severity.

Disturbance-based restoration silviculture system

This is a gap-driven NDR and it likely does not need restoration. When infrequent fires occur, they can be stand replacing. Sub-alpine forests are protected by FLOM. It is permitted to pick up branches and dead trees for fuel, and to gather non-timber products such as pine nuts. FLOM does not define sub-alpine forest in sufficient detail to tie to existing maps. Wingard (2001) noted that sub-alpine has been delineated at a scale of 1:500,000. It is assumed that this NDR meets the intent of FLOM, and once mapped, will provide the basis for this legal zone. Mapping is needed at an operational planning scale (1:50,000). Considering the infrequency of fires and the mixed severity of forest when they occur, most of the forest regeneration occurs in gaps as trees die or where windthrow creates favourable seed bed conditions. Larix germinates well on mineral soils.

6.4 Silviculture Trials

Silviculture trials are recommended, in order to begin to collect data on changes associated with restoration. The HNFR 3 is the highest priority for restoration and will benefit from trials. HNFR 4 is next highest in need of restoration and thinning trials. Trials, however, will also broaden understanding of gap dynamics in HNFR 5. HNFR is not considered a priority, as there is little intervention permitted, little activity in the zone and lack of access, all of which are expected to protect this zone.

The purpose of silviculture trials is to measure the response of the trees and understory to thinning from below over time. Does thinning from below release trees so that they increase in height, diameter and volume post thinning? Is the same biomass accumulated in trees? What is the response of the understory? Silviculture restoration thinning trials require measurement at periodic intervals in order to gauge treatment response and reporting of findings. Varying the removal of smaller stems to compare results is also recommended for trials. This means that permanent-type plots need to be established in fairly extensive forest types and under some varied stand structure types. Untreated controls are also needed with sufficient rigor to assign cause and effect. It is also expected that some trials will be burnt in order to assess mortality and response pre- and post-fire. The types of materials removed from the site also need to be documented to help forecast potential volume in posts, rails, timber, and fuel on site.

References

Andison Dave, W., 2003. Tactical Forest Planning and Landscape Design. In Burton et al. 2003.

Association of British Columbia Professional Foresters. 2005. Position Paper. Forest Fires in British Columbia. How Policies and Practices Lead to Increased Risk. http://www.abcfp.ca/publications_forms/publications/documents/PositionPaper_Fire%20Management(July%202005).pdf

British Columbia Government. 1995. Biodiversity Guidebook. Ministry of Forests and Ministry of Environment, Lands and Parks. Forest Practices Code of British Columbia. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm

Burton, P.J., C. Messier, D.W. Smith, and W.L. Adamowic. (Editors). 2003. Towards Sustainable Management of the Boreal Forest. National Research Council of Canada. http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_book_e?mlist5_556

Crip, N., J. Dick, and M. Muellins. 2004. Mongolian Forest Sector Review. World Bank. Pp. 143.

D'Arrigo, G. Jacoby, D. Frank, N. Pederson, E. Cook, B. Buckly, B. Bachin, R. Mijiddorj and C. Dugargav., 1739 Years of Mongolian Temperature Variability Inferred from a Tree-Ring width Chronology of Siberian Pine. Geophysical Research letters, Volume 28, No. 3, Pp 543-546.

Davi, N. K., G.C. Jacoby, A.E. Curtis, and N. Baatarbileg. 2005. Extension of Drought Records for Central Asia UsingTree Rings: West-Mongolia. Journal of Climate, Volume 19.

Enkhbat, A. and J. Tsogtbaatar with H. Yhkanbai 1997. Forest and Forest Management in Mongolia. RAP publication: 1997/4. FAO Bangkok. Pp. 42.

George D.W. and R. W. Mutch. 2001. Mongolia, Strengthening Forest Fire Management. Food and Agriculture Organization of the United Nations. Rome. Italy. Pp 58.

Gray, Robert. 2006. Proposed World Bank Project: Forest Landscape Recovery and Sustainable Management. Pp 49.

Grumbine R. E. 1994. What is Ecosystem Management? Conservation Biology, Volume 8. No. 1. pp 27-28.

Haeussler, S. and D. Kneeshaw. 2003. Comparing forest management to natural processes. In Burton et al. 2003.

Ministry of Forests, 2000. Risk Management and Statutory Decision Making Handbook BC Government. http://www.for.gov.bc.ca/hen/publications/risk_manage/risk_manage_chapter05.html

Ing, S. K., 1999. The Social Conditions for Wildfire in Mongolia. Global Fire Monitoring Centre and Fire Ecology Research Group. Max Planck Institute for Chemistry, Freiberg. Germany.

Johnson, E.A., H. Morin, K. Miyanishi, R. Gagnon, and D.F. Greene. A process approach to understand disturbance and forest dynamics for sustainable forestry. In Burton et al. 2003.

Khuldorj, B., editor. Author team (B. Badarch, Ch. Chuluuntsetseg, A. Demberel, D., Jayana, N., Oyun-Erdene, P. Tsetsgee). 1999. Mongolian Action Plan

Lieffers, V.J., C. Messier, P.J. Burton, J.-C. Ruel, and B.E. Grover. 2003. Nature-based silviculture for sustaining a variety of boreal forest values. In Burton et. al. 2003.

Lindenmeyer, D.B. and J. Franklin. 2002. Conserving Forest Biodiversty. A Comprehensive Multi-Scaled Approach. Island Press. Pp 351.

Myagmarsuren, D., editor. 2000. Special Protected Areas of Mongolia. Government Regulatory Agency, Environmental Protection Agency, Mongolia GTZ Project Nature and Buffer Zone Development. Pp 102.

Nelson H., I. Vertinsky., M. K. Luckert, M. Ross and Bill Wilson. 2003. Designing institutions for sustainable forest management. In Burton et al. 2003.

O'Hara, Kevin. L, and Penelope A. Latham. 1996. A Structural Classification for Inland Northwest Forest Vegetation. Western Journal of Applied Forestry, Volume 11 No. 3. Pp 97-102.

Pavlov, D.S.T. Galbaatar, R.V. Kamelin, and N. Ulziykhutag. 2005. Ecosystems of Mongolia. Joint Russian – Mongolian Complex Biological Expedition. Moscow. Pp 48.

Troupe, R.S.. 1928. Silvicultural Systems. Oxford Univeristy Press. Oxford Ul. Pp 199.

United Nations Environment Program (UNDEP) and the Mongolian Ministry of Nature and Environment. 2002. State of the Environment Mongolia. Pp 79.

Valendik, E. N, G.A Ivanova, Z.O. Chuluunbator and J. G. Goldammer. 1998. Fire in Forest Ecosystems of Mongolia. Fire Ecology Research Group Max Planck Institute for Chemistry. IFFN No. 19.

Wingard J. R., and N. Erdenesaikhan. 1998. Khan Khentii Protected Area, Mongolia. German – Mongolian Technical Cooperation GTZ Integrated Fire Management Project.

Wingard, J. R. and Purevdolgor. 2001. Compendium of Environmental Law and Practice in Mongolia. GTZ Commercial and Civil Law Reform Project, Ulaan Bataar. Mongolia.